Chapter 2. A History of California Agriculture

Alan L. Olmstead and Paul W. Rhode

Abstract

The history of California agriculture entails a story of innovation and conflict as farmers and their allies repeatedly remolded their environment to create an extraordinarily diverse and production agricultural-industrial complex. This is not just a story of the triumph of individual entrepreneurial initiative in a largely unfettered competitive economy, because the actual outcomes often depended far more than commonly realized on aggressive government interventions that defined access to land, water, markets, technologies, and labor; and which helped, often despite farmer objections, control potentially catastrophic plant and animal diseases.

Authors' Bios

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Introduction

In recent years, California has accounted for over one-tenth of the value of the U.S. agricultural output. Perhaps more impressive than the value of farm output is the great diversity of crops, the capital intensity, the high yields, and the special nature of the state's agricultural institutions. California's agriculture evolved differently from what was found in the home states and countries of the immigrants who settled and farmed its soils. These differences were not just an outcome of the state's distinct geoclimatic features; they were molded by the farmers, laborers, researchers, railroad barons, and policymakers who interacted to create one of the most productive and dynamic agricultural-industrial complexes in the world.

Two contrasting legends dominate the telling of California's agricultural history. The first extols California farmers as progressive, highly educated, early adopters of modern technologies, and unusually well organized to use irrigation to make 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, and largely ignores agricultural workers. The second and darker legend sees the California agricultural system as founded by land-grabbers whose descendants continue to exploit 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 a more environmentally and labor-friendly system of family farms as in the Midwest. The contest between these competing interpretations of California's farm system has raged for the past one-and-a-half centuries, with each side seldom even talking to the other. Neither legend has engaged in a systematic and objective analysis of the available data nor offered 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 focus on major structural transformations: the rise and fall of the extensive grain-growing economy of the 19th 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, including farm power and mechanization, irrigation, and the labor market. In these areas, California's farmers responded aggressively to their particular economic and environmental constraints to create unique institutional settings. The results have been remarkable, albeit with significant environmental problems and continuing labor unrest.

The Grain Empire

Bonanza Farms

Early settlers found an ideal environment for raising wheat: great expanses of fertile soil and flat terrain combined with 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 quite differently from the family farms of the American North. The image is vast tracts of grain grown on huge bonanza ranches in a countryside virtually uninhabited except at harvest and plowing times. California grain farms were very large for the day and used labor-saving and scale-intensive technologies, pioneering the adoption of labor-saving gang plows, large headers, and combines. Californians vigorously pursued the development of technologies and production practices suited to early California's economic and environmental conditions. This search for large-scale, labor-saving technologies culminated in the perfection of the world's first commercially successful combined grain harvesters by the Holt Manufacturing Company and other local manufacturers in the early 1880s. Combines became common in the California grain fields by 1890 (Olmstead and Rhode, 1988), when California was the second largest wheat-producing state, following only Minnesota.

Some bonanza farms planted thousands of acres and were far larger than Midwestern operations. They would establish many precedents. 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. Their size, the extent of mechanization, and a reliance on hired labor would also become hallmarks of the state's farm sector.

Biological Innovation and Failure

In addition, California grain-farmers developed novel biological systems, growing different varieties of wheat and employing fundamentally different cultural techniques than their eastern brethren. When eastern farmers migrated to California, they had to relearn how to grow wheat. In the eastern United States, 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 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.

California's wheat experience exemplifies the importance of 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. By the 1890s, there were frequent complaints that what had been prime wheat land would no longer yield paying crops. In addition to declining yields, the grain's quality suffered, becoming starchy and less glutinous, and thus fetched a lower price. Contrary to first impressions, these unsustainable "soil-mining" practices may well have been "economically rational" for individual farmers, given California's high interest rates in the mid-19th century. The result of declining yields and quality was that, in many areas, wheat ceased to be a profitable crop and was virtually abandoned (Rhode, 1995; Olmstead and Rhode, 2008).

Intensification and Diversification

Indicators of Change

Between 1890 and 1914, the California farm economy 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.

Table 1 provides key statistics on the transformation of California agriculture between 1859 and 2007. Almost every aspect of the state's development after 1880 reflected the ongoing process of intensification and diversification. Between 1859 and 1929, the number of farms increased about 700 percent. The average size of farms fell from roughly 475 acres 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. These changes ushered in vastly different production arrangements driven by the differing requirements of extensive grain operations compared with intensive fruit farms. Movements in cropland harvested per worker also point to increased intensification after the turn of the century. The statewide land-to-labor ratio fell from about 43 acres harvested per worker in 1899

Table 1. California's Agricultural Development

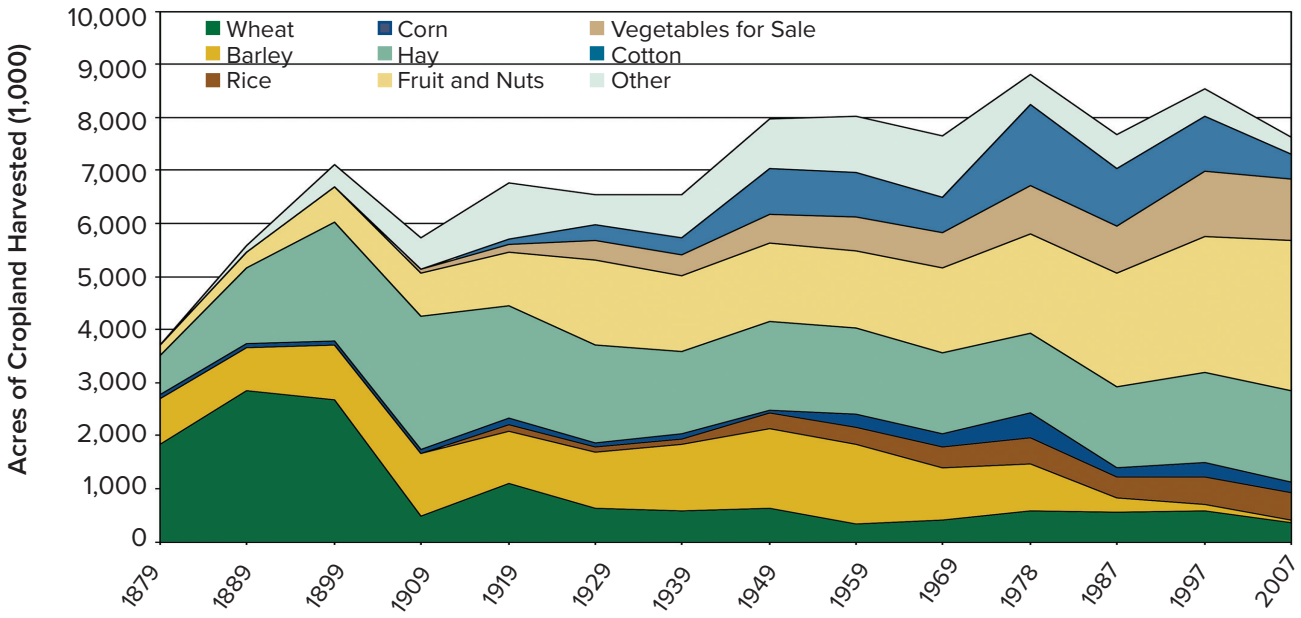
	No. of Farms	Land in Farms	Improved Land	Cropland Harvested	No. of Farms Irrigated	Irrigated Land	Ag. Labor Force
	(1,000)	--------(1,000 Acres)--------			(1,000)	(1,000 Acres)	(1,000)
1859	19	8,730	--	--	--	--	53
1869	24	11,427	6,218	--	--	60-100	69
1879	36	16,594	10,669	3,321	--	300-350	109
1889	53	21,427	12,223	5,289	14	1,004	145
1899	73	28,829	11,959	6,434	26	1,446	151
1909	88	27,931	11,390	4,924	39	2,664	212
1919	118	29,366	11,878	5,761	67	4,219	261
1929	136	30,443	11,465	6,549	86	4,747	332
1939	133	30,524	--	6,534	84	5,070	278
1949	137	36,613	--	7,957	91	6,599	304
1959	99	36,888	--	8,022	74	7,396	284
1969	78	35,328	--	7,649	51	7,240	240
1978	73	32,727	--	8,804	56	8,505	311
1987	83	30,598	--	7,676	59	7,596	416
1997	74	27,699	--	8,543	56	8,713	260
2007	81	25,364		7,633	52	8,016	NA

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; USDA, Census of Agriculture 2007 Census, Volume 1, Chapter 2: State Level Data. https://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_US_State_Level/

Thomas Weiss, Unpublished data.

Figure 1. Distribution of California Cropland Harvested, 1879–2007



Sources: USDA, Census of Agriculture 2007 Census, Volume 1, Chapter 2: State Level Data. https://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_US_State_Level/

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.

Data on the value and composition of crop output place California's agricultural transformation into sharper relief. Between 1859 and 1929, the real value of the state's crop output increased over 25 times. Growth was especially rapid during the grain boom of the 1860s and 1870s, associated primarily with the expansion of the state's agricultural land base. But improved acreage in the state peaked in 1889, and cropland harvested peaked in 1899. Subsequent growth in crop production was mainly due to increasing output per acre and was closely tied to a dramatic shift in the state's crop mix. After falling in the 1860s and 1870s, the share of intensive crops in the value of total output climbed from less than 4 percent in 1879 to over 20 percent in 1889. By 1909, the intensive share reached nearly one-half, and by 1929, it was almost four-fifths of the total. In terms of the crops produced—the scale of operations, the quantity and seasonality of the labor demanded, and the types of equipment needed—California agriculture was a very different place than it had been 50 years earlier.

Figure 1, which shows how cropland harvested was distributed across selected major crops over the 1879–2007 period, displays the transformation in further detail. In 1879 wheat and barley occupied 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 cropland harvested and the intensive crop share stood around 35 percent. In absolute terms, the acreage in the intensive crops expanded more than ten times over this half-century, while that for wheat and barley fell by more than one-third.

Explaining the Transition

Many of the commonly accepted explanations for the causes and timing of California's structural transformation—such as the advent of the transcontinental railroad,

the spread of irrigation, and the slump in world grain prices—fail under close inspection. The transcontinental railroad was completed in 1869, and one of the first effects was an increase in the importation of fruits from the East. At that time, California was not yet self-sufficient in fruit production. Monopoly railroad pricing limited exports from California, and shippers of canned and dried fruits found ocean transport preferable. In the 1880s, the Santa Fe Railroad connected to California, creating more competition. In addition, during roughly the first 15 years of railroad availability, the rudimentary Southern Pacific service was not well suited to handling perishable commodities. Key changes occurred in the mid-1880s, when the Southern Pacific began express shipments of entire trains carrying fruit in ventilated cars, and refrigerator cars were introduced in 1888. These changes in handling and shipping were facilitated by cooperatives that helped to assemble large quantities of fruit, which received preferential service from the railroads. So, the transcontinental rail service played little role in the initial spurt in the California fruit industry, but eventually became important for the fresh fruit trade. At first, most canned and dried fruit and wines still traveled via ship.

A second explanation argues that irrigation was essential for the transition to intensive agriculture. However, a close look at the data shows that irrigation lagged intensification. As late as 1899, irrigated land accounted for only 12 percent of California's improved farmland and less that 25 percent of all cropland harvested; over 70 percent of the state's grape acreage and about 60 percent of its orchard-fruit acreage was not irrigated. Thus, as with railroads, irrigation would become important, but it was not a causal necessity for the growth of the California fruit economy.

Another explanation points to the slump in world grain prices stimulating farmers to transition to orchard and vine crops. This story depicts intensive fruit farmers in direct competition with extensive wheat farmers: a decline in world wheat prices would reduce California wheat production, thereby freeing land and labor for fruit production. However, the real price of wheat fell by about 28 percent from 1870 to 1900; but in the late 1990s and the decade of the 1900s, real wheat prices recovered, rising at about one percent a year, precisely when California wheat production shrank most. Further evidence discrediting the hypothesis that the rise in fruit production was tied to the fall in wheat prices is that real fruit prices fell far more rapidly than grain prices, so movement in the ratio of wheat and grain prices favored wheat production. In addition, very little of the land taken out of wheat production was replanted in fruit trees and vines. Finally, the peak labor demands for wheat were much earlier in the year than for fruits. If anything, the two types of crops complemented each other by providing workers with steadier employment.

Hitherto Neglected Factors

If the usual explanations for the movement from extensive to intensive crops all fail, how do we account for the shift? The surprising result is that exogenous declines in real interest rates and "biological" learning deserve much of the credit for the transformation (Rhode, 1995; and Olmstead and Rhode, 2008).

The Cost of Capital

Isolated from America's financial markets, California farmers faced high—even astronomical—interest rates, which discouraged capital investments in activities such as tree crops that would not begin yielding an income for many years. Rates fell from well over 100 percent during the Gold Rush to about 30 percent circa 1860, and 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 (Burns, 1888)." 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 closely to the interest rate levels prevailing in California when horticulture began its ascent.

Biological Learning

A second key supply-side force was the increase in horticultural productivity associated with biological learning, as farmers gradually gained the knowledge of how to grow new crops in the California environment. 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 (U.S. Weather Bureau 1903; U.S. Bureau of the Census, *Tenth Census 1880, Vol. 6, Cotton Production, Part 2,* 1884).

California fruit growers engaged in a similar process of experimentation to find the most appropriate plant stocks and cultural practices. 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. Prune and plum trees were imported 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 (Tufts, 1946; Hodgson, 1993).

In part, the growth of horticultural knowledge occurred through the informal "folk process" but, 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, 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 (Teague, 1944; Cleland and Hardy, 1929). 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 high-quality horticultural products. This learning process eventually propelled California's horticultural sector to a position of global leadership. 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 (Olmstead and Rhode, 2008).

The application of science, strict quality control in the fields and packing houses (often via policies supported by cooperatives), and a rapid and quality-conscious transportation system to bring fruits to the market, all supported by a commercial financial network, was the landmark creation of California's agribusiness community. This integrated system became known as the "California Model," and was the envy of fruit producers around the world. It allowed California producers to capture the high-price end of markets across Europe.

A second major transformation took place before 1930, 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, requiring significant capital investments and significant increases in labor. The rise of row crops often led to a vast increase in productivity on 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. As with the shift to fruit crops, the shift to cotton was also associated with significant scientific and institutional innovations.

California's White Gold

The Introduction of Cotton

From Spanish times, visionaries attempted to introduce cotton into California on a commercial basis. A variety of factors—including the high cost of labor, the distance from markets and gins, and inadequate knowledge about appropriate varieties, soils, etc.—doomed these early efforts. The real breakthrough came during World War I when high prices, coupled with government research and promotional campaigns, encouraged farmers in the Imperial, Coachella, and San Joaquin Valleys to adopt the crop. Figure 2 illustrates acres harvested, bales produced, and yields per acre from 1910 to 2017. The tremendous absolute increase in California's cotton acreage from the 1920s to 1980 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 only behind Texas.

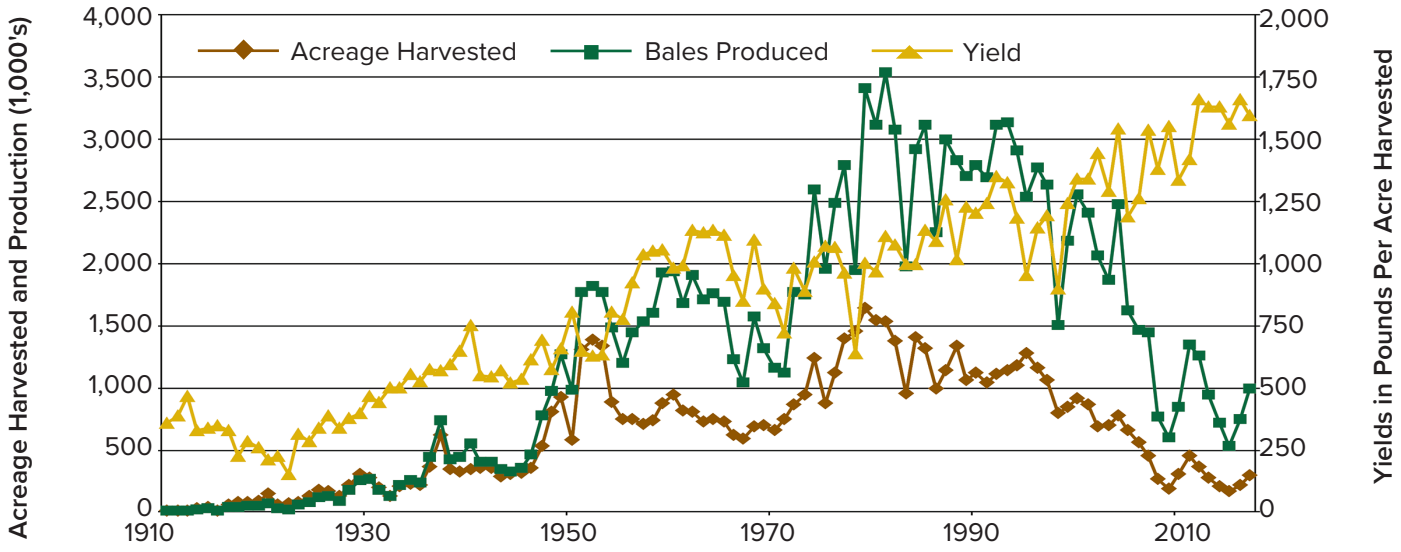
Several factors distinguished California's cotton industry from other regions. First, cotton yields were typically more than double the national average. High yields resulted from the favorable climate, rich soils, controlled application of irrigation water, use of the best agricultural practices and fertilizer, adoption of high-quality seeds, and a relative freedom from pests. Second, the scale and structure of cotton farms was remarkably different in California. From the mid-1920s through the 1950s, the acreage of a California cotton farm was about five times that of farms in the Deep South.[1] As an example of the structural differences between California and other important cotton states, in 1939 farms producing 50 or fewer bales grew about 17 percent of the output in California, but in other leading cotton states, farms in this class produced at least 80 percent of all cotton output. Thus, it is not surprising that California's gross income per cotton farm was almost nine times the national average (Musoke and Olmstead, 1982).

Mechanization

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

1 Some of these San Joaquin Valley farms would grow into immense holdings. The J.B. Boswell company is purportedly the world's largest private farm and cotton farm, credited with owning over 135 million acres. Arax and Wartzman, 2005.

Figure 2. California Cotton, 1910–2017



Source: USDA, National Ag Statistics Service: https://quickstats.nass.usda.gov/

was almost 20 times more likely to have a tractor than a Mississippi farm (U.S. Bureau of the Census, *U.S. Census of Agriculture: 1959, General Report: Statistics by Subjects*, Vol. II). The *Pacific Rural Press* in 1927 offered a description of the highly mechanized state of many California cotton farms: "men 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, six rows at a time, and cultivates 70 acres, four rows at a time (April 2, 1927)." The more rapid adoption of tractors 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 existed in 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 (California Committee to … March 15, 1951; Fisher, 1953). 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 peasant. The proverbial paternalism of Southern planters toward their tenants had few parallels in California. Tenants remained on their allotted plots year-round, while many California farmworkers followed the harvest cycle, migrating from crop to crop.

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. And roughly one-half of the country's machines were in California (Musoke and Olmstead, 1982).

One-Variety Community

California was also home to the largest one-variety cotton community. In the first decades of the 20th century, USDA cotton specialists became increasingly alarmed by the declining quality of American cotton due to the effects of the boll weevil, which prompted farmers to switch to earlier-maturing but lower-quality cottons. In addition, smaller production units in the South, seed mixing at gins, and market failures in cotton grading and marketing, contributed to the quality problem. After about a decade of one-variety experiences in the Southwest, the California legislature declared eight San Joaquin Valley counties and Riverside County as a one-variety community. The 1925 legislation stipulated that only Acala cotton, bred by an association research facility, could be planted, harvested, or ginned in an area of more than four million acres. In the early years, the California one-variety system probably had the desired effects of increasing quality and prices of the state's cotton. However, John Constantine, Julian Alston, and Vernon Smith demonstrated that by the late 1970s, this system was becoming increasingly inefficient, costing the state's cotton farmers about $180 million a year. In the rest of the nation, one-variety communities had faded away in the 1950s, but in California the system lingered on far too long (Constantine, Alston, and Smith, 1994; Olmstead and Rhode, 2008).[2]

As Figure 2 makes clear, after reaching a peak circa 1980, California's cotton acreage and production declined rapidly. Yields continued their upward march, and over the 2007–2011 period were still nearly double the national average. The dramatic fall in cotton's importance once again reflects the dynamism of California agriculture as growers responded to changing environmental conditions and opportunities. Rising water cost and growing pest problems made cotton production less lucrative while especially in Fresno County, farmers converted considerable acreage to more lucrative crops such as almonds, grapes, and tomatoes. Another change not evident in Figure 2 is that since the 1980s, there has been a marked increase in the importance of high-quality, extra-long staple, Pima cotton, which was planted on about one-half of the state's cotton acreage (Geisseler and Horwath).

2 For more traditional accounts see Turner, 1981; Weber, 1994; and Briggs and Cauthen, 1983.

Livestock Production

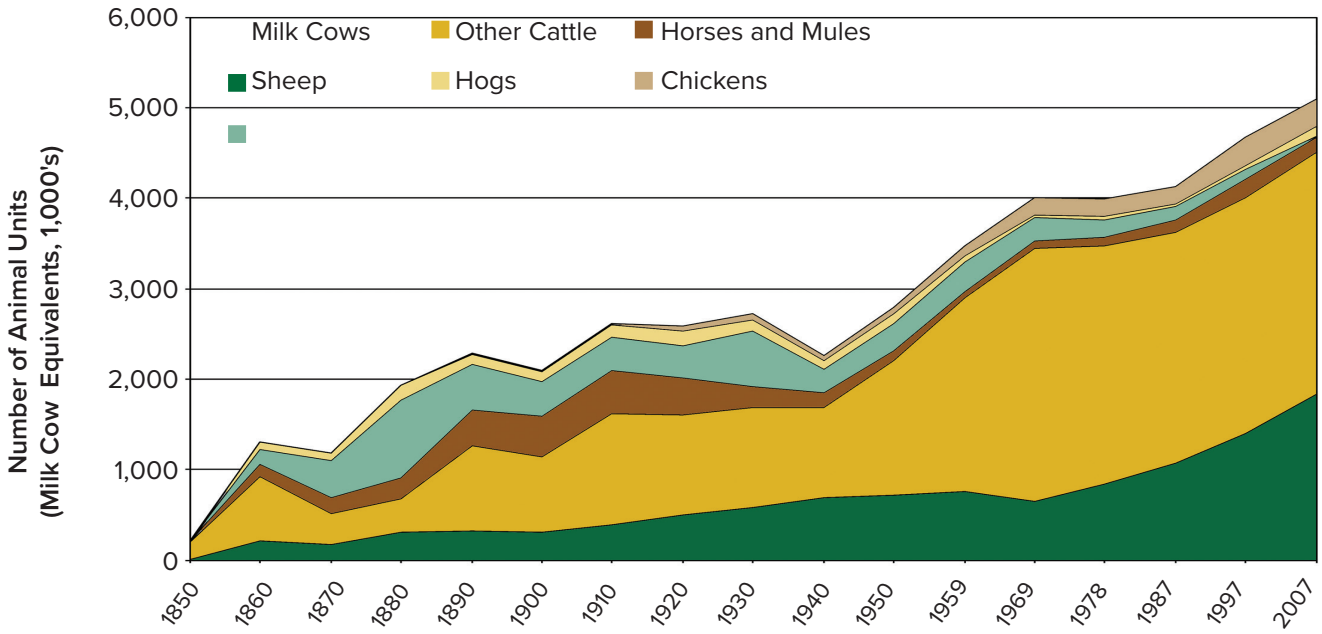
Ranching

Similar forces—early adoption of large-scale operations and advanced technologies—characterized California's livestock economy. The broad trends in livestock production in California since 1850 are reflected in Figure 3, which graphs the number of head on various types of livestock as aggregated into a measure of animal units fed.[3] California emerged from the Mexican period primarily as a cattle producer. A series of droughts and floods in the 1860s devastated many herds, and in the 1870s, sheep-raising had largely replaced cattle-ranching (U.S. Bureau of the Census, *Census of Agriculture 1959, General Report*, Vol. II).

Many of the livestock ranches of the nineteenth century, including Miller-Lux, Tejon, Kern County Land Company, Flint-Bixby, Irvine, Stearns, and Hearst, operated on extremely large scales. For example, Henry Miller and Charles Lux amassed more than 1.25 million acres of land, often with valuable water rights (Igler, 2001). With the intensification of crop production in California, aggregate livestock activities tended to grow slowly. Although the smaller, family-sized fruit farms began to replace the large bonanza grain farms and livestock ranches, "general" 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 has been relatively less important in California than in the rest of the country. The market value of livestock and livestock products sales as a share of the sales of crops, livestock, and livestock products has generally exceeded one-half nationally but usually hovered around a third in California.

3 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.

Figure 3. Livestock Inventories, 1850–2007



Sources: USDA, Census of Agriculture 2007 Census, Volume 1, Chapter 2: State Level Data. https://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_US_State_Level/

Dairy Herds

Dairy and poultry operations represent exceptions to the general pattern of slow growth of livestock farming in the first decades of the 20th century. These activities steadily expanded, primarily to serve the state's rapidly growing urban markets. In 1993 California replaced Wisconsin as the nation's No. 1 milk producer (USDA, *Agricultural Statistics,* 1995). 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 grew much faster as productivity per animal unit increased enormously, especially in the post-1940 period. From the 1920s to 2000, California was a leader in milk output per dairy cow in most years. For example, in 1924 milk production per dairy cow in California was 5,870 lbs., while similar figures for Wisconsin and the United States were 5,280 and 4,167 lbs. respectively (USDA, *Statistics Bulletin* 218, 1957). Revolutionary productivity changes have occurred in recent decades. In 2015 California remained the nation's largest milk producer with almost 41 billion lbs., Wisconsin was a distant second with 29 billion lbs., and no other state exceeded 15 billion lbs. But by this latter date, the breeding, feeding, and maintenance technologies that had propelled the increase in yields had diffused more widely. In 2015 California's 23,002 lbs. per cow ranked ninth in the nation, with Colorado's average of 25,685 topping the list (USDA, *Agricultural Statistics,* 2016).

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 (Committee on Agriculture, Nutrition, and Forestry, 1980). 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. 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. After the 1960s, larger commercial feedlots started to become more prevalent in the Southwest and in the Corn Belt (Hopkin and Kramer, 1965). Again, technologies and organizational strategies developed in California spread to reshape agricultural practices in other regions.

Government Interventions to Control Diseases

Few observers appreciate how vitally important federal government animal-health policies were in the development of California's livestock industry. The state faced many severe disease outbreaks that farmers, state and local officials, and private veterinarians were incapable of combating effectively. Two of the most destructive diseases were foot and mouth disease (FMD) and bovine tuberculosis (BTB). FMD hit California twice in the 1920s, with the most serious outbreak erupting in February 1924, when the affliction appeared in a Berkeley dairy herd. As officials raced to stamp out infected herds, the disease stayed one jump ahead, eventually spreading to 16 counties. At its peak, the USDA's Bureau of Animal Industry (BAI) quarantined parts or all of 23 California counties. The BAI sent 204 agents to California and hired numerous laborers, private veterinarians, and others to help in the fight. By the end of August, officials destroyed more than 100,000 animals.

The FDM crisis was a catastrophe for California's agricultural and tourist industries. Shortly after the crisis began, 37 U.S. states and territories and several foreign countries embargoed California products, barring livestock and poultry (and their products), straw, grain, grasses, fruit (including canned and dried fruit), vegetables, nursery stock, and more. Oregon and Arizona raised especially severe barriers, blocking roads, and stopping trains. Tourist traffic was diverted through Utah and Nevada. Civic and sporting events were canceled, and parks, hiking trails, and hunting and fishing areas were closed.

The problem was amplified because California's legal and constitutional provisions made it difficult, if not impossible, for state officials to efficiently cull animals, to pay compensation, and to cooperate fully with federal officials. This same class of problems also impaired to the state's

fight against BTB. By the 1930s, California dairy cattle had become the talk of the nation because of the high incidence of BTB, a disease easily transmitted from cattle to other livestock and from livestock to humans, either by direct contact or through animal products. The most likely path of transmission was in cows' milk and milk products.

Around 1910, about 15,000 Americans, mostly children, were dying from tuberculosis contracted from animals and animal products every year, and many more suffered painful and debilitating illnesses. The BAI undertook the first steps in what would become a successful national eradication program in 1917. County-by-county and state-by-state, BAI-approved veterinarians entered farms with or without the farmers' permission, tested animals, and ordered the destruction of animals that tested positive. Where needed, armed guards accompanied the veterinarians. This was an enormously controversial campaign that witnessed countless confrontations, some gun play, and the declaration of martial law in Iowa.

Contrary to California's image as a pacesetter, it was the last state in the Union to eradicate BTB due to exceptionally poor state leadership, corruption, funding pressures, state constitutional limitations, and vigorous opposition—including by mobs of farmers. The campaign pitted urban interests against dairy interests, dairymen with clean herds against those with suspect cattle, and reputable scientists against popular quacks. Only when other states and the federal government threatened to quarantine California cattle and cattle products, did the state enact the life-saving policies that allowed it to cooperate fully with federal officials and pay indemnities that were needed to gain farmer cooperation (Olmstead and Rhode, 2015).

Mechanization and Farm Power

Induced Innovation, Path Dependency, and Supply-Side Forces

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

The story of agricultural mechanization in California illustrates the cumulative and reinforcing character of the invention and diffusion processes. Mechanization of one activity set in motion strong economic and cultural forces that encouraged further mechanization of other, sometimes quite different, activities. On-farm mechanization was closely tied to the inventive efforts of local mechanics. Specialized crops and growing conditions created niche demands for new types of equipment. Protected by high transportation costs from 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 elsewhere. These advantages gave them the insight, skills, and financial wherewithal to support their penchant for tinkering. Nowhere was this more evident than on the bonanza ranches that 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 that further stimulated the incentive to find labor-saving alternatives. 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.

Farm Power

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 19th century relied increasingly on horses and mules for power. Horses on any one farm were essentially a fixed asset. A stock of horses accumulated for a given task was potentially available at a relatively low variable cost to perform other tasks. For these reasons, an examination of horses on California farms offers important insights into the course of mechanization. In 1870 the average number of horses and mules per male worker was more than twice the national average. Throughout the 19th century, California farmers were using an enormous amount of horsepower (Olmstead and Rhode, 1988).

California was a leader in the early adoption of tractors. By 1920, over 10 percent of California farms had tractors compared with 3.6 percent for the nation as a whole. In 1925 nearly one-fifth of California farms reported tractors, proportionally more than in Illinois or Iowa, and just behind the nation-leading Dakotas. These figures understate the power available in California, because the tractors adopted in the West were typically larger than those found elsewhere. Western farmers were the predominant users of large track-laying tractors.

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. In 1929 over one-half of California farms purchased electric power

compared with about one-tenth for the United States (U.S. Bureau of the Census, *Sixteenth Census …: 1940, Agriculture Vol. 1, Pt. 6*).

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 innovators. Tracing the changes in wheat-farming technology illustrates how the cumulative technological changes led to a markedly different path of mechanical development in the West.

Almost immediately after wheat cultivation began in California, 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 1.5 acres was a good day's work in 1880. In most of the prairie regions, 2.5 was the norm. In California, it was common for one man with a gang plow and a team of eight horses to complete six to ten acres per day. The tendency of California's farmers to use larger plows continued into the 20th century. After tractors came on line, the state's farmers were also noted for using both larger models and larger equipment in tow. This pattern influenced subsequent manufacturing and farming decisions (U.S. Bureau of the Census, *Tenth Census … 1880, Agriculture* Vol. 3; USDA, *Monthly Crop Report,* 1918).

The preference for large plows in California stimulated local investors and manufacturers: the U.S. Commissioner of Agriculture 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" (USDA, *Agricultural Report,* 1869)." Between 1859 and 1873, California accounted for one-quarter of the nation's patenting activity for multi-bottom plows, while the state's contribution to the development of small, single-bottom plows was insignificant (U.S. Patent Office, 1874). The experience with large plows directly contributed to important developments in the perfection and use of listers, harrows, levelers, and earth-moving equipment.

The Grain Harvest

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 (USDA, Agricultural Report, 1875). California farmers were sometimes accused of being slovenly for 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. Advanced, high-capacity endgate seeders of local design were among the broadcasting equipment used in California. By the 1880s, improved models could seed 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 (Rogin, 1931; Adams, 1921). 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.

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

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 (Higgins, 1958). 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 Manufacturing Company—located in Stockton, which became an important equipment-manufacturing center.

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 were experimental. In 1881 about 20 combines were being built in Stockton (U.S. Bureau of the Census, 1883). 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 other competitors combined (Rogin, 1931; Brewer, 1883). 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 (*Economist*, Nov. 28, 1914). These machines were powered by teams of 20 or more equines. At this date, the adoption of combine-harvesters east of the Rockies was still in its infancy.

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. In addition, eastern farmers generally lacked the horses needed to pull the large western machines and they often lacked the knowhow and will to manage such large teams. California farmers had gradually developed their ability to manage large teams because of their experience with gang plows and headers (Olmstead and Rhode, 1988).

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 for the soft soil of the Sacramento-San Joaquin Delta. 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. One 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 and production efficiencies. Entrepreneurs seeking their fortunes were in close tune with their potential customers' needs and vied with one another to perfect equipment that would satisfy those needs. Where these forces were not at work, the burdens of history severed the potential backward linkages that are so critical for economic development.

Irrigation

Reshaping the Landscape

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 from flooding. 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. Without these investments, much of the Central Valley's land could not have been planted in intensive crops (Kelley, 1998).

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 2007. Expansion occurred in two main waves: the first lasting from 1900 through the 1920s and the second, linked to the Central Valley Project, during the decade after World War II. Much of the historical growth of irrigation was the result of small-scale, private initiatives rather than large-scale, public projects that have attracted so much scholarly attention. Up until the 1960s, individuals and partnerships were the leading forms of organization supplying irrigation water. These forms accounted for roughly one-third of irrigated acres between 1910 and 1930, and over one-half by 1950.

These small-scale irrigation efforts were closely associated with the rising use of groundwater in California over the first half of the 20th 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. Significant technological changes in pumping technology and declining power costs underscored this growth. 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.

Irrigation Districts

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

As with so many other areas of California agriculture, success in managing water heavily depended on cooperative action, rather than just individual initiative. Water access has often been contentious, pitting farmers against urban interests and farmers against farmers. Everyone involved attempted to capture government to gain an advantage. Part of the problem is that historically, property rights in water were less well defined than in most private goods

and assets, and rights based on location or historic conditions invariably led to inefficient patterns of use.[4]

Adverse Consequences

Moreover, with few restraints on farmers' use of private pumps, individual farmers have predictably depleted aquifers, leading to deeper and more expensive wells and higher energy costs. In addition, decades of irrigation, along with the use of fertilizers and chemicals to control weeds and pests, have contaminated the soil with salts, selenium, and other chemicals. As one sign of the problemin the 1980s, the drainage of farm water into the Kesterson National Wildlife Refuge, located in the San Joaquin Valley, resulted in widespread birth defects in birds and fish from selenium poisoning. More troubling, many have noted high incidents of environmentally-related health problems of agricultural workers. The long-run survival of the current agricultural system is now being questioned (Leslie, 2010). One thing seems certain, especially in light of global warming ushering in an era of hotter and more variable climatic conditions: dealing effectively with these problems will require more regulation to preserve aquifers, use water wisely, and limit harmful practices.

4 Many books deal on this complicated history. Hundley, 1992; Pisani, 1984; and Reisner, 1986.

Labor

A History of Strife

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 gigantic iceberg. The Chinese Exclusion Act, the Gentlemen's Agreement aimed at Japanese immigrants, the forced repatriation of Mexicans during the Great Depression, the Great Cotton Strikes of 1933, 1938, and 1939, the Bracero Program (1942–64), the United Farm Worker (UFW) and Teamsters' organizing campaigns and national boycotts, the state's Agricultural Relations Act, the legal controversy over the mechanization of the tomato harvest, the current battles over illegal immigration, and now the growing concerns over the health of agricultural laborers 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.

Historians often concentrate on past labor-management conflicts. Just as farmers attempted to gain advantages through collective action (cooperatives, water projects, pest control, labor relations, capturing governments, etc.), workers attempted collective action in the form of labor unions. The strikes and unrest associated with Cesar Chavez's UFW organizing drives in the 1960s and 1970s are probably the best remembered labor-management confrontations, but these events were dwarfed in scale by the agricultural strikes in the 1930s. In 1933, 50,000 agricultural laborers walked out of the harvests. The largest of these many strikes saw nearly 20,000 cotton pickers in the San Joaquin Valley refuse to work. Hired thugs and police tear-gassed, arrested, and sometimes beat strikers. It is useful to contrast the experience of workers in the agricultural and non-agricultural sectors.

The National Labor Relations Act of 1935 granted most private sector non-agricultural workers the right to collective bargaining, but agricultural laborers in California did not receive this legal right until 40 years later with the passage of the California Agricultural Relations Act. Violence was most common during organizing strikes, when the very legitimacy of a union was in question, so the delay in granting a legal basis for agricultural unions enhanced the likelihood of conflict. In addition, agricultural strikes invariably occurred during the peak-harvest season, when the absence of labor could mean the loss of an entire year's crop for the farmer. In most mining and industrial enterprises, strikes could be disruptive, but they would not threaten an entire year's output. The fact that agricultural workers were often migrant minorities with little power in the community contributed to social differences and the possibility of violence, including by local police (McWilliams, 1939; Flores, 2016; and Olmsted, 2015).

A Comparative Perspective

For all the controversy, however, the state's farms have remained a magnet 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 national situation. 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 as a percent of total employment in California has generally been less important to the state than for the country. Agricultural labor is two percent of

Table 2. Agricultural Labor in California and the United States

	Farm Labor Force as a Share of:		Hired Labor Expenditures 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.
	----------percent----------					
1870	29.3	52.3	20.8	12.7	--	--
1880	28.6	49.4	--	--	--	--
1890	29.0	41.2	--	--	--	--
1900	25.0	37.6	19.6	7.6	--	--
1910	17.9	31.1	22.2	7.7	--	--
1920	17.3	27.0	16.4	6.3	--	--
1930	13.3	21.4	--	--	21.4	9.9
1940	11.0	18.9	--	--	25.3	11.7
1950	7.5	12.3	--	--	21.8	11.0
1960	4.7	6.7	--	--	17.7	8.5
1970	3.0	3.5	--	--	16.2	7.4
1980	2.9	3.0	--	--	14.7	6.4
1990	3.0	2.5	--	--	17.1	8.0
2000	1.8	1.5	--	--	14.7	7.7
2010	2.3	1.6			14.8	7.4

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.

USDA, 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.

USDA, Census of Agriculture 2007 Census, Volume 1, Chapter 2: State Level Data. https://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_US_State_Level/

the state's total labor force, but it generates a larger share of news and legislative interest due to the special nature of the state's labor institutions.

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 fully developed the institutions of slavery or widespread share-cropping as in the South. The parade of migrants who have toiled in California's fields have often been described as "cheap labor," and indeed they were near the bottom of the state's labor hierarchy. But the "cheap" appellation is something of a misnomer, because the daily wage rate in California was typically higher than in other regions of the United States, and the United States was one of the world's highest-wage countries.

Labor Mobility

In an important sense, the "cheap labor" in California agriculture was among the dearest wage labor on the globe. 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 been relatively narrow[5] due to the relatively high productivity of the state's agricultural sector. In addition, because workers "followed the harvest," moving from crop to crop, they worked more days in the high-productivity season than southern sharecroppers who experienced long periods of relatively low productivity, non-harvest work.

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 migrants, many with little facility in English, agricultural labor offered a stepping stone into the robust, high-wage economy. Hard work, high savings rates, and the availability of public education worked wonders: few of the descendants of the earlier generations of agricultural laborers toil in the fields today. Some of those separated by only a few generations from the original immigrants are in fact landowners, but most (who remained in the United States) have moved into urban blue- and white-collar professions with skills, educational levels, and incomes on par with citizens who are descendants from earlier waves of Northern European migrants. Over the span of decades, agricultural labor in California has not been a dead-end pursuit creating a permanent class of peasant laborers, but this result has been dependent on the existence of a growing non-agricultural economy.

The agricultural history literature often 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 represented one of the great failings of 19th century American society. The literature is particularly critical of California because of its large farms and high ratio of hired workers to farm owners. However, Engel's Law tells us that, as income per capita grows, a smaller percentage of income will be spent on food, so in a growing economy the agricultural sector shrinks relative to the non-agricultural sector. This is precisely what transpired. 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 19th century. Thus, unless farms were Balkanized into smaller and smaller units, there was no possible way for the 19th century ideal to have continued.

The Domar Model

Economic historians often explain the prevalence of the family farm in the northern United States by the workings of the Domar model—if there is free land, and crop production technology offers few economies of scale and requires little capital, then anyone can earn as much working for themselves as for anyone else (Domar, 1970). There will be no free hired labor, and if bound labor (slavery) is illegal, farms will be family-sized. Like many simple abstract models, the implications of the Domar hypothesis are starker than the realities, but its fundamental logic explains many features of the development of northern agriculture.

California's so-called "exceptionalism" also follows from the Domar model. In California, very large estates emerged from the legacy of Mexican and Spanish land grants, railroad land grants, and control of water. Gradually, many of the large estates were broken up by market forces as California's agriculture intensified, but many remained—especially in parts of the Central Valley and the Salinas Valley. A snapshot taken at any number of historical dates would show a handful of wealthy landowners and a multitude of itinerant laborers and their families. The legacy of this unequal "initial" distribution of property rights was that especially land with good access to water was not free in California. In part because of the initial distribution of land and in part due to environmental conditions, production tended to involve larger scale and greater quantities of capital (for machinery, irrigation works, and orchards). Hence, the gap between the assumptions of the Domar model and reality was greater in California than in the Midwest. It proved possible for farmers to pay workers more than they could earn working for themselves and still earn a profit. From the mid-19th century on, California was characterized by "factories in the fields" or "industrial agriculture" or, in more modern terms, "agribusiness."

5 The "development" gap is measured as (Yag/Lag)/(1-Yag)/(1-Lag) where Yag is the share of income generated in the agricultural sector and Lag is the share of the labor force employed there.

However, 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-19th century, and it has arguably become increasingly common throughout the United States over the 20th 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.

The Puzzle 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 must pay. But when the state first moved into the production of specialty crops, California producers of fruit and nuts also faced labor costs that were 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, drive European producers out of markets in their own backyards?

Wages, Land, and Transportation

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 four to eight 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 (Hecht and Barton 1950).

One important question is whether grain and fruit actually competed for the same land and labor. 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 complete 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 into 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.[6]

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 $1,000 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 acreage used for fruit cultivation was of a different quality (and ultimately higher market value) than that used for grains (Rhode, 1995; Adams, 1921; Sackman, 2005).

6 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 control the migrant flows of specific ethnic groups. By focusing on the political economy of migration, this literature helps to 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.

Conclusion

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. 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 for New York cost 17 cents per hundred weight while the freight on an equivalent quantity of California dried fruit averaged about one dollar.

An Emphasis on Quality

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 of 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/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 United States 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 (Morilla Critz, Olmstead, and Rhode, 1999). 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 provide another indicator of the importance of superior technology and organization in establishing California's comparative advantage.

This essay should provide a historical context for other chapters in this volume.[7] Responding to market forces, the state has witnessed numerous transformations in cropping patterns, labor sources, and technologies. Despite these changes, many fundamental characteristics have endured; many of the institutional and structural features found today have deep roots in the state's past.

Two issues of interest in the literature on agricultural development warrant mention. First, the history of agricultural mechanization in California conforms 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 environmental conditions. But to fully capture the reality of the state's development, it is useful

7 Our account has neglected many important crops and activities. 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.

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 (in the context of the literature, this means non-mechanical innovations) 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 and per worker (Olmstead and Rhode, 2008).

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