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A Declining Farm Labor Supply Could Cost California Farmers Billions

Zachariah Rutledge and Pierre Mérel

We analyze fruit and vegetable production and farm employment data to quantify the production and value losses from a declining supply of farm labor. We find that reduced labor availability could generate billions of dollars in losses over the next decade.

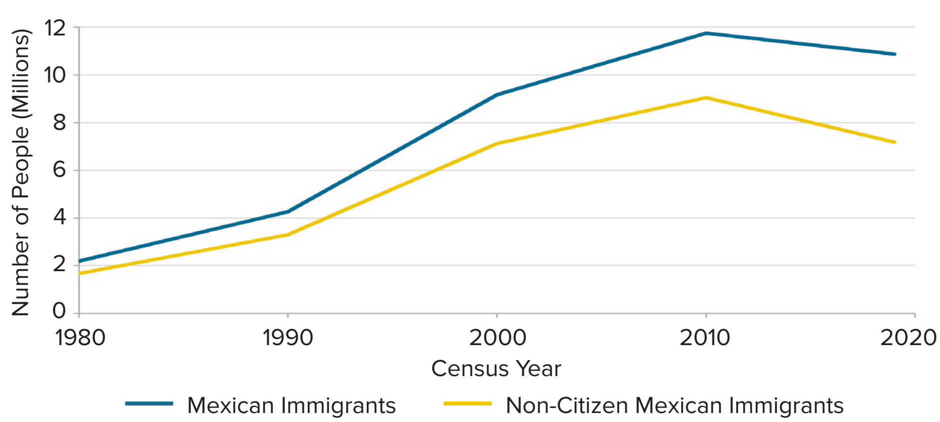
California's agricultural sector requires an army of workers to cultivate and harvest a multitude of labor-intensive crops. As the most prominent specialty-crop state in the United States, California produces two-thirds of the domestically produced fruits and nuts and one-third of the vegetables. However, in recent years, an alarming number of farmers have reported labor shortages that have reduced their capacity to harvest.

This issue has stimulated a dramatic surge in demand for the H-2A visa program, which allows domestic agricultural employers constrained by labor availability to hire temporary foreign-born workers. In fact, the number of H-2A jobs certified for work in California has increased by more than 1,900% over the past decade (from about 1,600 in FY2011 to 33,000 in FY2021). Indeed, a growing body of economic research shows that the supply of farmworkers in the United States has been on the decline.

A declining farm labor supply could fundamentally alter the nature of California agriculture by reducing profitability and causing farmers to opt out of labor-intensive crop production in favor of crops whose harvest can more easily be mechanized, such as tree nuts, field crops, or wine grapes. Reduced labor availability on domestic farms could also contribute to food price inflation and cause our nation to become increasingly dependent upon foreign producers, generating new social costs—e.g., in terms of transportation-related carbon emissions or lower food safety and quality. While the labor shortage issue has garnered media attention, highlighting farmer losses at harvest time, in this study we seek to quantify its economic impacts on California agriculture. We use detailed crop production and farm employment data from California counties to estimate the impact of changes in farm labor supply on the production and value of hand-harvested fruits and vegetables.

As shown in Figure 1, during the decade from 2010 to 2020, the number of Mexican immigrants in the United States declined for the first time in

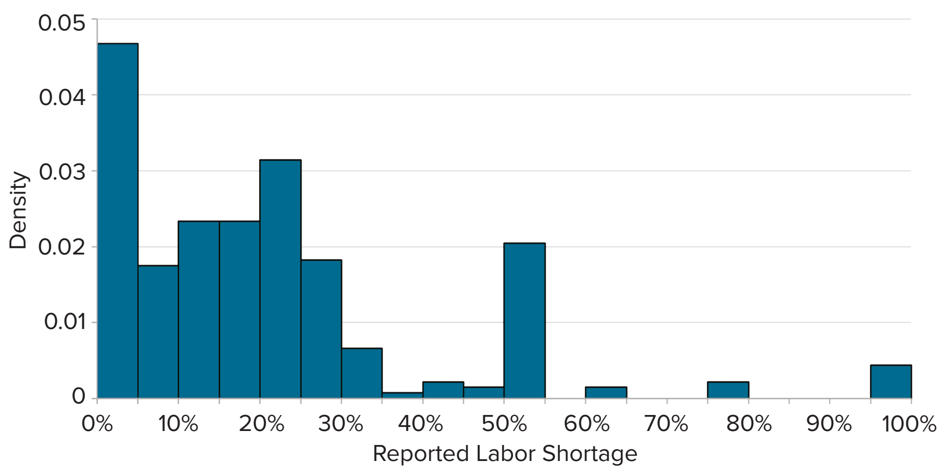
Figure 1. Number of Mexican Immigrants by Year, 1980–2019



Source: Authors' calculations of U.S. Census and American Community Survey data.

history. California's farm labor force is comprised primarily of Mexican immigrants, so a decline in the number of Mexicans residing in the country could reduce labor availability for fruit and vegetable producers. A recent survey conducted by UC Davis, Arizona State University, and the California Farm Bureau Federation, which gathered information from more than 900 California farmers in the spring of 2022, reveals that 45% of surveyed farmers reported problems hiring enough employees during 2020. These results echo a previous survey published in a 2019 issue of *ARE Update*. Figure 2 depicts the percentage of their desired workforce that farmers experiencing a labor shortage were unable to hire. Among those reporting difficulties hiring workers, the average shortage was 20%.

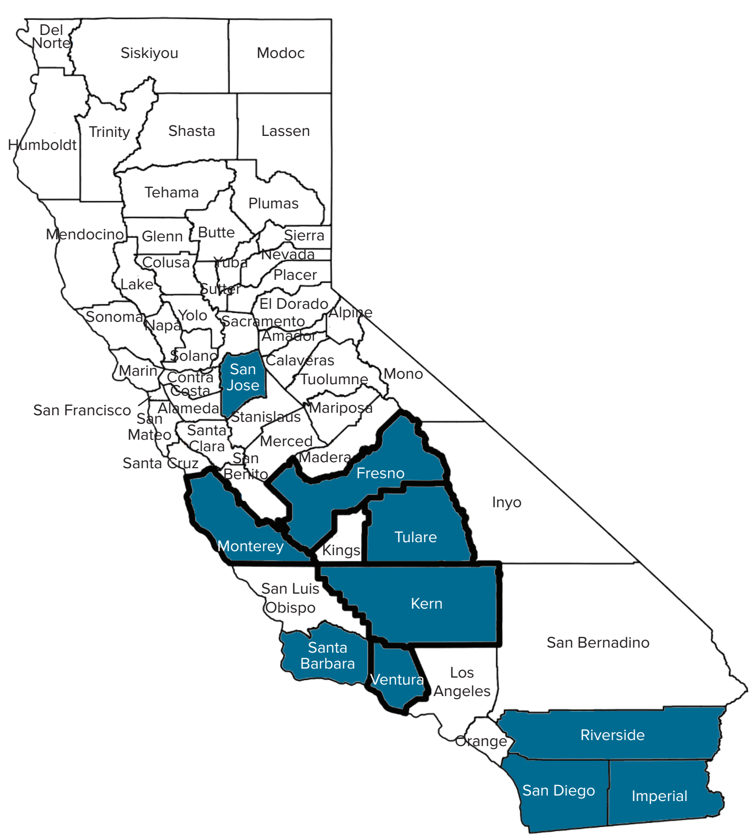
Figure 2. Histogram of Labor Shortage Intensity in 2020 for Surveyed California Farmers



Source: Authors' calculations of farmer responses from the 2022 CFBF Farm Labor Survey.

Note: Based on the responses of farmers who indicated they had a labor shortage, in answer to the question: "In percentage terms, approximately how many employees did you lack for the production of your [main crop] in [your main county] during 2020? Please enter a number between 1 (meaning 1%) and 100 (meaning 100%) in the box below or select 'I don't know.'"
Sample size: 274.

Figure 3. Top 10 Labor-Intensive Crop-Producing California Counties



Note: The top 10 counties are shown in blue. The top 5 counties are outlined with a thick black border.

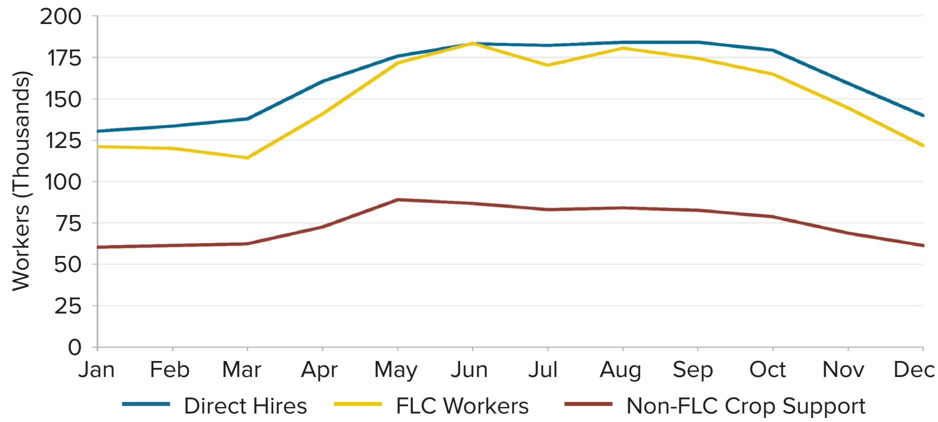
A number of factors have been linked to the decline in farm labor supply. To start, until recently, tighter border security measures have made it more difficult for undocumented workers to enter the country. Farmworkers in the United States have also settled down and are much less willing to engage in follow-the-crop migration, reducing the geographical reach of local labor markets. Furthermore, job opportunities in the U.S. construction, food service, and personal service sectors have reduced the labor pool available to U.S. agricultural producers.

Data Description

In this study, we use a statistical model to estimate a relationship between crop employment and production data from the top 10 fruit- and vegetable-producing counties in California (see Figure 3). Our analysis utilizes detailed crop production data from the California County Agricultural Commissioners' Reports and employment data from the Quarterly Census of Employment and Wages. We restricted our sample of crops to those that did not have a mechanical harvest technology available during our study period (1990 to 2019). Our employment measures include workers hired directly by crop farmers (NAICS code 111) and those that are brought to farms by farm labor contractors (FLC; NAICS code 115115), to capture the set of workers who are most likely to serve in the harvest labor force.

Our analysis measures farm employment during each county's peak employment quarter—the period of time when the bulk of the county's harvest activities take place and production activities are particularly sensitive to employee availability. Figure 4 shows monthly state-level crop employment for each group of crop workers in 2019, the last year in our sample. While this figure highlights the seasonal nature of agricultural employment in the state, it masks regional differences. For example, some counties, such as Imperial County, perform the bulk of their harvest activities in the winter and spring months; our analysis takes into account these differences.

Figure 4. Monthly Crop Farm Employment in 2019



Source: Quarterly Census of Employment and Wages.

Note: FLC is an abbreviation for the term farm labor contractor. Farm labor contractors are intermediaries who bring workers to farms to perform certain tasks, such as weeding, pruning, and harvesting.

Production Results

Fruits and Vegetables

The estimates from our statistical analysis indicate that a 10% reduction in the farm labor supply causes, at most, a 4.2% reduction in hand-harvested fruit and vegetable production in the top 10 counties. These production effects are driven mainly by a reduction in the number of acres harvested, but we also find small effects on crop yield. Specifically, a 10% decline in the farm labor supply could cause as much as a 2.8% decrease in the number of acres harvested and a 1.4% decrease in yield.

According to our data, in 2019, the top 10 counties produced about 16 million tons of hand-harvested fruits and vegetables on roughly 1.1 million acres. Thus, our estimates imply that a 10% decrease in the supply of farm labor could cause as much as 31,000 (1,100,000 x 2.8%) fewer acres of fruits and vegetables to be hand harvested each year, and up to 670,000 (16,000,000 x 4.2%) tons of lost produce. A reduction in crop yields may result from scarce crews engaging in selective harvesting to bring in the most valuable produce, or a reduction in the number of rounds of harvests that would have normally taken place for crops, like strawberries, that do not ripen uniformly during the growing season.

We also investigate whether production losses would be greater if fewer direct-hire workers were available, as opposed to fewer FLC workers, who tend to include a higher percentage of undocumented immigrants. Our estimates indicate that a decline in the supply of direct hires would have a greater impact on production, suggesting that a stable, documented workforce is important for labor-intensive agriculture. This finding may also be partly driven by the fact that direct-hire employees tend to have more employer-specific job experience. For example, data from the National Agricultural Workers Survey reveal that direct hires have an average of two additional years of work experience relative to their FLC worker counterparts and are about 15 percentage points more likely to have had only one employer during the previous 12 months (72% of direct hires had a single farm employer during the previous 12 months compared to 57% of FLC workers).

Mechanically Harvested Nut and Field Crops

We also perform a parallel analysis on mechanically harvested nut and field crops. One would expect the production of mechanically harvested crops to be much less sensitive to labor availability. Indeed, our analysis fails to uncover a statistically meaningful relationship between the supply of farm labor and the production of nut and/or field crops, suggesting that the aggregate production of mechanically harvested crops is largely unaffected by labor supply shocks. In some specifications, our estimates even suggest that a reduction in farm labor supply might cause an increase in the production of mechanically harvested crops. One possible explanation for this result is that farmers partially anticipate labor shortages and switch acreage towards labor-saving crops.

Production-Value Results

Our results suggest that the primary economic impacts of a labor shortage would be concentrated in the top five labor-intensive fruit- and vegetable-producing counties, where about two-thirds of the state's labor-intensive crops are grown. In those counties, we find that a 10% decline in the supply of farmworkers could cause at most a 5.5% decrease in the total value of labor-intensive crops. Our calculations indicate that if the farm labor supply were to decline at a rate of 1% per year, as recent estimates suggest, California farmers in these top five counties could lose as much as $3.7 billion dollars over the course of a decade. Due to the high value of California's hand-harvested fruit and vegetable crops, such a loss would account for about 3% of the total value of these crops.

Conclusions

California farmers have reported labor shortages for over a decade. Such shortages have caused undeniable production losses as well as changes to production- and labor-management practices. Previous economic studies have argued that the supply of farmworkers, which is comprised mainly of Mexican immigrants, is on a downward trajectory.

In this study, we quantify the extent to which decreases in the farm labor supply may affect the production and value of hand-harvested fruit and vegetable crops in California. Our analysis suggests that a declining farm labor supply could create billions of dollars in lost crop value over the next decade, yet the aggregate production of fruits and vegetables is expected to remain relatively stable. Importantly, our analysis shows that mechanically harvested crops are largely unaffected by changes in labor supply, suggesting that mechanized harvesters for currently hand-harvested fruit and vegetable crops could serve as an alternative if they were advanced enough to avoid damage that is considered unacceptable to buyers.

For instance, recent technology developments include tiered, targeted shake-and-catch harvest systems that prevent fruit from falling more than 12 inches, robotic arms that target specific branches on a tree, artificial intelligence (AI) vision systems that identify fruit location on tree branches, and co-robots that work along harvest workers. However, industry experts have cited concerns about these systems. Notably, there are lingering issues with speed and accuracy, damage caused to fruit and plants, ability to harvest all the marketable fruit, and costs of adoption.

In some cases, adoption would also require overhauling the production process, possibly through the use of plant varieties that are bruise resistant, or changes to infrastructure. For example, automated apple harvesters are being developed that require trees grown in a vertical trellis system, which enables the AI vision system's fruit-recognition software to identify ripened fruit in a two-dimensional canopy. Such systems require large up-front investments, and adoption may only be feasible for large producers who can spread the cost over a large volume. As a result, if these technologies evolve to a stage where they are ready to be deployed, smaller operations could be priced out of the market, and the scale of production could be altered.

True to its intentions, the H-2A foreign agricultural guest worker program, which has expanded rapidly over the past decade, has helped relieve agricultural labor supply pressures. However, employing workers through the H-2A program is significantly more expensive than employing immigrant workers who currently reside in the country. As a result, agricultural employers face a tradeoff between paying more for H-2A labor and the risk of not being able to secure U.S.-based workers during harvest time. Thus, even if the H-2A program serves as a short- to medium-run solution for the farm labor problem, it seems likely that labor costs will continue to rise and that consumers will ultimately bear some cost.

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Authors' Bios

Zachariah Rutledge received his Ph.D. from the ARE department at UC Davis. He is currently an assistant professor in the Department of Agricultural, Food, and Resource Economics at Michigan State University. Piere Mérel is a professor in the ARE department at UC Davis. They can be reached at rutled83@msu.edu and merel@primal.ucdavis.edu, respectively.

For additional information, the authors recommend:

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Dryland Cropping May Present a Cost-Effective Response to Dust From Idled Lands

Andrew B. Ayres and Caitlin A. Peterson

Agricultural lands idled to reduce groundwater demand in California's Central Valley can generate dust and pose risks for rural communities. To avoid the worst impacts, it may be necessary to support productive alternatives like dryland farming or other mitigation measures.

Overdraft of groundwater has led to land subsidence, infrastructure damage, water quality impairments, and the depletion of drought reserves in many of California's groundwater basins. The Sustainable Groundwater Management Act (SGMA), legislation passed in 2014, calls on local governing bodies to develop and implement plans to bring their groundwater basins into balance by the early 2040s.

However, the path to sustainability is fraught with difficult choices. In the San Joaquin Valley, home to most of the state's critically overdrafted basins, making up a two million-acre-foot annual groundwater deficit will require managing demand, most of which comes from agriculture. The valley could see half a million acres of cropland come out of irrigated production by the early 2040s, and potentially more, without new sources of supply (e.g., groundwater recharge).

The question of what happens to this newly fallowed cropland—or how to avoid fallowing altogether—is important both for the region's economy and for the well-being of valley communities. Fallowed cropland, whether left idle or tilled to manage weeds, can be a significant source of dust emissions. Wind mobilizes small soil particles from bare ground and lifts them into the air, dispersing them and exposing nearby communities. Coarse particulate matter (particulates 10 microns or less in diameter, PM_{10}) has been shown to negatively impact human health, particularly in children, and increased dust emissions from idled cropland could hinder the valley's recent progress on air quality.

Protecting communities from these impacts depends predominantly on disrupting the wind erosion processes that generate dust in the first place. Covering the ground with wind-stable elements such as mulch has been successful elsewhere, but it is expensive. Establishing vegetative cover is likely the simplest and most cost-effective solution for slowing wind speeds on the ground and inhibiting dust generation.

Adopting alternative, productive land uses presents an opportunity to achieve this mitigation while also minimizing the economic downside of fallowing. In particular, planting a winter dryland crop, such as a cereal or forage, could be one way to reduce dust and generate revenue. Dryland crops are produced only with rainfall and stored soil water. Some areas of the valley could likely establish these crops with no irrigation; elsewhere, small, targeted irrigation events—termed "water-limited" cropping here—could greatly reduce agronomic risks.

While both dryland and water-limited cropping can be challenging in drier areas of the valley, in some cases they could be viable alternatives to fallowing that mitigate dust and offset the costs of fallow management. Economic support to promote public benefits—whether for dryland cropping systems or other mitigation actions—could help reduce risks in priority areas.

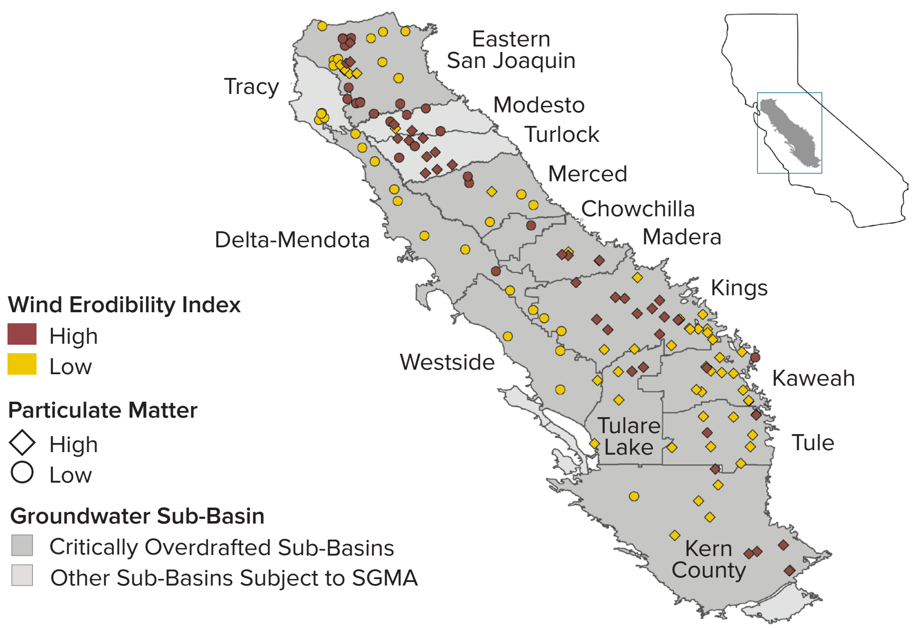
Understanding Dust Risk in the San Joaquin Valley

To understand the potential dust risks posed by large-scale land fallowing, we first characterized the net effect of idling lands on local concentrations of particulate matter. Regional stakeholders are particularly interested in this question because some tilling and harvest activities already generate significant emissions from agricultural lands. Second, we mapped the distribution of dust risk in the valley according to soil erodibility and baseline particulate matter concentrations. We focused on small rural communities, where nearby fallowing could cause immediate problems.

To analyze how different land cover types relate to local particulates, we compiled an annual dataset of groundwater basins from 2010–2016. It combines acreages of six major land cover types from the USDA Cropland Data Layer with local particulate matter (fine particles below 2.5 microns in diameter, $PM_{2.5}$) concentrations from NASA. We also controlled for wildfire activity during our analysis period with burn data from CAL FIRE.

This analysis supports two conclusions. First, the net effect of idling irrigated agricultural lands on local particulates depends on crop type: while idling annual crops (such as vegetables) would likely increase particulates, current harvest techniques for some orchard crops generate enough dust that idling may reduce particulate concentrations. Second, timing matters. Dust generation from orchards occurs primarily in late summer and early fall during harvest. Overall, relationships between land cover and local particulates are weakest in winter, when large wind events are less frequent.

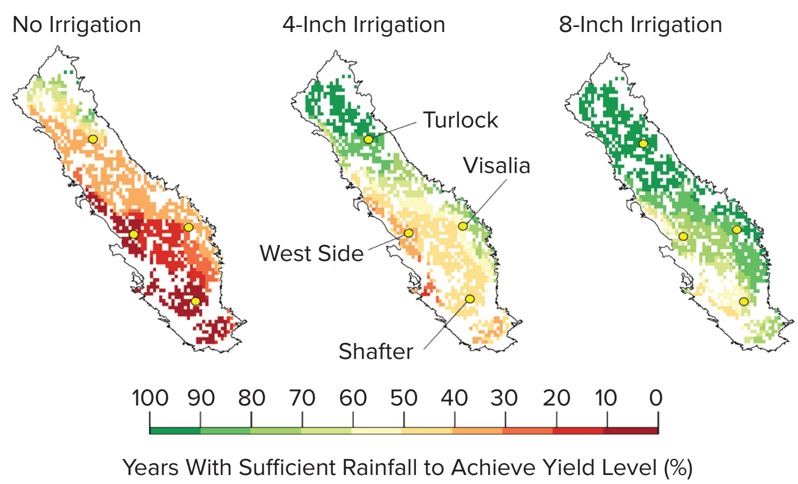
Figure 1. Distribution of Dust Risk Across San Joaquin Valley Communities



Source: Authors' estimates using data from NASA SEDAC (particulate matter concentration) and UC Davis (Wind Erodibility Index). Details in Ayres et al. (2022).

Note: Plotted points are community water systems and outlined areas are groundwater sub-basins. Dust risk is based on the Wind Erodibility Index (high: WEI>86) and particulate matter (PM) averages (high: ambient $PM_{2.5}$>12 μg/m³ over 2010–2016). All values are calculated within 1.5-mile buffers.

Figure 2. Probability of Attaining 5-Ton Winter Wheat Forage Yields Across the San Joaquin Valley



Source: Authors' estimates; precipitation from PRISM Climate Group; cropland mapping from the California Department of Water Resources. Details in Peterson et al. (2022).

Note: Probabilities reflect the relationship between simulated winter wheat biomass production and total water input (rainfall + irrigation), spatially extrapolated using PRISM 10-year average rainfall.

Dust risk varies across the valley. While particles can sometimes travel long distances from their source, landscape-based dust tends to contain larger particles that generate localized impacts. Rural areas surrounded by farmland are at the greatest risk, and we investigated their surrounding soil characteristics to characterize risk differences among them.

Using a dataset of water systems from the State Water Resources Control Board, we identified 147 rural locations surrounded predominantly by farmland. We summarized 1) soil erodibility using the USDA NRCS Wind Erodibility Index (WEI) and 2) local particulate concentrations using the NASA data described previously, and then defined thresholds for these variables to denote high risk.

Of the valley's rural communities, 63 face high risks due to erodible soil types (Figure 1). These are spatially concentrated in the valley's central-east and north-central areas, and most also exhibit high baseline particulate concentrations—a common feature of valley communities. The ultimate distribution of risk across communities will chiefly depend on where land is idled, including how farmers trade water to avoid fallowing. If there is no trading, and water-use reductions occur in areas with the greatest overdraft, the majority (75%) of high-risk locations will see fallowing, but this outcome could change significantly with trading of surface water and groundwater.

Dryland Crops Could be a Viable Dust Solution in Some Areas

Dryland crops offer a productive alternative to fallowing and can mitigate dust risks, but growing conditions across the valley vary substantially. Using the crop model APSIM (www.apsim.info), calibrated with empirical data from winter cereal field trials, we simulated winter wheat forage production for 20 years of historical weather at key sites in the San Joaquin Valley. Because rainfall constrains dryland crop productivity, we mapped the likelihood of successful crop establishment and productivity across the valley based on the relationship between modeled yield and average rainfall.

Grain yields can be low in dryland systems, so the most efficient use of water is often to harvest winter cereals for forage. In areas that receive less than 10 inches of rainfall annually, such as the southern and western portions of the valley, dryland wheat forage would fail in most years (Figure 2). In contrast, water-limited wheat that receives one to two applications of 4 inches of irrigation could produce five tons per acre of forage on orders of magnitude more land across the valley. If the crop and its residues are managed carefully, these systems could also control dust emissions.

But does this tactic pencil out? Not all areas that are suitable according to these models will actually transition from irrigated to dryland or water-limited crop production. Other considerations beyond agronomic potential will affect where and when these systems make sense as an alternative to land fallowing. For example, water-limited crops gain tractability when other lucrative land use options are unsuitable, small quantities of water cannot be banked or transferred elsewhere, or growers wish to implement a flexible crop that can be sacrificed should recharge floodwaters become available. Furthermore, water-limited crops are more likely to be financially self-supporting where growers can keep operating costs low.

We consulted UC Davis cost and return studies for winter wheat grain and forage and adjusted the assumptions to better reflect water-limited crop systems as well as recent price trends. Prices for forage products vary dramatically from year to year, so financial outcomes are sensitive to cost and price scenarios. When hay prices are high, positive net returns may be possible across a wide range of forage yields (Table 1). But at lower prices, higher yields are required to keep operations profitable. Such yields may not be possible in low-rainfall areas of the valley, or when supplemental irrigation is infeasible.

We found that, for a range of cost assumptions, four-ton forage yields resulted in positive net operating returns unless hay prices fell to $120 per ton. Five-ton forage yields resulted in more comfortable margins. However, when operating costs were high—we assumed $500 per acre-foot for water, $0.75 per pound for nitrogen fertilizer, and $5 per gallon for diesel fuel, in addition to costs for other inputs and labor—hay prices below $120 per ton still resulted in negative net operating returns at the five-ton yield level. Note that our estimates of operating costs did not include overhead (e.g., land rental); this is an important caveat, as operating returns would need to be high enough to cover overhead to result in a net profit.

Strategic applications of small amounts of irrigation on winter forages could represent a competitive value for water. Under a scenario with moderate costs and prices—$165 per ton hay price and $300 per acre-foot of water—going from zero to two applications of supplemental irrigation increased net returns by roughly $200–$300 per

Table 1. Net Operating Returns for Dryland (No Irrigation) and Water-Limited (8-Inch Irrigation) Forage Marketed as Hay

a) Net Operating Returns for High-Cost Assumptions

	No Irrigation					8-Inch Irrigation				
	Hay Price ($/Ton)					Hay Price ($/Ton)				
Hay Yield (Ton/Acre)	100	120	160	200	240	100	120	160	200	240
1	-157	-137	-97	-57	-17	-618	-598	-558	-518	-478
2	-107	-67	13	93	173	-568	-528	-448	-368	-288
2.5	-82	-32	68	168	268	-543	-493	-393	-293	-193
3	-57	3	123	243	363	-518	-458	-338	-218	-98
4	-7	73	233	393	553	-468	-388	-228	-68	92
5	43	143	343	543	743	-418	-318	-118	82	282
6	93	213	453	693	933	-368	-248	-8	232	472

b) Net Operating Returns for Low-Cost Assumptions

	No Irrigation					8-Inch Irrigation				
	Hay Price ($/Ton)					Hay Price ($/Ton)				
Hay Yield (Ton/Acre)	100	120	160	200	240	100	120	160	200	240
1	-137	-117	-77	-37	3	-299	-279	-239	-199	-159
2	-87	-47	33	113	193	-249	-209	-129	-49	31
2.5	-62	-12	88	188	288	-224	-174	-74	26	126
3	-37	23	143	263	383	-199	-139	-19	101	221
4	13	93	253	413	573	-149	-69	91	251	411
5	63	163	363	563	763	-99	1	201	401	601
6	113	233	473	713	953	-49	71	311	551	791

Source: Authors' estimates based on expert input and UC Davis cost and return studies for winter wheat grain and forage. Details in Peterson et al. (2022).

Note: The 8-inch irrigation scenario represents two 4-inch applications. Net operating returns are for a) high-cost assumptions ($500/acre-foot water, $0.75/pound nitrogen fertilizer, $5/gallon diesel) and b) low-cost assumptions ($100/acre-foot water, $0.42/pound nitrogen fertilizer, $4.16/gallon diesel). Costs for labor and inputs, such as seed and herbicide, are identical for both scenarios. Costs do not include overhead.

acre. This translates to $320–$460 per acre-foot of water, comparable to the marginal value of irrigation water for some of the valley's more profitable crops.

Other Ground Cover Approaches for Dust Mitigation Have Varying Costs

When there are agronomic or economic barriers to water-limited crop production, cover cropping, strip cropping, and other low-intensity approaches to maintain vegetative cover offer an alternative mitigation option. Likewise, interventions that cover or alter the landscape to reduce wind erosion have proven effective elsewhere in California. We combined a review of cost estimates from federal programs, additional cost studies, and interviews with valley land managers to estimate costs for these approaches.

Landscape alterations, often using gravel or mulch to cover the ground, can minimize dust for long periods of time if undisturbed, but they are also costly. Per-acre costs of several hundred or even thousands of dollars (2019 USD) will render them unattractive, especially if lands taken out of irrigated production are not contiguous and cannot benefit from economies of scale. However, there are some emerging, lower-cost options: mulch from decommissioned orchards and nut processing byproducts such as almond hulls can also be spread to reduce dust.

In contrast, vegetative cover and wind barriers can be established and reduce dust generation for much less. These measures need not cover the entirety of an idled field, which provides potential cost reductions. Cross-wind vegetative strips, for example, could cover as little as 20% of the field and cost as little as $10–30 per acre (2019 USD). However, the average per-acre cost depends on the size of the project, the method used to distribute seeds, the need for additional inputs (such as fertilizer), and maintenance requirements. These approaches are flexible, and some have a history of success elsewhere in California and the West.

As noted above, establishing vegetation in arid landscapes is challenging. Beyond water needs, new plantings also must contend with the legacy of fertilizer and other agricultural inputs that create conditions favorable for weed competition—which can reduce the likelihood of success and increase maintenance costs. Efforts to establish native vegetation for dust control on formerly irrigated lands in the nearby Antelope Valley encountered difficulties with weed competition, and reports emphasized the role that chance rainstorms played in supporting establishment of planted natives by providing much-needed moisture. Moving forward, these difficulties may grow as climate change increases drought intensity and air temperature, placing greater stresses on unirrigated plants.

Effective Mitigation May Require Support

As groundwater managers work with pumpers to reduce groundwater use, they will need to consider the consequences of reduced irrigation water availability. Where dryland farming can be profitable, it can help offset local economic losses from reduced water availability while alleviating dust impacts. Where land losing access to irrigation water doesn't have a clear productive use and must be actively managed for dust, it may become a financial liability—and complicate efforts to close groundwater deficits. In these cases, financial support for dust mitigation can expand opportunities for reducing risk in priority areas and alleviate the impacts of water scarcity on land value.

Existing programs can enable land transitions that responsibly control dust. For example, the NRCS Environmental Quality Incentives Program already supports similar activities elsewhere, and the state's new Multi-Benefit Land Repurposing Program can facilitate integrated solutions. Proactively setting up accessible systems can ensure solutions are ready to go when needed, helping to avoid costly environmental impacts on the valley's rural communities.

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Authors' Bios

Andrew B. Ayres is a research fellow in the Water Policy Center at the Public Policy Institute of California (PPIC). Caitlin A. Peterson is associate director and also a research fellow in PPIC's Water Policy Center. They can be reached at ayres@ppic.org and peterson@ppic.org, respectively.

For additional information, the authors recommend:

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Developments in the Avocado Sector and Their Implications for California Producers and Consumers

James E. Sayre

Avocado consumption per capita in the United States has tripled in twenty years, yet California has decreased its bearing acreage over the last decade. One state in Mexico has primarily fulfilled this surge in demand, but newer importers may compete more directly with California producers and drive down consumer prices.

It is almost unthinkable now to imagine fancy coffee shops without avocado toast, or a Super Bowl party without copious amounts of guacamole. However, the widespread popularity of avocados in the United States is a recent phenomenon. According to the U.S. Department of Agriculture (USDA) Economic Research Service (ERS), the quantity of avocados consumed per person in the United States tripled from 2000 to 2021; the average person now consumes more than eight pounds per year.

The proliferation of imports in the U.S. market has been a substantial reason for the rapid increase in avocado consumption. The USDA ERS reports that imports (almost 90% of which are from Mexico) now account for 90% of domestic consumption, whereas in 2000, they accounted for only 40% of consumption. With this increase in imports came the rise of marketing boards designed to preserve high domestic prices for producers. In a 2019 *ARE Update* article, Hoy F. Carman describes the development of the Hass Avocado Board (HAB), which imposes a fee on both domestic and foreign producers in order to fund U.S. avocado promotion programs designed to support greater domestic demand. Carman, Saitone, and Sexton also show that the HAB has been successful in expanding domestic demand amongst rising imports and achieves benefits for domestic producers several times larger than its costs.

Prior to 1970, avocados consumed in the United States came almost entirely from domestic sources, primarily California and Florida. Consumption was predominantly local and seasonal, with less supply in the winter. During this time, the Hass avocado became popular relative to other varieties—crucially, it had a thicker and darker skin, allowing for transport over longer distances without visible damage. Imports of Hass avocados increased in 1985, when Chile began exporting to the United States. Chile, whose harvest season ranged from August to January, had a growing season that complemented the U.S. growing season, and consumers began to have consistent year-round access.

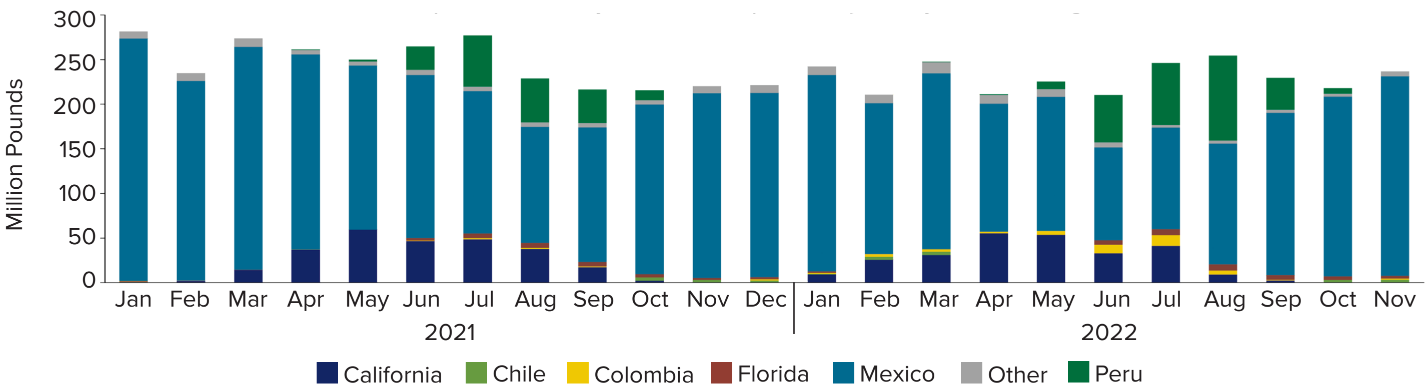
In 1914, the USDA imposed a phytosanitary quarantine on Mexican avocados to prevent the introduction of seed weevils, stem borers, and other pests. Due to this rule, Mexico was left out of the U.S. market for around 80 years. In the *California Avocado Society Yearbook*, Bender and Shepherd note that while pest concerns were legitimate initially, the quarantine remained in effect to protect California avocado growers from potential competition from Mexico.

In 1972, large farm owners in Michoacán and Sinaloa petitioned the USDA Animal and Plant Health Inspection Service (APHIS) for approval to export avocados. Field surveys performed in both areas found no evidence of pests, and the success of Mexican growers seemed so likely that newspapers in the state of Sinaloa prematurely reported that exports would be allowed into the United States. However, opposition towards potential imports mounted from California growers, and the industry was able to successfully lobby to forestall their introduction, according to Orden and Roberts in their article on phytosanitary restrictions on U.S. avocado imports.

Farmers near Uruapan, Michoacán, formed growing associations in the early 1990s to fulfill the requirements of USDA APHIS. The largest growers' association—the Association of Avocado Exporting Producers and Packers of Mexico (APEAM)—submitted a petition to export avocados to the United States but gained entrance only to Alaska. In the wake of NAFTA, the USDA proposed a rule that only allowed imports in from the Mexican state of Michoacán—despite the existence of exporters to other countries in the states of Guanajuato, México, Nayarit, Puebla, and Sinaloa. This agreement helped protect U.S. growers but concentrated production within Michoacán and decreased avocado production elsewhere in Mexico. Growers in other Mexican states to this day voice frustrations with the lingering implications of this rule and how it has hindered them from producing avocados for the U.S. market.

In 1997, the United States allowed imports to a limited number of states during the winter, and imports continued to expand. By 2005, Mexico surpassed Chile as the largest exporter of avocados to the United States. Finally, by 2007, imports were allowed into all states year-round, cementing the status of Mexico as the largest U.S. supplier. The United States is now the largest market for Mexico, accounting for 40% of its exported avocados.

Figure 1. Domestic and Imported Monthly Avocado Shipments in the United States, January 2021 Through November 2022



Source: USDA, Agricultural Marketing Service, *Market News*, movement data. Available at: https://www.ams.usda.gov/market-news.

In the California market, the increased popularity of avocados led to an increase in the bearing acreage of avocados from around 20,000 acres in 1960 to a high of 75,000 acres in 1990. Then, in the early 1990s, competition from Chile, combined with fears of (even healthy) high-fat foods, resulted in a market crash and a subsequent avocado acreage reduction. According to the California Avocado Commission, the bearing acreage of avocados has fallen by 15,000–20,000 acres between 2005 and 2022. Despite this decrease, the production value of the California crop has remained mostly constant over the last decade, largely due to the increasing prices of avocados.

New Developments in the Mexican Avocado Sector

Rising demand from East Asian countries opened the door for states other than Michoacán (namely Jalisco) to import avocados to the United States. Jalisco, more famous for its distilled agave production, produced few avocados before 2007, but good infrastructure and sophisticated growers allowed it to quickly enter the export market. The avocado industry in Jalisco was organized and productive, allowing it to fulfill the export requirements limiting other regions. This nascent industry in Jalisco opposed the rule that only permitted avocados from Michoacán to enter the United States and began a campaign to export there as well.

In 2016, given increasingly high prices for avocados, as well as increased recognition of Jalisco, the USDA APHIS allowed all Mexican states to import into the United States. Despite this, it took six more years for Jalisco to access the U.S. market; they first reached the U.S. market in late July 2022 and are expected to export between 175 and 220 million pounds this year. However, other states interested in exporting to the United States must undergo a complex process to apply for export certification. As of writing, no other regions appear poised to follow suit, despite the presence of avocado producers and exporters in those regions.

Due to the state-by-state restrictions on the exportation of avocados to the United States, production in Mexico outside of Jalisco and Michoacán has not experienced the same growth (and Michoacán has seen a recent decrease in the acreage of new avocado plantings). Since the United States is the largest export market for Mexico, these restrictions have likely diminished the role of Mexico in worldwide production relative to a counterfactual world without restrictions. In particular, this may have created space for new competitors such as Colombia and Peru, who may compete more directly with California producers.

Competition on the Rise

Researchers at the French Agricultural Research Center for International Development (CIRAD) project that from 2022 to 2025, the worldwide total of planted avocado acreage will increase by around 21%. CIRAD researchers found that the average world price for traded avocados has declined in the last six years, which is likely to continue. By 2027, CIRAD researchers estimate exportable production will double the 2020/21 levels, outstripping projections for demand. As North American and European markets account for 81% of current imports, these markets are expected to receive much of this supply.

The increases in North American-oriented supply are expected to come primarily from Colombia, Jalisco, and Peru. However, the degree to which each competes with California varies based on their growing seasonality. Although farmers can leave fruit on their trees for months and adjust their harvest to maximize revenues, the growing period tends to be relatively fixed by climatic conditions.

Jalisco, in particular, may have a more symbiotic relationship with California growers than some might expect. Although Mexico grows avocados year-round, harvesting in Michoacán peaks in April, and to a smaller degree in August, according to the Mexican Service of Agrofood and Fisheries Information (SIAP). In contrast, harvesting in Jalisco tends to peak between February and April, with a smaller peak in October. California production has historically peaked in June, so these growing seasons leave room for California producers to sell their output when production from Mexico is relatively lower.

Due to a lack of increased Mexican supply, distributors have sought new sources for avocados—namely Colombia and Peru. Although Chile used to be a large importer to the United States, Chilean imports have fallen to less than 1% of U.S. imports, shifting instead to Western Europe and domestic consumption. In contrast, Peru's imports have risen rapidly.

Peruvian imports went from 220 tons in 2010 to 134,000 tons in 2022 and now represent 7% of total U.S. imports. Importantly, the seasonality of Peruvian avocado production appears to be very similar to the seasonality in California, peaking in July, according to the Peruvian Ministry of Agrarian Development and Irrigation (MIDAGRI). This year California growers reported needing to sell their output earlier to receive higher prices before Peruvian supply picked up. Given the far distance, Peruvian fruit must be picked earlier than the California crop, and it trades at a discount due to its quality. Despite lower quality perceptions, importers have felt compelled to expand supply from Peru, given growing consumer demand.

Despite representing less than 1% of U.S. imports in 2021, Colombia has made big advances in imports this year (see Figure 1). This stems from investments in its nascent avocado industry, with more on the way—large numbers of export-oriented orchards will come into maturity after 2025. Colombian imports this year have arrived slightly earlier than most of Peru's crop, further pushing California growers to bring their fruit to market before the competition.

Implications for California Consumers and Producers

Although foreign competition has arguably reduced avocado acreage in California, it has also more than tripled domestic per-capita consumption. The year-round availability of avocados has contributed to greater consumption, and the complementary growing seasons of Mexico and the United States have protected California growers who have benefited from the change in consumer preferences. Place-based restrictions on avocado supply from Mexico have created space for newer avocado producers such as Columbia and Peru. While the two countries' rise bears the potential to lower prices for consumers, they are also in more direct seasonal competition with California growers. Although the HAB has successfully maintained demand growth among consumers in the United States, the United States alone cannot bear all the increase in world supply.

However, local and export markets hold potential for California growers. Despite much higher input prices, the California crop is known for its high quality, and industry participants have noted that exporters have tended to ship California avocados first to new markets to establish a reputation for taste and quality among consumers. This suggests there is potential for marketing credence attributes for California avocados, such as organic and quality labeling, fair labor, sustainability, and traceability practices. In particular, California provides more organic avocados to the U.S. market than any other supplier.

Export markets, particularly in East Asia, also hold promise for the California avocado industry. From 2009–2020, California exports increased more than fivefold. China, Japan, and Korea account for much of the recent export growth. Although demand has not increased greatly in recent years, these countries hold high potential for increased marketing. These markets are also known for high quality standards, which California is well positioned to fulfill. And, just as the supply of Mexican avocados has helped increase demand domestically by supplying avocados year-round, California has the opportunity to supply avocados to these new markets when other countries' exports are not seasonally available.

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Author's Bio

James E. Sayre is a Ph.D. candidate in the Department of Agricultural and Resource Economics at UC Berkeley. He can be reached via his webpage at: http://jaysayre.com.

For additional information, the author recommends:

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Giannini Foundation of Agricultural Economics, University of California

Department of Agricultural and Resource Economics
UC Davis
One Shields Avenue
Davis, CA 95616

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Ria DeBiase
Giannini Foundation of Agricultural Economics
Department of Agricultural and Resource Economics
University of California
One Shields Avenue
Davis, CA 95616
E-mail: rwdebiase@ucdavis.edu
Phone: 530-752-3508

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