

THE FUTURE OF AGRICULTURE AND FOOD SYSTEMS

A CALIFORNIA 100
REPORT ON POLICIES
AND FUTURE SCENARIOS



VISION & STRATEGY FOR
THE NEXT CENTURY





ABOUT CALIFORNIA 100

The California 100 Initiative envisions a future that is innovative, sustainable, and equitable for all. Our mission is to strengthen California's ability to collectively solve problems and shape our long-term future over the next 100 years.

California 100 is organized around 15 policy domains and driven by interrelated stages of work: research, policy innovation and engagement with Californians. California 100's work is guided by an expert and intergenerational Commission. Through various projects and activities, California 100 seeks to move California towards an aspirational vision—changing policies and practices, attitudes and mindsets, to inspire a more vibrant future.

This California 100 Report on Policies and Future Scenarios was produced as part of California 100's research stream of work, in partnership with 20 research institutions across the state. California 100 sponsored grants for data-driven and future-oriented research focused on understanding today and planning for tomorrow. This research, anchored in California 100's 15 core policy domains, forms the foundation for the initiative's subsequent work by considering how California has gotten to where it is and by exploring scenarios and policy alternatives for what California can become over the next 100 years.

The California 100 initiative is incubated through the University of California and Stanford.

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READ MORE ABOUT THE FUTURE OF AGRICULTURE AND FOOD SYSTEMS IN CALIFORNIA

For additional background information, read the related Facts-Origins-Trends report at California100.org. The Facts-Origins-Trends report contains all of the references and citations to support the content of this report.

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This Report is one of 15 reports that will be released in 2022 as part of the California 100 Initiative. We are proud to partner with the following research centers and institutes across California on our work:

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ABOUT CAL POLY'S COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENTAL SCIENCES

With 6,000 acres of agricultural production and research land on its main campus and access to 3,200-acre Swanton Pacific Ranch in Santa Cruz County, Cal Poly's College of Agriculture, Food and Environmental Sciences boasts one of the nation's most prestigious undergraduate food system and forestry programs. At the heart of Cal Poly's educational experience is its Learn by Doing methodology with laboratories that include working ranchland, orchards, vineyards and forests. Cal Poly's faculty work on a variety of topics of significance to the state of California including designing food system robotics, managing wildfire, addressing plant disease, and protecting water resources.

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FOREWORD

“As California Goes, So Goes the Nation, Alas.” That was a headline from a *Los Angeles Times* opinion column on April 30, 1989, which noted that, even though “Californians have long considered their state the cutting edge of social and political change... [it] no longer seems the vanguard of political innovation. Other states rarely look to California for policy initiatives.”

Fast-forward to 2022, and few would proclaim that California lacks in policy innovation. Quite the contrary. The state has enacted a variety of policies ranging from expansions in immigrant rights and voting rights to health care and higher education, and from large-scale experiments in guaranteed income to ambitious moves towards net-zero emissions in a variety of sectors. And despite the periodic waves of “doom and gloom” reporting about the state, California’s economic output over the last 25 years has grown faster than the national average, and on par with GDP growth for the state of Texas.

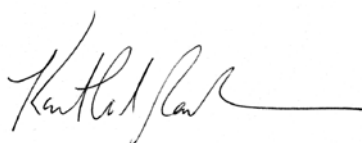
Even so, much remains to be done. The California Dream has always been marred by a high degree of racial exclusion, and it remains out of reach for millions in the state—whether measured by health outcomes, unaffordable housing, or massive disparities in income and wealth. California also recognizes that future progress depends on recognizing and correcting historical wrongs. Its Truth and Healing Council, for example, will provide recommendations aimed at prevention, restoration, and reparation involving California Native Americans and the State. If California’s racial diversity represents America’s demographic reality by 2100, our work is essential—not only for the long-term success of the state, but also for our country’s innovative and equitable future.

This future-focused work is especially pressing today. The COVID-19 pandemic has scrambled a state and nation already undergoing significant changes in economics, politics, and society. The harmful consequences of climate change are at our doorstep,

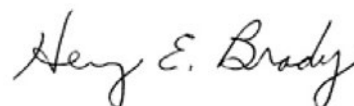
with forest fires and droughts that grow in frequency and intensity each year. The weakening of local media and the growth of disinformation threaten both our civic health and our public health. And staggering inequities in income and wealth, home-ownership and health, threaten the state's reputation as a haven for migrants, domestic and international alike.

In addition to immediate threats that affect our long-term future, we also see plenty of opportunity. Record increases in federal and state spending mean that billions of additional dollars are flowing to state, local, and tribal governments in California. Many jurisdictions are looking to invest in infrastructure that meets the long-term needs of their communities. Philanthropic institutions and individual donors are also looking to make transformative investments that have enduring impact. We have an opportunity to inform and enrich all of these plans and conversations.

Most institutions and organizations in California are focused on immediate challenges, and don't have the luxury of time, dedicated talent, and resources to focus on long-term futures. California 100 is grateful for the opportunity to provide added value at this critical time, with actionable research, demonstration projects, and compelling scenarios that help Californians—government agencies, stakeholder groups, and residents alike—to envision, strategize, and act collectively to build a more innovative and equitable future.



Karthick Ramakrishnan, Ph.D.
Executive Director



Henry E. Brady, Ph.D.
Director of Research



INTRODUCTION TO FOOD SYSTEMS IN CALIFORNIA

California occupies a unique and significant role in international and national food production and distribution. In 2020, the United States of America was the largest exporter of food (excluding fish) with \$124 billion of export value—or 10 percent of total global exports. Although other nations produce the most wheat (China) and beans (India), the United States is often listed in the top 10 producers of many crops, and is the largest global producer of almonds, pistachios, milk, and poultry. Unlike China and India which do not have much food surplus, the United States exports a large amount of food into global markets, including several commodities where California is the undisputed international export leader, such as almonds and milk products.



Running a commercial farm has become an increasingly marginal business for many farming families, as climate challenges across the state include multi-year droughts, intense wildfires, dwindling water supplies, and potential future “megafloods.”

Since its formation as a U.S. state nearly 175 years ago, California has extended its sphere of influence as a food center by expanding its production via large-scale irrigation projects and easily available cheap labor. In addition to producing food for its own residents—who comprise 12 percent of the total U.S. population—California has become synonymous with fresh market produce throughout the country. In fact, California produces and distributes the highest volume of fruits, tree nuts, berries, melons, vegetables, and milk of all U.S. states. Supply chains today stretch from the 24 million acres of farmland in California to grocery shelves across the Midwest to the East Coast. California also produces significant amounts of other foods, including cattle, eggs, rice, and wheat. Moreover, California has benefited from the early adoption of new technologies and innovations ranging from the development of new crops to the mechanization of harvests by innovative designs for tractors.

However, the climate and labor conditions that have enabled California to become a national food leader are changing. Running a commercial farm has become an increasingly marginal business for many farming families, as climate challenges across the state include multi-year droughts, intense wildfires, dwindling water supplies, and potential future “megafloods.” Moreover, regulations have





ended some long standing labor practices that resulted in paid workers, many of whom come from other countries, getting wages too low to afford to live in the state. Despite better working conditions than those of their predecessors, attracting new generations of farmworkers has become increasingly difficult. In many respects, the future of California's food system—pivotal for Californians as well as many other Americans who have come to depend on low-cost, high-quality food—is uncertain.

Today, California residents are continuing to design innovations intended to improve re-

silience, sustainability, and equity in the food sector. California food system innovators are investing in aquaculture, alternative proteins, climate-adapted crop genetics, robotic labor, livestock methane capture, and urban farming. The momentum driving these future opportunities at this pivotal point in California's food systems history is encouraging. Despite the very real and anxiety-provoking challenges of water-scarcity and recurring droughts, California food producers are still striving to ensure that fresh and healthy food production remains a core component of California's identity.

CALIFORNIA IS A MAJOR PLAYER IN NATIONAL AND INTERNATIONAL AGRICULTURE SUPPLYING FRESH FOODS AND MILK

California is the most profitable food-producing state in the U.S. with \$49.1 billion in national and international cash receipts in 2020. Leading the nation in production of a variety of crops—almonds, artichokes, avocados, broccoli, celery, dates, figs, garlic, grapes, kiwifruit, honeydew melons, nectarines, olives, clingstone peaches, pistachios, plums and prunes, rice, and walnuts—California produces about one-half of all the U.S.-grown fruits and nuts. According to the most recent U.S. Department

of Agriculture (USDA) Census, California farmers sold approximately \$27.8 billion of fruits, tree nuts, berries, and vegetables in 2017.¹ Additionally, California is the largest milk producer in the nation selling \$7.5 billion of milk, cheese, and other dairy products in 2020.

The USDA has referred to the state as the “Most Valuable Player” in U.S. agriculture with California's more than 70,500 farms earning \$45.2 billion in cash receipts in 2017 for a range

¹ The next U.S. Department of Agriculture Census is expected to be published at the end of 2022. According to California Department of Food and Agriculture statistics, California continues to be a leader in national production of fruits, nuts, vegetables, milk, and milk-related products.



of commodities, as described in Table 1 below. This amount was \$16 billion more than any other state that year. In general, California produces 74 percent of its sales from crops (primarily vegetables, fruits, and nuts) and 26 percent from animal products—primarily

milk, but California also has the third largest sales value for sheep and goats, 5th largest sales value for aquaculture, 7th largest sales values for poultry and eggs, and the 8th largest sales value for cattle and calves.

Table 1

California's Rank in the U.S. for Agricultural Products by Sales

Product	National Ranking (out of 50)	Sales
Fruits, tree nuts, berries	#1	\$19.7 billion
Vegetables and melons	#1	\$8.1 billion
Milk	#1	\$6.4 billion
Rice	#2	\$533 million
Cotton	#3	\$510 million
Sheep and Goat	#3	\$86 million
Aquaculture	#5	\$105 million
Poultry and eggs	#7	\$1.8 billion
Cattle and calves	#8	\$3.1 billion
Wheat	#17	\$96 million
Oilseeds, Dry Beans, Dry Peas	#21	\$1 billion
Corn	#22	\$255 million

SOURCE: U.S. 2017 Census of Agriculture.



In 2019, California shipped approximately 44 percent of its agricultural output worth \$21.7 billion of products abroad, as shown in Table 2 below. Almonds are a particularly lucrative commodity for the state. Grown on approximately 1.25 million acres, over \$2.4 billion worth of almonds were exported to the Eu-

ropean Union, China, and South Korea. Some counties in California have become increasingly dependent on these export flows with most of California's current almond production concentrated in just five counties in the Central Valley: Fresno, Kern, Stanislaus, Merced, and Madera.

Table 2

California's Top Six International Trading Partners 2020

Rank	Export Destinations	Export Value	Top Three Exports + Product Value for Largest Export
1	European Union	\$3.5 billion	Almonds (\$1.6 billion), Pistachios, Walnuts
2	Canada	\$3.2 billion	Wine (\$440 million), Almonds, Strawberries
3	China/Hong Kong	\$1.9 billion	Pistachios (\$690 million), Almonds, Dairy
4	Japan	\$1.6 billion	Rice (\$263 million), Almonds, Beef
5	South Korea	\$1.1 billion	Almonds (\$182 million), Oranges, Dairy
6	Mexico	\$1.0 billion	Dairy (\$265 million), Table Grapes, Almonds

SOURCE: California Department of Food and Agriculture, [California Agricultural Statistics Review 2019-2020](#); University of California, Agricultural Issues Center



CALIFORNIA PRODUCES FOOD ACROSS THE STATE WITH A CONCENTRATION OF AGRICULTURAL BUSINESSES IN THE CENTRAL VALLEY

California's approximately 24 million acres of farmland comprise roughly 23 percent of California's total land. This farmland includes fields for row crops, pasturelands, and orchards. Agricultural production lands are found across the state with different regions specializing in certain products (see Figure 1 on the next page). The **North Coast and Mountain** regions include the reclaimed agriculture land of the Tule Lake basin where substantial amounts of grain were historically produced,

Mendocino/Sonoma/Napa County wine production valleys, and Humboldt County coastal plain dairies. The **Central Coast** region includes primarily rangeland, but also the Salinas Valley "salad bowl" and the Paso Robles wine production area. Relying heavily upon imported water, the **Southern California** region is a major supplier of citrus and avocados. The **Desert** region, encompassing Imperial and Coachella Valley, produces the third highest gross value of vegetable crops in the state.



Figure 1

California's Major Agricultural Regions



SOURCE: Author.



California's agricultural production engine is the Central Valley, which spans parts of 17 counties and includes the Sacramento Valley, the San Joaquin Valley, and the Sacramento-San Joaquin Delta. Two-thirds of California's agriculture comes from this region. In fact, the Central Valley supplies about 25 percent of the U.S.' food output in terms of quantity on less than 1 percent of U.S. farmland. Eight percent of the value of U.S. agricultural output originates in the Central Valley. The top county for agricultural production for both California and the United States is Fresno County, generating approximately \$8 billion in crops each year.

In addition to its crop products, California has numerous active fishing regions along its very long coastline. While many of these ports are

not as active as they were historically (e.g., Monterey Bay's Cannery Row or the "tuna capital of the world" in the San Diego region), there are still valuable fisheries in Dungeness crab and squid creating \$1 billion of value in California.

In addition to its marine capture industry ("wild caught" fish), California is the fifth largest aquaculture producer in the U.S with fish and shellfish being raised both in coastal and inland farms. Freshwater and marine aquaculture farms in California breed and harvest fish and other water-grown organisms outside of the ocean. As of 2020, the state was home to more than 115 aquaculture farms with sales of fish and mollusks worth between \$105 million (USDA figure) and \$170 million (industry figure).



California's major contribution to the national aquaculture industry has been its offerings of a diversity of products: catfish aquaculture is concentrated in the Central Valley and the Imperial and Coachella Valleys while tilapia aquaculture in recirculating aquaponic systems is also located in southern California. In addition to freshwater fish, California has also been participating in oyster aquaculture since

the 1850s when the San Francisco Bay's oyster industry was the largest oyster producer on the West Coast until 1899. Oyster production continues today in Tomales Bay, Morro Bay, and Humboldt Bay. Uniquely, California is the only state with an abalone industry located primarily on the Santa Cruz and Central Coast coastlines.

CALIFORNIA'S FARMS ARE TYPICALLY FAMILY-OWNED AND OPERATED BY AN AGING WORKFORCE





Farming is relatively lucrative in California when compared to all other states, but the financial benefits flow to a limited number of individuals. In 2020, California had 69,600 farms earning it the ranking of the 8th largest number of farms in the U.S and 16th among U.S. states in its acreage of available farmland.² Most of these farms (approximately 93%) are family-owned and small, ranging between 1 and 49 acres.³ Many family-owned farms are also family-owned corporations rather than being managed under a single proprietorship. Based on 2017 data, almost one-third (29%) of

California's farms generated commodity sales over \$100,000. Most of the value is being produced by large-income family farms (earning \$1 million or more of gross cash farm income) that constitute 7 percent of California's family-owned farms but produce 60 percent of the value of all agricultural products. Smaller income farms (earning \$350,000 or less of gross cash farm income) account for 79 percent of all California farms but produce only 5 percent of the state's agricultural value. In 2020, the net farm income for all of California's farms was more than \$14.1 billion.

² The state with the largest number of farms is Texas with 247,000 farms, followed by Missouri with 95,000 farms, and Iowa with 85,000 farms.

³ In 2017, non-family-owned corporate farms only made up 1.3 percent of farms in California.



California's farm owners are predominantly aging, white males operating small, family-owned farms throughout the state. In the 2017 Census of Agriculture, 47,605 men and 32,155 women in California identified as "principal producers," meaning that they considered themselves to have a significant role in managing and operating a farm. Nearly 80 percent of male farm owner respondents identified as white. Most of California's principal food producers are nearing retirement age. In fact, California has very few young principal agricultural producers under the age of 35. Most

of these producers do not have other jobs, although there is a subset of farmers in California who have additional means of earning money outside of the farm.

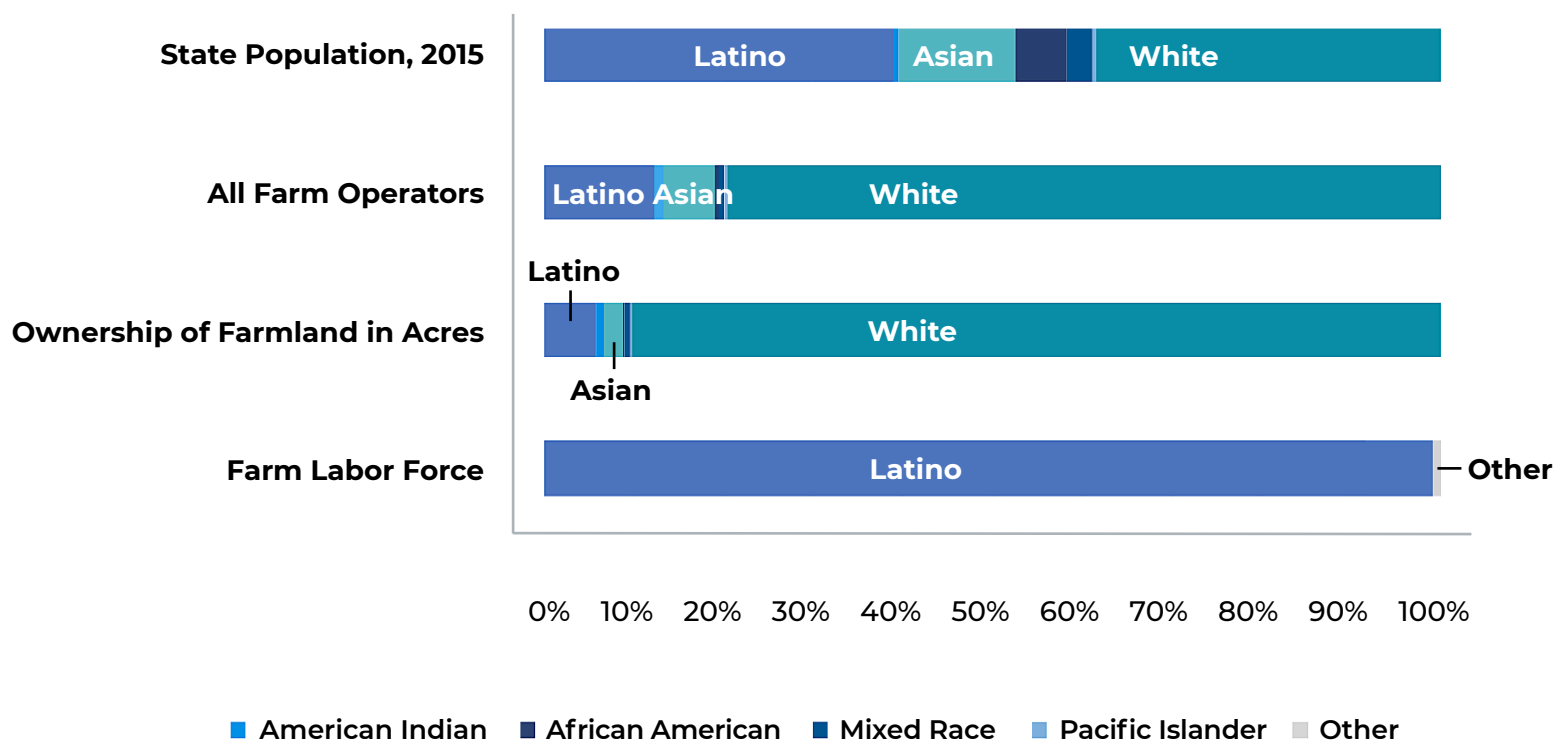
In general, women-run farms in the U.S. tend to have smaller acreage and earn 40 percent less farm income than similar sized farms run by men. Only 21 percent of men and 17 percent of women who responded to the 2017 Census identified as Black, Indigenous, or people of color (BIPOC). Of these farmers, as Figure 2 on the next page shows, almost two-thirds identi-

fied as Hispanic or Latino. These numbers are disproportionately low in California: although 65 percent of California's total population identifies as BIPOC, California only has about one-tenth of the U.S.' BIPOC principal farm

producers. Only 9,742 farms owned by BIPOC farmers earned \$50,000 or more in 2017, and there are many BIPOC producers who struggle to acquire land and sufficient capital to grow and sustain their farm operations.

Figure 2

California's Racial Demographics Working in Agriculture Compared to State Population



SOURCE: [Growing Inclusion at the California Department of Food and Agriculture: Implementation of the Farmer Equity Act of 2017](#); Beth Spitler, Goldman School of Public Policy, University of California, Berkeley.

DATA SOURCE: 2012 Census of Agriculture, California Budget 2015-16 Demographic Information, 2015 National Agricultural Workers Survey.



ACROSS THE SUPPLY CHAIN, CALIFORNIA'S FOOD SYSTEMS DEPEND ON LOW-PAID WORKERS.

Despite the demographics of farm owners in the state, California could not grow food at scale without hiring numerous farmworkers, who are typically undocumented immigrants from Central America. While the number of employed workers across the United States has reduced with on-farm mechanization, the proportion of hired farmworkers versus permanent workers has increased. Hired

farmworkers include field crop workers, nursery workers, livestock workers, graders and sorters, agricultural inspectors, and farm supervisors. Farm labor remains a significant employer in some regions of the San Joaquin Valley (Fresno, Tulare, and Kern), Central Coast (Monterey), and South Coast (Santa Barbara and Ventura).

Figure 3

Map of Major Agricultural Employment Areas



SOURCE: California Agricultural Employment, 2021 Annual Average; Labor Market Information Division, Employment Development Department, California Department of Labor.



Across the crop sector, California employs at least 186,000 farmworkers and potentially as many as 595,175 agricultural workers when crop support workers are included.⁴ In 2021, official California statistics listed 407,800 total agricultural workers with 28,000 individuals working in animal production (mostly dairy) and 158,000 individuals involved in crop production, mostly for fruit and tree nut crops (88,000).

Most of the farm production workers are younger Latino men born in Mexico and other Central American countries without high-school diplomas. A substantial percentage of these workers—around 58 percent according to 2010-2018 National Agricultural Workers Survey—have no work authorization due to their undocumented status.

Since around 2007, it has been increasingly difficult to find new farmworkers, in part because of low wages when compared to the cost of living in the state. According to the U.S. Department of Labor's national statistics, a California crop worker had a mean hourly wage of \$15.25 for an annual mean salary of \$31,770. Farm, ranch, and aquaculture farmworkers had a mean hourly wage of \$17.93 for an annual mean salary of \$37,300. To what extent these statistics reflect the lived reality of workers is a matter of perspective. Analysis of data from 2015-2019 from the Department of Labor's National Agricultural Workers Survey

published in 2021 reported crop workers earning an average hourly wage of \$12.13. Workers who had been employed 11 years or more with the same employer reported earning \$13.02 per hour.

Many of these jobs do not have full benefits with half of the farmworkers indicating that they were not covered by unemployment insurance if they lost their job. Similarly, 22 percent of respondents indicated that they were not covered for workers' compensation and most of these workers did not receive overtime benefits. However, with changes in state law that went into effect January 2022, California farmworkers are entitled to overtime benefits and must now earn \$15 an hour from employers with 26 or more employees. Farm owners have responded to these changes by reducing the number of hours for employees to prevent paying overtime benefits. The combination of recent labor shortages during harvest seasons with expected increasing labor costs for farmers has led to a development that will be discussed later to promote further mechanization and automation in California's "factory fields."

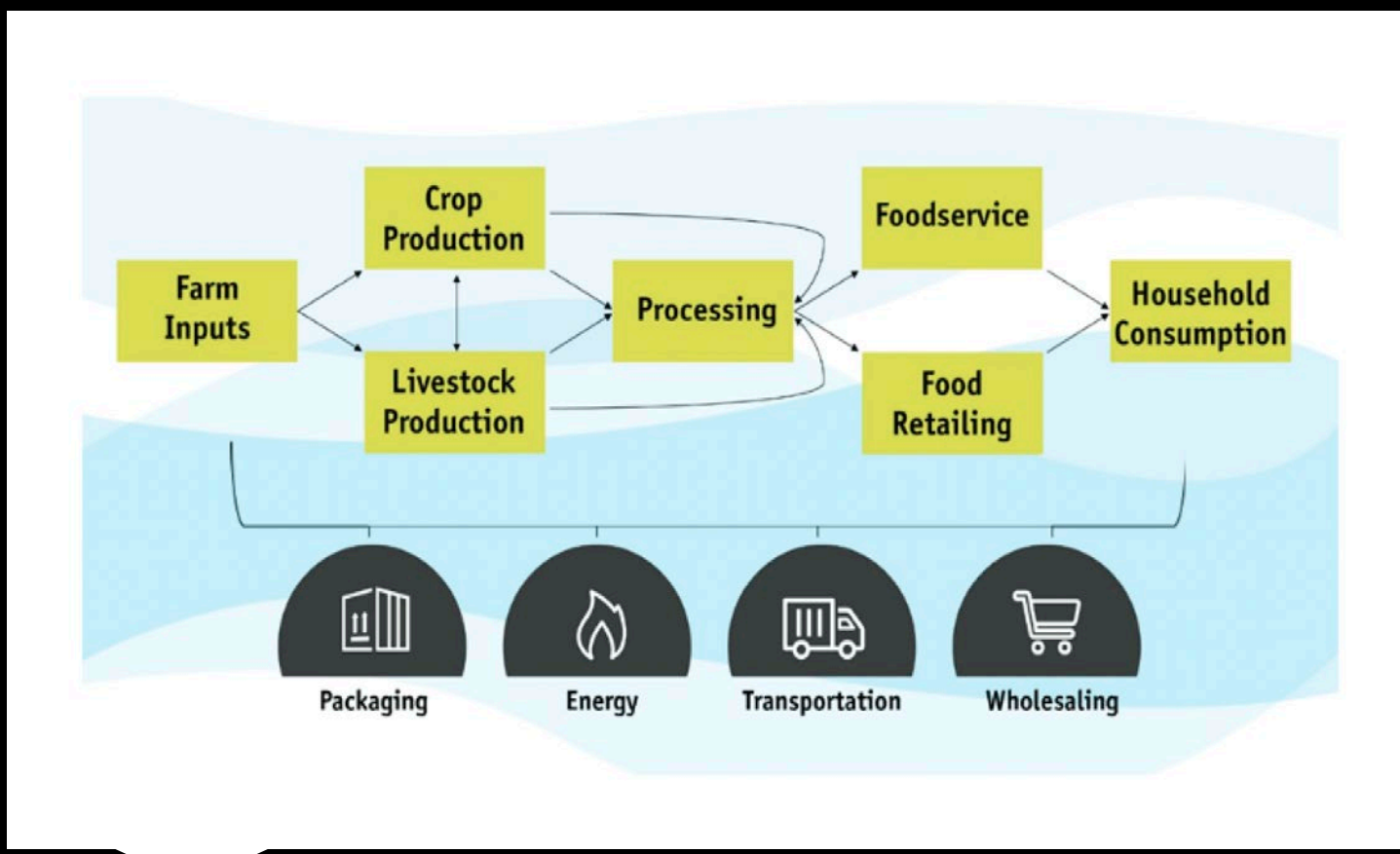
California's food system includes the entire supply chain process—from production, processing, distributing, and consumption as illustrated in Figure 4 on the next page. After the crop, nursery, and greenhouse sectors, California's second largest employer in the

⁴ Counting farmworkers—particularly those who may not have legal immigration status—is difficult, so estimates from government agencies and NGOs vary in terms of how many workers are employed in the agricultural sector to provide supporting services. These numbers also vary depending on the season with many workers being temporary contract workers.

food sector is the food and beverage processing industry. For example, dairy and wineries are the two leading processing sectors in the state, employing 198,000 full and part-time workers. Other food processing sectors include meat-packing and baking. In fact, food and beverage processing is California's overall third largest manufacturing sector in the state after electronics and chemicals. As such, California has more food manufacturing plants—3,421

establishments—than any other state. According to U.S. Bureau of Labor Statistics, California had the highest annual mean wage among the nation's food processing workers in 2021, earning \$35,680. Despite The majority of these workers live in the Los Angeles and Long Beach area, a high cost of living area where the average cost of living per month for one person is around \$2,865.

Figure 4 Supply Chain Stages in the U.S. Food System



SOURCE: USDA, Economic Research Service.



Food from the processing industries will end up in one of California's almost 4,700 supermarkets and grocery stores. Just as farmworkers are essential workers in the California economy, so too are the approximately 384,000 grocery store and general merchandise employees. The largest food retailers in California are general merchandise stores (e.g., Wal-Mart, Target, and Costco) with Costco as California's largest food retailer.

Many farmworkers, food processing workers, and retail food workers do not have the same access to health insurance or paid sick leave as managers or other employees working in the organization. This became particularly

obvious in 2020 and 2021 with many of these workers especially farmworkers disproportionately impacted during the COVID-19 pandemic due to a lack of access to health care and social services.

Another sizable portion of California's food workers are employed in food preparation. California's institutional food preparation and restaurant sector is the largest in the U.S. with over 1.2 million employees mostly women. As with other low-income workers employed across California's food system including in both supermarkets and farm work, low wages have created conditions of precarity.



FOOD PRODUCTION IN CALIFORNIA IS RESOURCE INTENSIVE

Because California produces food at a large-scale for a variety of national and international export markets, production is resource intensive and industry profits depend on successfully marshaling resources. Essential resources for California food production include:

- Water
- Labor
- Cheap energy
- Natural gas
- Pesticides and herbicides

WATER DRIVES CALIFORNIA'S AGRICULTURAL SUCCESSES

The availability of reliable water for irrigation is the greatest challenge for California's food system.

Cheap water that can be transported widely for irrigation use has been a key input for the substantial growth of the agricultural industry in parts of California with semi-arid climates. California uses about 40 percent of the state's available water to irrigate approximately 9 million acres of crops. However, irrigation water has become scarcer and, in some regions, much more expensive. For example, irrigation water rates in some regions were as high as \$2,130 per acre foot of water in 2021 for water that was previously pumped for free.

Irrigation water is often transported across the state through major California water storage and conveyance infrastructure, such as through aqueducts in the State Water Project, the federally managed Central Valley Project, and the All-American Canal. As explained in the next section, these projects have historically supplied substantial water to the irrigated agricultural sector and continue to supply water today, though with greater restrictions.



Figure 5 Surface Water Infrastructure in California

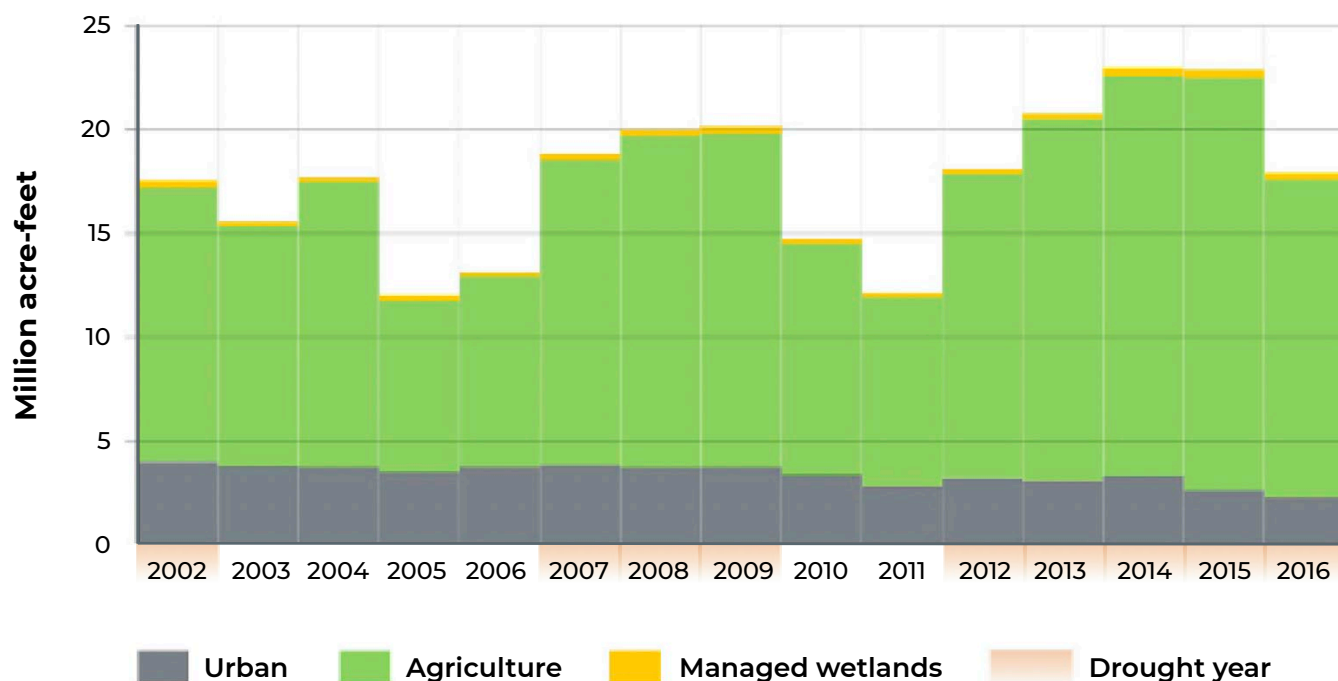


SOURCE: U.S. Bureau of Reclamation and California Department of Water Resources.

With limited availability of irrigation water, farmers across the state must depend on some combination of **surface water**—water that is open to the surface including lakes, rivers, and streams—and **groundwater**—water that exists underground—for agricultural irrigation. Families who have been farming for generations are more likely to have established surface water rights, especially for farms adjacent to rivers. Where surface water is not easily available or restricted, farmers may pump groundwater from one of California’s 515 groundwater basins and subbasins. Larger farms with more financial assets can afford to drill deeper than smaller farms can.

Groundwater supplies 46 percent or more of the statewide annual water supply during drought years, as Figure 6 shows. With uncertain amounts of surface water and more crops being planted, groundwater use nearly doubled from 2011 using 12,127 thousand acre-feet to 22,869 thousand-acre feet in 2015. During this same period, surface water use decreased significantly from 25,650 thousand acre-feet to 14,665 thousand-acre feet. Between 2011 and 2016, 83 percent of the state’s groundwater was used by agricultural users, while cities used only about 10 percent.

Figure 6 Statewide Annual Groundwater Use by Sector



SOURCE: California Groundwater Update 2020, California Department of Water Resources.

Figure 7

Locations of Critically Overdrafted Basins.



SOURCE: California Groundwater Update 2020, California Department of Water Resources.

Figure 7 on the previous page below shows that farms, particularly in the Central Valley regions, have over-drafted groundwater basins by taking more water than is being recharged (returned) into the basin from precipitation, runoff, or intentional recharge efforts. This means that groundwater reserves are now inadequate or dropping across the state, which means California may no longer have sustainable access to groundwater without taking active steps to recharge these basins.

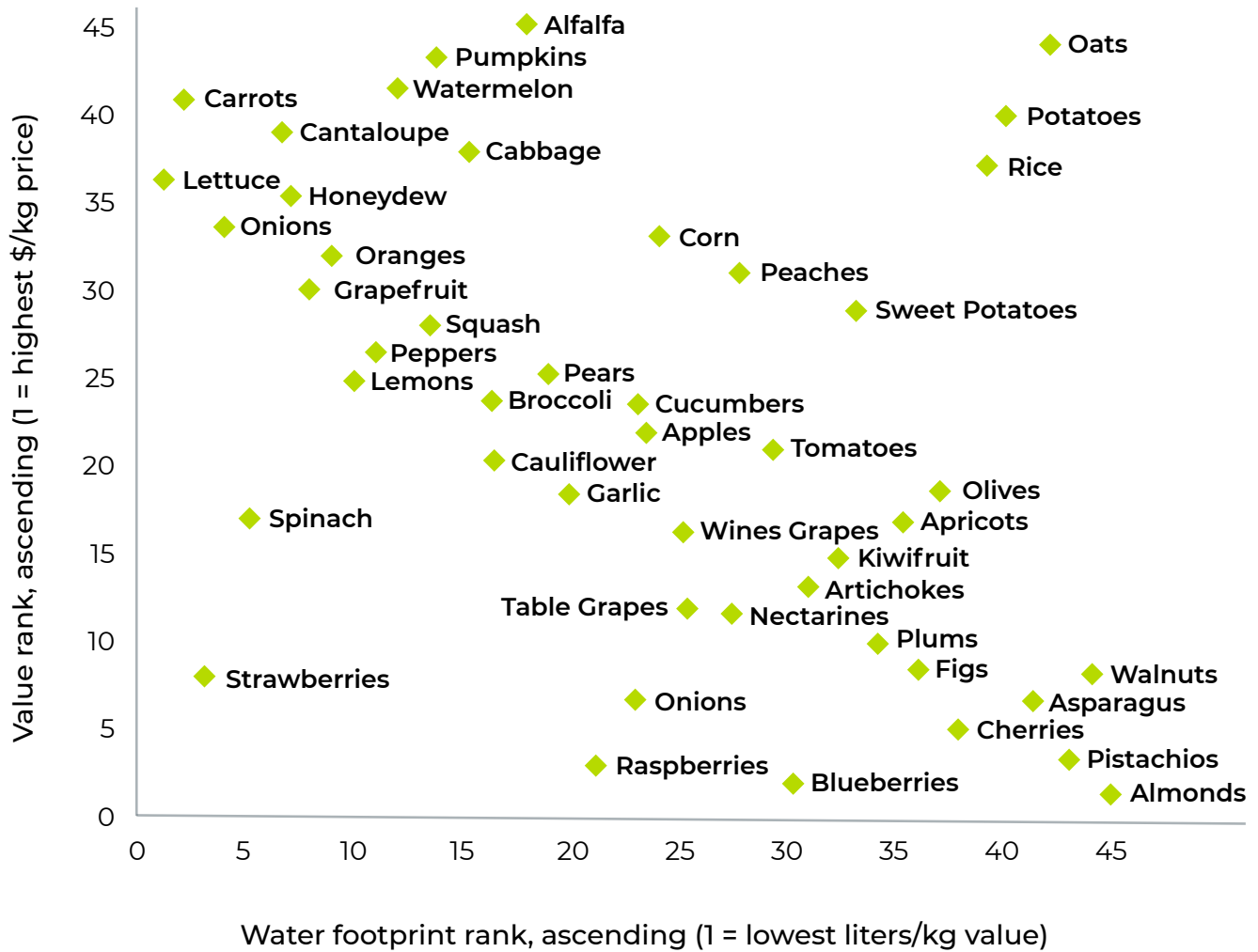
Unfortunately, from a water usage perspective, some of California's highest value products, particularly products for export, use substantial amounts of water. Figure 8 on the next page demonstrates how many of California's most economically lucrative crops also require the highest volumes of water to produce. In particular, almonds, pistachios, cherries, asparagus and walnuts all rank within California's top 10 crops based on economic value, but also require significant amounts of water, which the state struggles to provide.





Figure 8

Water-Intensity of Significant Products Grown in California by Export Value Rank



NOTE: The Value Rank (vertical axis) shows lower rankings (closer to the horizontal axis) as having the highest economic value for the state. Therefore, California's highest economic value crops shown above are almonds, blueberries, raspberries, and pistachios.

SOURCES: Julian Fulton, Michael Norton, and Fraser Shilling (2019) [Water-Indexed Benefits and Impacts of California Almonds](#), Ecological Indicators, Vol. 96: 711-717.



CALIFORNIA'S FOOD SYSTEM DEPENDS ON RELIABLE AND CHEAP ENERGY

California agriculture depends on cheap energy for pumping irrigation water and harvesting food. The industry directly uses around 5 percent of California's total electricity. The majority of that electricity is used to convey water through surface water infrastructure as previously shown in Figure 5 on page 28, or to pump water from the ground. Groundwater pumping during the summer months requires approximately the

same amount of energy as pumping energy across California's surface water infrastructure.

The agriculture sector also relies heavily on natural gas, largely due to the production of chemical fertilizers and pesticides, food processing (canning and freezing), and product drying. Fertilizer use for manufacturing is an indirect use of energy and is not typically calculated into the energy usage of the agricultural sector. Moreover, fuel is essential to operate tractors and farm engines. In 2022, Russia's war against Ukraine led to substantial spikes in diesel and gasoline prices. Farmers growing on contract could not pass on these prices to consumers for already-concluded contracts.



CONVENTIONAL FOOD PRODUCTION REQUIRES LARGE QUANTITIES OF PESTICIDES AND HERBICIDES

Conventional food producers in California apply numerous pesticides and herbicides to protect crops from insects, nematodes, weeds, plant diseases, mice, and fungi. In 2017, 200 million pounds of pesticide were applied to California soil. Among the largest application of pesticides and herbicides in particular

agricultural counties were 3.3 million pounds of sulfur spray applied to wine grapes in Sacramento County and a half a million pounds of glyphosate potassium salt applied to almonds and pistachios in Kern County.

This level of application increases potential pesticide and herbicide exposures of farmworkers, their families, and residents of agricultural communities. In 2018, the Pesticide Illness Surveillance Program of the California Department of Pesticide Regulation identified 99 episodes resulting in 287 cases of pesticide-related illness and injuries arising from agricultural pesticide due to direct contact, drift, and residue. Most of the fieldworker exposure was due to drift or residue.

HIRED FARMWORKERS ARE ESSENTIAL AND COSTLY FOR EXISTING FARM OPERATIONS

Even though farmworkers only represent around 2 percent of the state's total labor force, California depends almost entirely on hired farmworkers for planting and harvesting activities. Several regions including San Joa-

quin Valley (Fresno, Tulare, and Kern), Central Coast (Monterey), and South Coast (Santa Barbara and Ventura) would not presently be able to run existing agricultural operations without hired farmworkers. As noted earlier, the number of hired farmworkers employed at any given time varies greatly depending on whether it is harvest season. Historically, California farmers have spent more money on hired labor relative to farm production than farmers in other U.S. states because wages are higher in California.





HISTORICALLY, CALIFORNIA'S FOOD PRODUCTION HAS DEPENDED ON EXPORT MARKETS, LARGE LAND TRACTS, CHEAP WATER, AND CHEAP LABOR.

Looking backwards from our present vantage point it becomes clear that numerous both momentous and minor decisions have formed the trajectory for California's current export-oriented food industry fueled by cheap labor and water on large farms.

**EXPORT-ORIENTED
PRODUCTION AND
LAND LAW FAVORED
LARGE LANDOWNERS**

Even before statehood, the region that we today call California engaged in large-scale food production. Generations of Aboriginal California Indigenous people who typically lived in small groups harvested abundant diverse food sources from both the land and sea, including acorns, protein-rich insects, and seafood. Key food sources, such as oak trees, were actively and sustainably tended by Indigenous groups.

The Spanish missions introduced cattle as tradable commodities and created production-level ranches to fuel extensive trade in livestock-related commodities, including meat, hides, and tallow (for soap and candles). With the introduction of large-scale livestock operations, the Spanish missions destroyed Indigenous food sources. The stock population—cattle, sheep, goats, and swine—grew from 285,000 in 1807 to 400,000 animals in 1834.

When Mexico secured its independence in 1821, the Mexican Republic granted land to colonists in Alta California, including grazing permits. Mexico's 1833 "Secularization Act" removed land from missions and put it into the hands of mostly provincial elites. Between 1834 and 1846, Mexico issued 813 land grants covering more than 13 million acres—or 25 percent of Alta California. Although the California Indigenous people should have been beneficiaries of these land grants, the Mexican government ultimately assigned private property rights to an additional 470 *ranchos* land grants to upper-class families; only a small proportion of these ranchos were assigned to Indian grantees. These ranchos continued to trade in livestock-related commodities. During this period, California became connected to the rest of the world with the opening of the ports of Monterey and San Diego to meet the supply needs of Alta California.





After the 1848 discovery of gold in Northern California, Southern California *rancheros* supplied the gold mines with meat, but soon were in competition with cattlemen from other states to meet the growing demand of miners. New California ranchers who were not associated with the *rancheros* focused on breeding better stock and invested in fattening ranches instead of open-range cattle. An economy previously based on hides changed to an economy based on beef, with the cost of cattle peaking in 1849 at \$500 a head before eventually settling between \$50 and \$150 a head in the 1850s.

Key to the long-term investments in agriculture was land law that provided for acquisitions. When California joined the United States in 1850, the federal government

attempted to push out the remaining *rancheros* in favor of white settlers. Congress passed the 1851 Land Act, which transferred millions of acres of land from ranchos to white settlers. Certain public lands designated for sale in 1851 and 1852 were transferred to private owners to finance the California government. Rather than a systematic transfer of lands under the existing land laws which would have created 50,000 farms of around 160 acres each, there was, in the spirit of the “Gold Rush,” a rush to obtain land patents. Land ownership became concentrated in the hands of a few speculators with the eventual creation of around 7,000 farms. Many landowners purchasing these land patents were keen to develop their increasingly large farms with an eye towards creating surplus for export.



The completion of the transcontinental railroad and changes in railcar technologies were essential to California's eventual performance as an agricultural leader, particularly for fresh products. The introduction of the refrigerator car in the 1880s revolutionized the ability to ship fruits and vegetables, which was further supported by refrigerated warehousing. Certain areas of California with high density of rail lines, such as the Central Valley, benefited from the increased opportunities for shipments. Southern California—now linked to the Midwest and the Atlantic Coast—began to expand citrus production to encompass Riverside, San Bernardino, Los Angeles, Orange, Ventura, Santa Barbara, San Diego, and Imperial counties. Competition between railroads increased the miles of tracks leading to more export opportunities. Newly formed commodity cooperatives took advantage of this competition to negotiate low transcontinental shipping rates.

The Great Depression era of the 1930s was particularly critical for the continued emphasis on export-oriented commodities with a concentration of power in banks, railroads, processors, and retailers who collectively generated a vertically-integrated operation for agriculture. The Bank of Italy (today the Bank of America) was an agricultural lender who held a mortgage on one out of every 11 farms in the state in 1929 and was heavily invested in farm operations. Banks encouraged the “monocropping” of California—where farms produced only one commodity crop—in order to consolidate agriculture in the hands of fewer players to focus on quicker investment returns.

During the New Deal, big agribusiness benefited more than other operations in terms of financial recovery packages: 2 percent of California's farmers received 44 percent of California's Agricultural Adjustment Act crop subsidies. Farming families today continue to rely heavily on lending from banks to finance agricultural operations, and interest rates continue to impact crop investment decisions.

CHEAP LABOR

Cheap human labor has been essential to California's food production and processing successes. The history of the expansion of California agriculture is a product of not just the colonial enterprise, but of the privilege of capital. In terms of labor, farm owners sought to hire rotating farmworkers who would start work in one crop, such as wheat, and then rotate to another—like the grape harvest—in the subsequent season.

The Spanish missions changed labor practices in California's food systems by creating a specialized labor force around commodity production; most of this labor force was coerced and many Aboriginal Californians were decimated by disease. Similarly, the subsequent Mexican-owned ranchos relied on Indigenous *vaqueros* for managing cattle. After the Gold Rush, as land became concentrated in the hands of a small number of settlers, farm owners continued to rely on California Indigenous labor.

This reliance on cheap labor has continued through the 20th and 21st centuries. Food-



related businesses rely on large numbers of immigrant workers willing to work difficult jobs for low pay. While mechanization was introduced for wheat harvests in the late 19th century, California's "field factories" for fruits and vegetables have depended on a mix of immigrant farmworkers, including Chinese, Pacific Islanders, Japanese, Filipinos, sub-continent Indians, Mexicans, as well as domestic Midwesterners driven out by the Dust Bowl.

Racial and ethnic hostilities against immigrants have always plagued California's agricultural labor market. As Anti-Chinese hostility spread across the landscape in the 1890s, laws such as the Chinese Exclusion Act restricted immigration and ended the boom in inexpensive Chinese labor. For a period, Japanese farmers replaced the Chinese labor pool. In 1907, Japanese immigration was limited and in 1913, California passed the first Alien Land Law preventing individuals who were ineligible for citizenship from acquiring land.

In the 1920s, California revised the Alien Land laws to prevent American-born children of Asian immigrants or corporations controlled by Asian immigrants from leasing or owning land. Therefore, new farmworkers, including Mexican nationals and Mexican-Americans, began to replace farmers of Asian descent, particularly in the Imperial Valley and San Joaquin Valley. Even though over 5,000 Japanese farmers and their descendants farmed over 360,000 acres of land with production values of around \$67 million prior to the 1920s, the farmers of Japanese descent were increasingly squeezed out of meaningful

opportunities to participate in the agricultural industry. By the end of the 1920s, 70,000 Mexicans and Mexican Americans constituted almost 80 percent of California's farmworkers. These farmworkers moved about as seasonal workers to meet harvest demands.

Despite efforts by farmworkers to organize for better working conditions, employer violence and federal laws have still failed to protect worker rights. In 1933, 50,000 farmworkers left the harvest to demand better working conditions. In 1936, railroad owners and citrus farmers interfered with the ability for workers to organize, which resulted in arrests and physical harm to the strikers. In response to public outcry, the Senate Committee on Education and Labor held hearings about California's labor conditions with recommendations that federal labor laws that cover private sector nonagricultural workers be extended to also include farmworkers. This proposal failed, and farmworkers' labor rights today are still not protected under the National Labor Relations Act although California's 1975 Agricultural Labor Relations Act does protect such rights.

World War II exposed the tensions between California's agricultural reliance on cheap labor and the U.S. need for wartime labor. When farmworkers left the fields for deployment or employment in wartime industries, farm owners sought assistance from the federal government. In 1942, the California Citrus Growers Association announced that half of its crop would rot in the fields due to a lack of field labor. The Governor of California



informed the U.S. Secretary of State and U.S. Secretary of Labor that Mexican labor was essential to the war effort to ensure that food could be harvested. In response to California's need for farmworkers to prevent agricultural losses, the State Department negotiated with Mexico to initiate the *bracero* program in 1942, which permitted Mexican farmworkers to enter the U.S. for five years to work in agriculture. However, because braceros were still expected to negotiate contracts with their employers without federal standards, these workers received low wages. In fact, the pro-

gram was criticized by Department of Labor staff as “legalized slavery” due to inadequate wages and housing.

Although the program was supposed to conclude at the end of World War II, farm owners lobbied for the continuation of the program to continue cost savings for the farm owners. This benefited California. More than half of the 219,000 Mexicans who came to the U.S. under the bracero program between 1942 and 1947 went to California. In 1956, 445,000 braceros arrived to work primarily in California and



Texas. The program continued until the civil rights movement ended it. It was not until 1975 that farmworkers were able to organize for collective bargaining under the California Agricultural Relations Act. This outcome followed from the well-remembered strikes by the United Farmworkers led by Cesar Chavez. It is only beginning in 2022 that California farmworkers have a recognized right to overtime pay.

The California dream of large-scale agricultural production has been a story of demanding work and vision by “agricultural pioneers” but also a story of indigenous exploitation, land speculation and cheap labor. Revisiting history remains important for understanding current conditions and possibilities of chang-

ing trajectories to create a more resilient and just food system for all Californians.

CHEAP AND PLENTIFUL WATER

Much of California has always been dry, with California experiencing extended periods of drought interspersed with occasional and, sometimes, large floods.

California’s landscape has been reworked to control water supply since Spanish colonization. During the Mission era, California Indigenous labor constructed dams, reservoirs, and





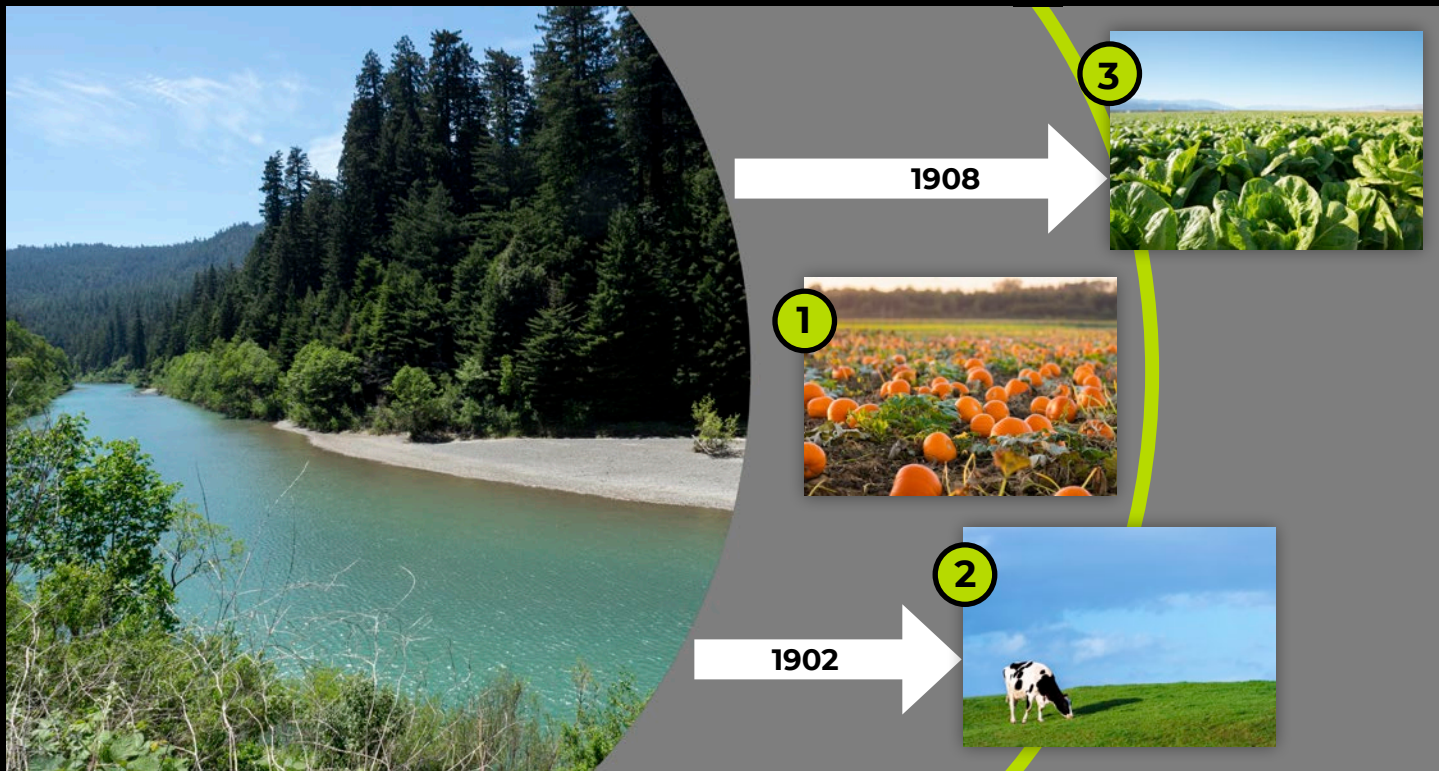
aqueducts to support field agriculture on the semi-arid lands near missions. Water diversions were also essential for California’s mining operations during the Gold Rush.

California’s large, arid landmass has made the state’s water rights system overly complex. Although English common law recognized **riparian rights**—the right to use water adjacent to land—this approach was insufficient for California farming because the land is too arid, and many farmers had acquired parcels that were not adjacent to waterways. As mining infrastructure was repurposed by farmers, a system of “prior appropriation” emerged where users who were “first in time” would have a right to access certain quantities of

water. As California farmland expanded after the Gold Rush, the California water rights system included both “prior appropriation” and “riparian rights,” as described in Figure 9 on the next page.⁵

To this day, legal precedence gives riparian rights stronger claims to water over prior appropriation rights. Riparian users can use water for agricultural purposes as long as they do not harm other riparian users. Today, riparian rights continue to receive precedence in the complex surface water rights system operating in California based on location of lands and prior use. In 1914, California created the Water Commission—which has since evolved to become the State Water Resources

⁵ There are other water rights recognized in California law including pueblo rights, prescriptive rights, and reserved rights. These rights only apply to a limited amount of water in California. Since 1914, the only way to acquire a “new” water right is from the State Water Board.

Figure 9**Riparian and Prior Appropriation Water Rights**

NOTE: The pumpkin patch owner (1) is a **riparian rights holder** whose rights run with the land that is adjacent to the stream. This holder can divert water from the stream for beneficial uses. Both the dairy farm owner (2) and lettuce farm owner (3) are not adjacent to the stream and therefore have to rely on **prior appropriation** rights. Because the dairy farm has been diverting water since 1902, the dairy farm owner is a **senior right holder** in relation to the lettuce farm owner, who is the last to be able to divert water for beneficial use among the three farms if there is a shortage in available water.

Control Board that exists today—and established the state’s water rights permit process. All pre-1914 rights were grandfathered in and all diversions after 1914 would require a permitting and licensing process.

Water has been transported across California since the earliest days of export-oriented agriculture, but the scale of this water infrastructure increased in the 20th century through three substantial projects: the Central Valley Project, the State Water Project, and the All-

American Canal/Colorado River Aqueduct (see Figure 5 on page 28 for this infrastructure). Using money from state bonds under the 1933 Central Valley Act, California sought to shift water from water-“surplus” areas to water-thirsty areas, including the San Joaquin Valley. However, California was unable to raise enough bond money, so the federal government took over the Central Valley Project (CVP). The CVP continues to be operated by the U.S. Bureau of Reclamation as a power and water management project.



In the 1960s, California began to build water storage and aqueducts as part of the State Water Project (SWP). The federal CVP and the SWP added nearly three million additional irrigated acres so that irrigated acreage grew from 4.3 million acres prior to World War II to 7.4 million acres by 1959 and eventually 8.5 million acres in 1978. The State Water Project refers to a California-built and -managed water storage and conveyance system collecting water from Northern California to be delivered to farmers and municipal users through a network of aqueducts and pumping stations. The Project also generates hydroelectricity. The State Water Project shares facilities with the Central Valley Project. Governor Pat Brown once remarked about the State Water Project that it was intended to “correct an accident of people and geography.”

In 1901 the California Development Company began diverting water from the Colorado

River into Imperial Valley via what is now the All-American Canal. In 1922, the Colorado River Compact provided equitable apportionment of the Colorado River, granting California a specific allocation of 4.4 million acre feet per year. The All-American Canal is an additional infrastructure project that conveys interstate water from the Colorado River into the Imperial Valley. The canal is owned by the Bureau of Reclamation but operated by the Imperial Irrigation District. A branch of this canal also delivers water to the Coachella Valley.

California continues to grapple with questions of water storage, conveyance, watershed management, water quality, and water efficiency. Water resources that were once cheap and plentiful are today the major limiting factor in sustaining California’s prominent role in national and global agriculture.



CALIFORNIA FACES ECONOMIC, SOCIAL, AND ENVIRONMENTAL CHALLENGES IN ITS FOOD SYSTEMS.

While California is a major food producer, it is unclear what the long-term trajectory of the sector holds if California is unable to address either its resource constraints or recurring social inequities. Some of the woes of California's food production and distribution systems began with specific resource challenges and have culminated with system-wide issues.

WATER WOES IMPACT WATER AVAILABILITY

Water today is rarely available when and where farmers need it most. In 1978, a University of California task force concluded that “the single most limiting resource likely to constrain food and fiber production in California was water.”

This fact remains true today. Historically, 60 percent of agricultural water has come from surface water primarily sourced from Northern California and the Colorado River. However, the reliability of these water sources has changed in recent years due to multi-year droughts. The 2022 Sierra snowpack, which is measured annually and supplies surface water, was dangerously low—the lowest level in seven years and the sixth-lowest measurement in state history.

California's aging water infrastructure contributes to the high-risk that the agriculture sector will not have enough water to operate in the future. Even if there was sufficient water in the snowpack, there are recurring concerns that a major earthquake or a failed dam would impact the water supply across the state.

Exacerbating California's statewide water woes is the ongoing experience of warming temperatures and drought. Drought is a period of extended dry conditions and low precipitation. Between 2007 and 2009 and again between 2012 and 2016, California experienced drought conditions that were considered a statewide emergency. 2021 was the second driest year on record, due to warm temperatures which caused snow to melt off early in the season. Surface water deliveries were reduced by 5.5 million acre-feet. 2022—when this report is being published—featured the driest year on record in over 128 years. Nearly all of California is characterized by the U.S. Drought Monitor as being in a severe drought, extreme drought, or exceptional drought.

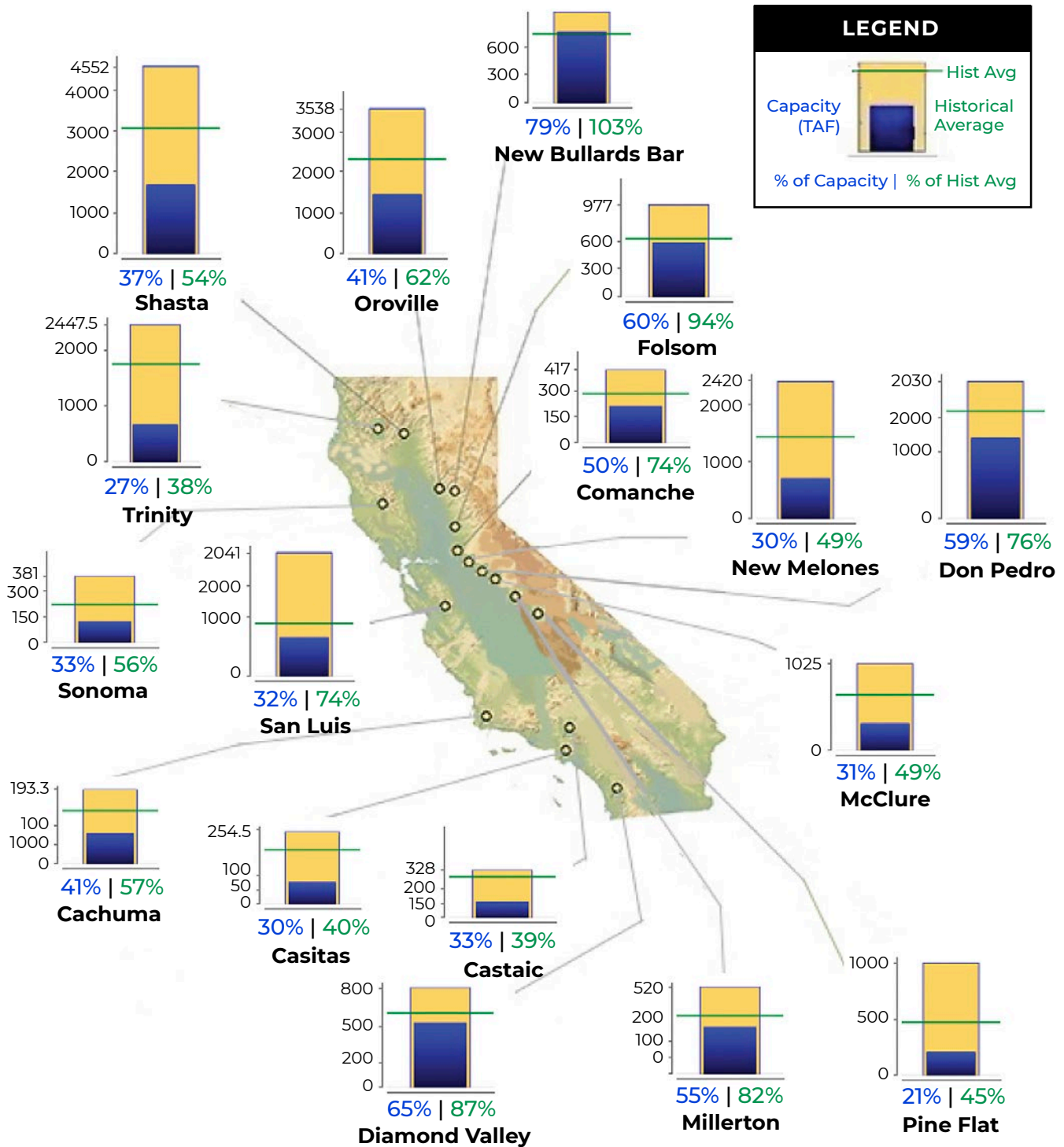
While the phenomenon of drought is nothing new in California's history, the recent trends in dry heat have exposed how fragile California's agricultural production system is when available water resources are insufficient. Dust Bowl droughts between 1928 and 1935 catalyzed the vast build-out of California's water moving and storage systems resulting in the Central Valley Project. The multi-year droughts beginning in the late 1940s convinced California to invest in the State Water Project. Unlike in the past, today, there is no new water source to tap.

The state's current megadrought has limited the amount of water available for agriculture. For example, the state announced that 29 public water agencies would receive no water from the State Water Project in late 2021 because all available water was needed for instream flows in the Sacramento-San Joaquin River Delta, and as a backstop for city drinking water and regional firefighting water. Likewise for 2022, most agricultural water service contractors are expected to receive zero percent allocation from the Central Valley Project with Shasta Reservoir at only 40 percent capacity (see Figure 10 on the next page).

In times of low water supplies from the projects, growers that rely on surface water find themselves needing to purchase water to avoid the loss of permanent crops. Alternative water supplies tend to be single-year or short-term contracts.

Figure 10

California's Existing Water Storage as Compared to Historical Averages of Storage



SOURCE: California Department of Water Resources, [Data Exchange Center](#), as of August 1, 2022.



Continued pumping of California's groundwater at the current rates of extraction is unsustainable and surface water is in jeopardy due to what has become a chronic drought for California. Given the mismatch between when crops need water and when limited precipitation falls in the state, there is no obvious panacea to California's water woes, but there are several efforts underway to conserve and reuse more.

TOO MUCH "SUMMER"

At the same time as water is disappearing, California is experiencing more warm days, which may reduce the viability of growing existing crops in the future. Some crops rely on cool days for production. Heatwaves decrease the size of fruit at harvest. For example, in 2015, a warm winter caused \$180 million of pistachio crop damage. The loss of winter chill may eliminate the production of some fruits and nuts. Droughts have immediate

costs. The 2021 drought cost California's agricultural industry around \$962 million of direct costs and a \$610 million reduction in value-added (difference between price on commodities and the cost for producing). The highest losses were calculated in the Central Valley (\$755 million) followed by the Russian River Basin (\$148 million).

One prediction by the USDA suggests that, by 2050, almost three-quarters of the Central Valley will become too warm for crops that need more than 700 chill hours of less than 46 degrees Fahrenheit (7.2 Celsius). By 2100, 98 percent of the region will be too warm. If this prediction comes to fruition, California may lose the ability to grow many of the current crops in the Central Valley. For example, depending on the variety, almonds require between 200-600 chill hours, peaches require between 400-1,000 hours, grapes require 100-400 hours, and pistachios require between 700-1,000 hours. Similarly, although California's



wine grapes are adapted to hot climates, extreme temperatures will impact wine grapes' sugar and flavor compounds, leading to lower quality wine. Temperatures above 95 degrees Fahrenheit have been associated with negative impacts on grape harvests. If California's prime agricultural land continues to experience drought, there may be a need to consider new drought-tolerant crops like date palms and carob trees in California intends to continue being an agricultural producer.

SOARING LAND PRICES AND PRODUCTION COSTS CREATE BARRIERS FOR FARM GROWTH AND ENTRY FOR NEW FARMERS

Land is expensive in California, and that includes agricultural land. The average acre of cropland in 2021 cost \$13,860 compared to a national average of \$4,420. California's farms sell for more than in other states, but this has consequences for young farmers and farmers from socially disadvantaged communities who may not be able to afford the start-up costs associated with food production. To farm, many of these farmers have to lease land without long-term lease arrangements. This makes it difficult for these farmers to plan for the future.

Production costs are also expensive: California farmers spent over \$41 billion in 2020. The three largest expenses for farm operators were labor (contract and hired)—costing almost one-third of expenses (\$12 billion),





feeds (over \$4 billion), and pesticides (over \$2 billion). The high ratio of costs and risks to benefits associated with food production may explain why California has very few young producers and relatively few farmers of color. California does have a Farmer Equity Act designed to include historically marginalized groups in farming, but this Act does not address the prohibitive costs of land and farm operations.

TOO MUCH SYNTHETIC CHEMICAL PESTICIDE EXPOSURE FOR FARM WORKERS AND THEIR COMMUNITIES

Synthetic chemical pesticides and herbicides have been effective in reducing some pests and improving agricultural yield, but often have detrimental unintended consequences for farm laborers and their families. Farmworkers are at the frontline of pesticide exposure through field preparation, drift from neighboring fields, and contact with pesticide residues on crops or in the soil. Agricultural workers may bring pesticide residues home that accumulate in house dust and expose family members. Pregnant agricultural workers may also have severe impacts during pregnancy, including premature births, miscarriages, or congenital disabilities. In 2018, the Pesticide Illness Surveillance Program of the California Department of Pesticide Regu-



lation identified 99 episodes resulting in 287 cases of pesticide-related illness and injuries arising from agricultural pesticide due to direct contact, drift, and residue.

Some farming communities remain exposed to legacy pollution from pesticides. In 2017, employees at California's State Water Board found potentially harmful levels of trichloro-propane in drinking water sources for 94 different public water systems mostly in the Central Valley that had been contaminated by soil fumigants used between the 1950s and the 1980s. Many of the impacted communities are marginalized farmworker communities.

In response to ongoing consumer concerns about public and environmental health, some California growers have expanded their commercial organic production, which generally

uses fewer toxic pesticides and other inputs. Between 2014 and 2020, California's organic production farmland increased 22 percent—from around 1.7 million acres to 2.1 million acres—making California the leading national supplier of organic foods, supplying 36 percent of the market. If organic production continues to replace conventional production in response to consumer demands, California farms will apply fewer synthetic pesticides and herbicides.

FIRE AND SMOKE

Wildfire has become an increasingly difficult challenge each year with the ongoing drought fueled by a warming climate and lack of regular precipitation. In 2021, over 2.5 million acres burned in the state, with more than 4.3 million acres burning in 2020. Many of these fires occurred near agricultural lands. In particular,





vineyards and grazing lands in the Coastal ranges and Sierra foothill communities have been heavily impacted. These fires create intolerable work conditions for farmworkers and exacerbate asthma, cardiovascular disease, and other health challenges for communities in close proximity. Wildfires have directly destroyed crops, grazing lands, and livestock. In wildfire season, with less sunlight from particulates or ash generated by fires, crops are damaged because they grow slower and are more vulnerable to disease load. In some cases, wildfire releases volatile compounds and changes flavors so that some crops, such as wine grapes, cannot be sold. Moreover, California's megafires create risks for California's water supply with the shutdown of hydropower plants and clean-up of reservoirs from debris and erosion runoff. Post-fire debris in reservoirs reduces water storage capacity and eventually water delivery.

Wildfire has impacted the ability of farms to acquire insurance since 2017, when insurance for some farms was not being renewed. In Napa Valley, one winegrower had his wildfire insurance premium increase from \$12,000 to \$55,000 in 2020. Farmers are increasingly dependent on short-term insurance plans underwritten by the state. Due to the limited amount of coverage for high-value operations, some wineries and ranchers are concerned that relying solely on state insurance, which is capped at \$4 million of recovery, will still result in bankruptcy.

AIR POLLUTION AND GREENHOUSE GAS EMISSIONS

California's agricultural sector is a major producer of air pollution and greenhouse gas (GHG) emissions. The California Air Resources



Board (CARB) estimates that agriculture is the fifth-largest source of California's greenhouse gas emissions, with 32 million metric tons of carbon dioxide equivalent. Most of these GHG emissions are attributed to methane from dairy cows generated by enteric fermentation and manure management. Responsible for 56 percent of the state's methane production, the agricultural sector emits the most methane of any sector in the state, producing 22 million metric tons of carbon dioxide equivalent. In addition to methane, CARB estimates that approximately 3.8 percent of the State's Nitrous Oxide (NOx) budget comes from cropland soils. However, this number is likely higher because the original study was geographically limited. Reducing emissions from the agricultural sector will be necessary for California to meet its 2030 greenhouse gas reduction targets.

Air pollution and GHGs disproportionately impact already socioeconomically disadvantaged communities. Latino populations, many of whom often work in agriculture, are exposed to greater respiratory risk than other groups due to air pollution events. As GHGs rise in the atmosphere to fuel higher recorded temperatures, these high temperatures impact largely Hispanic and Latino farmworkers, resulting in heatstroke or compounding existing problems, such as cardiovascular disease, respiratory disease, kidney failure, and premature births.

In addition to production-related emissions from farms, there are substantial diesel emissions associated with the cold chain which ensures the freshness of products, including refrigerated transportation and warehouses. Freezing and refrigeration are the most



significant GHG generators post-harvest. Particularly problematic is the leakage of hydrofluorocarbons (HFCs) from refrigerators. The EPA estimates that supermarkets leak an average of 25 percent of their refrigerants annually. In California, HFCs account for 4 to 5 percent of GHG emissions, which includes leaking refrigeration units. HFCs have hundreds to thousands of times more GHG warming potential than carbon dioxide. At the end of 2021, the California Air Resources Board adopted a rule prohibiting the use of certain HFCs for refrigeration. Under the regulation, any person who sells, leases, rents, installs, or uses a product is not permitted to install new or modify specific refrigeration equipment that uses listed HFCs. This specifically applies to household refrigerators and supermarket refrigerators. New cold storage warehouses will be regulated beginning January 1, 2023. Existing cold storage warehouses are not yet regulated at all.

Transport refrigeration units (TRUs) are also more likely to affect disadvantaged communities. TRUs travel to storage warehouses and food distribution centers that are more likely to be located in communities of color. Diesel

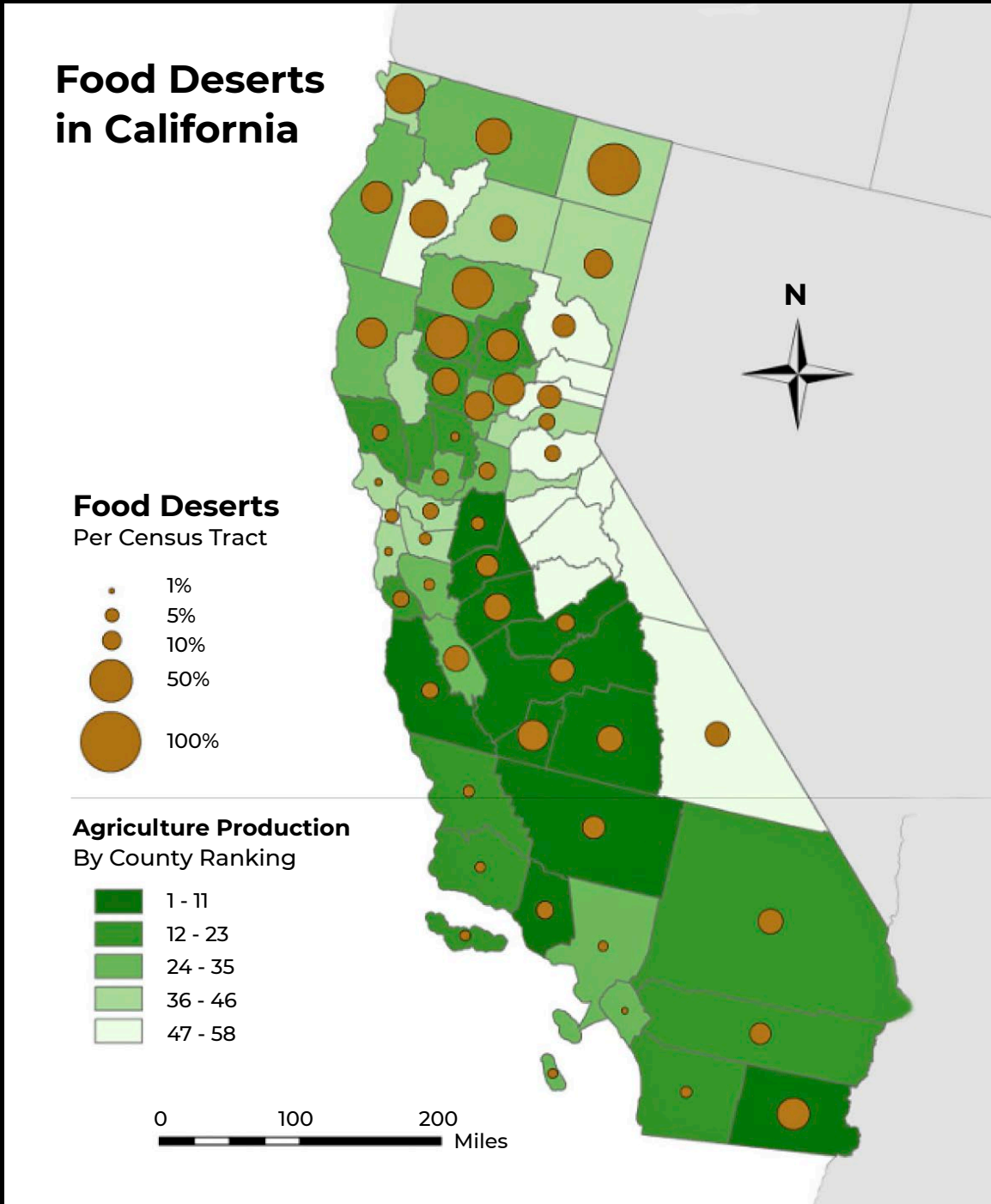
emissions associated with a truck pre-cooling, loading, unloading, or waiting for dispatch create “hot spots” for health problems associated with high diesel concentrations. California has recently adopted a resolution requiring all-diesel-fueled refrigerated trucks to be emission-free by 2030 to address the increasing number of TRUs that have less stringent particulate matter emission standards.

ACCESS TO FOOD AND FOOD INSECURITY

Despite California being the nation’s land of agricultural bounty, many Californians do not have adequate access to the food grown in the state. Food access is a problem in areas of major food production such as Fresno, Kern, and Tulare counties. Census tracts are classified as **food deserts** if there is a poverty rate of 20 percent or more or a median family income at or below 80 percent of the statewide median family access, and at least 500 persons or 33 percent of the population live more than one mile from a supermarket. Fresno, Kern, and Tulare, respectively, have 13.6, 17.9, and 20.5 percent of their areas classified as food deserts. Many of these food-insecure



Figure 11 Food Deserts in California.



SOURCES: U.S. Department of Agriculture.



In addition to rural communities, numerous lower-income urban neighborhoods lack access to healthy food.⁶ Existing state-based programs designed to improve food access include Supplemental Nutrition Assistance Program/CalFresh; Special Supplemental Nutrition Assistance Program for Women, Infants, and Children; and the National School Lunch and Breakfast Program. In 2019, these programs supported financial access to food for 10 percent of California's population (3.7 million). The majority of the recipients were families with children, elderly, or disabled. Of the households supported by these programs, 53 percent of the households were at or below 50 percent of the federal poverty level. In 2021,

challenges persisted in large urban areas, with one study finding one out of 10 residents of Los Angeles struggling with food insecurity. Most of these residents were low-income women, Latino, and between 18-40. More than three-quarters of the census tracts in the Los Angeles region that are "food deserts" had no food assistance providers.

Community efforts to develop and maintain urban farms are important opportunities to provide access to residents living in food deserts. Urban farms in San Francisco, San Jose, Oakland, San Diego, and Los Angeles frequently both expand food access in "food deserts" for local populations without easy access to fresh

⁶ In San Francisco and the San Jose metro area, 171 low-income neighborhoods have low food access accounting for 17 percent of San Francisco's neighborhoods and 21 percent of San Jose's neighborhoods.



produce and create positive community spaces. There is no single urban-farming model but most of the farms that are connected to communities tend to be small in acreage and produce a diversity of vegetables and fruits. Some urban farms raise backyard poultry or bees.

In 2013, the state adopted a program for “Urban Agriculture Incentive Zones,” which permits reduced property tax assessments if unimproved land is converted to agricultural use for at least five years. One of the recurring challenges for low-income urban communities is finding adequate, contaminant-free land that is close enough to residences to access by foot or public transit. Similarly, California’s FreshWorks program provides financing for urban food producers.

In 2021, the Governor initiated California’s first Urban Agriculture Program designed to support growth and stability of small farms. A good model of an urban farm is CRECE Urban Farms Co-op in Santa Ana where several

residents farm to supply affordable food to a low-income, primarily immigrant community. The Farm includes a “crop-swapping” program that allows residents to trade fruits from their neighborhood trees for vegetables.

Urban agriculture is an essential part of a short-term and long-term strategy for California to promote food justice while simultaneously strengthening ties across increasingly diverse urban communities. Two challenges for urban farms are ensuring that real estate booms do not eliminate opportunities for urban agriculture by paving over viable urban croplands and that farms have access to sufficient, reliable, and affordable water.

FOOD WASTE

Californians put around 6 million tons of food waste into the garbage annually, which constitutes an average of 18 percent of all the material going into landfills. In urban areas, organic material in landfills is even higher

with San Mateo County landfilling 71 percent of organic waste. This includes food from consumers, retailers, and wholesalers. Farms may also waste food when they do not harvest edible food due to poor market prices or insufficient harvest labor. It is harder to quantify these food losses. One study found, based on measurements in 123 fields for 20 hand-harvested crops, that between 2016 and 2017, approximately 11,300 kg per hectare of edible food was abandoned or not harvested for a total farm-level food loss of 33.7 percent of yield.

As increasing amounts of food waste are land-filled, increased methane emissions occur.

In an effort to reduce short-lived climate pollutants like methane, California passed legislation for businesses and multi-family residential units to reduce the amount of organic waste ending up in landfills with a target of 75 percent reduction by 2025 with 20 percent of edible food waste redirected to food-insecure communities.





MAJOR TRENDS FOR AGRICULTURE AND FOOD SYSTEMS IN CALIFORNIA

California faces a number of challenges in its role as a global food producer, and there are five major trends to pay attention to as stakeholders plan for future investments in California's food system.

CONTINUED WATER SHORTAGES FOR IRRIGATION

As described throughout this report, California's agricultural abundance depends on irrigation water. In the near future—without new investments in water, either in the form of new sources or using existing water more efficiently—there will continue to be water shortages. USDA data demonstrates that Cali-

fornia's irrigated agricultural land has already decreased from 8.8 million acres in 1997 to 7.8 million acres in 2017 due to changing water use, drought impacts on surface water supplies, and groundwater depletion. California's drought has exposed how fragile California's agricultural production system is when available water resources are insufficient. Unlike in the past, today, there is no new water source to tap in the state.

The Department of Water Resources (DWR) predicts a shortfall of 6-9 million acre-feet—requiring a 10 percent reduction of current use—of water by 2040. DWR released a 2022 resilience strategy with a plan to adapt to

losses through a combination of increased storm capture, increased desalination, increased water recycling, increased conservation and expanding storage by 2040. Meanwhile, farmers will have to adapt to a decline in irrigation water.

California has already faced numerous droughts from its earliest history as a U.S. state, and the state and federal government have used engineering ingenuity in the past to redirect water from more water-rich areas to water-poor areas. These water inputs served the agricultural sector of the state well for decades. However, with the scaling up of farms over the decades and the over-pumping of groundwater aquifers during multi-year droughts, California food producers are again facing water shortages. While efforts have been made to conserve existing water, there will need to be more creative approaches to obtaining water to ensure California's agricultural production remains solvent.

In the immediate future, this trend suggests that farmers will have to do more with less available water, which will mean tough decisions about what to grow and where to grow crops. Highly water efficient crops, such as date palms, could replace other orchards. Some farms may cease operations because irrigation water is too expensive. Almonds—the most water intensive crop—provide California with high economic production, particularly with foreign export markets. For that reason, it may be difficult for the state to move away from almond and other nut production despite water scarcity.

There is a growing recognition across California that water is the limiting factor for agricul-

tural production. However, only limited money is being invested in new water technology. Water researchers observed that only 1 percent of all U.S. venture capital is invested in water technology and California-based startups only received 21 percent of the small amount of investment. More innovation money may improve California's response to water shortages by creating innovative technologies to facilitate conservation, recycling, or desalination.

CONTINUED FARMWORKER LABOR SHORTAGES

For over a century, California has depended on inexpensive sources of labor for its export-oriented agriculture. Today, given the challenge of doing physically challenging harvest and planting work in increasingly warmer temperatures for low wages, it has become harder and harder to attract new workers to established agribusiness operations.

While there have been increases in the number of farmworkers in particular businesses, such as tree nuts, the general trend is a declining number of workers. In 1990, there were 202,700 farmworkers in California. By 2021, there were only 158,800 farmworkers.

This trend is both a product of more efficient planting and harvesting, but also a reflection of the challenge in accessing labor. Even with increased wages, California farmers have been unable to find sufficient farmworkers in part because fewer foreign farmworkers are coming to the U.S. Some of these would-be farmworkers are instead remaining in Mexico and Central America to work for agribusinesses located there.



CONTINUED STATEWIDE WARMING

In the coming years, California will continue to grow warmer. How much warmer it will be depends on a number of conditions. Depending on the success of greenhouse gas emission reductions in California, the average annual maximum daily temperature in the state is projected to increase between 2.5 and 2.7 degrees Fahrenheit by 2039 and between 4.4 and 5.8 degrees Fahrenheit by 2069. This amount of warming has cascading consequences for the business-as-usual food production sector.

Warmer air temperatures will lead to more evapotranspiration from fields meaning that more water will need to be applied to continue growing field crops. Short periods of intensive heat during critical times in a crop's growth cycle can impact crop development including, for example, causing male sterility in flowers or fruit to drop from trees. Without wintertime lows for many crops, many current California crops will not have sufficient "chill hours" leading to harvest failures or lower yields.

Continued warming is also likely to impact the ability to recruit future farmworkers. Global warming will disproportionately impact the health of field farm workers as long as they are exposed to poor air quality and unsafe heat conditions during harvest seasons.

This trend towards hotter and drier conditions in California with only intermittent precipitation events suggests that farmers may need to develop new growing strategies or make decisions to grow different crops that are more heat tolerant.

POTENTIAL LONG-TERM FLOODING

In a state that is as dry as California is much of the time, it seems an odd trend to note the potential for long-term flooding. However, California has historically experienced devastating floods. In 1861-1862, California experienced its "great flood" that lasted for 45 days and inundated the Sacramento and San Joaquin Valleys. In 1986, a storm dumped half of California's average annual precipitation in nine days resulting in a 1-in-1,000-year rainfall event with levees in flood control systems failing. More recently, 2017 floods impacted crops in the Central Valley leading to substantial losses of orchard tree, vines, and vegetable field crops. While the rains did recharge part of the aquifer and alleviated some of the concerns associated with ongoing drought, heavy precipitation presents its own challenges for farmers, including crop mildew.

Researchers suggest that as a result of climate shifts, California is likely to experience more large-scale flooding events. Based on modeling using historical data points, scientists expect that all coastal areas and mountain areas will experience 8 and 14 days of heavy precipitation events, respectively. These numbers will increase as California grows warmer. Future flood events are predicted to happen due to the intensifying "atmospheric rivers" and the melting snowpack that will release substantial amounts of water that will not be contained by existing natural waterways or human infrastructure. The trend for an otherwise-too-dry California is to be exposed to more flood hazards than it has in recent years.

What is clear from upcoming trends is that California's farmers must plan for what some have called "whiplash" events that can include a combination of both drought and flooding during the same growing cycle.

THE U.S. INCREASINGLY RELIES ON FOREIGN AGRICULTURAL IMPORTS

An increased reliance on imports has other implications for domestic growers, particularly those in California. The U.S. imports greater amounts of food during the winter, autumn, and early spring months, when fresh fruit and vegetable production is difficult domestically. In 2020, the value of U.S. fresh-market vegetable imports exceeded exports by \$7.6 billion. Most vegetable imports are warm-season crops (tomatoes, peppers, cucumbers) coming from Mexico and Canada. Mexico also produces strawberries almost exclusively for U.S. export. Domestic growers may be displaced by foreign producers in important high-value markets, such as organics, because of the lower costs of production (especially labor) in places like Mexico. Between 2018 and 2020, Mexico accounted for 87 percent of organic fresh vegetable imports. The volume increased 799 percent from 2011-2013 to 2018-2020.

Mexican and Canadian imports, which were originally only intended for the seasons between California's ability to produce its own crops, have begun to "creep" into seasons that have been traditionally the high seasons for domestic producers. One of the reasons for this increase in imports is cheaper pricing. In

Mexico, the minimum daily wage is around \$6.80 (141.7 pesos) outside of the Free Trade Zone and \$10.24 (213.39 pesos) within the Free Trade Zone. This cost contrasts with \$17.51 per hour for H-2A workers in California. This disparity in wages raises an equity issue for Mexican farmworkers who are paid significantly less than American-based farmworkers. Workers in Mexico will earn \$18-28 per day for strawberry harvesting in contrast to \$14-18 per hour in the U.S. Therefore, domestic producers may be unable to compete given the higher costs of inputs in California as compared to Mexico.

However, it is uncertain for how long the reliance on foreign exports will be sustainable. Mexico, like California, has limited water availability. Most of the water consumed in the arid northern regions of Mexico is used by export agribusiness. Therefore, the availability of water for communities and agribusinesses in Mexico is not guaranteed. Additionally, some of the imported vegetables are grown in greenhouses. While greenhouses cause the same sustainability concerns in the U.S., greenhouse imports may have long-term sustainability concerns, including greenhouse gas generation, particularly when greenhouses are fueled with fossil fuel.

For the immediate short-term future, increasing amounts of imports into the U.S. market will come from Central and South America in direct competition with California-produced foods. Without solving some of California's existing challenges in its food system including access to affordable food, California may increasingly rely on imports to provide food for its residents.

THE FUTURE OF AGRICULTURE AND FOOD SYSTEMS

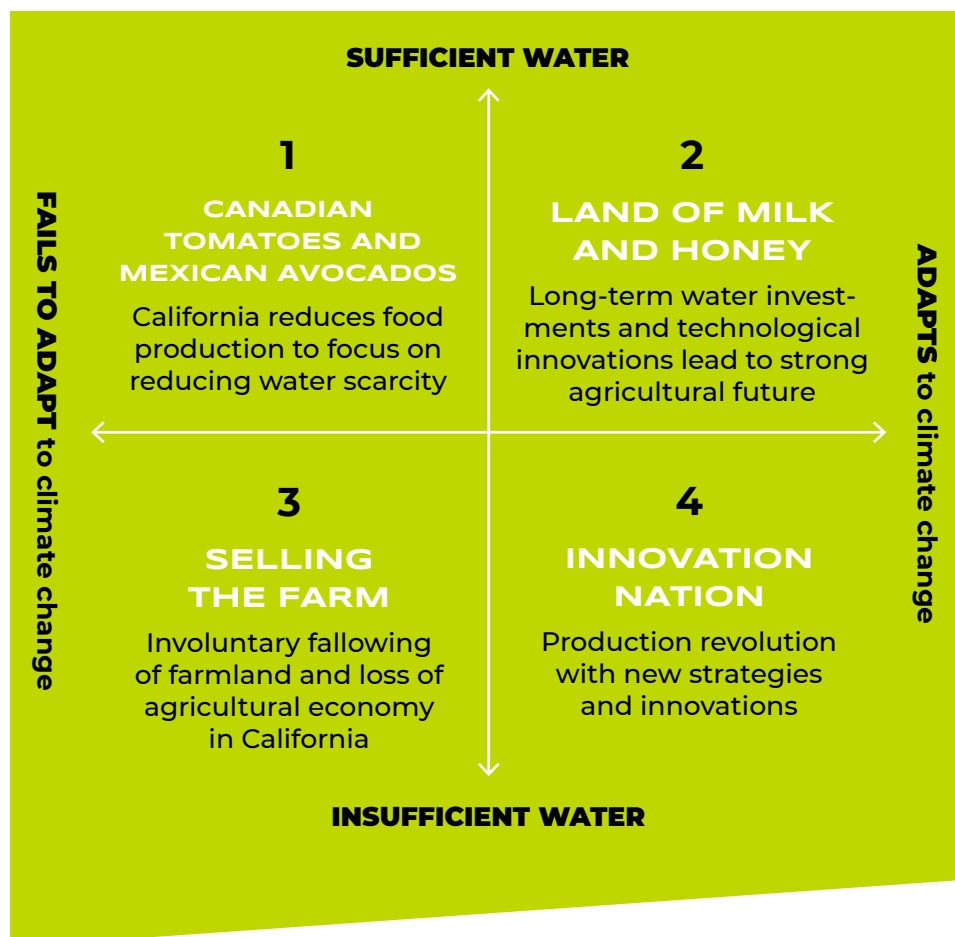
FOUR ALTERNATIVE SCENARIOS

SCENARIOS FROM THE FUTURE

AGRICULTURE AND FOOD SYSTEMS

Foresight practitioners use scenarios to help make future possibilities more vivid and tangible. Scenarios immerse the reader in the details of a future world so that they can imagine what it would feel like to live there. Without scenarios, the signals, trends, and other research that underlie strategic foresight work can feel distant and abstract. Scenarios can be used to center a group conversation in a positive and concrete picture of a future. Stakeholders can then pursue a shared vision for how to reach a desired possibility, or they can mobilize to avoid an undesirable outcome.

To imagine plausible future scenarios for food systems in California, we chose to focus on production challenges for the state. Based on our evaluation of facts and trends related to California's food systems, there are two critical uncertainties that the state will face in both the near- and long-term future. First, as the state faces significant effects from climate change, including extreme wildfires and decade-long droughts, California will either adapt to climate change in order to maintain its status as a major food production state or it will fail to adapt to climate change, ultimately requiring an increased reliance on food exports and losing the monetary value of agriculture in the state. Second, will California find a way to ensure its agriculture and food processing sectors have access to sufficient water? Without this access to water sources, California will face a future that cannot maintain its role in the world's current food systems. In introducing the following four scenarios, we are well positioned to think about what we want to stay the same and what might need to change in the decades to come to ensure access to quality food for all Californians and viable production in a changing climate.



CANADIAN TOMATOES AND MEXICAN AVOCADOS

California reduces food production to focus on reducing water scarcity



As California fails to achieve climate adaptation measures for the agricultural sector, the federal government and California's public sector halt investments in California agriculture due to nutrient-exhausted land, costly production inputs, severe and frequent wildfires, and public health threats for farm laborers working in excessive heat. Large-scale agricultural production shifts out of California to other places in North America (including other U.S. states), Central America, or South America. Agriculture in other U.S. states offsets some of the losses from California, but the country must still rely on additional imports. Where the U.S. does not have a guaranteed import right, the country will have to compete in a global market for fresh food supplies. With less competition from California, other states increase prices on fruits and vegetables leading to more costly access to healthy food for California residents.

With the shift in California from a production state to a consumer state for major agricultural products, California's reservoirs have more water at the end of the growing season. This surplus allows municipalities to access more water, resulting in urban and suburban expansion for dry regions of the state, such as Southern California. As agribusiness leaves the state, population centers in the Central Valley are drained of residents of former farmworkers; agricultural landscapes revert to "natural" conditions, improving biodiversity objectives; and community public health outcomes improve as fewer pesticides and herbicides pollute the air.

○—○→ HISTORICAL PRECEDENTS

Gold Rush Food Importer: California imported basic foods from other parts of the country and world to feed its burgeoning population and focus its growth on perceived high-value gold.

1992: Central Valley Project Improvement Act.

In the past couple of decades, instream water flows to protect spawning fish have become a priority for regulators. In 1992 Congress passed the Central Valley Project Improvement Act requiring 800,000-acre feet of water to protect fish and habitat.

➤➤➤ FUTURE DRIVERS

Cheaper overseas production: could continue to shift production away from California to other states.

More interest in local production of food across the United States: in response to "regional food" markets.

Continued favorable international trade treaties: may encourage production in less water-constrained regions.

More demand for municipal water needs: may lead to residential users taking priority over agricultural users.

⚡→ SIGNALS

Greenhouse agriculture is a growing business in Canada

WHAT: According to the 2021 Agricultural Census, Canada's greenhouse sector, which supplies fresh produce, has increased by 25 percent since 2016 for fruit and vegetable production.

SO WHAT: Canadian agribusiness is continuing to make investments in fruits and vegetable greenhouse production, which was a \$1.4 billion business in 2020, and the U.S. is the number one export destination for Canada's fruits and vegetables.

Source: Government of Canada, 2021 Census of Agriculture.

U.S. food systems increasingly rely on imports

WHAT: With improvements in road, containerized shipping, new varieties of foods developed for growth in warmer climates, and better storage technology, more than half of the fresh fruits and almost a third of fresh vegetables in the U.S. in 2018 were imported from other countries.

SO WHAT: Supply chains in the United States are already dependent on imported fruits and vegetables, so a possible reduction in supply from California may be less of a supply chain shock for the U.S.

Source: [New York Times 2018](#).

Public and private interests increasingly focus on restoring ecological values in agricultural landscapes

WHAT: California adopted an executive order to protect 30% of the state's lands by 2030.

SO WHAT: The Nature Conservancy and other public and private entities are pursuing multi-benefit land restoration projects across California including compensating farmers for dedicating agricultural land to habitat restoration.

Source: [Bryant et. al. 2020](#).

LAND OF MILK AND HONEY

Long-term water investments and technological innovations lead to strong agricultural future



After years of strong water innovation policy including extensive water recycling, groundwater recharge, and desalination efforts, farmers’ fields have become optimized to conserve water. Adequate water for the state also comes from regional water markets that transport water from water-rich areas outside of the arid U.S. west through interstate water infrastructure. Through these efforts, as well as capturing runoff from large flood events, California achieves sustainability for its groundwater aquifers. With fewer restrictions on water usage, California farmers begin to experiment more with expanding perennial crops, which require less energy and labor. Moreover, new robotic farming platforms become prevalent across California’s agricultural lands in tandem with more localized water infrastructure developments in order to better conserve both existing and new sources of water.

In order to achieve the state’s total water and climate adaptation, California focused the majority of its general fund budget on these efforts, reducing funds for K-12 education and statewide infrastructure. However, the farmers throughout the state commit to ensuring these efforts remain sustainable through the coming years: farms transition to cover crops meant to create green manure instead of fossil fuels and synthetic fertilizers; others practice conservation tillage to enhance soil health. Commercial freshwater fisheries as well as land- and coastal-based aquaculture operations flourish throughout the state to expand the economic market.

○—○→ HISTORICAL PRECEDENTS

Late 19th and early 20th century: Regional experience building large-scale water infrastructure via the Los Angeles Owens’ Valley, Central Valley Project, State Water project, All-American Canal.

1991: West Coast’s first municipal seawater desalination plant

built on Catalina Island demonstrating proof of concept.

1998: Public-private partnership in San Diego launches the Carlsbad desalination project—the largest, most technologically advanced and energy-efficient seawater desalination plant in the U.S.

>—>—> FUTURE DRIVERS

Water policy: desalination, water recharge, infrastructure for capturing water runoff.

Renewables: With increasing amounts of renewable energy in the grid, it may become feasible to invest in desalination.

Planning for “megafloods” that would allow for water

to be recaptured and put into a larger water storage and transport system.

Transitioning existing fossil fuel pipeline infrastructure to transport water regionally and using existing pipeline routes.

Affordable robotic farming platforms.

+—+—+→ SIGNALS

Small-scale desalination using brackish groundwater

WHAT: Technology exists that would allow for small-scale desalination plants to be powered by passive solar power in order to deliver freshwater without long-distance transport costs.

SO WHAT: Small-scale desalination could allow for the use of brackish groundwater. The U.S. has 800 times more brackish groundwater than the amount of groundwater currently available for use.

Source: [Popular Science 2022](#).

California’s focus on aquaculture permitting

WHAT: California has put efforts and resources into advancing permits for large-scale production projects.

SO WHAT: Aquaculture offers a not-yet-saturated market sector. California municipalities can invest in aquaculture facilities that are likely to bring new tax revenue and jobs.

Source: [Chase 2022](#).

California farms employ advanced advanced indoor robotic platforms

WHAT: Industries, such as the strawberry sector, have made significant investments in indoor harvesting robots to offset increasing concerns over climate warming, new chemical regulations, and labor shortages.

SO WHAT: Robotic platforms, as part of precision agriculture, are likely to become the farming standard over labor, when available, because they allow for long-term cost savings for farm owners and higher quality products for consumers.

Source: [Los Angeles Times 2022](#).

SELLING THE FARM

Involuntary fallowing of farmland and loss of agricultural economy in California



California continues to grow some food, but the costs exceed the benefits for individual farmers because there is not enough surface water or groundwater for agriculture. Climate change also makes it impossible to grow some crops and others are damaged by extremes of weather and wildfire smoke. Even senior water right holders who have been running farms for multiple generations are forced to ration water. As small, family-owned farms fail to obtain affordable water from other sources, it becomes impossible for some to continue production.

Consumers are unwilling to pay the costs of agricultural production in California, so the agricultural industry begins to dry up. The first crops fallowed in California are those that are water-intensive since consumers can shift to other competitive markets for items, such as hay and cotton. Where feasible, some farmers may transition to drought-tolerant crops such as date palms, but livestock production decreases significantly. Larger corporate farms seek alternative growing areas in other parts of the country and leave California. Certain regions of California, particularly the Central Valley, begin to empty out as jobs disappear. This exodus has consequences beyond these communities, as a ripple effect results in less affordable and lower quality (especially fruits and vegetables) food available to wholesalers and retailers.

→ HISTORICAL PRECEDENTS

The Dust Bowl of the 1930s: Multiple years of drought and poor farming practices during the Great Depression devastated farming families—some of whom eventually moved to California.

1980s Farm Recession: Financial crisis impacted Midwest farms who during the 1970s were called upon by the Secretary of Agriculture to “get big or get out.” Farming families took on more debt when land values increased, but when lending policies changed, numerous family farmers were forced off land.

→ FUTURE DRIVERS

Continued drought: Temperatures continue to warm, and precipitation levels remain low compared to previous decades.

No new sources of water: Without water quantity increases, there is no additional water available for production.

Fewer farms and fewer farmers: Fewer individuals want to invest in large-scale agribusiness.

Cheaper food: California residents can get cheaper food from producers outside of California.

→ SIGNALS

Drought in the West will continue

WHAT: The current drought in California is not going away. Half of the U.S. population is living in a drought-stricken area, and many of these areas in California are also key agricultural centers for farmers and ranchers.

SO WHAT: The current drought has lasted longer than the historic Dust Bowl droughts. Major water reservoirs are at historic lows and the state has not yet taken significant action.

Source: [Scientific American 2021](#).

Farming communities are already shrinking

WHAT: Communities are seeing farms vanish as fields are left unplanted due to the current drought and other difficulties with accessing water. The Central Valley produces around 8% of the U.S.’ fruits, vegetables, and dairy, which means many of the communities there rely on farm work for their primary income.

SO WHAT: As water becomes more difficult to come by and farmers lose their abilities to produce crops, communities built around agriculture will feel the effects of these economic losses.

Source: [Washington Post 2022](#).

Farmers are intentionally fallowing farmlands

WHAT: With the continued drought, farmers are fallowing substantial acreage of farmland, which means that farmers are intentionally not sowing the land for at least one vegetative cycle.

SO WHAT: As fallowed land reduces the amount of food a farm can produce, it is likely that food will become more expensive if there is a scarcity of food, which will impact food security for many households.

Source: [Marketplace 2022](#).

INNOVATION NATION

Production revolution with new strategies and innovations



California continues to be a major food producer due to its expanded use of a wide variety of production methods in preparation for climate change. In the preceding decades, California made the full transition to renewable energies, which allows farmers to produce more food using “next-generation” greenhouses, aquaculture, cell-cultured proteins, and precision fermentation that still require energy, but less of other inputs. As the state transitions from hand labor to robotics, California food producers increasingly rely on mechanized labor in fields and greenhouses requiring new hardware and software engineering. This shift requires the next generation of food producers to have different and often advanced skill sets, which also results in a younger population operating the food sector throughout the state.

Although the state still struggles with finding sufficient water for residents, the strain on water scarcity no longer comes from the agriculture sector. With more foods produced using new production methods, there are fewer inputs required, including water and fertilizer. In some cases, it becomes possible to grow foods without pesticides and herbicides. Existing food production areas, such as in the Central Valley, continue producing food for a national market, but use indoor farming technologies to do so.

○→ HISTORICAL PRECEDENTS

Drought of 1976-1977: The 1977 drought sparked a water conservation movement across the state encouraging residents to refrain from typical household routines like waterlawns and washing cars. Agricultural operations also increasingly pursued water-saving innovations during that drought, such as drip irrigation, which has now become common practice.

2000s and 2010s: California-based companies, Beyond Meat and Impossible Foods, provided new cell-cultured, non-meat proteins at large-scale in commercial markets. In 2019, Burger King released Impossible Whoppers (made by Impossible Foods) to provide a nationwide, fast food, non-meat burger option.

>>> FUTURE DRIVERS

Venture capital investments.

Widespread acceptance of alternative proteins.

Mechanization of food production: More farm-level investments in managing agricultural inputs, especially for precision watering.

Technological and scientific advances: Advances in technology for bioreactors and harvesters using artificial intelligence; Other advances including genetic editing for drought resistance.

⚡→ SIGNALS

Increasing investments in animal-free protein and dairy alternatives

WHAT: The largest commercial player in precision fermentation for dairy is “Perfect Day,” a California-based company with technology that has already entered the consumer market. In fact, some of the U.S.’ largest food production players, such as General Mills, are using precision fermentation to manufacture animal-free dairy products.

SO WHAT: As animal-free dairy products become more widely and cheaply available, the need for farm-raised cattle may decrease, reducing farms and pollutants throughout the state.

Source: [Business Insider 2022](#).

More venture capital in agricultural technology startups than ever

WHAT: The third quarter of 2021 saw \$4 billion in venture capital investment for agriculture technology startups, particularly for water- and fertilizer-saving technologies.

SO WHAT: The venture capital being invested into the market may form the basis for a new “green revolution” in agriculture, particularly in California, allowing for better production with less inputs.

Source: [UNDARK 2022](#).

California’s megadrought is forcing the state to adapt to new practices

WHAT: Climate change has made the current Western drought 40% more severe than it would have been without climate change. Experts expect the drought to last until at least 2030.

SO WHAT: California’s food production needs to accept that far less water will be available and that “unconventional” agriculture, including indoor farming, may eventually become “conventional.”

Source: [Williams 2022](#).

FUTURE FOOD SYSTEMS POLICIES IN CALIFORNIA

Choices among governmental policies depend partly upon which future scenarios are most attractive to California residents and partly on our perspectives on the proper role of government in making policy, on the resources available to government, and on the likelihood that the government will succeed. Doing nothing is sometimes the best policy option but doing nothing often uncritically accepts the current mix of policies and the future they entail without considering alternatives. If we do nothing in the case of water for agricultural production, there will not be enough water to sustain the current levels of production. For the foreseeable future, California will need to adapt either by slowing food production in the State, finding new water, or changing how we use the current water that is available.

Because we are thinking about the future and we do not want to be hemmed in by the status quo or a lack of imagination, we put forth an array of alternative policies that we tie to different scenarios. Readers can decide which ones (or combination of them) that they think are feasible. Given the economic significance of food production to so many California families, we prefer the “Milk and Honey” and “Innovation Nation” futures. Ideally California will remain committed to California continuing to use its expertise to produce food for the future. Readers should consider for themselves which scenario or scenarios best capture the California they want to live in and decide which policy recommendations can be effective in creating the future we want.

There is a commitment across all food producers to take steps that will improve water reliability access to good quality water. The question is what steps to take first or in tandem. What is clear after 2021—California’s driest year in 40 years—is that California’s water needs to be managed for the realities of drought. For California to achieve a more innovative, resilient, inclusive, sustainable, and equitable food system, there are many possible steps in the years to come; some of the following proposals are more ambitious and more likely than others. This report recommends the following three priority steps:

- 1) California must understand its food system “infrastructure” at a far more granular level and identify individual places where there is “waste”—whether that be water leaking from canals that do not recharge groundwater or consumable crops left in a field.
- 2) California needs to improve its general agricultural conservation practices in the field and require farmers to participate in cover-cropping and conservation range practices. While some California farms and ranches are conservation leaders, there needs to be broader participation in “greening” California’s food systems.
- 3) California should invest in research efforts to promote indoor farming practices and alternative food production (e.g., fermentation, culturing, multi-trophic aquaculture) as alternatives to existing food production through public research grants.

LAND OF MILK AND HONEY

This scenario requires the California government, private sector, and groups such as irrigation districts to focus most of their resources on saving existing water that is already in the California system and investing in means to acquire new water for California to meet the parallel existing needs for community drinking and cooking needs, habitat uses, and food production. If California can acquire more water from new sources, there will be new opportunities to sustainably expand California's food production beyond current production levels.

California repairs infrastructure leaks across the entire water system.

Numerous municipal, industrial, and agricultural users have leaky systems. California will finish needed repairs to restore the capacity of the Friant-Kern Canal, the Delta-Mendota Canal, and the California Aqueduct. Water distributors have a state mandated obligation to submit a water audit of every utility owned pipe every three years indicating where leaks exist and how leaks will be repaired. Water leak repairs will be covered with an increase in water rates for users who consume more than a minimum amount of water, indicated by the State Water Resources Control Board, to meet basic human right to water. State-funded grants will be available to water systems where rate hikes may pose a direct or indirect threat to public health.

California increases its regional infrastructure for tertiary treatment of recycled water with a priority on water recovery in the South Coast, San Francisco Bay, San Joaquin River, Tulare Lake, and the Central Coast.

California has made substantial progress on water reuse including capturing stormwater over the decades with its Water Reuse Law of 1974 and the Water Recycling Act of 1991. California anticipates having new regulations by 2023 on direct potable reuse. Given the need for access to quantities of



potable water for food production, under this scenario, water will be recycled to tertiary standards so that it can be used for irrigation waters. This will require substantial infrastructure investments. One possibility to cover these expenses is to levy a tax on produce being exported outside of California as part of a “water consumer-pays” scheme. This would be an equitable approach of sharing the water-related costs of producing food in California for an export market.

California re-examines its existing water rights system.

The current system of water rights in a water restricted environment needs to be re-examined. The State Water Board should exercise jurisdiction over not just surface water rights but also any groundwater pumping that has a measurable effect on surface water resources.

The California Department of Food and Agriculture develops scorecards for farmers.

The CDFA could assist with farm-level water efficiency by providing scorecards for agricultural water users so that they can see how they rank in water usage per acre compared to other farmers for similar crops and how they compare to a farm implementing best practices. This may have the intended effect of improving on-farm water efficiency as farmers recognize the achievability of additional on-farm conservation efforts.

California requires water treatment technology for large packing houses where food is cleaned for packaging.

California packing houses should have water treatment technology available so that water from cleaning can be recycled within a facility rather than relying on freshwater from municipal or well sources.

California invests in efforts to repurpose existing fossil fuel pipelines to transport water.

Assuming effective climate adaptation that moves California away from its reliance on fossil fuel and as part of a long-term strategy to provide emergency water during years of drought, California will tie into a national network of repurposed oil and gas pipelines and pumping stations that will transport water instead of fossil fuel. The U.S. currently has 2.3 million miles of oil and gas pipeline. Workers who formerly worked on maintaining and operating oil pipelines will be able to transition their skill sets to manage networks of water pipelines. Freshwater to supply this system could be collected from flood-prone states along watersheds such as the Mississippi River to be redistributed westward for treatment and use or from water collected during California “megaflood” events.

California Water Resources Control Board works with statewide agricultural irrigation districts and initiatives, such as Central Valley Salinity Alternatives for Long-Term Sustainability, to designate a network of mini-desalination plants.

Desalination remains a favorite tech-fix for California’s water woes, but large-scale coastal desalination is expensive and may pose environmental threats to marine communities. Mini-desalination could be used in areas where groundwater is critically overdrafted and the sub-basin is subject to the Sustainable Groundwater Management Act. These investments would be prioritized in the Central Valley where over-pumping of groundwater and salination pose existential threats.



California universities and crop boards provide farmers with seeds and produce starts for new types of drought-resistant or drought-tolerant perennials. CDFA provides grants to cover operational costs of establishing certain low-water perennials until the plantings produce their first crops.

The advantage of perennials is that plantings can last for years and sometimes decades. Examples of existing perennials include asparagus, certain varieties of broccoli, certain varieties of spinach, yams, orchard fruits, nuts, and berries. New perennials will become available through genetic selection. Planting more perennials will reduce the amount of labor and inputs needed to establish a crop and reduce soil erosion caused by tilling. Regular water and fertilizers will still be essential. Some of these inputs are likely to be delivered by improved precision farming systems in the future on a plant-by-plant or area-by-area basis rather than through conventional irrigation systems.

California fast-tracks projects promoting multi-trophic aquaculture and land-based aquaculture projects that meet certain environmental conditions.

Aquaculture farms can provide high quality sources of protein. One of the challenges for many of these ventures has been complex permitting across numerous agencies. In this scenario, regulatory permits will be easy to obtain for projects that meet certain conditions such as projects that contribute to better water quality including shellfish farms and projects that are largely self-contained.

The state revises the California Environmental Farming Act to present a harmonized standard for sustainable and equitable farm production conceiving of food production as a “service” sector rather than a “product” sector.

The existing California Environmental Farming Act is expanded beyond incentives being delivered to motivated farmers who adopt specific environmental practices. As a service sector (like a utility), California can develop standards that will not only provide food products in a manner that protects environmental habitats and human health but also ensure socio economic sustainability through delivery of affordable fresh produce in return for reasonable profits for growers.

INNOVATION NATION

Without large-scale investments in water efficiency or tapping new water sources beyond California that will require both social and physical changes, California will need to reconsider what constitutes advancements in the food sector. Without sufficient quantities of freshwater, California is unlikely to be able to continue production in fields at the current scale. In this scenario, California will adapt to warming temperatures by rethinking both the parameters of what constitutes nutritional “food” and also how food can be produced. Food will no longer be grown exclusively in fields but California can remain a leading “food” producer if it is proactive in creating a regulatory system that protects the public and makes investments in equitable food production and long-term climate change adaptations. In this scenario, much more food will be produced indoors in controlled environments or potentially with genetic modifications for climate adaptation purposes.



California Department of Public Health partners with the U.S. Food and Drug Administration in its efforts to ensure that “new foods” from California, such as cell-cultured protein, meet the standards of “generally recognized as safe.”

California continues to innovate in terms of “new foods.” The key to the commercial success of these foods is recognition by the U.S. Food and Drug Administration that the foods are “generally recognized as safe” under the Food, Drug, and Cosmetic Act. Given concerns about genetically modified organisms in food, California should provide some specific regulatory guidelines for producers of synthetic biology food products to ensure that the products will meet standards of “generally recognized as safe.”

California provides regulatory oversight of synthetic biology research, design, and commercial operations to protect against uncontrolled releases into the environment.

Synthetic biology including tools such as CRISPR become more mainstream as food producers seek to address climate constraints such as ongoing drought conditions. California ensures regulatory oversight of these operations to ensure that there is a contingency plan to protect against uncontrolled releases of genetic material from these operations into the environment.

CDFA requires life-cycle analyses as part of the conversion process from field crops to greenhouse.

Because not all areas of California are equally vulnerable to the threats of droughts, it will be possible to continue producing food in some regions of California. Because building greenhouses will have environmental impacts

including on biodiversity with the footprint of buildings potentially interfering with habitat, life-cycle analysis reviews become required as part of farm-based plans to convert from fields to greenhouses to avoid perverse changes.

California government directs Disadvantaged Business Enterprise funds for the repurposing of light industrial sites into advanced greenhouses sites for horizontal farming.

Some of California's most food-poor residents live in disadvantaged urban communities with vacant light industry sites where food might be able to be produced with some decontamination of a site. California can generate new food production employment opportunities in these regions in the form of advanced greenhouses or horizontal farming warehouses to meet a proportion of local food needs. In exchange for startup funding and employing local community members, a business enterprise could contract with the state to sell a proportion of their production locally.

CANADIAN TOMATOES AND MEXICAN AVOCADOS

In this scenario, California has failed to adapt the agricultural sector to climate change impacts (e.g., no adaptation to heatwaves) and food is now being supplied in California by either other U.S. states or offshore food production due to California failing to adapt to address non-water related issues such as prolonged heatwaves and nutrient-depleted soil. With the agricultural sector no longer using as much water across the state, there will be additional water for other purposes. This scenario would lead to new decisions for land and water use associated with former agricultural lands. Under this scenario, formerly rural agricultural communities adjacent to existing urban and suburban areas will be rezoned by municipal leaders from agriculture designations to other uses to allow



for either build out of human communities or wildlife habitat. Formerly rural agricultural communities separated from urban/suburban centers may become open spaces where landscape-level ecological restoration may be viable. Large family farms that U.S. families no longer want to maintain will be sold to the state, county, city, or national organizations such as The Nature Conservancy. In some cases, these large family farms may be sold to international agribusiness investors coming from states with either land or water-scarcity (e.g., China or the Middle East).

California shrinks its government investment in food production.

The California Department of Food and Agriculture closes many of its offices. Funds that were previously used by the Department will be used instead to inspect international food imports in California for safety. Funds from the United States Department of Agriculture that were formerly available to California will either be spent in other U.S. states who expand agricultural production or used to bolster favorable trade relationships.

California's foreign missions change objectives in relation to California's supply chain.

Presently California's trade missions promote export of California's agricultural products to foreign markets. These missions will need to advance cooperation on importing agricultural products into California to meet the needs of California's residents. This will include concluding new food-focused international agreements like the existing 2019 Memorandum of Understanding between Mexico and California to cooperate on agriculture and agricultural technologies.

California develops larger emergency food stocks.

With a reduction in production within California but continued threats such as health pandemics and earthquakes, California invests in larger emergency food stocks to guard against disruption in the case of a short-term or long-term disaster.

California offers additional retraining opportunities or expect an outmigration of some workers.

With an outflux of workers from primary food production and also food processing, California prepares to offer retraining opportunities for individuals connected to California's food system while agriculture was still an important source of revenue for the state. Without work opportunities, some residents working in the agricultural sector will migrate to states where food production is still a major part of the economy. Other residents who are unable to transition will need to turn to state-based benefits.

SELLING THE FARM

Considering the recent droughts and the actual fallowing of farmland, this scenario represents the status quo of food systems in California. It is a challenging scenario because it means that California loses both water and farm production because it failed to make choices in a timely fashion regarding climate adaptation and water management. No longer the nation's leading state in agricultural production, California will need to quickly find new food sources. Unlike in the scenario of "Canadian hothouse tomatoes and Mexican avocados," California will not have actively created import relationships to help California transition its food system to a new supply chain and there will be no long-term strategy to compensate farmers for their farmland as it



is repurposed for wildlife habitat or municipal needs. California will just be competing for food with other places with potentially increasing numbers of Californians who have been displaced from agricultural industries unable to access food. Some farmers may survive but this will depend on the availability of appropriate land and appropriate crops.

California puts all future agriculture-related investments into developing drought-tolerant crops.

Without investments in new “foods” as in the “Innovation Nation” scenario, California’s best strategy for coping with a continued loss of water and recurring droughts is to invest in drought-tolerant crops. Drawing inspiration from global desert regions, certain nutritious crops will survive with marginal amounts of water including date palms, maize, sorghum, millet, cowpeas, and cassava.

California scales up its government incentives for precision farming.

In an environment of scarcity, California enhances its investments in precision farming to allow those farms that are able to survive with less water in hotter temperatures to “do more, with less.” Unlike the “Innovation Nation” scenario that imagines moving farming indoors, this scenario imagines precision farming in the existing fields. Yields are likely to shrink because the ability of “precision farming” to overcome environmental hurdles will have its physical limits.

In preparation for numerous farmers and farm workers facing unemployment or inability to maintain a profitable farm, the State of California invests in mental health resources and basic benefits for rural farming-dependent communities.

The individual transitions expected from this scenario will create conditions of chronic stress as families lose land assets and jobs. Economic recessions impacting certain parts of the state more than others will have social consequences. Farmers are more likely to take their lives than many other professions due to a combination of economic uncertainty, vulnerability to climate, and lack of support. Rural areas have been more prone to the opioid epidemic due to socioeconomic vulnerability and hopelessness. As the number of “ghost towns” increase in rural areas that empty out in response to climatic changes, California will need to consider how to deliver basic benefits to individuals who are unable to relocate. Without municipal funds to cover water, sewer, police, fire, and garbage services from taxes or levies, the state may need to bring in emergency managers and should be preparing today for this scenario by setting aside funding to cover basic emergency services.

California increases non-perishable or less-perishable food supplies for emergency food banks with wholesale purchases.

The inability to produce at similar scales to today will increase hunger across California as farmers, farmworkers, and food supply chain related employees lose essential income streams. This may lead to more demands on local food banks that may have been receiving shipments of surplus food from farms, wholesalers, processors, or retailers. California can invest in foods with long-shelf lives to distribute to residents in need.

