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DIMENSIONS AND ISSUES



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CHAPTER 1

The Evolution of California Agriculture 1850-2000

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Two competing legends dominate the telling of California's agricultural history. According to the first legend, California farmers are progressive, highly educated, early adopters of modern machinery, and unusually well organized. Through irrigation, they made a "desert" bloom. Through cooperation, they prospered as their high-quality products captured markets around the globe. This farmers-do-no-wrong legend is the mainstay of the state's powerful marketing cooperatives, government agencies, and agricultural research establishment. According to the opposing legend, the California agricultural system was founded by land-grabbers who continue to this day to exploit impoverished migrant workers and abuse the Golden State's natural environment. (Even in its mildest form, this view faults California farmers for becoming full-fledged capitalists, rather than opting for more traditional family farms like their midwestern brethren.) Although the contest between these competing interpretations of the nature of California's farm system has raged for the past one-and-a-half centuries, neither account has engaged in a systematic accumulation and dispassionate analysis of the available data, and both have generally lacked the comparative perspective needed to assess why California agriculture developed as it did.

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. The results have been remarkable. In recent years, this one state alone has accounted for one-tenth 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.

EXTENSIVE CROPS IN 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. As examples, they pioneered the adoption of labor-saving gang plows, large headers, and combined harvesters.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.

Not only were California wheat farms typically larger and more reliant on labor-saving machinery and animal (and later steam) power than midwestern and eastern wheat farms, Californians grew fundamentally different varieties of wheat and employed different cultural techniques than their eastern brethren. These biological differences, although not generally appreciated, were critical to the success of the early California wheat industry. In fact, when eastern farmers migrated to California they had to relearn how to grow the crop. In the eastern U.S. (as well as in northern Europe), grain growers planted either *winter-habit* varieties in the fall to allow the seedlings to emerge before winter or *spring-habit* varieties in the spring shortly before

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.

the last freeze. The difference was that winter-habit wheat required prolonged exposure to cold temperatures and an accompanying period of dormancy (vernalization) to shift into its reproductive stage. Spring-habit wheat, by contrast, grew continuously without a period of vernalization, but generally could not survive extreme cold. With the mild winters of California, farmers learned it was advantageous to sow spring-habit wheat in the fall (as was common in the Mediterranean but unheard of in the eastern U.S.).

California's wheat experience exemplifies what happens in the absence of continual biological innovation. After learning to cultivate Sonora and Club wheats in the 1850s, 1860s, and 1870s, California grain growers focused most of their innovative efforts on mechanization, and purportedly did little to improve cultural practices, introduce new varieties, or even maintain the quality of their seed stock. 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. The grain also deteriorated in quality, becoming starchy and less glutinous. It is interesting to note these unsustainable "soil mining" practices may well have been "economically rational" under the high interest rates prevailing in the state in the mid-nineteenth century. The result was such sharply declining yields in many areas that wheat, formerly the state's leading staple, ceased to be a paying crop and was virtually abandoned (as indicated in Figure 1).²

THE GROWTH OF SPECIALITY CROPS

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 1997. 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 one percent to five 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.

² Shaw, *How to Increase the Yield of Wheat in California*, pp. 255-57; Blanchard, *Improvement of the Wheat Crop in California*, pp. 1-5.

Table 1. California's Agricultural Development

Year	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
1997	74	27,699	--	8,543	56	8,713	260

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 1997*, California, downloaded from http://www.nass.usda.gov/census/census97/volume1/ca-5/ca1_01.pdf; *1990 Census of Population*, California, Section 1; *2000 Census*, "Industry by Sex : 2000 Data Set: Census 2000 Summary File 3 (SF 3)—Sample Data" downloaded at <http://factfinder.census.gov>.

Thomas Weiss, Unpublished data.

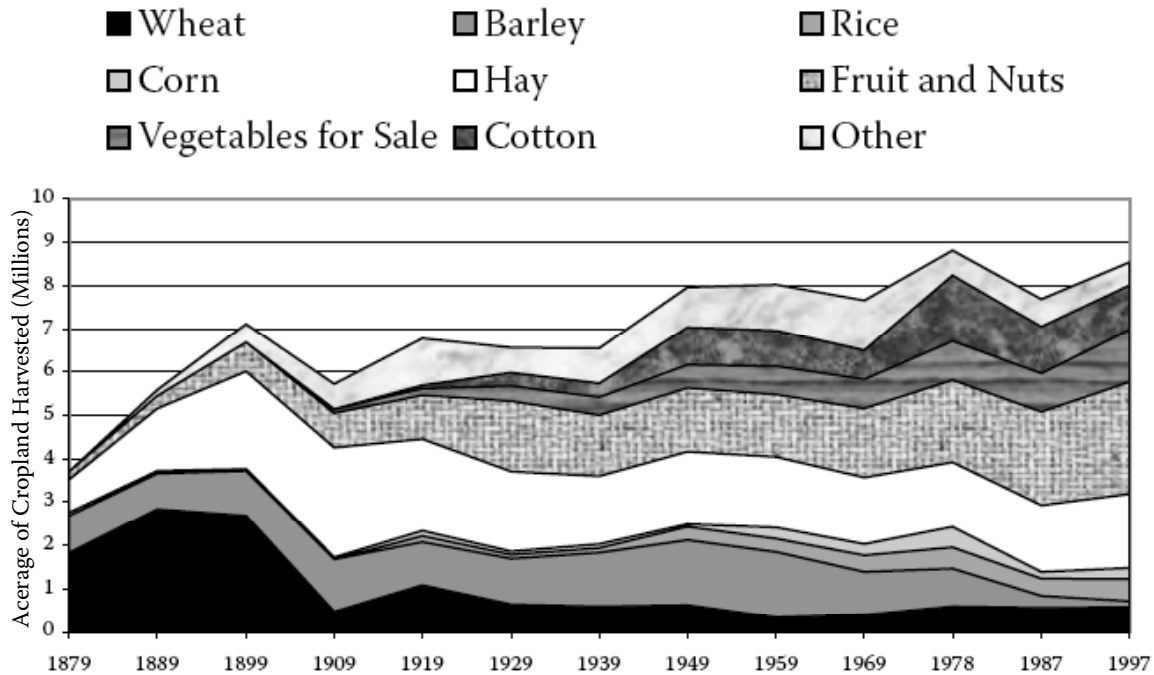
Data on the value and composition of crop output put California's agricultural transformation into sharper relief. Between 1859 and 1929, the real value of the state's crop output increased over 25 times. Growth was especially rapid during the grain boom of the 1860s and 1870s, associated primarily with the expansion of the state's agricultural land base. 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

Figure 1 provides further documentation of the transformation of California's crop mix over the late 19th and early 20th centuries. The Figure shows how cropland harvested in California was distributed across selected major crops over the 1879-1997 period. The acreage data reveal that in 1879, wheat and barley were grown on over 75 percent of the state's cropland whereas the combined total for the intensive crops (fruit, nuts, vegetables, and cotton) was around five percent. By 1929, the picture had changed dramatically. Wheat and barley then accounted for about 26 percent of the

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.

cropland harvested and the intensive crop share stood around 35 percent. In absolute terms, the acreage in the intensive crops expanded over ten times over this half-century while that for wheat and barley fell by more than one-third.⁴

Figure 1. Distribution of California Cropland Harvested, 1879-1997



Data on shipments of California fresh, dried, and canned fruits and nuts reveal the sector's spectacular expansion over this period. During the 1870s and 1880s, growth rates exceeded 25 percent per year (no doubt, in part, reflecting the small base). Shipments continued to grow at robust rates of about eight 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.

The spectacular growth in California production of specialty crops 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.⁵

⁴ The data also show that the corn crop, which nationally always accounted for more acreage than the wheat and barley crops combined, was of far less significance in the state.

⁵ José Morilla Critz, Alan L. Olmstead, & Paul W. Rhode, "Horn of Plenty: The Globalization of Mediterranean Horticulture and the Economic Development of Southern Europe, 1880-1930," *Journal of Economic History* (June 1999), pp. 316-52.

Explanations for the causes and timing of California's structural transformation have long puzzled 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."⁶ 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.⁷ 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 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.⁸

⁶ J. Burns, "A Pioneer Fruit Region," *Overland Monthly*, 2nd Series, Vol. 12, No. 67, 1888.

⁷ 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.

⁸ 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.

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.⁹ 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.¹⁰ 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.¹¹

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 (see Figure 1). 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.

The California Cotton Economy

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

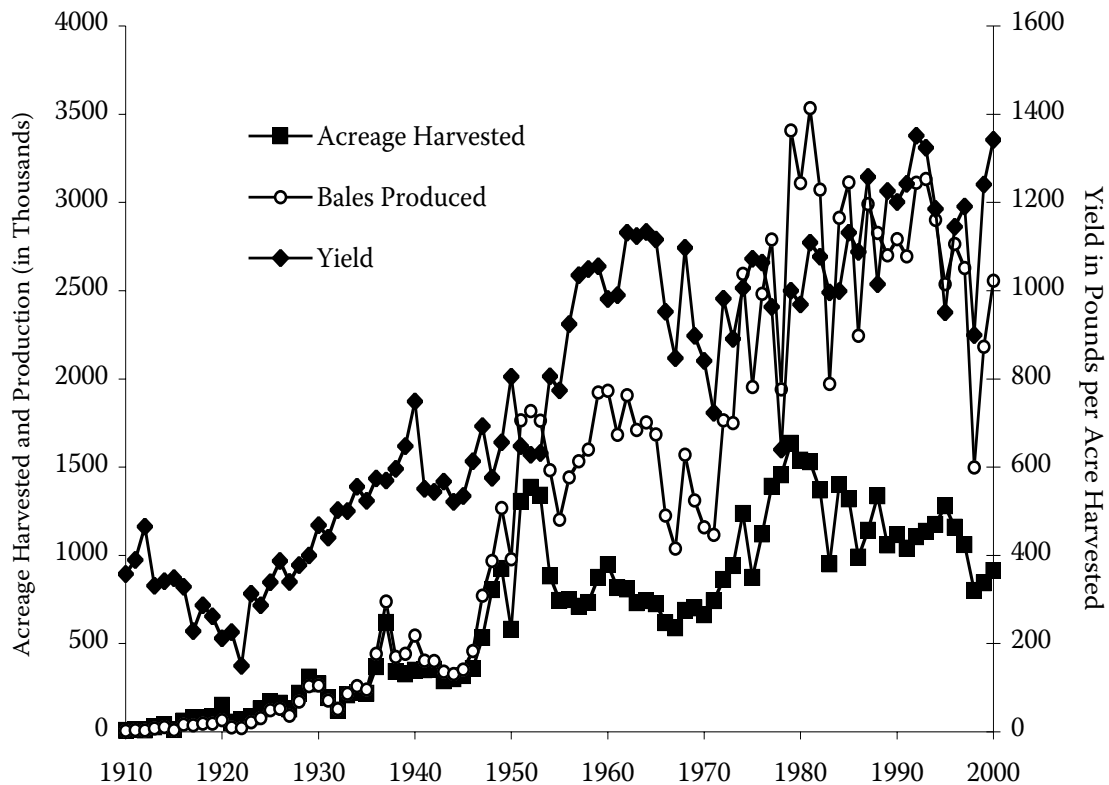
⁹ William Parker, “Agriculture,” *American Economic Growth: An Economist’s History of the United States*, Lance Davis et al., Editors, Harper and Row, New York, 1972; Charles Teague, *Fifty Years A Rancher: The Recollections of Half a Century Devoted to the Citrus and Walnut Industries of California 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.

¹⁰ 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.

¹¹ Alan L. Olmstead and Paul W. Rhode, “The Red Queen and the Hard Reds: Productivity Growth in American Wheat, 1800-1940,” *Journal of Economic History*, Vol. 62, No. 4, December 2002, pp. 929-966.

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.

Figure 2. California Cotton, 1910-2000



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 were 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 to 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.¹²

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.¹³ 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."¹⁴ 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.

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.¹⁵ 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.¹⁶

LIVESTOCK PRODUCTION

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 of various types of livestock in the state as aggregated into a

¹² 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.

¹³ U.S. Bureau of the Census, U.S. Census of Agriculture: 1959, *General Report: Statistics by Subjects*, Vol. II.

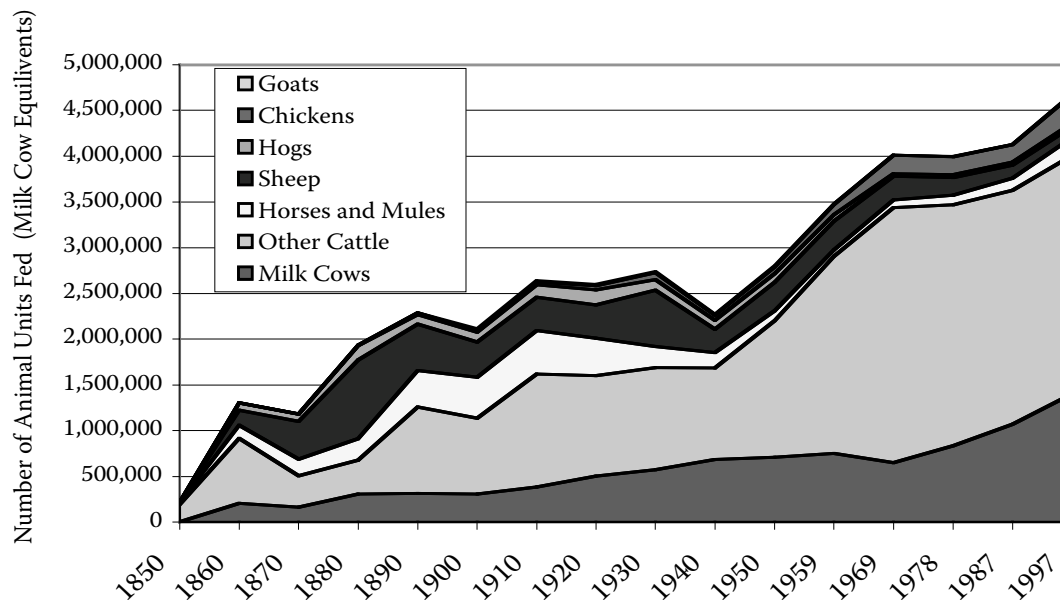
¹⁴ *Pacific Rural Press*, April 2, 1927. One of the more notable growers in Kern County was Herbert Hoover, who regularly raised 400 acres of cotton on his 1,200 acre farm during the 1920s. See *Los Angeles Times*, Farm and Tractor Section, May 8, 1921; *California Cotton Journal*, April 1926.

¹⁵ 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.

¹⁶ Musoke and Olmstead, 1982.

measure of animal units fed.¹⁷ 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.¹⁸

Figure 3. California Livestock Inventories, 1850-1997



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 remained rare. This is reflected in the relatively small role of swine production in Figure 3. Largely as a result, over the 20th century, livestock production was relatively less important in California than in the country as a whole. For example, over the 1930-97 period, the share of the market value of sales of livestock and livestock products in the combined market value of sales of crops, livestock, and livestock products has almost always exceeded one-half nationally whereas, in California it usually hovered around one-third.

¹⁷ 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.

¹⁸ U.S. Bureau of the Census, *Census of Agriculture 1959*, General Report, Vol. II.

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.¹⁹ 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.²⁰ A similar pattern is found more recently. In 2000, California dairy cows produced an average of 21,169 lbs. of milk. The U.S. average was 18,204 lbs., while Wisconsin lagged behind with an average of 17,306 lbs.²¹

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.²² By 1953, large feedlots 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 feedlots 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 feedlots 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 feedlots started to become more prevalent in the Southwest and in the Corn Belt.²³ Thus, as in other cases, technologies developed in California spread to reshape agricultural practices in other regions.

MECHANIZATION AND FARM POWER

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,

¹⁹ U.S. Department of Agriculture, *Agricultural Statistics*, 1995.

²⁰ U.S. Department of Agriculture, *Statistics Bulletin* 218, 1957.

²¹ U.S. Department of Agriculture, *Agricultural Statistics*, 2002. http://www.usda.gov/nass/pubs/agr02/02_ch8.pdf. The 2002 data are preliminary.

²² 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.

²³ John A. Hopkin and Robert C. Kramer, *Cattle Feeding in America*, Bank of America, San Francisco, February 1965.

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 mechanics. 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.

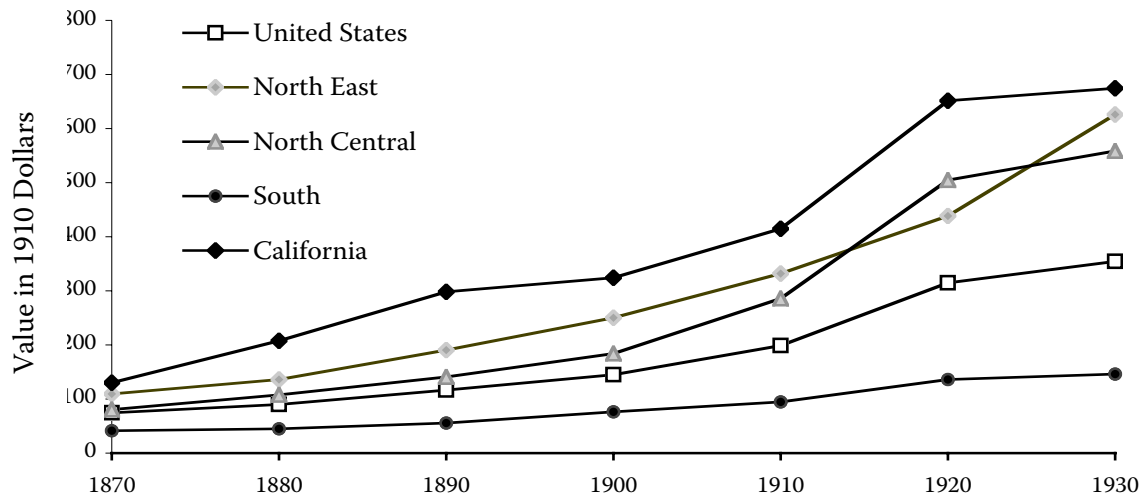
As an index of the level of mechanization, Figure 4 shows the real value of implements per farm in California and other major regions. Over the years 1870 to 1930 the average value of implements per California farm was about double the national average. The new generation of farm equipment of the nineteenth century relied increasingly on horses and mules for power. Horses on any one farm were essentially fixed assets. 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. Throughout the nineteenth century, California farmers were using an enormous amount of horsepower.²⁴

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

²⁴ Alan L. Olmstead and Paul Rhode, 1988.

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.²⁵ 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.²⁶ 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.²⁷

Figure 4. Real Value of Implements Per Farm, 1870-1930



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.²⁸

²⁵ U.S. Bureau of the Census, *Sixteenth Census of the United States: 1940, Agriculture Vol. 1, Part 6*.

²⁶ *Electrical Times*, January 2, 1948; U.S. Bureau of the Census, *Fifteenth Census of the United States: 1930, Agriculture Vol. 11, Part 3*.

²⁷ In the early period many of these pumps were driven by steam and internal combustion engines.

²⁸ For further development of these general themes, see Nathan Rosenberg, *Inside the Black Box: Technology and Economics*, Cambridge University Press, Cambridge, 1982.

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 were 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.²⁹

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 largely exceed in number those granted for inventions of a like character from all the other states of the Union."³⁰ 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.³¹ 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.³² 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.³³ 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.³⁴

California wheat growers also followed a different technological path in their harvest operations by relying primarily on headers instead of reapers. This practice

²⁹ 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.

³⁰ U.S. Department of Agriculture, *Agricultural Report*, 1869.

³¹ 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.

³² U.S. Department of Agriculture, *Agricultural Report*, 1875.

³³ 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.

³⁴ 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.

would have important 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 that 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.³⁵ 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 under construction in Stockton.³⁶ 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.³⁷ Soon thereafter, machines in the Holt line overtook the Houser. 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.³⁸ 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.³⁹ In California the opposite attitudes were said to prevail. The

³⁵ F. Hal Higgins, “John M. Horner and the Development of the Combine Harvester,” *Agricultural History*, Vol. 32, 1958; *Farm Implement News*, 1888.

³⁶ U.S. Bureau of the Census, 1883.

³⁷ Rogin, 1931; William H. Brewer, “Cereal Report,” U.S. Census of 1880, *Agriculture*, Vol. 3, 1883.

³⁸ *Economist*, Nov. 28, 1914.

³⁹ Alan L. Olmstead and Paul W. Rhode, “The Agricultural Mechanization Controversy of the Interwar Years,” *Agricultural History*, Vol. 68, No. 3, Summer 1994.

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.”⁴⁰ California farmers had gradually developed their ability to manage large teams as a result of their experience with gang plows and headers.⁴¹

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.⁴² 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) 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.

BRINGING WATER TO THE FIELDS

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 1997. 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

⁴⁰ Wesley Buchele and Graeme Quick, *The Grain Harvesters*, American Society of Agricultural Engineers, St. Joseph, 1978.

⁴¹ Olmstead and Rhode, 1988.

⁴² Caterpillar Tractor Company, *Fifty Years on Tracks*, Caterpillar Tractor Co., Peoria, IL, 1954.

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.⁴³

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 in 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

⁴³ 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.

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 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 2 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 United States. 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 2 indicates, until the last two decades, 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.

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 has 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 United States, one of the world's highest wage countries.⁴⁴ In an important sense the "cheap labor" in California agriculture was among the dearest wage labor on the globe.⁴⁵ 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.⁴⁶ 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 impoverished regions of the world. 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.

⁴⁴ The available statistics suggest that circa 1900-10, Asian workers in California were paid within 10-15 percent of the wage of white workers.

⁴⁵ Almost surely, if more migration of non-white population was permitted in the late nineteenth century, the state could have attracted more labor.

⁴⁶ The "development" gap is measured as $(Y_{ag}/L_{ag})/(1-Y_{ag})/(1-L_{ag})$ where Y_{ag} is the share of income generated in the agricultural sector and L_{ag} is the share of the labor force employed there.

Table 2. Agricultural Labor in California and the United States

	Hired Labor Expenditures as a Share of					
	Farm Labor Force as a Share of Total Labor Force		Gross Value of Farm Production		Market Value of Farm Products Sold	
	California %	U.S. %	California %	U.S. %	California %	U.S. %
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
2000	1.8	1.5	--	--	14.7	7.7

Sources: Margaret Gordon, *Employment Expansion and Population Growth*, UC Press, Berkeley, 1954.
U.S. Dept. of Commerce, *Regional Employment by Industry, 1940-1970*.
U.S. Census Office: *Compendium of the Ninth Census 1870*; U.S. Bureau of the Census: *Twelfth Census 1900, Agriculture*; *Fourteenth Census 1920, Agriculture*, Vol. 5; *Census of Agriculture 1959, California*, Vol. 1, Part 48; *1980 Census, Population*, Vol. 1; *1990 Census, "Labor Force Status and Employment Characteristics: 1990 Data Set: 1990 Summary Tape File 3 (STF 3)—Sample data"* and *2000 Census, "Industry by Sex—Percent Distribution: 2000 Data Set: Census 2000 Summary File 3 (SF 3) —Sample Data"* downloaded at <http://factfinder.census.gov>.
U.S. Dept. of Agriculture, *Census of Agriculture 1997*, Table 1 on "Historical Highlights" for United States and California downloaded from: http://www.nass.usda.gov/census/census97/volume1/us-51/us1_01.pdf and http://www.nass.usda.gov/census/census97/volume1/ca-5/ca1_01.pdf.

Over the long run of California's history, agricultural labor has not been a dead-end pursuit creating a permanent class of peasant laborers. This is an important point, because the agricultural history literature laments the end of the "agricultural ladder," whereby workers start off as laborers or sharecroppers and work their way up to cash tenants and then owners of their own farms. According to the traditional literature, ending this process represents one of the great failings of nineteenth century American society. The literature is particularly critical of California because of its large farms and high ratio of hired workers to farm owners. But a little serious thought suggests how misguided these concerns are. Engel's Law tells us that as income per capita grows, a smaller percentage of income will be spent on food. This suggests that in a growing economy the agricultural sector would diminish in size relative to the non-agricultural sector. At the same time the closing of the frontier meant that the total supply of agricultural land could not continue to grow as it did for most of the nineteenth century. Thus, unless farms were Balkanized into smaller and smaller units there was no possible way for the nineteenth century ideal to have continued. In California, although many members of immigrant groups succeeded to move up the rungs of the

agricultural ladder, the focus on agriculture totally misses the key point. The descendents of the past waves of Chinese, Japanese, Portuguese, Sikh, Italian, and Armenian laborers who now work outside of the agricultural sector are generally not anxious to give up their white and blue collar jobs to return to farming.

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.⁴⁷ 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 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.

International Competition and the Puzzling Success of Labor-Intensive Crops in a High-Wage Economy

Today California farmers often complain about the high cost of labor relative to what their international competitors have to pay. But when the state first moved into the production of specialty crops, California producers of fruit and nuts faced labor costs several times higher than their competitors in the Mediterranean Basin. Given these conditions how did the early Californian producers not only survive, but in many cases actually drive European producers out of markets that were in their own backyards? For many crops such as wheat and cotton, California producers competed by relying more on mechanization to save labor, but that option was less available to orchardists. More fundamentally, the Hechsher-Ohlin model predicts that countries or regions should produce commodities that intensively use their abundant factors and sparingly use their scarce factors. Given this insight, why would the Californians even choose to try to produce labor-intensive crops?

⁴⁷ E. Domar, "The Causes of Slavery or Serfdom," *Journal of Economic History* (1970).

There is no doubt that California was a high-wage economy in the national, not to mention global, context. For example, in 1910, California farmers paid monthly agricultural laborers 71 percent more than did their counterparts nationally; day harvest labor was paid a 36 percent premium. The wage differentials with traditional producing countries in the Mediterranean Basin were much larger, with California farmers paying roughly 4 to 8 times more. Moreover, most fruit and nut crops were characterized by high labor-to-land ratios. For example, the U.S. Department of Agriculture estimated that in 1939 producing almonds on the Pacific Coast required 96 hours per bearing acre, dates 275, figs 155, grapes 200, prunes 130, and walnuts 81 hours; this compared with only 6.6 hours of labor per acre of wheat.⁴⁸

Underlying the Hechsher-Ohlin analysis is the notion that wheat farmers competed directly with fruit and nut growers for the labor and land. But this notion needs to be qualified in ways that help explain the success of California fruit producers. On the Pacific Coast, the labor requirements of both activities were highly seasonal and their peak harvest demands did not fully overlap. In California, for example, the wheat harvest was typically completed by early July whereas the raisin and wine grape harvest did not commence until September and continued through late October. Hence, a worker could, in principle, participate fully both in the grain and grape harvests. Rather than conceiving of the different crops as being competitive in labor, we might be better served by considering them as complimentary. As an example, in the lush Santa Clara Valley harvest workers would migrate from cherries to apricots to prunes to walnuts and almonds over a roughly six month season. Adding other semi-tropical crops, such as cotton and navel oranges, stretched the harvest season in large sections of California into the winter months. By filling out the work year and reducing seasonal underemployment, the cultivation of a range of crops in close proximity increased the attractiveness to labor of working in Pacific Coast agriculture. The succession of peak-load, high-wage periods allowed California workers more days of high-intensity and high-pay work in a year than was possible in most other regions.⁴⁹

It is also important to recognize that the land used for grain and fruit crops was largely “non-competing.” Prime quality fruit lands, with the accompanying climatic conditions, were so different from the lands that remained in grain production that they constituted a “specific input.” Differences in the land values help bring these points home. According to R. L. Adams’ 1921 California farm manual, the market value of “good” wheat land in the state was approximately \$100 per acre in the period immediately before the First World War. “Good” land for prune production was worth \$350 even before planting and valued at \$800 when bearing. The “best” land for prunes had a market value of \$500 not planted and \$1000 in bearing trees. Similarly, “good” land for raisin grape production was worth \$150 raw and \$300 in bearing vines; the “best” sold for \$250 not planted and \$400 bearing. Focusing on physical labor-to-land ratios in comparing wheat and fruit production can be seriously misleading because the

⁴⁸ Rueben W. Hecht and Glen T. Barton, *Gains in Productivity of Labor*, USDA Technical Bulletin No. 1020. Washington, D.C.: USDA, Dec. 1950, pp. 38, 98.

⁴⁹ This argument also draws attention to the important role of labor mobility in the region’s agricultural development, and in particular to the manifold and often conflicting efforts of local authorities to encourage, discourage, and otherwise control the migrant flows of specific ethnic groups. By focusing on the political economy of migration, this literature helps undermine the notion that labor scarcity was a “natural” immutable feature of the region. Rather it was in part an outcome of collective political decisions. The migrant flows presumably would have been far larger but for exclusionary agitation and legislation.

acreage used for fruit cultivation was of a different quality (and ultimately higher market value) than that used for grains.⁵⁰

A further reason why horticultural crops could compete was that, unlike the key agricultural staples, many fruit and nut products enjoyed effective tariff protection during the late-19th and early-20th centuries. Tariffs almost surely sped up the growth of Mediterranean agriculture in the United States and were strongly supported by domestic producers, railroads, and packers.⁵¹ One of the recurrent justifications for tariffs offered by domestic growers was to help offset high transportation differentials. Almost across the board, Mediterranean producers enjoyed lower freight rates to the key markets of the northeastern United States (not to mention northern Europe) than their American rivals did. For example, circa 1909, shipping currants from Greece to New York cost 17 cents per hundred weight while the freight on an equivalent quantity of California dried fruit averaged about one dollar.⁵²

For the Pacific Coast fruit industry, the cost of transportation remained an important factor, shaping production and processing practices. This is reflected in an observation that has entered textbook economics, that the best apples are exported because they can bear the cost of shipping. It also helps explain one of the defining characteristics of the region's fruit industry, its emphasis on quality. Local producers and packers devoted exceptional efforts to improving grading and quality control, removing culls, stems and dirt, reducing spoilage in shipment, and developing brand-names and high quality reputations. This focus makes sense given the high transportation cost that western producers faced in reaching the markets of the U.S. Atlantic Coast and Europe.

To a large extent, the ability of Californians to compete with the growers in southern Europe depended on capturing the higher end of the market. With only a few exceptions, California dried fruits earned higher prices than their European competition because the state's growers gained a reputation for quality and consistency. As an example, the U.S. produced far higher quality prunes than Serbia and Bosnia, the major competitors, and as a result American prunes sold for roughly twice the price of the Balkan product in European markets. Not only were California prunes larger, they also enjoyed other significant quality advantages stemming from the state's better dehydrating, packing, and shipping methods.⁵³ Similar quality advantages applied virtually across the board for California's horticultural crops.

It is interesting to note that at least some of California's current problems with foreign competition stem directly from the ability of others to copy the state's methods. After the California horticultural industry established its strong market presence, the message eventually got through to other producers. The extensive efforts that producers in other New Areas (such as South Africa, Chile, and Australia) and in Europe made to copy the California model provides another indicator of the

⁵⁰ For an analysis of the competition between wheat and fruit for an earlier period, see Rhode, "Learning," pp.773-800. R. L. Adams, *Farm Management Notes* (Berkeley, University of California Associated Students' Store, 1921), pp. 53, 81, 97.

⁵¹ But it is worth noting that prunes and raisins successfully competed in international markets by the mid-1890s, suggesting that, in the known absence of dumping policies that discriminated between domestic and foreign markets, the tariffs on these crops had little remaining impact. These cases conform nicely to the prescriptions of those favoring infant industry protection. The tariffs helped the industries, comprised of a large number of small producers, overcome high learning costs, but market forces ceased to have significant adverse efficiency or distribution effects once the industries matured. By contrast, the tariffs on fresh grapes, figs, dates, and the nut crops appear to have had a continuing impact on imports, prices, domestic production, and grower profits through the 1930s.

⁵² The U.S. competitive disadvantage was declining over time. Transportation rates on Greek currants declined by roughly one-third in real terms between 1889 and 1909; those on California raisins by more than one-half.

⁵³ Shear, *Prune*, pp. 5, 37-57; Stroykowitz, *Recherches*, pp. 186-93.

importance of superior technology and organization in establishing California's comparative advantage.

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.⁵⁴ 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.⁵⁵

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 and 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 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

⁵⁴ Kelsey B. Gardner and Irwin W. Rust, *Sunkist Growers, Inc.: A California Adventure in Agricultural Cooperation*, USDA, Farmer Cooperative Service, Circular 27, 1960.

⁵⁵ 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.

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.⁵⁶ Nevertheless, it should provide a historical context for other chapters in

⁵⁶ 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.

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.⁵⁷

⁵⁷ 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

Cross Sections of a Diverse Agriculture: Profiles of California's Agricultural Production Regions and Principal Commodities

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California agriculture defies simple, accurate generalizations. This chapter gives the reader two of many possible cross-sectional views of the state's agriculture 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 afield, 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, founded on self-sufficiency goals of early Alta California missions, developed in less than two centuries from a predominantly livestock grazing economy, providing wealth to large, Rancho land holdings 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 a large number of "small" and part-time farming operations.¹ Today's agricultural bounty consists of hundreds of 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.

¹ See McCalla and Johnston for a stylized history of California agriculture from 1769 to the present. Also see Adams.

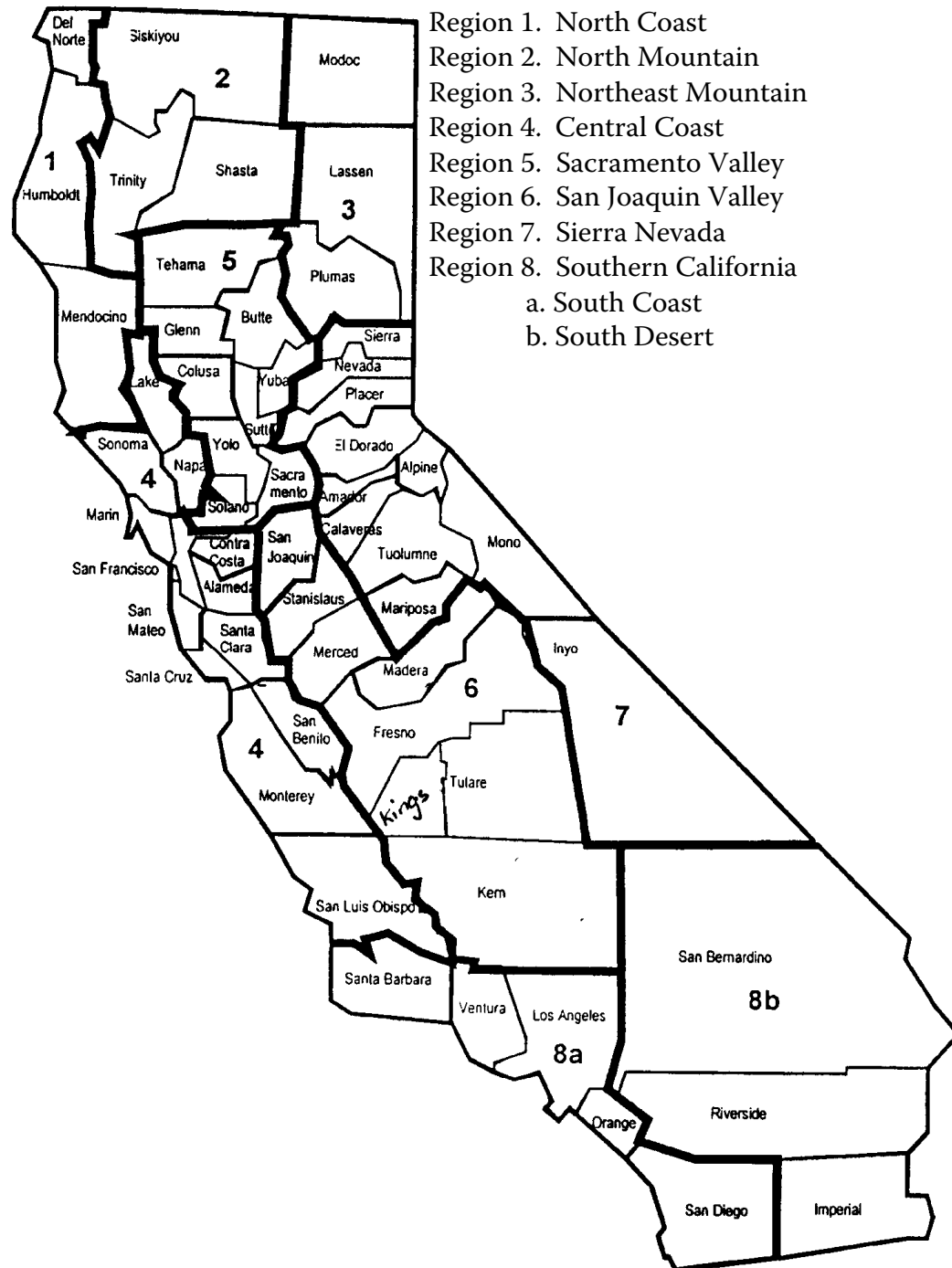
The challenge to California farmers and ranchers has always been to match available, and often limited, physical, human, financial, and managerial resources to produce and market alternative outputs chosen from a long and constantly evolving set of potential agricultural commodities and value-added products. 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 re-examination 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 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 accelerated greater diversity in types of farming and number of commercial commodities or products.

This chapter portrays some of the 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, in 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.²

² 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.

Figure 1. Agricultural Production Regions of California



THE AGRICULTURAL PRODUCTION REGIONS OF CALIFORNIA³

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 northwest corner of the state and at higher elevations in the Sierra Nevada and Coast ranges.⁴ 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.⁵ 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 in southern interior areas are located in steppe or desert climatic zones.⁶ Growing seasons range from year-round frost-free areas along the coast to relatively short seasons in higher elevation mountain valleys. The more than 700 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 soils) vary greatly in 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.⁷ 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 Sierra Nevada region.⁸

Forty-nine percent of California lands is in public ownership, most of it controlled by the federal government (Table 1).⁹ Public land ownership is highest in the

³ 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 1997 Census of Agriculture and 1995 annual crop reports of California County Agricultural Commissioners.

⁴ 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).

⁵ Mt. Whitney, 14,494 feet above sea level, and Death Valley, 282 feet below sea level.

⁶ See, for example, either Durrenberger or Hartman.

⁷ 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.

⁸ 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.

⁹ The federal government owns 45 million of the nearly 49 million acres in public ownership (County Supervisors Association of California).

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

	Total for California	North ^a	Central Coast	Sacramento Valley	San Joaquin Valley	Sierra Nevada	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 1,000 acres	48,960	10,870	2,002	1,349	5,132	10,718	3,622	14,466
Percent of land area that is privately owned	51	48	80	81	71	31	59	28
3. Land in Farms 1,000 acres	27,699	3,526	5,269	3,967	9,764	1,423	1,827	1,923
Percent of total land not in farms	28	17	52	55	56	9	21	10
4. Cropland 1,000 acres	10,804	718	1,182	2,091	5,339	209	468	797
Percent of land in farms that is cropland	39	20	22	53	55	15	26	41
5. Irrigated land 1,000 acres	8,713	486	563	1,712	4,793	136	325	699
Percent of cropland that is irrigated	81	68	48	82	90	65	69	88
6. Number of farms	74,126	4,521	11,803	10,329	27,489	3,709	11,165	5,060
Average farm size in acres	374	771	446	384	355	384	164	380
7. Average value of Farm Products Sold \$ per acre \$ per farm	832 311,000	123 95,000	702 314,000	506 194,000	1,193 424,000	87 33,000	1,425 233,000	1,308 497,000
8. Average value of land & buildings \$ per acre	2,519	1,059	2,581	2,484	2,939	1,549	3,989	2,298
9. Top 5 commodities	Dairy Grapes Nursery Lettuce Cattle & Calves	Cattle & Calves Wine Grapes Nursery Dairy Alfalfa hay	Wine Grapes Lettuce Nursery Broccoli Strawberries	Rice Nut crops Prunes & Peaches Proc Tomatoes Wine Grapes	Dairy Grapes Cotton Poultry Almonds	Cattle & Calves Hay Pasture & Range Wine Grapes	Flowers & Foliage Nursery Vegetables Strawberries Avocados	Vegetables Cattle & Calves Alfalfa hay Nursery Eggs
Sources: Lines 1-2: County Supervisors Association, <i>California County fact Book '88-'89</i> . Kubes 3-8: <i>U.S. Census of Agriculture, 1997</i> . Line 9: California Department of Food and Agriculture, California Agricultural Resource Directory, 2002.								
a) Combined North Coast, North Mountain and Northeast Mountain regions (Agricultural Production Regions 1-3, Figure 1.)								

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, 28 percent of the land area is in farms. Of the land in farms, 39 percent is cropland; and of the land in cropland, 81 percent is irrigated. The 1997 Census tallied 74,126 farms, which averaged 374 acres in size and sold an average of \$311,000 of farm products per farm. The size and value-of-sales statistics include both small, part-time and larger full-time farm units.¹⁰ Among regions, the highest average per acre sales were reported for the more intensive South Coast and South Desert subregions (Southern California region) and the San Joaquin Valley region.

The following discussion includes brief descriptions of California's agricultural production regions as denoted in Figure 1 and summarized in Table 1. Regional values of agricultural production are based on 2001 crop reports prepared by County Agricultural Commissioners. Regional production is distributed among five categories: (1) Field crops, (2) Fruit and Nut crops, (3) Vegetable crops, (4) Livestock, poultry and products, and (5) Nursery, Greenhouse and Floriculture crops (see, for example, CASS 2002a).

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 (17 percent), and of that land only 20 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, commonly used for summer grazing. 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 Tulalake 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.

¹⁰ 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.

However, significant acreage has been lost to urban development as California's population has grown. For example, farmland 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 and electronic industries. Because of agreeable climate and other coastal amenities, pressures for urban development continue in many 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 half (48 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).¹¹ 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 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 farmland, nearly 70 percent of the state's cropland, and 75 percent of the irrigated land, this is California's agricultural heartland.¹² 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. Eighty-two (82) 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

¹¹ 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.

¹² 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.

others, and more recent additions of federally developed (CVP) 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 (CVP) and state (SWP) 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; both wheat and corn are included in irrigated crop rotations; and alfalfa, 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.

The San Joaquin Valley

About a third of California's farmland and 55 percent of its irrigated lands lie in the San Joaquin Valley. Nearly 90 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 is two lake basins, historically 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 bringing more acreage into agricultural production. In the post-World War II period, federal and state surface water development brought additional 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 1987-93 drought and by reduced allocations from CVPIA (Central Valley Project Improvement Act) and CALFED decisions. 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 on the east side 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 but total cotton acreage has fallen due to poor profitability. 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 (two percent).¹³

The Sierra Nevada 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; less than 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)—, 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 because the geographic location of fruit and nut production (mostly wine grapes), and nursery products recorded for the region, actually occur on the west slope, foothill "valley" portions of several mountain counties.¹⁴

¹³ 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 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 \$500 million in the 1995 crop year.

¹⁴ 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 west slope of the Sierra Nevada mountains.

The South Coast Sub-region

This area is still a base for significant agricultural production despite progressive development with a large urban population. Los Angeles County was once the most important agricultural county in the United States, measured by the value of its agricultural production. Los Angeles County was ranked as California's number one agricultural county into the 1950s. Despite urbanization, 21 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 farms is the smallest among state agricultural production regions, while the average value of farm products sold per acre is the highest. With 69 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. 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.

The South Desert Sub-region

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 10 percent of the land area is in farms. Because of the severe climatic conditions, a high proportion of cropland is irrigated (88 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.

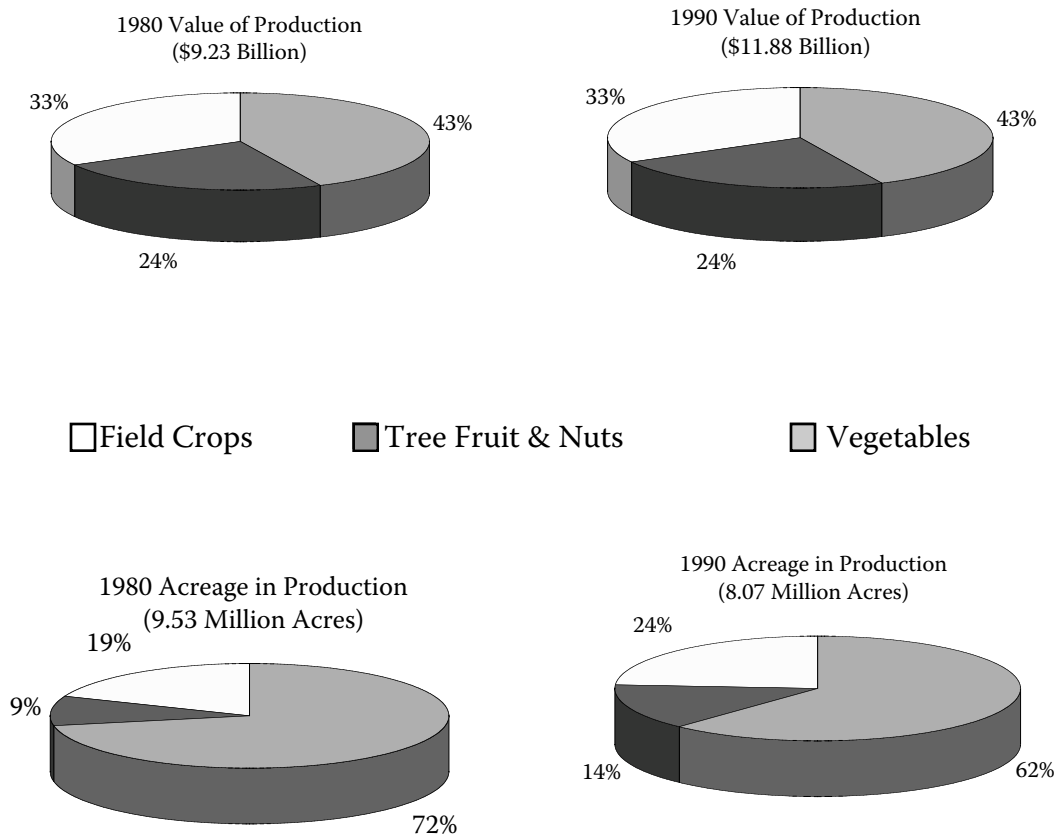
Livestock and livestock product activities contribute the greatest proportion of the value of production in the South Coast region (42 percent) by capitalizing on the region's proximity to markets (poultry, eggs, dairying) and a long tradition of cattle feeding in the Imperial Valley and other desert 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 temperate winters and nearly frost-free growing seasons to produce a variety of high-valued fruit and vegetable crops that are in supply during 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.

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



Risk is substantially greater in the production and marketing of perishable fruits and vegetables than in more stable commodities.¹⁵ 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 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.

The composition of California agricultural production is compared for the years 1955, 1975 and 1995 in Figure 3. Total value of agricultural production grew three-fold from 1955 to 1975, from \$2.68 to \$7.43 billion. Change in composition 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 period.¹⁶ 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, and total value of agriculture production amounted to almost \$22 billion. 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.

In 2001, the value of nursery, greenhouse and floriculture exceeded the value of field crops, and the dairy sector alone accounted for 17 percent of the state's value of agricultural production (Figure 4). As a consequence, the share produced by livestock, poultry, and products actually rose from 25 percent in 1995 to 28 percent in 2001.

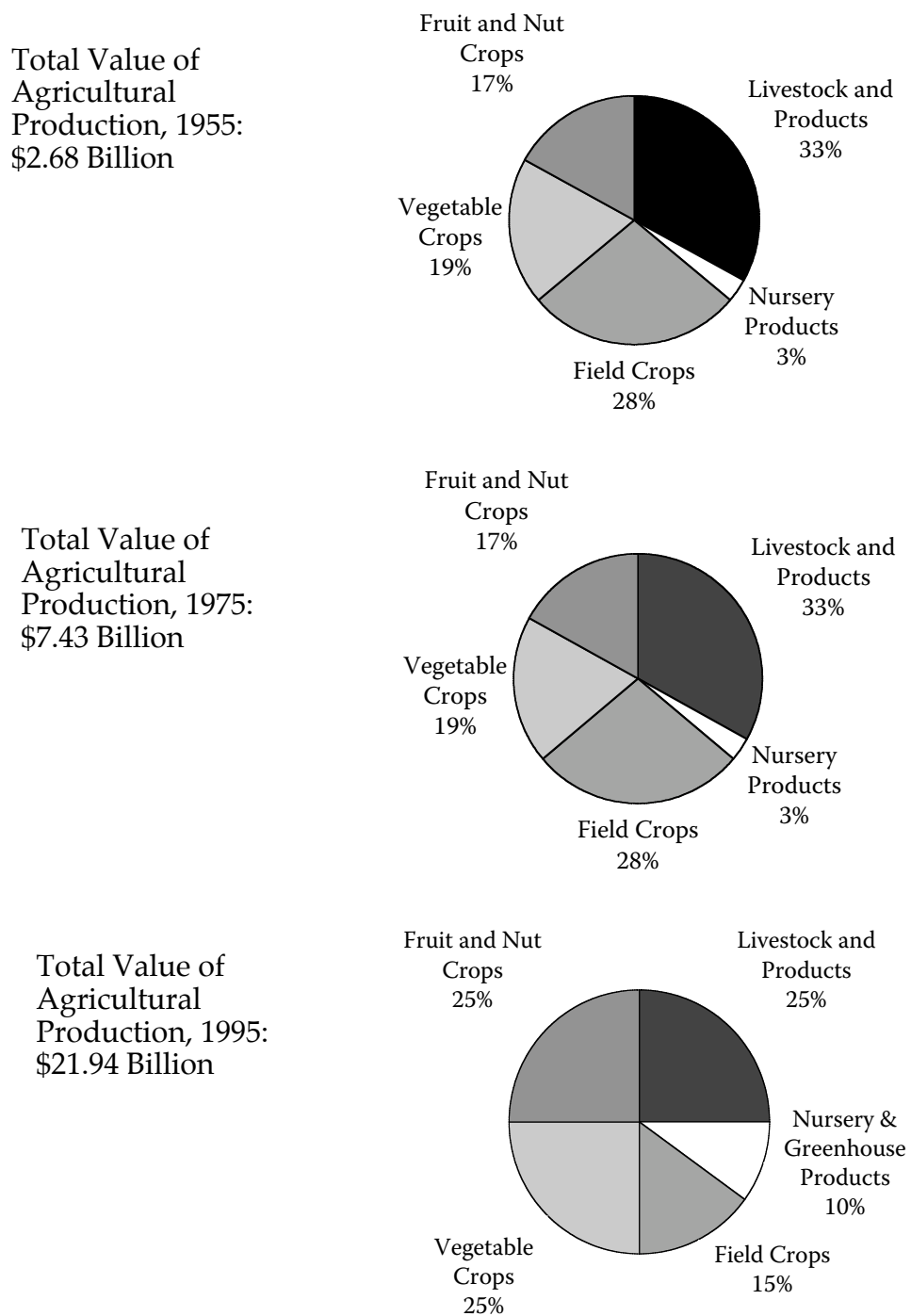
CALIFORNIA'S "TOP TWENTY" CROP AND LIVESTOCK COMMODITIES

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 2001 crop year, with comparisons for 1981 and 1961. Comparison of the 1961 and 2001 lists shows that whereas there were a total of 12 livestock/livestock products, and field crops identified in 1961, only 5 were on the 2001 list. In sharp contrast, there are now 13 fruit, nut, and vegetable crops on the 2001 list, compared to only 8 on the 1961 list. Nursery products and foliage and cut flowers have been added since 1961, appearing on both the 1981 and 2001 lists.

¹⁵ See Blank et al, for a discussion of the increased risk.

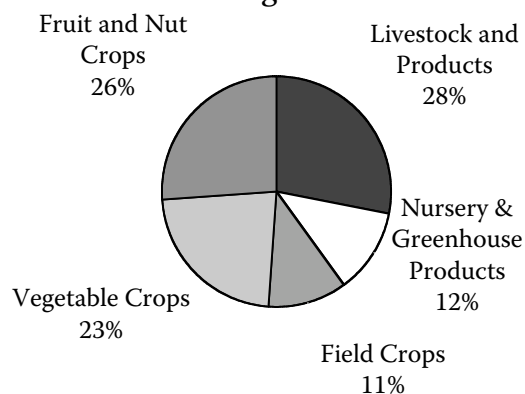
¹⁶ For example, the State Water Project began agricultural water deliveries to the west side of the San Joaquin Valley and to Kern County in the south in the late 1960s.

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



Sources: California Crops and Livestock Reporting Service, 1957
 California Crops and Livestock Reporting Service, 1976
 California Department of Food and Agriculture, 1996

Figure 4. The Composition of California Agricultural Production, 2001: \$26.46 Billion



Source: California Department of Food and Agriculture, 2003

Table 2. CA "Top 20" Crop & Livestock Commodities: 2001, 1981 & 1961 Crop Years

Agricultural Commodity	2001	1981	1961
Milk and Cream	1	1	2
Grapes, All	2	4	6
Nursery Products	3	6	n/a
Lettuce, All	4	8	10
Cattle and Calves	5	2	1
Hay, All	6	5	5
Flowers and Foliage	7	9	n/a
Strawberries	8	18	18
Tomatoes, All ¹⁷	9	13	(7)
Almonds	10	14	19
Cotton, All	11	3	3
Chickens, All	12	16	20
Oranges, All	13	15	8
Broccoli	14		
Carrots, All	15		
Walnuts	16	17	
Avocados	17		
Celery	18		
Cantaloupe Melons	19		
Peaches, All	20	16	14
<i>Top Twenty from 1981</i>			
Wheat	(36)	7	
Rice		10	12
Eggs, Chicken		11	4
Sugar beets	(52)	12	15
Potatoes	(26)	19	13
Turkeys	(23)	20	11
<i>Top Twenty from 1961</i>			
Barley	(71)		9
Prunes (Dried Plums)	(34)		16
Beans, dry	(53)		17

Sources: 2001 Crop Year — California Department of Food and Agriculture (2002)

1981 Crop Year—California Department of Food and Agriculture (1982)

1961 Crop Year—California Crop and Livestock Reporting Service (1962)

¹⁷ Processing Tomatoes only in 1961

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. Lettuce (ranked fourth) is the highest grossing vegetable. Cattle and calves rank fifth.

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.¹⁸

1. Milk and Cream

- 18 percent of U.S. value of milk production
- 2001 Gross Farm Income: \$4,630 million
- Top 5 Counties: Tulare, Merced, Stanislaus, San Bernardino, Kings
67 percent of total value of production
- Other counties with >2.5 percent of state production: Fresno, Kern, Madera, Riverside, 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, ten times larger than the national average, and cows are, on the average, significantly more productive. Dairy processing capacity has more than doubled during the 1990s.

The state's dairy industry evolved from "local" dairies that originally provided fluid milk to nearby 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 production. 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. Processing continues to be concentrated there as well. Continuing urbanization and waste disposal challenges have caused more dairies to move into Central Valley and South desert areas, principally into the San Joaquin Valley.

California's dairies are highly specialized. As the number of dairies decreased, their size has become significantly larger, requiring more capital-intensive specialized production 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 3,000 or more cows daily and use waste effluents and solids on silage and forage crops on adjacent cropland.

¹⁸ The stylized heading for each section is based on the following sources: California percentage of U.S. production: NASS 2002; value of California production: CDFA 2002; Top 5" major counties of production: CASS 2002a and 2002b. Narrative information draws heavily on sources that include Cook et al. (1994), Johnston (1985, 1994), Scheuring (1983), and McCalla and Johnston (forth coming).

2. Grapes, All

- 91 percent of U.S. production
- 2001 Gross Farm Income: \$2,651 million

Grapes are produced throughout most of California for one of three end uses: for the wine crush, for the fresh table grape market, or for 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 has traditionally found use 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 third, table grapes fourth, and raisins twelfth (CDFA 2002).

Wine-type Grapes

- 94 percent of U.S. production of grapes crushed for wine
- 2001 Gross Farm Income: \$1,814 million
- Top 5 Counties: Sonoma, Napa, San Joaquin, Monterey, San Luis Obispo
62 percent of value of production
- Other counties with >2.5 percent of state production: Fresno, Kern, Madera, Mendocino, Merced, Sacramento, Santa Barbara, Stanislaus, Tulare

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 and again in the 1990s. By 2001, there were 480,000 bearing acres of wine grapes with an additional 90,000 nonbearing acres. The specter of oversupply is real, affecting marginal plantings, particularly in the San Joaquin Valley, as new and potentially higher yielding vineyards incorporating disease-resistant rootstocks and up-to-date trellising, irrigation, and management systems come into production. Marginal plantings are often removed out of economic necessity during periods of oversupply.

Table-type Grapes

- 98 percent of U.S. production of table grapes
- 2001 Gross Farm Income: \$434 million
- Top 5 Counties: Kern, Tulare, Fresno, Riverside, Madera
99 percent of value of production

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-type Grapes

- 99+ percent of U.S. production of dried grapes
- 2001 Gross Farm Income: \$401 million
- Top 5 Counties: Fresno, Madera, Tulare, Kern, Merced
99 percent of value of production

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 labor-intensive method of laying them out in the sun. There is a conversion of economically-viable vineyards to dried-on-the-vine trellising which will permit mechanical harvesting. Bearing acreage is being reduced by removals of non-economic vineyards because of poor returns since 1999.

3. Nursery Products

- 21 percent of U.S. production of nursery and floriculture products
- 2001 Gross Farm Income: \$2,087 million
- Top 5 counties: San Diego, Orange, Ventura, Los Angeles, Santa Clara
48 percent of value of production
- Other counties with >2.5 percent of state production: Kern, Monterey, Riverside, San Joaquin, San Mateo, Stanislaus

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. Lettuce, All

- 70 percent of U.S. production of head lettuce
- 85 percent of U.S. production of leaf lettuce
- 74 percent of U.S. production of romaine lettuce
- 2001 Gross Farm Income: \$1,370 million
- Top 5 counties: Monterey, Imperial, Fresno, Santa Barbara, San Benito
83 percent of value of production
- Other counties with >2.5 percent of state production: Riverside, San Luis Obispo, Santa Barbara

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 romaine and leaf lettuce.

5. Cattle and Calves

- 3 percent of U.S. value of production
- 2001 Gross Farm Income: \$1,352 million
- Top 5 counties: Tulare, Fresno, Imperial, Merced, San Bernardino
55 percent of value of production

Almost all breeds of beef cattle are raised in California. The dairy sector also contributes a significant quantity of steers, culled cows, and bulls as animals marketed for beef. Cattle and calves were California's #1 agricultural commodity until 1980, when the number one position was taken by milk and cream. Later, grapes and nursery products moved ahead of cattle and calves. Lettuce became the fourth most important crop in 2000. Cattle and calves are now California's #5 agricultural commodity.

More than two-thirds of the state's land area is essentially non-tillable 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. Cattle are also shipped out of state to feed lots closer to midwest feed supplies.

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.

6. Hay, All

- 9 percent of U.S. production of alfalfa hay
- 2 percent of U.S. production of other hay types
- 2001 Gross Farm Income: \$1,021 million
- Top 5 counties-alfalfa hay: Imperial, Kern, Tulare, Merced, Fresno
55 percent of value of production
- Other counties with >2.5 percent of state alfalfa hay production: Kings, Madera, Riverside, San Joaquin, Stanislaus, Yolo
- Top 5 counties-other than alfalfa hay:
Sudan hay—Imperial
Grain hay—Merced, Stanislaus, Kern, Yolo

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 eight to ten cuttings per year; in the cool northern intermountain region, farmers harvest only two to four 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.

7. Flowers and Foliage

- 21 percent of U.S. production of nursery and floriculture products
- 2001 Gross Farm Income: \$998 million
- Top 5 counties: San Diego, Santa Barbara, San Luis Obispo, Ventura, Monterey
83 percent of value of production
- Other counties with >2.5 percent of state production: San Mateo, Santa Cruz

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, extending southwest 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.

8. Strawberries

- 82 percent of U.S. production of fresh market strawberries
- 86 percent of U.S. production of processing strawberries
- 2001 Gross Farm Income: \$841 million
- Top 5 counties: Monterey, Ventura, Santa Cruz, Santa Barbara, Orange
93 percent of value of production

About three-quarters 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.

9. Tomatoes, All

- 93 percent of U.S. production of processing tomatoes
- 29 percent of U.S. production of fresh market tomatoes
- 2001 Gross Farm Income: \$766 million
- Top 5 counties-processing tomatoes: Fresno, Yolo, San Joaquin, Colusa, Merced
77 percent of value of production
- Top 5 counties-fresh market tomatoes: Merced, San Joaquin, San Diego, Fresno, Stanislaus
85 percent of value of production
- Other counties with >2.5 percent of state production: Kern, Monterey

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 fostered the growth of the processing industry in California which now produces 9 to 10 million tons annually, and as much as 12.2 million tons in 1999. Prices have fallen, as has acreage, while the industry is undergoing structural changes and reduced profitability.

Tomato production is specialized and capital-intensive. Processing has changed from consumer products produced at multi-product plants to now include 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. Almonds

- 99+ percent of U.S. production
- 2001 Gross Farm Income: \$732 million
- Top 5 counties: Kern, Fresno, Stanislaus, Merced, Madera
75 percent of value of production
- Other counties with >2.5 percent of state production: Butte, Colusa, Glenn, San Joaquin, Tulare

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. Almonds are California's #1 export crop, with about two-thirds of production exported.

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, and to 525,000 acres by 2001. 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, as well as a myriad of new food service products 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 Valley, 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.

11. Cotton, All

- 22 percent of U.S. production of cotton
9 percent of upland cotton
91 percent of pima cotton
- 2001 Gross Farm Income: \$658 million
- Top 5 counties: Fresno, Kings, Kern, Merced, Tulare
92 percent of value of production
- Other counties with >2.5 percent 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. 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 in the 1990s. 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.

12. Chicken, All

- 3 percent of U.S. production of broilers
- 2001 Gross Farm Income: \$532 million
- Top 5 counties: Merced, Stanislaus, San Bernardino, Placer, San Joaquin
99 percent of value of production

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. 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 production 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.

13. Oranges, All

- 21 percent of U.S. production of oranges
- 2001 Gross Farm Income: \$514 million
- Top 5 counties: Tulare, Kern, Fresno, Riverside, Ventura
94 percent of value of production
- Other counties with >2.5 percent of state production: San Diego, San Bernardino

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 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. Two southern San Joaquin Valley counties, Tulare and Kern, now produce three-quarters of orange production. Orange County, which had 60,000 acres of oranges in 1950, reported only 115 acres in 2000!

14. Broccoli

- 88 percent of U.S. production of broccoli
- 2001 Gross Farm Income: \$438 million
- Top 5 counties: Monterey, Santa Barbara, San Luis Obispo, Imperial, Fresno
89 percent of value of production
- Other counties with >2.5 percent 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 tenfold between 1970 and 2000, 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 uses and one-third to fresh marketings. By 1987 acreage increased to 108,000 acres, with three-fourths of the crop going to fresh use. With 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. Production now involves 120,000 to 130,000 acres.

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.

15. Carrots, All

- 75 percent of U.S. production of fresh market carrots
- 22 percent of U.S. production of processing carrots
- 2001 Gross Farm Income: \$434 million
- Top 5 counties: Kern, Imperial, Riverside, Monterey, Ventura

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 growth of a premium product and mechanical harvesting of the crop. In some areas there is intense competition among growers for suitable land.

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.

16. Walnuts

- 99+ percent of U.S. production of walnuts
- 2001 Gross Farm Income: \$342 million
- Top 5 counties: San Joaquin, Stanislaus, Butte, Tulare, Sutter
67 percent of value of production
- Other counties with >2.5 percent 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, from that area 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 a third of the crop is exported.

17. Avocados

- 89 percent of U.S. production of avocados
- 2001 Gross Farm Income: \$316 million
- Top 5 counties: San Diego, Ventura, Riverside, Santa Barbara, San Luis Obispo
95 percent of value of production
- Other counties with >2.5 percent of state production: Orange

California's avocado production is concentrated near the coast in Southern California, and is also produced in inland areas that also have a low incidence of frost. San Diego County alone produced about half of the California crop.

Total acreage has been reduced by urban competition for land from about 75,000 acres in the 1980s to 60,000 acres during the 1990s. Demand has grown over time as a result of increased population, popularity of Mexican food and consumer incomes. Imports tripled during the 1990s and now account for about a third of the annual supply of avocados to U.S. consumers.

18. Celery

- 94 percent of U.S. production of celery
- 2001 Gross Farm Income: \$260 million
- Top 5 counties: Ventura, Monterey, Santa Barbara, San Luis Obispo
97 percent of value of production

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.

19. Cantaloupe Melons

- 59 percent of U.S. production of cantaloupe melons
- 2001 Gross Farm Income: \$252 million
- Top 5 counties: Fresno, Imperial, Merced, Riverside, Stanislaus
95 percent of value of production
- Other counties with >2.5 percent of state production: 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.

20. Peaches, All

- 71 percent of U.S. production of peaches
54 percent of California production: Clingstone peaches
46 percent of California production: Freestone peaches
- 2001 Gross Farm Income: \$247 million
- Top 5 counties: Fresno, Tulare, Sutter, Stanislaus, Merced
71 percent of value of production
- Other counties with >2.5 percent of state production: Kings, San Joaquin

California produces two distinct types of peaches—clingstone canning and freezing peaches and freestone peaches, largely sold fresh. Both were produced on about the same acreage, about 30,000 acres at the start of the 1990s.

Clingstone peaches are produced in two areas of the state, in Sutter and Yuba counties in the Sacramento Valley and in Merced and Stanislaus counties in the San Joaquin. Consumer demands have declined for canned fruits in general and low profitability in the canning industry and loss of processing capacity has affected growers, as well. Current acreage is about 28,000 acres after peaking at 31,000 in the mid-1990s.

Freestone peaches are the most popular of the fresh stone fruits (peaches, nectarines, plums and apricots), produced primarily in the central San Joaquin Valley (Fresno, Tulare and adjacent areas). Varieties are available that have expanded seasonal production from late-spring to fall. Rising consumer demands (increased per capita consumption, and increased population) have brought an increase in acreage by a third, to nearly 40,000 acres. Exports of fresh peaches (and nectarines) in 2001 amounted to 11 percent of the quantity produced.

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CHAPTER 3

The Measure of California Agriculture and its Importance in the State's Economy¹

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California agriculture is large, diverse, complex and dynamic. This chapter documents the industry and its relationship to the rest of the economy. It also provides an overview of unifying forces and trends. Our aim is to supply a convenient compilation of facts and figures from a variety of sources, and to help the reader interpret the wide array of data presented.²

California agriculture is far larger, measured by sales, than that of any other state. California agriculture produces more value than most countries and is larger than, for example, such major agricultural producers as Canada or Australia.

¹ This chapter is updated and adapted from “*The Measure of California Agriculture, 2000*,” by Nicolai V. Kuminoff, and Daniel A. Sumner, with George Goldman, University of California Agricultural Issues Center.

² Data used are the most recent available. Whenever possible, we used preliminary data from the most recent Census of Agriculture, (U.S. Department of Agriculture, National Agriculture Statistics Service, 2002 Census of Agriculture). However the complete 2002 census data were not available at the time this chapter went to press.

DEMAND AND SUPPLY

California is part of the national and international agricultural markets. Californians consume food that is produced in the state, as well as food that is imported from other states and countries. Agriculture in California is the largest among the states, and produces a variety of animals and animal products, fruit, tree-nuts, vegetables, field crops, and nursery and floriculture products. The Central Valley (composed of the Sacramento and San Joaquin Valleys) accounts for more than half of the State's gross value of agricultural production.

Commodity Demand

Between 1970 and 2001 United States per capita consumption of food increased in most categories. In the meat category, decreases in red meat consumption were more than offset by increases in poultry and fish. The largest percentage increases in consumption were in the fresh fruit, tree-nut and processed vegetable categories. Eggs were the only category showing a decrease. (Comparable data by state are not available.)

Table 1. United States Per Capita Consumption of Major Foods, 1970-2001

Year	Eggs ^a	Meat, Poultry, & Fish	Dairy Products	Fruit, Fresh	Fruit, Processing	Vegetables, Fresh	Vegetables, Processing	Tree- Nuts
-----Pounds-----								
1970	40.2	177.3	563.8	101.2	136.5	152.9	182.5	1.7
1975	35.9	170.9	539.1	101.8	150.3	147.1	189.9	1.9
1980	35.2	179.6	543.2	104.8	157.5	149.3	187.2	1.8
1985	33.1	185.4	593.7	110.6	158.8	156.1	201.9	2.4
1990	30.5	183.5	568.4	116.3	157.1	167.2	215.6	2.4
1995	29.8	190.5	576.2	122.5	159.3	180.8	227.4	1.9
2000	32.2	195.8	593.4	126.9	153.1	201.8	226.7	2.5
2001	32.4	192.2	587.2	125.8	149.9	196.6	216.3	2.2

a: From 1970 to 1990, figures are given in dozens and transformed into pounds by a factor of 1.56 lb/dz

Source: 1) Putnam, Judith Jones, and Jane E. Allshouse, *Food Consumption, Prices, and Expenditures, 1970-97*, Food and Rural Economics Division, Economic Research Service, USDA.

2) USDA/ERS Agricultural Outlook, May 2003.

Although California is the nation's largest agricultural producer, Californians still consume many foods shipped in from other states and countries. Almost all of the pork, much of the beef and much of the grain used for baked products, pasta and livestock feed come from midwestern states. Tropical products that don't grow well in the state, such as bananas, are imported from Central and South America, or from Asia and Africa. During the local off-season, California imports commodities, such as winter tomatoes from Florida and Mexico, that are exported in other seasons.

Although overall United States food consumption has increased in recent decades due to population growth and other factors, increasing per capita income and falling relative price of food have led to food taking up a smaller part of Americans' budgets. In 2001, Americans spent 10 percent of their disposable personal income on food, compared with 21 percent in 1952. Meals away from home now represent 40 percent of expenditures on food, compared to 17 percent in 1952.

Leading Commodities and Cash Receipts

California agriculture generated about \$26 billion in cash receipts in 2001, 88 percent higher than cash receipts of the second most important agricultural state, Texas. California has been the nation's top agricultural state in cash receipts every year since 1948. Farmers have gradually increased their share of United States farm cash receipts from 9.5 percent in 1960 to 12.8 percent in 2001. Total agricultural cash receipts in 2001, in nominal terms, were above the last record high of 1997.

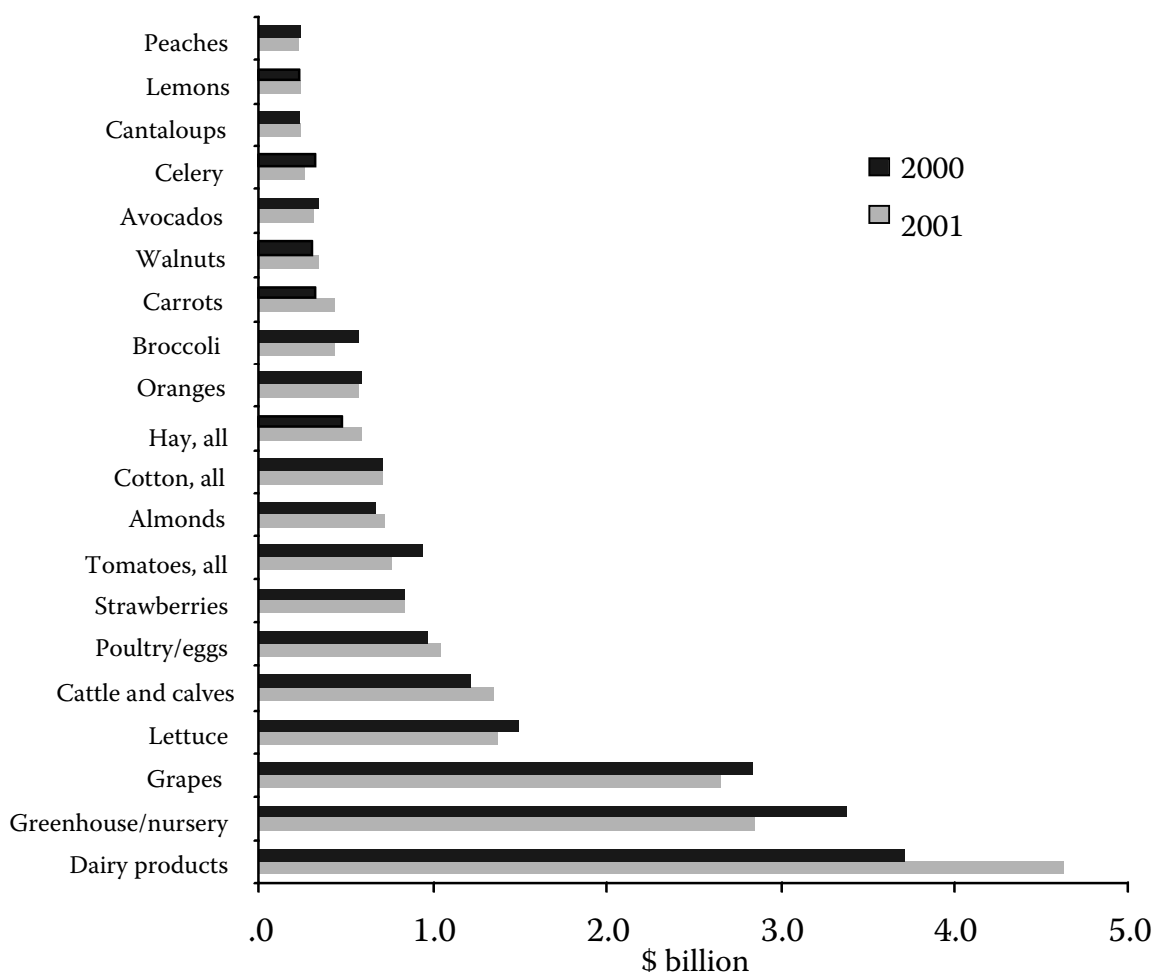
Table 2. California's Leading Commodities by Cash Receipts, 2001

Rank	Items	Value of Receipts 1,000 Dollars	Percent of Total Receipts	Cumulative Percent	Percent of U.S. Value
	All commodities	25,892,319	100.0	--	12.8
1	Dairy products	4,630,171	17.9	17.9	18.7
2	Greenhouse/nursery	2,851,339	11.0	28.9	20.7
3	Grapes	2,653,623	10.2	39.1	90.8
4	Lettuce	1,370,004	5.3	44.4	71.8
5	Cattle and calves	1,351,500	5.2	49.6	3.3
6	Poultry/eggs	1,040,197	4.0	53.6	4.2
7	Strawberries	841,031	3.2	56.8	77.4
8	Tomatoes, all	766,260	3.0	59.8	46.0
9	Almonds	731,880	2.8	62.6	100.0
10	Cotton, all	706,138	2.7	65.3	14.3
11	Hay, all	588,931	2.3	67.6	12.9
12	Oranges	571,445	2.2	69.8	41.7
13	Broccoli	438,118	1.7	71.5	86.9
14	Carrots	433,919	1.7	73.2	75.2
15	Walnuts	341,600	1.3	74.5	100.0
16	Avocados	313,061	1.2	75.7	95.2
17	Celery	259,865	1.0	76.7	94.0
18	Cantaloupes	252,277	1.0	77.7	60.0
19	Lemons	247,042	1.0	78.7	90.4
20	Peaches	227,554	0.9	79.6	47.7

Source: USDA/ERS. Farm Income, online data. URL: <http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm>

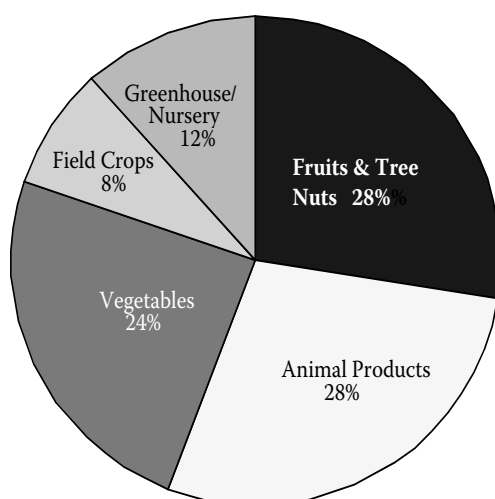
Most agricultural states specialize in production of a few commodities. California is unique in its crop diversity. The top 20 agricultural commodities in California (including some aggregate categories such as greenhouse and nursery products) constitute only about 80 percent of its total agricultural cash receipts, and the top 50 constitute 93 percent. Dairy products, nursery products, and grapes have been the top commodities, ranked by cash receipts from 1995-2001. With the largest gross sales, dairy products represented about 18 percent of the state's total agricultural cash receipts in 2001, while nursery products and grapes accounted for about 11 percent and 10 percent respectively. Winegrape acreage has increased dramatically from 300,000 acres in 1995 to almost 500,000 acres in 2002.

Figure 1. Value of Leading California Farm Products, by Cash Receipts, 2000-2001



Source: USDA/ERS. Farm Income, online data. URL: <http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm>

Figure 2. California Cash receipts by Commodity Group, 2001



Source: USDA/ERS. Farm Income, online data. URL: <http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm>

California provides more than 99 percent of the following agricultural products: almonds, artichokes, dates, figs, raisins, kiwis, olives, pistachios, prunes, and walnuts. It is also the leading state in producing asparagus, broccoli, carrots, grapes, hay, lemons, lettuce, milk, peaches, strawberries, and processing tomatoes, among many others.

Table 3. State Rankings for Cash Receipts and Net Farm Income, 2001

State	Cash Receipts \$1,000	State	Net Farm Income \$1,000
California	25,892,319	Texas	4,288,138
Texas	13,795,618	California	3,768,764
Iowa	11,550,109	North Carolina	3,201,148
Nebraska	9,488,580	Georgia	2,298,556
Kansas	8,121,044	Florida	2,166,133
Minnesota	8,101,875	Iowa	1,946,475
North Carolina	7,730,633	Nebraska	1,610,282
Illinois	7,547,087	Alabama	1,581,452
Florida	6,415,882	Illinois	1,418,739
Wisconsin	5,896,293	Arkansas	1,399,823

Source: USDA/ERS. Farm Income, online data. URL: <http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm>

California's net farm income was second to Texas in 2001. Net farm income results from subtracting input costs, taxes, depreciation and factor payments from the value of production, and adding direct government payments. California accounts for 12.8 percent of national cash receipts, but receives only about 3 percent of direct

government payments to agriculture. These payments represent 2.1 percent of the state's value of production, compared to an average of 10.2 percent for the other 49 states. California's net farm income is equivalent to 8.2 percent of the U.S. net farm income.

Table 4. Net Farm Income and its Components as Percentages of Value of Production, 2001

	CA	Other 49 States Average
Purchased inputs	57.0	56.4
Property taxes, fees	2.3	3.5
Capital consumption	3.8	9.8
Payments to stakeholders	25.3	19.3
Direct Government payments	2.1	10.2
Net farm income	13.7	21.2

Source: USDA/ERS, Farm Income, online data. URL: <http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm>

Agricultural Commodity Exports

The most important market for California agricultural production is in the rest of the United States. Exports to international markets account for 16 percent to 19 percent of California's agricultural annual production. In 2001, international exports were valued at about \$6.5 billion, in nominal terms. In constant terms, total export value shows a decreasing trend from 1996 to 2001.

Table 5. California Agricultural Exports, 1996-2002, Millions of 2000 constant dollars

Commodity	1996	1997	1998	1999	2000	2001	2002
Top 10 commodities	4,209	3,957	3,782	3,126	3,485	3,422	3,415
Other commodities	3,220	3,357	3,110	3,003	3,042	2,948	2,809
Total Exports	7,429	7,314	6,893	6,129	6,526	6,371	6,223

Source: Based on UC Agricultural Issues Center, online data. URL: <http://aic.ucdavis.edu/pub/exports.html>

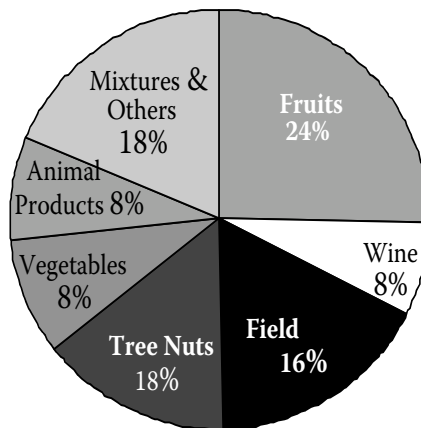
Values deflated by the GDP Implicit Price Deflator, Bureau of Economic Analysis.

Together, tree-nuts, cotton, wine, table grapes, raisins, dairy products, and citrus accounted for more than 50 percent of exports. The other 50 percent was spread across dozens of commodities. Export markets typically take between one-third and two-

thirds of the almonds, cotton, walnuts, rice, prunes and pistachios. Exports are less important for livestock products, fresh vegetables and ornamental horticulture.

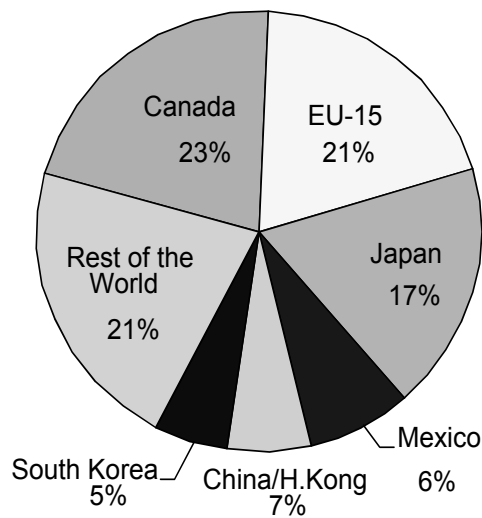
The top six export destinations in 2002 were Canada, the European Union, Japan, China-Hong Kong, Mexico and South Korea. Looking at destinations by commodity group, East Asia received more than 60 percent of animal product exports, 56 percent of field crops exports, and about half of fruit exports. North America accounted for 70 percent of vegetable exports, and Europe almost two-thirds of wine exports and about half of tree-nut exports.

Figure 3. CA Agricultural Exports by Commodity Groups, 2002, Share of total value



Source: UC Agricultural Issues Center, online data.
URL: <http://aic.ucdavis.edu/pub/exports.html>

Figure 4. CA Agricultural Exports by Market Destination, 2002, Share of total value



Source: UC Agricultural Issues Center, online data.
URL: <http://aic.ucdavis.edu/pub/exports.html>

Organic Agriculture

In 1997-98, 1,526 registered organic growers in California reported more than \$155 million in gross sales on about 68,000 acres. In 2002 they reported more than \$263 million in gross sales on about 177,708 acres. Their combined gross sales increased by a factor of 3.5 during the last decade and in 2002 represented 1 percent of the state's total agricultural sales.

Total gross sales in 2002 had more than doubled since 1992-93. Farmers using organic techniques produced over 70 different commodities in 1997-98.

Organic agriculture in California is characterized by the predominance of vegetable, fruit and tree-nut crops, which represented about 91 percent of those farms, 74 percent of acreage and 91 percent of gross sales. Livestock accounted for slightly more than 1 percent of organic farms and sales, and data on acres devoted to organic livestock were not available.

CALIFORNIA FARMS AND FARMERS

More than a quarter of California's landmass is used for agriculture. Just over half of the 27.7 million acres of agricultural land is pasture and range and about 39 percent is cropland. Most California farms are small in terms of area, cash receipts and total sales, and almost all are family owned and operated. California has a greater share of female farm operators and farmers with Hispanic, Asian and Pacific Islander backgrounds than the United States as a whole. As the state's population has grown, a share of agricultural land has been converted to residential, industrial and commercial uses, yet agriculture remains a vibrant industry.

Land Use

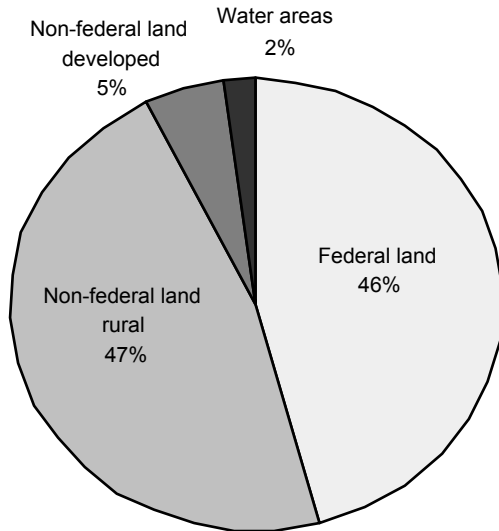
About 93 percent of California's 101.5 million acres is in rural uses. This rural area is divided evenly between federal and non-federal ownership. The federal land mostly includes national forests, national parks and wildlife areas, and "other land," such as marshes, open swamps, and bare rock deserts. Roughly 11 percent (about 5 million acres) of the federal rural land is grassland pasture and range used for agriculture.

Of California's 53 million acres of non-federal land, about 80 percent is grassland pasture and range, forest land, and cropland. About 5.5 million acres of California's non-federal land are defined by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture as "developed" for residential, industrial, and commercial use. However, the intensity of use varies widely, with much of this land relatively unpopulated. The California Department of Conservation Farmland Mapping and Monitoring Program (FMMP) defines 3.1 million acres of California's non-federal land as "urban and built-up," that is, land occupied by structures with a building density of at least one unit to one and one-half acres. This suggests that roughly 2.4 million acres of "developed" land in the NRCS survey are still relatively rural, or not mapped by FMMP.

In total, about 27.7 million acres, including 5 million acres of federal grazing land, are used for agriculture in California. More than half is pasture and range, about 39 percent is cropland, and the remainder is divided between woodland and other land.

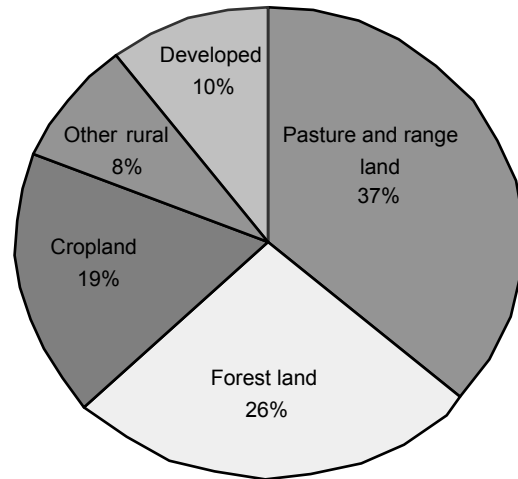
Like the rest of the Western United States, California has a greater ratio of pasture and range to cropland than the United States as a whole.

Figure 5. Federal and Non-Federal Land Use in California, 1997



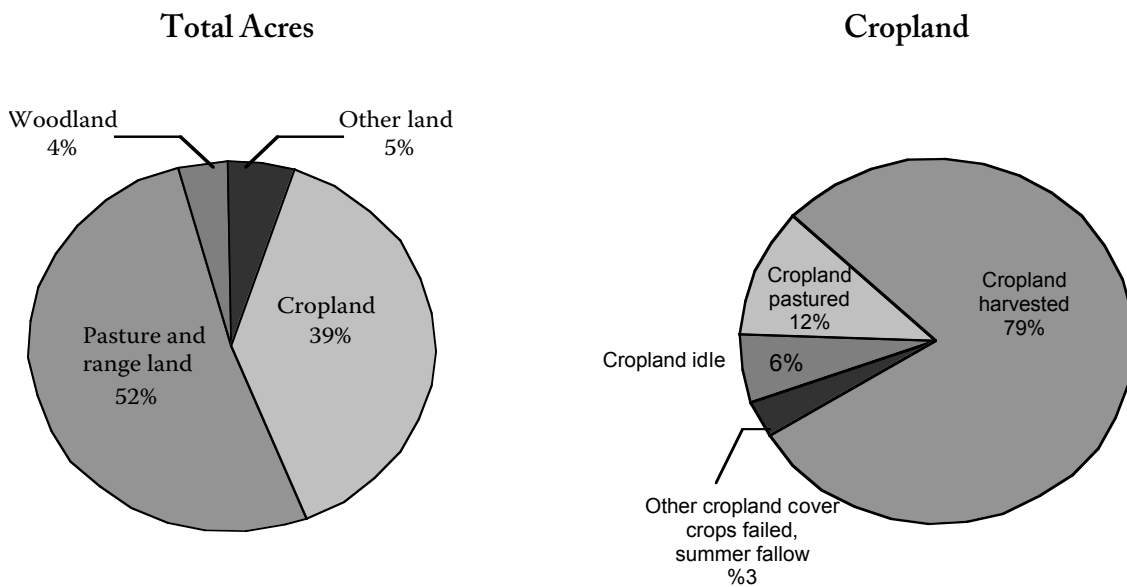
Source: USDA, Natural Resources Conservation Service, *Natural Resources Inventory*, 2000.

Figure 6. Non-Federal Land Use in California, 1997



Source: USDA Natural Resources Conservation Service, *Natural Resources Inventory*, 2000.

Figure 7. Agricultural Land Use in California,



Source: USDA/NASS, 1997 Census of Agriculture.

California's planted cropland has shifted over time toward higher value per acre crops such as fruits, tree-nuts and vegetables, while acres of field crops have decreased. Barley, a major crop in 1964, has declined dramatically since then. Harvested acreage for cotton and wheat increased substantially during the 1960s and 1970s, peaking during the early 1980's, but then declining during the 1990s. Rice acreage surpassed its 1982 acreage by about 600 acres in 2000, but has declined since.

Table 6. Agricultural Land Use, 1982-1997 (1,000 acres)

Census Year	Pasture and Range Land	Total Cropland ^a	Other Land ^b	Woodland & Woodland Pasture	Total Agricultural Land
<i>California</i>					
1982	17,980	11,257	1,437	1,483	32,157
1987	17,111	10,895	1,241	1,351	30,598
1992	16,191	10,479	1,158	1,150	28,979
1997	14,385	10,804	1,394	1,116	27,669
<i>U.S.</i>					
1982	418,264	445,362	36,082	87,088	986,796
1987	410,329	443,318	30,929	79,894	964,470
1992	410,835	435,366	25,369	73,962	945,532
1997	396,885	431,145	32,300	71,465	931,795

a) Includes harvested cropland, cropland used only for pastures, and other cropland.

b) Houses and barns, lots, ponds, roads, and wasteland.

Source: USDA/NASS, 1997 Census of Agriculture.

Table 7. California Harvested Cropland by Category, 1964-2001

Category	1964	1982	1992	1997	2001
Orchards and Vineyards	1520	2158	2246	2582	2626
Hay, all types ^a	1702	1416	1531	1699	1540
Vegetables and Melons	626	895	1017	1209	1312
Cotton	759	1313	1066	1036	864
Wheat for Grain	267	929	569	581	461
Rice	343	567	401	514	471
Barley for Grain	1319	583	204	130	110
Other Crops ^b	1310	904	727	792	992
Total Harvested Cropland	7846	8765	7761	8543	8376

a) Hay includes alfalfa, other tame, small grain, wild grass, silage, and green chop varieties.

b) Acres of other crops were calculated by subtracting all reported categories from Total Harvested Cropland, except for 2001, where other crops such as dry beans and potatoes were added together directly from the CDFA Resource Directory.

Sources: U.S. Bureau of the Census, Census of Agriculture 1964-92; USDA/NASS, 1997 *Census of Agriculture*; CDFA, *Resource Directory 2002*.

Farmland Conversion

Conversion of agricultural land to urban uses continues to be a public policy issue in the United States and in California. In California between 1988 and 2000, according to the California Department of Conservation Farmland Mapping and Monitoring Program (FMMP), about 549,000 acres (approximately one half of 1 percent of California's landmass) were converted to urban and built-up uses. At these conversion rates, about 4.2 million acres would be converted in the next 100 years. Of the total acres converted from 1988-2000, 213,000 were formerly cropland (near 2 percent of total current cropland) and 100,000 were formerly grazing land. Another 235,000 acres were formerly "other land," as classified by the FMMP. A significant portion of the "other land" was idled farmland previously removed from agricultural production in anticipation of development. This indicates that the figures for cropland and grazing land conversion may be understated.

Farmland conversion is a topic of particular interest in the Central Valley, which has over half of the state's agricultural land and 64 percent of the cropland. The Central Valley has had a lower proportion of its cropland and grazing land converted than the rest of the state. The Valley recorded 43 percent of statewide cropland conversion between 1988 and 2000. Similarly, the Central Valley grazing land, about 44 percent of the state total, contributed only 25 percent of the total grazing land conversions.

Table 8. Acres Converted to Urban and Built-up Land by Region, 1988-2000

Sacramento Valley^a

Cropland ^b	Grazing Land	Other Land ^c	Converted	Total Acres
1988-90	4,772	3,783	6,535	15,090
1990-92	6,450	3,088	3,421	12,959
1992-94	2,516	1,122	1,935	5,573
1994-96	2,868	2,312	2,186	7,366
1996-98	3,377	3,212	3,640	10,342
1998-00	7,038	3,704	4,810	15,552
Cumulative Total	27,021	17,221	22,527	66,882

San Joaquin Valley^a

Cropland ^b	Grazing Land	Other Land ^c	Converted	Total Acres
1988-90	5,347	1,807	5,373	12,527
1990-92	16,940	442	6,576	23,958
1992-94	6,817	1,369	2,093	10,279
1994-96	7,867	532	2,137	10,536
1996-98	16,749	2,720	6,451	25,967
1998-00	11,073	1,011	5,648	17,732
Cumulative Total	64,793	7,881	28,278	100,999

Central Valley^a

Cropland^b	Grazing Land	Other Land^c	Converted	Total Acres
1988-90	10,119	5,590	11,908	27,617
1990-92	23,390	3,530	9,997	36,917
1992-94	9,333	2,491	4,028	15,852
1994-96	10,735	2,844	4,323	17,902
1996-98	20,126	5,932	10,091	36,309
1998-00	18,111	4,715	10,458	33,284
Cumulative Total	91,814	25,102	50,805	167,881

California

Cropland^b	Grazing Land	Other Land^c	Converted	Total Acres
1988-90	40,003	20,863	57,364	118,230
1990-92	39,141	14,729	45,394	99,264
1992-94	23,453	10,464	20,390	54,307
1994-96	25,954	13,303	19,185	58,442
1996-98	37,585	17,057	34,919	89,997
1998-00	46,859	24,403	57,816	129,161
Cumulative Total	212,995	100,819	235,068	549,401

a) Sacramento Valley is Butte, Colusa, Glenn, Sacramento, Shasta, Solano, Sutter, Tehama, Yolo and Yuba counties. San Joaquin Valley is Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties. Central Valley is the sum of the Sacramento and the San Joaquin Valleys.

b) Cropland is defined here as all agricultural land that is not classified as grazing land by the FMMP.

c) Other land includes idle land previously removed from agricultural production.

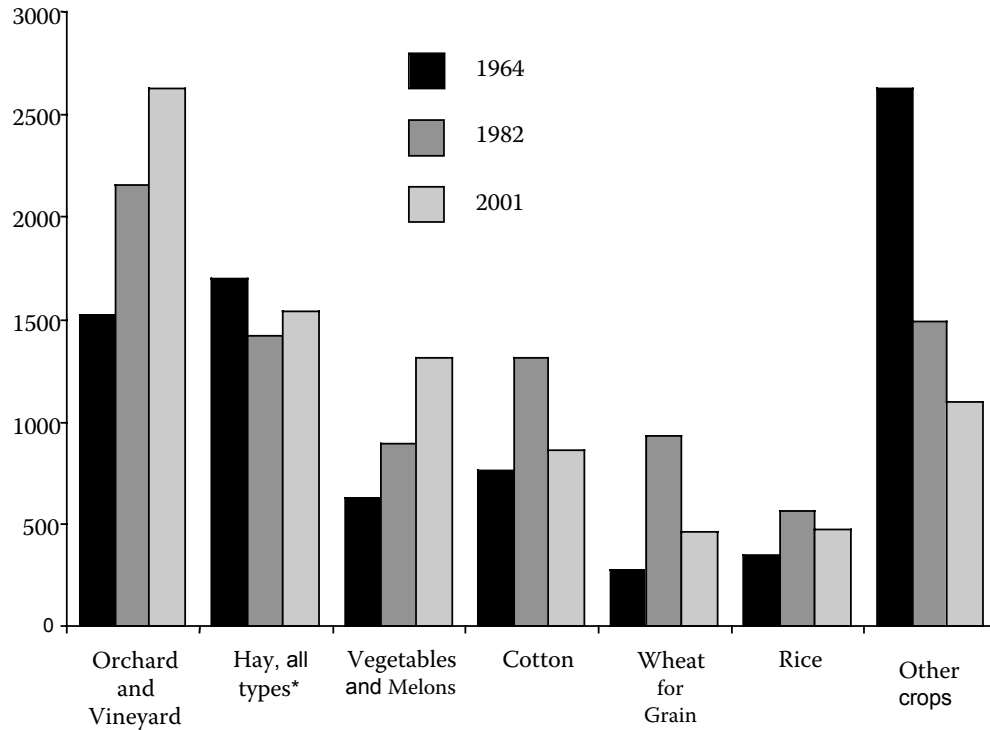
Source: California Department of Conservation, Farmland Mapping and Monitoring Program, 2000, and online data. URL: http://www.consrv.ca.gov/DLRP/fmmp/stats_reports/county_conversion_table.htm.

Farmland conversion to urban uses is associated with population growth. California's population increased by about 76 percent between 1970 and 2002, while the Central Valley's population doubled. There is general agreement that state population growth will continue, but little consensus on precise projections of future growth rates. The Bureau of the Census estimates that the state population will be about 50 million by 2025.

Farm Size

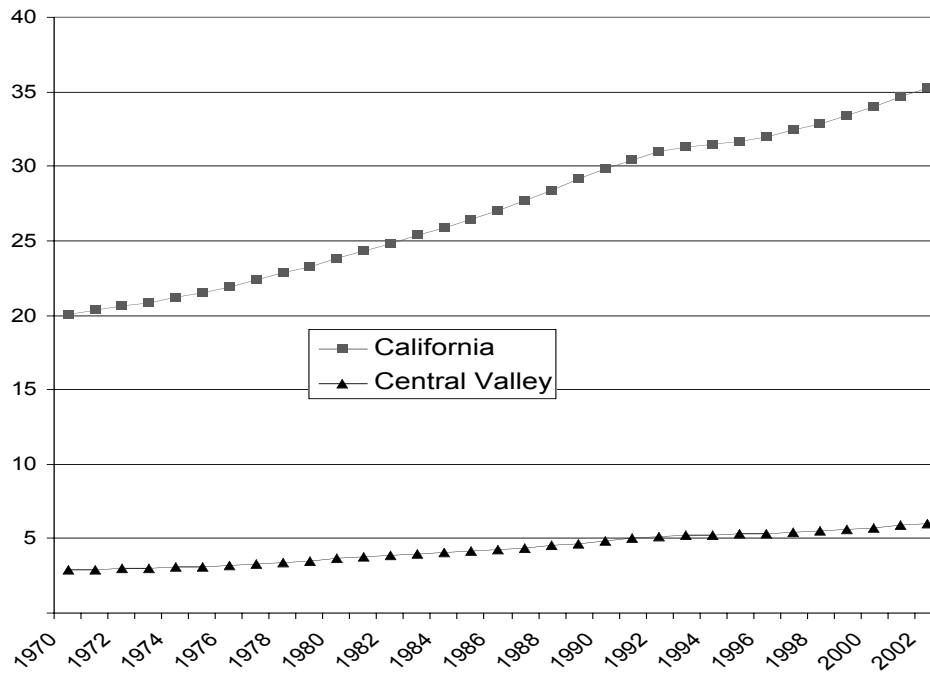
Nationwide, over the last half-century, the number of farms and the total land in farms have decreased, while the size of an average farm has increased. This trend has been less pronounced in California. While the average U.S. farm doubled in acreage between 1954 and 2002, the average California farm increased by about 13 percent. The official definition of a "farm" was changed in 1954, 1959, and 1974, to remove many of the smallest "farms" from census statistics. Each of these definitional changes decreased the reported number of farms and increased the average farm size. Since

Figure 8. California Cropland Harvested by Crop, 1964, 1982, 2001



(Source: Table 7)

Figure 9. California Population, 1970-2002 (Million)



Source: California Department of Finance, Demographic Research Unit. Year 2002 is preliminary.

Table 9. Farm Acreage, Number and Acres per Farm

Year	Number of farms	Land in Farms (1000 acres)	Average Acreage	Number of farms	Land in Farms (1000 acres)	Average Acreage
	-----California-----			-----United States-----		
1940	132,658	30,524	230	6,102,417	1,065,114	175
1945	138,917	35,054	252	5,859,169 ^a	1,141,615 ^a	195
1950	137,168	36,613	267	5,388,437	1,161,420	216
1954	123,075	37,795	307	4,782,416 ^a	1,158,192 ^a	242
1959	99,274	36,888	372	3,710,503	1,123,508	303
1964	80,852	37,011	458	3,154,857	1,110,187	352
1969	77,875	35,328	454	2,730,250	1,062,893	389
1974	67,674	33,386	493	2,314,013	1,017,030	440
1978	73,194	32,727	447	2,257,775	1,014,777	449
1982	82,463	32,157	390	2,240,976	986,797	440
1987	83,217	30,598	368	2,087,759	964,471	462
1992	77,669	28,979	373	1,925,300	945,532	491
1997	74,126	27,699	374	1,911,859	931,795	487
2002 ^b	79,709	27,627	347	2,129,226	939,507	441

a) Excludes Hawaii and Alaska. b) USDA/NASS estimate.

Sources: U.S. Bureau of the Census, Census of Agriculture, 1940-1992.

USDA, National Agricultural Statistics Service, 2002 and 1997 *Census of Agriculture*.

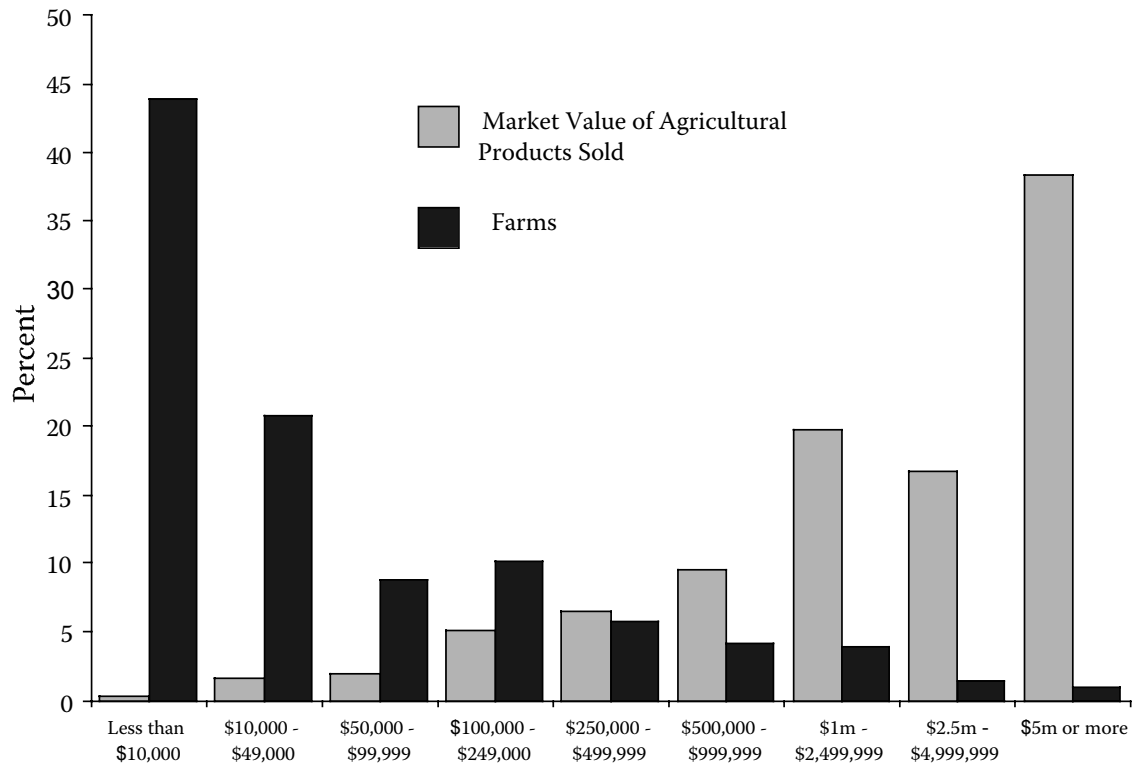
USDA, National Agricultural Statistics Service, *California Agriculture Statistics 1992-2001*.

1974 a “farm” has been defined in the Census of Agriculture as a place that generates agricultural sales of at least \$1,000 annually. Under the current Census of Agriculture definition, the average acreage of California farms decreased by 30 percent between 1974 and 2002. The 2002 Census introduced a new methodology for estimating total number of farms and operators’ demographics. The Census has been conducted via mail returns, and coverage has been always below 100 percent, especially among very small operations. The 2002 methodology accounts for all farms.

In 2002, about 80 percent of California farms were less than 180 acres, yet the “average farm” size was 347 acres. These two statistics highlight the fact that a small percent of large farms account for a large percent of total acreage. These large farms include ranches that graze livestock and may generate relatively little total revenue.

By sales value, California agriculture is comprised of a large number of small farms, while a small number of large farms represent most of the sales. The 16 percent of California farms with sales of more than \$250,000 in 1997 also represented over 90 percent of total sales value. In 1997, almost 44 percent of California farms sold less than \$10,000 of agricultural products. Retired or part-time farmers operate most of these farms.

Figure 10. Share of California Farms and Market Value of Agricultural Products Sold, by Total Sales Category, 1997



Source: USDA, National Agricultural Statistics Service, *1997 Census of Agriculture*.

Legal Organization

More than three-quarters of all farms in California are individual or family proprietorships, and another 15 percent are partnerships. About 7 percent of all California farms are legally organized as corporations. About 85 percent of these are family held. Non-family held corporations (1 percent of the farms) produce about 6 percent of total agricultural sales both in the United States and in California.

Farmer Demographics

There appears to be a continuing trend toward fewer young people choosing farming as an occupation. Between 1987 and 2002 there were fewer farmers in the younger age categories and an increase in the oldest category. The percent of California farmers over 65 increased from 23 percent to almost 30 percent. Farming is likely a retirement occupation for an increasing number of individuals. Meanwhile, the share of the state population over 65 remained unchanged at about 10.5 percent between 1990 and 2000.

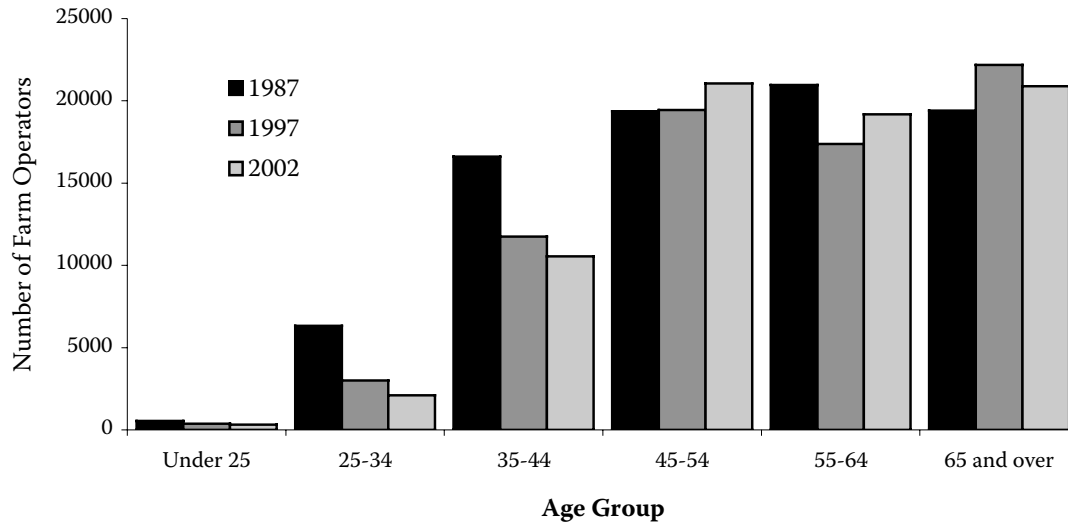
Anecdotal information suggests that many family farms remain in the name of the oldest family members, even if they are less actively involved in farming than younger members. This trend may place an upward bias on age estimates since almost all of California's farms are family owned and operated. In 1997, about 19 percent of U.S. farm operators described themselves as retired.

Table 10. Legal Organization of Farms, 1997

		Individual or Family	Partnership	Corp. Family Held	Corp. Not Family Held	Other ^a	All Farms
<i>California</i>							
Farms	<i>percent</i>	76.6	14.6	6	1.1	1.8	100
Average Area	<i>acres</i>	249	708	975	1,103	529	374
Total Area	<i>percent</i>	51	28	16	3	3	100
Average Sales	<i>\$1,000</i>	130	655	1,541	1,770	222	311
Total Sales	<i>percent</i>	32	31	30	6	1	100
Average Value of Land and Buildings	<i>\$1,000</i>	595	1,710	3,054	3,535	1,232	941
<i>United States</i>							
Farms	<i>percent</i>	86	8.9	4	0.4	0.8	100
Average Area	<i>acres</i>	356	881	1571	1507	4,378	487
Total Area	<i>percent</i>	63	16	13	1	7	100
Average Sales	<i>\$1,000</i>	62	210	603	1,395	117	103
Total Sales	<i>percent</i>	52	18	23	6	1	100
Average Value of Land and Buildings	<i>\$1,000</i>	360	791	1,338	1,769	1,357	450
a) Other includes cooperatives, estates, trusts, and institutionals.							
Source: USDA, National Agricultural Statistics Service, <i>1997 Census of Agriculture</i> .							

One third of California farm operators do not consider farming their principal occupation and many spend more days employed off the farm than on it. In contrast, about 51 percent did not report any days spent employed off the farm, but a significant proportion of those farmers may be retired from off farm occupation or from full-time farming.

Figure 11. California Farm Operators by Age Group



Source: USDA, National Agricultural Statistics Service, 1997 *Census of Agriculture*.

The percent of California farmers who consider farming their principal occupation increased from 50.4 percent to 53 percent between 1987 and 1997, while that ratio for the United States decreased from 54.5 percent to 50.3 percent.

Table 11. Farm Operators by Number of Days Employed off the Farm, 2002 (Percent)

	None	Less than 100 days	Between 100 and 199 days	200 days or more
California	50.6	9.8	6.9	32.9
U.S.	45.2	8.8	6.8	39.1

Source: USDA, National Agricultural Statistics Service, 1997 *Census of Agriculture*.

The number of women reported as the principal farm operator almost doubled in California between 1978 and 1997. This number has been increasing in California and in the United States, though California has consistently had a greater ratio of female to male farm operators than the national average. In 2002, 5.8 percent of California farms and 8.6 percent of U.S. farms reported a female principal operator, compared with 7.6 percent and 5 percent in 1978.

California has a greater share of farm operators of Hispanic origin (10 percent) than the United States as a whole (2.4 percent). Those with Asian or Pacific Islander origins represent 4.8 percent of California farm operators. The biggest change in *Census*

of Agriculture data on ethnicity is the percentage increase in those reporting their ethnicity, although 13 percent of California farmers and 14 percent of U.S. farmers still did not report their ethnic background in the most recent Census. The 1997 and 2002 *Census of Agriculture* reported making "special efforts" to capture the number of minority farmers.

Table 12. CA Farm Production Expenses, 1981, 1991, 2001 (In constant 1996 dollars)

Item	1981	1991	2001	% Change 1981-2001
-----Thousand-----				
Purchased feed	3,160,901	1,762,840	2,374,668	-25%
Purchased Livestock and poultry	938,818	650,528	592,093	-37%
Purchased seed	298,171	472,590	867,627	191%
Fertilizers and lime	825,243	672,941	743,514	-10%
Pesticides	720,596	729,366	951,093	32%
Petroleum fuel and oils	842,177	458,762	557,197	-34%
Electricity	396,173	557,541	787,485	99%
Repair and maintenance of capital items	450,042	671,791	721,286	60%
Machine hire and customwork	410,380	557,682	678,506	65%
Marketing, storage, and transportation expenses	903,321	1,069,988	1,944,764	115%
Contract labor	571,060	887,048	1,570,506	175%
Miscellaneous expenses	1,059,750	1,977,027	2,612,494	147%
Hired labor	2,634,153	3,239,873	4,727,557	79%
Net rent received by nonoperator landlords	603,062	596,260	390,571	-35%
Real estate and nonreal estate interest	2,555,602	1,164,775	1,269,232	-50%
Property taxes and other fees	466,328	465,461	574,811	23%
Total farm Expenditures	16,835,777	15,934,471	21,363,404	27%
Estimated Number of farms	83,000	83,000	85,000	--
Average per farm	202,841	191,982	251,334	24%
Source: USDA/ERS, Online Farm Income Data. URL: http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm U.S. Bureau of Economic Analysis.				

RESOURCES AND FARM PRODUCTIVITY

California farmers use a variety of inputs to produce agricultural products. Financial capital, machinery, fuel, family and hired labor, livestock feed, chemicals and fertilizer, and water are some of the inputs that are commonly associated with agricultural production. Research and development and new technology are also important contributors to California agriculture that, over time, have led to productivity increases and changes in farming practices.

Expenditures by California farmers on production inputs, on a per farm basis, increased by 24 percent between 1981 and 2001 in constant (1996) dollars. The largest increases were in purchased seeds, contract labor, miscellaneous expenses, and marketing and transportation.

Capital

California has about 7.3 percent of the nation's farm assets, 10.1 percent of its debt, and 6.8 percent of its equity. This leaves the aggregate California farming sector with higher debt-to equity and debt-to-asset ratios than the United States as a whole. California has also much higher value of sales to assets or equity than the rest of the United States.

The average value per acre of land and buildings per farm in California is nearly three times the United States average. Half of California's farms have land and building values between \$100,000 and \$499,999.

Table 13. Farm Balance Sheet, December 31, 2001

	California	United States
<i>Farm assets</i>	<i>-----Thousand Dollars-----</i>	
Real estate	78,197,670	998,704,964
Non Real Estate	13,124,534	252,302,719
Livestock and poultry	4,601,836	73,157,850
Machinery and motor vehicles	4,513,580	90,730,928
Crops	465,908	25,238,754
Purchased inputs	471,375	4,212,374
Financial	3,071,835	58,962,813
Total	91,322,204	1,251,007,683
<i>Farm debt</i>		
Real estate	11,852,086	103,009,801
Non Real Estate	7,588,162	89,017,129
Total	19,440,248	192,026,930
<i>Equity</i>	71,881,956	1,058,980,753
Debt/equity	27.0	18.1
Debt/assets	21.3	15.4
Source: USDA/ERS, Farm Balance Sheet data online. URL: http://www.ers.usda.gov/Data/FarmBalanceSheet/Fbsdmu.htm		

Table 14. Value of Land and Buildings, 1982-1997 (current dollars)

Census Year	Total Value ^a \$1,000,000	Average Value Per Farm(\$)	Average Value Per Acre(\$)	Total Value ^a \$1,000,000	Average Value Per Farm(\$)	Average Value Per Acre(\$)
-----California-----			-----United States-----			
1982	61,565	746,577	1,918	775,084	345,869	784
1987	48,571	583,668	1,575	604,170	289,387	627
1992	63,693	820,063	2,213	687,432	357,056	727
1997	69,765	941,170	2,605	859,855	449,748	933

a) Computed as the product of the average value per farm and the total number of farms.
 Sources: U.S. Bureau of the Census, *Census of Agriculture*, 1982-1992;
 USDA, National Agricultural Statistics Service, *1997 Census of Agriculture*.

Hired Farm labor

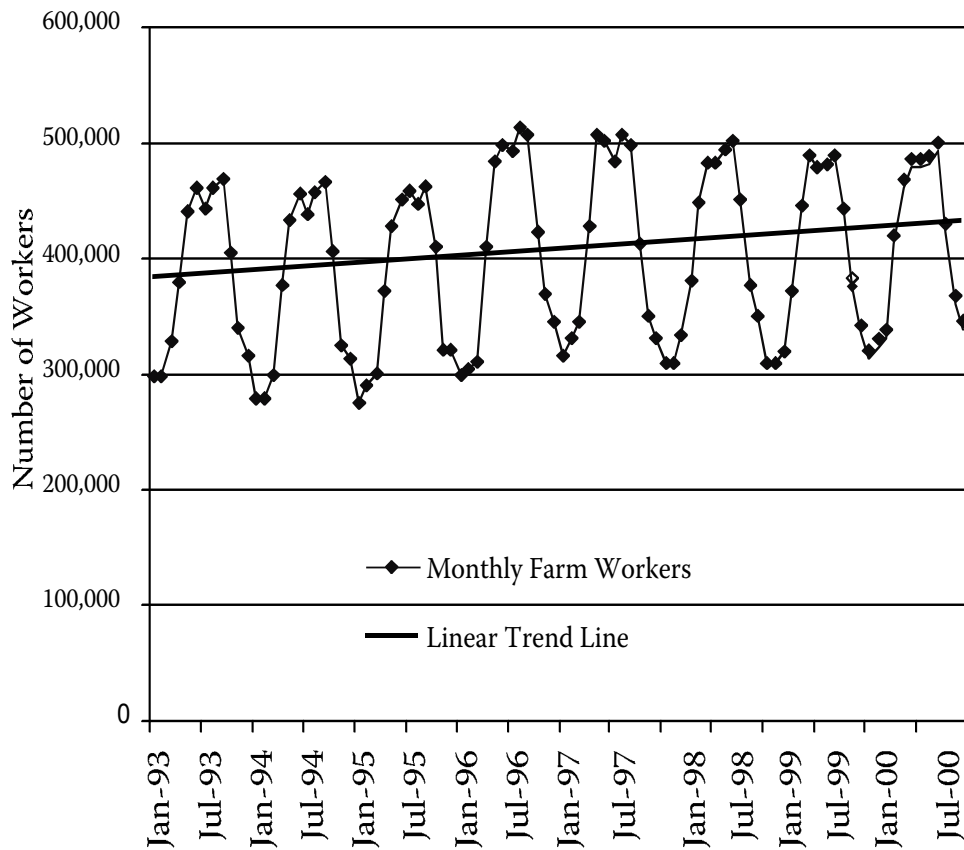
In 1997, the Central Valley had about 58 percent of California's 549,265 hired farm laborers, according to census data. Most worked in the San Joaquin Valley. Monthly data in Figure 12 displays the cyclical nature of the farm labor employment market, and an upward trend in average annual employment between 1993 and 2000. The number of employed workers rises in the summer months and drops in the winter. The higher employment total for the *Census of Agriculture* data in 1997 (549,265 compared to the Employment Development Department's monthly high of about 500,000) suggests that different definitions or sampling methods are employed in the two data sources.

Table 15. Hired Farm Workers by Region, 1997

	Sacramento Valley	S. Joaquin Valley	Central Valley ^a	California
Farms with Hired Workers	5,130	14,947	20,077	36,450
Total Hired Workers	57,657	264,575	322,232	549,265
Workers Hired 150 days or more	16,308	80,469	96,777	186,358
Workers Hired less than 150 days	41,349	184,106	225,455	362,907
Payroll (\$1,000)	313,519	1,383,042	1,696,561	3,392,577

a) Central Valley is the sum of the San Joaquin and Sacramento Valleys.
 Source: USDA, National Agricultural Statistics Service, *1997 Census of Agriculture*.

Figure 12. California Hired Farm Workers, 1993-2000



Source: California Employment Development Department.

Table 16. Characteristics of California Crop Workers, 1995-97

	Percent of Workers
Foreign Born	95
Male	82
Under 34	63
Married	61
Family in United States	60
In United States Less than 5 Years	53
2 to 4 Farm Jobs per Year	53
Unauthorized	42

Source: Martin, Philip, and J. Edward Taylor, "For California Farm workers, Future Holds Little Prospect for Change," *California Agriculture* 2000.

The California agricultural labor market is characterized by (1) an almost entirely foreign-born (mostly Hispanic) workforce, and (2) relatively low annual average earnings compared to other occupations. Low earnings are the result of relatively low hourly wages and less than full-time employment.

Table 17. Pesticide use in California, selected years

Category	Pounds of Active Ingredient applied:		
	1992	1997	2000
1 Reproductive Toxin ^a	30,393,943	34,483,130	26,227,436
2 Carcinogens ^b	14,218,972	24,543,280	22,889,829
3 Cholinesterase inhibitor ^c	14,352,300	16,153,697	11,570,792
4 Groundwater Contaminant ^d	2,143,420	2,347,882	2,432,815
5 Air Contaminant ^e	24,170,357	25,561,393	21,651,013
6 Oil based	24,355,035	33,089,845	27,634,736
7 Reduced Risk	0	72,838	553,268
8 Biopesticides	64,674	188,180	332,851
Total	109,698,701	136,440,245	113,292,740
Category	Cumulated acres treated:		
	1992	1997	2000
1 Reproductive Toxin ^a	3,868,087	4,170,939	3,890,210
2 Carcinogens ^b	3,406,238	4,285,583	5,899,480
3 Cholinesterase inhibitor ^c	10,236,375	12,135,586	8,479,224
4 Groundwater Contaminant ^d	1,179,383	1,651,236	1,757,983
5 Air Contaminant ^e	3,584,293	4,137,785	4,342,186
6 Oil based	2,250,273	2,494,361	2,370,087
7 Reduced Risk	0	399,715	2,509,530
8 Biopesticides	659,894	1,272,516	1,066,648
Total	25,184,543	30,547,721	30,315,348

Categories of pesticides:

a) Proposition 65 list (known to cause reproductive toxicity).

b) B2 carcinogens, or Proposition 65 list (known to cause cancer).

c) Cholinesterase inhibitors (organophosphate or carbamate).

d) Materials on the DPR's groundwater protection list.

e) Materials on the DPR's toxic air contaminants list.

Source: California Environmental Protection Agency, Department of Pesticide Regulation (DPR), Pesticide Use Reporting.

Chemicals and Fertilizer

Total pesticide use in California agriculture shows an upward trend, with total reported pounds applied fluctuating from year to year depending on pest problems, weather, and acreage and types of crop planted. Also, the types and forms of the pesticides have changed to meet new pests and environmental demands. In 2000, more than 550,000 pounds of chemicals defined by the United States Environmental Protection Agency as “reduced risk” were applied by commercial agriculture in California. This was equivalent to about one half of one percent of total pounds of pesticides applied to California crops.

In 1990, California became the first state to require reporting of the agricultural use of all pesticides: insecticides, herbicides, rodenticides, fungicides, and sanitizers. In contrast, much of the non-agricultural uses such as chlorine for swimming pools and home and garden pesticides are not reported.

About one-third of all California farms (22,300) did not report using any chemicals or fertilizer in the 1997 Census of Agriculture. California has about 1,526 registered organic farmers, only a tiny portion of those farms that did not report using any chemicals or fertilizer. Therefore, care is needed in interpreting these Census of Agriculture figures. Many farmers may have failed to respond to this particular question or were small livestock growers or other operators whose farms used no chemicals or fertilizer without being defined explicitly as “organic.”

Table 18. Agricultural Chemical and Fertilizer Use Reported by California Farmers

		1969	1974	1978	1982	1987	1992	1997
<i>Chemicals or Fertilizer</i>	Number of Farms	43,656	37,627	52,746	51,435	57,579	52,917	51,819
<i>Commercial Fertilizer</i>	Number of Farms	36,337	32,865	42,857	41,909	44,683	42,602	42,312
	Expenditures (\$1,000)	121,905	290,455	335,444	427,823	427,924	568,772	746,325
<i>Agricultural Chemicals</i>	Number of Farms	N/a	N/a	46,449	43,142	52,614	45,721	44,327
	Expenditures (\$1,000)	N/a	N/a	288,968	468,604	544,779	694,549	957,006
<i>Number of Farms on which Chemicals were Used to Treat:</i>	Insects	23,617	19,297	24,706	30,460	32,959	30,022	28,451
	Nematodes	2,995	2,512	3,325	3,526	3,603	3,520	3,553
	Diseases	8,042	6,802	17,553	15,280	17,446	14,693	16,207
	Weeds	12,602	14,106	22,385	28,192	35,003	28,292	28,807
	Growth, fruits or Defoliation	3,748	2,761	5,461	5,483	6,173	4,673	5,231

Sources: U.S. Bureau of the Census, Census of Agriculture, 1969-1992.

USDA, National Agricultural Statistics Service, 1997 Census of Agriculture.

Water

California receives about 200 million acre-feet (maf) of precipitation in a normal non-drought year. Roughly 65 percent of this is lost to evaporation or vegetation. The remaining 71 maf of average runoff, plus imported water, supplies the state's water "budget," traveling through California's complex water distribution system to environmental, agricultural, and urban uses. Groundwater is an additional important source.

In 1998 the California Department of Water Resources released a normalized water budget showing the state's supply and use of applied water in an "average" non-drought year. Figures in the "average" year budget were based on the distribution infrastructure in place in 1995. The 1.6 maf shortage is largely accounted for by groundwater overdraft that was not included in the budget.

More than 70 percent of the average annual runoff occurs north of Sacramento, but about 75 percent of the state's water demand is south of Sacramento. California uses a combination of federal, state, and local water projects to capture, store, transport, and import surface water to meet demand around the state. The largest water projects are the federal Central Valley Project and the State Water Project.

Table 19: California Water Budget and Supplies

California Annual Average Water Budget ^a		California Annual Average Water Supplies ^a	
<i>Water Use</i>	<i>Million Acre-Feet</i>	<i>Surface Water</i>	<i>Million Acre-Feet</i>
	8.8	Central Valley Project	7
Agricultural	33.8	Other federal Projects	0.9
Environmental	36.9	State Water Project	3.1
Total	79.5	Colorado River	5.2
<i>Supplies</i>		Local	11.1
Surface Water	65.1	Required Environmental Flow	31.4
Groundwater ^b	12.5	Reapplied	6.4
Recycled & Desalted	0.3	<i>Groundwater^b</i>	12.5
		<i>Recycled & Desalted</i>	0.3
Total	77.9		
Shortage	1.6	Total	77.9

a) Normalized date for a non-drought year.

b) Excludes overdraft.

Source: California Department of Water Resources, The California Water Plan Update, Bulletin 160-98.

The amount of water per acre used by urban areas varies according to land use, population density and water use efficiency. In some areas agriculture may use less water per acre than nearby urban development while in other areas the opposite case may be true.

Groundwater provides 30 percent of the supply used by agriculture and the urban sector in a normal non-drought year. Agriculture accounts for over 90 percent of the groundwater used in the San Joaquin, Tulare Lake, and Central Coast hydrologic regions. Only a portion of the applied water is actually used by the crop. The remainder percolates through the soil, flows downstream to other uses, or is irrecoverably lost due to other factors. Crop water use is measured as evapotranspiration of applied water (ETAW). The ratio of ETAW to applied water is an indication of irrigation efficiency.

The amount of water applied to a particular crop depends on many factors including plant evapotranspiration, soil properties, irrigation efficiency, and weather. Plant intake is the primary purpose of water application, but water is also applied to crops for cultural purposes such as frost control, facilitating cultivation and leaching of salts out of the crop root zone. There is a wide range in water application rates among crops and hydrologic regions. For example, depending on the hydrologic region, anywhere between 2 and 10-acre-feet/acre are applied to alfalfa annually. Hay production, including alfalfa, accounts for almost 15 percent of total irrigation water used in agriculture. Cotton accounts for about 12.5 percent. The top 12 commodities, those that represent 60 percent of the total value of California agriculture, account for about 48 percent of the water used for irrigation in the state.

Agricultural surface water costs differ greatly by hydrologic region and source of supply. According to the Department of Water Resources, the 2003 Central Valley Project contract rates range from \$2 per acre-foot in the Sacramento Valley to \$27 in the county of Tulare and almost \$30 in some areas of the Delta.

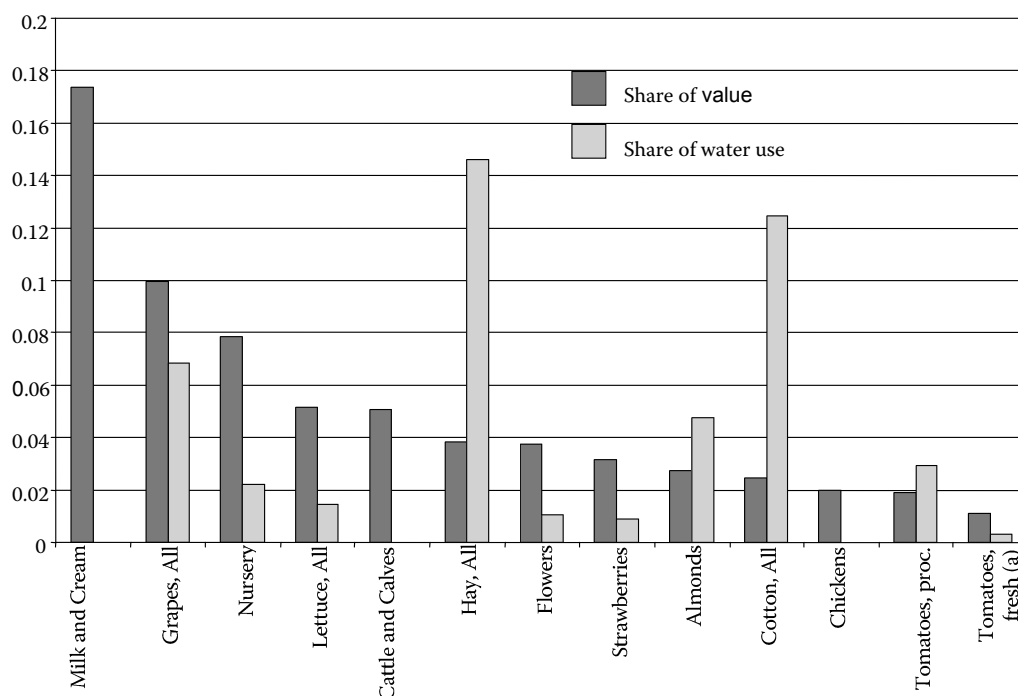
Almost one-third of California's irrigated acreage used sprinkler, drip or trickle systems in 1998. The rest used gravity flow systems such as furrows. More than one method was used on some acreage.

Table 20. California Land Irrigated by Water Distribution Method, 1998

	Gravity Flow Systems	Sprinkler Systems	Drip or Trickle Systems	Subirrigation	All Irrigation
Farms	19,575	7,870	14,697	2,710	40,121
Acres Irrigated (1,000)	5,820	1,528	1,022	55	8,140
Acres Irrigated (percent)	71	19	13	1	--

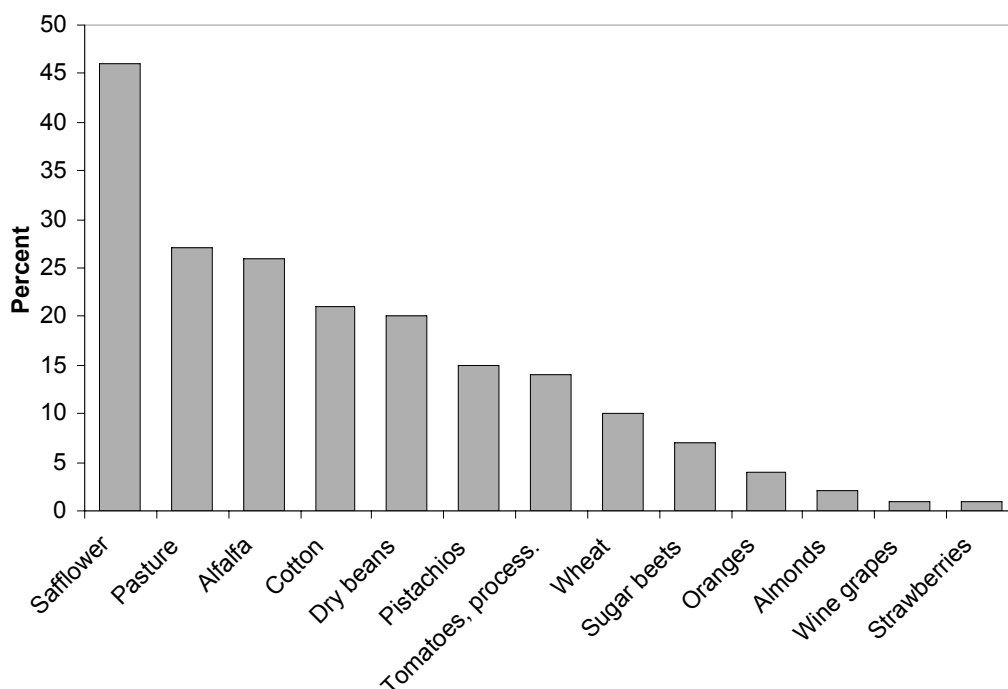
Source: USDA, National Agricultural Statistics Service, Census of Agriculture, Farm and Ranch Irrigation Survey, 1998.

Figure 13. Distribution of Water Use Among the Top 12 Commodities, CA, 2002



a) Fresh tomatoes are listed here for comparison purposes; Source: California Department of Water Resources.

Figure 14. Water Costs as a Percent of Operating Costs for Selected Crops



Source: UC Davis, Department of Agricultural and Resource Economics. Costs and Returns Studies. URL: <http://www.agecon.ucdavis.edu/outreach/crop/crop.htm>.

Table 21. California Irrigated Acreage, 1995^a (Thousand acres)

Crop	1995
Rice	517
Grain	900
Cotton	1,244
Sugar Beets	178
Corn	438
Other Field	467
Alfalfa	1,094
Pasture	933
Tomatoes	357
Almond/Pistachios	534
Other Deciduous	602
Subtropical	455
Grapes	736
Other	1,060
Total Irrigated Crop Area	9,515
Multiple Crop	447
Irrigated Land Area	9,068

a) Normalized data.

Source: Department of Water Resources, *The California Water Plan Update*, Bulletin 160-98.

Technology

Technological innovation, fueled by research and entrepreneurship, has been a driving force in U.S. agriculture during the past century, leading to both higher yields and lower prices. In California, technological change has facilitated significant yield increases for many crops as well as other changes. Inputs have been used more efficiently to produce greater quantities of output. For instance, cash receipts (in constant 1996 dollars) per irrigated acre increased by 35 percent between 1960 and 1995. This can be attributed partially to the development and implementation of more efficient irrigation, such as drip systems, and partially to a change in the type of crops produced.

The most recent analysis available finds that the productivity index for California agriculture (the index of total farm production outputs divided by the index of total farm production inputs) doubled between 1949 and 1991.

During the 1990s, particularly toward the end of the decade, computers were increasingly incorporated into farming operations. In only two years, between 1997

and 1999, the number of California farms with Internet access doubled to 46 percent, and reached 51 percent in 2001. Overall, about 36 percent of California farms reported using computers in their business operations in 2001, compared to 29 percent for the United States as a whole, although there are several states with higher usage than California.

Table 22. Three-Year Average Yield per Harvested Acre, Representative Crops

Crop	Units/Acre	Average 1976-78		Average 2000-02	
		<i>Other 49 States</i>	<i>California</i>	<i>Other 49 States</i>	<i>California</i>
Corn for grain	bushels	93	117	135	170
Cotton, upland	pounds	393	880	619	1,392
Lettuce, head	hundredweight	204	266	360	382
Rice, medium grain	pounds	4,111	5,483	6,349	8,200
Strawberries	hundredweight	60	405	150	562
Sugar Beets	short tons	19	26	21	36
Tomatoes, Processing	short tons	17	23	30	37
Wheat, winter	bushels	26	52	42	72

Source: USDA, NASS, selected years.

In 1998, California farmers invested \$2.4 million in computers to operate irrigation systems on 273,047 acres. About 675 farms reported using computer simulation models to decide when to irrigate.

Research and Development

In 2001, U.S. agricultural experiment stations (mainly associated with land grant universities) collectively spent \$2.3 billion on scientists' agricultural research. The University of California Division of Agriculture and Natural Resources (DANR) accounted for about 10 percent of those resources. The DANR includes scientists with the UC Berkeley College of Natural Resources, the UC Davis College of Agricultural and Environmental Sciences, the Division of Biological Sciences, and the School of Veterinary Medicine; and the UC Riverside College of Natural and Agricultural Sciences.

The DANR's two major organizational units are the Agricultural Experimental Station (AES) and the Cooperative Extension (CE). The AES is basically a multi-campus research organization, with a staff of near 700 academics distributed in more than 50 different departments. The CE constitutes the main outreach program, with about 400 specialists and advisors dispersed throughout the state.

During the 1990s DANR aggregate funding stayed approximately constant at an average of \$235 million per year. From 1999 to 2002, total funding increased in constant terms by 25 percent. The three campuses (Berkeley, Davis, and Riverside),

accounted for 72 percent of the 2002 annual DANR expenditures, while regionally based units accounted for 14 percent of the budget, and statewide academic programs and their support 12 percent.

In 2002, about 80 percent of total funding came from government sources (state and federal); 13 percent came from private gifts, grants and contracts, and 7 percent from other sources, such as county government, endowments, sales, services, etc.

Table 23. University of California Division of Agriculture and Natural Resources Annual Expenditures, 1993-2002, in constant 1996 dollars

Year	Cooperative Extension	Agricultural Experimental Station	Other ^a	Total
1993	68,510	157,789	2,234	228,534
1994	65,693	159,182	2,329	227,204
1995	68,530	163,779	2,058	234,367
1996	69,079	165,392	2,117	236,588
1997	68,223	168,763	2,167	239,153
1998	67,823	170,257	2,258	240,337
1999	70,961	168,885	2,922	242,768
2000	73,042	187,403	2,909	263,354
2001	80,785	200,812	3,194	284,791
2002	83,167	217,416	3,372	303,954

a) Other includes Research and Extension Centers, Farming income, Operation and Maintenance Plant, and International Agricultural Visitors Program.

Source: Based on UC DANR, Office of the Controller and Business Services, *Annual Report of Expenditures, 2001-2002*. Values deflated by the GDP Implicit Price Deflator, Bureau of Economic Analysis.

The number of CE County Advisors decreased by about 18 percent between 1990 and 1999, from 326 to 265, and their distribution among program areas has changed. Agriculture Program Area now accounts for 60 percent of the UC Cooperative Extension County Advisors, up from 55 percent in 1990, while Human Resources (Youth Development, Nutrition, Food & Consumer Sciences, and Community Development) decreased from 34 to 30 percent. Natural Resources program changed slightly from 11 to 10 percent of the CE County Advisors.

BROAD ECONOMIC IMPACTS³

Agriculture creates significant ripple effects throughout California'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. These multipliers may be applied to the county, state and regional levels using

³ This section is based on MOCA 2000 and , in particular, chapter 5 which relied on the work of George Goldman.

the IMPLAN⁴ model. Multiplier effects can be represented by four measures that reflect the impact that agriculture has on the state.

The first measure, *sales impact*, records how agricultural purchases influence total private sector sales. A second measure is the amount of *personal income* produced directly and indirectly by the economic output of agriculture and agricultural processing. The third measure calculates the total *value-added* 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) used to produce those goods. A final measure is the number of *jobs* in agriculture, agricultural processing and other sectors of the economy related to agriculture in the state.

These multiplier effects may be demonstrated by tracing the activity of an individual farm. A farm's *sales impact* would include all the inputs used on that farm, such as machinery, fertilizer, electricity—anything farm dollars buy. The *personal income* from the farm would include the farm's income and a portion of the income of those from whom the farm purchased inputs. The farm's *value added* would be equal to the cash receipts from sales of farm products less the costs of inputs (excluding labor) that went into producing those goods. The *jobs* related to the farm's efforts would include labor on that farm as well as in input and output industries that rely on business from that farm. For example, agricultural machinery manufacturers, chemical manufacturers, processors, and people working in retail food trade have jobs that are related to agriculture.

The economic impacts shown in Table 22 can be interpreted as an indication of how the state would be affected if agricultural production and processing were to cease, and the associated inputs (such as capital and labor) were not reemployed in any other economic use.

Multiplier effects differ by commodity since some commodities may be related to more input and processing industries than others. For example, dairy production is related to a relatively extensive processing sector, for which a wide range of inputs and specialized machinery has been developed. Hence, the dairy industry may have a greater effect on the economy in terms of multiplier effects than some other commodities.

Multiplier effects may differ by region due to geographic dispersion of industries related to agriculture, aggregate size of agriculture and type of commodities produced in that region. Some industries have more local impacts, while others have impacts that are spread farther afield. For example, county or multi-county multiplier effects do not include input and processing industries located outside of that region, even if those industries are located elsewhere in the state. Similarly, state multiplier effects do not include input and processing industries located outside of the state. Thus, multiplier effects for commodity groups with geographically diffuse input and processing sectors may be underestimated.

Through multiplier effects, agricultural production and processing account for about 6 percent or 7 percent of the state's total income, value-added, and jobs. Fruits,

⁴ The IMPLAN (Impact analysis for PLANning) system was designed by the U.S. Forest Service/United States Department of Agriculture, to be able to estimate economic input-output models for any county, or group of counties, in the United States. 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.

tree-nuts, and vegetables represent about half of these totals, while dairy and poultry products, and grains are also major contributors.

Table 24. Economic Impacts of CA's Agricultural Production and Processing, 1998

Major Commodity Group	Direct Sales	Sales	Total Income	Value Added	Number of Jobs ^a
	(\$1,000)	(\$1,000)	(\$1,000)	(\$1,000)	
Dairy/Poultry Products And Processing	10,086,973	24,176,605	8,596,001	9,191,304	153,385
Livestock, Processed Meats	3,479,492	7,222,525	2,223,538	2,426,778	60,531
Cotton, Fabric/Yarn/Thread Mills	1,747,026	3,657,114	1,518,524	1,645,278	30,876
Food/Feed Grains, Hay and Flour/Grain Mill Products	11,399,212	24,118,097	9,771,929	10,569,063	192,422
Fruits, Tree-nuts, Vegetables, Processed Fruits/Vegetables, And Beverages	33,367,903	70,076,737	30,378,455	33,909,883	567,388
Sugar/Misc. Crops and Confectionery Products	3,942,442	8,953,166	3,357,571	3,644,463	60,522
Greenhouse/Nursery Products	1,749,356	3,006,458	2,088,240	2,173,433	40,382
Other ^b	1,877,847	4,191,248	1,553,260	1,710,400	26,576
Total	67,650,251	145,401,951	59,487,518	65,270,601	1,132,083
California State Total (agricultural and non-agricultural)	--	--	900,900,000	1,098,962,275	15,360,600
Agriculture as a Percent of California State Total	--	--	6.60%	5.94%	7.37%

a) Adjusted for inflation to 1998.

b) Includes vegetable oil mills, shortening/cooking oils, roasted coffee, and manufactured ice.

Sources: California Personal Income, 1998: U.S. Bureau of Economic Analysis, Released: July 27, 1999.

California Estimated Gross State Product, 1998: Estimated applying 1997 Ratio of Gross State Product/Personal Income to 1998 Personal Income.

California Employment, 1998: Labor Market Information Division, EDD, Sacramento, Website Data File.

1997 Economic Census, Manufacturing, Geographic Area Series, U.S. Census Bureau.

In 1998, fresh and processed fruits, tree-nuts, and vegetables had the greatest impact of any commodity group on California's economy, generating about half the direct and indirect sales, total income, value added and jobs related to agriculture. About one third of the \$33 billion in direct sales in this category was attributable to sales of alcoholic and non-alcoholic beverages. Examples of beverages linked to fruit, tree-nut and vegetable production include wine and juice. Some of the beverages included in this category (beer and spirits for example) may reflect processing of grain products rather than fruit, tree-nuts and vegetables.

Dairy and poultry products and grains also had significant economic contributions, accounting for between 10 percent and 20 percent of the total income, value added, and jobs related to agriculture.

CHAPTER 4

Marketing California's Agricultural Production

Hoy F. Carman, Roberta Cook and Richard J. Sexton

Hoy F. Carman is a Professor, Roberta Cook is a Cooperative Extension Specialist, and Richard J. Sexton is a Professor, all in the Department of Agricultural and Resource Economics, University of California, Davis.

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. The California Department of Food and Agriculture estimates that the state is the leading U.S. producer for about 65 crop and livestock commodities. Fifty-five percent of the value of California agriculture's \$26.1 billion in 2002 farm gate sales is contributed by the fruit (\$6.0 billion), vegetable (\$6.6 billion), and nut (\$1.8 billion) industries. Indeed, California dominates the U.S. horticultural sector, accounting for approximately 37, 55 and 85 percent, respectively, of the 2002 farm gate value of the principal vegetables, fruit, and tree nuts produced in the United States (USDA/ERS).

California's leading position in the \$30.8 billion U.S. horticultural industry is explained by climatic, technological, and infrastructure advantages, as well as the market- and consumer-driven orientation of its agribusiness managers. Given the importance of horticultural crops to California agriculture, and to the nation, our discussion draws 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. This competition has intensified given the high rate of new product introductions and expanded year-round availability of formerly seasonal items, often through imports. Both of these factors have led to a greater array of substitute products, frequently dampening demand for large-volume staples like oranges and apples.

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. supply of key commodities such as almonds, lemons, olives, lettuce, prunes, strawberries, table grapes, processing tomatoes, and walnuts, California producers and marketers traditionally had unique opportunities to exercise control over the markets for those commodities. However, expanding world supply of many commodities has reduced California's share, increasing competition and presenting new marketing challenges.

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 AGRICULTURE

The U.S. food industry is the largest in the world. The final value of food sold through all retail channels was \$485.2 billion in 2002 with an additional \$415 billion sold through foodservice channels (hotels, restaurants and institutions) (The Food Institute, 2003). 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 21 percent in 2001. 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.

Table 1. Farm Share of Retail Value for Major Agricultural Commodities, 2001

Product	1980	1990	2001
-----Farm Value percent-----			
Meat products	51	46	31
Dairy products	52	39	34
Poultry	54	44	41
Eggs	64	56	35
Cereal and Bakery Products	14	8	5
Fresh Fruit	26	23	16
Lemons			14
Oranges			19
Fresh Vegetables	27	28	19
Lettuce	21	22	23
Processed Fruit & Vegetables	23	26	16
Pears			13
Tomatoes			7

Sources: <http://www.ers.usda.gov/Briefing/FoodPriceSpreads/spreads/table1a.htm>;
<http://www.ers.usda.gov/Briefing/FoodPriceSpreads/basket/table2.htm>; Food Cost Review, 1995, Agricultural
Economic Report No. 729, U.S. Department of Agriculture, Economic Research Service, April 1996; Fruit and
Tree Nuts Situation and Outlook Yearbook, FTS-2002, U.S. Department of Agriculture, Economic Research
Service, October 2002; Vegetables and Melons Situation and Outlook Yearbook, VGS-2002, U.S. Department
of Agriculture, Economic Research Service, July 2002

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 2001 the farm share of the food marketing bill was 19 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 2002, such expenditures accounted for 46 percent of the food budget compared to 37 percent in 1990 and 32 percent in 1980.

KEY TRENDS IN MARKETING STRATEGIES AND U.S. FOOD CONSUMPTION: SPOTLIGHT ON THE FRUIT AND VEGETABLE SECTOR

While the overall U.S. food market is characterized by slow growth, eating habits are becoming more diverse. Demographic and psychographic trends, such as ethnic diversity and new attitudes about food consumption as it relates to self-identity and well-being, have contributed to a much more segmented market. Food marketers must increasingly target specific consumer segments rather than employing mass marketing strategies. More retailers are looking to their suppliers to assist them in understanding and better serving different types of consumer segments. In response, many suppliers are becoming involved in new types of marketing services, including consumer research and category management. The latter is designed to help retailers improve net profitability for a category of products through efficient assortment, pricing, promotion and shelf-space management. For suppliers the aim is to focus on identifying and

servicing the evolving needs of specific accounts as a preferred supplier, rather than marketing more homogeneous products with fewer support services on a spot market basis. We discuss three important food-marketing trends:

- buyer consolidation, changing procurement patterns and implications for suppliers
- demand, focusing on trends in fresh produce consumption
- international trade and competitiveness.

Buyer Consolidation, Changing Procurement Patterns and Implications for Suppliers

The U.S. retail industry is dominated by chain stores. In 2002, retail chains (defined as a food retailer operating 11 or more stores) accounted for 83 percent of supermarket industry sales vs. 58 percent in 1954 (The Food Institute, 2003). The remainder of sales is by independent stores, although the vast majority of these stores are affiliated to buying groups, either voluntary chains such as Supervalu or to a lesser extent retailer cooperatives such as Associated Wholesale Grocers. In 2002 there were 32,981 supermarkets including all format types.

Firms in the U.S. food-marketing sector often 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. Due to the difficulty of capturing sizable market share from rival firms, many U.S. food marketers have pursued share growth through mergers and acquisition of rivals. Mergers and acquisitions in the food sector occurred at a rapid pace in the 1980s, temporarily peaked in 1988 at 573 mergers, declined and then reached an all-time high of 813 in 1998, since declining to 415 in 2003 (The Food Institute, 2004a). Although the growth in merger activity has temporarily abated, cumulative activity in recent decades has likely had important implications for the structure of competition in the U.S. food sector.

Consolidation occurring at the food manufacturing level has progressed rapidly for some time. About 16,000 food and tobacco processing companies operate in the U.S., but in 1997 about 75 percent of sales were by the 100 largest of these firms. The largest sales growth, fueled mostly by mergers and acquisitions, has been recorded by the top 20 of these 100 firms, which in 1997 were estimated to account for about 50 percent of value added in food manufacturing (Rogers, 2000). 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, the most recent year for which data are available.

In contrast to the food manufacturing sector, over the decade 1987-97 retail concentration ratios were quite stable with the share of U.S. food sales accounted for by the top 4, 8 and 20 retailers at about 20, 30, and 40 percent, respectively. During this decade new players were emerging in the U.S. food system, including value-oriented retailers such as Wal-Mart with its fast expanding supercenter and club store formats, specialty food retailers like Trader Joe's, European entrants into U.S. food

retailing, and other mass and drug store merchandisers entering the food business. This phenomenon is called channel blurring and continues with the recent emergence of "Dollar Stores," on-line food shopping and the on-going competition from the foodservice sector for the consumer food dollar. This challenging marketplace motivated many conventional retailers to become larger in hopes of improving their competitiveness. From 1997-1999, in particular, mergers occurred between several already large retail chains, beginning to induce important and still unfolding changes in relationships between buyers and suppliers. By 2002 the estimated share of U.S. food sales accounted for by the top 4, 8 and 20 retailers had reached 31, 45, and 57 percent, respectively. This means that in 2002 suppliers faced a market where only 20 retail firms sold at least \$276 billion in food.

Despite the mergers, the United States has no truly national supermarket chains. In 2002 only eight chains had 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. However, the recent high merger activity has contributed to much larger chains than ever before, with five surpassing \$25 billion in sales in 2002, and four with stores in over half of the country. Still, many local and regional chains remain quite competitive by staying in close contact with their customers and implementing highly targeted marketing strategies. The regional, ethnic and demographic diversity of U.S. consumers leads some to predict that small to mid-size chains may have an important role to play for some time to come.

Within the retail channel the supercenter concept has emerged as a major industry force, which further concentrates buying power in the hands of a few very large new players. Supercenters are a type of mass merchandising format combining a full-line supermarket with a full-line discount department store and range up to 24,400 square meters in size (more typically 11,100), compared to 4,900 square meters for the average supermarket. Total 2002 grocery-equivalent sales of supercenters (excluding the non-grocery department sales) were estimated at \$45.5 to \$50.3 billion with total supercenter sales reaching \$116.7 billion (The Food Institute, 2003).

The largest entrant to this format is Wal-Mart, with an estimated \$29.3 billion in U.S. grocery-equivalent 2002 food sales, a 75 percent share of national supercenter sales and 1,333 supercenters as of mid-2003. Already the largest retailer in the world, operating in ten countries, Wal-Mart is opening over 200 new supercenters per year in the U.S. alone, and is fast becoming the dominant global player in grocery retailing with \$244.5 billion in 2002 global sales among all its store formats, including large discount stores (with limited grocery assortments) and warehouse club stores (Sam's Clubs). Wal-Mart has also entered the conventional grocery-retailing sector in the U.S. with 52 neighborhood markets in 2002, and growing.

Wal-Mart's immense buying power combined with its approach of driving non-value-adding costs out of the food system appears to have raised the competitive benchmark for conventional retailers. It emphasizes supply chain management via co-vendor managed automatic inventory replenishment procurement systems. Vendors have shared responsibility for growing the category and have real-time access to data on sales of their products via Wal-Mart stores. In exchange, they provide special services, packs and support, such as category management, tailored to the needs of the Wal-Mart account. Even for volatile fresh produce items Wal-Mart tends to operate

on a seasonal or annual contract basis with a small number of preferred suppliers per product or category. Other retailers are also developing closer linkages with preferred suppliers, gradually causing a shift away from the spot market, the traditional *modus operandi* in fresh produce procurement.

Another factor contributing to greater food retailer market power is the intensifying battle for their limited shelf-space by food marketing firms. During 2003, food-marketing firms introduced 11,574 new food products (The Food Institute, 2004b). Since the average supermarket carries about 30,000 product codes, 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. Until recently, fresh produce was exempt from slotting allowances, but these fees entered the produce department in the latter half of the 1990s with the introduction of branded fresh-cut produce. These items, like other consumer packaged goods commonly subject to slotting allowances, require dedicated shelf-space year-round. While bulk produce items are still not usually subject to slotting allowances, payment of other types of fees has increased marketing costs for growers and shippers (Calvin et al., 2001).

Increased retail buying power is influencing supplier strategies and inducing marketing alliances and joint ventures at the shipper level. Shippers have increasingly sought to come closer to matching the scale of the fewer, larger buyers. Marketing alliances between shippers appear to be the mechanism of choice as they allow each party to maintain its own growing, packing and cooling operations. This seems important for fresh produce shippers, most of which are family-owned and not publicly traded even if their businesses are structured as corporations. The larger scale obtained from marketing alliances helps firms to make greater investments in marketing systems and services, since they can be spread over a higher sales volume. Each year more suppliers are offering category management services, broadening their product lines, and becoming year-round, either via domestic or international diversification of supply sources. This greater vertical coordination can enable both suppliers and retailers to plan more effectively and reduce transaction costs, thereby improving the horizontal competitiveness of each party.

Demand, Focusing on Trends in Fresh Produce Consumption

U.S. food demand trends reflect the preferences of an older, wealthier, more ethnically diverse and more educated population today than 20 years ago. The entrance of more women into the workforce, in conjunction with higher incomes, has led to an increased demand for convenience in food preparation and consumption. In general, lifestyle and demographic trends have stimulated demand for eating out as well as for more value-added, higher-quality, specialty and convenient food products sold in retail establishments. In response to decades of market share erosion to foodservice, food retailers increasingly seek to compete by providing ready-to-eat home meal replacement offerings. This implies greater retail recognition that their offerings have traditionally been “ingredients to prepare” while consumers have increasingly sought

“meals to eat.” Food suppliers are actively assisting retailers in launching these more convenient new products.

More and more, differentiated, specialty food products may also be organically grown, as both growers and marketers seek points of difference to compete in a saturated food marketing system. Organic foods are estimated to account for around 2 percent of U.S. retail food sales, about \$9-9.5 billion in 2001 (Greene and Kremen, 2003). As the nation’s largest producer of organically grown commodities California producers are major participants in the growth of this sector (see Chapter 10).

Fruits and vegetables have benefited from many demographic and lifestyle trends occurring over the last 25 years, a plus for California’s horticultural-reliant agriculture. For example, higher-income households on average consume more fresh produce than do lower-income households; in 2000 households earning more than \$70,000 per year on average spent \$496 dollars on fresh produce annually, compared to \$302 for households in the \$15,000 to \$29,999 range (The Food Institute, 2002). Hispanic households, the most rapidly growing segment of the population, consume more fresh produce than do non-Hispanic Whites or African Americans (\$456/household compared to \$336 and \$260, respectively). Hispanics currently represent around 13 percent of the population and are projected to reach 18 percent by 2020.

However, despite the forces favoring healthful diets, U.S. consumers have become more overweight, with two-thirds of adults estimated by USDA to be overweight in 2000, including one-third obese. According to ERS’s loss-adjusted annual per capita food supply series, average daily calorie consumption was 12 percent, or roughly 300 calories, above the 1985 level (Putnam et al., 2002).

As heightened attention has been brought to bear on obesity as a serious national health concern, in conjunction with mounting scientific evidence regarding the health benefits of fresh produce, more governmental effort is now focused on relaying positive messages to consumers about the potential health rewards of fruit and vegetable consumption. For example, there are new federal school lunch program initiatives featuring fruits and vegetables and a revamped USDA Food Guide Pyramid. The benefits of fruits and vegetables are being promoted by the Produce for Better Health Foundation (5 A Day program) in conjunction with numerous organizations such as the National Cancer Institute. Increasingly, consumer awareness of the benefits of eating fruits, vegetables and nuts is rising.

Per capita consumption of fruits and vegetables, in both fresh and processed form, increased 15 percent from 1976 to 2002, reaching 324 kg, as shown in Table 2. 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. Health claims benefited fresh fruits and vegetables proportionally more than processed ones, with 59 percent of total fruit and vegetable consumption in fresh form in 2002, compared to 49 percent in 1976. Fresh fruit and vegetable consumption totaled 145 kg in 2002, up 8 percent over 1989 and 29 percent relative to 1976. These gains are impressive in a developed country with a mature (slow growth) food market in the aggregate.

Vegetable consumption, in both fresh and processed form, grew much more rapidly from 1976-02 than did fruit consumption. Vegetable per capita consumption increased 20 percent to 195 kg, while per capita total fruit consumption grew by only 7

Table 2. U.S. Per Capita Fruit and Vegetable Consumption/Utilization (kilograms), 1976-02

Item	1976	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Growth 89-02	Avg. Growth per year 89-02	Growth 76-02	Avg. Growth per year 76-02
Fruit																						
Citrus																						
Fresh	12.95	10.99	10.86	11.53	10.70	9.69	8.63	11.00	11.70	11.22	10.81	11.15	12.03	12.06	9.20	10.62	11.00	10.83	1.2%	0.1%	-16.4%	-0.7%
Processed	46.46	43.22	38.58	34.06	36.57	34.85	36.04	31.49	38.13	36.50	37.01	42.81	42.21	44.17	41.99	42.72	40.91	39.63	8.4%	0.6%	-14.7%	-0.6%
Subtotal	59.41	54.21	49.44	45.59	47.27	44.54	44.67	42.49	49.83	47.72	47.83	53.96	54.25	56.23	51.19	53.34	51.92	50.46	6.7%	0.5%	-15.1%	-0.6%
Non-Citrus																						
Fresh	24.75	31.56	33.01	32.63	32.90	32.10	31.98	33.70	32.98	34.07	33.19	33.10	34.10	34.06	36.57	35.09	33.44	34.56	5.1%	0.4%	39.7%	1.3%
Processed	35.41	42.54	42.31	43.93	42.82	42.70	41.19	43.96	43.30	41.87	41.02	41.31	44.54	41.10	42.17	43.34	41.21	43.34	1.2%	0.1%	22.4%	0.8%
Subtotal	60.16	74.10	75.32	76.56	75.71	74.80	73.17	77.65	76.28	75.94	74.20	74.41	78.64	75.16	78.74	78.43	74.65	77.91	2.9%	0.2%	29.5%	1.0%
All Fruits																						
Fresh	37.70	42.55	43.88	44.16	43.60	41.79	40.61	44.69	44.68	45.29	44.00	44.25	46.13	46.11	45.78	45.71	44.45	45.39	4.1%	0.3%	20.4%	0.7%
Processed	81.87	85.76	80.88	77.99	79.39	77.55	77.23	75.45	81.44	78.37	78.03	84.12	86.76	85.27	84.16	86.06	82.12	82.97	4.5%	0.3%	1.3%	0.1%
Fruit Total	119.57	128.31	124.76	122.14	122.99	119.34	117.84	120.14	126.11	123.66	122.03	128.38	132.89	131.38	129.93	131.76	126.57	128.37	4.4%	0.3%	7.4%	0.3%
Vegetables																						
Vegetables * Excluding Potatoes																						
Fresh	52.03	60.18	63.30	64.66	68.12	66.20	64.17	67.49	69.46	72.70	70.53	73.77	76.02	74.64	77.41	80.75	80.07	79.01	16.0%	1.1%	51.9%	1.6%
Processed	54.11	54.17	54.13	52.95	56.22	60.24	61.41	60.09	60.68	60.15	59.95	59.08	58.42	58.56	57.93	57.53	54.06	55.24	-1.7%	-0.1%	2.1%	0.1%
Subtotal	106.14	114.35	117.44	117.61	124.34	126.45	125.58	127.58	130.14	132.85	130.48	132.85	134.45	133.21	135.34	138.28	134.13	134.24	8.0%	0.6%	26.5%	0.9%
Potatoes																						
Fresh	22.41	22.14	21.73	22.50	22.68	21.18	22.77	21.91	22.73	22.50	22.32	22.63	22.00	21.32	21.77	21.46	20.96	20.41	-10.0%	-0.8%	-8.9%	-0.4%
Processed	34.38	34.97	35.43	32.98	34.93	35.02	38.06	37.01	39.28	39.51	39.78	43.14	42.14	41.32	40.14	41.46	41.55	40.78	16.8%	1.2%	18.6%	0.7%
Subtotal	56.79	57.11	57.15	55.48	57.61	56.20	60.83	58.92	62.01	62.01	62.10	65.77	64.14	62.64	61.92	62.91	62.51	61.19	6.2%	0.5%	7.7%	0.3%
All Vegetables																						
Fresh	74.44	82.32	85.03	87.16	90.80	87.38	86.94	89.39	92.18	95.20	92.85	96.41	98.02	95.96	99.18	102.20	101.03	99.42	9.5%	0.7%	33.6%	1.1%
Processed	88.50	89.14	89.56	85.93	91.14	95.26	99.47	97.11	99.97	99.66	99.73	102.22	100.56	99.89	98.08	98.99	95.61	96.02	5.3%	0.4%	8.5%	0.3%
Vegetable Total	162.93	171.46	174.59	173.09	181.94	182.65	186.41	186.50	192.15	194.86	192.58	198.63	198.59	195.85	197.26	201.19	196.64	195.43	7.4%	0.6%	19.9%	0.7%
Fruits and Vegetables																						
Fresh	112.13	124.87	128.91	131.32	134.40	129.17	127.56	134.09	136.86	140.49	136.85	140.66	144.15	142.08	144.96	147.91	145.47	144.81	7.7%	0.6%	29.1%	1.0%
Processed	170.37	174.91	170.44	163.91	170.53	172.81	176.70	172.56	181.40	178.02	177.76	186.34	187.32	185.16	182.23	185.04	177.74	178.99	5.0%	0.4%	5.1%	0.2%
Grand Total	282.50	299.78	299.35	295.23	304.93	301.98	304.25	306.65	318.26	318.52	314.61	327.00	331.47	327.24	327.19	332.95	323.21	323.80	6.2%	0.5%	14.6%	0.5%

*USDA reports only aggregate sweet potato and mushroom consumption. Fresh and processed sweet potato and mushroom utilization estimated based on normal market allocations. Only 75% of sweet potato per capita utilization is included since the remainder is for non-human uses. Dry beans and lentils are also excluded.

Sources: Compiled by Dr. Roberta Cook, UC Davis from data from the Economic Research Service, USDA, Fruit and Tree Nuts Situation and Outlook Yearbook, October 2003 and Vegetables and Specialties Situation and Outlook Yearbook, July 2003.

percent to 128 kg. Key forces driving the increase in vegetable consumption include the emergence of fresh-cut salads and vegetables (such as bagged/package salads, baby washed carrots or broccoli and cauliflower florets), growth in the fast food industry with its usage of processed tomatoes, primarily for pizza, and processed potatoes, primarily for French fries.

The growth in fresh-cut produce is rapidly reshaping the produce sector. In 2002 fresh-cut produce sales were estimated to have reached \$12.6 billion (approximately 16 percent of total fresh produce sales), with about 60 percent sold via foodservice channels and the remainder through retail. However, to date primarily vegetables have benefited from this trend. In 2002 the value of fresh-cut fruit sold through supermarket channels was still quite small, \$238 million according to IRI, with total sales including through foodservice channels estimated by industry sources at over \$600 million. Recently fresh-cut fruit new-product introductions have risen and fresh-cut fruit postharvest technology is improving. Growing consumer demand for convenient, healthy snack foods and desserts lead some to predict that fresh-cut fruit may be poised for the same type of rapid growth experienced by fresh-cut vegetables over the last decade. California fruit shippers should benefit from this growth, both as producers and as sourcing agents.

The diversity of fresh produce offerings in U.S. supermarkets has expanded at an astounding rate. The number of items carried by the average supermarket produce department increased from 133 items in 1981 to 350 items in 2001. 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, designed to respond to the growing consumer demand for convenience. The abundant supply of increasingly diverse and convenient fruit and vegetable offerings should support continued growth in per capita consumption.

International Trade and Competitiveness

Exports have come to represent an increasingly important growth market for U.S. food marketers, in light of a mature domestic market. The importance of the export market varies widely by commodity and state, with a weighted average export share of 18 percent for the top 50 products produced in California in 2002 (Bervejillo and Sumner, 2003). Among horticultural crops export shares are higher for nuts than for fruit and vegetables, due to the lower perishability of nuts (facilitating trade) and California's important role in world production. Over 60 percent of California's almond crop is exported annually compared with 10 percent of lettuce and around 12 percent of strawberries. With certain important exceptions (including avocados, asparagus, table grapes and kiwifruit) California is a net exporter of most of the crops it produces, even those facing import competition. Most fresh produce imports tend to enter during the off- or early-season when domestic production, including in California, is low.

Trade liberalization negotiated under the Uruguay Round of the GATT and implemented under the World Trade Organization (WTO), as well as through regional trade agreements such as NAFTA, has expanded market access and strengthened mechanisms for combating non-tariff trade barriers such as scientifically

unfounded phytosanitary restrictions. Advances in postharvest technology, including the development of container-level modified atmosphere technologies, have also facilitated exporting perishables to distant markets. Total U.S. horticultural exports, including fresh and processed fruits, vegetables, and nuts, were \$11.3 billion in 2002, up from \$2.7 billion in 1985. California firms captured a sizable share of this export growth, exporting \$4.9 billion worth of horticultural products in 2002 according to USDA. However, trade liberalization has also led to greater import demand, with U.S. horticultural imports reaching \$18.7 billion in 2002. In recent years imports have grown more rapidly than exports but imports are still a small share of total U.S. horticultural consumption, 18 percent in 2001.

As markets become more open, they become globalized and many California commodity sectors are increasingly impacted by changes occurring in international markets. Expanding export demand, in particular in Asia, led by Japan, in the first half of the 1990s caused producers to increase plantings of perennial fruit crops, for example. By the time this area was coming into production as of around 1995 and beyond, export markets had peaked and declined due to Japan's economic recession and the resulting Asian flu. A growing export market in Mexico also temporarily peaked in 1995 due to an economic crisis there. Simultaneously, greater world production of many commodities also grown in California has increased competition for California firms in third country markets.

The rapid emergence of China as a major producer and growing exporter of fruits and vegetables is already having a competitive impact on demand for California products in Asian markets and will continue to do so as China improves its infrastructure and export quality. China is the world's largest producer of vegetables, apples and pears. Although most of the production remains in China to serve internal demand generated by its 1.3 billion inhabitants, even a small export share can be significant relative to the international volumes normally traded in any given commodity. On the other hand, income growth should expand import demand as Chinese consumers demand a greater array of higher quality food products, including fruits and vegetables. Import demand is being further stimulated by the explosion in supermarkets which require year-round availability of produce.

Indeed, a recent trend throughout the developing world away from wet markets and toward supermarkets bodes well for international fresh produce trade, and hence, for California producers. It is estimated that the 30 largest retail grocery chains now account for at least 10 percent of world food sales. Many of these chains have stores located on several continents and their global procurement practices and cold chain management investments and exigencies mean that these modern produce departments must be kept full year-round. Since no country produces all of the fruits and vegetables it needs year-round, international trade will undoubtedly expand.

As some California commodity sectors adjust to new market realities, structural adjustments may occur. However, in general, California agriculture remains very competitive with imports still a small share of supply. California growers and shippers substitute capital and technology for labor, enabling them to remain competitive even in the most labor-intensive horticultural crops. The primary crops for which sizable production has moved off-shore, in this case to neighboring Mexico, are those requiring bunching at harvest, such as green onions, asparagus and radishes. Still, over

the next decade it is likely that many California commodity sectors will face greater import competition and more competition in export markets. While competition in third country markets will be strong, total international trade should expand as trade liberalization continues under the WTO.

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 marketing systems for fresh produce and processed fruits and vegetables.

Marketing Fresh Produce

The principal marketing channels in the U.S. fresh fruit and vegetable marketing system are shown in Figure 1. Final value in 2002 is estimated to be at least \$81 billion with roughly equal amounts distributed through foodservice and retail channels and around 2 percent comprised of direct farm to consumer sales. In California, there are about 400 Certified Public Markets and many fresh produce growers participate in these markets for at least a part of their sales.

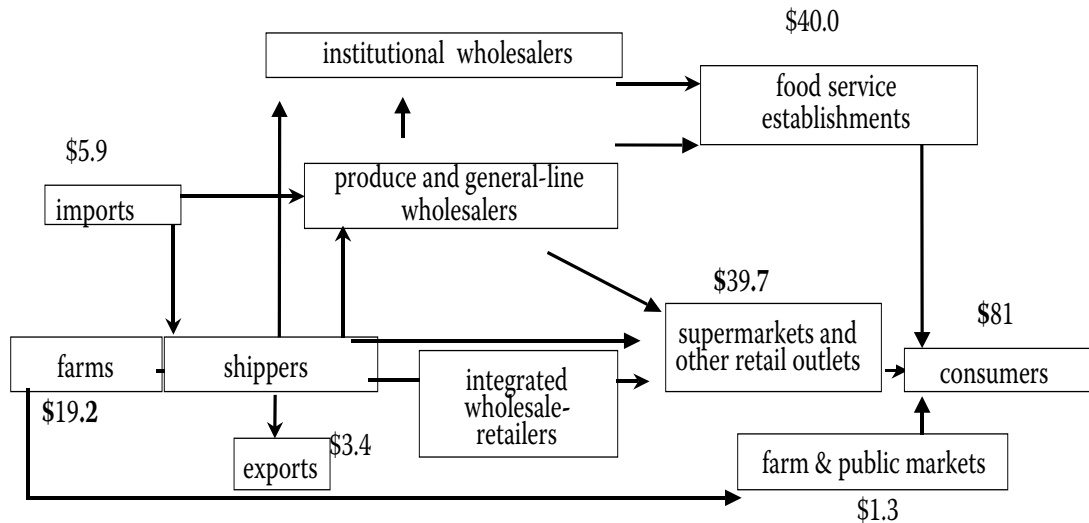
Produce sold in retail or foodservice outlets may be procured directly from shippers or from wholesalers operating in terminal markets or in independent warehouses in local communities. Terminal markets have steadily declined in importance since the 1950s. Today there are major terminal markets serving only 15 cities, and these markets primarily handle the residual fresh market domestic production that cannot be marketed directly to retail or foodservice buyers. The largest terminal markets tend to be located near port areas since many imports are still handled by importers/intermediaries physically receiving the product upon arrival to the U.S. 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, which operate large-volume centralized buying operations, and enhance efficiency by purchasing directly from the source, bypassing the wholesaler and thereby avoiding intermediary margins and handling costs. Also, the retailer- or foodservice-buyers are able to communicate directly with suppliers concerning important issues such as desired product quality, safety/traceability, packaging characteristics and shipment timing, improving their management of the supply chain. For fresh products, direct production-source-to-buyer shipments have the additional advantage of not breaking the cold chain, better preserving product quality.

Brokers may be used by either buyers or sellers at any level of the distribution system. Most brokers do not take title to or physically handle the goods, and, rather, assist in making the sale and possibly arrange transportation and other logistics. Their role had grown in importance since World War II. However, retail consolidation has been reducing the role of brokers as buyers seek closer relationships with preferred

suppliers with strong category management skills. Today successful brokers tend to be those with global sourcing capabilities and account-specific service-orientations, including category management, designed to meet specialized buyer needs.

Figure 1. U.S. Fresh Fruit & Vegetable Value Chain, 2002 Estimated Billions of Dollars



Source: Estimated by Dr. Roberta Cook, UC Davis.

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. It is estimated that there are about 16,500 fruit, vegetable and nut growers in California producing about half of the total volume of these crops grown in the U.S. However, most fresh produce growers don't market their own produce, marketing instead via shippers acting as agents. Most shippers are large growers that have integrated their operations downstream into the marketing of their own production and the production of other growers—hence their designation as forward-integrated “grower-shippers.” These grower-shippers generally control harvesting, packing, and cooling, and arrange for domestic and export sales, transportation, and promotion of production. They are the dominant type of marketer of California fresh produce.

According to the Red Book Credit Services there are around 5,000 fresh produce shippers in the U.S. as a whole, with about 900 located in California. These shippers are selling to an estimated total of 1,079 principal buyers, including 267 retail chains, 188 produce wholesalers, with the difference accounted for by independent retailers and other types of buyers. The bulk of retail chain purchases are being made by 161 retail chains each selling at least \$64 million in 2001 (Progressive Grocer, 2002).

Consolidation at the buying end of the food marketing system has driven consolidation at the production level. Today's large, integrated wholesale-retailer and

foodservice buyers demand more services from their suppliers, tailored to their specific needs, including: (1) category management, (2) ripening and other special handling and packaging, including private labels, and (3) year-round availability of a wide line of consistent-quality fruits and vegetables. Grower-shippers have responded with improved communication and information management programs and by becoming multiregional and multicommodity in focus. The ability to provide account-specific products and services represents a major change from the days of uniform product offerings. While these services can be costly, many shippers are finding that they enable them to become preferred suppliers to large buyers, potentially stabilizing demand and somewhat lowering market risk.

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 were relatively common in the foodservice sector, they are new to retail. The entrance of supercenters 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 buyers' contracting requisites.

RETAILER-BUYER POWER IN THE PROCUREMENT OF FRESH PRODUCE

The evolution of the California produce industry has enhanced its efficiency by cutting marketing costs and 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, Zhang, and Chalfant (2003) and Richards and Patterson (2003) analyzed this issue recently for several fresh fruits and vegetables. Although the results differed among the commodities studied, in general the authors concluded that retailers were often able to reduce prices to growers below competitive levels as a consequence of their market power.

In addition to apparently exerting buyer market power for at least some commodities, the manner in which retailers set prices to consumers for those

¹ Year-around sourcing by California marketers is controversial because some growers believe it benefits competing producers. 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.

commodities can also have an important effect on producer welfare. To the extent retailers exercise oligopoly power to consumers by marking up the price of a commodity above full marginal costs, they reduce sales of the commodity, an outcome detrimental to producers. Further, evidence from scanner data shows that retailers set prices for produce commodities with little regard for the underlying trends in the farm-commodity market. For example, among 20 retail chains studied by Sexton, Zhang, and Chalfant, nine maintained the same weekly price for iceberg lettuce over the two-year period from 1999-2000, despite wide fluctuations in the FOB price received by producers.

Table 3. Farm and Retail Price Correlations for Iceberg Lettuce Los Angeles Retail Chains 1999-2000

	FOB	LA 1 Private Label	LA 1 Head	LA 2 Fresh Express	LA 2 Dole	LA 2 Ready Pac	LA 2 Head	LA 3 Dole	LA 3 Ready Pac	LA 3 Head	LA 4 Fresh Express	LA 4 Ready Pac	LA 4 Head
FOB	1.000												
LA 1 Private Label	0.110	1.000											
LA 1 Iceberg	0.688	0.073	1.000										
LA 2 Fresh Express	-0.133	0.124	-0.035	1.000									
LA 2 Dole	-0.169	0.015	-0.279	0.389	1.000								
LA 2 Ready Pac	0.103	0.021	0.139	-0.083	-0.063	1.000							
LA 2 Head	0.446	0.174	0.613	0.005	-0.238	0.125	1.000						
LA 3 Dole	-0.237	0.015	-0.405	0.179	0.385	-0.330	-0.146	1.000					
LA 3 Ready Pac	0.011	0.133	-0.007	0.018	0.216	-0.349	0.072	0.137	1.000				
LA 3 Head	0.534	0.029	0.775	-0.047	-0.465	0.122	0.717	-0.332	-0.078	1.000			
LA 4 Fresh Express	0.033	0.009	0.027	-0.078	-0.002	0.065	-0.008	-0.155	-0.027	0.014	1.000		
LA 4 Ready Pac	-0.201	-0.032	-0.280	0.221	0.214	-0.014	-0.178	0.058	0.032	-0.272	0.028	1.000	
LA 4 Head	0.456	0.063	0.660	0.063	-0.268	-0.032	0.659	-0.192	0.046	0.733	0.019	-0.232	1.000

Table 3 illustrates the wide variability among four Los Angeles retail chains in setting prices for iceberg head lettuce and iceberg-based bagged salads. The table contains the correlations in the weekly retail prices charged by the various chains for iceberg head lettuce and the various brands of iceberg-based bagged salads (Dole, Fresh Express, Ready Pac, and private label). Correlation with the FOB (farm gate) price for iceberg lettuce is also provided. Correlation coefficients fall in the range of -1.0 (perfect negative correlation) to 1.0 (perfect positive correlation), with values near zero indicating very little correlation between the movements over time for the particular price pair. Each chain's head lettuce price is positively correlated with the FOB price (column 1), but the correlations are much lower than if the retailers were merely adding a cost-based mark up to the FOB price. Correlation between retail and farm pricing essentially disappears for the bagged salads, however. In all cases, the correlations are nearly zero, and in some cases are negative, meaning the retail price moved on average in the opposite direction of the farm price.

To understand retailer pricing for fresh produce commodities, one needs to appreciate that the modern retailer sets prices for 30,000 or more product codes.

Pricing decisions are not made with an eye towards profitability of any single product, but, rather, are oriented toward the profitability of the entire store. The produce section is traditionally a source of high profits for retailers, and, because of the importance consumers attach to produce, retailers can use their produce aisle as a way to differentiate themselves and attract consumers to the store. Accordingly, stores' pricing policies for produce vary widely. Some stores prefer to offer consumers stable prices week in and week out (referred to as every-day-low pricing). Other stores regularly feature produce as a sale item, so prices vary dramatically from week to week (often referred to as hi-lo pricing). Neither pricing strategy is likely to be beneficial to producers. Sexton, Zhang, and Chalfant demonstrated that retailers who maintain stable prices over time despite fluctuations in sales and price at the farm level cause lower producer income on average because price must fluctuate even more in those sectors, such as foodservice, which do not artificially stabilize price, in order for the market to clear.

MARKETING PROCESSED FOODS

Marketing arrangements are different for processed foods, including fruits and vegetables, nuts, grains, meats, and dairy. Growers in these industries sell to processing firms rather than to food retailers. Like the food-retailing sector, the food-processing sector has also become increasingly concentrated, and effects of high processor concentration 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. 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), Diamond (walnuts), Lindsay (olives), and Sunkist (citrus). Processors who lack dominant brands sell primarily to foodservice 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. 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. 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. The efficient operation of processing facilities and the effective processing of the harvest require that a processor's deliveries be spread uniformly over an extended harvest period of 20 or more weeks. Similarly, processors specialize in producing different types of tomato products. Some plants produce only bulk tomato paste, which is then remanufactured at other locations into various processed tomato products, while others produce whole tomato products. The preferred 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. Price terms in these contracts are set with the intervention of a producer bargaining cooperative.

The Role of Cooperatives in Marketing in California

Cooperatives are firms that are owned by the producers who patronize them, although many cooperatives also do business with nonmembers. California is home to many large and important food-marketing cooperatives. Producers who are members of a marketing cooperative essentially have vertically integrated their operation downstream into the processing and marketing of their production. A number of incentives can account for producer cooperative integration, including avoidance of processor market power, margin reduction, and risk reduction (Sexton and Iskow, 1988).

Cooperatives are the leading marketing firm in several California agricultural industries including almonds (Blue Diamond), walnuts (Diamond), prunes (Sunsweet), citrus (Sunkist) and raisins (Sunmaid). However, the recent years have represented difficult times for some California marketing cooperatives. Tri Valley Growers (TVG), a fruit and tomato processing cooperative, formerly the second largest cooperative in California, declared bankruptcy in the summer of 2000. Around

this same time the Rice Growers Association, a large and long-lived rice milling operation closed its doors, as did Blue Anchor, a diversified fresh fruit marketer.

Reverberations from the failure of these prominent California cooperatives were felt nationally and caused some to wonder whether the model of cooperative marketing was well suited for 21st century agriculture. Indeed cooperatives do face some important challenges competing in the market environment we have described here. As noted, retailers prefer suppliers who can both provide products across an entire category and provide them year around. Cooperatives are traditionally organized around a single or limited number of commodities and member production is likely to be seasonal. Cooperatives can attempt to surmount these difficulties by undertaking marketing joint ventures with, for example, other cooperatives, and sourcing product from nonmembers, including internationally. However, cooperatives may face impediments relative to investor-owned competitors in pursuing such strategies. For example, various laws affecting cooperatives specify that at least 50 percent of business volume must be conducted with members. Joint ventures with firms that are not cooperatives are not afforded legal protection under the Capper-Volstead Act.² Doing business with nonmembers may also adversely affect a cooperative's membership, if it is perceived that most of the benefits of the cooperative can be obtained without incurring the financial commitment associated with membership. This issue was important for TVG when it appeared that tomato producers selling to TVG under nonmember contracts received a better deal than member growers.

Cooperatives may also face challenges in procuring the consistent high-quality production that the market place now demands. Cooperatives usually employ some form of pooling mechanism to determine payments to members. In essence, revenues from product sales and costs of processing and marketing flow into one or more "pools." A producer's payment is then determined by his/her share of the total production marketed through each pool. The problem with some pools is that high-quality and low-quality products are commingled and producers receive a payment based upon the average quality of the pool. Such an arrangement represents a classic adverse selection problem, and its consequence is to drive producers of high-quality products out of a cooperative to the cooperative's ultimate detriment. Cooperatives can obviate this pooling problem through operating multiple pools and/or by designing a system of premiums and discounts based upon quality, but the key point is that investor-owned competitors face no similar hurdles in paying directly for the qualities of products they desire.

Offsetting these limitations on cooperative marketing in the 21st Century at least to an extent is the recognition that the marketing clout producers can attain from joint action may be as important now as ever. As we have documented in this chapter, the food retailing and processing sectors have consolidated. Although producers, too, have generally gotten larger in absolute scale, the typical producer's power in the market place pales in comparison to that of the firms with whom he/she conducts business.

Also worthy of mention is that some cooperatives have evolved the structure of their organization to "keep up with the times." Such cooperatives are usually known as

² Because the horizontal coordination among producers that takes place within an agricultural cooperative could be construed as a violation of the U.S. antitrust laws, the Capper-Volstead Act was passed by Congress in 1922 to provide cooperatives with partial immunity from the antitrust laws.

“new generation cooperatives” or NGCs. Typical features of an NGC include grower contracts that include both delivery rights and delivery obligations. Delivery rights, however, are transferable and can function somewhat analogously to capital stock, i.e., if a cooperative is successful, its delivery rights will increase in value. These rules are intended to give the cooperative assurance of a stable supply but also to regulate the amount of product it must process and sell in line with market conditions. To date, the NGC structure is most common among cooperatives in the midwestern U.S. and has made few inroads in California. Interestingly, TVG underwent a re-organization to an NGC structure in 1995-96. Although it is doubtful that this re-organization had much impact on TVG’s ultimate demise, its failure may have made Californians skeptical of the NGC structure.

Two types of cooperative organizations are relatively unique to California. They are information-sharing cooperatives and bargaining cooperatives. Information-sharing cooperatives 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 due to the Capper-Volstead Act, which 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 (1992) 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 transaction 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

³ Sexton and Sexton (1994) discuss the experience with an information-sharing cooperative in the California iceberg lettuce industry.

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/she is a member of the cooperative. For example, Blue Diamond was a leader in opening new 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

In addition to undertaking joint action in marketing through cooperatives, U.S. legislation at both the national and state levels allows producers and marketers of many agricultural products to act collectively through a legal structure to control various aspects of the marketing of their products. Enabling legislation for federal marketing orders is provided by the Agricultural Marketing Agreement Act of 1937 (AMAA), while state orders and agreements are governed by the California Marketing Act of 1937, with amendments. California also has more than 20 individual laws for the formation of commodity commissions and councils. There are differences between the use of federal and state marketing programs. 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 on research programs and promotion.

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. The popularity of government-mandated commodity programs is clearly reflected by their continued use by a large number of commodity producers. California had 17 federal marketing orders and 48 state marketing programs effective in 1993 (Lee et al., 1996). Those programs covered commodities that accounted for 54 percent of California's 1990 agricultural output, based on value. There are 12 federal orders and 51 California commodity marketing programs effective in 2003. As shown in Table 4, these commodities accounted for 55 percent of California's total agricultural output in 2002. The largest proportional drop in marketing program coverage between 1990 and 2002 was for vegetables (from 55 to 43 percent).

Among the 17 federal marketing orders operating in California in 1993, four were eliminated and coverage of California production was dropped by two. The terminated federal programs included the marketing order for Tokay grapes and the long-standing marketing orders for California-Arizona Navel oranges, Valencia oranges, and lemons. The marketing orders for Northwest winter pears and spearmint oil, while still in effect, no longer apply to California production. There is one new federal order, the Hass Avocado Promotion, Research and Information Order, and another has been proposed for pistachios. Thus, there was a net loss of 5 federal marketing orders for California commodities between 1993 and 2003.

There have also been changes in the coverage of California marketing programs. The marketing orders for apricots and fresh tomatoes have been dropped and there is a new state order for garlic and onion dehydrators and a "Buy California" marketing agreement. The California Egg Commission is no longer operating but there are new California Commissions for dates, rice, tomatoes, and sheep. The total number of California marketing programs went from 48 in 1993 to 51 in 2003 for a net gain of three.

Table 4. Value Shares of California Commodities Under Mandated Marketing Programs, 2002

Category ^a	California Total	Commodities Under Marketing Programs	Ratio of Value Under Programs to Total
<i>--value of production (\$1,000)--^b</i>			
Field Crops	3,827,859	795,094	0.21
Fruits and Nuts	9,705,335	7,139,711	0.74
Vegetables	6,701,580	2,888,087	0.43
Animal Products	7,090,660	5,586,287	0.79
Nursery	3,310,099	365,945	0.11
Total	30,635,533	16,775,124	0.55

a) Fishery and forestry products are excluded.

b) Commodities listed are based on 2003 marketing programs but value of production data are for 2002, the most recent year that consistent value data were available for all of the categories.

Source: California Agricultural Statistics Service. Summary of County Agricultural Commissioners' Reports, 2002. Sacramento, California. California Department of Food and Agriculture, List of Marketing Programs <http://www.cdffa.ca.gov/mkt/mkt/mktbrds.html>

Government-mandated marketing programs operate under legislation that empowers growers to act collectively to improve their profitability through orderly marketing. The programs are initiated based upon requests by producers to solve particular marketing problems. The Secretary of Agriculture (or her state counterpart) holds public hearings on provisions to be included; the finalized orders must be approved on a producer vote by a super majority, and are then binding on all

producers in the designated geographic area covered by the order.⁴ Marketing order activities are financed by the affected producers and/or handlers, 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 of product between markets (e.g., foreign and domestic or fresh and processed), reserve pools, and market flow regulations. 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.

Each marketing order or commission program specifies a maximum assessment rate, usually in terms of dollars per unit as a percentage of total value of sales. The Secretary of Agriculture (or California counterpart) approves assessment rates for each fiscal year based on the budget 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 in turn deduct such assessment payments from any money owed to their producers. For example, the California Avocado Commission collected an assessment of 4.25 percent of gross revenues paid to producers during the year ended October 31, 2002. Dried plum growers paid an assessment of \$30 per ton during the 2001-02 marketing year, while the assessment rate recommended by the Cherry Marketing Board may not exceed 50 cents per package, with one-half of the assessment paid by the packer and one-half paid by the grower.

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 obtain. 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

⁴If the provisions of a proposed order have a direct impact on processor/handlers, they are also subject to an approval vote by the affected handlers.

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.

Volume 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 price 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 include quantity control provisions (Table 5), although the use of quantity controls has decreased over time as a result of problems noted above. The federal marketing orders for citrus, with their prorated provisions, were terminated at the end of the 1993-94 crop year after more than 50 years of almost continuous use. The citrus prorates set the amount of lemons and oranges that could be shipped to the domestic fresh market on a weekly basis. Fruit in excess of a handler's fresh market prorated amount could be exported or processed without limits. The demand facing packers in the fresh market is very inelastic relative to the demands in the processing and export market. Thus, price discrimination against the fresh market, by restricting the flow of product to it, is both possible and profitable.

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, prorated production resulted in increased acreage and production of citrus, as well as increased exports and processed products (Thor and Jesse, 1981; Shepard, 1986).

Opponents of the citrus volume regulations, who had been sued in 1983 by the United States for violations of prorated production, discovered evidence of over shipments by a large number of competing orange and lemon packing houses. Because of allegations of limitations violations of shipments under the order, 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.

Table 5. Authorized Activities for California Commodity Marketing Programs^a

Commodity	Grade & Size	Quantity Controls	Advertising & Promotion	Research Effective	Year
<i>Federal Marketing Orders</i>					
Almonds	A	A	I	A	1950
Dates	A	I	A	A	1955
Grapes-California Desert	A	I		A	1980
Kiwifruit	A			I	1984
Hass Avocado			A	A	2002
Nectarines	A		A	A	1958
Olives	A		A	A	1965
Peaches-Fresh	A		A	A	1939
Potatoes, Oregon-California	A			I	1942
Prunes-Dried	A	I		I	1949
Raisins	A	A	A	A	1949
Walnuts	A	I		A	1948
<i>State Marketing Orders</i>					
Alfalfa Seed Production				A	1973
Artichoke Promotion			A	I	1960
Dry Bean	A		A	A	1979
Buy California Marketing Agreement			A	A	2001
Cantaloupe	A		A	A	1988
Carrot (fresh)			A	A	1992
Celery				A	1976
Cherry			A	A	1993
Citrus Research				A	1968
Figs (Dried)	A	A	A	A	1944
Garlic & Onion Dehydrator		A			1999
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
Dried Plum			A	A	1947
Potato Research				A	1974
Rice Handlers			A		1984
Rice Research				A	1969
Strawberry (Processing)	A		I	A	1960
Tomato (Processing)	A				1986
Wild Rice		I	A	A	1968
<i>State Commodity Commissions</i>					
Apple Commission	I		A	A	1994
Asparagus Commission			A	A	1990
Avocado Commission	I		A	A	1978
Date Commission			A		1996
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
Rice Commission			A		1999
Sheep Commission			A	A	1999
Strawberry Com. (Fresh)			A	A	1955
Tomato Commission			A	A	1996
Walnut Commission			A		1986
Wheat Commission			A	A	1983
Lake County Winegrape Com.			A	A	1992
Lodi-Woodbridge Winegrape Com.			A	A	1991
<i>Councils</i>					
Beef Council			A	A	1957
Dairy Council			A	A	1945
Salmon Council			A	A	1991
Seafood Council			A	A	1991

a) A designates active use; I designates inactive use.

Source: Lee, Alson, Carman and Sutton, pp. 20-23. CA Department of Food and Agriculture site: <http://cdfa.ca.gov/mkt/mkt/mktbrds.html>

Raisins provide another good illustration of volume controls in California. 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. 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.

Finally, the experience of the California almond industry illustrates how changing market conditions can alter the effectiveness of volume controls. 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 to the Secretary of Agriculture 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 (over two thirds of the crop is now exported annually), 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 indicate that U.S. and Spanish producers each increase production when returns appear favorable (Murua, Carman and Alston, 1993). 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. As a consequence of these various considerations the almond industry has not implemented volume controls for the past several years.

Quality Controls

All existing federal marketing orders for California fruits, vegetables, and nuts include provisions for grades and minimum quality standards. However, only ten 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 an adverse selection problem. 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 applies 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. 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, 1985).

Advertising and Promotion

California federal and state marketing orders, commodity commissions and councils budgeted over \$140 million for demand expansion activities during the 2002/03 or 2003/04 fiscal years—mainly generic advertising and promotion. Promotion has accounted for about three-fourths of commodity group total expenditures. For fruits, nuts and vegetables, the largest 2003 promotional budgets were for almonds (\$13.9 million), table grapes (\$12.1 million), avocados (\$9.8 million), walnuts (\$7.1 million), pistachios (\$6.1 million), dried plums (\$5.2 million), and strawberries (\$4.8 million). Groups allocating over 75 percent of their budgets to promotion for the period 1970 through 1994 included walnuts, raisins, plums, table grapes, dried plums, and avocados (Lee et al., 1996).

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.”⁵ Research completed and underway 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. (1997) 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 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. Studies of the estimated returns from advertising and promotion programs for other California commodities include avocados (Carman and Craft, 1998), prunes (Alston et al., 1998), almonds (Crespi and Sexton, 2001), eggs (Schmit, Reberte and Kaiser, 1997), raisins (Kaiser and Liu, 2001), and walnuts (Kaiser, 2002). Each of these studies found that advertising and promotion increased the demand for the product and that program returns exceeded costs by a significant margin.

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 15 commodity boards, commissions, and other groups promoting only California fruits, nuts, and vegetables totaled \$18.67 million in fiscal year 2002. These funds accounted for 18.7 percent of \$100 million awarded to all organizations. Organizations that promote products produced in other states as well as California (e.g., Cotton Council, U.S. Apple Association, U.S. Dairy Export Council, U.S. Rice Producers) also received large allocations. California organizations receiving 2002 awards greater than \$1 million included Blue Diamond Growers/Almond Board of California, California Prune Board, California Table Grape Commission, California Walnut Commission, Raisin Administrative Committee, Sunkist Growers, Inc., and Wine Institute.

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

⁵ 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.

\$8.5 million (Lee et al., 1996). This increased to 38 California programs with a total 2002/03 or 2003/04 budget of \$20.2 million. The largest research budgets were for citrus (\$2.8 million), rice (\$2.2 million), market milk (\$1.9 million), almonds (\$1.85 million), avocados (\$1.6 million), fresh strawberries (\$1.6 million), and walnuts (\$1.0 million). Overall, research expenditures increased from about 7.5 percent of total 1992 commodity group expenditures to just over 10 percent of 2003 expenditures. In terms of the total farm level value of production, research budgets averaged just over 0.1 percent of the 2001 value of covered commodities.

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, 1995). Consider, for example, the case of 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 record high average yields of 30.75 tons per acre in 1991, the highest in the world, are due largely to 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 (1995, 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 (1995) provide an excellent summary of this work. Depending upon the relative price elasticities of demand and supply, consumers may receive half or more of the short-run benefits from production research. Huang and Sexton (1996) 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 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 nowadays use them infrequently. Informed observers agree that it will be very difficult to gain approval for a new marketing order with strong quantity controls.

Programs compelling producer and handler support of commodity advertising programs have faced withering legal challenges in recent years based upon the argument that they represent an undue restriction on commercial free speech under the First Amendment to the U.S. Constitution. Two recent rulings on the issue by the U.S. Supreme Court have done little to clarify matters.⁶ Additional litigation is working its way through the court system. If the courts find ultimately that producers and handlers cannot be compelled to support an industry's advertising program, it will likely 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.

CONCLUSIONS

Marketing-related expenditures 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.

⁶ Recently, the U.S. Supreme Court upheld a lower court's ruling in *U.S. v. United Foods* [U.S. 00-276 (2001)] that marketing orders created primarily for generic promotion and advertising violated the First Amendment of the U.S. Constitution. However, marketing orders whose regulations extend beyond simple promotion activities, appear to be legal (*Glickman v. Wileman et al.*, [521 U.S. 457 (1997)]), because, in the Supreme Court's view, generic promotion in those industries arises as part of a broad pattern of regulation. As Crespi and Sexton (2001) have argued, this distinction drawn by the Court, based upon the degree of extant regulation in an industry, is probably a prescription for further law suits, as litigants argue whether the circumstances of their industry better fits the mushroom or the tree-fruit decision.

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 this chapter 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 5

International Trade and the Road Ahead for California Agriculture

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This chapter surveys California's agricultural trade environment and prospects. We pay particular attention to the impacts of the 2002 United States (US) Farm Bill, the Farm Security and Rural Investment Act (FSRIA) on California's trade in agricultural products and the prospects for California agriculture from further agricultural trade liberalization. We argue that foreign markets are extremely important to California agriculture, and that increased trade liberalization will be beneficial to most California producers since they competitively supply specialty products and continue to face barriers to trade in important markets. We also discuss the benefits of subsidies provided to agriculture in California and agricultural exports in particular. While a quantitative comparison of this support versus the potential benefits of increased trade liberalization is beyond the scope of this chapter, there is suggestive evidence that California agriculture would be better off with reduced subsidies to U.S. agriculture and concomitant increased access to markets abroad. Thus, to the extent that the political fallout from the Farm Bill results in less ambitious World Trade Organization (WTO) negotiations, the 2002 Farm Bill is costly for the California agricultural sector.

The remainder of this chapter is organized as follows: First, the chapter describes the main characteristics of California's agricultural trade. Second, the international trading environment facing California agriculture is discussed. Third, we review and discuss elements of the Farm Bill that have important implications for California's agricultural trade. These include the export programs, the highly controversial country-of-origin-labeling (COOL) guidelines, and environmental programs. Fourth, we discuss how the 2002 Farm Bill affects the U.S.'s ability to meet its current WTO obligations and its potential effect on current liberalization talks from which California has much to gain.

CALIFORNIA'S AGRICULTURAL TRADE

California agricultural producers rely on foreign markets for a significant portion of their revenues and export relatively more than producers in other states do. The value of California agricultural exports totaled about \$6.5 billion in 2002, or about 20 percent of the value of agricultural commodities produced in California.¹ While it is not surprising that California's export earnings exceed those of every other state since its farm cash receipts are the highest in the country, exports are relatively more important to California than to other states. While California accounts for 12 percent of national farm cash receipts (USDA/NASS 1997), it accounts for an estimated 15 percent of total U.S. agricultural export revenue. To put these figures in an international context, the state of California exports more agricultural products than some leading agricultural countries do, including such countries as Chile and China. The annual value of Mexico's agricultural exports is only slightly larger than California's estimated value (FAO 2002).

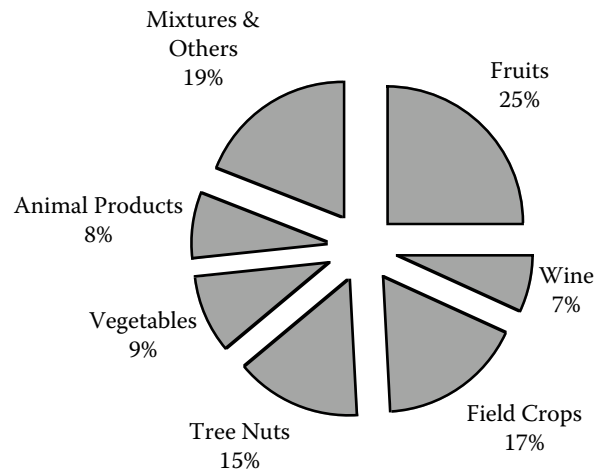
California exports a wide variety of high-value specialty crops. As shown in table 1, the top six food product exports from California in 2002 (and for most recent years) were almonds, cotton, wine, table grapes, dairy, and oranges. The state is not a significant producer or exporter of grain crops such as corn, wheat, or soybeans. In fact, the state is a net importer of feed grains.

Figure 1 highlights the diversity of California's exports. The top five products account for just over one-third of California's agricultural exports by value. Even when exports are aggregated into commodity groups, as opposed to individual products, the range of products exported by California is striking (see figure 2). According to UC Agricultural Issues Center (AIC) statistics, fruit exports comprise 25 percent of the state's agricultural exports, followed by field crops (17 percent), tree nuts (15 percent), vegetables (9 percent), animal products (8 percent) and wine (7 percent).

This diversity of exports reflects California's production diversity and differentiates the state from other important agricultural states in the U.S., which tend to produce only a few commodities. For instance, the agricultural sector in Iowa and

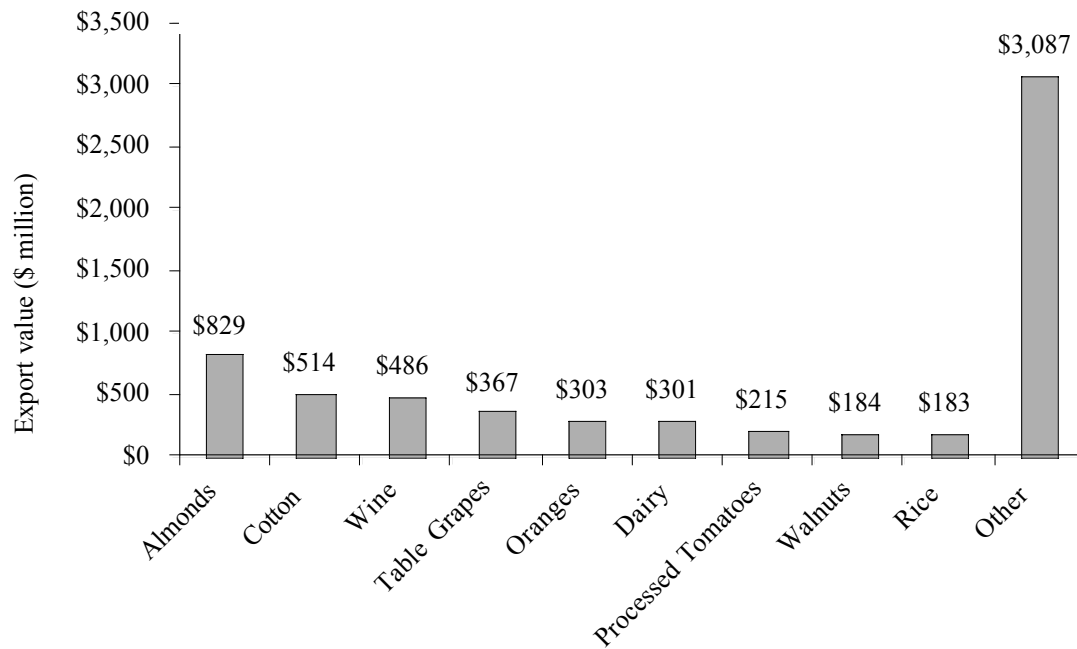
¹ Any data analyses in this chapter are constrained by the fact that state level trade data are limited (see Carter 1997 for further discussion). For example, there are no reliable data on California's agricultural imports. Almost all trade data is collected at the national level rather than the state level. In addition to this obstacle, the California Department of Food and Agriculture (CDFA) changed the method of calculating state-level export values in 1992 and then again in 1999. This makes any long-term analysis of state export trends problematic. The UC Agricultural Issues Center (AIC) has improved the reliability of California agricultural export statistics and the figures now published by the CDFA are compiled by the AIC (www.aic.ucdavis.edu).

Figure 1. California's main agricultural exports, 2002



Source: UC Agricultural Issues Center.

Figure 2. California agricultural export value by commodity group, 2002



Source: UC Agricultural Issues Center.

Illinois is concentrated in just three commodities: corn, soybeans and hogs, which account for 70-80 percent of those states' farm cash receipts. Nebraska's production of corn and cattle generates over 70 percent of that state's farm receipts. Texas depends on the cattle sector, which produces 50 percent of its farm cash receipts (ERS/USDA 2001b).

Of any other state in the U.S., the profile of Florida's agriculture is perhaps most similar to California's. While the value of agricultural production in Florida is about 25 percent of that in California, Florida's agriculture is quite diversified and the state produces fruits, vegetables, and dairy products. However, Florida is not as dependent on foreign markets as California is; many of the state's fruits and vegetables are sold domestically. Not surprisingly, this means that Florida's growers tend to be more protectionist than growers in California. As we explain a little later, California growers have a great deal to gain from breaking down foreign barriers to trade in fruits and vegetables; this is less true for Florida growers.

California's exports are destined for a diverse group of relatively high income countries, with the exception of the increasingly important Chinese market. The major foreign markets for almonds and wine are in Europe, while significant markets for the other top commodities are in Canada, Mexico, and Asia. Penetration of these desirable markets is all the more impressive because these countries remain quite protectionist with respect to agriculture, as discussed in the next section. It is estimated that about 40 percent of California agricultural exports is destined for Asia, 20 percent to Europe, and 30 percent to North America. California exports nearly twice as much of its agricultural output to the relatively wealthy European Union (EU) markets compared to the U.S. as a whole (ERS/USDA 2002b).

Table 1. California's Major Export Markets and Commodities Exported by Destination, 2002 (\$million)

Canada	EU	Japan	Mexico	China and Hong Kong	S. Korea
Lettuce (113)	Almonds (422)	Rice (97)	Dairy (86)	T. Grapes (80)	Oranges (75)
Tomatoes (112)	Wine (284)	Almonds (90)	T. Grapes (43)	Oranges (62)	Beef (56)
T. Grapes (105)	Walnuts (89)	Hay (74)	Tomatoes (20)	Cotton (43)	Cotton (38)
Strawberries (105)	Pistachios (82)	Wine (71)	Cotton (18)	Almonds (39)	Dairy (18)
Wine (76)	Prunes (61)	Cotton (61)	Almonds (13)	Beef (26)	Hay (18)

Source: UC Agricultural Issues Center.

The UC AIC estimated that as of 2002, leading export destinations for California agricultural commodities included Canada (\$1,119 million), the European Union (\$1,128 million), Japan (\$905 million), Mexico (\$293 million), China and Hong Kong (\$345 million), South Korea (\$274 million), and Taiwan (\$212 million). Major crops sent to these markets are summarized in table 1. This table again shows the diversity of California's exports, but also suggests that products are targeted to different markets; each market is dominated by a different set of products, with little overlap between them. In 2002, almond exports from California were primarily destined for the EU (51 percent of California's exports), Japan (11 percent), India (8 percent) and Canada (5 percent). Most of the cotton in 2002 was sold into South Korea, Japan, Indonesia, Taiwan, and Mexico. The EU serves as the major market for California wine, followed by Canada and Japan. Canada and China/Hong Kong imported 51 percent of California's table grapes in 2002, with Canada buying 29 percent alone. The largest markets for California dairy exports are Mexico (39 percent), Japan (18 percent), and China/Hong Kong (21 percent). Korea is the largest international market for California oranges (25 percent), followed by Canada (24 percent), China/Hong Kong (21 percent) and Japan (17 percent). Processed tomato exports were shipped primarily to Canada (52 percent), Mexico (9 percent), and the EU (9 percent). The EU and Japan imported 69 percent of California's walnuts in 2002, with the EU accounting for 49 percent of sales. Most of the rice exports from California (53 percent) were sold to Japan.

California's integration into world agricultural markets is not unidirectional. Residents of the state also consume significant amounts of agricultural imports. For commodities not grown in the U.S., such as cocoa, coffee, and bananas, California relies entirely on imports. While data on import value by state is not readily available, a sense of the magnitude of import consumption can be estimated by relying on the proportion of U.S. population resident in California (12 percent in 2001) (U.S. Census Bureau 2001). In 2001, the U.S. as a whole imported beef and veal worth \$2.4 billion, \$1.6 billion worth of cocoa and related products, \$2.7 billion worth of coffee and related products, and \$1.2 billion worth of bananas and plantains (ERS 2001). If 12 percent of these products were destined for California, then, in 2001, consumers in this state spent \$950 million on imports of these commodities alone.

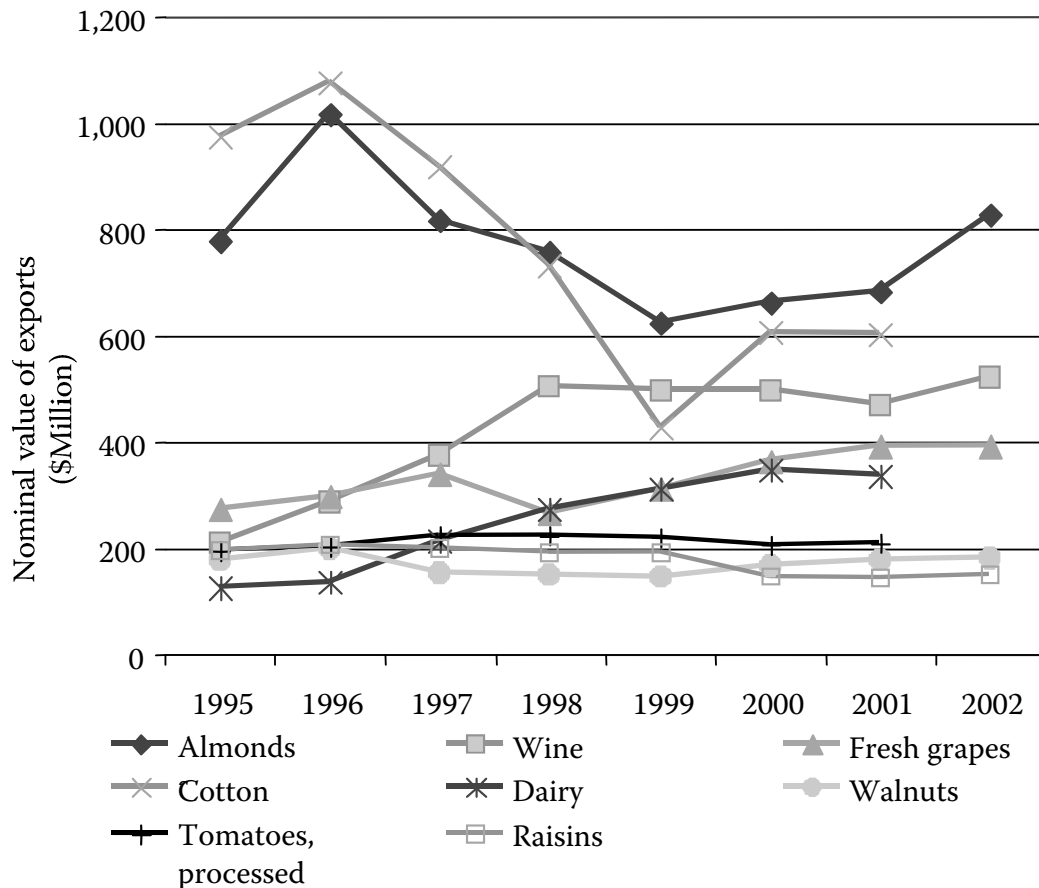
California Agriculture's Trading Environment

California agriculture faces a complex international trading environment, characterized by import tariffs, non-tariff trade barriers, new competitors, and relatively little traditional federal assistance compared to other states. In this section, we review the market environment in which California's agricultural producers compete. Increasing foreign competition and relatively closed markets have created demand within California for both increased government support for agriculture (particularly funding for foreign marketing), and further trade liberalization in foreign markets (California Farm Bureau Federation 2001, 2001b). The internal contradictions between these positions have not been resolved. We argue later that California receives little benefit from the taxpayer dollars spent on foreign marketing; consequently, the California agricultural industry may wish to concentrate on

achieving global trade liberalization even if this necessitates funding reductions for foreign marketing activities.

In the last decade, the nominal value of total U.S. agricultural exports grew by about 30 percent. Exports of some commodities important to California grew more rapidly and some less rapidly than the national average. Over this time period, U.S. dairy exports increased by 265 percent and fresh vegetable exports increased by 73 percent. Figure 3 shows how the nominal values of some major California exports changed over the period 1995-2002. According to UC AIC and the Foreign Agricultural Service (USDA/FAS FATUS database), the fortunes of California's commodities have been mixed; almonds and wine have fared somewhat better than tomatoes and raisins. While the total nominal value of California's agricultural exports has declined by about 5 percent since 1995, this figure masks widely divergent trends across commodities, so no general conclusions can be drawn.

Figure 3. California agricultural export values (nominal values), 1995-2002 (Million)



Notes: Data for 1995-2001 from UC AIC; 2002 data from USDA/FAS FATUS database; 2002 data were not available for products grown in states besides California.

Source: United States Department of Agriculture, Foreign Agriculture Service, Foreign Agriculture Trade of the United States (FATUS) database and UC Agricultural Issues Center.

In the 1990s the most significant import growth in world markets was in high-valued and processed food products like those grown in California. The share of high-value and processed agricultural products in world agricultural trade has increased from less than 40 percent in the early 1980s to well over 50 percent by the end of the 1990s (WTO 2001). At the same time, the share of fruits and vegetables in world agricultural trade remained at about 17 percent from 1990 to 2001, with a dollar value of \$69.8 billion in 2001, up from \$51 billion in 1990 (FAO 2002). The fact that fruit and vegetable trade did not increase any faster than total agricultural trade is very surprising given the growing per capita demand in developed countries for fresh fruits and vegetables. The stagnant share of fruit and vegetable trade no doubt reflects the high level of protectionism around the world for these food categories. For instance, two-tiered tariffs known as tariff-rate quotas (TRQs) are commonly used to restrict imports of fruits and vegetables. Worldwide, there are more than 350 TRQs placed on trade in fruits and vegetables, and more than 25 percent of all agricultural TRQs are concentrated in the fruit and vegetable trade (Skully, 2001). This phenomenon critically affects California agriculture.

As an exporter of high-value food commodities, California must contend with the fact that import tariffs in important markets such as in the EU are generally higher on processed agricultural products than on the primary commodities. This tariff wedge between a processed commodity (e.g., processed fruit) and its corresponding primary commodity (e.g., fresh fruit) is referred to as tariff escalation, and this is a significant obstacle to California exports. Tariff escalation produces a trade bias against processed agricultural products and value added products. There is general evidence of tariff escalation in OECD countries (such as Australia, Canada, the EU, and New Zealand), especially for fruits, vegetables, and nuts—major California exports. For many countries, bound tariffs tend to be higher for processed food products than for unprocessed products (WTO, 2001). Furthermore, recent tariff reductions on agricultural products exceeded tariff reductions on processed food products in Australia, Canada, the European Union and Mexico (OECD, 2002).

Government transfers to the agricultural industry have contributed to the sector's profitability in California, particularly for those farmers not growing nuts, fruits and vegetables. Agricultural producers in California received \$586 million in federal assistance in 2001; Of this about \$242 million came as production flexibility contracts and loan deficiency payments. Supplemental funding of \$258 million was paid directly to California farmers. The remainder of government payments to farmers came in the form of marketing support and conservation payments, which we discuss later in this chapter.

While these federal government support payments are low in total compared to those states where the major agricultural products are grains or oilseeds, this does not imply that some agricultural producers in California do not benefit greatly from subsidies and protectionist measures.² Over 100 farms in California received more than \$425,000 each in subsidies in 2001 (Environmental Working Group 2002). Dairy, sugar and cattle producers receive significant protection from import barriers, and

² Twelve states received higher total federal government payments to agriculture than California in 2001. Since these states are smaller than California in both area and population, even this ranking understates the extent to which California receives a disproportionately small share of federal government agricultural subsidies.

many producers receive subsidized inputs, particularly irrigation water. Sumner and Hart (1997) estimated the Producer Subsidy Equivalent (PSE) paid to California agriculture in 1995 (updated to take the 1996 Farm Bill into account), where the PSE is defined as all government transfers to the industry including but not limited to production subsidies. They calculate that the California agricultural sector receives annual PSE transfers of \$2.3 billion per year or about 11 percent of total commodity receipts. This is about one-half of the percentage PSE for all U.S. agriculture at the time, mainly because fruits and vegetables receive fewer transfers than the average commodity. However, California's PSE is higher than the percentage PSE received by producers in liberalized markets like Australia and New Zealand (Sumner and Hart 1997) where the 1995 PSE was about 3 percent. While the specific estimates of PSE vary over time, the general pattern identified by Sumner and Hart, that California producers have a lower PSE than the U.S. national average but higher than that for other agricultural exporters, holds today.

Key Markets

A review of the characteristics of important markets for California's agricultural products shows potential for gains to producers from further trade liberalization in these countries. However, in addition to serving as important markets for California products, the EU, Mexico, and China also compete against California in agricultural trade. This suggests that increasing trade flows will entail both risks and benefits for California agricultural producers.

Canada

The formation of the Canada-United States Free Trade Agreement (CUSTA) in 1989 and the North American Free Trade Agreement (NAFTA) in 1994, has led to greatly expanded agricultural trade between Canada, California's top market, and the U.S. NAFTA was designed to integrate economic activity among three nations: Canada, the U.S. and Mexico. It serves as a free trade agreement rather than a customs union or common market. Since 1989, U.S. agricultural exports to Canada have expanded by about 3 and one-half times, from \$2.24 billion to \$7.65 billion. Over the same period, agricultural imports from Canada have risen almost three-fold, from \$2.93 billion to \$8.66 billion. Fruits and vegetables account for more than one-third of Canada's agricultural imports from the U.S., so California plays an important role in this north-south trade.

However, in spite of the CUSTA and NAFTA, Canada continues to intervene in agricultural trade flows. The country uses non-tariff barriers such as licenses that restrict imports of bulk produce, fresh fruits, vegetables, and wine. For instance, Canadian regulations on fresh fruit and vegetable imports prohibit consignment sales of fresh fruit and vegetables without a prearranged buyer (USTR 2002). Canada also severely limits imports of dairy products, eggs, and poultry. According to the WTO Appellate Body, Canada's supply management system for dairy provides implicit export subsidies for these products (USTR 2002).

Producer groups in the U.S. have called for the greater use of non-tariff barriers to limit agricultural imports from Canada. This has often been accomplished by the use

of U.S. trade remedy laws. Trade remedy laws are intended to offset “unfair” trade that injures domestic producers as a result of either foreign sales that are “dumped” into the U.S. at less than fair value or influenced by foreign government subsidies. The regular use of trade remedy laws within NAFTA illustrates the fact that any transition to freer trade in agriculture, even between countries at relatively similar stages of development, may be politically difficult.

An example of the agricultural trade tensions between Canada and the U.S. is the recent “tomato wars,” in which U.S. producers accused the Canadians of “dumping” tomatoes in the U.S. market. In October 2001, the United States government made a preliminary ruling that Canadian growers were dumping greenhouse tomatoes into the United States at prices below the Canadian cost of production. As a result of this finding, Canadian sales into the United States were assessed an average tariff of 32 percent. Several weeks later, the legal tables were turned as the Canadian government initiated an anti-dumping investigation against the U.S. fresh tomato industry (Barichello 2003). The Canadian counterclaim may not have been a coincidence. Rather, it may have been a tit-for-tat reaction to the steep U.S. duties imposed on Canadian greenhouse tomato sales to the United States. By July 2002, both cases were resolved with identical rulings of no material injury. While U.S. exports of fresh tomatoes to Canada declined 10 percent over the previous year during the period of investigation, Canadian imports of greenhouse tomatoes to the United States actually increased 17 percent over that year (ERS/USDA 2002d).

Japan

Despite the fact that Japanese agriculture receives high levels of government support and has limited market orientation (OECD 2001), it is also the world’s largest net importer of agricultural products. The United States supplies roughly one-third of Japan’s agricultural imports, and in 2002, Japan’s agricultural imports from the U.S. were valued at \$8.3 billion (ERS/USDA 2003). About 20 percent of these U.S. exports to Japan originated in California. Japan is California’s third largest export market for agricultural products, with rice, cotton, almonds, beef, and oranges ranking as the top commodities (see table 2). Japan’s weak economy has dampened its total agricultural imports in recent years (ERS/USDA 2003).

In the 1990s, the most significant import growth in Japan was in the area of fruits and vegetables, wine, and beef (USDA/FAS 1996). More recently, grains and oilseeds have done better (ERS/USDA 2003). Japan continues to restrict imports of horticultural products, livestock products, and processed foods, all of which are important exports for California. Recently, beef exports to Japan were halted in response to the BSE scare in Europe; and Japan continues to consider implementing a “beef import safeguard,” which could further lower imports even further. At the time of this writing, Japan had halted all imports of U.S. beef, due to the discovery of BSE in the U.S. (ERS/USDA 2003).

Citing phytosanitary concerns, Japan blocks imports of U.S. fresh fruit, vegetables, and other horticultural crops, keeping Japanese domestic prices of horticultural products artificially high. Government subsidies are also provided to farmers to encourage them to divert land out of rice production and into vegetables (Kenzo and Dyck 2002). Japan also has country-of-origin labeling requirements for

agricultural products that principally affect fruits, vegetables and animal products (USTR 2002b). This acts as a non-tariff barrier to trade. Japan maintains high tariffs on beef, citrus, and processed foods. In addition, imported high quality California rice is strictly controlled and rarely reaches the consumer food table in Japan. The over-quota rice tariff in Japan exceeds 400 percent.

Until recently, Japan's system of food imports used mainly non-tariff barriers such as quotas and licenses, instead of tariffs. Sazanami et al. (1995) 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 737 percent. Despite the tariffication required by the Uruguay round of trade liberalization, of Japan's agricultural imports remain highly protected (e.g., beef tariffs of 38 to 50 percent). In addition, Japan continues to use health and safety regulations to serve as barriers to trade.³

In the case of fresh oranges and lemons, the U.S. (primarily California and Arizona) is the largest supplier to Japan, accounting for over 80 percent of Japan's imports. Other exporters of oranges and lemons of lesser importance in Japan are Australia, Chile, and South Africa. The Japanese Government continues to impose a high import tariff on fresh oranges. The tariff rate is 32 percent for imports during the December-May period, (the marketing season for domestically-produced citrus) and 16 percent during June-November. (USDA/FAS 2002i).

European Union

California's second most important market, the EU, provides export subsidies for beef, cheese, other dairy products, and processed fruit, in competition with California. It also provides generous production subsidies on horticultural products such as tomatoes, grapes, peaches and lemons. The EU's subsidized production of these products affects California's competitiveness in third markets.

More generally, the EU's Common Agricultural Policy (CAP) significantly isolates European farmers from international competition. The CAP is a system of subsidies and market barriers that include mandatory land set-asides, commodity-specific direct payments, and export subsidies (for an overview of EU agricultural policy, see ERS/ USDA 1999, 2002). Support to agricultural producers as a share of total agriculture receipts is 40 percent higher in the EU than in the U.S. (OECD 2002b). Much of this support comes in the form of higher prices paid by domestic consumers. Recently, there has been increasing pressure to significantly reform the CAP; the program has been called by the popular press an "extravagant folly" (Financial Times September 24, 2002) and "demented" (The Economist October 3, 2002). These publications and others have argued that reform of the CAP will be a critical element of the next round of trade negotiations, if these talks are to be successful. Enlargement of the EU to include ten Central and Eastern European countries will also create pressure for further reform.

Structural reforms of European agricultural policy will have important implications for California, both because the region competes in third markets with California, and because the region is an important customer, as discussed earlier. If the

³ There are exceptions that are important to California. For example, raw cotton imports enter Japan duty free.

existing EU agricultural policy is applied to the 10 new member countries, the incentive will be to increase production and agricultural exports. Several of the new member countries have a comparative advantage in agriculture, especially in the area of wheat, coarse grains, and livestock. California agriculture will benefit if this expanded production results in budgetary pressure to reform the CAP. In addition, California agriculture may well benefit from projected income growth in Central and Eastern Europe that results from EU membership. Higher incomes in this region will lead to increased demand there for high-valued food, of the type exported from California.

An ongoing trade dispute between the US and the EU concerns the use of geographical indicators (GIs). The EU wants to prohibit foreign producers of food and beverage products from labeling products with European regional names (e.g., Italian Parma ham or French Roquefort cheese). The list of products that will receive this protection is an on-going subject of negotiation at the WTO. For California there is a trade-off associated with GI protection. On the one hand, California would have to stop using certain names if the EU is successful (e.g., Basmati rice or Feta cheese as these names refer to regions of other countries). On the other hand, California agriculture could use GI protection to develop niche markets for its food and beverage products, potentially capturing a price premium.

China

China is a relatively new member of the WTO, and developments in China's agricultural trade are being carefully watched by the California industry. China's land area sown to fruits, nuts, and vegetables has grown rapidly in the past decade, and trade is expected to take on a greater importance for China in coming years now that it has joined the WTO. China's horticultural exports account for more than one-half of its agricultural exports (Carter and Li 2002). Given China's rich agricultural resources, abundant labor supply, and large population, it has great potential to play a much more prominent role in agricultural trade in the coming years, as both an exporter and an importer.

China uses both tariff and non-tariff barriers to restrict agricultural imports. China has in place high import tariffs on certain agricultural commodities currently exported by California, such as citrus, table grapes, wine, beef and dairy products. There is also evidence that the value added tax in China, as currently applied, results in a price break for domestic field crops as compared to imports, of about 4 percent (USDA/FAS 2002). China has import tariffs on citrus and table grapes of approximately 10 percent and maintains a restrictive tariff rate quota (TRQ) on cotton. As part of its WTO accession negotiations, China agreed to a significant lowering of these tariffs to around 10 to 12 percent. In addition, if the WTO liberalizes world trade in clothing and textiles (e.g., removes restrictive U.S. import quotas), then China will undoubtedly expand exports of clothing and textiles. This could result in increased imports of cotton into China.

Domestic developments in China not directly related to trade policy but related to rising incomes may also present opportunities for California agricultural exports to that country. For example, both the USDA Foreign Agricultural Service (USDA/FAS 2002b) and the popular press (Barboza 2003) have recently highlighted the growing

importance of western-style supermarkets in Chinese cities, replacing more traditional markets. This may present a new opportunity for California producers, with new opportunities to supply pre-packaged or processed products and products that require refrigeration. Another example of the effect of increasing incomes on potential demand for California products is the increasing popularity of wine among the urban middle class (USDA/FAS 2002c). Coupled with the dismantling of monopolies on alcohol imports as part of WTO accession, this increasing demand may be an important opportunity for California.

China has the potential to become a serious export competitor with the U.S. in third markets for rice and horticultural products. This is partly a result of the relative size of the two countries; the harvested area of fruits and vegetables in China is about 22 million hectares, or seven times the U.S. area for these products. As China's agricultural sector moves away from its historical focus on land-intensive grains and concentrates more on labor-intensive cash crops, markets in other parts of Asia will be subject to increased competition from China. Since joining the WTO, export opportunities have greatly improved for China for such products as rice, fruits and vegetables (Theiler and Tuan 1994). Entry into the WTO will also mean that China's consumers will have more open access to world food markets and a potential for increased imports.

There is uncertainty over the trade patterns that are likely to unfold as China opens its doors further to agricultural trade (Bhattasali, Li, and Martin 2002). There is no doubt that China has a comparative advantage in labor-intensive agricultural products such as fruits and vegetables and that exports of these products from China have been growing into markets important for California (Huang 2002). The U.S. response to China's production of these products will affect how competition from China impacts California producers.

An example of the policy response to the emergence of China as a competitor is the recent skirmish over the garlic market. Normally California accounts for over 80 percent of U.S. garlic production but it faced stiff competition from China in the mid 1990s. U.S. imports of Chinese garlic increased from about 3 million pounds a year in 1992 to 64 million pounds by 1994. This raised concerns among California producers, so California garlic growers lobbied for, and won, import relief from Chinese imports in 1994, when the U.S. government issued an antidumping order and imposed a 376 percent tariff on garlic imports from China.

Garlic production in California is highly concentrated, with less than 10 producers accounting for about 80 percent of the annual harvest. These few growers joined together to seek protection from foreign competition and they were quite successful. China never regained its market share after the antidumping case. In 1994 when the case was initiated, the value of U.S. imports of garlic from China decreased from \$11.9 million to \$4.1 million, a drop of 65.5 percent. However, while China's value of exports to the United States fell to \$250,000 in 1995, Mexico's exports nearly doubled in value to \$20 million, and Argentina's exports increased by an additional 19 percent to \$3.9 million. California agriculture was involved in similar antidumping cases against China in mushrooms in 1998, concentrated apple juice in 1999, and honey in 2001.

Hong Kong

Hong Kong is physically small, very densely populated, and relatively affluent. Hong Kong's population is 7.3 million, compared with China's 1.3 billion. Hong Kong's income per head is high, at nearly \$25,000 annually (CIA 2002). Because of its size, Hong Kong is highly dependent on the rest of the world for food. The California farmer plays an important role in supplying this high-valued market. For instance, fruits 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 25 percent of the market in 2002. The United States is second, with about 15 percent of the market (FA/USDA 2003). China and California compete head-on in this market exporting similar products such as fruits, vegetables, nuts and rice.

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, while non-tariff barriers such as phytosanitary or plant quarantine regulations, are almost nonexistent. Even rice imports, historically protected with tariffs and quotas in many Asian markets, have been liberalized. In 2003, the Hong Kong rice import quota system was eliminated. While the market is expected to be dominated by Thai rice, there remain new opportunities for California producers (USDA/FAS 2003b).

In 2002, total U.S. agricultural exports to Hong Kong were \$1.14 billion, with California supplying about 60 percent of these sales. Hong Kong ranks as the seventh largest export market for U.S. agricultural products (ERS/USDA 2003). U.S. agricultural exports to Hong Kong increased by about 80 percent from 1990 to 2000 and peaked at \$1.7 billion in 1997. 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. However, California is facing strong competition for the Hong Kong market and California's market share may be eroding slightly. The U.S.'s market share of Hong Kong's fruit imports fell to 26 percent in 2000 from 33 percent in 1996 (FAS/USDA 2001d).

Even though Hong Kong is an important final market for California, it re-exports a considerable amount of fruits and vegetables from California. Mainland China is the major destination for most of these re-exports. About 30 percent of Hong Kong's fruit imports are re-exported to China. Table grapes, oranges, and apples are the key products re-exported. For example, in 2001 the U.S. sold table grapes worth \$62 million to Hong Kong and \$36 million worth of this trade was legally re-exported to China (FAS/USDA 2002l). In addition, some re-exports of agricultural products to China via Hong Kong are undocumented. As a result of China's high tariffs and restrictive phytosanitary requirements on imports.

With further economic integration between Hong Kong and China, farmers in China will be given incentives to improve the quality of their fruits and vegetables in order to more effectively compete with California. China has the agronomic potential to export high-quality food to Hong Kong. The hurdles in China are lack of proper incentives and inadequate infrastructure. As these hurdles are overcome, California's competitiveness in the Hong Kong market will be affected.

Mexico

Mexican agricultural trade is highly dependent on its two partners in NAFTA. Agricultural provisions were an important component of the NAFTA agreement (Orden, 1996), with agricultural tariff and non-tariff barriers being phased out over varying time periods up to 15 years. Within U.S. and Mexican agriculture, some groups supported the agreement while others opposed it. In response to these concerns, NAFTA gives special consideration to the centrality of corn in Mexican agriculture, so the country maintains significant tariffs on corn imports even as other trade barriers have been removed more quickly. In 2003, the tenth year of the NAFTA agreement, a new round of tariff reductions within the free trade area came into affect. These tariff reductions are expected to significantly affect Mexican farmers, who will face new competition from American and Canadian producers in such products as potatoes, barley and wheat, and, importantly for California, cotton, fresh apples, frozen strawberries and certain milk products (EIU 2003).

According to reports in the popular press, the competitive pressures generated by NAFTA have been economically painful for Mexican producers. This is at least partly due to the fact that structural inefficiencies in the Mexican economy (e.g., high transportation costs) increase costs of production and marketing (The Economist November 2002). Some Mexican policymakers suggest that it is also a result of the subsidies received by U.S. farmers that the Mexican government cannot hope to match (The Wall Street Journal March 2003).

At the outset of NAFTA, there was significant opposition to the agreement from U.S. agriculture. Opposition came from producers of wheat, sugar, peanuts, citrus, and winter fruits and vegetables (Orden 1996). Some agricultural interests in California opposed NAFTA because of fear of competition from low-wage Mexican agriculture in the production of labor-intensive crops. Proponents argued that NAFTA would drive down agricultural wage rates in California and thus restore the competitiveness of California's agriculture.

Factor price equalization lies at the root of the debate over the effects of liberalized trade on the competitiveness of California agriculture precisely because a large percentage of California's agricultural production is labor intensive, using 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 1997). 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. This labor-intensive production means that California and Mexican agriculture differ less than might be predicted by comparing incomes per capita; thus the two regions are likely to compete against each other in third markets.

Despite protectionism on both sides of the border, there has been progress towards freer trade and cross-border investment between the U.S. and Mexico since NAFTA. 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 probably help in alleviating trade barriers to Mexican peaches, nectarines and cherries. Accumulated U.S. investment in Mexican agricultural production equaled \$45 million from 1994 to 1997, with even greater investment in the food processing industry in Mexico of about \$5 billion in 1999 (Bolling and Jerado 2001).

FEDERAL SUPPORT FOR CALIFORNIA AGRICULTURE

California agriculture receives relatively few subsidies from the federal government compared to other states. However, California does benefit from several programs designed to either explicitly subsidize exports or promote demand for California products in foreign markets. Funding for these programs continues in spite of the public commitment by the U.S. government to phase out export subsidies, and the (likely non-binding) cap placed on this form of support by WTO commitments. The programs that explicitly subsidize exports are the Export Enhancement Program (EEP) and the Dairy Export Incentive Program (DEIP). The Market Access Program (MAP) and the Foreign Market Development Program (FMD) subsidize the cost of market development activities overseas. A new program called Technical Assistance for Specialty Crops Program (TASC) is intended to fund projects that address technical barriers to the export of specialty crops. Among these programs, the most important to California producers is the MAP, which received increased funding in the 2002 Farm Bill. In this subsection, we describe each of these programs, and their importance to California agriculture.

Export Subsidy Programs

The 2002 Farm Bill, as with previous Farm Bills, authorized Export Enhancement Program (EEP) export subsidies for such commodities as wheat, rice, barley, eggs, and frozen poultry. FAS authorizes export subsidies for these products either when prices are low or as “self-defense” when other countries engage in what FAS defines “unfair” trading practices (Schumacher 1998). The 2002 Farm Bill allocated \$478 million annually to EEP (ERS/USDA 2002c), but the share of this subsidy that will flow to California will probably be small. In recent years only frozen poultry has qualified for EEP subsidies (totaling about \$6.8 million in 2001), because world market prices have been sufficiently high for other eligible commodities, though the potential scope of the EEP was expanded in the 2002 Farm Bill. This may increase the size of the EEP subsidy captured by California producers. Specifically, the 2002 Farm Bill allows export subsidies to offset “a trade restriction or commercial requirement (such as a labeling requirement) that adversely affects a new technology (including biotechnology).” As Hudson (2002) points out, this may open up EEP to many new agriculture products not covered in earlier years.

The DEIP subsidizes exports of milk powder, cheese, and butter. These dairy products, unlike the products that are eligible for the EEP, are subject to federal dairy price support, creating a gap between domestic prices and world market prices. The price support is administered by the Commodity Credit Corporation, which pays “bonuses” to exporters to compensate these firms for the differential between prevailing international market prices and artificially high domestic prices

(FAS/USDA 2001b). The stated intention of the program is to develop export markets for U.S. dairy producers in markets where dairy is subsidized. In 2001, so-called bonuses of \$1.76 million were awarded for U.S. cheese exports and \$6.8 million was paid to U.S. non-fat dry milk exporters (FAS/USDA 2001). These low figures, far below WTO ceilings, reflect the fact that relatively little of the dairy output from most U.S. producers is actually exported. Perhaps 5 percent of volume is exported, with most going to Mexico (Brunke 2002). Butter and butter oil lost DEIP funding in 2001 and 2002 due to high domestic prices and a fragile butter market, while similar market conditions eliminated support for whole milk powder those same years (Rouse 2002). As shown in table 2, DEIP awards to California producers vary widely from year-to-year, depending on world market prices, though the bulk of export subsidy payments consistently goes to non-fat dry milk (FAS/USDA 2001c, 2002d).

Export Promotion Programs

California is a major recipient of federal DEIP funding but could benefit more from the Market Access Program (MAP) and Foreign Market Development Program (FMD). In both of these programs, authorized CCC funds share foreign market development costs with trade associations or companies for activities such as generic commodity or consumer promotions. This support is not subject to WTO caps, as discussed later.

Table 2. California DEIP Awards

Exporter	Commodities	FY 2000 (\$ millions)	FY 2001 (\$ millions)	FY 2002 (\$ millions)
Dairy Farmers of America	Non-fat dry milk	1.37	0	0
	Whole milk powder	0.05	0	0
DairyAmerica	Non-fat dry milk	0.51	0.02	26.55
Gerber California	Non-fat dry milk	5.20	1.69	0.01
	Whole milk powder	1.42	0	0
Luxor California Exports Corp.	Cheddar cheese	1.00	0	0
Matin Trading Co.	Non-fat dry milk	0.03	0	0
Sorrento Cheese Co.	Mozzarella cheese	0.04	0	0
Total non-fat dry milk		7.11	1.85	26.65
Total DEIP awards		9.62	1.85	26.65
Source: FAS/USDA Detailed Report of Exporter awards (2001, 2002). Authors' identification of exporters based in California by address of corporate headquarters.				

Under the 2002 Farm Bill, Congress authorized gradual increases in MAP funding from an annual \$90 million in 1996-2001 to \$100 million in 2002, \$110 million in 2003, \$125 million in 2004, \$140 million in 2005, and \$200 million in 2006 and 2007 (ERS/USDA 2002c). The MAP program funds up to 50 percent of a company or trade group's cost of branded promotion in overseas markets. Qualifying activities include trade shows, advertising, product demonstrations, and in-store and food-service promotions (FAS/USDA 2002e, 2002g). Because support is provided for the promotion of brand-name products, the MAP has been controversial and sometimes described as a form of "corporate welfare" (see for example, Cato Institute 1998).

Table 3. California Market Access Program Allocations

Trade Organization	FY 2001 Award (\$ millions)	FY 2002 Award (\$ millions)
Blue Diamond Growers/Almond Board of California	1.17	1.16
California Agricultural Export Council	0.37	0.47
California Asparagus Commission	0.18	0.20
California Cling Peach Growers Advisory Board	0.32	0.16
California Kiwifruit Commission	0.14	0.12
California Pistachio Commission	0.75	0.75
California Prune Board	1.86	1.76
California Strawberry Commission	0.51	0.47
California Table Grape Commission	1.87	1.87
California Tomato Commission	0.47	0.47
California Tree Fruit Agreement	0.73	0.76
California Walnut Commission	2.16	0.21
Raisin Administrative Committee	1.78	1.73
Wine Institute	2.72	3.13
Cotton Council International	7.66	6.74
Sunkist Growers, Inc	1.81	1.64
USA Rice Federation/ U.S. Rice Producers Assoc.	2.13	2.33
U.S. Dairy Export Council	1.56	1.48
Total	28.51	27.66
Source: FAS Online: Market Access Program Allocations, Fiscal Years 2001 and 2002.		
Notes: Payments to cotton, rice, and dairy producers not limited to California. Sunkist products are grown in Arizona and California.		

California agricultural interests receive a large portion of the federal MAP funds. Table 3 lists California companies and trade associations receiving recent MAP assistance, including national or regional trade associations of which California producers are members. While all \$28 million shown in Table 5 does not flow solely to California producers and their trade associations, at least \$15 million does benefit

California producers through the MAP program.⁴ This amount alone is approximately 15 percent of the entire MAP budget in 2001 (FAS/USDA 2002j), meaning that California receives more than 15 percent of the MAP budget. Since California accounts for about 15 percent of U.S. agricultural export revenues but receives more than 15 percent of the MAP budget, it benefits disproportionately from MAP funds.

FMD differs from MAP in that FMD's stated goal is to target long-term development of overseas markets for generic commodities through trade associations rather than the promotion of individual brand products by companies. According to FAS/USDA, FMD gives preference to non-profit U.S. agricultural and trade groups that represent an entire industry or have a nationwide scope and is intended to support the export of value-added products to emerging markets (FAS/USDA 2002f). The FMD is also supposed to support a wider variety of marketing activities than MAP, allowing applicants to submit a marketing plan describing the world market for the given commodity, a marketing budget, and those promotional activities the trade association will undertake. In the latest Farm Bill, Congress increased annual funding for this program from \$27.5 million to \$34.5 million annually (ERS/USDA 2002c). Trade associations pertinent to California agriculture that received FMD funding in 2001 are listed in Table 4 (FAS/USDA 2002h). However, because FMD targets trade associations of a national scope, only one trade association included in the table represents solely California producers.

Table 4. Trade associations related to California receiving FMD funding (\$1000)

Trade Association	2001 FMD Awards	2002 FMD Awards
California Agricultural Export Council	11	12
Cotton Council International	2,087	2,312
National Cottonseed Products Association	121	91
USA Rice Federation	1,688	1,649
U.S. Dairy Export Council	809	818
Total	4,716	4,882

Source: FMD Cooperator Program Budget, Fiscal Years 2001 and 2002.

The new TASC program is targeted at specialty crops, which are important to California. The program, funded at \$2 million per year through 2007, is intended to subsidize the cost of activities such as seminars, field surveys, pest and disease research, and pre-clearance programs that may lower phytosanitary and technical barriers to trade for specialty crops (FAS/USDA 2003c). Peanuts, sugar, and tobacco are not eligible for support. Like the MAP, this program is open to private firms as well as non-profit trade associations, suggesting that it will be vulnerable to the same

⁴ Payments to Sunkist, Cotton Council International, USA Rice Federation, and U.S. Dairy Export Council are shared by California and other participating states.

criticism that MAP has faced. Table 5 lists California organizations that will receive TASC funding in 2002.

Table 5. Trade associations related to California receiving TASC funding (\$1000)

Trade Association	2002 TASC Awards
California Fig Advisory Board	78
California Grape and Tree Fruit League	67
California Table Grape Commission	160
California Tree Fruit Agreement	92
California Walnut Commission	34
California-Arizona Lettuce Export Council	160
Total	591
Source: FAS/USDA 2003b	

Evidence on the effectiveness of export subsidy and promotion programs

Export subsidy programs like EEP and DEIP are constrained by current WTO commitments, and the California Farm Bureau Federation (CFBF) has taken the position that they should be phased out entirely as part of on-going WTO negotiations (Wenger 2001, Dillabo 2000). However, the CFBF's position with respect to the MAP and FMD programs is vastly different. There seems to remain a consensus in California agriculture that these programs deserve further and increased funding (CFBF 2001b).

Despite political support in California for export promotion programs, whether MAP and FMD actually benefit California's international competitiveness remains unclear. FAS claims benefits from these programs using a methodology that the General Accounting Office (GAO) has called faulty and inconsistent with Office of Management and Budget guidelines (GAO 1999). A 1997 study of agricultural export programs sponsored by the GAO finds that there is no conclusive evidence that these programs benefit the aggregate economy (GAO 1997). Agricultural export programs "reallocate production, employment, and income between sectors" rather than increasing total economic activity (GAO 1997). The original justification for these programs was to support the export of government grain stocks created by domestic subsidy programs which have since been reformed. Another stated purpose, to counter agricultural subsidies in competitor countries, remains an objective of MAP. However, the GAO finds that it is difficult to effectively target MAP funds to achieve this goal because foreign subsidies are not readily identifiable.

Perhaps the most problematic element of MAP, and potentially of the TASC, is that even if it successfully increases exports of assisted commodities to targeted markets there is evidence that this is often to the detriment of unassisted products. For

example, proponents of MAP point to a projected increase of \$5.30 over 40 years in walnut exports to Japan for every \$1.00 spent on walnut promotion. However, another study found that while every dollar spent on walnut promotion increased walnut exports by \$1.42, it actually reduced the exports of eight other horticultural products by \$3.57 per dollar spent, resulting in a net reduction in U.S. agricultural exports for every dollar spent by \$2.15 (GAO 1997). Studies on meat exports to Japan are also mixed, with some concluding positive findings for beef promotion with no positive effects for pork or poultry, while others only find statistically significant increases for U.S. exports of beef offal. While the targeted overseas markets may purchase more of the targeted commodity, agricultural export programs merely benefit certain U.S. exports by displacing others and do little to increase the American share of the world agricultural market (GAO 1997). Halliburton and Henneberry (1995) also conclude that there is little economic evidence that export promotion programs are effective.

Economic theory predicts that programs like the MAP are not cost-effective uses of public budgets, and thus it is not surprising that it is difficult to find economic evidence in favor of the MAP. If the private benefits of marketing efforts exceed their cost, then firms should find it profitable to undertake these efforts without government assistance. Government assistance uses taxpayers' money to underwrite marketing efforts with high costs relative to benefits. While well-known arguments are made for government support for investments that have "externalities" associated with them, that is, benefits that accrue to many groups whether they pay the cost of the investment or not. However, the marketing of name-brand agricultural products is not likely to be such an investment.

MANDATORY COUNTRY-OF-ORIGIN LABELING

In the 2002 Farm Bill, Congress mandated country-of-origin-labeling (COOL) for fresh and frozen food commodities such as meats, fish, fruits and vegetables, and peanuts.⁵ The new law is an amendment to the Agricultural Marketing Act of 1946 and will impose new traceability responsibilities of uncertain magnitude on suppliers at all stages of the food marketing chain. As a result, COOL has been met with heated reactions within the food and agriculture industry, and its implementation has recently been delayed by several years.

In this section we describe the COOL legislation, and suggest that current practices in the meat-packing industry will make implementation difficult. We also discuss the economics of COOL and the conditions under which this regulation could increase the profits of domestic producers. This outcome is by no means assured. Benefits to society as a whole from COOL are even less likely. As we discuss, the logic of revealed preference predicts that if consumers were prepared to pay for country-of-origin information amounts in excess of the cost of providing this information, voluntary labeling schemes would be adopted. After discussing the economics of COOL, we turn to political economy issues and review various interest groups' lobbying positions at the time the 2002 Farm Bill legislation was passed. We next consider the international trade implications of COOL which is likely to act as a non-

⁵ For expositional purposes, the acronym COOL refers to mandatory labeling, unless specified otherwise.

tariff trade barrier. Whether the rule would, if implemented, be challenged in the World Trade Organization (WTO) remains unclear.

The Legislation

The commodities that COOL applies to include muscle cuts of beef, lamb, and pork, ground beef, lamb, and pork, wild and farm-raised fish and shellfish, fresh and frozen perishable agricultural commodities (fruits and vegetables), and peanuts. Under previous law, there were country-of-origin labeling requirements, but these mostly applied at the wholesale level (ERS/USDA 2001c). Shrink-wrapped packages of apples had to convey country of origin to the customer at the supermarket, while a crate of imported pears only had to indicate its country of origin to the retailer receiving the package, who by placing the pears in a bin, had no obligation to inform his/her customers of the pears' origin. Similarly, imported meat that underwent processing in the U.S. was not required to be labeled for retail sale unless that meat was received in the exact form in which it would be sold to the consumer.

The new regulation covers both domestic and imported food commodities and requires that retailers inform retail consumers of country of origin for the covered commodities. Thus, the number of businesses that must comply with COOL (if implemented has risen exponentially with the 2002 Farm Bill. Furthermore, products that lend themselves to multiple origins such as meat and fish are difficult to track, and it may be difficult to maintain records necessary for compliance.

Effective October 11, 2002, the Secretary of Agriculture, through AMS, issued voluntary guidelines for producers, retailers, or importers, as the law dictated (for more information, see AMS/USDA 2002a). Public comment was solicited during development of the program, and the Secretary was to release mandatory labeling requirements by September 30, 2004. However, as of December 2003, a House-Senate conference committee delayed mandatory compliance with COOL for all products except farm-raised and wild fish until September 2006. Strong opposition to COOL by producers and retailers is largely responsible for the postponement of this regulation. A review of the voluntary guidelines released in October reveals the complexity of the situation.

According to Federal Register 67-198, to qualify for a "United States Country of Origin" label, beef, lamb, or pork must come from an animal exclusively born, raised, and slaughtered in the United States. For beef, an animal may be born and raised in Alaska or Hawaii and transported through Canada for up to 60 days before slaughter in the United States to merit a U.S. origin label. Fish and shellfish labeled as U.S. origin must come from farmed product hatched, raised, harvested, and processed in the United States or from wild seafood harvested in U.S. waters or aboard a U.S. flagged vessel and processed either on said vessel or in the United States. Seafood labels must also indicate whether the product is farmed or wild. Peanuts and perishable agricultural commodities must be exclusively produced in the United States for U.S. origin distinction.

The exception made for beef from Alaska and Hawaii demonstrates some of the complications inherent in characterizing meat as the product of one country or another. Before slaughter and sale, an animal may pass through multiple countries and

therefore cannot be labeled as the product of a single country. In Federal Register 67-198, AMS addresses the problem of multiple origins, but an abundance of fine distinctions that a producer or retailer must consider indicates a potential for difficult and inconsistent labeling. For example, ground beef normally contains meat from more than one animal and thus could include beef from both the U.S. and another country. The new law will require the processor to verify the origin of each animal and determine the proportion used of each so that the label can reflect country of origin by prominence of weight. Thus, a label reading “From Country X, Slaughtered in the United States; Product of Country Y; and United States Product” would classify a product primarily from cattle born and raised in Country X but slaughtered in the U.S. followed by imported Country Y beef trimmings and beef trimmings of U.S. origin (AMS/USDA 2001a p. 63370).

Products exempt from the mandatory COOL regulation include ingredients in a processed food item and food sold in restaurants or through the food service channel. AMS defines an ingredient in a processed food item as either “a combination of ingredients that result in a product with an identity that is different from that of the covered commodity” or “a commodity that is materially changed to the point that its character is substantially different from that of the covered commodity” (AMS/USDA 2002a, p. 63368). Examples of the former definition could be peanuts in a candy bar or salmon in sushi. Under this definition, a bag of frozen mixed vegetables would remain a covered commodity because it maintains its identity, but the peanuts and salmon in the earlier example would not. Examples of the latter definition include anything cooked, cured, or dried like corned beef briskets or bacon. These are to be considered functionally different products than the meat the processor began with, whereas vacuum-packed steaks or roasts retain their identity after processing and thus require mandatory labeling under COOL.

COOL regulations do not affect restaurants, but have implications for nearly everyone else within the unprocessed food chain. The law states that “the Secretary may require that any person that...distributes a covered commodity for retail sale maintain a verifiable record keeping audit trail...to verify compliance” for a period of up to two years (AMS/USDA 2002a, p., 63371). This includes foreign and domestic farmers and ranchers, distributors and processors, and retailers. We discuss the ramifications of this audit trail requirement for the cost of compliance below.

Do the Benefits of Mandatory Labeling Outweigh its Costs?

The cost of COOL implementation can only be estimated at this time. The major direct costs of the program include the costs of segregating and tracking product origins, the physical cost of labels, and enforcement costs. AMS itself projects that domestic producers, food-handlers, and retailers will spend \$2 billion and 60 million labor hours on COOL in the first year, though these figures were questioned by the GAO in a 2003 report. The GAO (1999b) reports that the Food and Drug Administration has estimated that the cost of monitoring COOL for producers will be about \$56 million annually. The costs of implementation for produce will likely be lower than the costs of implementation for meats as some fruits and vegetables are already labeled by country of origin. From a policy perspective, whether these uncertain costs outweigh the

benefits to society of the program, and the extent to which retailers, producers and consumers will share these costs, are of equal importance.

The extent to which COOL may benefit domestic producers depends on two considerations, (1) whether country-of-origin information will induce and/or allow consumers to demand more domestic products relative to their foreign counterparts (assuming all other attributes are identical), and (2) whether the costs of COOL implementation will be differentially higher for foreign suppliers than domestic suppliers. If COOL costs foreign suppliers more to comply than domestic suppliers, the transaction costs imposed by COOL will be lower for domestic suppliers than for foreign suppliers. Even if the price elasticity of demand for foreign and domestic goods is the same, demand for foreign products will fall more than demand for domestic products, and some consumers who previously bought foreign goods will switch to buying domestic ones. This effect will be exacerbated to the extent that labels themselves affect consumers' preferences or allow them to act upon preferences that were unsatisfied before mandatory labeling. If consumers truly prefer domestic products relative to foreign ones, all other characteristics being equal, COOL will be accompanied by increased demand for domestic goods. If this effect and the differentially higher compliance costs for foreign goods are large enough, this could theoretically offset the reduced demand for labeled goods occasioned by the transactions costs imposed by COOL. Gains to domestic producers are limited by the size of the market share claimed by foreign producers prior to the introduction of COOL, but in this case domestic producers would benefit from the regulation. Consumers could be net beneficiaries as well if mandatory labeling satisfied a preference that the market previously failed to serve.

Economic theory and empirical evidence both suggest that the benefits of COOL are unlikely to outweigh the costs of compliance. Both consumers and suppliers are likely to be worse off as a result of this regulation. The major support for this conclusion comes from the concept of "revealed preference." In the absence of market failures, the fact that producers have not found it profitable to provide COOL to customers voluntarily is strong evidence that willingness to pay for this information does not outweigh the cost of providing it. If the benefits outweighed the costs, profit-maximizing firms would have already exploited this opportunity. Of course, this argument depends on whether the market for agricultural products functions well and would be responsive to consumer demands for COOL if it existed. In this section, we argue that this is indeed the case, and provide empirical support for the theoretical argument that the costs of COOL exceed its benefits. These findings are consistent with the conclusion of the U.S. Food Safety and Inspection Service (2000), that there is no evidence that "a price premium engendered by country of origin labeling will occur, and, if it does, [that it] will be large or persist over the long term."

There is little evidence that imperfections in the food market prevent producers from providing country-of-origin-labeling. Asymmetric information, where one party in a potential transaction has better information than the other, can indeed lead to inefficient outcomes. However, in standard economic theory this result arises either because a seller would like to signal that his product is of high quality but is unable to do so convincingly, or because a seller that has a low-quality product can pretend that

it is high quality.⁶ But this situation does not plausibly apply in the case of COOL in agriculture. There is nothing now that inhibits producers from “signaling” the national origin of their products.

Whatever their revealed preference, do consumers have a stated preference for country-of-origin labeling? The GAO (1999b) summarizes survey evidence as indicating that American consumers claim they would prefer to buy U.S. food products if all other factors were equal, and that consumers believe American food products are safer than foreign ones. However, surveys also suggest that labeling information about freshness, nutrition, storage, and preparation tips is more important to consumers than country of origin (GAO 1999b; for further a review of survey evidence see Robinson 2003). Revealed preference arguments in their simplest form suggest that if consumers truly preferred domestic food products, it would only take one grocer to limit store items to domestic-only products before other stores saw this grocer’s success and followed suit (Golan, et al. 2000).

Many producers have voluntarily provided labeling information for a variety of reasons. Producers of organic products have voluntarily labeled their products to attempt to capture a premium, as have producers of “dolphin-safe tuna.” If demand for information exists, agricultural producers have generally been adept at seizing this opportunity. Similarly, many lamb imports from Australia and New Zealand already bear obvious country-of-origin labels going beyond legal requirements because consumers prefer this product to domestic lamb and lamb from the rest of the world (Golan et al. 2000). Thus, Australian and New Zealand suppliers have an incentive to label their lamb products because they infer a positive net benefit to doing so, while producers and retailers who abstain from the practice must know that sales will not increase enough from offset labeling costs.

There are other non-economic arguments used to support mandatory COOL that relate to food safety. It is possible that COOL would make tracing disease outbreaks easier, thus reducing the health costs of food-related diseases. This is less likely than might initially seem to be the case, because of the long delay between disease outbreaks and the shipment of contaminated products (GAO 1999b). If domestic products are systematically safer than foreign products, substitution towards domestic goods could also increase the average safety level of food consumed. However, there is little evidence that foreign food products are systematically less safe than domestic products. Existing inspection rules ensure that foreign and domestic meats meet the same standards.⁷ Foreign fruits and vegetables do not systemically carry more pesticide residue than their domestic counterparts (GAO 1999b). There is insufficient evidence to determine if bacteria levels differ between foreign and domestic produce (GAO 1999b).

⁶ The classic example of this is the used car market where sellers will always claim that cars are not lemons; would-be buyers have difficulty determining which claims are legitimate. See, Akerlof (1970).

⁷ The fact that this inspection process results in foreign meat bearing a sticker reading “USDA Grade” in grocery stores was raised as a complaint during the debate over COOL. It was argued that this misleads consumers into assuming that the meat they purchased originated in the U.S.

⁸ Concerns about food safety may become more salient in coming years, making mandatory labeling more desirable and the marginal cost of the COOL regulation lower. For example, the FDA has proposed that, under the authority of the 2002 Bioterrorism Act, it will require the food industry to improve record keeping (GAO 2003). If this occurs, the incremental costs of COOL implementation will be reduced.

Not surprisingly, in light of revealed preference arguments, many retailers have argued that the cost of COOL implementation will be excessive and burdensome (see for example, the comments of U.S., Canada and international pork organizations sent to the U.S. Secretary of Agriculture (Roper et al. 2002)). As noted above, AMS has forecast an annual cost of \$2 billion to implement the regulation. These costs will be borne by the private sector as the Farm Bill provides no funds to alleviate industry costs for developing and maintaining the necessary record-keeping systems (AMS/USDA 2002b). In addition, the statute prohibits the development of a mandatory identification system for certification purposes. Instead, USDA must “use as a model certification programs in existence on the date of this Act” (AMS/USDA 2002a). As discussed earlier, USDA is also allowed to require a verifiable recordkeeping audit trail from retailers to verify compliance.” These seemingly contradictory directions to the USDA—no mandatory identification system is allowed, but an audit trail from retailers may be required—could limit the AMS’s ability to implement the COOL legislation, but is likely intended to act as a prohibition against any efforts to mandate full-scale “traceback” requirements that would track products from the farm gate to the grocery store (Hayes and Meyer 2003). Such a formal traceback requirement would impose costs with legal incidence on producers in the field unlike a certification program, where the legal incidence of the costs of regulation falls mostly on retailers and processors. Of course, the economic incidence of the costs of this regulation will be determined by the price elasticity of demand (and derived demand) for products, as explained in the discussion that conceptualized COOL as a transaction cost.

While retailers’ organizations, like the Food Marketing Institute, have generally been against mandatory COOL, perhaps the loudest complaints about the cost of COOL have come from the meat packing and processing industry. In particular, the costs of tracking and labeling the origin of ground meat products are expected to be relatively high. For example, the president of the American Meat Institute, a trade group representing meat packers and processors has claimed that COOL regulation will be costly and complicated and that it will “force companies to source their meat not based on quality or price, but based on what will simplify their labeling requirements” (Boyle 2002). The National Pork Producer’s Council also opposed COOL legislation (Roper et al. 2002), and has since funded a study that estimates that the cost of COOL implementation will translate into a \$0.08 per pound increase in the average retail cost of pork (Hayes and Meyer 2003). A key element of this study is an argument that, whatever the intention of the authors of the COOL legislation, implementation will in practice require complete “traceback” capability from the farm to the retail level. With the 2003 discovery of BSE in the U.S., a comprehensive traceback system for livestock may receive greater political support.

Agricultural ranchers and growers have largely welcomed the COOL legislation. The California Farm Bureau (CFBF 2003), the Rocky Mountain Farmers Union (RMFU 2002), and the Western Growers Association (McInerney 2003), among other such organizations, have endorsed this regulation. These organizations generally argue that (1) consumers “want” labeling, (RMFU 2002), (2) consumers have a “right” to country-of-origin information (Delta Farm Press 2001), and (3) that the legislation is a valuable “marketing tool” (Maralee Johnson, Executive Vice President of the

Illinois Beef Association, as quoted in the Tarter 2000). The first of these arguments is weakened by the logic of revealed preference. In the case of meat products, the comments of the president of the American Meat Institute above explain the logic of the third justification; packers may demand more domestic inputs if this lowers the cost of COOL compliance. There is also some suggestion that the alleged market power exercised by the relatively concentrated meat-packing industry has created rents that COOL will dissipate (Tarter 2000). That is, the bargaining position of producers relative to packers will be improved as a result of these rules. This is at least in part because legal liability for failure to comply with COOL will rest with retailers, not with suppliers closer to the farm gate.

COOL as a Non-tariff Barrier to Trade

COOL has been justified as an attempt to favor domestic products in the U.S. market, and early indications suggest that foreign suppliers believe it will do so. Canadian cattle groups have suggested that beef be given a “North American” label if it comes from any country in NAFTA (Hord 2002). Meat producers in New Zealand have stated their disappointment with the regulation (Southland Times 2003).

International trade considerations may have made COOL more politically palatable in 2002 than it had been in the past. In 2002, the EU required member states to label all beef at the retail level, including ground beef, with information about the country of birth, fattening, and slaughter. This tightens regulations that have been in place since 2000 (European Union 2000). Canada, Mexico, and Japan all have some version of COOL regulation. Other labeling initiatives have also been introduced in the EU, particularly for foods containing genetically modified organisms (GMOs), regulations which are generally thought to be detrimental to U.S. products (Rousu and Huffman 2001).

One of the main arguments in favor of COOL, discussed above, has also been used to justify mandatory GMO labeling in Europe. That is, the consumer has a “right to know” what they are eating. Ironically, the U.S. government has strongly opposed mandatory GMO labeling, and for good reason. In practice, GMO labeling has not given EU consumers greater choice, because food processors in Europe have recombined ingredients away from GMOs to avoid labeling. As suggested by comments from meat packers, the same pattern may develop with COOL.

Just as intended, COOL is a non-tariff barrier to trade; this does not necessarily mean that it will be challenged at the WTO, but it could be vulnerable to such a challenge, or subject to negotiation. At the WTO, country-of-origin labeling is covered as a technical regulation subject to the WTO Agreement on Technical Barriers to Trade which states that countries are allowed to take measures to protect human health or prevent deception of consumers, subject to the requirement that countries are not unjustifiably discriminated against, and that measures do not constitute a disguised restriction on trade.^{9,10} In NAFTA, country of origin labeling is allowed, but

⁹ The precise wording of the text is: “no country should be prevented from taking measures necessary for the protection of human, animal or plant life or health, of the environment, or for the prevention of deceptive practices, at the levels it considers appropriate, subject to the requirement that they are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail or a disguised restriction on international trade....”

requirements must be minimally difficult and costly. Concerns about meeting this requirement may have been what initially prompted Secretary of Agriculture Ann Venneman to speak positively about the suggestion that a “North American” label could be appropriate (Hord 2002b). COOL compliance may be most costly for developing country suppliers to the U.S. market who lack recordkeeping infrastructure to maintain audit trails. To this extent, COOL directly conflicts with the spirit of trade liberalization in the Doha Development Agenda, which aims to give preference to the trade agendas of developing countries.

To justify the continued existence of the Export Enhancement Program, which purports to offset subsidies and other trade-distorting practices used by other countries, Congress expanded its list of unfair trade practices to include “unjustified trade restrictions or commercial requirements, such as labeling, that affect new technologies, including biotechnology” (ERS/USDA 2002c). The irony of this new requirement in the same bill mandating country-of-origin labeling will not be lost on U.S. trading partners where consumer distrust of biotechnology, whatever its scientific merits, is an important phenomenon. Challenging labeling of GMOs at the WTO may be more difficult after the passage and implementation of the 2002 COOL regulation.

IMPLICATIONS OF ENVIRONMENTAL PROGRAMS FOR INTERNATIONAL TRADE

The 2002 Farm Bill roughly doubles annual federal expenditure on environmental programs, including the Environmental Quality Incentive Program (EQIP), the Conservation Reserve Program (CRP) and the new Conservation Security Program (CSP), from \$2 billion to \$4 billion, over 1996 levels.¹¹ Each of these programs benefits producers in California. The CRP pays farmers to convert environmentally sensitive cropland to conservation uses. EQIP provides technical assistance, cost-sharing, and incentive payments for producers that undertake qualifying practices that provide environmental benefits. The new CSP provides incentive payments of about \$300 million per year for the maintenance or implementation of soil, water, and air quality conservation activities. By paying producers to maintain practices they have previously found to be profitable to undertake, CSP payments are not necessarily intended to internalize environmental externalities but are certainly intended to support agricultural incomes.

The continued exemption of environmental payments from support ceilings makes payments for environmental benefits (compensation for the cost of internalizing environmental externalities created as a result of agricultural production) an attractive program for policy makers wishing to subsidize agriculture while meeting WTO obligations.

International trading rules have only recently become potential constraints on the form and content of U.S. domestic support to agriculture. The Uruguay Round Agreement on Agriculture (URAA) introduced a major reform that the U.S. must take

¹⁰ COOL differs from geographic indication protection (e.g., rules which require that only wine produced in Bordeaux can be labeled as Bordeaux wine), which is covered in the Trade-Related Aspects of Intellectual Property Rights Protection, though both forms of protection can act as non-tariff barriers to trade.

¹¹ For an overview of these programs and other environmental or conservation elements of the 2002 Farm Bill, see Anderson 2002, and Lovejoy and Doering 2002.

into account when setting domestic agriculture policy: a ceiling on so-called trade-distorting domestic support for agriculture.¹² All support for agriculture must be classified as trade distorting, minimally trade distorting, or non-trade distorting, and, while total support levels are unconstrained, trade-distorting support must fall at or below a negotiated cap (now equal to about \$19 billion for the U.S.) that declines over time.¹³ “Amber box” support is trade-distorting and counts towards countries’ negotiated cap, and “green box” support is deemed not trade-distorting and may be allowed without limits.¹⁴ Since supposedly non-distorting “green box” spending is not subject to a cap on support expenditure, identifying support measures that can qualify as “green box” is valuable from the perspective of policymakers wishing to both subsidize agriculture and meet WTO obligations. Green box support includes income support not related to production decisions (i.e., fixed “decoupled” payments or income insurance), environmental and land retirement program payments, domestic food aid, research and extension services, and export promotion programs like the MAP. Over 80 percent of U.S. domestic support for agriculture in 1998 was defined as “green box” by the USDA in 1998 (for a review of the WTO categories into which current U.S. support for agriculture falls, see Nelson 2002).¹⁵ From 1995 to 1998, U.S. aggregate measure of support to agriculture (Amber box support that is not *de minimis*) declined while Green box support grew slightly (these trends are discussed in detail by Paggi 2002).¹⁶

While the rules for some of the environmental programs, in particular the CSP, are still being developed, in general, environmental payment programs can be designed for inclusion in the WTO green box, making increased funding for these programs attractive. Domestic support qualifies for the WTO green box if the measure, (1) is paid for by federal government revenues (as opposed to consumers through a price mechanism), (2) does not provide price supports, and (3) does not distort trade or has minimal effects on trade. Environmental payments in particular must be limited to the extra cost or loss of income incurred as a result of participation in the program.

Some authors have argued that, whatever its merits as a negotiating position, subsidies for agriculture as a means of generating desirable joint outputs (such as stewardship) or environmental benefits is poor public policy (Normile 1999). This is principally because subsidies for agriculture or payments to agricultural producers for environmental services do not directly target the production of the desired nonfood outputs (e.g., open space, or rural livelihoods) but do so indirectly (see OECD 2001). In general, less transparent programs lacking clear environmental goals are unlikely to be cost-effective means of achieving desired environmental outcomes. Bohman et al. (1999) give the example of beautiful meadows to illustrate this claim. Meadows are desirable, and one way of creating them is to provide support to dairy farmers; in this

¹² The URAA also required all countries to convert non-tariff barriers to trade to tariffs (“tariffication”) and to reduce tariffs over time. Developing countries were given a separate, less stringent, set of commitments.

¹³ Technically countries have agreed to caps on their aggregate measure of support (AMS). The AMS totals, commodity by commodity, all support directly tied to prices or production. It is related to the producer subsidy equivalent (PSE).

¹⁴ However, if the amber box support level is “*de minimis*,” that is, the subsidy is product-specific but less than 5 percent of the value of production, or it is non-product specific and less than 5 percent of the total value of agricultural production, then it is exempt from the amber box support cap. There is another category of support, used by European countries. So-called blue box support, which is trade-distorting, but not subject to reduction commitments.

¹⁵ European support for agriculture is far more heavily concentrated in the amber box than U.S. policies (Beierle 2002), though recent reforms to the EU Common Agricultural Policy do appear to increase the role of green box support (Kelch, Hash, and Normile 2002).

¹⁶ From 1998 to 2000, AMS actually increased in the U.S. according to unofficial calculations (Korves and Skorburg 2000)

case, meadow existence is indirectly supported. A more transparent policy, more closely targeted to meadow creation, would be to compensate people for maintaining meadows. Dairy farmers may or may not be the most efficient providers of the desired good. More generally, other social objectives can be accomplished by broader development initiatives (e.g., tax breaks for business location in rural areas), and environmental externalities can be internalized through targeted and transparent regulations and taxes. The key empirical question, on which further research is needed, is which desirable nonfood outputs are genuinely joint outputs of food production, and which of these would be supplied at a socially inefficient level if food production were not subsidized (OECD 2002). Too often, proponents of multifunctionality may overstate the extent to which positive environmental or social externalities are truly joint outputs of food production as an excuse to avoid the politically difficult task of reducing subsidies to agriculture. Environmental goals might be more cost-effectively achieved with policies not intended to subsidize agriculture.

WHAT'S AT STAKE FOR CALIFORNIA AT THE WTO?

California agricultural producers cannot all win from increased trade liberalization. Ending government support for agriculture and lowering tariff barriers will inevitably benefit some more than others. On the whole however, California producers sell high-value competitive products, and their major markets, especially Japan and the EU, remain protected and difficult to penetrate. Coordinated liberalization that affords California increased access to these markets, even if at the expense of increased competition from China and Mexico, could be an important opportunity. This is all the more true because most of California's agricultural producers have few subsidies to give up. Even the loss of the export promotion programs would not be very costly; these programs provide little benefit to the industries they support.

Because California agricultural producers as a whole stand to gain from global trade liberalization, if the 2002 Farm Bill jeopardizes the possibility of wide ranging reform at the WTO, it may be correct to conclude that the Farm Bill was costly to California farmers. Negotiations are currently stalled; largely over disputes about government support to agriculture in the U.S. and EU.

The international response to the 2002 Farm Bill has generally been negative; the Bill has been characterized as politically motivated, and a violation of the spirit, if not the law, of the U.S. commitment to reduce domestic subsidies for agriculture undertaken in the URAA and at the commencement of the Doha round of negotiations (European Union 2002, *The Economist* May 9, 2002). It does appear that the U.S. will not violate its support cap of \$19 billion as a result of the 2002 Farm Bill (Babcock 2002), although this depends on whether the U.S. commits explicitly to reducing support outlays in the event that a violation appears likely. Yet there is some suggestion that the moral authority of the U.S. as a proponent of liberalization (generally agreed to be beneficial for food-exporting poor countries) at negotiations has been compromised. Others argue that new provisions of the Farm Bill may represent bargaining chips that can be used in negotiations to encourage other developed countries to reduce their own support for agriculture (Babcock 2002). The

current U.S. negotiating position, announced in July 2002, proposes further tariff reductions, an end to export subsidies and a somewhat tighter cap on amber box domestic support (USTR 2002c).

Despite the negative international reaction to the Farm Bill, there remains a relative consensus, at least in the popular press, that the EU's CAP is possibly more damaging to developing country agriculture than U.S. farm policy. In addition, as recently as January 2003, the French government reaffirmed its commitment to protect French farms from international competition. It is difficult to predict how this unapologetic stance, in contrast to the continuing claims by U.S. representatives at the WTO that their country is committed to reform, will impact WTO negotiations.

The U.S. balancing act between a stated commitment to trade liberalization at the WTO and the 2002 Farm Bill also contrasts with the position of the Cairns Group of countries at the WTO.¹⁷ The Cairns Group countries (a coalition of developed and developing country agricultural exporters), provide little domestic support for agriculture and are relatively competitive producers expected to benefit from trade liberalization. The Cairns group has called not only for substantial reductions in distorting domestic support and an end to export subsidies, but also a stricter interpretation of the rules for including support measures as green box support. The group's negotiating proposal states that "since the conclusion of the Uruguay Round the green box has been abused" (Cairns Group 1998).¹⁸ Certainly, it is plausible that, even if individual programs in a country's green box claim do not distort trade, the total level of green box support may do so. Given the wide differences between the visions of the EU and the Cairns Group, with the U.S. somewhere in between, trade negotiations will continue to be difficult.¹⁹

CONCLUSIONS

California's agricultural trading environment holds both new challenges and new opportunities. Established markets in developed countries continue to erect barriers to California's specialty crops, and the developing Chinese market holds uncertain benefits, but also the promise of new competition. Lowering barriers to trade in the protected EU and Japanese markets will undoubtedly benefit California, even if it comes at the cost of reduced subsidies and support at home.

Further trade liberalization in agriculture is a promising avenue for the expansion of California's agricultural trade. As such, California producers should guard against the temptation to support the expansion of domestic policies and non-tariff barriers that make far-reaching genuine liberalization less likely. Growers in Florida can afford to be protectionist because they are not so dependent on foreign markets; California

¹⁷ The Cairns Group includes Argentina, Australia, Bolivia, Brazil, Chile, Colombia, Costa Rica, Guatemala, Indonesia, Malaysia, Paraguay, Philippines, South Africa, Thailand, and Uruguay.

¹⁸ Notably, green box spending by the U.S. has expanded significantly in the recent past. In 1986-88 total expenditures that would have qualified for the green box totaled about \$26 billion. As of 1997, they stood at \$51 million (Hart and Babcock 2001).

¹⁹ The difficulty of multilateral liberalization of agricultural trade was much in evidence in 2003. At negotiations under the auspices of the WTO, a group of developing countries (called the G-22) formed a coalition to fight against generous farm subsidies, particularly for cotton and sugar, in the EU and the U.S. The G-22 effectively stalled the Cancun WTO Ministerial, refusing to negotiate further without concessions on agricultural subsidy policy from richer countries, and will likely remain an important negotiating party.

growers have no such luxury. The 2002 Farm Bill, to the extent that it has damaged prospects for liberalization in WTO negotiations, may be costly to California agriculture. The challenge going forward will be to support policymakers taking difficult political decisions that can further liberalization efforts.

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CHAPTER 6

Commodity Policy and California Agriculture

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Government influences agriculture everywhere. 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 chapter describes government programs that support California commodities and attempts to quantify that description. We present new producer support estimates (PSEs) building on the work of Sumner and Hart.

Federal government programs and some California state programs support California agriculture. The central legislative basis for federal farm programs is now the Farm Security and Rural Investment Act (FSRI Act) of 2002 (PL 107-171). The law affects program crops and provides a framework for government support of some conservation programs that affect a wider array of commodities. We also discuss the implication of implementation of the Uruguay Round Agreement on Agriculture (URAA), 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 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 are particularly important in California. Labor market policy is also important and the subject of a separate chapter. 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 government support for agriculture. We highlight major programs that affect the most important handful of the 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 provisions 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 Support Estimates by policy and by commodity for California agriculture.

USE AND LIMITATIONS OF THE PRODUCER SUPPORT ESTIMATE

The Producer Support Estimate can be used as an approximate indicator of the magnitude of the net subsidy from a policy. 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 (Organization of Economic Cooperation and Development (OECD), 2002).

The Producer Support Estimate 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 barriers, price support, or deficiency payments, the movement of market prices may dominate

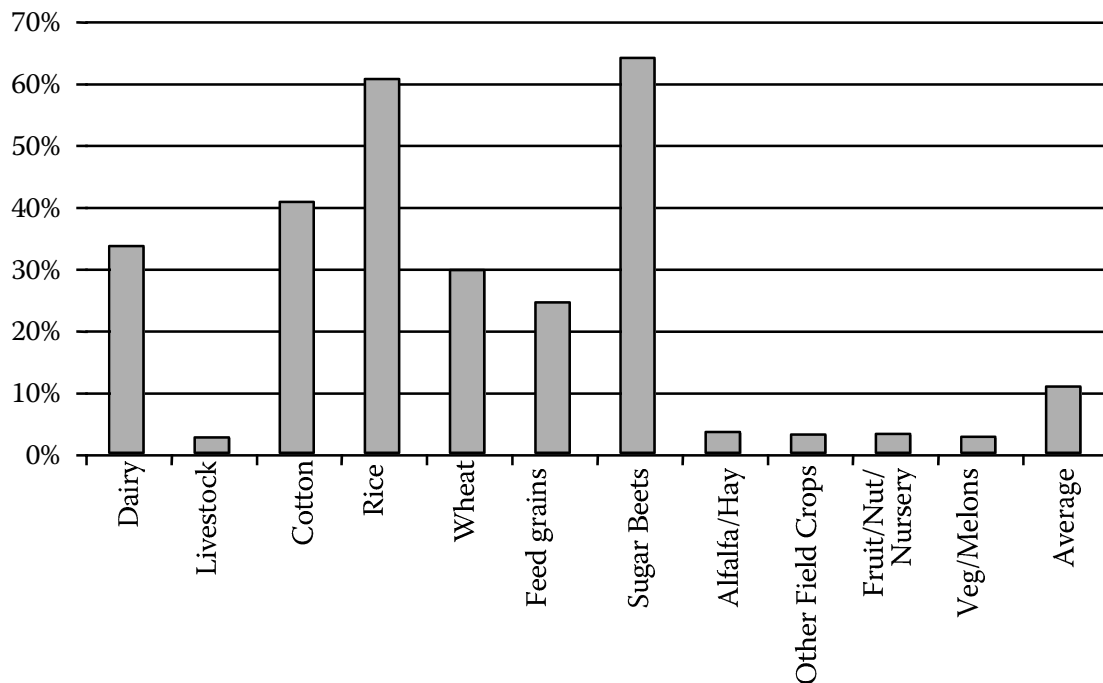
movements in the PSE over time. This means also that a PSE for a single year may not reflect accurately the degree of government support for a commodity in other years.

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 SUPPORT FOR AGRICULTURE AS MEASURED BY PSES

Column 3 of Table 1 reports the dollar value of the Producer Support Estimate by commodity, using methods and data similar to that used by the OECD (2002). Column 2 reports the value of production by commodity so that PSEs can be compared across commodities. The value of production for each commodity includes the value of direct payments and, of course also reflects trade barriers or other policies that raise the market price. Column 4 of Table 1 presents the percentage PSE. In Figure 1, we summarize the percentage PSE for major commodities and commodity aggregates. These PSE figures are based on detailed analysis of data that is reported in the appendix.

Figure 1. Producer Support Estimates by Commodity or Commodity Group



Source: Table 1

Table 1. Producer Support Estimate (PSE) by Commodity^a

Commodities	Value of production ^g	Support	PSE
	----- (Thousand dollars)-----		Percent
Dairy	4,705,171	1,571,330	33.4%
Cattle/calves	1,351,500	33,691	2.5%
Poultry ^b	980,110	23,081	2.4%
Other Livestock/poultry	384,478	10,141	2.6%
Sugar Beets	53,306	34,047	63.9%
Rice	456,194	275,851	60.5%
Cotton	987,875	400,399	40.5%
Wheat	142,475	42,071	29.5%
Feed Grains ^c	120,914	29,392	24.3%
Hay, all	1,020,510	34,252	3.4%
Other Field crops	1,018,197	30,279	3.0%
Almonds	753,720	27,997	3.7%
Other tree nuts ^d	482,016	15,609	3.2%
Grapes, rest ^e	2,249,650	68,582	3.0%
Raisins	401,256	11,090	2.8%
Citrus ^f	736,564	19,037	2.6%
Strawberries	832,515	19,444	2.3%
Other Fruit	1,401,503	68,526	4.9%
Tomatoes, proc.	654,156	24,011	3.7%
Tomatoes, fresh	290,081	7,049	2.4%
Lettuce, all	1,331,292	30,272	2.3%
Other Vegetables	4,149,622	101,858	2.5%
Nursery/Flowers	3,096,506	70,512	2.3%
Total	27,599,611	2,948,522	10.7%

a) The support estimates are generally an average of the period 1999-2001, except for government payments. For federal government payments we used the federal fiscal year 2001 through 2003 for production flexibility contract payments (replaced in 2002 Farm Bill by a direct payment program) and market loss assistance payments (replaced in 2002 Farm Bill by a counter cyclical payment program). We used data from crop years 2000 through 2002 for loan deficiency payment and marketing loan gains.

b) Poultry includes broilers, eggs, and turkeys

c) Feed grains includes corn, barley and oats

d) Other tree nuts include walnut and pistachios

e) Grapes, rest include table and wine grapes

f) Citrus includes oranges and lemons

g) Value of production includes government payments

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 the calculation of the PSE. For many of the programs there is relatively little change from year to year. For these we have mainly use the most recent year available, often federal fiscal year 2000 (October 1 1999 to September 30 2000), fiscal year 2001 or 2002. In some cases we use calendar year 2001 or calendar year 2002 data.

In many cases we measure a portion of the government support as an average of recent years. For example, for commodity payments under the Farm Bill we use the average for crop years 2000 through 2002 for loan base program benefits (Loan Deficiency Payments and Marketing Loan Gains) and federal fiscal years 2001 through 2003 for payment programs under the Production Flexibility Contracts, Market Loss Assistance, Counter Cyclical Payments and Direct Payments. For discussion of the FSRI Act of 2002 see USDA publications by Westcott, Young and Price, and Sumner, 2003.

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 the California budget data for California fiscal year 2000 or 2001 as available. The California fiscal year runs from July 1 to June 30 so, that fiscal year 2001 runs from July 1 2000 to June 30 2001. Other specific measurements 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 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. The crop PSE has likely been declining gradually over time as the share of relatively less subsidized crops has expanded. However, dairy, which is a high subsidy commodity, has an expanding share of California farm value.

As noted in Table 1, the state PSE is about \$3 billion or 10.7 percent of the total value of output and payments (See also Figure 1). The OECD calculates and reports PSEs for member countries for six major crop categories and seven livestock products. Fruits, vegetables, and other horticultural crops are not included in OECD figures. For 2001, the OECD reports an aggregate PSE range from about 1 percent for New Zealand (down from 3 percent in 1994) to over 69 percent for Switzerland (80 percent in 1994). Norway, Iceland, Japan and Korea all have PSEs over 59 percent. The average PSE for all OECD member countries in 2001 was 31 percent (38 percent in 1994). The OECD reports an aggregate PSE of 21 percent for the United States. For the thirteen commodities classified by the OECD, the average PSE in California is roughly equal to that of the United States as a whole. Support levels tend to be lower for fruits, vegetables and other horticultural commodities in the United States and some other countries. The crops that are less subsidized are particularly important in

California and therefore the average PSE we report is well below the PSE for the United States as a whole as reported by OECD.

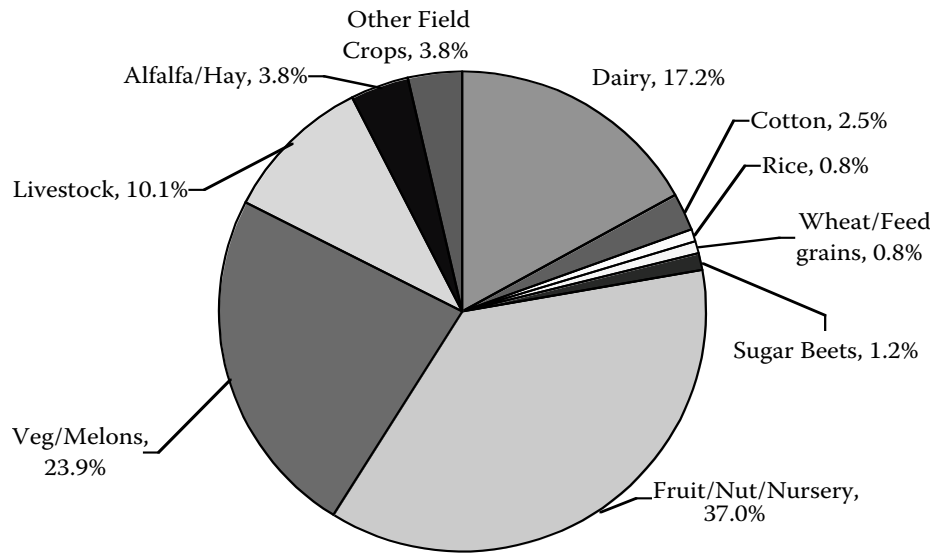
Figure 1 illustrates substantial variation across commodities in the percent PSE. At that high end, sugar has a PSE of 63.9 percent. Rice is next at about 60.5 percent followed by cotton at about 40.5 percent. Wheat has a PSE of about 29.5 percent. Dairy, the state's most important commodity in terms of value of production has a PSE of 33.4 percent. Feed grains, which include corn, oats and barley, have a PSE of about 24.3 percent. The PSEs for all other California commodities are in the single-figure percentage range, which is below the state average of 10.7 percent. Alfalfa and hay, for example, has a PSE of about 3.4 percent. Among the horticultural crops, PSEs range from 3 percent to 5 percent. Other livestock and poultry and the remaining crop categories have PSEs between 2 percent and 5 percent. These low PSE groups include 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, fruits, and nursery crops) comprise well over half of all agricultural receipts in California. Dairy is the most important single commodity with about 17 percent of all receipts. Of the field crops, alfalfa hay is most important, followed by cotton and rice.

Figure 2 is presented to provide a basis for comparison with Figure 3, which shows the distribution of total support by commodity. Now the dairy industry is dominant in terms of its share of total support. Dairy is an important industry in California and also has a relatively high degree of government support. About 54 percent of all support in California agriculture is provided to the dairy industry. Notice that, because of their importance in total receipts, even the less subsidized categories of horticultural crops receive a combined total of over 19 percent of all the PSE for the state. Also, the heavily subsidized but relatively minor crops, cotton and rice, show up significantly in Figure 3.

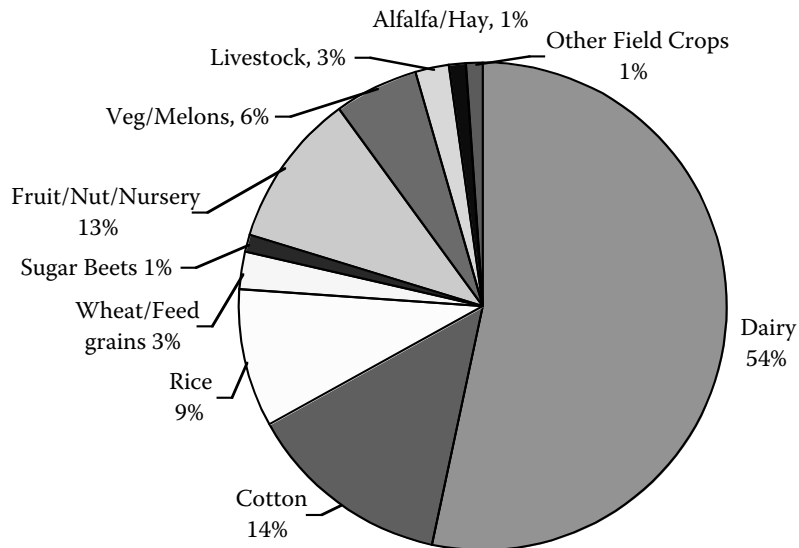
Table 2 provides an alternative categorization of the aggregate PSE. Rather than providing a distribution across commodities, Table 2 distributes the PSE by policy area and more specific policy tools. Import barriers account for the largest share of support, followed by government payments. Input assistance is ranked third. By far the most important policy tool in terms of the aggregate PSE is the dairy import barrier, valued at more than \$1.15 billion per year. Government payments are an important policy, accounting for an annual average of \$210 million in Market Loss Assistance payments (replaced by the Counter-Cyclical Payments under the FSRI Act) and \$194 million in Production Flexibility Contract payments (replaced by the Direct Payment Program under the FSRI Act). Support from marketing loan benefits and Loan Deficiency Payments is valued at nearly \$277 million. Direct payments account for about 25 percent of the total support in California agriculture.

Figure 2. Commodity Share of Total Value of Production



Source: Table 1

Figure 3. Share of Total Support by Commodity



Source: Table 1

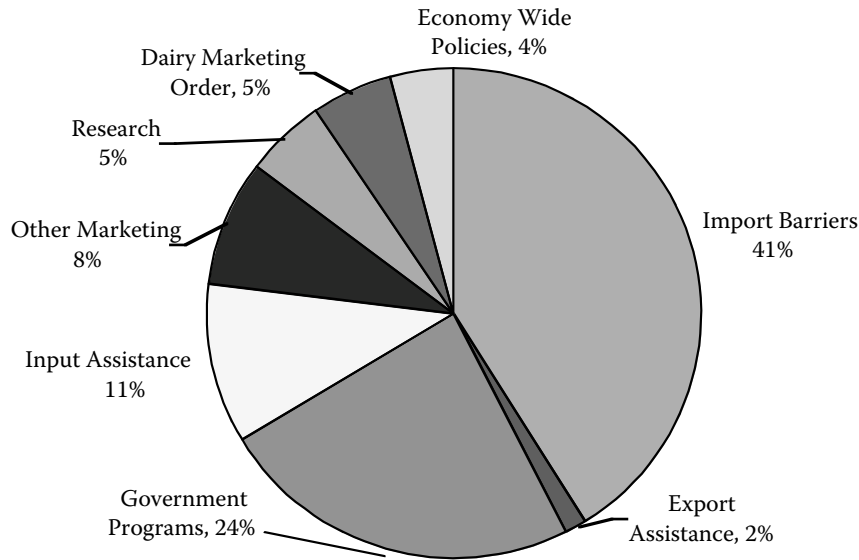
Table 2. California PSE Contributed by Each Policy Tool^a

Policy Tool	Value	Share
	(thousand dollars)	%
<i>Import Barriers</i>	1,180,643	40.0%
Dairy	1,150,360	39.0%
Sugar Beets	30,284	1.0%
<i>Export Assistance</i>	43,382	1.5%
Dairy Export Incentive Program/Export Enhancement Program	20,002	0.7%
Foreign Market Development/Market Access Program	23,380	0.8%
<i>Government Payments</i>	756,235	25.6%
Production Flexibility Contract Payments	194,231	6.6%
Market Loss Assistance Payments	209,808	7.1%
Loan Deficiency Payments and Marketing Loan Gains	277,196	9.4%
Milk Income Loss Contract Payments	75,000	2.5%
<i>Input Assistance</i>	303,998	10.3%
Water	81,810	2.8%
Crop Insurance/Disaster Payments	219,229	7.4%
Grazing Fees	2,959	0.1%
<i>Other Marketing</i>	242,630	8.2%
Inspection	147,149	5.0%
Processing and Marketing	58,300	2.0%
Upland Cotton User Marketing Certificate.	37,181	1.3%
<i>Dairy Marketing Order</i>	154,368	5.2%
<i>Research/Extension</i>	148,842	5.0%
<i>Economy-wide Policies</i>	118,424	4.0%
Total	2,948,522	100.0%

a) The support estimates are generally an average of the period 1999-2001, except for government payments. For federal government payments we used the federal fiscal years 2001 through 2003 for production flexibility contract payments (replaced in 2002 Farm Bill by a direct payment program) and market loss assistance payments (replaced in 2002 Farm Bill by a counter cyclical payment program). We used data from crop years 2000 through 2002 for loan deficiency payment and marketing loan gains.

Figure 4 provides an illustration of some of the data in Table 2. This figure emphasizes visually how widely the aggregated 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.

Figure 4. Share of Support by Policy



Source: Table 2

The rest of the 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.

DAIRY POLICY

Dairy policy in California is important and unique. 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 in other parts of the United States, some of the instruments are unlike those used elsewhere. The California dairy industry participates in the U.S. federal price support program, the direct payment program (MILC) and the industry benefits from U.S. import barriers and export subsidies. But California operates its own regulated milk marketing system, which has some features that differ from the federally regulated

system governing most milk markets outside California and some federal programs have different effects in California (Balagtas and Sumner).

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 (NFDM), and American cheese from processors at prices calculated to ensure that the farm price of milk used for the manufacture of those programs 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 (approximately one percent of milk revenue). The FAIR Act of 1996 was to have eliminated price support program, but that was first delayed and then reversed. The dairy price support program was phased down 15 cents per hundredweight per year, from \$10.35 per hundredweight, and was supposed to be completely eliminated by the year 2000 (at which time it is to be replaced by a recourse loan program). The assessment on dairy production was eliminated immediately and this affected producers immediately (Cox and Sumner, 1997). The FSRI Act continued the price support until 2007 at a rate of \$9.90 per hundredweight of milk.

Trade barriers are the most significant feature of U.S. dairy policy, and no serious trade policy reform was even contemplated in the discussions leading to the 1996 FAIR Act or the FSRI Act of 2002. In general, imports of dairy products in the United States have been limited to about 2 to 3 percent of U.S. consumption. The United States maintains binding tariff-rate quotas with high in-quota tariffs for imports of most major dairy products. These trade barriers have insulated U.S. dairy product markets from world market forces, with domestic prices for major agricultural products typically significantly higher than world prices. California's dairy industry, which produces nearly half of the nation's non-fat dry milk and approximately 20 percent of its cheese, benefits from these border measures. As part of the Uruguay Round Agreement on Agriculture 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 are prohibitively high; therefore, the effects of the TRQs remain the same as the absolute quotas that were replaced. The Uruguay Round GATT agreement also provided for a gradual increase in the quantity of dairy product imports into the United States under the TRQs. This provision allowed for a gradual increase in import access into the U.S. dairy market until 2000. The North American Free Trade Agreement (NAFTA), which became effective in 1994, eliminated dairy trade barriers with Mexico, but Mexico is a high-cost milk producer and so no new imports have arrived. Canada insisted that dairy be largely outside that bilateral free trade regime. Imports of some products, notably casein and milk protein concentrates are outside the TRQ regime. The U.S. dairy industry has proposed imposing new trade barriers to limit imports of these products, but such proposed legislation is still pending and would require some accommodation with WTO trading partners.

Current trade negotiations, initiated with the Doha Round, might increase that import access further. Even under the proposal urged by the United States substantial

increases in imports would be likely. However, a multilateral deal would also allow more imports into Europe and protected Asian markets and reduce export subsidies from Europe, so world prices would be likely to rise substantially. Dairy trade is a significant issue in the proposed free trade agreement with Australia. Australia is a major non-subsidized dairy product exporter and opening the border with Australia would likely place downward pressure on U.S. and California milk prices, especially through the impact on the price of products that contain milk fat.

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 1.15 billion to the dairy PSE in California (we are using USDA data on world prices). 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 has been scaled back over the 1995-2000 period as part of the Uruguay Round Agreement. The average 1999-2001 dairy export subsidy had a relatively small impact on the dairy industry with a value of \$20 million. The 2002 Farm Act also extended DEIP through FY 2007. DEIP payments in 2002 were higher at about \$28 million, of which, under the Uruguay Round WTO agreement most went to exports of NFDM.

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 raw milk according to the class of its end use (classified pricing). 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 FAIR Act of 1996 required the USDA to consolidate current federal orders from about 33 to between 10 and 14 within three years. Today, there are 11 federal marketing orders for milk.

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 NFDM. The California milk marketing order provides for price discrimination, with different minimum prices set by the state for fluid products with relatively inelastic demands.

The California marketing order 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). 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 differences between the average of the high price uses and the average of the low price uses. This difference averaged approximately \$1.70 per hundredweight. 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 calculation. The underlying assumption is that the flow benefits 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 quota amount.

The FSRI Act of 2002 introduced a new direct payment for dairy, the Milk Income Loss Contract (MILC). This payment was designed to limit the total payment to individual producers, thus favoring smaller producers. Research has shown that supply responses to the payments resulted in lower milk prices and that for most California producers, as well as large producers throughout the country, reduced milk revenues due to lower milk prices have outweighed the MILC payment (Balagtas and Sumner, 2002). The direct payments from the MILC payment to California dairy producers totaled approximately \$75 million in 2002.

OTHER TRADE BARRIERS

Aside from dairy, import barriers also apply for the sugar sector in California. 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 prices of sugar in the United States. The sugar import barrier provides California sugar beet producers with over 80 percent of total support.

Other trade barriers for California commodities have relatively small effects. A potential exception relates to selected phytosanitary or food safety and sanitary regulations (Sumner, editor 2003). 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 United States were challenged, and the barrier was slightly relaxed in 1993 and again in 1997 and 2002 (APHIS, 2003). Following the practice of OECD and 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 Support Estimates.

EXPORT SUBSIDIES

In the 1980s and early 1990s, explicit export subsidy programs were 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 on Agriculture (URAA) 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. The FSRI Act of 2002 extended the annual funding through 2007 at the current funding level of \$478 million per year. Budget projections suggest that these authorizations will not be used.

Export credit guarantees, food aid and export promotion programs were not explicitly included among the export subsidy programs facing restrictions in the WTO. However, some of these programs are being challenged in WTO disputes. In this chapter, we have included foreign market development and credit programs as part of export assistance. The Market Promotion Program (MPP), renamed to 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, non-profit trade organizations, state and regional trade groups, private companies and agricultural cooperatives use government money to develop markets mostly for high-value and processed products.

The FSRI Act of 2002 increased MAP funding from \$90 million to \$100 million in 2002 and then to \$200 million in 2007. The FSRI Act of 2002 authorized the use of CCC funds to support the FMD program and increased funding to \$34 million per year.

GOVERNMENT COMMODITY PAYMENTS, CONSERVATION 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 cotton, rice, wheat and feed grains (Sumner, 1995a). The FAIR Act eliminated deficiency payment programs and authority for acreage reduction programs. The price support and marketing loan programs were retained and under the direct payments base land may be used for almost any agricultural activity, including fallow, except fruit and vegetable production (Young and Shields, 1996; Nelson and Schertz, 1996). Under the FAIR Act, participants were to receive a predetermined payment each year for seven years, based on a declining percentage of past deficiency payments. These payments were to be independent of market prices and allow a large range of “agricultural” uses for program base land (Young and Shields, 1996; Smith and Glauber, 1996). However, agricultural prices fell considerably and remained depressed in the late 1990s through 2001. At the same time federal budget deficits became surpluses and Congress responded with annual ad hoc legislation (Market Loss Assistance (MLA) payments) that raised direct payments by 50 percent in 1998 and doubled payments for 1999 through 2001. In addition, the continuing marketing loan programs triggered billions of additional payments. According to the USDA (2003), subsidies jumped from about \$4.6 billion in fiscal year 1996 to \$19.2 billion in fiscal year 1999 and \$32.3 billion in fiscal year 2000. By 2002, subsidies had fallen to \$15.6 billion, because market prices had risen.

The 2002 FSRI Act reauthorized the marketing loan program at slightly adjusted loan rates. Marketing loan programs are also made available for peanuts, wool, mohair,

honey, small chickpeas, lentils, and dry peas. The 2002 Act further replaced the production flexibility contract payments of the FAIR Act with direct payments that are roughly equal to the payments that applied in 2001. These payments are not tied directly to current production of any crop, but are based on historical payments of a specific program crop and continue to forbid planting of wild rice, fruits, tree nuts or vegetables on base land. In addition, farmers were allowed to update the base areas used to determine payments. The third main payment program in the FSRI Act, the counter-cyclical program (CCP) was designed to replace the ad hoc MLA payments that were made from 1998 to 2001. In 2003 payments under the new CCP program were lower than the magnitude of MLA payments in 2001.

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 were in California. Due to the relatively small use of CRP in California, and the requirement of the land idling offset the value of the payments received, CRP contracts were not included in our PSE calculations. Under the 2002 FSRI Act, the CRP along with other major conservation programs was reauthorized and extended. The CRP ceiling increased from 36.4 million acres to 39.2 million acres, so that additional land will be removed from crop production for 10-year periods. The 2002 Act also created a new Conservation Security Program (CSP). This program provides annual payments to farms that use environmentally approved practices in their production operations. Because many farms here in California already apply a number of environmentally approved practices in their operations, this program would provide an additional direct subsidy to farmers on a per acre basis up to relatively small payment limits. But this program has not yet been fully implemented and is very small in total funding.

Crop Insurance

Based on recent data, the Federal Crop Insurance Program provided about \$37 billion in protection on about 78 percent of the nation's insurable acres in 2001 (USDA, 2002). The crop insurance program has experienced rising participation during the past decade as subsidies have increased and coverage has been extended to more crops. The 2001 level was nearly three times as high as the level in 1990, when crop insurance guarantees amounted to about \$13 billion. This protection cost taxpayers about 2.8 billion in 2001. Producers paid about \$1.2 billion in premiums and received about \$3.1 billion in indemnities.

The Agricultural Risk Protection Act of 2000 resulted in increased premium subsidies and adjustments to the formulas used to calculate coverage. Under the new law premium levels at higher levels of coverage have increased. For example, the old subsidy level for a coverage level of 50/100 was 55 percent. It now amounts to 67 percent. For a higher coverage level of 75/100, the subsidy level increased from 24

percent to 55 percent. This change produced significant cost savings for producers purchasing revenue insurance compared to previous years and also led to a higher number of producers choosing a higher level of coverage.

This policy reform has the effect that the crop insurance plays a more important role in the present PSE calculations than it has done under past calculations, because more producers are likely to participate in the program due to the lower cost (higher subsidy). On a nationwide basis, the 2000 Act invests an additional \$8.2 billion over 5 years to improve federal crop insurance.

With regard to California crops, the subsidy resulting from crop insurance in 2001 was substantial for cotton, all grapes, almonds, prunes, apples and wheat. Most other fruits, vegetables and field crops received only little subsidy as a consequence of participating in the crop insurance program.

IRRIGATION WATER SUBSIDY

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) systems 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 then released into the 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 the PSE calculations we assembled data on irrigation water usage by crop and then developed estimates of the subsidy implicit in the CVP. Based on data from the California Department of Water Resources, we were able to obtain figures on irrigated acreage per crop and irrigation region. This enabled us to calculate the total amount of acre-foot of water applied per crop and region. These calculations are based on average irrigated crop acreage during the 1988-1998 period. For commodities without individual number in DWR data, the share is determined by value of production (commodity share of total value).

The subsidy rates for irrigated water from the Central Valley Project are based on data from the Bureau of Reclamation. We calculated the subsidy rate as the difference of the contract rate that a water district pays per acre-foot and the actual cost per acre-foot. Generally, the contract rate ranges from \$10 to \$30 per acre-foot for most regions, but it is very low at \$2 dollars per acre-foot for most contractors in the Sacramento River region. Subsidy rates varied from \$10 to \$40 per acre-foot depending on region. The water subsidy for California is estimated to total almost \$88 million.

We do not consider SWP water in the PSE calculations because it is not subsidized on interest rate or operating cost, which is apparent in the substantially higher cost for SWP water as compared to CVP water. Also, Imperial Valley water is not included here, because the Imperial Valley successfully argued that they are not subject to the National Reclamation Act (Howitt, 2003).

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 exempt from federal gasoline taxes, and these exemptions are reflected in the PSE. Pest and disease control refers to outlays for Animal Plant Health and Inspection Service. 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 provided approximately \$147 million for agricultural plant and animal health, pest prevention and food safety services. Outlays for the Foreign Agriculture Service, Agricultural Marketing Service, and Office of Transportation comprise the federal portion of processing and marketing assistance. For the 1999-2001 period, the average state outlays for California Department of Food and Agriculture marketing, commodities and agricultural services totaled around \$60 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 the contribution to the PSE. Finally, there are state and federal marketing order, board and commissions for many California commodities. These are generally financed by check-off systems that apply a kind of excise tax on the marketed commodity to support promotion or research (Lee et al, 1996).

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 is 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 United States, 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., Sokolow, 1990).

A REVIEW OF PSES FOR SELECTED COMMODITIES

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 dairy 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 \$34 million. Most of this, about \$15 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 \$12 million of the water subsidy to hay is ultimately of benefit to the dairy industry. If the \$12 million were added to a subsidy of about one billion dollars, it would raise the overall dairy subsidy from 33.4 percent to 33.6 percent. In other words the effect of irrigation subsidy on dairy is very small, especially compared to the subsidy from other sources.

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 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 programs). In the citrus industry, crop insurance and disaster payments comprise almost 30 percent of the support; large payments were made following the 1990 freeze that took a heavy toll on the California citrus industry (Lee, Harwood and Somwaru, 1995).

Most 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, walnuts). The share of support from research is relatively high for these commodities, around 25 percent. Nevertheless, since these percentages equal very small PSEs for the horticultural commodities, the overall subsidy is quite small.

Cotton and Grains.

The federal programs for these commodities were discussed in detail above. Direct government payments provide the lion's share of support: 90 percent for rice, 74 percent for cotton, 86 percent for feed grains, and over 76 percent for wheat. Cotton, wheat, and rice have active marketing orders but compared to the value of the direct income supports, 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 2.2 percent.

Meat and Poultry

Cattle and calves and poultry have similar policies and a similar overall level of support; both have a PSE of around 2.5 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 states marketing orders to facilitate market promotion and research. A small share of the poultry PSE originates in support under the Export Enhancement Program.

CONCLUSION

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. This chapter does not provide 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 figures for the United States 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, many of these segments of California agriculture expect to prosper as markets are opened and subsidies reduced.

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APPENDIX

Producer Subsidy Calculations

- CCC Payments: For federal government payments we used average federal fiscal year figures for 2001 through 2003 for Production Flexibility Contract Payments (replaced in the 2002 Farm Bill by a Direct Payment Program) and Market Loss Assistance Payments (replaced in the 2002 Farm Bill by a Counter-Cyclical Payment Program). The data is available at the USDA Farm Service Agency (FAS) website at (<http://www.fsa.usda.gov/dam/bud/bud1.htm>). We used national payments and apply the California commodity share of value of production. We used three-year average data from crop years 2000 through 2002 for Loan Deficiency Payment and Marketing Loan gains. The California data is available at the FAS website at <http://www.fsa.usda.gov/dafp/psd/reports.htm>. The PSE for cotton also includes the Step 2 user marketing payments X California share of cotton value. Here we applied the average for the federal fiscal years 2001 and 2002.
- Crop Insurance: The PSE measure from crop insurance is not the expected value but the actual net cash flow to producers in a given year. This is equal to the total indemnities minus the sum of the total premium, the subsidy, the farmer's cost share and the premium discount, which are essentially the total indemnities minus the producer premium. Recent crop insurance data for crop and states is available from the USDA Risk Management Agency at <http://www.rma.usda.gov/data/>
- Trade Barrier, Dairy: (California price-world price) X California production. Monthly 2002 California production is used for cheddar cheese, butter and non-fat dry milk and monthly 2002 prices are used (*California Dairy Information Bulletin*, 2002). The world price is a simple average of the EU export price and the Oceania export price (*Dairy World Markets and Trade*, USDA FAS, 2002).
- Trade Barrier, Sugar: 2001 California value of production X the ratio of 2001 world price to 2001 domestic price. We calculated the price ratio to be 0.43 (the world price is 43 percent of the U.S. price). The benefit to sugar producers is 57 percent of their revenue. U.S. and world sugar prices come from the USDA ERS Sugar and Sweetener Yearbook, 2003, available at <http://www.ers.usda.gov/Briefing/Sugar/Data/data.htm>. California sugar beet value of production comes from the *2002 California Agricultural Resource Directory* (2002).
- Grazing Fees: Difference between private and public price for grazing AUM X the total number of California AUMs on public lands. (The AUM is the amount of forage needed by an "animal unit" (AU) grazing for one month. The animal unit in turn is defined as one mature 1 000 pound cow and her suckling calf). The private price per AUM was obtained from the USDA, NASS Agricultural Prices, available at: <http://jan.mannlib.cornell.edu/reports/nassr/price/zap-bb/agpran02.pdf>. The public price per AUM was obtained from the Bureau of Land Management (<http://www.ca.blm.gov>).
- 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).
- Export Subsidy: EEP (and DEIP) 2000-2002 average expenditures X California commodity share of national receipts. EEP (DEIP) expenditures are from USDA Foreign Agricultural Service Export Program Statistic Summary (2003), available at <http://www.fas.usda.gov/export.html>. For dairy and poultry, California market share is calculated from data available at the USDA National Agricultural Statistical Service. DEIP benefit determined from Uruguay Round Agreement maximum DEIP levels.

- FMD/MAP: 1999-2001 average allocation by commodity X California share of U.S. value of production. Allocations are often made to specific trade organization, for instance the California Prune Board. In such cases 100 percent of the payment was counted toward the PSE. In more general payments, California share of U.S. value of production was taken into consideration. Vegetable, fruit and nut expenditures divided by share of commodity value in those categories. Expenditures are found at the USDA Foreign Agricultural Service Export Program Statistic Summary (2003). The California share of U.S. value is calculated from data of the USDA, NASS (2002).
- Water: Subsidies apply for water from the Central Valley Project (CVP). The California Department of Water Resource (DWR) supplied data on averages of irrigated acreage per crop and irrigation region, and on average amount of acre-foot per acre of irrigated crop. The product (total irrigated acreage X acre foot per acre) yields the total amount (in acre foot) of water applied per crop per irrigation region. Subsidy rates were obtained from Bureau of Reclamation data, which lists figures for the contract rates and actual costs per acre-foot in the CVP regions. The difference between the actual cost and the contract rate is assumed to be approximately equal to the subsidy rate. DWR crops were almost identical with the crop selection in the PSE calculations. When that was not the case, crops were grouped into existing groupings according to their value of production.
- Inspection: Average state expenditures (1999-2001) X commodity share of California value. Inspection includes payments for Animal and Plant Health Inspection Service, Grain Inspection, Packers and Stockyard Administration and Food Safety Inspection Services. State expenditures on agricultural plant and animal health, pest prevention and food safety services are available in the Governors' budget (2002).
- Processing and Marketing: This includes 2001 CDFA expenditure for marketing, commodities and agricultural services. CDFA expenditures are 2001 expenditures from the *Governor's Budget 2001-2002* (2002).
- Research: (California share of average U.S. expenditures (1998-1999)) X (commodity share of California value) X (0.3). The California share of U.S. expenditures is calculated by multiplying the market share derived from USDA National Agricultural Statistical Service data (13 percent of U.S.) with the research expenditures in the U.S. notification to the WTO (1999). The total expenditure listed here also includes California expenditure for the Cooperative State Research, Extension and Education Service (CSREES). Commodity shares are found in the *2001 California Agricultural Resource Directory* (2002) data. The 30 percent factor represents the authors' estimate of the benefit from expenditure to producers.
- Disaster Payments: Average national disaster payments (1996-2001) X (California share of U.S. agricultural value) X (commodity share of California value). National disaster payment totals are available at the USDA's Economic Research Service (Statistical Indicators). The California share of U.S. agriculture value is based on USDA National Agricultural Statistical Value data. Commodity shares are found in the *2001 California Agricultural Resource Directory* (2002) data.
- Farmer's 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 obtained from the USDA's National Agricultural Statistical Service (2003) and the commodity shares are from the *2002 California Agricultural Resource Directory* (2003).

CHAPTER 7

Water Infrastructure and Water Allocation in California

Richard Howitt and Dave Sunding

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One of the major problems in California is that the state's water is concentrated in the north, but the majority of the state's urban population and irrigated agriculture is located in the south. California contains 32 million acre-feet of developed water, of which 84 percent is used to irrigate 9.68 million acres of agricultural land. Because such a large proportion of water resources is used for irrigated agriculture, most water management conflicts involve the movement of water to or from irrigated agriculture. While most of the water is used to irrigate field and fodder crops, the high value vegetable and fruit crops generate the majority of agricultural revenues.

State Water Project and Federal Central Valley Water Project

From the 1950's to 1970's different government agencies at the State and Federal level implemented a massive water development program in California. This program was built upon the traditional supply augmentation approach to water development. Unfortunately this approach to water development is flawed. The main weakness of the traditional supply based method is that it assumes that the demand for water is perfectly inelastic and unchanging over time. An inelastic demand assumes that there is little quantitative response to changes in the price of water. Under this planning approach the quantity of water to be delivered by a water project is fixed, and the only question is how to minimize the costs of supplying it. Economic analysis is then performed to see if the total costs of the water project are less than the total benefits.

Both the State Water Project (SWP) and the Federal Central Valley Water Project (CVP) were developed using the principles of the supply-based approach to water development. The SWP was originally projected to supply an average annual quantity of 4.2 million acre-feet of water in two stages. The first stage of 2.2 million acre-feet was built and put into service in the late 1960's and early 1970's. However, subsequent attempts to build the remaining 2 million acre-feet capacity have met with effective opposition from environmental interests, who want to prevent any further water development, and current contractors, who know that the average cost of water delivered by the system will have to increase by up to 300 percent to finance the completion of the planned project.

In 1994 the SWP project contractors and operators met to renegotiate the conditions for water sales among contractors and the allocation of cuts in water deliveries during drought periods. The resulting Monterey agreement also enabled contractors who overlie a state operated groundwater storage project to exchange the control of the project for surface water entitlements; these entitlements could then be transferred to urban contractors. Finally, the agreement sanctioned the permanent transfer of 130 thousand acre-feet of water from agricultural to urban users.

The CVP parallels the SWP and delivers 4.6 million acre-feet of water to both urban and agricultural contractors. Urban contractors receive 10 percent of total water deliveries while the remaining 90 percent of water is diverted to agricultural contractors. The CVP was operational in 1965, but by 1992 there was considerable political pressure to modify the operation of the project to reduce environmental damage to different fish populations in the Sacramento River Delta. The resulting Central Valley Project Improvement Act (CVPIA) reallocated water to environmental uses by cutting water deliveries by 1 million acre-feet in normal rainfall years and by 804 thousand acre-feet in critical rainfall years. The CVPIA mandated that 800 thousand acre-feet of water be reallocated to instream uses to protect the salmon runs, while 400 thousand acre-feet of water be reallocated to wildlife refuges (Hanak, 2003).

Water markets in the CVP districts are limited to local sales among agricultural contractors. These sales are short in duration and are generated by differences in the water allocations between farm regions and years. Due to institutional constraints, CVP water is still largely used for agricultural irrigation despite a three-fold difference between the value of water in nearby urban sectors and agricultural sectors.

In recent years, State and Federal law have mandated a set of modifications that affect both the state and federal water projects in California. In 1996 and 1997 California developed the 4.4 Plan that aims to reduce diversions from the Colorado River to 4.4 million acre-feet over a period of 15 years. Moreover, in 2000 the Environmental Water Account (EWA) was implemented by the state and federal governments. The purpose of the EWA is to regenerate the fisheries of the San Francisco Bay-Delta system while simultaneously securing water supplies to both urban and agricultural users. Both these developments have encouraged water trading.

PEACE BREAKS OUT ON THE COLORADO RIVER

The year 2003 may have marked the end of a different sort of water conflict in California—the long-running battle among districts drawing supplies from the Colorado River. Resolution of this dispute, in particular the long-term transfer of water from the Imperial Irrigation District to the San Diego County Water Authority, was key to California retaining access to the Interim Surplus allocated to the state from the Colorado River. The agreement was outlined in the Quantification Settlement Agreement (QSA) signed in October by IID, SDCWA, Metropolitan Water District and Coachella Valley Water District.

Under the QSA, the IID agreed to cap its annual water use at 3.1 million acre-feet. From that amount, the IID would transfer:

- 104,000 acre-feet yearly to the Metropolitan Water District of Southern California under a 1988 agreement;
- 11,500 acre-feet to miscellaneous holders of present perfected rights;
- 67,700 acre-feet annually from recovered seepage from the All-American Canal to the San Diego County Water Authority for two 55-year terms;
- 200,000 acre-feet annually to the SDCWA at an initial ramp-up of 10,000 acre-feet yearly beginning the first year of the transfer, and at an increased ramp-up beginning in 2017 until the maximum is reached;
- 103,000 acre-feet annually to the Coachella Valley Water District at a ramp-up of 4,000 acre-feet yearly beginning in 2008;
- 1.6 million acre-feet, in two transfers of 800,000 acre-feet, for environmental mitigation during the first 15 years of the transfer, with the first transfer increasing at 5,000 acre-feet yearly beginning the first year of the QSA. The second quantity would ramp-up at 20,000 acre-feet yearly beginning about 2008. The first quantity would be sold for \$62.50 an acre-foot, while the second would be sold for \$175 per acre-foot. Both quantities would be sold to the California Department of Water Resources, which would then sell them to MWD. The profits from the sale would go to environmental mitigation.

Other provisions of the QSA covered restoration of the Salton Sea, compensation for third party impacts of the transfer, exemption from state environmental regulations, canal lining and other improvements, allocation of surplus water, and “peace treaties” whereby the four parties agree not to challenge each other with respect to certain areas of conflict (i.e., wheeling laws, water rights, etc).

This transfer, while historic, is more like an intergovernmental reallocation than a prototypical water market exchange. The QSA settled a large array of issues regarding use and conveyance of Colorado River water, many of which were unrelated to the transfer itself. There is also some question as to the willingness of IID to enter into the agreement. While it appears that many landowners and the IID itself will benefit substantially from the agreement, local opposition to the transfer remained strong until the Bureau of Reclamation found under a Section 517 proceeding that IID's use of water exceeded "reasonable and beneficial" amounts. This finding raised the possibility that, unless transferred, IID stood to lose a significant share of its annual use with no compensation.

WATER MARKETS IN CALIFORNIA

State sponsored water spot markets developed in 1991 in response to severe droughts and were repeated in 1992 and 1994. Since then, water trades by other agencies have grown, so that by 2000 the total quantity of water traded under non-drought conditions equaled 1991's extreme drought trades (Hanak, 2002). The increase in water trades since 1996 has predominantly been driven by environmental demands.

Table 1. Water Purchase Quantities by Institution (1000 acre-feet)

Year	Private	District	Wholesale	Bank	State	Federal	Total
1996	341	634,364	45,181	0	0	27,055	950,484
1997	39,707	606,441	62,342	62,755	20	545,024	1,316,294
1998	59,998	433,325	48,433	199,839	19	216,423	958,042
1999	27,096	672,392	151,187	256,722	20,309	369,629	1,497,341
2000	9,148	709,584	336,192	175,557	0	509,722	1,740,203
Average	27,258	611,218	128,665	138,973	4,071	382,273	1,292,474
% Average	2.11	47.29	9.96	10.75	0.31	29.58	--

Source McCann & Cutter (2002)

Table 1 shows the breakdown of water purchases between 1996 and 2000 in California by type of institution. McCann and Cutter (2002) classify water institutions by the controlling agency: "private" denotes private water purchasers; "district" denotes independent local water districts; "wholesale" denotes water trades negotiated by third party water traders; and "bank" denotes water banks run by the state or federal water agencies. It is clear from this data that the California water market was been active over the five years from 1996 to 2000 even though hydrological conditions were favorable, a fact that is also reflected in Figure 1. It is also apparent that two groups have dominated the water purchasing market. Local water districts accounted for 47 percent of water purchases, and federal agencies initiated 30 percent of water

purchases over this five year period. In contrast to purchases, water sales have been more evenly distributed among the different agencies. Between 1998 and 2000 the different institutions accounted for the following percentages of average water sales: “private”—4 percent; “district”—39 percent; “wholesale”—20 percent; “bank”—15 percent; “state”—16 percent; and “federal”—6 percent. Evidently, local water agencies play a dominant role in both water purchases and water sales.

Figure 1 shows that the incidence of water markets has varied considerably over the past 17 years. To detect any systematic trend in the market, the effect of changes in water scarcity and supply, shown in figure 2, needs to be disentangled from market trends.

Figure 1. Total Water Transfers—California

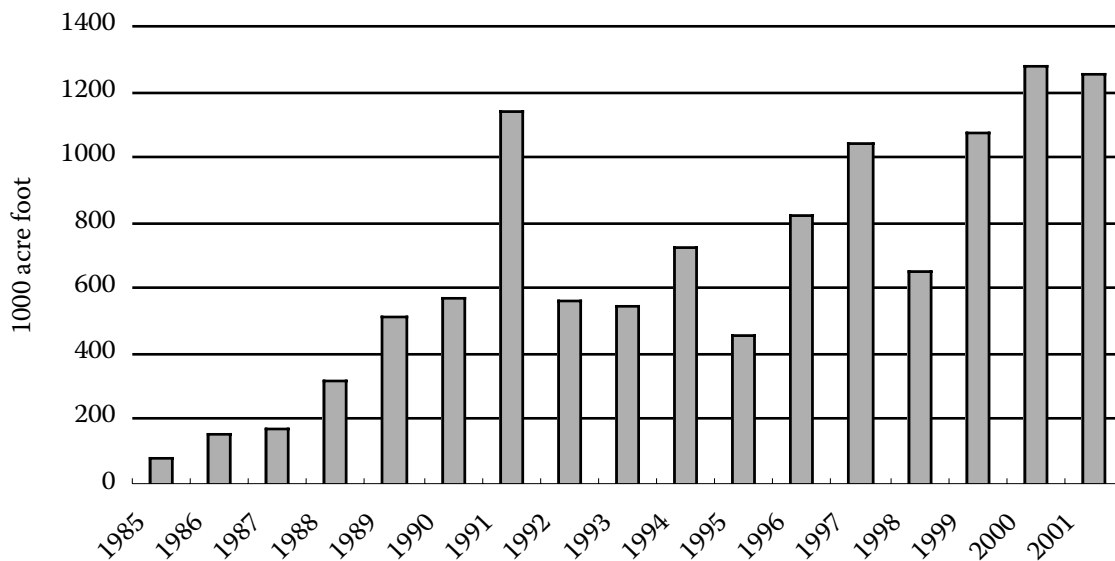


Table 2. Regression Statistics

R Square		0.813		
Adjusted R Square		0.770		
Standard Error		184.369		
Observations		17		
Regression	Degrees of freedom	F statistic	Significance of	
	3	18.843	F statistic	
	Coefficients	Standard Error	t Statistic	p-Value
Intercept	348.563	133.338	2.614	0.021
Ordinances	5.568	16.376	0.340	0.739
Water Index	-46.046	16.892	-2.726	0.017
Time Trend	69.382	21.944	3.162	0.007

Figure 2. Water Runoff Index—Sacramento Valley

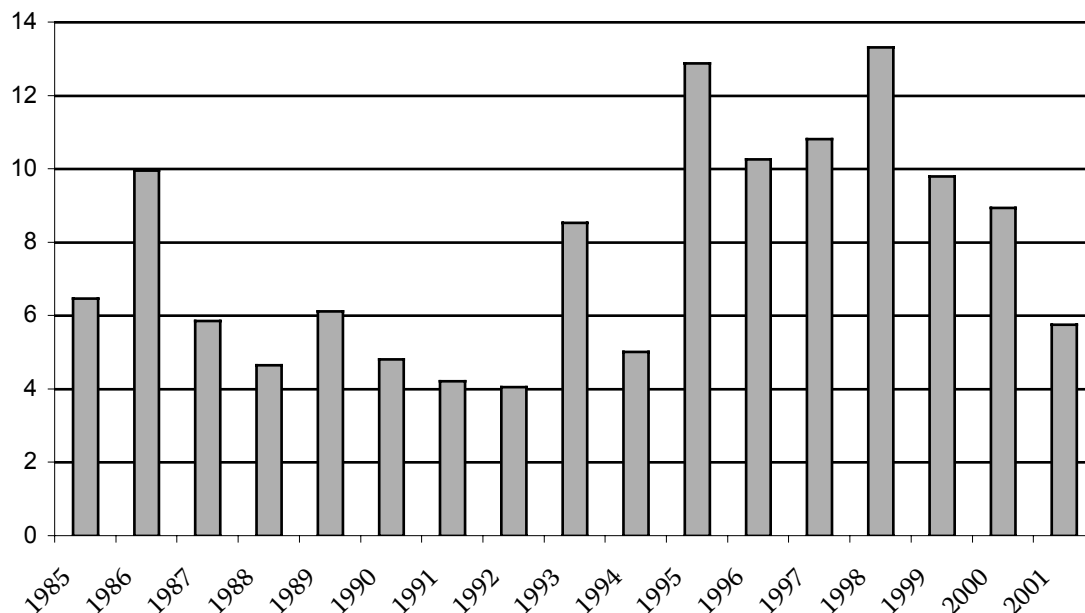
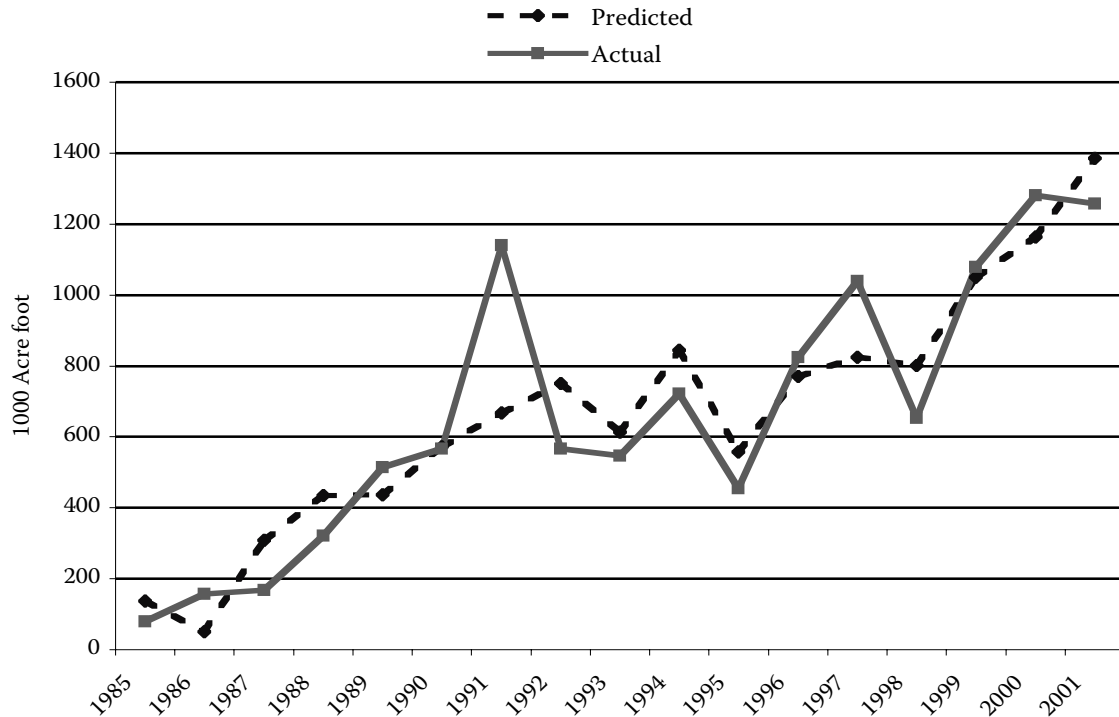


Figure 3 plots both actual transfers and regression predictions of water transfers in California between 1985 and 2001. The regression fitted to water transfer data confirms that rainfall levels have a significant effect on annual water transfers (Table 2). The data also confirms a positive correlation between the time trend and water transfers. When expressed as a percentage of the mean (1993) level of water transfers, the regression time trend shows an annual growth rate of 1.26 percent over the period. We can conclude that the current data shows a steady growth in water markets despite the recent predominance of relatively wet years.

In spite of the active and growing water market, Hanak (2003) points out that California's water market only accounts for 3 percent of total annual water use. Hanak estimates that Central Valley farmers have accounted for approximately three-quarters of all water sales, while the rest of the water has been supplied from Imperial and Riverside Counties. According to Hanak, environmental regulations, rather than urban agencies, have been the major sources of the increased demand for water. Direct purchases for instream uses and wildlife reserves constituted over one third of increased water trades since 1995, while agricultural activities in the San Joaquin valley accounted for over half of the increase in water purchases. This increase in agricultural demand for water stems from the reduction in contractual water deliveries under environmental regulations. However, municipal agencies are the principal purchasers of long-term and permanent water contracts, which constitute approximately 20 percent of total water trades. The 2001 legislation that requires that local governments ensure adequate water supplies for development is likely to increase the urban demand for long-term water transfers.

Figure 3. Total Water Transfers—California



RESISTANCE TO WATER TRADING

Within California there is considerable resistance to water trading which stems from communities in the source regions. These communities are concerned that water sales will generate significant “third-party” effects; i.e. trades may have an adverse impact on both local groundwater users and the local economy. These concerns have arisen from communities’ perception of the impacts of short-term water transfers in the early 1990’s, which involved the implementation of fallowing contracts by the state to purchase water for the 1991 drought water bank. Water transfers, which were accompanied by land fallowing, slightly reduced the demand for labor and other farm inputs and also decreased the supply of raw materials to local processors. Howitt (1994) estimated that losses in county income in two counties that transferred water ranged between 3.2 percent in Solano County, where 8 percent of the acreage was fallowed for transfers, to 5 percent in Yolo County, where 13 percent of the irrigated acres were fallowed.

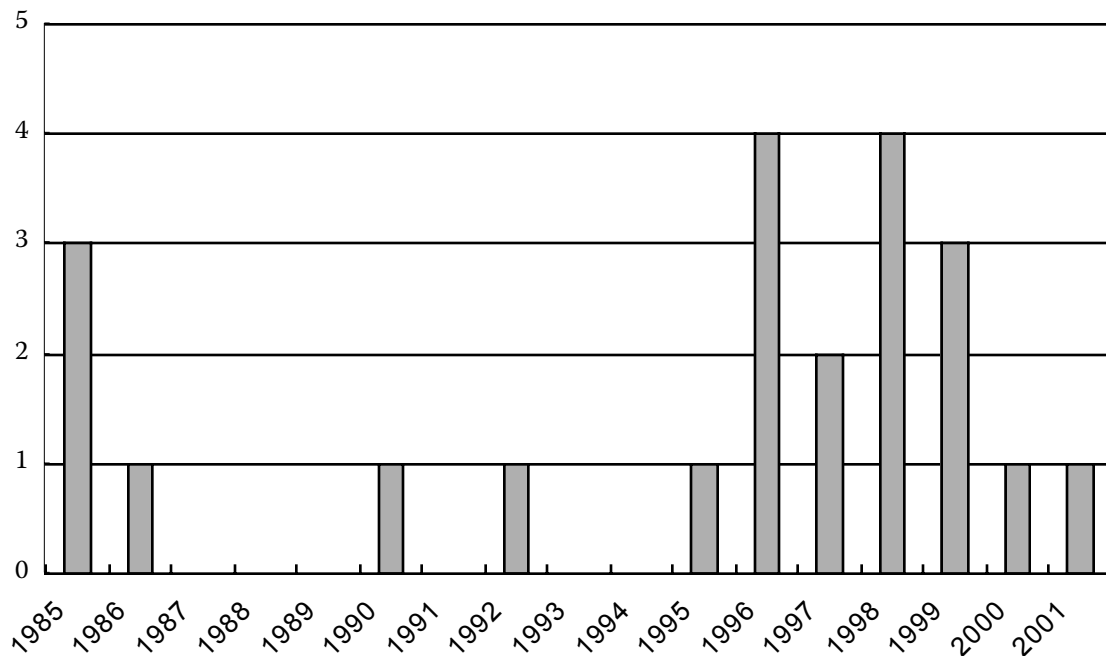
Those farmers who replaced the surface water they had sold by pumping additional groundwater were accused of reducing both the quantity and quality of water available to other users. Because groundwater resources are not regulated by the state, the implementation of the Californian water market has sparked concerns that aquifers will be subject to uncontrolled mining. The experience of the 1990’s has exacerbated another source of anxiety: local officials fear that once water has been

transferred elsewhere, local communities will have insufficient money and political influence to retrieve these water entitlements (Hanak, 2003).

Currently, state approval is only required for water transfers pertaining to surface water entitlements that were acquired since 1914, certain types of groundwater banking and any water that is conveyed through a publicly owned facility. The state only actively safeguards against negative economic impacts on source counties when water is conveyed through these publicly owned facilities. In the other two cases, traders are obligated not to harm other surface water rights-holders, fish and wildlife.

Rural counties have attempted to protect their water interests by implementing local restrictions on water marketing in the form of local ordinances (Figure 4). By late 2002, 22 of the state's 58 counties had put ordinances into effect (Hanak, 2003). These ordinances mandate the acquisition of a permit before exporting groundwater or extracting groundwater to substitute for exported surface water. Individuals who wish to obtain a permit have to undergo an environmental review process. According to Hanak, the very low number of permit applications indicates that this process acts as a deterrent to water trades, rather than as a screening mechanism. Statistics for 1990 to 2001 suggest that the implementation of groundwater export restrictions reduced a county's water trades by 14,300 acre-feet and transferred 2,640 acre-feet of water purchases to in-county buyers. Since 1996 total groundwater exports were reduced by 932,000 acre-feet or 19 percent and total water sales were reduced by 787,000 acre-feet or 14 percent (Hanak, 2003).

Figure 4. County Ordinances Passed



While the 1994 appellate court decision favoring Tehama County sanctioned the implementation of groundwater ordinances, counties do not have the legal authority to ban crop fallowing, although several counties have implemented such policies. According to Hanak, these counties tend to have boards that are elected by the general community, as opposed to boards that only permit landowners to vote. In general, landowners are more likely to fallow land for the water market, especially when crop prices are low.

Section 1745.05 of the Water Code mandates that any fallowing proposal that exceeds 20 percent of the local water supply must undergo a public review. Hanak found that water districts that implement fallowing programs tend to include restrictions in these programs that ensure that the viability of idled land is maintained and that landowners who engage in land idling are not solely engaged in selling water.

In summary, a well functioning water market is seen as essential to California's ability to adapt its restricted developed water supplies to changing demands for water. Over the past seventeen years the water market has evolved different forms and has shown steady growth despite relatively good water years. However in recent years, local resistance to water markets has taken the form of local ordinances. These ordinances need to reflect both the interests of local communities and state water users to enable the development of effective markets without imposing undue costs on local communities.

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CHAPTER 8

Hired Workers on California Farms

Philip Martin and Bert Mason

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Agriculture is a major industry and major employer in California. Over the course of a year, some 35,000 of the state's 750,000 employers hire a total 800,000 individuals to work on the state farms, so that about 5 percent of California's 16 million workers are "farm workers" sometime during a typical year.

Agriculture is a seasonal industry, hiring a peak 455,000 workers in September 2002 and a low of 288,000 in February 2002. Since most farm workers are employed for fewer hours than manufacturing workers, and earn lower hourly wages, they have lower than average annual earnings. Average hourly earnings in California agriculture are about half of average manufacturing wages, \$7 to \$8 an hour versus \$14 to \$15 per hour,¹ and farm workers average about 1,000 hours a year, so that farm workers have annual earnings of \$7,000 to \$8,000 a year, a fourth of the \$30,000 to \$35,000 average for factory workers.

¹ California's minimum wage has been \$6.75 an hour since January 2002.

Since 1975, farm workers have had organizing and bargaining rights, but there have been elections on only about 5 percent of the state's farms, and there are contracts on only about 1 percent. Farm worker unions have about 30,000 farm worker members; the organizing and bargaining activities of the dominant union, the United Farm Workers, have increased since founder Cesar Chavez died in 1993. Beginning in 2003, the state can require mandatory mediation that results in an imposed contract if employers and unions cannot negotiate a first agreement.

During the 1990s, the percentage of unauthorized farm workers increased along with the market share of farm labor contractors and other intermediaries who, for a fee, bring workers to farms. Wages and fringe benefits generally declined in the 1990s, and farmers, fearing losses if unauthorized workers were to be removed suddenly, have lobbied in Congress since the mid-1990s for an employer-friendly guest worker program. They have not yet succeeded in winning such a program, and the debate in 2003 is whether surging Mexico-U.S. illegal migration is best managed with guest workers, legalization, or a combination of the two, so-called earned legalization, under which unauthorized foreigners in the U.S. would obtain a temporary legal status that could be converted to an immigrant visa with continued U.S. employment.

FARM EMPLOYERS

Food and fiber is produced on farms, which are defined in the U.S. Census of Agriculture as places that sell at least \$1,000 worth of farm commodities a year. Most of the 2.2 million U.S. farms are considered family farms, a term that is not defined officially, but a common definition is that a family farm uses less than 1.5 person-years of hired labor.² Most family farms are diversified crop and livestock operations that provide work for farmers and family members year-round, and the mechanization of many farm tasks has enabled most farm families to include one or more persons employed in nonfarm jobs.

California farms are different because of specialization, size, and the presence of hired workers. Instead of combining crops and livestock, most California farms specialize, producing only lettuce, peaches or grapes. These FVH crops—fruits, nut and berries, vegetables and melons, and horticultural specialties that range from nursery and greenhouse crops to Christmas trees, mushrooms, and sod—require large amounts of labor for short periods of time, so large FVH farms can require hundreds of workers for 3 to 6 weeks, and only a handful the rest of the year. In California, FVH commodities occupy a third of the state's irrigated crop land and account for half of the state's farm sales.

Producing FVH commodities with hired workers in California fields is often compared to manufacturing products on factory assembly lines. Like factories, the farms bring together people, land, water, and machines to transform seeds into crops, with agriculture's biological production process marked by risks that do not arise in manufacturing production processes governed by engineering relationships. FVH commodities are considered "labor-intensive:" labor costs range from 20 percent to 40 percent of total production costs—higher than labor's 20 percent share of average

² This is the definition of a family farm in the Food Security Act of 1985. Other definitions are that the farmer and his/her family members must do more than half of the work on the farm: see <http://www.ers.usda.gov/briefing/FarmStructure/Questions/familyfarms.htm>.

production costs in manufacturing, but less than labor's 70 to 80 percent share of costs in many service industries.

The people relationships on California farms are also different from stereotypical U.S. family farmers. Unlike family farmers who do most of the farm's work with their hands every day, the managers responsible for most of California's labor-intensive crops rarely hand-harvest themselves. Indeed, many are unable to communicate with the workers in their native languages: most managers are U.S.-citizen non-Hispanic whites, while most farm workers are Hispanic immigrants. 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, 1).

Production and employment are concentrated on the largest 5 percent of the state's farms, and in most commodities, the 10 largest producers account for 30 to 50 percent of total production. However, there are many small farmers and small farm employers, which tend to obscure the degree of concentration. Dole Food Company is probably the largest California farm employer, issuing over 25,000 W-2 employee-tax statements annually. However, Dole does not show up in state employment records as a farm employer. Dole's Bud of California vegetable growing operation is one of the largest employers in Monterey County, and is considered in the business of selling Groceries & Related Products, not farming (<http://www.calmis.cahwnet.gov/file/MajorER/monteER.htm>). Sun World International is also classified in Groceries & Related Products, as is Grimmway Farms. Similarly, Beringer Blass Wine Estates is classified as a Beverages manufacturer, as is Giumarra Vineyards Corp. and Ironstone Vineyards.

Many of these nonfarm operations use custom harvesters and labor contractors to bring workers to their farms, and they are required to report their employment and wages to EDD. During the 1990s, when average annual farm employment rose to a peak 413,000 in 1997, so did the percentage of workers on farms whose employers were non-farmer intermediaries—usually labor contractors who are classified as farm services by EDD. The percentage of workers on farms whose employer is a non-farmer intermediary is about 45 percent, up sharply from less than 30 percent in the mid-1980s.

Table 1. Average Annual Wage and Salary Employment in California Agriculture

	1985	1990	1995	2000	1985-2000-change
Farm Production	232,700	229,700	228,400	228,500	-2%
Farm Services	102,700	133,800	145,100	179,500	75%
Total	335,400	363,500	373,500	408,000	22%
Farm Sers Share	31%	37%	39%	44%	

Source: [http://www.calmis.ca.gov/file/indhist/cal\\$haw.xls](http://www.calmis.ca.gov/file/indhist/cal$haw.xls)

DEMAND FOR LABOR

Seasonal Patterns

Employment in California agriculture is highly seasonal. The most labor-intensive phase of production for most commodities is farming, and the peak demand for labor shifts around the state in a manner that mirrors harvest activities. Harvesting fruits and vegetables occurs year-round, beginning with the winter vegetable harvest in Southern California and the winter citrus harvest in the San Joaquin Valley. However, the major activity during the winter months between January and March is pruning—cutting branches and vines to promote the growth of larger fruit. Pruning often accounts for 10 to 30 percent of production labor costs but, because pruning occurs over several months, there are fewer workers involved, and many pruners are year-round residents of the area in which they work.

Harvesting activity moves to the coastal plains in the second quarter of April–June, as lemons and oranges are harvested in southern California and vegetable crops are thinned and then harvested in the Salinas Valley of northern California. June marks the second highest month of employment on the state's farms, as workers harvest strawberries and vegetables as well as early tree fruits, including cherries and apricots; melons and table grapes are harvested in the desert areas. Other workers thin peaches, plums, and nectarines, remove leaves in some vineyards, and thin large acreage crops such as cotton.

Farm employment peaks in September, during the third quarter, reflecting the harvests of crops from Valencia oranges to tomatoes to tree fruits in the Central Valley of the state. However, the single largest labor-intensive harvest involves raisin grapes—some 40,000 to 50,000 workers have been hired to cut bunches of 20 to 25 pounds of green grapes and lay them on paper trays to dry into raisins. The workers typically receive \$0.20 a tray, and the contractor who assembles them into crews of 30 to 40, and acts as their employer, receives another \$0.05 a tray. During September, there is something of an early morning traffic jam, as vans ferry workers to fields and orchards, and employers wanting to wait as long as possible to harvest to raise the sugar content of their grapes worry that not enough workers will show up.

During the fourth quarter, harvesting activities slow, and after the last grapes, as well as olives and kiwi fruit are harvested in October, most seasonal farm and food processing workers are laid off. Most workers remain in the areas in which they have worked—most workers are not migrants who follow the ripening crops—but many were born in Mexico, and some return to Mexico with their families for the months of December and January.

If workers were willing to follow the ripening crops, and to switch between citrus and grapes, they could harvest work for 6 to 8 months a year. But few workers migrate from one area to another, and few switch crops within an area. In the mid-1960s, when migrancy was at its peak, a careful survey of farm workers found that only 30 percent migrated from one of California's six major farming regions to another (California Assembly, 1969). A 1981 survey of Tulare county farm workers found only 20 percent had to establish a temporary residence away from their usual home because a farm job took them beyond commuting distance (Mines and Kearney, 1982), and surveys of

California farm workers in the 1990s found that fewer than 12 percent followed the crops (www.dol.gov/asp/programs/agworker/naws.htm). A 2000-01 survey of 300 farm workers found 19 percent who moved in the previous two years to find farm work; fewer than 25 percent planned to move in the current year to find a farm job (Alvarado and Luna).

There are many reasons why most farm workers stay in one area of California: the harvesting of many fruits and vegetables has been stretched out for marketing and processing reasons; the availability of unemployment insurance makes migration less necessary; and some farm workers with children who are not likely to follow them into the fields realize that migrancy makes it very difficult for children to obtain the education needed to succeed in the U.S. An easy test of the degree of follow-the-crop migrancy is to check turnover in a farm labor center. If follow-the-crop migrants filled the center, workers and families would be constantly arriving and departing, as they moved on to another job in a distant area. In fact, most migrant centers fill as soon as they open, and keep the same tenants for the season: workers know that they can obtain services for themselves and their children, especially in the state-run centers, and it is very hard to find alternative housing if the family packed up and sought another job in the manner of John Steinbeck's Joad family.

Table 2. Monthly Employment in California Agriculture: 1993, 2000

	2000 Max	2000 Min	2000 Difference	2000 Ratio	1993 Max	1993 Min	1993 Difference	1993 Ratio
Farm Prod	266,400	179,600	86,800	1.48	267,200	175,500	91,700	1.52
Farm Sers	219,900	133,000	86,900	1.65	176,700	103,500	73,200	1.71
Total	486,300	312,600	173,700	1.55	443,900	279,000	164,900	1.59

Source: <http://www.calmis.ca.gov/file/indhist/fresnhws.xls>

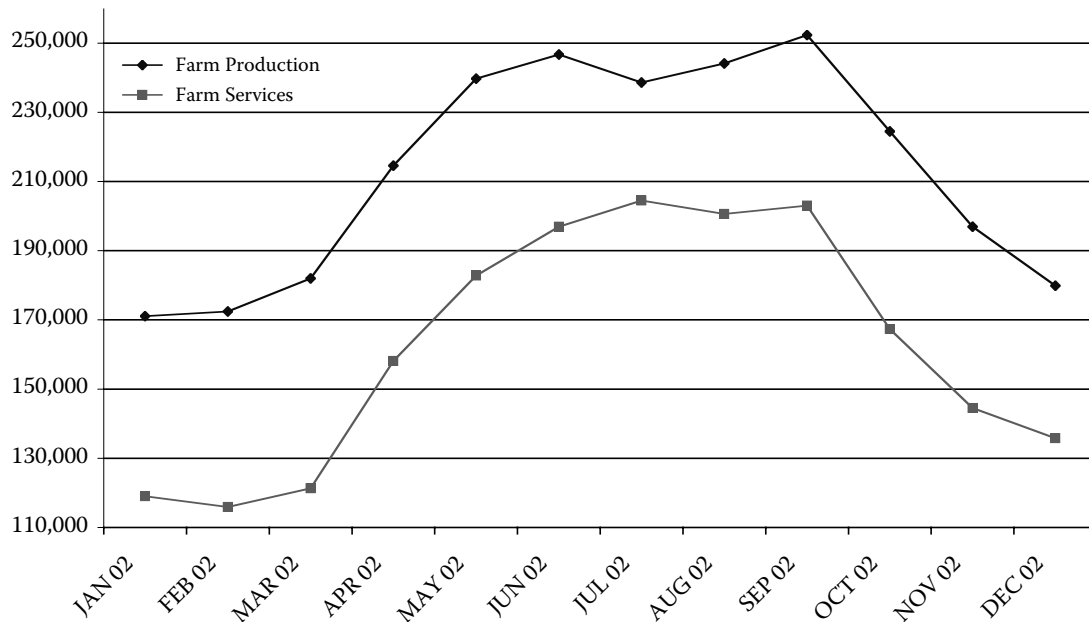
Until the 1940s, it was common for the wives of field workers to be employed in the packing houses that canned, froze or dried fruits and vegetables. However, after unions pushed packing-house wages to twice field worker levels in the 1950s and 1960s, packing-house jobs became preferred to field worker jobs, often representing a first rung up the American job ladder for field workers. About 40,000 workers are employed in the preserved fruits and vegetables subsection of the state's manufacturing industry, down from 50,000 in the early 1990s.³

Trends in farm and near-farm jobs are mixed. In the case of some vegetables and melons, nonfarm packing and processing jobs have been turned into farm worker jobs by field packing, having workers in the field put broccoli or cantaloupes directly into

³ Annual average employment was 50,600 in 1987, and ranged from 38,500 in January to 77,100 in August.

cartons rather than having the crop picked by field workers and packed by nonfarm workers in packing houses.⁴ In other cases, farm jobs have become nonfarm jobs, as when the cutting and packing of lettuce in the field is replaced by fewer workers simply cutting lettuce, and when there are more nonfarm jobs in packing plants as lettuce is cut and bagged: bagged lettuce uses almost 40 percent of U.S. lettuce.

Figure 1. Farm Production and Farm Services Employment



Source: EDD

Mechanization Trends

Employment on California farms was expected to drop sharply in the 1960s, as the end of the Bracero program, which brought Mexicans to work in U.S. fields between 1942 and 1964, was followed by sharply rising wages and unionization—the United Farm Workers union won a 40 percent wage increase in its first table grape contract in 1966.

Processing tomatoes provides an example of the sharp drop in farm worker employment as a result of labor-saving mechanization. In 1960, a peak 45,000 workers, 80 percent Braceros, hand picked 2.2 million tons from 130,000 acres of the processing tomatoes used to make ketchup. In 2000, about 5,000 workers were employed to sort 11 million tons of tomatoes from 350,000 acres that were picked by machines. The keys to tomato harvest mechanization included cooperation between scientists and between farmers, government, and processors. Plant scientists developed smaller tomatoes more uniform in size that ripened at the same time, and were firm enough so that the stalk could be cut, and the tomatoes shaken off, without damage. Engineers

⁴ Fieldpacking has farm workers picking and packing the commodity for shipment to market in the field, and is widespread for iceberg lettuce, broccoli, melons, and table grapes. Workers walk behind a conveyor belt that moves slowly through the field, pick and place the head of lettuce or melons on the belt so that packers riding on the machine can wrap and pack the commodity. Field packing involves less handling, and field workers' wages are generally lower than packinghouse wages.

developed a machine to cut the plant, shake off the tomatoes, and use electronic eyes to distinguish red and green tomatoes and discard the green ones (Rasmussen, 1968). Processors agreed to accept tomatoes in 12.5 ton truck mounted tubs rather than 60-pound lugs, and the government established grading stations at which random samples were taken to determine the quality and price. The cost of mechanizing the tomato harvest was relatively small—less than \$1 million—and the estimated rate of return was hundreds of percent.⁵

The rapid diffusion of tomato harvesting machines in California—none were harvested by machine in 1960, and all were harvested by machine by 1970—was expected to usher in an era of machines replacing men on farms, economists and engineers boldly predicted that, by 2000, there would be practically no jobs left for unskilled seasonal farm workers by 2000 (Cargill and Rossmiller, 1969).⁶

However, the cooperation between researchers, farmers, processors, and the government that transformed the processing tomato industry in the 1960s proved to be the exception, not the rule. Farmers remained very interested in and supportive of mechanization research during the 1970s, when there were hundreds of public and private efforts to develop uniformly ripening crops and machines to harvest them, but interest waned in the late 1970s due to rising illegal immigration and a lawsuit.

Mexico devalued the peso in 1976, and in 1977, for the first time, apprehensions of unauthorized Mexicans in the U.S. first topped 1 million. Apprehensions remained at about 1 million a year until after 1982, when another peso devaluation caused them to jump by 25 percent, and the rising number of unauthorized Mexicans, many of whom were from rural Mexico and sought jobs on U.S. farms, guaranteeing an ample supply of hand workers. Meanwhile, the UFW and California Rural Legal Assistance in 1979 filed a lawsuit against the University of California (UC), charging that efforts to develop labor-saving machines were an unlawful expenditure of public funds because they displaced small farmers and farm workers (Superior Court of California, Case 516427-5, September 4, 1979). The suit asked that UC mechanization research be halted and a fund was created to assist small farmers and farm workers equal in size to what UC earned from royalties and patents on agricultural innovations (Martin and Olmstead, 1985). The suit was eventually settled by establishing a committee to review research priorities, but public and private support for mechanization research decreased, and scientists and engineers moved on to other issues.

Most labor-saving research today is conducted by the private sector, and most of it is far less visible than machines replacing 90 percent of the hand harvesters, as in tomato processing. Precision planting and improved herbicides have dramatically reduced the need for thinning and hoeing labor. Many farmers have planted dwarf trees to increase yields, which can also reduce harvest labor needs. Much of today's mechanization is motivated as much for non-labor reasons as to save on labor costs. For example, drip irrigation systems reduce the need for water as well as irrigator labor, and a machine harvesting wine grapes at night results in higher-quality grapes and uses less labor.

⁵ 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 (Seckler and Schmitz, 1969, 14).

⁶ A UC study concluded that "California farmers will continue the intensive search for labor solutions, particularly mechanical harvesting." Dean et al. 1970, 52

FARM WORKERS

Waves of Immigrants

In the 19th century, U.S. agriculture in general and California agriculture in particular were considered land-abundant and labor short, which led to labor shortages that were compounded in California by the dominance of large and specialized farms. California began producing fruits in the 1870s, when the completion of the transcontinental railroad and falling interest rates encouraged a shift from grazing cattle and growing grain without irrigation to labor-intensive, irrigated fruit and vegetable farming. The expectation was that large farms, many derived from Spanish and Mexican land grants, would be broken up into family-sized units and sold to farmers arriving on the railroad, because only with a family-farm system would there be enough workers for labor-intensive agriculture (Fuller, 1940).

However, large farms were not broken up into family-sized units because new workers were available to be seasonal farm workers. Some 12,000 Chinese workers had been imported to help build the railroad through the Sierra Nevada mountains and, when they were laid off in 1870, they were kept out of urban jobs by anti-Chinese movements (Fuller, 1940, 19809). Chinese workers were paid low wages only when they were needed which helped to raise land prices, and made it hard for family farmers to buy land and get started in farming, and gave landowners an incentive to keep the door open to immigrants. However, anti-Chinese sentiment eventually led to a halt to Chinese immigration in 1883, but a new source of immigrant workers was found, in Japan. Japanese immigration was stopped in 1907, and workers were imported from present-day India and Pakistan until World War I.

There was little immigration during World War I, when Mexico was experiencing a civil war. The U.S. government was trying to restrict immigration from Europe, imposing head taxes and literacy tests on new arrivals in 1917, but western farmers won an exemption for Mexican farm workers coming to the United States for up to one year, beginning the U.S.-government-approved recruitment of Mexican farm workers. There were many problems with this first Bracero program, and government-approved recruitment was halted in 1921, but Mexicans continued to arrive and travel around California seeking farm work.

Many Mexicans were sent back to Mexico during the Great Depression, and the source of farm workers in the mid-1930s shifted to the Midwest, where many of the Okies and Arkies who lost their farms during the so-called Dust Bowl moved to California, expecting to become small family farmers. The gaps between farmers and farm workers in California led to some of the most enduring American literature, including John Steinbeck's 1939 novel, *The Grapes of Wrath*.

Okies and Arkies continued to be the mainstays of the seasonal harvest work force in the 1940s, when "fruit tramps" migrated from farm to farm, but their children often went in to the military during World War II, or found jobs in wartime factories, and California farmers asked the federal government to once again approve the recruitment of Mexican Bracero workers. The federal government agreed, and the first of a series of Bracero agreements was signed in 1942; almost 5 million Mexican workers were admitted over the next 22 years—many individuals returned year after

year, so that only 1 to 2 million Mexicans gained experience working on U.S. farms. Illegal Mexico-U.S. migration increased along with Bracero admissions, and over the 22-years of the Bracero program, there were more apprehensions than legal admissions—both data series measure events, not unique individuals.

Table 3. Bracero Admissions, Apprehensions, and Immigrants, 1942-64

Year	Mexican Braceros	Mexican Apprehensions	Mexican Immigrants
1942	4,203	--	2,378
1943	52,098	8,189	4,172
1944	62,170	26,689	6,598
1945	49,454	63,602	6,702
1946	32,043	91,456	7,146
1947	19,632	182,986	7,558
1948	35,345	179,385	8,384
1949	107,000	278,538	8,803
1950	67,500	458,215	6,744
1951	192,000	500,000	6,153
1952	197,100	543,538	9,079
1953	201,380	865,318	17,183
1954	309,033	1,075,168	30,645
1955	398,650	242,608	43,702
1956	445,197	72,442	61,320
1957	436,049	44,451	49,321
1958	432,857	37,242	26,721
1959	437,643	30,196	22,909
1960	315,846	29,651	32,708
1961	291,420	29,817	41,476
1962	194,978	30,272	55,805
1963	186,865	39,124	55,986
1964	177,736	43,844	34,448
Total	4,646,199	4,872,731	545,941
Source: INS Statistical yearbook, various years			

During the 1960s and 1970s, California's farm work force was dominated by Mexican Americans, many of whom joined Cesar Chavez's United Farm Workers union, which aimed to transform the farm labor market by having UFW hiring halls rather than labor contractors organize crews of farm workers. In 1975, California enacted the Agricultural Labor Relations Act, which granted farm workers organizing and bargaining rights and established a state agency, the Agricultural Labor Relations

Board, to supervise elections in which workers decided whether they wanted to be represented by a union, and to resolve charges that the ALRA was violated.

The UFW reached its high water mark in the late 1970s, when it had about 200 contracts with California farms, and claimed more than 60,000 members. However, in 1978-79, when the first contracts signed under the ALRA were expiring, the UFW demanded a 40 percent wage increase, which employers, especially Imperial Valley vegetable growers experiencing increased illegal Mexico-U.S. migration, rejected. The UFW called a strike, and the supply of iceberg lettuce shipped fell by one third, but the price tripled, since demand was inelastic. The UFW won a Pyrrhic victory—some vegetable firms, such as Sun-Harvest (Chiquita bananas), agreed to the 40 percent wage increase, went out of business, and were replaced by independent growers less vulnerable to UFW-mounted consumer boycotts.

In the early 1980s, the farm work force was about a quarter unauthorized, and patterns of illegality were linked to the risk of losses if there were Border Patrol raids. For example, there were fewer unauthorized workers in highly perishable strawberries than in citrus, since oranges and lemons can be left on trees for a week or two without damage. However, a decade long federal effort to reduce illegal immigration culminated in the Immigration Reform and Control Act of 1986, which for the first time imposed sanctions—fines and prison terms—on U.S. employers who knowingly hired unauthorized workers. Sanctions were expected to reduce illegal Mexico-U.S. migration and, to assure agriculture a legal work force, unauthorized workers in 1985-86 could apply for immigrant status, and the theory was that wages would have to rise and benefits would have to improve for farmers to retain these Special Agricultural Workers (SAW).

Table 4. SAWs and Unauthorized Workers, 1989-98

Year	SAWs	Unauthorized
1989	37	8
1990	30	17
1991	27	19
1992	23	33
1993	12	44
1994	20	38
1995	19	40
1996	16	50
1997	17	51
1998	15	52

Source: NAWS,
<http://www.dol.gov/asp/programs/agworker/naws.htm>

Some 1.1 million unauthorized foreigners were legalized as SAWs in 1987-88,⁷ far too many in a legalization program rife with fraud (Martin, 1994). Most did not continue working in agriculture. In 1989-90, 33 percent of U.S. crop workers, and 58 percent of California crop workers, said they were SAWs; a decade later, the share of SAWs among crop workers was down to 16 percent in the U.S., and 26 percent in California. During the 1990s, the movement of SAWs out of agriculture almost exactly matched the increase in unauthorized farm workers.

NAWS: 1990s Workers

The most widely cited farm worker data are from the National Agricultural Workers' Survey (NAWS), a survey conducted in 85 counties across the U.S. three times a year for the U.S. Department of Labor. The NAWS is not designed to estimate the number of workers, only their characteristics. In USDA surveys of employment on crop and livestock farms, California accounts for 30-35 percent of U.S. farm worker employment, and the percentage of NAWS interviews done in California was 30-33 percent in the 1990s.

California had higher percentages of Mexican-born and male workers than other states in the early 1990s, but the rest of the U.S. caught up to California during the 1990s. Between 1990 and 2000, the percentage of foreign-born workers rose from 60 to 80 percent in the entire U.S., while the percentage of foreign-born farm workers remained at 93-96 percent in California. Similarly, the percentage of males rose outside California from 72 to 81 percent, but remained at 75 to 85 percent in California.

Farm workers were asked a series of questions about their place of birth and legal status—authorization to work in the U.S. was inferred from their answers. The percentage of unauthorized workers in the entire sample increased sharply in the 1990s, from 12 to 52 percent. In California, the percentage of unauthorized workers was lower than in the rest of the U.S. in the early 1990s, but also increased fourfold during the decade.

Farm workers are unlike other U.S. workers. In 1998, about 54 percent of U.S. workers were male, and 39 percent were under 35 years of age. About 80 percent of crop workers in the U.S. and California were men, and 67 percent were under 35. About 84 percent of U.S. crop workers speak Spanish and 12 percent speak English; 85 percent, compared to 11 percent of all U.S. workers, have not completed high school. The median years of schooling of the workers who were interviewed was six, and most crop workers completed their education in Mexico. Alvarado and Luna found similar characteristics, a work force that was 76 percent male, an average 33 years old, with 5.7 years of education. In California's Central Valley, 83 percent of the workers interviewed were employed by FLCs, and it was hard to find seasonal workers who were employed directly by growers.

⁷ Another 70,000 farm workers were legalized under the general legalization program; they should have been in the U.S. continuously since January 1, 1982. At least half of the foreigners who received SAW status did not do this requisite farm work (Martin, 1994).

Migration

Since most farm workers were born abroad, their first migration is entering the U.S., usually at age 18 to 25. During the 1990s, a rising percentage of farm workers seemed to shuttle between homes outside the U.S. and U.S. farm jobs—in California, the percentage of “international shuttle migrants” in the NAWS rose from 27 to 46 percent, even as the Border Patrol made illegal entry more difficult with more agents, fences, and lighting. The increased percentage of international shuttle migrants may be a statistical artifact, reflecting the high percentage of recently arrived workers—30 percent of California farm workers, and 41 percent of non-California crop workers, entered the U.S. to do farm work within the previous two years, and such workers are considered shuttle migrants. Since the September 11, 2001 terrorist attacks, shuttle migration has decreased.

The 4,199 workers interviewed around the U.S. between 1996 and 1998 had a total 7,697 farm jobs—60 percent had only one job, while seven percent had four or more jobs. This suggests that relatively few workers fit the stereotype of a migrant who follows the ripening crops from south to north, working on many farms.⁸

NAWS defined a migrant as a worker who moved 75 miles or more from his usual residence to find a U.S. farm job; an overnight stay away from home was not required to be considered a migrant. The largest group of crop workers interviewed, 44 percent (750,000 of an estimated U.S. total of 1.7 million) were not migrants. Another 39 percent (660,000 in the U.S.) were international shuttle migrants⁹—their usual homes were generally in Mexico, and they traveled more than 75 miles from these usual Mexican homes to their U.S. farm jobs. Only 17 percent (290,000) crop workers were stereotypical follow-the-crop migrants who have one farm job and then travel at least 75 miles for another farm job.

The myth of widespread follow-the-crop migration persists for several reasons. First, there is significant migration—if one in 6 crop workers needs at least two U.S. homes to do farm work, then almost 300,000 U.S. farm workers, and 100,000 to 125,000 in California, need temporary homes, and there are relatively few in inspected private or public farm labor centers. For example, the state of California has 2,100 family housing units in 26 centers and each houses fewer than two workers. State inspectors certified 1,044 units to house five or more workers in 1999, the most recent data available, so that about 4,000 workers were housed in state centers, and another 21,000 in inspected private housing (HCD, 2000).

Second, shuttle or commuter migrants between Mexico and the U.S. are often grouped with follow-the-crop migrants, even though they remain in one U.S. home while here for 6 to 10 months—or since their arrival, for the newly arrived.

Third, the federal government provides about \$1 billion a year to government agencies and NGOs that serve migrant and seasonal farm workers. The original 1960s War on Poverty justification for federal Migrant and Seasonal Farm Worker

⁸ In the nonfarm labor market, 143.2 million workers had at least one job in 1997, and 15.6 million experienced unemployment—annual average employment was 129.6 million, and annual average unemployment was 6.7 million. An average eight million workers held two or more jobs simultaneously in 1998—about 4.5 million had one full-time and one part-time job. For more information: <http://www.bls.gov/news.release/work.nws.htm>.

⁹ NAWS defined shuttle migrants as persons who spent at least 28 days a year outside the U.S., so that a worker who was interviewed soon after arrival in the U.S. could be considered a shuttle migrant even if the move to the U.S. was permanent. The home base of 88 percent of shuttle migrants and 43 percent of the follow-the-crop migrants is Mexico, usually rural areas.

assistance programs was that many states had residency requirements to be eligible for welfare assistance, so the federal government stepped in to provide services to migrant workers in the state only a few months. These residency requirements disappeared in the 1970s, but MSFWs remain among the poorest U.S. workers, and service providers continue to seek federal funds to assist them by arguing that farm workers have special needs not easily accommodated in regular assistance programs (Martin and Martin, 1994).

Employment and Earnings

About 70 percent of U.S. crop workers interviewed in the NAWS found their current job through a friend, relative, or work mate; 25 percent applied on their own, and one percent used the Employment Service. Of the workers interviewed, 33 percent were employed in fruits and nuts, 28 percent in vegetables, and 14 percent in horticultural specialties—these crops employed 75 percent of the workers interviewed. About 80 percent of the workers were employed directly by the growers.

Across the U.S., workers averaged \$5.93 an hour in 1997-98 for 38 hours a week, which generated weekly earnings of \$225—average weekly earnings for all private sector workers were \$442 in 1998 (the federal minimum wage rose from \$4.25 to \$4.75 on October 1, 1996 and to \$5.15 on September 1, 1997). The quarterly USDA publication, *Farm Labor*, reports higher average hourly earnings and hours worked—an average \$6.98 an hour for field and livestock workers in 1998, and 40 hours a week, but USDA includes hired managers and supervisors.

Farm workers interviewed in the NAWS averaged 24.4 weeks of farm work, for farm earnings of \$5,500 in 1997-98. They also averaged 4.6 weeks of nonfarm work, for nonfarm earnings of \$1,000. Farm workers averaged 10 weeks of unemployment in the U.S. and 12 weeks abroad. Weeks of farm and nonfarm work in the U.S. have been declining, while weeks abroad have been increasing, reflecting the rising share of recently arrived and unauthorized workers—that is, if workers are interviewed in July soon after their arrival in the U.S., they appear in the NAWS as having, e.g., 4 weeks of farm work and 20 weeks of time spent abroad.¹⁰

Unemployment is pervasive, even during the summer months. If the status of workers is recorded on a month-by-month basis, the percentage of workers doing farm work peaks in the summer months at 55 to 60 percent, when the unemployment rate is at least 15 percent, meaning there is one unemployed farm worker for each three or four at work. During the winter months, the percentage of workers employed is 35 to 40 percent, and unemployment is 20 to 23 percent, meaning one unemployed worker for every two employed workers. A third of workers are outside the U.S. in the winter months, but the post September 11, 2001 tightening of border controls has probably discouraged unauthorized workers from returning to Mexico during the winter months.

The crop workers interviewed in 1997-98 had an average eight years of U.S. farm work experience. This eight year average may be misleading, since the half of the workers who were U.S. work-authorized had an average of 13 years of U.S. farm

¹⁰ The NAWS defines a newcomer farm worker as one who first entered the U.S. less than 24 months before being interviewed, and who has less than 12 months of U.S. work (farm or nonfarm) or unemployment.

work experience, while the half who were unauthorized had an average of four years of U.S. farm work experience—that is, workers were concentrated at the two extremes of the U.S. farm work experience spectrum. About half of the crop workers interviewed in 1997-98 said that they intended to remain farm workers as long as possible; the other half intended to exit the farm work force within five years. About 60 percent of farm workers said they had relatives or friends with nonfarm U.S. jobs, and 35 percent thought they could find a nonfarm U.S. job within one month.

Farm employers must provide some benefits to workers—in California, mandatory benefits include Social Security, unemployment insurance and worker's compensation. Farm employers may provide additional benefits, including pensions, health insurance and vacation pay. Many farm workers interviewed by the NAWS did not think that they were covered by mandatory benefits, and few received voluntary benefits. For example, about 60 percent said that they were not eligible for UI benefits, a result that may be explained by the fact that, in many states, only workers employed on the largest farms must be covered by unemployment insurance, and unauthorized workers are not eligible for UI benefits, even if their employers pay UI taxes on their wages. Workers compensation pays for medical costs associated with work-place injuries and provides payments to workers who cannot work as a result of work-place injuries. About half of the states do not require farmers to provide workers compensation coverage for farm workers, and two-thirds of farm workers said they were not covered. About five percent of crop workers received health insurance for off-the-job injuries to themselves or their families, and 10 percent received vacation pay.

NAWS obtains income data by range; it does not obtain point estimates of individual or family income. Half of the workers had 1997 incomes of less than \$7,500, and half had family incomes of less than \$10,000, which means that most individuals and families had incomes below the poverty line—\$8,350 for an individual in 1997, and \$12,800 for a family of three. About 20 percent of farm workers said that they or someone in their family received UI benefits within the past two years. Since 50 percent of farm workers are unauthorized, and 14 percent work year-round, this means that many of the 36 percent who would appear to be eligible for UI benefits received them. About 17 percent of those interviewed received benefits through means-tested programs: one-third of the legally authorized farm workers received means-tested benefits—the three most common assistance programs accessed were Medicaid (Medi-Cal), Food Stamps, and the Women, Infants and Children (WIC) program.

FARM LABOR MARKET

Labor markets match workers and jobs by performing recruitment, remuneration or motivation, and retention functions. These 3 R's are handled in unique ways in agriculture. For example, farmers rarely place ads in newspapers to recruit workers, or send recruiters to high school or college campuses in search of workers. More typical is how one farmer described his recruitment strategy: "when we need X amount of workers, we call up the contractor, and they supply the workers." Agriculture has one of the highest percentage of jobs paid piece rate wages—a third or more—which makes careful screening of workers, and supervision to encourage fast work, less

necessary. Finally, few farm employers have personnel systems aimed at forming long-term relationships with seasonal workers. Instead, most farmers believe it is more efficient to work collectively to ensure an ample supply of workers.

Recruitment

Recruitment matches workers and jobs. In seasonal industries such as agriculture that require a large number of workers to fill seasonal jobs, a central clearinghouse for farmers to list vacancies and for workers seeking jobs should be the most efficient way to match hundreds of thousands of workers with a similar number of jobs. A clearinghouse could be operated by employers, unions (hiring halls), or the tax-supported Employment Service (EDD in California).

The logic of a job-worker clearinghouse to minimize uncertainty for growers and unemployment for workers is clear, but there are few examples of their successful operation in agriculture. Until the early 1970s, the Employment Service and employer associations were the major clearinghouses. However, DOL curtailed its farm job-matching to settle lawsuits that charged the ES discriminated against farm workers by not telling them about nonfarm jobs (Goldfarb, 1981). Many employer associations that served as clearinghouses disbanded after their workers voted for union representation in the 1970s.

The UFW tried to become an alternative clearinghouse with union-run hiring halls in the 1970s, but farmers who did not have contracts requiring them to obtain workers via UFW-run hiring halls did not do so, and many workers objected to having to pay dues to the UFW before being sent to farm jobs. The UFW tried to operate hiring halls in the 1970s without the benefit of computers, and deployed those seeking jobs on the basis of their seniority with the UFW, which sometimes split families and workers who wanted to work together; with the loss of contracts in the 1980s, most of the UFW-run hiring halls closed.

Today job-worker matching in California agriculture is decentralized, with farm labor contractors (FLCs) and other intermediaries assembling crews of workers to fill seasonal jobs. FLCs, for a fee, organize crews of workers and bring them to farms. 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 his 20 to 30 compatriots. In the 1920s, FLCs became independent businesses whose profit was the wedge between what an employer pays to have a job done and what is paid to the worker.

FLCs can often “drive the hardest kinds of bargain” with immigrant workers because they know the circumstances from which they come (Fisher, 1952, p. 43). 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. Enforcement has not prevented widespread labor law violations.

The key intermediary is a foreman or crew boss in charge of a crew of 20 to 40 workers. Smaller FLCs may have only one crew, but most California FLCs have multiple crews, and they make a foreman responsible for hiring and disciplining a

crew. Most hiring is via networks, as 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. 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.

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 to make money off them and because newly-arrived workers often need such services. Federal and state governments have enacted an ever-growing body of laws and regulations that attempt to regulate these sideline activities of farm employers such as crew bosses, but they are not widely enforced—it is not unusual for a worker to pay for rides to work as a condition of getting the job.

In some “farm worker towns,” especially those along the U.S.-Mexican border, workers are recruited in so-called day-haul labor markets. Workers begin to congregate in parking lots at 3 or 4 am, where contractors arrive with buses, posting on the bus the task and the wage. The workers then board the bus that seems to offer prospects for the highest earnings. Some workers board the same bus every day, while others switch from bus to bus.

Remuneration or Wages

The second function of labor markets is to remunerate or motivate workers. There are two major pay systems in which wages are used to motivate workers: hourly and piece rate. Employers pay hourly wages when they want slow and careful work, such as pruning trees and vines, when the employer can easily control the pace of the work, as when a crop such as broccoli is harvested by workers following a conveyor belt through the field whose speed is controlled by the driver/employer, and when piece rate wages would yield low hourly earnings, as for early season fruit picking.

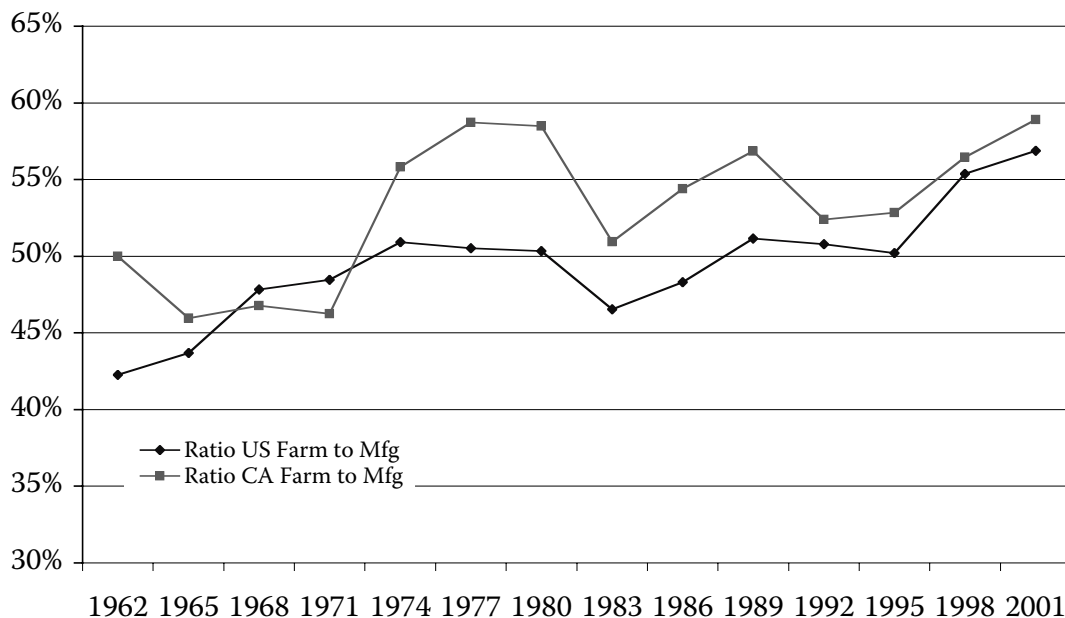
Piece rates are common when it is hard to regulate the pace of work, as when workers climb trees to pick fruit (and are thus often out of sight), when quality is less important (as for picking oranges that will be processed into juice), and when an employer wants to keep labor costs constant with a diverse work force—it costs the employer \$100 to have 1,000 pounds of table grapes picked if the piece rate is 10 cents a pound whether one fast picker or 3 slow pickers do the work. If workers are paid piece rate wages, employers must record the units of work and hours worked of each worker and, if a piece rate worker does not earn at least the minimum wage, the employer must provide “make up” pay, so the worker gets at least the minimum wage. As the minimum wage has risen, some farm employers have switched to hourly wages to reduce record keeping.

The U.S. minimum wage has been \$5.15 an hour since September 1, 1997; the California minimum wage has been \$6.75 since January 1, 2002. Most farm employers pay the minimum wage or \$0.50 or \$1 an hour more, and increase their entry-level

wage when the minimum wage rises. When reviewing farm wage data, it is important to remember that most data sources report earnings, which is what workers who are employed under a variety of wage systems—hourly, piece rate and others—actually earn, not the wage rate that would be announced to a newly hired worker. Piece rate workers tend to earn more per hour, \$8 to \$10 versus \$7 to \$8, but most piece rate workers cannot sustain their typically faster pace of work for more than 6 to 7 hours a day, so that the weekly earnings of piece rate and hourly workers are similar because the hourly workers tend to be employed more hours. Average hourly earnings on California farms were almost 60 percent of average manufacturing worker earnings in the late 1970s, fell to 55 percent in the 1990s, and rose in the late 1990s with the state's minimum wage increases.

The cost of employing workers includes wages as well as mandatory and voluntary fringe benefits. Mandatory benefits are those that the employer must provide to workers—social security, unemployment and disability insurance, and workers compensation. Voluntary fringe benefits include health insurance, paid vacations and holidays, and extra pension benefits. The U.S. Bureau of Labor Statistics computes the cost of wages and fringe benefits, and in March 2000 reported that the total cost of employing workers in the U.S. private sector was \$21 an hour, including \$15 an hour in wages and salaries (73 percent) and \$6 an hour in benefits (27 percent). The cost of mandatory fringe benefits was \$1.67 an hour or nine percent of total compensation, and employers provided voluntary fringe benefits worth \$4.33 or 19 percent of total compensation, including \$1.42 an hour for paid leave (vacation and holiday pay) and \$1.36 for health and other insurance.

Figure 2. Ratio of Farm to Manufacturing Worker Earnings, 1962-2001



Source: U.S. DOL and USDA

Fringe benefits can be expensive for farm workers with low earnings, since benefits such as health insurance for workers and their families that cover off-the-job injuries and illnesses require monthly payments that are independent of earnings. A low-cost \$160 a month or \$1 an hour health insurance premium for a full time worker adds 16 percent to the cost of a worker earning \$6 an hour and 7 percent to the cost of a \$14 an hour worker.

Farmers in the past often provided housing in order to attract and retain good workers. However, poor farm worker housing led to higher standards and, since farmers are not required to provide housing, many responded to tougher housing rules by closing their housing. Farm workers were thus pushed into cities and towns in agricultural areas, where they competed with other tenants for housing, sometimes living in rented houses or sheds that were no better than the on-farm housing that was closed. However, the cost of living in cities was usually more than what farmers charged—often \$50 to \$100 a week—and workers living away from the fields must usually pay for rides to work, which adds another \$20 to \$25 a week to their costs of working. The government, which used to regulate farmer-provided housing, today primarily makes grants and loans to provide subsidized housing for farm workers, often families with children. Alvarado and Luna found that 13 percent of SJV farm workers in 2001 lived in housing provided by their employers, and 50 percent lived with non-family members; they paid an average \$238 a month in rent. Fewer than a third of the workers interviewed had a California drivers' license, and 70 percent paid an average \$5 a day for transportation from the city or town in which they lived to their farm job.

Retention

The third key labor market function is retention—identifying and keeping the best workers, or encouraging the best seasonal workers to return next year. Most U.S. employers have formal evaluation systems under which supervisors evaluate each worker, and these evaluations are used to determine promotions and wage increases. Few farm employers have formal personnel systems. Instead, there are two methods of recruitment and worker evaluation that illustrate agricultural extremes in personnel practices. Some farmers, especially those who work closely with one or a few year-round workers in dairies and similar operations, treat hired workers “as part of the family,” selecting workers carefully and providing them with housing near the farmer’s home (Billikopf, 2001). The other extreme is exemplified by a grower who hires a crew of workers through a contractor or a foreman, and never deals directly with workers.

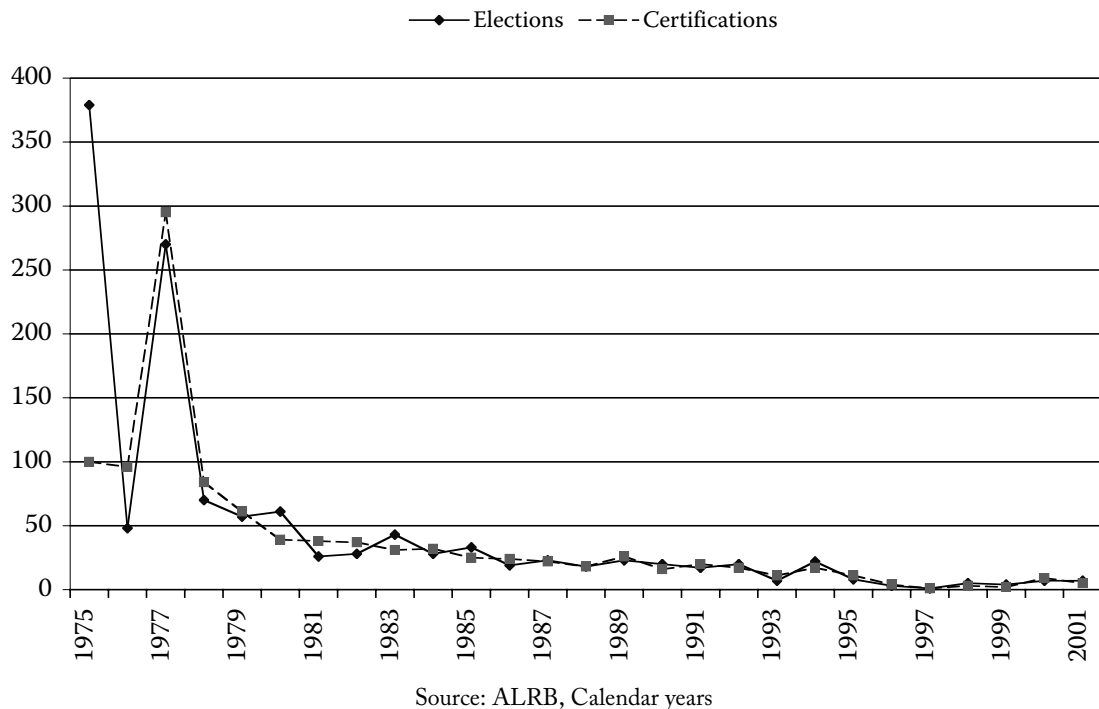
Crew-based hiring explains why recruitment and retention are often part of the same labor market function in agriculture. Indeed, an analogy to obtaining irrigation water may be helpful to understand the recruitment and retention options. There are two major ways to supply irrigation water to crops: a field can be “flooded” with water so that some trickles to each tree or vine, or fields can be irrigated with a drip system that involves laying plastic pipes down or under the rows and dripping water and nutrients to each tree or vine. If water is cheap, farmers flood fields with water; if water is expensive, farmers may invest in drip irrigation systems. The analogy to recruitment and retention is clear: farmers more often work collectively to flood the

labor market with workers, usually by getting border gates opened or left ajar, instead of recruiting and retaining the best farm workers for their operation, the drip irrigation model. The best way to ensure plenty of irrigation water is to invest in more dams and canals; the best way to flood the labor market is to invest in politicians willing to ease access to foreign workers.

UNIONS, BARGAINING, MEDIATION

Farm workers were not granted federal collective bargaining rights in the 1935 National Labor Relations Act, and remain excluded from the NLRA. In 1975, California enacted the Agricultural Labor Relations Act to provide state-level organizing and bargaining rights: the purpose of the ALRA was to end a decade of strife in the fields, to “ensure peace in the agricultural fields by guaranteeing justice for all agricultural workers and stability in labor relations.” The ALRA includes three major elements: organizing and bargaining rights for farm workers, unfair labor practices that employers and unions can commit when they interfere with these worker rights, and a state agency, the Agricultural Labor Relations Board (ALRB), to supervise elections in which farm workers decide if they want to be represented by unions and to remedy ULPs. Between 1975 and 1984, there were over 1000 elections on California farms, and unions were certified by the ALRB to represent workers on 70 percent of these farms (ALRB). Since then, there have been fewer than 250 elections, and unions were certified on less than 50 percent of the farms on which they requested elections (Martin, 2001).

Figure 3. ALRB Elections and Union Certifications, 1975-2001



Farm worker unions were often unable to negotiate first agreements with most of the farms on which they were certified to represent workers, and in many cases, were unable to re-negotiate first agreements. The number of collective bargaining agreements in California agriculture has never exceeded 300 at any time, and in 2002 was about 225—80 percent of the current contracts cover 3-4 workers under Christian Labor Association contracts with dairy and poultry farms. The United Farm Workers (UFW), Teamsters, and other unions representing field workers have fewer than 30 contracts covering less than 25,000 workers.

Unions such as the UFW charge that farm employers are able to avoid reaching first or subsequent contracts by refusing to bargain toward agreement. In 2002, the UFW led an effort to amend the ALRA to provide for state intervention to ensure contracts on farms on which workers voted for union representation. The UFW's original goal was binding arbitration, under which a union and employer that cannot negotiate a contract typically go through a three-step procedure. First is mediation, when a neutral third party listens to each party separately and makes suggestions to narrow differences and allow them to reach a voluntary settlement. Second is fact finding, when a neutral party listens to both sides and proposes a non-binding settlement. Third is binding arbitration, when a neutral party proposes either any settlement deemed best or when the arbitrator is required to recommend one of the party's final offers at the bargaining table. Binding arbitration is normally restricted to public employees such as police and firefighters who cannot strike lawfully.

The California Legislature approved binding arbitration in agriculture, but Governor Gray Davis threatened to veto the bill, so a last-minute compromise, "mandatory mediation," was approved. Mandatory mediation, which went into effect January 1, 2003, requires unions and farm employers to bargain for at least 180 days for a first contract. If they cannot reach agreement, a mediator tries to help the parties to resolve their differences for another 30 days but, if mediation fails to produce an agreement, the mediator must, within 21 days, recommend the terms of a collective bargaining agreement that the ALRB can then impose on the parties. Although mandatory mediation might result in a greater number of collective bargaining agreements, other factors suggest that the new law will not affect a large number of agricultural employers or employees while it is in effect through at least 2007 (Martin and Mason).

IMMIGRATION REFORM

The hired farm workers of tomorrow are growing up today outside the U.S., usually in rural Mexico and Central America. A major federal policy issue is what conditions, including what housing provisions, U.S. farm employers should satisfy to get access to these foreign workers. The U.S. has a guest worker program for farm workers, known as the H-2A program. It requires DOL to certify a farmer's need for H-2A guest workers. In order to obtain certification, a farmer must satisfy certain recruitment, wage, and housing regulations, including applying for certification and trying to recruit U.S. workers at least 45 days before they are needed, offering to pay the higher of the minimum, prevailing, or Adverse Effect Wage Rate, and offering to provide free and approved housing to out-of-area U.S. and H-2A workers.

Except for sheep farmers, California farm employers have traditionally not obtained workers through the H-2A program; most admissions have been in eastern states such as North Carolina. But the number of H-2A admissions in these eastern states has been rising, and H-2A workers for non-shepherding jobs were approved in California in March 2002, when a Ventura county custom harvester/FLC brought 38 H-2A workers from Mexico to California to harvest lemons, possibly a precursor to more H-2A farm workers. If the H-2A program expands, there would likely be an increased demand for barracks or dorm style housing, and inspectors to check it.

Instead of expanding the H-2A program, three other concepts are being debated to regulate the access of farmers to foreign farm workers: temporary guest workers, legalization, and earned legalization. Temporary guest workers are nonimmigrants, persons in the U.S. to work generally for one employer, who must leave when the work ends—guest workers, under U.S. law, do not generally obtain any preference for admission as immigrants.

During the 1990s, the SAWs—unauthorized farm workers legalized in 1987-88—and their replacement with newly arrived unauthorized workers increased the risk to farmers that they may be fined or lose their workers at critical harvest times. Farmers could avoid such risks by having DOL certify their need for H-2A workers, but certification required offering at least a DOL-set wage and free housing.

Many California farmers want an alternative guest worker program that does not require certification, and they do not want to offer free housing to legal guest workers. In July 1998, the U.S. Senate approved one grower proposal, the Agricultural Job Opportunity Benefits and Security Act (AgJOBS), which avoided the need for farmers to be certified by creating a registry in each state to enroll legally authorized farm workers. Under AgJOBS, farmers would apply to the registry, for example, requesting 100 workers. If only 60 registry workers were available, the farmer would be automatically “certified” to recruit and have admitted to the U.S. 40 foreign workers. AgJOBS would also end the housing requirement by allowing the governor to certify that there is “sufficient” farm worker housing in the area, and then the farmer could offer a housing allowance equivalent to “the statewide average fair market rental for existing housing for nonmetropolitan counties for the State...based on a two-bedroom dwelling unit and an assumption of two persons per bedroom,” about \$500 a month in the northern Sacramento Valley and \$800 a month in San Benito in 2000. However, most California agriculture is in metro counties, where 40th percentile fair market rents in 2000 are about \$525 (Fresno-Tulare-Kern) to \$1,100 (Santa Cruz) for two-bedroom units. Under AgJOBS, typical housing payments for guest workers would have been \$125 to \$150 per worker per month in California.

President Clinton opposed AgJOBS, and issued a statement: “When these programs were tried in the past, many temporary guest workers stayed permanently and illegally in this country. Hundreds of thousands of immigrants now residing in the U.S. first came as temporary workers, and their presence became a magnet for other illegal immigration.” In 1999, after consultations with worker advocates, a new concept was added to AgJOBS: earned legalization. Legalizing unauthorized farm workers might encourage many of them to leave for nonfarm jobs, as SAWs did in the 1990s, so farmers who wanted guest workers and worker advocates who wanted legalization agreed to a program that would grant unauthorized workers a temporary legal status.

Under their compromise, unauthorized workers who could prove that they did 100 or 150 days of farm work in the preceding year would get a temporary legal status that permitted them to live and work in the U.S. In order to maintain this temporary legal status, and eventually apply to become a regular U.S. immigrant, the temporary worker would have to do a certain amount of farm work each year for several years, e.g., 80 or 100 days of farm work for three to five years. Thus, after several years and 240 or 500 days of farm work, the temporary legal worker could earn an immigrant status.

Farmers and worker advocates argued over the details of a revised AgJOBS program that included earned legalization throughout 2000, with farmers wanting more days of farm work to qualify for eventual immigrant status, and worker advocates fewer days. After the November 2000 elections, some worker advocates, noting that both U.S. President Bush and Mexican President Fox favored a new guest worker program, agreed to a compromise that won the endorsement of the United Farm Workers and the National Council of Agricultural Employers. Under this December 2000 compromise, unauthorized workers who did at least 100 days of farm work in the preceding 18 months could qualify for temporary legal status, and they could convert this temporary legal status into an immigrant status if they did at least 360 days of farm work in the next six years. The compromise included (1) freezing the minimum wage that had to be paid to foreign workers for several years and (2) giving farmers the option of providing a housing allowance rather than housing to workers. The AgJOBS compromise came close to Congressional approval in December 2000, but was blocked by those opposed to any type of amnesty for unauthorized foreigners.

The atmosphere changed in 2001, especially after U.S. President Bush and Mexican President Fox met in Mexico in February 2001 and agreed to establish a migration working group that was charged with creating "an orderly framework for [Mexico-U.S.] migration that ensures humane treatment [and] legal security, and dignifies labor conditions." Senator Phil Gramm (R-TX) became the leading proponent of the guest worker-only approach, favoring a program that would permit unauthorized Mexicans already in the U.S. to obtain seasonal or year-round work permits: seasonal workers could return to the U.S. indefinitely, and year-round workers could remain in the U.S. three years, and then they would have to stay in Mexico at least one year before returning legally. U.S. employers and guest workers would pay social security taxes to a trust fund that would reimburse U.S. hospitals that provided emergency medical care for injured guest workers; the balance of the social security taxes paid would be placed in individual IRA-type accounts that workers could receive when they surrendered their work permits to U.S. consulates in Mexico.

Gramm's proposal covers Mexicans employed in all U.S. industries, but does not include a path to immigrant status. The other extreme is legalization. Under a plan embraced by the AFL-CIO and many church and ethnic groups, unauthorized foreigners in the U.S. from any country, and employed in any industry, could become immigrants, and then sponsor their families for admission. Rep. Luis V. Gutierrez (D-IL) introduced a bill that would grant immigrant status to all persons who were in the U.S. at least five years, and temporary legal status to those in the U.S. less than five years. When unauthorized foreigners reach the five-year U.S. residence mark, they could apply to convert their temporary status to an immigrant status.

Earned legalization is billed as the compromise between guest workers and legalization. Only unauthorized foreigners who have worked in the U.S. would be eligible, and they must continue working (in agriculture under AgJOBS) to maintain their temporary legal status and to eventually become immigrants. Earned legalization appeals to those who associate immigration with work in the U.S., and allows Mexican President Fox to keep his promise of improving conditions for the migrants he calls “heroes” for working in the U.S. and sending remittances to Mexico. A spokesperson said President Bush supports “a new temporary-worker program that would allow for some of the [unauthorized] workers to achieve permanent residency status over a period of time.” In 2003, it appears that Democrats, unions and immigrant rights groups will settle for earned legalization, but they oppose new temporary worker programs, while Republicans and most employers favor new temporary worker programs, but oppose an easy transition to legal immigrant status.

CONCLUSIONS

California agriculture continues to employ large numbers of seasonal workers to prune, irrigate and harvest a vast array of crops. Since the 1970s, labor-saving changes have been more than offset by increased plantings of labor-intensive fruits, vegetables and horticultural specialty crops, so that the average annual employment on the state’s farms has risen.

Most farm workers are employed seasonally and, since the 1880s, when labor-intensive agriculture developed, most of the seasonal workers were from other regions and countries. Since 1942, when the federal government assured farmers foreign workers through the Bracero program, most farm workers have come from Mexico. Despite legalization in 1987-88, a majority of the Mexicans employed on California farms are not authorized to work in the U.S. Most children of farm workers educated in the U.S. do not follow their parents into the fields, which explains why over 90 percent of California farm workers are born outside the U.S. and gives farmers a keen interest in immigration policies and their enforcement.

One significant change in farm labor markets in the 1980s and 1990s has been the rising market share of farm labor contractors: their share of average annual farm employment has almost doubled. The state government has aimed to increase the regulation of farm labor contractors, requiring them to be registered, and requiring bonds as well as passage of tests to be registered. There have also been efforts to increase penalties for labor law violations and require safer transportation for farm workers.

Historically, agriculture was exempted from many federal and state labor laws. Regulation of the farm labor market has increased, reducing the agricultural exceptionalism as minimum wage, workers’ compensation insurance, and workplace safety requirements were extended to agricultural employment. The most recent state attempt to regulate farm labor markets is the 2002 mandatory mediation amendment to the Agricultural Labor Relations Act, which will allow imposition of a collective bargaining contract by a third-party mediator/arbitrator, suggesting that state policy makers may switch from exempting agriculture from labor laws to developing unique farm labor laws.

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CHAPTER 9

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 half-century 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 issues such as 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; and odor pollution associated with livestock. 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 fifty 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. Fish and 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 county 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.

A survey 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 overly strict policing of agricultural activities that are likely to cause environmental side effects. For example, 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 the 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 (1975) 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 criteria, even in instances where balancing marginal benefits with marginal costs might be more appropriate.

Another practical difficulty in determining environmental quality is its multidimensionality. 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 alter 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 issues arising from California agriculture, and describes the conclusions of recent economic research that has analyzed the efficacy of various approaches to handling these issues. The diversity of problems and policy issues is illustrated here through discussion of control of animal wastes, pest control and the regulation of pesticides, endangered species protection, climate change, and the growing role of agricultural land as a source of recreational amenities.

DAIRY PRODUCTION AND THE ENVIRONMENT

California is the United States' major dairy producer, and is home to approximately one-sixth of the nation's dairy cow population. These 1.64 million cows account for over one-fifth of all milk produced in the United States (California Department of Food and Agriculture, 2002). Although the United States milk cow inventory

decreased by approximately 130,000 head between 1997 and 2001, the number of milk cows in California increased by 14 percent during this time. Milk production per cow has also increased by approximately five percent during the same period (National Agricultural Statistics Service, 2002). In short, California dairy production has been increasing both in scale and efficiency in recent years.

Until recently, the dairy industry in California had been closely concentrated near the larger population centers in Los Angeles and Northern California. The largest dairy-producing region in the state had been the Chino region near Riverside, not far from Los Angeles. These patterns were in accordance with the models of agricultural land use first developed by Johann von Thünen almost 200 years ago. Von Thünen modeled the allocation of land uses around a city as a function of the economic return, or “rent” to the land, which in turn is a function of transportation costs. In the city’s core, urban uses such as residences and industry will determine the highest value of the land. Von Thünen hypothesized that dairying and other intensive farming industries would be located immediately outside of the urban core, because they had the highest transportation costs, both in absolute terms and in terms of the losses that would be suffered by any delays in getting easily spoiled products to market. Less intensive industries such as forestry, extensive field crops, and ranching would be located further outside of the central city.

The allocation of land predicted by von Thünen’s model does not take environmental externalities into account, however. Recent studies suggest that when the cost of environmental quality is taken into account, then the location of various activities have to balance transportation and pollution costs (Goetz and Zilberman). Thus, pollution-intensive industries either have to reduce their pollution or relocate farther away from the city. The new modeling suggests that incentives (taxes on waste or subsidies to remove waste) or zoning may be introduced to induce industries to modify their behavior. Furthermore, in some cases optimal resource allocation, which takes into account both pollution and transportation costs, may lead to establishment of green zones separating animal production from urban areas.

The disposal of animal manure in the Chino area has historically caused severe groundwater contamination problems. Dairies in this region designated certain lands as disposal areas where all liquid and solid animal wastes are disposed. 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 performed at the time to assess the economic impacts of this standard suggested that it would reduce the dairy cow population drastically and reduce the economic surplus that this industry generates by about 80 percent (Moffitt, Just and Zilberman; Hochman, Zilberman and Just). Not surprisingly, 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. This policy was adopted, and enabled the industry to survive for another two decades. The use of disposal areas for animal waste is not optimal and is not sustainable in the long run, however. A major challenge for the California dairy industry is to find better solutions for disposal of animal wastes.

Accommodating the animal waste regulation requires investment in waste disposal facilities. Some farmers may have significant credit constraints and not be able to obtain the resources from private lenders to invest in the waste disposal facilities. Government credit provision may alleviate this problem and reduce the difficulty of adjusting to the waste disposal regulation. Macdougall *et al.* (1992) show that credit support policies can significantly reduce the cost of adjustment to water quality regulation in the Chino area. They also show that the ability of the dairy industry to withstand animal waste regulation is much higher in periods of low interest rate and economic prosperity and thus that regulation should be introduced in such periods.

The concern with the environmental side effects has resulted in a wide variety of constraints and regulation that resulted in outcomes that are consistent with the theory presented above. Many 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. Four of the five leading dairy counties in California are now in the San Joaquin Valley: Tulare, Merced, Stanislaus, and Kings (California Department of Food and Agriculture, 2002). Part of this move is certainly a shift away from the high land values brought by residential development, but much of it is also due to decreasing the environmental costs.

California has not yet found the balance between transportation costs and environmental concern in locating its animal facility and managing its land resources. The design of optimal policies to control the side effects of animal agriculture will be one of the major challenges to policymakers and agricultural economists in the coming years.

EXOTIC PESTS

Agriculture is about managing living systems, and these systems evolve over time. One of the biggest challenges to California agriculture is the control of pests, and these pests have evolved genetically and migrated from other locations. With growing trade and tourism, California has been exposed to infiltration of exotic pests originated elsewhere. Two of them are especially expensive and difficult to control. The Mediterranean fruit fly has coexisted with agriculture for some time now, whereas various sharpshooters, carrying Pierce's disease, have recently posed a potentially huge threat to California's vineyards.

The Mediterranean Fruit Fly

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 since.

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.)

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.

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.

Pierce's Disease

The presence of Pierce's Disease (PD) makes it almost impossible to grow European-type (*Vinifera*) grapes for wine in the southeastern United States (Purcell). PD requires two components to spread. One is the bacterium *Xylella fastidiosa*; the second is a vector of transmission. Two vectors appear in California. One is the xylem-feeding sharpshooter leafhoppers (*Cicadellinae*), and the other, the glassy-winged sharpshooter (*Homalodisca coagulata*), is native to the southeastern states, from Florida through Texas.

The sharpshooter leafhoppers

The sharpshooter transfers the bacteria from an infected host plant to other plants. Once infected, yield decreases, and often the vine will die. The leafhoppers breed over winter in riparian vegetation, ornamentals, and/or pastures, picking up the *Xylella* bacteria from host plants. The insects then migrate in the spring to feed on succulent vegetation, such as grape vines, infecting the vines as they spread. An infectious blue-green sharpshooter has more than a 90 percent chance of transmitting the bacteria. Recent PD outbreaks in California's Napa Valley wine grapes, one of the premier wine-producing regions of the United States, are estimated to have cost vineyard owners \$46 million in 1999 (Johnson, 2000).

Insecticides have limited effectiveness on PD in vineyards where the sharpshooters enter each spring from riverbank vegetation. Applying insecticide to the riparian area where the insects are concentrated might control the spread of PD, but applications are constrained due to wildlife and water quality concerns. Removal of the bacterial and sharpshooter host plants at their riparian sources might reduce incidences of the disease, but the riparian vegetation may be protected by legislation. Brown et al. considered the economic impact of planting crops between the source area and the grape vines. These crops act as a barrier to transmission in order to slow or prevent the sharpshooter migration, but this strategy requires taking land out of grape production.

The optimal barrier crop strategy depends on the profitability of the barrier crop relative to wine grapes and the effectiveness of the barrier crop, measured by percentage reduction in pest penetration per unit of barrier length. Growers in the Napa Valley considered the use of Christmas trees as a barrier crop. Brown et al. (2002) estimated the optimal length of a barrier for an 800-foot long row of grapes originated at a riparian zone. They found the length of the barrier declined with the effectiveness of the barrier crop and the profits of grapes relative to the barrier crop.

The average profits per acre of grapes without PD were \$5,230, and the baseline return from Christmas trees was \$1,764 per acre. A barrier characterized by an effectiveness parameter of .05, .25, and 1.0, respectively, requires the grower to plant barriers only 69, 21, and 12-feet wide while reducing profit per acre on average from \$5,230 to \$4,856, \$5,127, and \$5,175, respectively. Without any barrier, the average profit per acre will decline to \$3,054, as most of the rows near the riparian zone will be decimated. Thus, a barrier crop with a .25 effectiveness allows the grower to earn 98 percent of the profit earned in the case of no PD, while effectiveness of .05 leads to a loss of about 9 percent of the profits and, without a barrier, close to 40 percent of the average profits are lost to PD.

Brown et al. also considered a mixed strategy that allows removal of the riparian zone in addition to riparian buffers. Their analysis assumed the price of \$1,489 per ton of grapes as a baseline. Removal of riparian vegetation to control PD is being hotly debated in California. The U.S. Fish and Wildlife Service, which has jurisdiction over riparian areas, opposes clearing vegetation. The results of the simulations suggest that partially removing the host vegetation is suboptimal regardless of society's willingness to pay for riparian habitat. As the price of grapes rises, the breakeven social value of riparian vegetation increases linearly. With the bench price of \$1,489 per ton, the removal of a 6 foot by 100 foot strip of riparian vegetation would be socially optimal if it provided less than \$5,481 in environmental benefits. Alternatively, the value of the riparian zone strip is implicitly above \$5,481 if the riparian zone is maintained. Recent research focuses on modification of the riparian zone, which will replace plants that are hosts to the bacterium and vector, while maintaining a riparian zone.

The glassy-winged sharpshooter

This insect, and the PD it carries, is not just a threat to raisins and table and wine grapes, but it also has the potential to spread the disease to other important agricultural commodities. A joint state-federal plan has dedicated a total of \$36 million to eradicate and prevent the spread of the glassy-winged sharpshooter (GWS), a new arrival in California. The federal government will allocate \$22 million to augment state and private agricultural industry efforts to control the spread of the GWS and support research to find methods to cure PD.

The GWS is active in warmer climates. It has already decimated most of the grapevines in Temecula in Southern California, and it is a problem in Los Angeles and Kern counties. Purcell's (1999) simulations predicted that the GWS will spread to 15 grape-growing counties including Fresno and Tulare, which produced over \$500 million worth of grapes in 2000. The damage potential of PD spread through GWS can reach billions of dollars over time (Lynch, Brown and Zilberman, 1999). GWS transmitted PD from oleanders and other host crops, especially citrus, and it is now being controlled by spraying pesticides in host citrus orchards adjacent to grape vines. The bacterium *Xylella fastidiosa* affects other crops besides grapes including almonds, peaches, and oleander. Brown et al. suggests that the net present value of potential damage is greater than \$2 billion. Ongoing research aims to find biological control and biotechnology solutions to these pests, but for now the solution is through application of chemical pesticides.

THE REGULATION OF PESTICIDES

A driving factor behind pesticide regulation in the United States is the desire to protect consumers from harmful residues on food. The Food Quality Protection Act (FQPA) was unanimously passed by the U.S. Congress in 1996 and hailed as a landmark piece of pesticide legislation. It amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and the Federal Food, Drug, and Cosmetic Act (FFDCA), and focused on new ways to determine and mitigate the adverse health effects of pesticides. FQPA is different from past legislation; it is based on the understanding that pesticides can have cumulative effects on people, and that policy should be designed to protect the most vulnerable segments of the population. Recent research described below has investigated some of the impacts that FQPA's provisions—many of which have yet to be fully implemented—may have on California growers and consumers.

Pesticides are also regulated to mitigate the impact on worker health or the greater environment. Of particular interest to many Californian growers is the pending ban on Methyl bromide, an extremely effective soil fumigant that is being phased out because of its impact on the ozone layer.

The Food Quality Protection Act

The publication of the National Research Council report *Pesticides in the Diets of Infants and Children* (1993) showed that pesticide residues have disproportionate effects on children. Children eat and drink more as a percentage of their body weight than adults; they also consume fewer types of food. These dietary differences account for a large part of the exposure differences between adults and children. The committee also found that pesticides have qualitatively different impacts on children because children are growing at such a rapid pace. This concern for the differential impact pesticides have on children is reflected in regulatory changes required by the FQPA. For instance, the “10X” provision of the FQPA requires an extra ten-fold safety margin for pesticides that are shown to have harmful effects to children and women during pregnancy.

The FQPA has also resolved the “Delaney Paradox” created by the Delaney Clause of FFDCA. Prior to FQPA, the Delaney clause prohibited the use of any carcinogenic pesticide that became more concentrated in processed foods than the tolerance for the fresh form. This was supposed to protect consumer health, yet it had the paradoxical effect of promoting other non-carcinogenic pesticides that created other (possibly more serious) health risks for consumers. FQPA standardizes the tolerances for pesticide residues in all types of food, and looks at all types of health risks.

The federal Environmental Protection Agency (EPA) must now ensure that all tolerances are “safe,” defined as “a reasonable certainty that no harm will result from aggregate exposure to the pesticide” (EPA, Office of Pesticide Programs, 1999). Historically, pesticide exposure was regulated through single pathways, either through food, or water, or dermal exposure. Now the EPA must consider all pathways of pesticide exposure, including cumulative exposure to multiple pesticides through a common mechanism of toxicity. This means that even though pesticides may be sufficiently differentiated that they are used on different crops to control different

pests, they can have similar health effects on people. The result is that in some instances, pesticide tolerances for seemingly different insecticides must be regulated together based on their cumulative effects.

The Costs of Banning Organophosphates

When FQPA was first signed into law, 49 Organophosphate (OP) pesticides were registered for use in pest control throughout the United States, and accounted for approximately one third of all pesticide sales (Casida and Quistad, 1998). OP insecticides are highly effective insect control agents because of their ability to depress the levels of cholinesterase enzymes in the blood and nervous system of insects. It has been suggested that while dietary exposure to a particular OP may be low, the cumulative effects of simultaneous exposure to multiple OP insecticides could cause some segments of the U.S. population to exceed acceptable daily allowances (Byrd, 1997). Reducing the risk from these aggregate effects is specifically addressed in the FQPA and is one of the reasons the EPA has chosen OP pesticides for the first cumulative risk assessment.

Due to their popularity and widespread use, many in the agricultural community are worried about FQPA implementation resulting in increased restrictions on OP pesticides. By the time EPA released the Revised OP Cumulative Risk Assessment in 2002, 14 pesticides had already been canceled or proposed for cancellation, and 28 others have had considerable risk mitigation measures taken (U.S. Environmental Protection Agency 2002). Risk mitigation may include: Limiting the amount, frequency, or timing of pesticide applications; changes in personal protective equipment requirements (for applicators); ground/surface water safeguards; specific use cancellations; and voluntary cancellations by the registrant.

Economic theory suggests that these increased restrictions and cancellations from the eventual implementation of FQPA will result in a reduced supply of commodities currently relying on OP pesticides for pest control. This will result in higher prices for consumers and a lower quantity sold. In order to estimate the possible welfare effects on the state of California, University of California researchers conducted a study on the effects of a total OP pesticide ban on 15 crops. The estimated price and quantity changes are presented in Table 1.

Results of the economic analysis suggest that the total loss to producers and consumers in California from banning all OP use will be approximately \$200 million. There is significant uncertainty as to the final level of OP restrictions; this is only an order of magnitude estimate of the effects. However, these effects only represent about 2 percent of the total revenue generated by the 15 crops studied in California. While the overall effects seem small, they may be more intense in some segments than others. The researchers found that the degree of impact rests on the effectiveness of alternative pest control strategies producers have to choose from when faced with an OP ban. In some cases, OP pesticides have no close substitute, and cancellation will have larger effects. For instance, the losses in broccoli, one of the crops most sensitive to an OP ban, are driven by the lack of an alternative insecticide to treat cabbage maggot.

Table 1. Price and Production Changes from Organophosphate Ban

Crop	Change in Price	-----Change in Production ^a -----	
	(percentage)	California	Rest of US
Alfalfa	0.93	-184,845	48,743
Almond	0.48	-1,356	n/a
Broccoli	16.00	-111,285	2,083
Carrots	>0.01	-5	-3
Cotton	1.69	-1,148	-19,214
Grapes	0.05	-999	-265
Lettuce, Head	0.36	-12,778	3,864
Lettuce, Leaf	0.46	-1,510	-148
Oranges	0.32	-40,517	-28,137
Peaches & Nectarines	0.32	-1,561	-2,016
Strawberries	0.26	-508	-743
Tomatoes, Fresh	0.03	-388	-223
Tomatoes, Processed	0.16	-10,849	114
Walnuts	0.58	-1,091	n/a

a) Change in tons

Source: Metcalfe, et al. The Economic Importance of Organophosphates in California Agriculture, 2002.

Trading One Disease for Another?

As illustrated above, it is generally true that removing a pesticide from the production process will result in an increase of the price of the treated commodity. If consumers respond to the increased prices by reducing consumption of the affected fruits and vegetables (and perhaps shifting consumption to less nutritious foods), they may suffer a loss of health benefits associated with the change in consumption. Scientific evidence is accumulating which shows a protective effect from fruits and vegetables in the prevention of cancer, coronary heart disease, ischemic stroke, hypertension, diabetes mellitus, diverticulosis, and other common diseases. The level of protection suggested by these studies is often quite dramatic. A recent review of several studies found that “the quarter of the population with the lowest dietary intake of fruits and vegetables compared to the quarter with the highest intake has roughly twice the cancer rate for most types of cancer” (Ames, Gold and Willett, 1995).

Negative health outcomes from a change in dietary behavior may offset the direct health benefits of a pesticide ban, such as reduced exposure to carcinogenic residues on produce. A recent study by Cash (2003) investigates the possible magnitude of such offsetting health effects. Using data on what over 18,000 people eat and previous findings on how people respond to changes in the price of fruits and vegetables, the author simulated some of the health effects of a small increase in produce prices. Specifically, Cash examined the effects of a one-percent increase in the price of broad categories of fruits and vegetables on coronary heart disease and ischemic stroke, two

of the most common causes of death in the United States. The results are reported in Table 2.

Table 2. Cases of Coronary Heart Disease and Ischemic Stroke Induced in the U.S. Population by a one percent Increase in the Price of All Fruits, All Vegetables, or All Fruits and Vegetables

Disease	All Fruits	All Vegetables	All Fruits and Vegetables
Coronary Heart Disease	1,442	2,951	6,903
Ischemic Stroke	744	1,482	3,022
Total	2,186	4,433	9,925

Source: Cash, *Essays on the Economics of Protecting Health and the Environment*, 2002.
Results reported are the simulation means from a series of Monte Carlo trials (n=100,000).

For a one percent increase in the average price of all fruits and vegetables, the simulations indicate an increase of 6,903 cases of coronary heart disease and 3,022 ischemic strokes. In order to offset these 9,925 cases in a population of 253.9 million people, a pesticide action would have to prevent 1 in 25,580 cancers. This is almost four times as protective as the mean risk of pesticide uses that were banned between 1975 and 1989 (Van Houtven and Cropper, 1996). Although these results can not be applied directly to most individual pesticide bans—which typically only affect the price of a few crops—the study shows that pesticide regulations that reduce relatively small risks at high cost may actually have a negative impact on overall consumer health. Furthermore, the research also suggests that low-income consumers may be the hardest hit by the negative health impacts of price-induced dietary changes, whereas high-income consumers tend to reap the greatest direct benefits from reduced residue exposures.

Economic theory tells us that regulatory intervention is justified in the presence of market failures. In the case of pesticide residues on food, the two most salient sources of failure are externality and incomplete information. The externality arises because the costs faced by dietary exposure to pesticide residues are not borne by the producers who make the application decisions. The incomplete information problem arises because a consumer can not easily determine the level of pesticide residue on produce. Even if this were readily apparent, the risks posed by these residues are not well understood.

The problem illustrated in the previous section is that regulatory decisions that are based on narrow criteria may give rise to other undesirable outcomes. When the target risk is small and the costs of reducing it are relatively large, there is a strong possibility that the net effect of a regulatory effort may be negative. Although consideration of such tradeoffs may be repulsive when the metric is in “body counts,” the reality is that it is impossible for government to eliminate all risks to our health and well-being. A

standard of discretion must be applied, whether it be benefit-cost analysis, established levels of acceptable risk, or some other measure.

The Food Quality Protection Act is a wide-reaching law that will have a large impact on California agriculture in the coming years. While an increased awareness of the effects of agricultural chemicals on vulnerable groups—especially infants—is a welcome addition to the nation’s pesticide laws, regulators need to take into account the potentially high costs of additional pesticide bans on both producers and consumers. These costs can be measured not just in dollars, but also in dietary changes that may have negative health consequences. In implementing the regulations required by the FQPA, EPA should keep in mind that this most recent overhaul of the pesticide laws specifically grants the agency discretion in setting standards when use of the pesticides prevents other risks to consumers or avoids “significant disruption in domestic production of an adequate, wholesome, and economical food supply” (U.S. House of Representatives, 1996). Too narrow of a regulatory focus that ignores economic responses and countervailing health risks is misguided, as the net effect on public health could be negative.

Banning Methyl Bromide

Pesticides often come under the regulatory microscope for reasons other than the health effects of chemical residues on food. Methyl bromide (Mbr), a commonly used soil and commodity fumigant, is both highly volatile and extremely toxic to non-target organisms, including humans. Although its use has been regulated to protect worker health for several years, it is now facing a complete ban because of its potential global impact. When Mbr 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, currently scheduled in the United States for the year 2005.¹

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.

¹ As of the writing of this chapter, a United Nations panel had recommended that critical use exemptions for several agricultural uses be approved, including strawberries, tomatoes, cut flowers, and golf course maintenance (Revkin, 2003). If finalized, this exemption would apply to growers across the United States and in twelve other countries.

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, Nematicure, 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.

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	--	11.1	--	26.4	30.5	19.4	27.5
Fresh 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

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.

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.

ENDANGERED SPECIES

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 2003, there were 149 animals listed as endangered or threatened under state or federal law, or both (California Department of Fish and Game, 2003a). There were also over 200 species of plants listed as endangered, threatened, or rare (California Department of Fish and Game, 2003b).

An overall estimate of economic impact for California agriculture is highly difficult, because effects and recovery plans vary by species. 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.

Forest, rangeland, and abandoned farmland might be most affected by 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.

Case Studies

Despite the far-reaching scope of the ESA, no estimates of the total impact of the Act on California Agriculture exist. 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 small compared to its gross value, but individual farmers and crops might be seriously affected. Recent studies have looked at the potential California impacts of individual protection plans for vernal pools, the California gnatcatcher, and the kit fox.

Vernal pools are seasonal wetlands that fill sporadically during the rainy season. They occur in shallow depressions on flat land, and provide important habitat to plant and animal species that are specifically adapted to the extreme cycle of wet and dry that characterizes large parts of California. Because at least 11 federally protected endangered species depend on vernal pools, the United States Fish and Wildlife Service (USFWS) has designated 1.6 million acres of land in California and southern Oregon as critical habitat for vernal pool species. A draft study commissioned by the Fish and Wildlife Service estimated that the total costs of this designation over 20 years would be between \$128 and \$135 million (Economic and Planning Systems, 2002).

A study conducted by Sunding, Swoboda, and Zilberman (2003) takes specific issue with both these estimates and the methodology employed by USFWS in conducting such analyses. Sunding and his colleagues argue that a total cost estimate includes the impact of the restrictions on housing and agricultural prices; losses borne by parties other than the affected landowners, such as consumers and developers; the costs imposed by regulatory delays; and the effects that designation plans may have on congestion, sprawl, and regional economic activities. Their analysis suggests that the USFWS study underestimates the actual economic impacts of the proposed vernal

pool designation by 7 to 14 times, implying that the actual damages may exceed \$1 billion. Furthermore, Sunding *et al.* find that consumers are likely to face the largest portion of these costs, contradicting the USFWS study's implicit assumption that landowners bear all of the costs of critical habitat designation.

In a related study, Sunding (2003) examined the potential costs of critical habitat designation for protection of the coastal California gnatcatcher, or *Poliophtila californica*. The California gnatcatcher is a non-migratory bird that primarily inhabits coastal sage scrub. Its habitat is centered on highly populated areas of southern California. Rapid urban and agricultural development in the region contributed to the decline of the gnatcatcher population, and it was listed as a federally threatened species in 1993. In April 2003, USFWS designated almost 500,000 acres of critical habitat for the gnatcatcher in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties.

Sunding's analysis suggests extremely high economic impacts for this designation—between \$4.6 and \$5.1 billion for the period from 2003 to 2020. This implies costs of approximately \$10,000 per designated acre, and of \$150,000 per developed acre. In this case, the costs are primarily borne by consumers in the form of higher housing prices, as the designation will impose serious restrictions on the development of new housing. According to Sunding, these costs are largely imposed in three ways: the increase in out-of-pocket costs to developers, the delay of completion of housing projects, and the reduced scale of these projects.

Agricultural activity can sometimes be restricted by ESA designation in very specific ways. For example, in the 1990s the USFWS proposed to ban the use of two non-restricted anticoagulant pesticides, chlorophacinone and diphacinone, because their use to control ground squirrels and jackrabbits on cropland were impacting the endangered San Joaquin kit fox. Although the kit fox does not generally consume the treated crops, it is a predator that often feeds on the affected target species. Since these pesticides accumulate in the liver of the dead pest, the kit fox could be poisoned through biological magnification of the anticoagulants. Zilberman, Siebert and Zivin (1997) estimated that the direct costs of the proposed restrictions to growers in Kern County would be in excess of \$70 million per year. They termed these costs as short-run, because they hypothesized that suitable alternatives to the restricted pesticides may be developed, although there would likely be some delay before their implementation.

CLIMATE CHANGE

Climate change, caused by increased stock of greenhouse gases (GHGs), is potentially one of the most serious environmental problems facing mankind. Clouds and GHGs allow the sun's heat to pass through to the earth, but they form a barrier to the outgoing infrared heat, thus acting as a greenhouse. A greater concentration of GHGs increases this, leading to the possibility of climatic change and global warming. The atmospheric concentration of carbon dioxide (CO₂), the major GHG, has increased by approximately 30 percent since the Industrial Revolution.

The Intergovernmental Panel on Climate Change (IPCC), a United Nations-sponsored research group, identifies a number of recent climate changes that are

attributable in part to human activity. The estimated global mean temperature has increased by 0.6° plus or minus 0.2° C over the last 50 years. Continental precipitation has increased by 5-10 percent in the Northern Hemisphere, and decreased in some regions.

In the absence of policy intervention, CO₂ concentrations are projected to increase by 75 to 350 percent above pre-specified levels during the next century (Gitay *et al.*, 2001). Temperature is projected to increase by $.14$ - 5.8° C, a change approximately two to 10 times larger than the estimated increase during the last century.

There is a growing body of literature on the impact of climate change on agriculture. Many of these studies are based on the ecosystem movement paradigm, which assumes that “ecosystems will migrate relatively intact to new locations that are close analogs to their climate and environment” (Gitay *et al.*, 2001). The estimated levels of global warming are likely to cause 100-to-200-mile movement of climate and ecosystems away from the Equator and towards the Poles. With that, the Sacramento Valley may have the climate conditions of Bakersfield, and the San Francisco Bay will have the weather of Los Angeles. Under these assumptions, some regions close to the Equator will be deserted, and currently uncultivated lands close to the Poles will enter production. Some lands will switch from “cold climate” crops to “warm climate” crops, and current use patterns will continue on much of the agricultural lands with some modifications. Since the area of arable landmass declines as one moves away from the Equator, the “ecosystem movement” may result in reduction of supplies of food products. The higher carbon sequestration levels associated with climate change will also result in a “fertilization effect” that will increase yields per acre. Climate change will increase food supplies if the “fertilization effect” dominates the “ecosystem movement” effect, and it will decrease if the “ecosystem movement” effect is dominant.

Studies reviewed by Gitay *et al.* (2001) suggest that climate change does not pose a serious threat to the U.S. and global food capacity. The estimated annual impacts of climate change on U.S. agriculture range in most studies between a net loss of \$10 billion to a net gain of \$10 billion. On the other hand, the empirical simulations mentioned above suggest that the distributional effects of climate change are likely to be substantial. Adams, Hurd, and Reilly (1999) found that northern regions in the United States are likely to gain from climate change while southern regions are likely to lose. In particular, northern regions in California and Oregon may gain from climate change, while southern California regions may lose.

Most of the analysis on the impact of climate change was based on regions with rainfed agriculture. California agriculture is unique in its reliance on irrigation, which requires heavy investment in fixed infrastructure. Furthermore, perennial crops that are prominent in California are also investment incentives. Thus, the adjustment to climate change may require high cost of fixed investment of relocation. Most of the water infrastructure in California has been subsidized by the public sector and, thus, historical private costs of production are not good indicators of cost after adjustment to climate change (Fisher, 2002). Without the subsidies, the cost of water is likely to increase, and that will reduce the profitability of agriculture and restrict the extent to which agricultural production capacity is relocating.

Climate change will change the precipitation pattern of California, and that will add extra cost in addition to the relocation effect. Increase in temperature will increase

the amount of rain relative to snow during the winter. Less water will be stored in snow packs, and larger volumes of runoff will be released earlier in the season, exacerbating the risk of flooding and reducing the availability of water for agriculture in the late spring and summer when demand is at its peak (Fisher, 2002). Adjusting to these changes will require extra investment in dams and infrastructure.

Most of the impact assessments of climate change treat it as a transition occurring at a given moment in time. However they tend to underestimate the cost and complexity of adjusting to climate change, since it is a continuous process that at present is subject to much uncertainty. Thus, several modifications of infrastructure and production patterns may occur as climate change progresses, and the lack of certainty may increase the adjustment cost (Zilberman, Liu, Roland-Holst, and Sunding, 2003).

While much of the literature suggests that the impacts of climate change on U.S. agriculture are likely to be modest, the analyses in the case for California suggest that the cost of adjustment to climate change may be quite substantial.

AGRICULTURAL LAND AS A SOURCE OF ENVIRONMENTAL AND RECREATIONAL AMENITIES

Much of the preceding discussion has illustrated how regulation seeks to mitigate the negative environmental externalities that arise from agriculture in California. Yet there is also recognition by both the public and the government of the role that agriculture plays in land stewardship. There are major government programs that reward participating farmers for conservation activities. Furthermore, agriculture provides valuable recreational amenities to consumers, both indirectly and directly.

The U.S. Department of Agriculture, through the Farm Service Agency and the National Resource Conservation Service, offers programs such as the Conservation Reserve Program (CRP), Wetland Reserve Program, Grasslands Reserve Program, and the Environmental Quality Incentives Program (EQIP) to encourage farmers to engage in conservation activities. In the same way that taxes can be used to discourage activities that have negative side effects, governments may choose to subsidize those activities with “positive externalities”—that is, activities that carry benefits that are enjoyed by parties other than those who have direct control over the resource. The economic justification for such subsidies is that in their absence, private decision-making will result in too few of these conservation activities. By subsidizing the desirable activities, governments can increase the private benefits to the farmers, and thus encourage a move toward a more optimal level of provision.

The Conservation Reserve Program is the largest of these programs. Under the CRP, farmers are paid to retire environmentally sensitive cropland from production. Agricultural land may be eligible if it is highly prone to erosion, contributes to a serious water quality problem, provides important wildlife habitat, or can provide other substantial environmental benefits. Farmers can also receive additional reimbursement for conservation expenses, such as planting cover crops to reduce erosion on retired land.

Although the CRP was established in its current form in the 1985 Farm Bill, it has its origins in the 1950s, when Congress established similar programs in the Soil Bank

Act. These programs were explicitly touted as a way of avoiding a repeat of the 1930s Dust Bowl. The renewed interest in such programs in the 1980s was in large part a response to the depressed agricultural commodity prices of the time. The CRP was not only seen as a way of achieving environmental protection, but it also allowed for another channel of payments to distressed farmers and helped to ease overproduction by retiring land from active use.

The CRP has been reauthorized in every subsequent farm bill, and has been growing at a moderate pace in recent years. USDA will pay out \$1.6 billion to American farmers under the CRP between October 2003 and September 2004; these payments cover over 34 million acres in all fifty states. Participation in California is fairly modest, with 383 farms receiving \$4.4 million in payments for just under 143,000 acres of set-aside land in 2003-2004. In contrast, Texas farmers will receive over \$142 million for conservation of over 4 million acres of land. At the same time, the average payments received by participating farms in California (\$11,380) are well over the national average of \$4,354 per participating farm (United States Department of Agriculture, 2003).

The EQIP program is of much greater importance to California farmers. EQIP was first enacted in the 1996 Farm Bill, and its reauthorization in the 2002 Farm Bill provides \$11.6 billion in assistance over ten years. EQIP grants farmers payments for specific environmental improvements on their land. Participating farmers can receive cost share assistance for up to 75 percent of the cost of environmental projects that fit in to the priority areas chosen for each state. In California alone, \$38.6 million was allocated for the fiscal year 2003. About half of this money was designated for special programs such as water conservation in the Klamath basin, replacement of diesel engines, and statewide surface and groundwater conservation projects. The other half goes to "regular appropriations," which are distributed on a per-county basis. For 2003, Fresno, Merced, Riverside, Stanislaus, and Tulare counties were each slated to receive over one million dollars in EQIP funds (United States Department of Agriculture, 2003b).

Such "green payment" programs are likely to become more important in the future, as the liberalization of international trade makes it increasingly more difficult for governments to continue traditional agricultural price support programs. Under current WTO regulations, agricultural conservation programs are considered more acceptable than price supports, because they support farmers in ways that have less of an impact on agricultural markets. This trend, if it continues, may be of particular benefit to many California farmers, who receive relatively less benefit from price support programs than farmers in other parts of the country.

It is interesting to note that agricultural support programs have traditionally received strong support from urban, as well as rural, residents. This is probably due in large part to the role that agriculture plays in maintaining the rural qualities enjoyed both by Californians and the state's many visitors. Visitors to the countryside enjoy the scenery, connection to the nation's history, and perceived lifestyle offered by agricultural activities. Even those individuals who rarely visit rural areas may benefit from simply knowing that these areas are being maintained in a certain way, a phenomenon that economists refer to as "existence value." For these reasons, society's interest in providing public support to agricultural activities extends beyond an

altruistic concern for the welfare of farmers or arguments of domestic food security. Society may seek to provide assistance to the farmer both for protecting the environment and for maintaining the rural way of life.

This desire to maintain the scenic and recreational amenities of agricultural areas can also translate to private incentives for conservation of agricultural activities and the environment. For example, vineyards in northern California's wine country are sources of tourist revenue as well as income from wine production. The wineries benefit directly from the crowds of visitors who crowd the tasting rooms every weekend, and the region is home to numerous bed and breakfasts to house these guests. Such examples of "agri-tourism" can be pursued anywhere that farm activities are scenic, rather than noxious, from the point of view of the potential visitor. In California, agri-tourism activities also include dude ranches, self-pick berry and apple farms, corn mazes, and farm-animal petting zoos (Warnert, 1999). The potential economic impact of these activities is unknown, but it may be informative to note that golf courses, a quasi-agricultural land use, resulted in a total sales impact in California of \$7.8 billion in 2000, directly supporting over 62,000 jobs (Templeton *et al.*, 2002).

In the preceding discussion of dairy production, we noted that the negative externalities involved in dairy production counteract the other benefits of having these facilities located close to population centers. In contrast, the positive externalities associated with the recreational and environmental amenities of some farming activities are magnified when these operations are located closer to urban areas. Although Napa Valley wine would still taste as sweet if it were located 200 miles further from San Francisco, there would be far fewer people enjoying a drive through wine country on any given Sunday. Everything being equal, farmers who are closer to population centers will be able to reap greater private benefit from provision of new agri-tourism opportunities.

CONCLUSIONS

Agricultural activities affect the environment both directly, through the transformation of wildlands into farmlands, and indirectly, through a spillover of residues that may cause pollution and other negative side effects. A large body of legislation has been established to control the impact of agriculture on the environment. This legislation may restrict the availability of resources, both land and water, for agriculture.

This chapter shows that compliance to various regulations of control of animal waste and other pollutants is costly. The selection of the right policy tool to control pollution is essential as the use of incentives and targeted policies may reduce the cost of compliance drastically and will enable obtaining higher levels of environmental quality with much lower cost. We also found that the intensive farm systems of California have to deal constantly with pest problems, and the environmental regulation may increase the cost of pest control and present a challenge to the university and farming community to develop technologies to control pests in an environmentally friendly and cost-effective manner. At the same time, excessive control of pesticide use, while improving environmental quality, may result in undesirable human health and nutrition problems, and the regulation of pesticides involve trade-offs among the economic cost, the environment, and human health.

The growth of California agriculture and its costs of operation are also restricted by limited access to land and water resources, resulting from the Endangered Species legislation. To reduce the cost of complying with this regulation, it is important to better understand the behavior of wildlife and fish and the resources they need to survive. Thus, to some extent effective regulation and management of the future of agriculture require ecological understanding and knowledge of the value and function of land and water resources that are outside agriculture. Moreover, California agriculture by itself is a source of valuable environmental amenities and, as society's concern for environmental issues and willingness to pay for environmental amenities increase, there is a growing emphasis on improving stewardship of natural resources and maintaining and improving environmental quality in farming.

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CHAPTER 10

Organic Agricultural Production in California

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The California Organic Foods Act (COFA), signed into law in 1990, provides protection to producers, processors, handlers and consumers in that foods produced and marketed as organic must meet specified standards. As part of the regulatory process, COFA requires annual registration of all processors, growers and handlers of commodities labeled as organic. State registration is separate from, and does not act as a substitute for, organic certification. Registration is mandated by state law and is administered by CDFA while certification is mandated by federal law and is conducted by certification organizations accredited by USDA.

The Organic Foods Production Act (OFPA) of 1990 requires the United States Department of Agriculture (USDA) to develop national organic standards for organically produced agriculture and to develop an organic certification program. The final regulations for implementation of the OFPA were published in the Federal Register in December, 2000. The new rule took effect April 21, 2001 and marked the beginning of the transition period. Full compliance with the rule was required by October 20, 2002 at which time products began to use the National Organic Program organic label. The final rule includes a list of allowed synthetic and prohibited non-synthetic materials as well as labeling requirements. Unlike COFA, OFPA requires all growers grossing \$5,000 or more to obtain certification from a USDA accredited certification organization.

Interest in organic agricultural production has never been greater due to the continuous and rapid rate of expansion and the relatively higher prices commanded for organic products. This chapter quantifies the current size and growth of the organic industry in California with respect to acres, farm gate sales, and number of growers. The chapter looks at size and growth with respect to major commodity groups and subregions of California. The state's counties are divided into eight geographic regions based on similar groupings used by the California Department of Food and Agriculture (CDFA) in their annual statistical reports (Figure 1). The six major commodity group classifications presented also parallel the CDFA reports and include: field crops; fruit crops; nut crops; livestock, poultry and products; nursery, forestry and flowers; and vegetable crops (Table 1). The most important individual commodities will also be discussed.

When interpreting the results, the following points should be considered. The numbers contained in this chapter are derived solely from information provided in the annual registration forms of organic growers. In other words, the numbers are presented as reported to CDFA by growers. Only sales from products marketed as organic are required to be reported to CDFA. This means that income from sales of organically grown products sold in the conventional market may not be included. Similarly, income from government payments is not reported. Further, the registration information does not reveal whether or not a farm also has conventional production. Therefore, the size of the farm operation is not known from the registration data; only the size of the organic enterprise is known. There are a number of conventional growers in California who devote only a portion of their total acreage to organic crop production. Therefore, some of the growers that are categorized as "small" or "medium-sized" organic farmers may actually be larger conventional growers experimenting or diversifying with some organic acreage.

Under CDFA regulations, producers of organic commodities pay graduated registration fees based on an operation's total sales. However, registrants grossing over \$5 million annually were not obligated to report sales above that amount prior to 2003. While most registrants reported actual amounts over \$5 million, some registrants reported at the ceiling. Therefore, the total value of production in this chapter is undoubtedly underestimated because income realized by some high-revenue producers may not have been fully accounted for.

CALIFORNIA ORGANIC PRODUCTION IN 2002

A total of 1,949 registered organic farmers reported gross sales of \$260 million for organically grown commodities from 170,000 crop production acres during 2002. (Tables 2,3, and 4). Organic agriculture represented approximately one percent of the total cash income from marketings for all agriculture in the state in 2002, excluding livestock, poultry and products. Organic fruits and nuts represent 1.4 percent of the state total and organic vegetable crops represented 2 percent of total vegetable marketings (CDFA, 2003).

Figure 1. California Regions



Table 1. Commodity Groups, Commodity Types, and Individual Commodities

Commodity Group	Commodity Type	Individual Commodity
Field crops	Alfalfa Barley Beans Buckwheat Cane Clover Cotton Field Corn Flax Jojoba Legumes Oats Pasture Peas (dried) Popcorn Rice Rye	Ryegrass Safflower Seed crops Sesame Sorghum Soybeans Sudan Grass Sugar beets Sunflower Tea Vetch Wheat Wild Rice
Fruit & nut crops	Berries Citrus & subtropicals Grapes Nut crops Pome fruits Stone fruits	Blackberries, blueberries, boysenberries, cranberry, olallieberry, raspberries, strawberries Avocados, bananas, cherimoya, dates, figs, guavas grapefruit, jujube, kiwifruit, kumquats, lemons, limes, loquats, mandarins, oranges, tangelos, tangerines, mangos, olives, persimmons Juice, raisin, table, wine Almonds, cashews, chestnuts, coconut, macadamias, peanuts, pecans, pistachios, walnuts Apples, Asian pears, crabapple, pears, pomegranate Apricots, cherries, cherimoya, nectarines, peaches, plums, prunes
Livestock, poultry & products	Apiary Cattle Dairy Hogs & pigs Layer hens Poultry Sheep & lambs	Honey Meat products Dairy products Meat products Eggs Chicken, turkey Meat, wool products
Nursery, forestry & flowers	Aloe vera & cactus Flowers Transplants Firewood, Christmas trees	Container plants Vines, canes
Vegetable crops	Alliums Brassicas Chenopods Composites Cucurbits Legumes & sprouts Solanaceous crops Succulent vegetables & sweet corn Umbells & herbs Other	Garlic, leeks, onions, shallots Arugula, broccoli, Brussel sprouts, cabbage, cauliflower, Chinese cabbage, collards, horseradish, kale, kohlrabi, mustards, radish/Daikon, turnip, watercress Beets, chard, spinach Artichokes, burdock, cardoon, chicory, endive (frieze), lettuces, radicchio, salad mix, spring mix, salsify Cucumbers, gourds, melons, pumpkins, squash String beans, peas, sprouts Eggplant, peppers, potato, tomatillo, tomato Asparagus, mushrooms, sweet corn Carrots, celery, fennel, herbs Jicama, rhubarb, sweet potatoes, yams

Table 2. Organic Acreage by Commodity Group and Region in CA, 2002

Region	Fruit	Nuts	Vegetable Crops	Field Crops	Nursery & Flowers	Livestock, Poultry & Products	Total Acres
Bay area	302	37	665	1,308	10	7	2,329
Cascade Sierra	822	67	299	14,020	53	27	15,288
Central Coast	2,138	897	17,475	1,147	49	1	21,706
North Coast	7,463	1,030	2,124	1,507	86	2,509	14,720
Sacramento Valley	3,039	1,402	2,538	21,588	45	137	28,748
San Joaquin Valley	13,875	2,298	24,970	15,714	5	3,066	59,926
South Coast	12,801	29	4,304	193	78	65	17,470
Southeast Interior	2,660	31	5,508	1,339	9	65	9,612
Total acres	43,099	5,791	57,883	56,816	334	5,876	169,799

Table 3. Gross Sales for Registered Organic Growers by Commodity Group and Region in CA, 2002

Region	Fruit	Nuts	Vegetable Crops	Field Crops	Nursery & Flowers	Livestock, Poultry & Products	Total sales
Bay area	\$720,860	\$65,812	\$4,377,087	\$64,599	\$513,432	\$4,680	\$5,746,468
Cascade Sierra	788,023	12,122	403,803	1,784,633	19,599	264,113	3,272,292
Central Coast	13,115,224	581,236	44,755,913	216,801	2,879,602	3,065	61,551,841
North Coast	13,786,502	398,151	3,705,384	115,538	1,166,965	4,430,451	23,602,990
Sacramento Valley	6,041,772	4,709,178	10,865,271	8,394,535	834,280	5,900	30,850,936
San Joaquin Valley	23,343,635	3,786,854	25,175,938	997,017	166,685	16,069,340	69,539,467
South Coast	22,206,669	18,235	24,682,868	289,448	325,872	322,959	47,846,052
Southeast Interior	8,387,200	3,300	6,809,969	487,073	1,239,047	182,150	17,108,739
Total Sales	\$88,389,885	\$9,574,887	\$120,776,232	\$12,349,643	\$7,145,481	\$21,282,659	\$259,518,786

Table 4. Registered Organic Growers by Commodity Group and Region in CA, 2002

Region	Fruit	Nuts	Vegetable Crops	Field Crops	Nursery & Flowers	Livestock, Poultry & Products	Total Growers
Bay area	25	3	33	14	19	5	51
Cascade Sierra	81	22	64	43	21	8	134
Central Coast	133	44	138	30	48	5	250
North Coast	223	84	153	45	73	29	377
Sacramento Valley	124	63	75	109	30	5	270
San Joaquin Valley	179	69	66	34	8	16	284
South Coast	449	24	102	25	37	10	490
Southeast Interior	79	6	30	17	4	5	106
Total growers	1,290	315	654	316	240	83	1,949

Organic Commodities

Produce (vegetable, fruit and nut crops) includes the commodity groups of most consequence to registered organic agriculture in California. In 2002, produce was grown by the majority of organic farms (83 percent of the total farms) and acreage (63 percent of the total acreage). Compared to all of California agriculture, produce is an even greater proportion of organic marketings than conventional marketings, representing 84 percent of total organic sales and 60 percent of total sales from California's agricultural commodities. In contrast, livestock, poultry and products represent only 8 percent of organic sales in 2002 but routinely contribute more than one fourth of statewide income from agriculture.

In 2002 there were 45 different commodities with over \$1 million in organic sales. The highest grossing commodity was grapes followed by lettuces, carrots, strawberries and tomatoes (Table 5). Of the top 20 grossing commodities, eight were fruit crops (grapes, strawberries, dates, apples, raspberries, oranges, avocados, and peaches), seven vegetable crops (lettuces, carrots, tomatoes, spinach, celery, broccoli, and mushrooms), two livestock commodities (dairy and chicken) and one nut crop (almonds). The top 20 commodities represented 60 percent of total sales.

Table 5. Sales of Top 20 Organic Commodities, Total Sales, and Organic Percentage of Total Sales, California 2002 (\$1,000)

Rank	Commodity	Organic	% of Organic	Total ^a	% of Total	Organic % of Total
1.	Grapes—all	26,768	10.3	2,650,873	10.1	1.0
	<i>wine</i>	14,557	5.6	1,815,292	0.1	0.8
	<i>raisin</i>	4,072	1.6	401,256	1.5	1.0
	<i>table</i>	8,139	3.1	434,325	1.7	1.9
2.	Lettuces	21,945	8.5	1,370,004	5.2	1.6
3.	Carrots	14,268	5.5	433,919	1.7	3.3
4.	Strawberry	12,525	4.8	841,031	3.2	1.5
5.	Tomato—all	10,126	3.9	766,260	2.9	1.3
	<i>fresh market</i>	6,228	2.4	269,452	1.03	2.3
	<i>processing</i>	3,898	1.5	496,808	1.90	0.8
6.	Spinach	8,490	3.3	135,780	0.5	6.3
7.	Dairy	8,289	3.2	4,630,171	17.7	0.2
8.	Rice	7,118	2.7	138,564	0.5	5.1
9.	Almond	6,830	2.6	731,880	2.8	0.9
10.	Celery/Celeriac	6,522	2.5	259,865	1.0	2.5
11.	Date ^b	6,229	2.4	52,246	0.1	11.9
12.	Nursery	6,025	2.3	2,087,447	8.0	0.3
13.	Chickens (meat)	6,007	2.3	532,452	2.0	1.1
14.	Apple	5,630	2.2	97,380	0.4	5.8
15.	Raspberry	5,525	2.1	41,168	0.2	13.4
16.	Broccoli	5,501	2.1	438,118	1.7	1.3
17.	Orange	4,713	1.8	514,460	2.0	0.9
18.	Avocado	4,520	1.7	315,842	1.2	1.4
19.	Peach	4,435	1.7	246,743	0.9	1.8
20.	Mushrooms	3,664	1.4	160,873	0.6	2.3
Total sales		259,520	100.0	26,137,315	100.0	1.0

a) Includes conventional and organic b) Includes majool variety dates Sources: CDFA, NASS

In 2002 there were 35 different organic crops with over 1,000 planted acres. More acreage was planted to rice (14,431 acres) than to any other single crop representing 8 percent of all organic acreage and one fourth of all field crop acres. Rice sales generated over \$7 million, 3 percent of total organic marketings for the state. Grapes were second in acreage (9,681 acres), with three quarters planted to winegrapes. Total grape sales equaled \$22.7 million, with two thirds from winegrapes. Grapes contributed nine percent of total organic marketings for the state and over half of fruit sales. Lettuces were planted on over 15 thousand acres, half of that to salad mix. Total marketings from lettuces were almost ten percent of all organic sales.

Organic Producers

Produce growers represented 78 percent of the total number of growers in 2002 (Figure 2). Almost half (44 percent) of all organic growers produced fruit crops, about one fourth (23 percent) grew vegetable crops and 11 percent grew nut crops. Field crops were grown by 11 percent of producers, nursery and flowers by 8 percent and livestock, poultry and products by only 3 percent. These percentages don't add to 100 because over one third of organic growers reported sales in more than one commodity group, most typically vegetable crops and fruit crops.

Over half of the registered organic growers grossed under \$10,000 in 2002 while three percent grossed over a million dollars (Figure 3). Ninety percent of sales were from the 17 percent of growers grossing \$100,000 or more. The remaining 10 percent of sales was captured by the 83 percent of growers grossing under \$100,000 in annual sales.

Geographic Distribution of Production

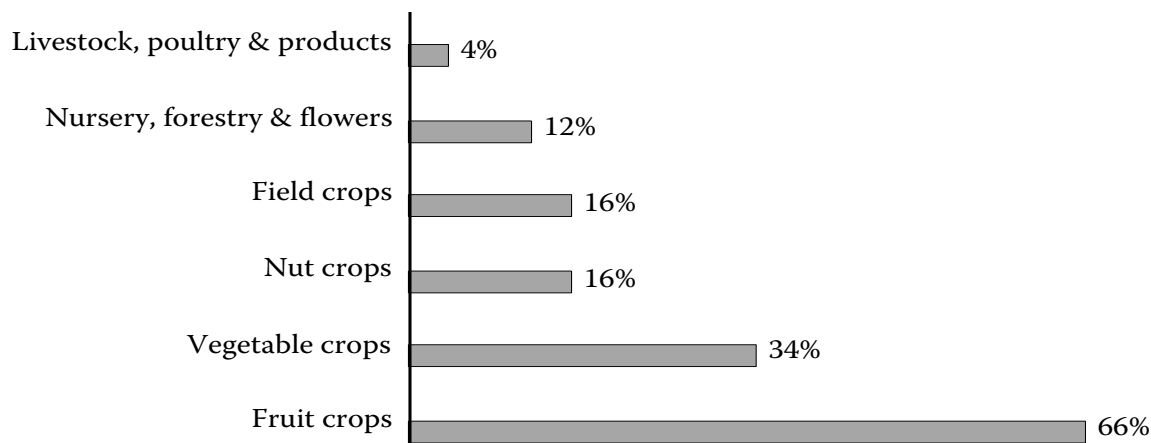
Distribution of Acreage. Over one third of the state's total organic acreage was located in the San Joaquin Valley in 2002 (Table 2). Vegetable crops comprised 42 percent of that acreage, fruit and nut crops 27 percent, and field crops 26 percent. The Sacramento Valley recorded 17 percent of the state's organic acreage, with three fourths of the region's acreage planted to field crops and the rest mostly divided among fruit, nut, and vegetable crops.

The Central Coast represented 13 percent of the total acreage (Table 2). Eighty percent of that acreage was planted to vegetable crops. The South Coast had another 10 percent of the acreage of which almost three fourths was fruit crops. The North Coast and Cascade-Sierra each had 9 percent of the acreage. Half of the North Coast acreage was devoted to fruit crops while 91 percent of the acreage in the Cascade-Sierra was in field crops.

Distribution of Gross Sales. The San Joaquin Valley garnered \$70 million in sales representing over one fourth of the state total (Table 3). Seventy percent of the San Joaquin Valley income was split evenly between fruit and vegetable crops and another 23 percent was from field crops. In contrast, the Central Coast generated \$62 million in sales but 94 percent were from fruits and vegetables and less than one percent from field crops. The South Coast was the third highest grossing region with \$48 million in sales with fruits and vegetables evenly splitting 98 percent of sales.

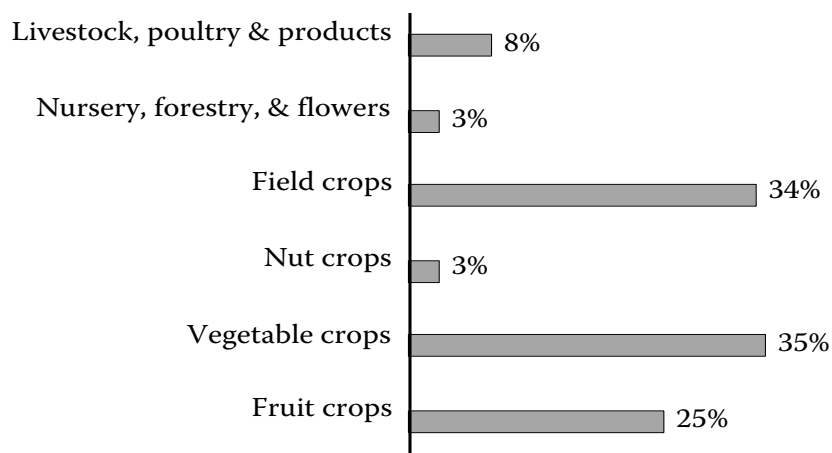
Figure 2. Registered Organic Agriculture by Commodity Group as Reported to CDFA, 2002

GROWER NUMBERS^a



a) Totals more than %100 because of multiple responses to some commodity groups.

CROP ACREAGE



GROSS SALES

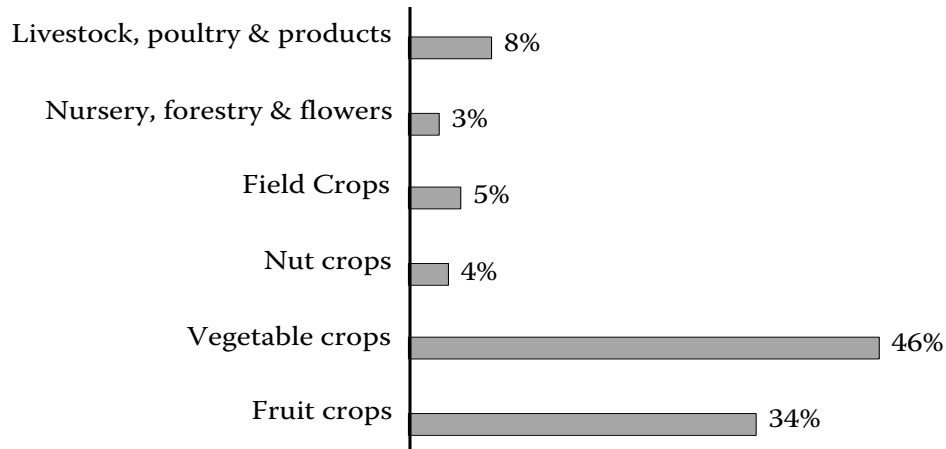
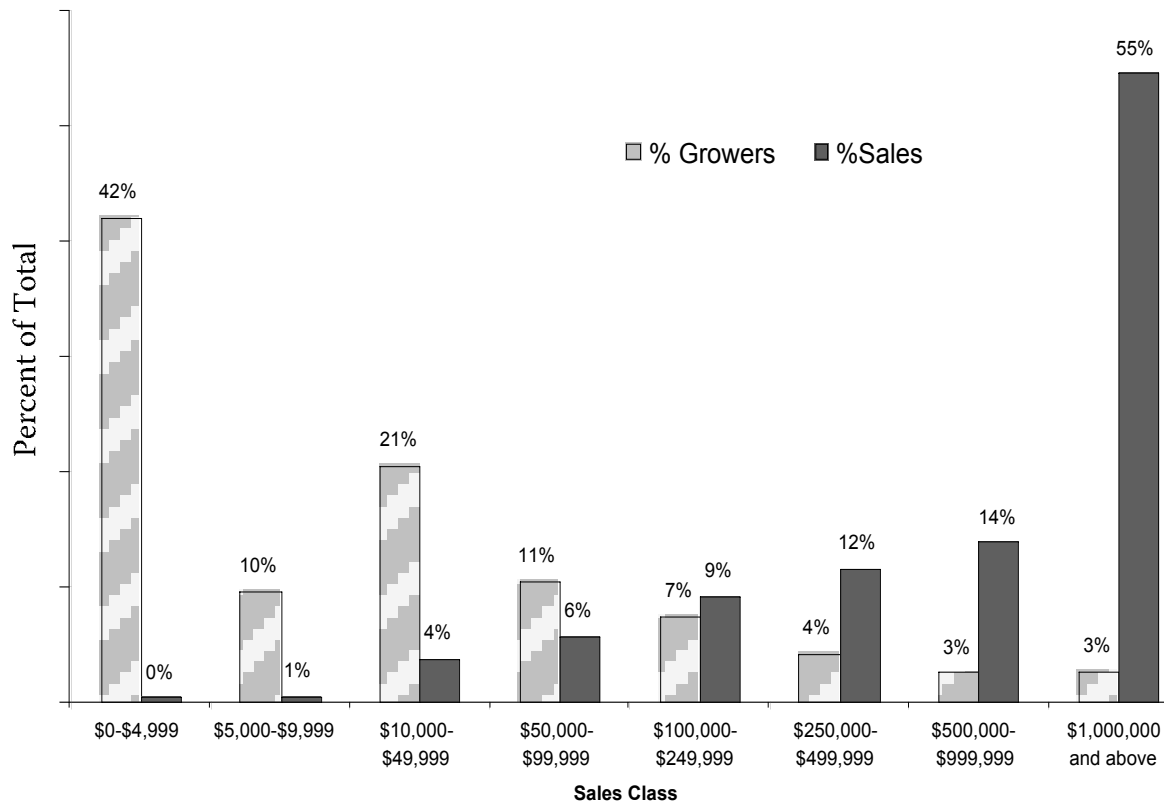


Figure 3. Income Concentration in CA Organic Agriculture, 2002



Distribution by Commodity Groups. The San Joaquin Valley was the leading region for fruit production with 32 percent of the acreage and 26 percent of sales. The South Coast followed closely with 30 percent of the acreage and 25 percent of the sales. The North Coast had 17 percent of the acreage and 16 percent of the sales. Two thirds of the nut acreage was in the San Joaquin Valley and Sacramento Valleys with 89 percent of the sales split between these two regions. The remaining nut production was split between the Central Coast and North Coast.

Three fourths of the vegetable crop production took place in the Central Coast and San Joaquin Valley. These two regions accounted for 58 percent of sales. The Central Coast had 30 percent of the acreage and 37 percent of the sales while the San Joaquin Valley had 43 percent of the acreage but only 21 percent of sales. Field crops were grown primarily in the Sacramento Valley and San Joaquin Valley with two thirds of the acreage and three fourths of the sales. Livestock and poultry production took place primarily in the North Coast and San Joaquin Valley with 95 percent of the acreage and 97 percent of the sales.

INDUSTRY TRENDS 1992-2002

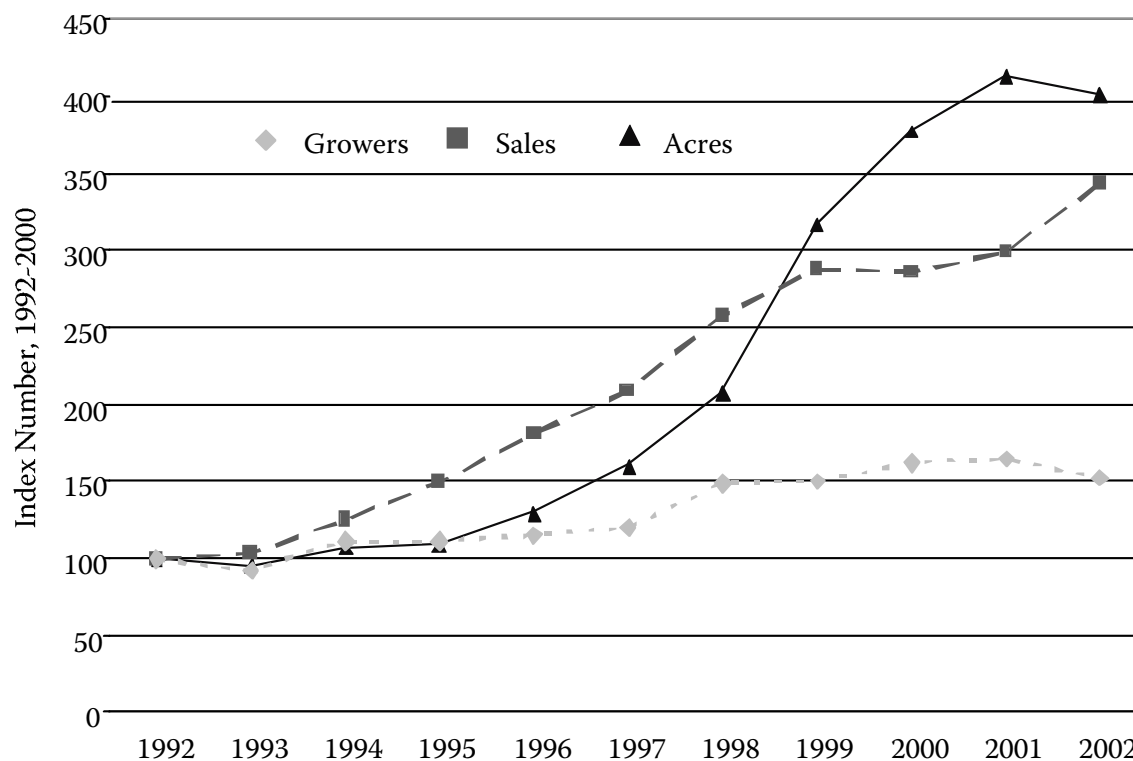
The number of registered organic farms in California increased by over 50 percent during the eleven-year period 1992-2002 from 1,273 to 1,949 growers (Table 6, Figure 4). But the growth has not been even, with the largest growth in 1994, 1998, and 2000.

The numbers actually declined from the previous year in 1993 and 2002. By far the largest absolute change in number of growers has been in fruit and nut crops, increasing by over 700 growers.

Table 6. Registered Organic Growers in CA by Commodity Group, 1992-2002

Year	Fruit & Nuts	Vegetable Crops	Field Crops	Nursery & Flowers	Livestock, Poultry & Products	Total Growers
1992	797	409	45	11	11	1,273
1993	750	305	42	14	7	1,185
1994	971	387	46	15	9	1,428
1995	984	427	45	24	12	1,427
1996	1,229	476	70	39	14	1,475
1997	1,063	500	97	68	11	1,533
1998	1,376	678	231	163	37	1,909
1999	1,385	683	271	203	63	1,919
2000	1,523	734	298	227	72	2,075
2001	1,574	723	339	252	82	2,102
2002	1,467	654	316	240	83	1,949

Figure 4. Index Numbers of Growth in CA Organic Agriculture, 1992-2002



Over the same period of time acreage quadrupled increasing from 42,000 acres in 1992 to almost 170,000 acres in 2002 (Table 7, Figures 4 and 5). Three fourths of the increase was accounted for by vegetable crop and field crop expansion. Field crop acreage increased by 49,000 acres, almost a seven fold increase. Almost all of the growth occurred between 1996 and 2001. Acreage actually decreased in 2002 compared to 2001. Vegetable crop acreage increased by 43,000 acres, a four fold increase. Growth took place steadily from 1994-2001 with the largest spurts in 1999 and 2001 but adjusted downward in 2002. Fruit and nut crop acreage was two and a half times higher in 2002 than 1992, a net expansion of 29,000 acres. Expansion has been constant and greatest between 1997 and 2002.

Sales increased to three and a half times what they were in 1992 by 2002, but the rate of increase tapered off in 2000 and 2001 only to pick up again in 2002 (Table 8, Figure 4). The absolute increase was \$184 million, from over \$75 million in 1992 to almost \$260 million in 2002 (Table 8). Eighty percent of the increase was due to produce sales (fruits and nuts \$64 million increase and vegetables \$83 million increase). Livestock, poultry and products contributed 11 percent of the increase, field crops 5 percent and Nursery and Flowers 3.5 percent. The most rapid rate of growth was in livestock, poultry and products increasing from only \$37,000 in sales in 1992 to over \$21 million in 2002.

Table 7. Organic Acreage in CA by Commodity Group, 1992-2002

Year	Fruit & Nuts	Vegetable Crops	Field Crops	Nursery & Flowers	Livestock, Poultry & Products	Total Acres
1992	19,494	14,503	8,289	16	--	42,302
1993	20,188	12,960	7,412	11	--	40,571
1994	21,731	15,744	7,583	12	--	45,070
1995	21,783	16,709	7,743	24	--	46,258
1996	21,867	21,052	11,816	33	--	54,768
1997	23,758	26,637	17,309	121	--	67,826
1998	29,847	30,203	26,499	272	1,083	87,904
1999	38,112	47,757	45,627	759	2,001	134,256
2000	40,430	55,431	58,791	544	4,664	159,860
2001	43,621	70,260	56,194	338	4,515	174,928
2002	48,890	57,883	56,816	334	5,876	169,799

The number of growers increased by a much smaller percentage than the number of farmed acres, suggesting that established growers increased crop acreage and/or that some new growers entered the program with above average farm size (Figure 4). This is consistent with the observation that almost 40 percent of the growth in acreage was in field crops which tend to have much higher acreage per farming unit than produce crops. Acreage also grew at a faster rate than gross sales (401 percent and 344 percent respectively). This is again attributable to an increasing importance of field

crops (increasing from one fifth of acreage in 1992 to a third of total acreage in 2002) that have lower sales per acre than any of the other commodity groups.

Table 8. Sales for Registered Organic Growers in CA by Commodity Group, 1992-2002

Year	Fruit & Nuts	Vegetable Crops	Field Crops	Nursery & Flowers	Livestock, Poultry and Products	Total Sales
1992	34,057,964	37,961,561	2,937,723	442,512	37,057	75,436,817
1993	29,985,496	44,889,371	2,570,137	846,886	39,405	78,331,295
1994	32,684,588	57,569,204	3,761,960	939,373	144,261	95,099,386
1995	35,467,208	72,432,639	3,339,036	1,223,797	850,809	113,313,489
1996	42,635,225	83,091,797	7,217,878	1,904,878	2,233,378	137,083,156
1997	50,905,893	91,030,468	10,154,452	2,033,551	4,163,516	158,287,880
1998	73,678,175	99,141,940	14,041,172	2,776,963	5,439,214	195,077,465
1999	80,254,117	108,968,096	12,964,298	6,943,236	8,631,207	217,760,954
2000	78,336,232	101,533,773	18,371,669	4,764,557	13,267,641	216,273,872
2001	92,798,034	94,848,681	15,508,996	7,086,226	15,723,673	225,965,611
2002	97,964,772	120,776,232	12,349,643	7,145,481	21,282,659	259,518,786

Comparing the organic subsector to the whole of California agriculture, gross sales of organically grown commodities tripled between 1992 and 2002 while overall agricultural sales in California increased by 30 percent over the same period. Growth in organic sales averaged 20 percent a year between 1993 and 1998 but slowed to an average of eight percent from 1998 to 2002. In the five year period 1998-2002, organic sales increased by 33 percent while state total sales were stagnant. Organic crop acreage increased four-fold between 1992 and 2002 despite a decrease in land in farms for the state over the same period. Organic agriculture nevertheless represented only 1 percent of total cash income for California by 2002. Organic produce (vegetable, fruit, and nut crops) was slightly more prominent, with 2 percent of vegetable sales and 1.4 percent of fruit and nut sales in 2002.

Organic Commodities

From 1998-2002, vegetable crops posted a 48 percent increase in the number of acres (27,680 acre increase) but only a 22 percent increase in total sales (\$21.6 million increase), although this varied widely across regions. Over 90 percent of the increase in vegetable crop acreage took place in the Central Coast and the San Joaquin Valley. Vegetable crops with the greatest increase in sales include spinach, celery, endive, mushrooms, lettuces, and fresh market tomatoes. Salad mix sales actually decreased over the period. Commodities with the largest increase in acreage include salad mix, lettuces, spinach, carrots and mustard. The acreage data can be somewhat misleading in that the greatest increase came from fallow acreage and acreage in cover crops for

rotation purposes. It may be that this is a change in reporting practices rather than an actual change in acreage.

Considering all salad crops as lettuces (including salad mix, endive, radicchio and arugula) the greatest increase in acreage attributed to a vegetable commodity came from lettuces expanding from 2,600 acres in 1998 to 6,500 acres in 2002. In fact, lettuces account for over one third of the increase in vegetable acreage. However, sales did not increase in proportion to the acreage, increasing by 23 percent due, primarily, to the decrease in sales from salad mix. Furthermore, the percentage increase in gross sales is reduced when growers with sales above the \$5 million reporting ceiling accurately report increased acreage but do not report the corresponding increase in gross sales, only the requisite \$5 million.

Organic fruit crops posted a sales increase of 28 percent (\$19 million) between 1998 and 2002, with a 40 percent increase in acreage (17,040 acres). The most important commodities for sales growth were strawberries, raspberries, wine grapes, dates, avocados, apples, and peaches. Organic wine grapes increased in sales by over \$4 million and acreage expanded by over 3,000 acres. In contrast, sales of table grapes almost halved over the period while acreage reduced only slightly. The most important nut crops remained almonds and walnuts, with sizeable increases in sales and acreage for both.

Figure 5. Organic Acreage in California, 1992-2002

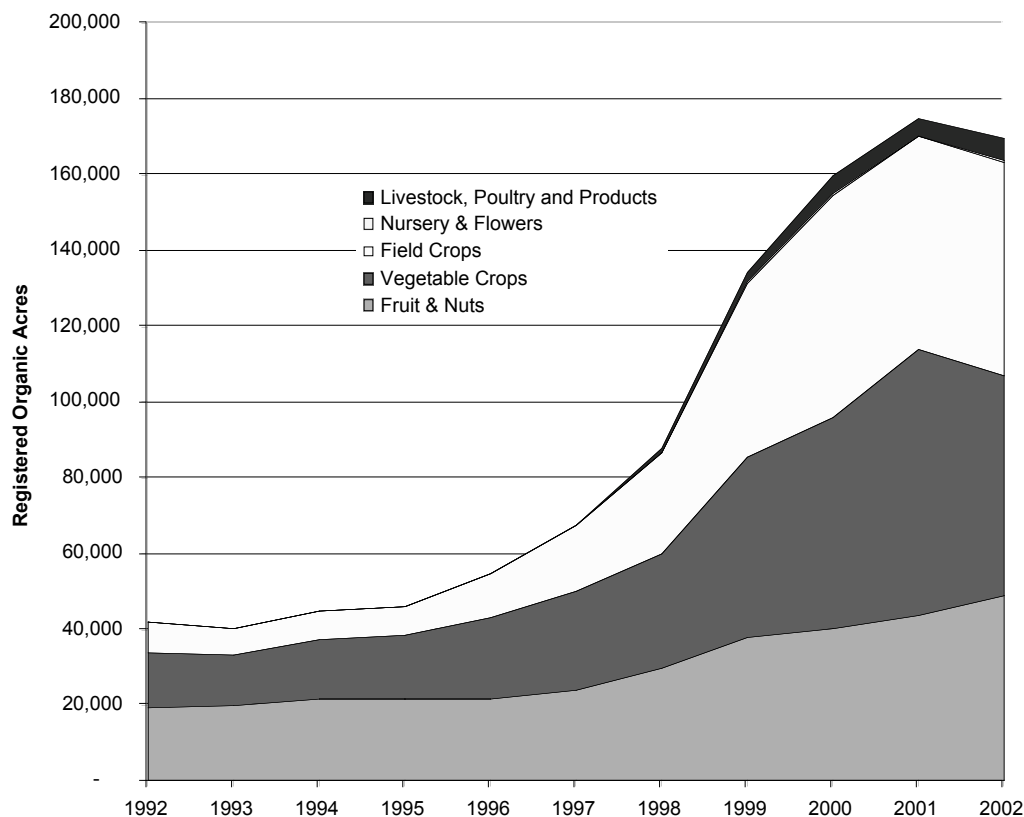
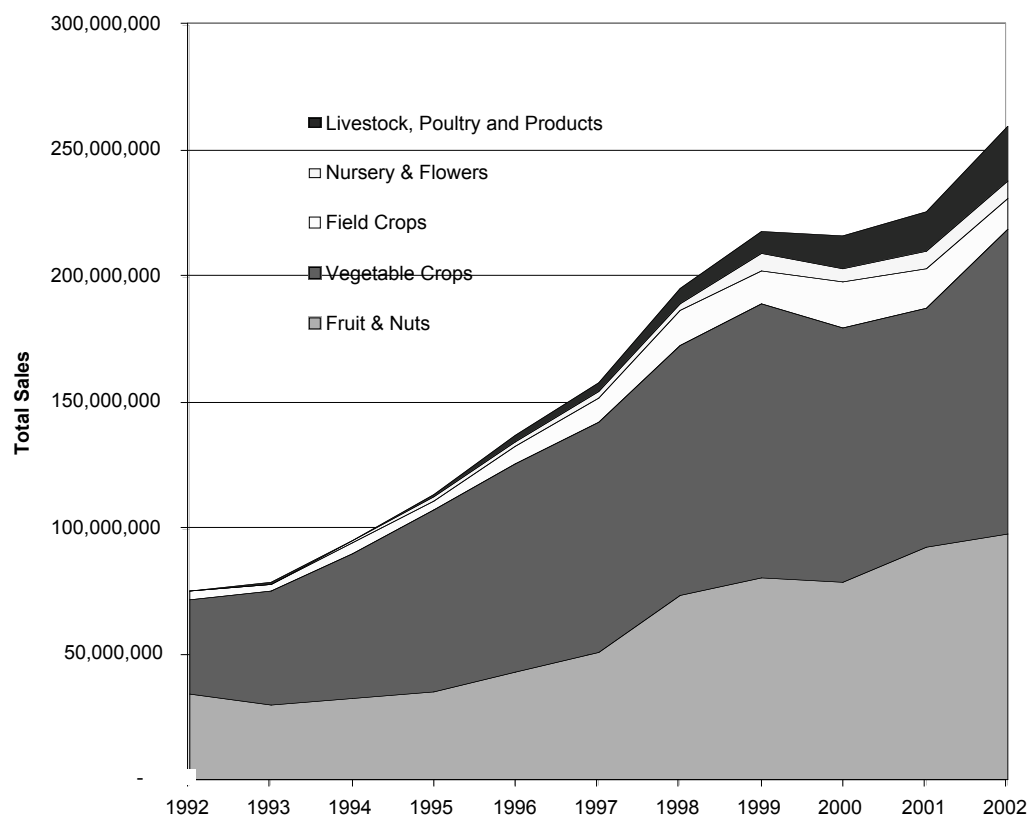


Figure 6. Organic Sales in California, 1992-2002



Field crops grew in acreage from 1998-2002, with the number of farmed acreage increasing by over 50 percent (30,317 acre increase). One third of the increase in acreage is attributable to pasture and rangeland paralleling the increase in livestock and dairy production. Another 25 percent reflects increases in rice, alfalfa, and wheat acreage. Rice remained by far the most important field crop during the period but with stagnant sales at around \$7 million. Alfalfa was the second most important field crop with sales increasing from less than half a million dollars in 1998 to \$1.3 million in 2002. The importance of field crops to organic agriculture remained small, falling from 6 percent of sales in 1998 to less than 5 percent of sales in 2002. This decrease in importance is explained by an absolute decrease in sales over the five year period in almost every region. The decrease in importance is also related to the dramatic increase in sales of livestock, poultry and products.

Sales from livestock, poultry, and related products increased by 389 percent over the past five years, although they remained less than 3 percent of the organic industry. Dairy production increased from \$4 million to over \$11 million. Sales of organic meat were not permissible prior to 1998 due to differential labeling requirements for organic meat and other foods. Sales of organic chicken reached over \$6 million in 2002 with beef and turkey each at about \$300,000. Organic eggs sales were \$3.6 million in 2002.

CONCLUSION

California organic agriculture expanded rapidly from 1992 to 2002, with double-digit average annual growth in registered acreage and sales. Growth of organic agriculture using these measures was considerably faster than in California agriculture as a whole. However, organic agriculture accounted for only one percent of all crop sales and a much smaller percentage of livestock and livestock product sales. Produce (fruits, nuts and vegetables) remains the dominant part of organic agriculture in California despite rapid recent growth in dairy and poultry products.

It is generally assumed that marketing outlets are different for different sales classes of growers. Small growers most likely rely on direct sales (e.g., farmers' markets, roadside stands and CSAs [Community Supported Agriculture]) while larger growers sell through wholesalers and distributors as well as directly to retailers. Market saturation is a concern that is often expressed by those within the organic industry at all levels of production. Anecdotal evidence suggests that some sell in the conventional market when they are unable to find a suitable venue for their products in the organic market or when conventional prices are as high as organic. The value of commodities produced in accordance with organic standards but sold on the conventional market is not required to be reported to CDFA.

Statistics contained in this chapter draw attention to several important questions concerning the future of the organic agricultural industry in California. Perhaps the most obvious questions are—can the organic industry in California sustain the rate of growth realized over the past decade, and if so, what will this growth look like? As the industry expands, will new marketing outlets such as expansion of natural food store chains, organic sales in conventional grocery stores, and Internet sales augment current venues? Will current consumers of organic commodities change their purchasing patterns to include a more varied organic shopping basket, and to what extent will new organic consumers emerge to purchase an ever-increasing supply of organic products? As new products using organic ingredients are developed, how will the distribution of acreage devoted to the various commodity groups change? In addition, the impact of the National Organic Standards, now finalized, is still not clear. Also not clear is how broader legislation concerning food quality protection, water quality, biotechnology, international trade and a host of other issues will be felt by the organic subsector.

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CHAPTER 11

Science and Technology

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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 in 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's 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.

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.

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 and other general developments in agricultural technology, especially improved varieties and production practices.

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

4. the spread of irrigation;
5. the increased availability of "cheap" labor;
6. the importation of technology from other countries with similar climates, partly through immigrants bringing their 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, 1949-1991²

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 337).

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 977), while output of field crops (including wheat, rice, cotton, and corn) grew much more slowly (the index went from 100 to 266). 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 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 355). The use of capital services—including physical inputs such as automobiles, tractors, trucks and combines, as well as biological inputs

² Craig and Pardey (1996) 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 were taken from Acquaye, Alston, and Pardey (2003), who revised 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.

such as dairy cows, ewes, and breeder pigs—grew by over 75 percent from 1949 to 1991 (an increase from 100 to 176). However, quality-adjusted land and labor use in agriculture declined. 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 by 58 percent, from 100 to 158.

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

Year	Total Output	Field Crops	Fruits & Nuts	Livestock	Vegetables	Greenhouse & Nursery
1949	100	100	100	100	100	100
1950	102	93	100	106	109	106
1955	128	120	113	137	134	141
1960	148	158	108	161	146	196
1965	168	161	133	188	147	245
1970	183	168	133	208	176	278
1975	229	262	181	216	197	409
1980	272	302	234	245	221	607
1985	294	284	249	272	250	726
1990	333	278	249	336	305	962
1991	337	266	270	339	280	977

Source: Compiled by Alston and Zilberman using data provided by Acquaye, Alston, and Pardey (2003).

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

Year	Total Input	Land	Labor	Capital	Purchased Inputs
1949	100	100	100	100	100
1950	102	100	101	103	102
1955	108	100	88	129	130
1960	123	99	88	155	178
1965	128	97	77	188	208
1970	120	93	68	134	235
1975	126	96	83	123	229
1980	136	100	76	143	286
1985	134	94	71	170	271
1990	155	92	87	180	334
1991	158	92	90	176	355

Source: Compiled by Alston and Zilberman using data provided by Acquaye, Alston, and Pardey, 2003.

That the 237 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 213). 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. Alternatively, to produce the output in 1991 using 1949 technology would require using twice as many inputs as were actually used. In other words, more than half of 1991's agricultural output is directly attributable to improved technology; and less than half is attributable to conventional inputs.

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

Year	Output	Input	Productivity	Productivity
	-----California-----			U.S.
1949	100	100	100	100
1950	102	102	100	98
1955	128	108	119	111
1960	148	123	120	121
1965	168	128	131	128
1970	183	120	153	143
1975	229	126	182	169
1980	272	136	200	181
1985	294	134	219	215
1990	333	155	215	220
1991	337	158	213	224

Source: Compiled by Alston and Zilberman using data in Tables 1 and 2.

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.³

Complete, specific data on inputs, outputs, and productivity in California and U.S. agriculture, comparable to those in Tables 1 through 3, are not yet available for the years after 1991. However, the data that are available suggest that the 1990s reflected a

³ This estimate is lower than the estimates obtained in most studies of rates of return to agricultural research, which are more often in the range of 40 to 60 percent per annum (see Alston, Chan-Kang, Marra, Pardey, and Wyatt, 2000, for a critical review of this literature, and a meta-analysis of the estimates). 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.

return to a more-normal rate of productivity growth in California, sustaining the longer-term average rate, in the range of 2 percent per annum. Mullen et al. (2003, pp. 16-19) applied California's 1949-1991 average annual agricultural productivity growth rate of 1.81 percent per year to the period 1949-1999. They found that with 1950s productivity and the actual inputs used, output in 1999 would have been only 42 percent of the actual value of \$25.3 billion. Hence, the factors that gave rise to productivity growth since 1950 accounted for \$14.8 billion worth of output in 1999 alone. Considering the period 1949-1999, Mullen et al. estimated that if public agricultural R&D accounted for one-sixth of the productivity growth (a conservative estimate) the benefit-cost ratio for public investments in agricultural R&D would still be 6:1 (a return of \$6 for every \$1 invested).

Changes in inputs, outputs, and productivity in California agriculture paralleled similar changes in other states and around the world, but with some important differences reflecting elements unique to California. As a result of these changes, farms and farming today are very different from what they were in the early part of the twentieth century. 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.⁴ 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.

⁴ See Cochrane (1993); Hayami and Ruttan (1970); Olmstead and Rhode (1993).

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 20 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 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.⁵ 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 use 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, especially, the range of fruits and vegetables from Asia. The international spillovers of genetic material are not confined to exotic species, however. For instance, 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.

⁵ 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.

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.⁶

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.⁷

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 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 farmland is

⁶ 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.

⁷ Alston (2002) reviewed the evidence on interstate and international technology spillovers. In most U.S. states, spillins from public research conducted in other countries and states may be as important as own-state public research investments as a source of new agricultural technologies. At the same time, spillouts of agricultural technologies from the United States have been very important for agriculture in other countries.

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.

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 farmland has been leveled over the years, making flood and ditch-and-furrow irrigation efficient and cost-effective.

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

Year ^a	-----Sprinkler-----		-----Gravity ^b -----		--Drip or Trickle ^c --		Subirrigation	
	<i>Farms</i>	<i>Acres</i>	<i>Farms</i>	<i>Acres</i>	<i>Farms</i>	<i>Acres</i>	<i>Farms</i>	<i>Acres</i>
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.

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

⁸ This observation is credited to the late Yair Guron.

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 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 the 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 have not always been fully appreciated. The total impact on farm workers of harvest mechanization depends on both the effect on labor intensity (negative), and the effect on the scale of production (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

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.

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.

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 mechanically harvested (Johnson 1977); by 1978, 20 percent (Zahara and Johnson 1979). Currently, perhaps half of the crush is mechanically harvested.¹² On the other hand, by 1975 virtually all almonds, pecans, filberts, and walnuts were mechanically harvested; mostly produced in California.

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).

¹² Personal communication, Pete Christensen.

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

California's grape industry has been devastated in the past by pests, such as Phylloxera, and is currently threatened by Pierce's Disease, transmitted by the Glassy-Winged Sharpshooter. The use of resistant rootstocks, a form of genetic improvement, was the solution for Phylloxera, and genetic resistance (perhaps through biotechnology) is seen by many as the long-term solution for Pierce's disease as well.

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

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.

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 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 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 the expense of 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.

Biotechnology. Barriers to the development and adoption of new technologies include market, social, and other economic factors as well as regulatory constraints. Taken together, these aspects are presenting substantial barriers to the development and adoption of genetically engineered crop varieties, generally, and for California's specialty crops these barriers may preclude access to new varieties developed by genetic engineering. The same types of factors may leave many California crops as orphans with respect to conventional pest control technologies as well—for many such crops the market is too small and the research, regulatory, and other costs are too large to allow profitable development of new, specific pest-control technologies.

Pest Management

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. 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. As discussed by Carter (2001), the highly valuable methyl bromide is linked to the depletion of atmospheric ozone, and, under the U.N. Montreal Protocol it is scheduled for banning in 2005.¹⁶

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. 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

¹⁶ California strawberry growers and others have sought a special use exemption, such that they might be permitted to use methyl bromide beyond 1995, but it is not expected to be available for application in the long run. California growers have applied about 16 million pounds of methyl bromide per year, about one half of the national total. Strawberry growers account for about one-third of California's use. Carter (2001) suggests that a methyl bromide ban would result in a 15 percent reduction in the value of strawberry production.

experimenting with 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, to promote and expand IPM use.¹⁷

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.

Biotechnology. 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, and California has played some leading roles in biotechnology research. 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.

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

¹⁷ In a recent study of the returns to pest-management R&D conducted by the University of California, Mullen et al. (2003) documented the pivotal role of UC leadership in the development and adoption of IPM not only in California but more generally in the United States. The study emphasizes IPM as an element of the University's total effort in pest-management R&D, and documents case studies for several commodities.

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. In the dairy industry, California has developed and improved its technology more rapidly than the rest of the United States. Milk production has grown relatively rapidly, dairy is now the largest agricultural industry in California, and 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 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

In the United States, both State and Federal governments are extensively involved in agricultural R&D. The main form of involvement is the government production of agricultural science—in government labs or in public Universities—using general government revenues. This is justified both in principle and by the evidence that the rates of return to public agricultural research have been very high—even with very extensive government intervention to correct the private-sector under-investment in agricultural R&D. This evidence suggests that the government intervention to date has been inadequate, that it could have profitably spent much more on agricultural R&D.

It is not sufficient to argue that the government should spend more on agricultural science. Important issues include: What research should be done? How should public agricultural R&D be managed to make sure that the net benefits are maximized from the limited funds that are available? Who should provide those funds and how? In terms of government policy, these issues can be couched in terms of questions about:

1. the institutional arrangements that are put in place to determine the total funds made available for public agricultural R&D, the allocation of those funds among research institutions and across research projects and programs, among fields of science, and between research and extension;
2. how the public resources are managed and used (and whether this will be done efficiently and effectively to obtain the greatest possible net benefits);
3. property rights regimes that will strengthen private incentives for invention.

An important element of this institutional structure is the division of labor between Federal and State governments, in terms of both the funding and the execution of public agricultural R&D. If results from research are widely applicable in the nation, it may be best financed federally (perhaps done in USDA labs), but if it applies in only a small number of states, the Federal role might be limited to encouraging States to cooperate or do more than they would otherwise (e.g., by providing funds for State research).

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 the CAES is the largest public agricultural research enterprise based on the U.S. land grant system model.¹⁸

Global and National Context

Pardey and Beintema (2001) discuss trends in R&D policy and spending more broadly, and provide important data on global trends in agricultural R&D and private-versus public-sector spending patterns, as well as longer-term trends in U.S. public agricultural R&D. A brief review of these elements from Pardey and Beintema provides a context and perspective for contemplating California's agricultural R&D policy patterns.

In 1995, about \$490 billion dollars was spent on all the sciences worldwide, which is about 1.6 percent of global GDP in that year (or \$1.64 per 100 dollars of GDP). Rich countries did the preponderance (i.e., about 85 percent) of this research (the U.S. share alone was 42 percent), and rich countries only devote a small share (3 percent) of their total research expenditure to agricultural R&D compared with less-developed countries (17 percent).

Growth in spending on all science stagnated during the 1990s. Agricultural science shared in this stagnation, but in some countries was hit harder than more general science (medical and military research are the big ticket items). This has been associated with general economic conditions and a waning public enthusiasm for science generally, but also a decline in political support for publicly funded agricultural R&D in many countries, and within that, a shift away from public funding of "near-market" research. In the United States these trends have been less pronounced than in some other countries, but recent years have seen a tightening of support, from both Federal and State governments for funding agricultural research and extension. Agricultural R&D has lost ground recently relative to other non-defense research, especially the National Science Foundation and the National Institutes of Health.

Global spending on agricultural R&D in 1995 was about \$33 billion, about one-third (\$11 billion) private and the remaining two thirds (\$22 billion) in the public domain. The United States accounted for 19 percent of this global total in 1995, down from its 29 percent share two decades earlier. However, the United States commands an even bigger share of the private- and public-sector total—22 percent of the 1995 global total of \$33 billion.

The private-sector share has been growing relatively rapidly, but this research takes place mainly in a small number of rich countries. In the United States, private agricultural research spending more than doubled in real terms from 1970 to \$4.6 billion in 1998 (compared with \$3.4 billion of public agricultural R&D in that year). This growth has been associated with improvements in intellectual property rights (especially pertaining to plant varieties), and modern biotechnology, among other things. Table 5 shows trends in U.S. public and private agricultural research funding. The public funding includes both State and Federal government funds.

Worldwide, public spending on agricultural R&D nearly doubled, in inflation adjusted terms from 1976 to 1995. It grew faster in less-developed countries, which

¹⁸ 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 Mullen et al. (2003).

now account for more than half of public-sector spending (53 percent in 1995), though still less than half of total agricultural R&D spending (37 percent in 1995). Spending has stagnated since the mid-1990s and in some places has fallen in nominal as well as real terms.

Table 5. U.S. Agricultural Research Funding in the Public and Private Sectors, 1970-1998: Millions of real (1998) dollars

Year	Public R&D Funding	Private R&D Funding	Total R&D Funding
1970	2,450	2,120	4,570
1975	2,820	2,427	5,247
1980	3,217	3,419	6,636
1985	3,341	3,756	7,097
1990	3,540	4,048	7,588
1995	3,750	4,598	8,348
1998	3,648	4,887	8,535

Source: National Research Council (2003, pp. 190-191).

Importantly, in recent years, the U.S. public sector has been declining in relative and perhaps absolute importance as a source of new agricultural technologies. The rising importance of private-sector investments in proprietary technologies will have important implications for the balance in the types of technologies that are being produced and to whom they are available. In particular, subsistence crops in developing countries and specialty crops in places like California are more likely to become technological orphans in the changing institutional structure.

National Trends in U.S. Public Agricultural Research and Extension

U.S. Federal intramural research is conducted by the Agricultural Research Service (ARS), and the Federal Government also helps fund agricultural research at State Agricultural Experiment Stations (SAESs) through four major mechanisms:

1. *Formula funds* allocated to States by formula;
2. *Competitive grant funds* allocated by panels of relevant scientific peers after consideration of research proposals submitted to the review panel;
3. *Special grants* provided to SAESs, other public institutions, and individuals to study problems of concern to USDA, as specifically designated by Congress;
4. *Cooperative agreements* between USDA agencies that perform research and SAESs.

While farm acts authorize certain levels of USDA funds to be used for particular programs, actual expenditures are set annually by agricultural appropriations acts.

In 1889, shortly after the Hatch Act was passed, federal and state spending appropriations totaled \$1.12 million. Over a century later, in 2000 the public agricultural R&D enterprise had grown to over \$3.5 billion, an annual rate of growth of 7.81 percent in nominal terms and 4.29 percent in real terms. In recent years total spending on public agricultural R&D (including extension) stalled, in real terms growing by only 0.12 percent per year during the 1990s. The slowdown began at least a decade earlier. Intramural USDA and SAES research accounted for roughly the same share of public research spending until the late 1930s, after which the SAESs' share grew to 72 percent of total public spending on agricultural R&D by 2000. The general trends include: a long-term trend for the SAESs to grow relative to the USDA intramural research; a decline in USDA intramural research since about 1980; a slowdown in growth in the SAESs since 1980, and a stagnation in the 1990s.

The USDA also contributes substantially to financing the SAESs. Of the funds spent in the SAESs in 2000, 30 percent was from federal sources, 47 percent from state government, and 22 percent from industry, income earned from sales, and various other sources. The share of SAES funds coming from federal sources has been declining recently, and the composition of those funds has changed too, with an increase in competitive grants and a decline in formula funds.

The federal government is also involved in financing extension conducted by the states. In 1915, the first year in which federal funds were made available for cooperative extension between the USDA and various State extension agencies, almost \$1.5 million dollars of federal funds were combined with \$2.1 million dollars made available from various state and local government sources for a total of \$3.6 million. This total grew by 3.76 percent per annum to reach \$1.6 billion by 1999. The public provision of extension services in the United States is essentially a state or local activity. Consequently, funds from within-state sources accounted for 74 percent of the total funds for extension with federal funds accounting for the remaining 26 percent in 1999.

Table 6. Research, Education, and Economics by Agency for FY 1985-2001 Budget Authority, millions of real (year 2000) dollars

Year	ARS	CSREES	ERS	NASS	Total
1985	915	1,123	81	101	2,220
1990	846	1,029	69	91	2,035
1995	914	1,102	64	96	2,176
2000	903	1,091	64	100	2,158
2001	970	1,095	65	96	2,226
2002	1,157	958	65	106	2,286

Source: National Research Council (2003, pp. 186-187).

Table 6 shows the components of the USDA's Research, Education, and Economics budget, expressed in real 2000 dollars including allocations for intramural research by the Agricultural Research Service (ARS) and the Economic Research

Service (ERS) and for the collection of statistics by the National Agricultural Statistics Service (NASS) as well as allocations to the Cooperative State Research Education and Extension Service (CSREES), which administers formula and competitive grant funds for research and extension conducted by states.

California's Agricultural Research Investment Patterns

Trends in California's public research and extension expenditures are summarized in Table 7, in both real and nominal terms.

Table 7. Public Research and Extension Expenditure in California, 1970-1997

Year	Nominal Research Expenditure	Nominal Extension Expenditure	Real Research Expenditure	Real Extension Expenditure	Real Total R&E Expenditure
	<i>(current dollars, millions)</i>		<i>(year 2000 dollars, millions)</i>		
1970	30.7	14.0	113.1	51.5	168.6
1975	48.5	20.6	129.4	55.1	184.5
1980	77.6	34.3	145.5	64.5	210.0
1985	118.6	50.1	172.0	72.7	244.7
1990	171.6	63.7	212.1	78.8	290.9
1995	191.0	63.2	208.2	68.9	277.1
1997	205.5	69.0	215.5	72.4	287.9

Source: Mullen et al. (2003, pp. 23-24).

From 1970 to 1997, in real (year 2000) dollar terms, California's public agricultural research expenditure almost doubled, from \$113.1 million to \$215.5 million (i.e., by a factor of 1.9). Over the same period, California's public agricultural extension expenditure increased much more slowly, from \$51.5 million to \$72.4 million (i.e., by a factor of 1.4). The total expenditure on research and extension increased from \$168.6 million to \$287.9 million (i.e., by a factor of 1.7). However, most of this growth, especially in extension, took place in the 1970s and early 1980s. Real extension expenditures in 1997 were roughly equal to their 1985 values, and real research expenditures in 1997 were very close to their 1990 values. The longer-term trends reflect a shift in emphasis toward research relative to extension, and a shift toward a shrinking share of funds from the federal government as a share of total funding for public agricultural research and extension in California.

The 2002 Farm Bill provides for a continuation of the recent past and the trends that have been evident over the past 20 years. Specifically,

1. Stagnant total real federal support for agricultural research and extension

2. A declining share of extension in the total
3. A declining share of formula funding in the total (no change in the formulas)
4. An increasing share of competitive grants in the total
5. Increasing application of constraints on the use of competitive funds
6. Increasing Congressional earmarking of funds

These factors combined mean little total growth in funds available from the federal government for agricultural R&D, and an ambiguous effect on the efficiency with which those funds are being used. The state budget crisis in California has exacerbated the funding situation. Together these factors have resulted in a significant reduction of funding for research, and especially extension, in California, with cuts over two years (FY2002-03 and FY2003-04) in the range of 20 percent for research and 35 percent for extension. Further cuts may be anticipated in future years.

California's public research and extension is mainly undertaken through the UC Division of Agriculture and Natural Resources (ANR). In FY2001-02, ANR reported the spending of \$336.4 million, of which \$240.6 million was spent on CAES research, and \$92.0 million was spent on cooperative extension.

The sources of funds for CAES research have varied over time. 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.¹⁹

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 R&D.²⁰

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,

¹⁹ 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).

²⁰ For more details on technology transfer and the evolution of biotechnology, see Postlewait, Parker, and Zilberman (1993) and also Parker, Zilberman, and Castillo (1997).

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 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.

One of the most interesting trends in university research is growing transfer of rights to proprietary technology from the university to the private sector. University researchers, in many cases, develop patents that are basically concepts and ideas, and their commercialization requires significant investment. Companies will not engage in this investment unless they are sure that they will capture the benefits from the investment. Lack of investment in university technologies was one of the reasons that motivated the U.S. Senate to pass the Bayh Dol Act in 1980, and that gave universities the right for a patent of research financed with federal money.

Once this Act passed, the process of commercialization of university innovations accelerated. In many cases, universities do not sell the right to innovations to establish multinational companies, but instead university professors establish alliances with venture capitalists and start startup companies, which may become major players on their own (as in the case of Genentech, Sun Microsystems, and many others), or may be taken over by a multinational (as was the case with Calgene, that was taken over by Monsanto). Technology transfer has been a source of significant revenue to universities, and the University of California has been the leading income earner from royalties (in excess of \$100 million annually—see Graff et al., 2003). Nevertheless, the royalties cover, at most, 2 percent of university expense on research, and the main benefit of technology transfer is that the university becomes a source of innovation and competitiveness. In many cases, the main threat to established companies is new innovations that originate at universities (Google that originated at Stanford, really reduced the market power of Yahoo!)

The technology transfer from the university to the private sector has been crucial for the evolution of medical biotechnology, and has been important in agricultural biotechnology. Many crucial ingredients of agricultural biotechnology (for example, the agricultural *biobacturium*), were patented by universities, but the rights were sold to private companies. Companies, such as Monsanto and Dupont, have invested in university technologies, and there has been a growing tendency for university-private-sector alliances. For example, several years ago Novartis gave the University of

California, Berkeley, \$5 million annually for research for five years, where Novartis received the first rights to consider commercialization of the results of this research.

The success of technology transfer is a testimony to the complementarity between the university and private-sector research. Scientists are pursuing, as Graff et al. (2003) suggest, fame, fortune and freedom. At the university, they are rewarded, mostly, for original research and expanding the frontier of knowledge; working in private companies, scientists may have less freedom and fame, but more fortune, and their research is more restricted to enhance product development.

Public-Sector Intellectual Property Rights for Agriculture

It has been shown, for several lines of research, that the share of university patents is declining as the products mature. The infusion of funds, as well as access to intellectual property of companies associated with university private sector partnerships, have helped to enhance university research. But the increased privatization of knowledge has a significant size effect. There are barriers to access to technology, and sometimes university scientists may not be able to utilize technologies that were originated in the university but were transferred to the private sector. Furthermore, the increased reliance on private sector research for product development may result in “orphan crops,” that may be too small to warrant private investment in product development, even though the total benefit to consumers and producers combined would justify the investment.

The specialty crops of California are examples of possible orphan crops, and indeed, the private sector has not invested much in biotechnology for such crops. In many cases, lack of access to intellectual property rights is an added barrier to investment in technologies for these crops by either the private or the public sectors. One solution that was introduced recently is the clearinghouse for Ag Biotech (see Atkinson et al., 2003), where universities have pooled their intellectual property together to develop a public sector “pool” of patents that will reduce reliance on private sector IPR, and increase the bargaining power of public sector research as they try to negotiate rights to private sector IPR. The organization PIPRA (Public Sector Intellectual Property Rights for Agriculture) also aims to develop precise technology transfer arrangements that would lead to universities transferring the rights to their innovations, only for applications that would be pursued by the private sector partners, and retaining rights for applications that are most likely to be pursued by others. Graff et al. (2003) show that universities have 24 percent of the patents in agricultural biotechnology, which is more than any private company, and thus, pooling their intellectual property rights together may be indeed a mechanism to enhance their productivity and independence in pursuing product development.

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 new 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.

The United States has in the past provided a substantial share of the world's agricultural research investments, and technologies produced in the United States have spilled over to many countries, especially in the developing world. The long-term trend is for a rising proportion of agricultural R&D to be conducted in the private sector, and this will have implications for the nature of research undertaken and the mixture of research products that are available and on what terms. Some countries (especially the world's poorest) and commodities (especially subsistence and specialty crops) are increasingly likely to become agricultural technological orphans in a world where research is conducted increasingly on a for-profit basis, and where technological regulation is progressively eliminating technological options and raising the cost of developing alternatives.

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CHAPTER 12

California's Edge Problem: Urban Impacts on Agriculture

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Much of California's agriculture operates in the direct shadow of urbanization. In this state, the nation's leader in both farm production and ongoing population growth, the agriculture-urban edge problem has economic, land use, life style, and health dimensions. With so many people living so close to so much commercial farming, the negative impacts flow in both directions. For farmers, operating in the midst of urban neighbors often means reduced productivity and income, regulatory constraints, vandalism, and legal liability. For urban neighbors, the issues concern the dust, noise, odor, and even health affects of living adjacent to industrial-like activities that use chemicals, heavy machinery, and concentrated animal facilities.

The geographical proximity of agricultural and non-farm residents is not a new pattern in California. Edges have existed in this state for the past century and a half, since the development of commercial farming and since European settlers began to build country homes. What is relatively new is the scale and intensity of residential encroachment into rural areas and the further industrialization of farm activities. Just in the half-century since World War II, urban and suburban populations have rapidly spread out and converted close to a million cropland acres, first in coastal agricultural areas and then increasingly in the vast Central Valley. As well as creating numerous edges, this growth brought to rural areas numerous residents with urban backgrounds who, while desiring the amenities of country living, were not acquainted with its discomforts including the industrial aspects of farm practices. At the same time, plant and animal agriculture activities intensified greatly, applying new technologies that increased production but also generated more off-farm impacts. California agriculture during this period also became a more regulated industry, particularly in the use of pesticides and other chemicals and in its impacts on water quality, as a result of the expanded public interest in environmental and health protection.

By now it is a truism in California that the agricultural-urban edge problem is a serious consequence of our continuing urbanization and land use patterns. Along with decrying the urban "paving over" of rich farmland, newspaper accounts frequently document specific examples of edge conflicts between farmers and residential neighbors. In some respects edge conflicts are a more serious California problem than the direct loss of farmland to urban uses. While the farmland conversion rate currently averages about 50,000 acres statewide annually, edge tensions continually affect many times as many agricultural acres.

This discussion, however, is largely informed by anecdotes and impressions. It lacks a body of solid and research-derived evidence about problem causes, circumstances, and solutions. We recognize the widespread existence of the edge problem in California, but we don't understand in a systematic way how it varies in intensity and impacts different communities, farm commodities, urban configurations, and other circumstances. Clearly conflicts and negative impacts are not found in all the places where farming and urban residences are in close proximity; some edges are characterized by a peaceful coexistence between farmers and urban neighbors.

This paper is an exploratory examination of the edge problem in California agriculture that is drawn from a variety of sources. Considering the lack of systematic research in California, some of these sources are studies carried out in other states. We review here (1) available information about the extent of urban-farm borders in the state, (2) the nature of impacts on both sides of the edge, (3) variations in the extent of the problem, (4) farm operator adaptations in urban-influenced areas, and (5) policy and private-sector mechanisms for dealing with the problem.

MORE THAN 10,000 EDGE MILES

Agricultural-urban edges are pervasive throughout California. By one linear measure, in 1998 urban areas throughout the state were bordered by 17,301 kilometers of all kinds of agricultural uses—or 10,726 miles. About two-thirds of this total represented cropland and one-third grazing land. The calculations are based on the digitized

(Geographic Information Systems) maps generated by the Farmland Mapping and Monitoring Program (FMMP) of the California Department of Conservation. Combining soil survey information with the results of aerial photographs, the FMMP every two years maps the agricultural and urban land uses of most of the non public lands territory of the state with an emphasis on tracking farmland conversions to urban use. The estimate of 10,726 miles is probably an undercount of true extent of the total edge distance, since the FMMP does not map a few agricultural areas of the state where modern soil information is lacking, and the mapping does not capture isolated urban pockets of less than 10 acres (the “urban and built-up” map category is defined as at least six structures in a 10 acre area).

This thin, linear measure does not give us a sense of how many farms or how much agricultural land is actually located adjacent to urban uses in California. It is difficult to translate kilometers and miles into a more meaningful area measure, such as acres, without knowing more about farm sizes in relation to linear borders. A conservative estimate is that about 2.2 million agricultural acres statewide are located adjacent to urban edges, based on the assumption that urbanization affects farm operations up to a third of a mile on the average from urban borders. This represents about 8 percent of California’s 28 million total agricultural acres. The same assumption produces an estimate of 1.5 million cropland acres in edge areas, about 13 percent of all cropland in the state.

Table 1. Edge Borders, Population and Urban Acres for Top CA Agricultural Counties

Counties, Ranked by Farm Market Value, 2000	Crop-Urban Border in Kilometers ^a		-----Population-----		-----Urban Acres-----	
	1998	88-98% Increase	2000	90-2000% Increase	1998	88-98% Increase
1. Fresno	788	34.9	779,407	19.7	93,315	21.0
2. Tulare	650	34.5	368,021	17.7	48,522	27.0
3. Monterey	240	25.2	401,762	12.9	50,037	14.1
4. Kern	493	34.4	661,645	21.7	100,779	24.5
5. Merced	489	37.7	210,554	17.9	30,559	46.6
6. San Joaquin	693	15.7	563,598	17.2	71,596	12.2
7. San Diego	409	27.8	2,813,833	12.6	311,491	13.2
8. Stanislaus	486	9.2	446,997	20.6	50,481	17.2
9. Riverside	1,290	25.6	1,545,387	32.0	240,889	28.0
10. Ventura	367	3.5	753,197	12.5	95,522	14.2
11. Imperial	304	20.3	142,301	30.1	23,952	24.4
12. Kings	265	6.0	129,461	27.6	28,244	17.0
Average	539	22.9%	--	20.2%	--	21.6%

a) Calculations of data from the Farmland Mapping and Monitoring Program (California Department of Conservation), prepared by Nick Kuminoff using Arcview GIS 3.2.

Source: California Department of Conservation, Office of Land Conservation, Farmland Mapping and Monitoring Program, county Agricultural Commissioner reports, U.S. Census of Population.

Cropland edges in California are concentrated in the leading agricultural counties—the counties with the highest farm market values and most of the best cropland defined as prime farmland. Table 1 makes this point in examining the edge circumstances of cropland in the 12 top counties in farm market value, including seven Central Valley and three coastal counties. All but the bottom two on the list had market values in 2000 of at least \$1 billion each. Most of the state's urban-cropland borders are found in these high value counties—6,465 kilometers in 1998, or about 90 percent of the state's total. Moreover, they are among the leading counties in prime farmland, 2.6 million acres in 1998, most of the state's total of about 4.3 million prime acres.

Table 1 also notes the large increase in cropland-urban edge borders in the ten years between 1988 and 1998—an average of a 22.9 percent increase in edge kilometers for the 12 counties. This reflects of course the comparable increases in population and urban areas during the approximate or same ten-year periods. However, for several counties—Fresno, Tulare, Monterey, Kern, and San Diego—percentage increases in cropland edge kilometers vastly exceeded the increases in population and acres devoted to urban use.

DIMENSIONS OF THE PROBLEM

Identifying the extent and location of geographical edges tells us little about the incidence and intensity of the conflicts and the specific issues that arise from the close proximity of farms and urban neighbors. We can speculate that such conflicts are concentrated in a relatively few places throughout the state, while farm-urban relations are generally peaceful in most edge areas.

The reasons are that urbanization proceeds at varying rates in different communities, farmers generally adjust their operations to edge realities, and most residential neighbors learn to tolerate some discomfort from nearby agricultural operations as the price to pay for living in the countryside.

Still there is substantial anecdotal information about the types of impacts that qualify as edge problems. The common understanding in California's agricultural areas is that farm operators and residential neighbors are affected in particular ways by their respective behaviors. As duplicated in Table 2, a short list of such issues was included in the summary report of the 1996 conference, *California's Future: Maintaining Viable Agriculture at the Urban Edge*, organized by the UC Agricultural Issues Center. Longer lists of edge issues are found in other reports, including those issued in other states. A New York State guidebook on reducing edge conflicts, for example, identifies 26 different kinds of rural residents' complaints against farmers, including unsightly farmsteads, trash, inconsiderate behavior by farmers, and wandering livestock (Farming Alternatives Program, p. 5).

What is clear from Table 2 is that farmers and residents at the edge differ in their interests and views of how they are negatively affected by their interactions. For farmers, the issues largely concern the costs and efficiencies of producing their commodities—largely economic considerations. For residential neighbors, the impacts deal with questions of health (particularly concerning the application of pesticides and other chemicals) and quality of life. This difference in how edge issues are defined by

the respective parties suggests how difficult it may be to resolve such issues when conflicting positions are strongly held.

Table 2. Edge Problems Frequently Cited by Farmers and Urban Neighbors

Farmers	Urban Neighbors
Restraints on what otherwise would be routine practices such as spraying and cultivating.	Pesticide use, particularly drift problems.
Liability for trespassers.	Nighttime farming—lights and noise.
Theft, vandalism, litter.	Odor, particularly from livestock operations and food processors.
Damage from dogs.	Dust and smoke.
Imported pests—for example, weeds spreading from urban areas.	Flies, mosquitoes and other pests.
Increased traffic on local roads.	
Source: Coppock and Kreith, 1997.	

Edge issues are expressed in local settings and frequently in personal terms. A sampling of recent newspaper accounts throughout California presents these examples:

- Horrified when viewing the castration of calves on the adjacent ranch, a rural resident of El Dorado complains to the rancher who then reports this as harassment to the sheriff's office (Leavenworth, 2000).
- In the Rosedale area immediately west of Bakersfield in Kern County, a neighborhood of alternating farms, rural residents, and new residential subdivisions, a rancher reports the vandalizing of a well pump three times in a short period, chasing cars and motorcycles through his orchard, and thefts of tree produce (Prince, 1994).
- Largely because of the displacement of their operations by urbanization in southern California, dairymen propose new or enlarged mega-dairies with herd sizes exceeding 8,000 cows in the southern San Joaquin Valley. Environmentalists and local residents strongly oppose these proposals, citing water quality, odor, and other issues (Sokoloff, 1999).
- Farmers in an area of San Luis Obispo County, concerned about restrictions on their pesticide spraying and increased local traffic, protest school district plans to locate a new high school in their area (Ome, 1998).

Variations in Extent and Intensity: Farm Commodities and Practices

Obviously edge issues are not equal in their distribution and how they are perceived by the parties to these conflicts. We expect the extent and intensity of edge problems to vary from location to location, depending on the characteristics of both the agricultural and urban sides of the boundary. Critical agricultural variables are the types of commodities grown and the farm practices used to produce them. In California, conflicts over the agricultural use of pesticides and herbicides seem to be more visible and widespread than in most other farm states. Our state specializes in tree, vine, and vegetable crops that require extensive cultivation and protection from pests. Much of the production of such crops occurs in edge areas, where high costs for purchasing or renting agricultural land impels operators to grow high value and high yield commodities.

What may limit in many localities the extent of neighborhood opposition to farm use of pesticides and other chemicals is the tight regulation of such applications by state and local governments in California. Human health risks and potential water contamination are controversial issues. Regulation takes place primarily through the permitting actions of county agricultural commissioners, the licensing of applicators, and the work of county health departments. Despite these controls, excessive drift from aerial and ground spraying is an ever-present concern. Residents in some agricultural communities, either attributing specific health problems to spray drift or fearing the risk, have organized to protest chemical use and to question the adequacy of the regulatory system (Phillips, 1997; Van Driesche, 1987).

In many other states the most conflictual farm-urban issues increasingly revolve around the location and effects of concentrated animal feeding operations, a type of agricultural activity that now has its own acronym—CAFOs. Reflected here is the growing industrialization of animal agriculture in the nation, marked especially by the trend in southern, eastern, and midwestern states to larger and more specialized hog and poultry raising operations (Castle, 1998). Local operators typically are integrated via contractual arrangements into the feed, processing, and marketing processes of national firms. From a community and environmental perspective, the most critical feature of these factory farms is the concentration of so much animal waste in such small areas—the “piling up of too much stuff in one place” according to one observer (Schwab, 1998, p. 2). The threat to surface waters and aquifers is the central issue. Public agencies are not always aggressive in controlling the siting of such farms and in overseeing their waste disposal processes. CAFOs also generate other negative impacts in their neighborhoods, primarily odor and air pollution.

The California version of the CAFO problem largely involves the development of larger dairy farms. As noted above, this is a major public policy issue in the southern San Joaquin Valley, now the most productive milkshed in the nation. County governments through their planning and land use powers are largely responsible for controlling the location of new or enlarged dairies, while the water quality aspects of dairy operations are in the hands of environmental regulators in state and federal governments.

Variations in Extent and Intensity: Urban Perceptions and Configurations

The key variables on the urban side of edge areas are the characteristics of residents and the configurations of their urban neighborhoods. Certainly the negative impacts of living next to certain kinds of intensive farming operations have a clear and objective reality. Nobody likes dust on their backyard laundry, to be awakened at 5 a.m. by the sound of heavy machinery, or to be subject to possible exposure to the drift from chemical applications. Yet, perceptions also determine how people personally regard and react—or don't—to such conditions. Levels of tolerance to farm operations vary quite a bit, with some urban neighbors more disposed than others to identify specific incidents as more than minor annoyances and more inclined to complain to farmers and government offices.

What seem to generate such perceptual differences, according to anecdotal information, are lifestyle backgrounds. The generalization is that newcomers who move to agricultural locations directly from urban areas are less tolerant of the discomforts of living close to farms than longtime residents who have farm or other rural backgrounds (Van Driesche, 1987). Particularly contributing to the unhappiness of urban newcomers with their new neighborhoods is how the realities of intensive agricultural practices clash with their expectations of pleasant living in the country. Notes the mayor of Patterson, an expanding small city in western Stanislaus County: "Most of us have grown up with crop-dusters at dawn, but not the new constituents" (Morain, 1991). Lacking so far systematic research on the topic, this generalization about levels of tolerance is merely a reasonable hypothesis.

The configuration of residential neighborhoods in edge areas also likely affects the extent of conflict. The larger the exposure or interface between farm activities and nonfarm residences, the more opportunity for problems. By implication, this is an argument for planning and residential design that confines urban development in relatively small blocks, as compared to a pattern of scattered homesites throughout an agricultural area. The difference is between sharp, solid edges separating farms and residences and ill-defined and fragmented edges that blur the distinction. A separate kind of problem is posed by the location in the middle of agricultural areas of schools, churches, and other facilities that concentrate large numbers of people at certain times.

The Impermanence Syndrome

As well as immediate impacts, there are also long-term consequences for agricultural operations located in areas of ongoing urbanization. Some writers refer to the "impermanence syndrome," a term which takes in a variety of meanings, but generally suggests a high degree of uncertainty among farmers about their ability to continue productive operations in areas beset by rapid population increase and land use change. Anticipating either that they will have the chance to sell their land for development or that surrounding urbanization will restrict their farming activities, farmers in such situations avoid continuing investment in their enterprises with capital improvements, new technologies, and management time and energy. This uncertainty about the future may in fact serve as a self-fulfilling prophecy, pushing landowners to seek development deals and thus accelerating the rate of farmland conversions in high growth areas. In the interim, much farmland may be idled or underutilized, production shifted from

more to less intensively cultivated crops, and individual farm parcels bypassed or surrounded by development. For California farmland owners, the annexation plans of nearby cities are a key sign as to whether or not agriculture is likely to survive in particular areas (Pandol, 1997). Research in other states suggests that urban-related uncertainties often lead to inefficient land use (Berry and Plaut, 1978; Larson, Findeis and Smith, 2002; Lockertz, Freedgood and Coon, 1987; Zollinger and Krannich, 2002).

FARM OPERATOR ADAPTATIONS

Not all agricultural landowners in edge locations give up on the future, accepting what others regard as the inevitable demise of productive farming in their areas. There are sufficient stories of individual farmers continuing to invest in and aggressively manage their edge properties to suggest that continued farming in the shadow of urbanization is an important pattern for California agriculture. One reason is that not all edges experience ongoing development pressures. Even in high growth regions, California cities do not grow out in all directions at the same time; rates of expansion also are often gradual, allowing years of stability to some edges. Some landowners thus are unrealistic in anticipating that the path of urban expansion in their area will give them the near-future opportunity to sell their land for development. In a guide to the easement option for California agricultural landowners, the authors estimate that more than three-quarters of Central Valley farmland "cannot realistically be expected to develop to urban uses within the next 40 years" (Kirkpatrick, Kozloff and Berwald, 2001).

Yet even in stable edge areas where agricultural operations are likely to continue indefinitely, the very proximity to residential and other urban land uses usually requires some degree of adjustment on the part of farmers. Operating in the shadow of urbanization demands more in farm management skills and the use of technology, according to some accounts. These abilities and the willingness to adapt and continue to farm in urban-influenced areas are not equally distributed among farmers in such locations. Age and family circumstances play a role. A study of dairy farms in a Hudson Valley area of New York experiencing growth pressures, finds that younger operators with fewer family problems were more likely to stay in business at that location and adapt their operations to the urban environment (Hirschl and Long, 1993).

Adaptations include various kinds of changes in production practices to minimize negative impacts on urban neighbors and to secure crops and equipment from vandals and trespassers. Integrated Pest Management (IPM) techniques for reducing or controlling the use of pesticides and other chemicals are widely used by California farmers, drawing from a large body of university and private sector research. IPM covers both biological and engineering innovations, including investment in new spray equipment (Phillips, 1997). Other changes include muffling pump motors, measures to reduce dust, and avoiding late-night and early morning operations that are noisy. Because of these and other adaptations, production costs for edge farming are usually higher than in other locations, whether because of equipment investment or the inefficiencies created by operational changes.

One example of urban-influenced adaptation is provided by the experience of Southern California's poultry farmers during the 1980s. They invested in new types of buildings to remove laying hens from the floor and thus isolate waste material, changed procedures for drying and disposing of waste, landscaped the areas around poultry housing, and improved fencing and installed alarm systems to reduce vandalism and theft (Roger-Reynells, 1997). Some poultry farms in the region chose instead to sell their land for development and relocate in more remote locations, investing some of their proceeds in new facilities—the ultimate strategy by farm operators impacted by urban growth.

High Value Crops in Metropolitan Counties

A different kind of adaptation among edge growers is to change the commodities grown. Generally this means shifting to higher value commodities, or to those that are less vulnerable to urban impacts. Commodities that produce more income per acre, such as tree, ornamental, and vineyard crops, also typically involve more intensive and expensive cultivation practices. But the motivation for shifting in this direction is the already higher costs of farming in urban-influenced areas, including the land costs for farms that acquire more land to expand their operations (Coppock and Kreith, 1997).

Such adaptations allow some productive and profitable agricultural operations to continue in locations highly impacted by urban growth. This is suggested by changes in farm operations in several of California's largest metropolitan counties recorded in the half century between 1950-2001, a period of considerable population growth and farmland conversion. Table 3 shows the changes during this period in population, agricultural market value, and top four farm commodities for five of the state's eight counties with more than 1 million residents (as of 2001).

Located in coastal areas, they include the four most populous counties (Los Angeles, Orange, San Diego, and Santa Clara) of California. All five counties recorded a substantive shift in dominant commodities over the half century, with nursery products or flowers taking over the top spot. Citrus, poultry, dairy products, and field crops—ranking commodities in 1950—were largely eliminated from the top four spots by 2001. The significance of the shift to nursery plants is that they are often grown in greenhouses, enclosed environments that limit impacts on urban neighbors and are relatively secure from vandalism and other encroachments. Nursery products also have a ready market in nearby urban areas.

Table 3 also reveals the continued importance of agricultural to local economies in four of these metropolitan counties. With the exception of Alameda, all had farm market values of at least \$250 million in 2001. Even Los Angeles County made this list in 2001, due to \$152 million in nursery sales, although the agricultural significance of this most populous California County dropped greatly from the late 1940s when it was the state's (and the nation's) top producer in market terms. In 2001 Los Angeles ranked 27th in farm value among California's 58 counties.

San Diego County stands out as the only county in this sample with an increase in farm market value during 1950-2001 (+1718%) that exceeded the rise in California's consumer price index (+696%) during this half-century. In 2001 San Diego ranked

eighth in the state with a market value of \$1.3 billion, fueled by more than \$700 million in nursery and flower production and \$138 million in avocados.

Table 3. Agriculture in Metropolitan Counties, 1950-2000

Population (million)	Alameda County	Los Angeles County	Orange County	Santa Clara County	San Diego County
1950	.740	4.151	.216	.290	.556
2000	1.440	9.519	2.846	1.682	2.814
<i>Agriculture Market Value (\$ million)</i>					
1950	33.2	95.4	79.2	84.1	70.9
2001	36.5	258.2	319.0	288.1	1,289.6
% Increase	9.9%	170.4%	302.7%	242.5%	1,718.0%
<i>Top Commodities</i>					
1950	1. Vegetables 2. Nursery 3. Poultry 4. Dairy	1. Citrus 2. Nursery 3. Vegetables 4. Field Crops	1. Citrus 2. Dairy 3. Field 4. Poultry	1. Fruits-Nuts 2. Beef 3. Vegetables 4. Poultry	1. Vegetables 2. Dairy 3. Poultry 4. Eggs
2001	1. Nursery 2. Grapes 3. Cattle 4. Flowers	1. Nursery 2. Vegetables 3. Fruit 4. Onions	1. Nursery 2. Strawberries 3. Tomatoes 4. Avocados	1. Nursery 2. Mushrooms 3. Peppers 4. Flowers	1. Flowers 2. Nursery 3. Avocados 4. Eggs
Source: Annual reports, county Agricultural Commissioner reports; U.S. Census of Population.					

In pointing to the survivability of farming in metropolitan areas, however, these numbers are more suggestive than conclusive. The “metropolitan” designation is only a rough and imprecise indication of the extent to which local agriculture is influenced by urbanization. The counties in this small sample in fact contain vast rural areas, leaving open the possibility that many of the most productive farms are not close to urban development. Also not examined in this analysis is the extent to which commodity shifts are the result of other factors, including market forces and water supply.

The Advantages of Urban Proximity

Research in several eastern states supports the survivability thesis for urban-influenced farming. The common generalization from several studies is that urban proximity can provide profit-making opportunities as well as problems for farmers, considering the potential for direct marketing, other forms of access to urban consumers, and off-farm income for operators. (Edelman, et al., 1999). But only certain kinds of intensely-cultivated farms, including vegetable producers, seem to benefit from such locations (Larson, et al., 2001). A USDA review of the available information on farms in metropolitan areas characterizes them as smaller, producing

more per acre, more diverse, and more focused on high-value production than farms in non-metropolitan areas (U.S. Department of Agriculture, 2001).

POLICIES AND TOOLS FOR RESOLVING EDGE PROBLEMS

California has a large array of tools for dealing with and resolving edge issues, as displayed in Table 4. Some are implicit in the policies and regulatory actions of city and county governments, the public agencies given the authority in state law to control land use. Others involve practices in the private sector that attempt to bridge the gap between farmers and urban neighbors.

Table 4. California Strategies for Reducing Urban-Agricultural Edge Conflicts

<i>Land Use Policies and Tools</i>
1. Concentrate urban growth in cities and other existing urban centers
2. Limit new residences in agricultural areas
3. Efficient urban development—high density projects
4. Cluster development
5. LAFCO (Local Agency Formation Commission) control of city annexations
6. County-city agreements on the direction of urban development
7. Environmental review of proposed development and mitigation of farmland impacts
8. Agricultural Buffers
9. Agricultural zoning
10. Design urban neighborhoods and homesites to limit exposure to nearby farmland
11. Build new communities on poor farm soils
<i>Farm-Neighbor Practices</i>
1. Right-to-farm ordinances
2. Regulation of chemical use in farm operations
3. Clean water requirements for animal facilities
4. Conflict resolution procedures
5. Conflict prevention—good neighbor communications and accommodation
6. Agriculture education for urban residents

Source: Sokolow, 2002.

Land Use Policies

Land use policies and regulations can be seen as largely proactive efforts to direct the location and form of new urban development in ways that would minimize impacts on agricultural activities. This is the general intent of policies that call for keeping

development away from agricultural areas, in particular restricting residential growth in the countryside and directing it instead to existing cities, either as infill development or as incremental additions to municipal areas as cities gradually annex adjacent territory. Some conversion of farmland is inevitable in this process where cities are surrounded by agricultural uses, as throughout the Central Valley. But the assumption is that this is preferable to allowing building in unincorporated areas, because city development occurs at relatively high densities that convert less farmland in relation to population housed, it is less costly in public infrastructure terms, and it is more likely to produce solid and less exposed edges with farming. Also cities that are surrounded by agricultural land of varying quality and productivity have the option of directing their expansion away from the best farmland.

City-oriented growth strategies are supported by the LAFCO process and county-city agreements on the location of future urban development. LAFCOs (Local Agency Formation Commissions) are California's boundary control agencies at the county level, semi-independent boards that have the power to review, deny, or change city plans to annex territory and to designate their future growth areas (spheres of influence). LAFCO actions, guided by orderly growth and farmland projection objectives, are a major restraint on extensive sprawl. Some counties and cities in agricultural areas have negotiated agreements that divert urban development from unincorporated areas to city areas, usually in return for financial considerations that allow the county to share in municipal growth revenues (Sokolow, 1997).

The two land use policies that most specifically address edge issues are agricultural buffers and mitigations imposed on new development for the loss of farmland or to limit negative impacts on farming. The two are closely related, since buffers are a type of mitigation frequently recommended by the environmental reviews (under the California Environmental Quality Act—CEQA) conducted by county and city governments of proposed urban projects. Buffers essentially create a separation between agricultural and urban uses, using barriers or distance to minimize negative impacts on both sides of an edge boundary, especially the effects of chemical drift from farming activity.

Agricultural buffers come in different forms—natural barriers created by landscape features such as waterways, roads, landscaping, walls, residential setbacks, open space greenbelts, and combinations of various types. Key issues in their design and creation are their permanence, maintenance, and which landowners—developer/homeowner or farmer—provide the land or barrier. Although the general plans of many California counties and cities call for use of buffers to protect farmland, the implementation of the technique and application to specific urban projects is quite spotty, as Mary Handel noted in a 1994 M.S. thesis in Community Development at UC Davis. Especially controversial are the desired widths for setbacks and greenbelts, with farm chemical applicators and other agricultural experts calling for the biggest possible separations while urban developers and city governments argue for smaller widths because of land cost considerations. In Handel's study of buffer use in 16 counties and 6 cities, designated widths range between 50-800 feet. She also finds great variations among farmers and urban neighbors in the perceived effectiveness of different forms of buffers to limit specific negative impacts. For example, farmers generally judge setbacks or open space buffers as ineffective in

dealing with trespass, vandalism, litter, theft, and dogs while urban residents see them as generally effective in reducing chemical drift, odor, and dust from farm operations (Handel, 1994). More recently, the Great Valley Center published a short guide on agricultural buffers for urban planners (Great Valley Center, 2002).

Farm-Neighbor Practices

As contrasted with the land-use control approach of trying to head off edge problems by influencing the location and design of urban development, other strategies seek to deal more directly with farm-urban neighbor tensions, often after they have emerged. Government policies and programs in this category include right-to-farm ordinances, California's extensive regulation of pesticides and other agricultural chemicals, and restrictions on farm animal facilities driven by clean water policies.

When first adopted by California local governments in the late 1980s after enabling state legislation, right-to-farm ordinances were seen as a promising tool for protecting routine farm operations from nuisance law suits and complaints by urban neighbors. The central feature of most such local laws is a disclosure requirement—notifying homebuyers of parcels adjacent to farms of the possibly negative effects of agricultural operations. In this way, the assumption goes, new residents especially would learn about the realities of modern farming and would be less inclined to complain or even go to court over sprays, dust, odors, noise and other results of nearby agriculture. Some ordinances also provide procedures for handling formal complaints by neighbors.

Most California counties and a number of cities now have right-to-farm ordinances, a popularity seemingly driven by the belief on the part of local officials and others that this is an easy way to provide farmland protection that avoids hard political choices. (Right-to-farm is also a common technique in other states.) Because they are not regulatory tools and rely primarily on the dissemination of information, however, the ordinances lack teeth and legal effect. It is uncertain to what extent they have reduced conflicts in edge areas. But the ordinances do serve a useful purpose, according to many agricultural leaders and county officials, in educating residents and asserting as a policy matter the value of agriculture in particular communities (Wacker, et al., 2001).

More generally, conflicts between farmers and urban neighbors over farm activities can be addressed by a variety of techniques for dealing with community-level disputes. Practitioners in this field make a distinction between conflict resolution and conflict prevention. Resolution processes often involve a form of third party mediation, in which facilitators get both sides together, factual information on the source and elements of the dispute is developed, alternatives are deliberated, and an effort is made to reach an agreement among the parties as to actions to be taken such as changes in farm management (Abdalla and Kelsey, 1996). The state of New York has formalized such processes, with a Community Dispute Resolution Center in each county with resources for dealing with edge and other local conflicts (Farming Alternatives Program, n.d.).

Preventing edge conflicts typically involves less formal methods, with the emphasis on encouraging farm operators to maintain open lines of communication with

their urban neighbors. The assumption is that friendly relations can head off serious disputes in the future over specific matters. One piece of advice to farmers in a New York state guidebook on reducing edge conflicts is to notify neighbors in advance of the timing and need for particular practices that may generate negative impacts. The guidebook goes further to suggest 15 strategies that farmers can use to foster good neighbor relations, including farm tours, providing gifts of farm produce, and setting aside an acre or two for wildlife (Farming Alternatives Program, n.d.).

SUMMARY: RESEARCHABLE QUESTIONS

As new residents steadily move into rural areas, the extent of the farm-urban edge problem increases in California. Our rough estimates place the total linear scope of agriculture-urban edges at more than 10,000 miles throughout the state, increasing by 23 percent in the ten year period of 1988-98. Agriculture is increasingly impacted by this exposure to urban populations, leading to restrictions on farm productivity and efficiency. The negative effects flow in the other direction as well, since the industrial-type processes of California agriculture are incompatible with residential comfort, quality of life, and even health.

It is misleading to generalize the dimensions of the problem, since edge circumstances vary greatly depending on commodities grown, differences in farm cultivation and management practices, the configurations of urban neighborhoods, and perceptions of both residents and farmers. A further complication is that management changes and commodity shifts allow some edge farmers to adapt successfully in urban-influenced areas.

All of this suggests a currently inadequate knowledge base for understanding the problem and searching for the most effective solutions. Achieving edges that allow the stable coexistence of farms and urban neighbors calls for a combination of public policy measures, farm management practices, and human behavior. A short list of the key questions for building the knowledge base include the following:

1. What are the full dimensions of the farm-urban edge problem in California? Is it possible to generalize about location, causes, and circumstances—or to classify these specifics into meaningful categories and variables that point the way to solutions?
2. How can proactive planning and land use regulations minimize future edge problems in the location and design of urban uses near agricultural areas?
3. What educational and political strategies can help implement effective edge policies at the community level?
4. For farm operators, what management strategies and cultivation techniques are most cost-effective for adjusting to edge constraints, and under what conditions?
5. Beyond such management adaptations and their required adherence to applicable regulations, what can farm operators do to bring about more positive relations with urban neighbors?

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