RESEARCH ARTICLE

Adaptation and sustainability: Lessons from Central Coast organic farmers during the pandemic

Diversity in both cropping and marketing practices helped organic farmers meet pandemic challenges.

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Abstract

The challenges faced by organic vegetable farmers in California during the COVID-19 pandemic included uncertainty about food safety rules and best practices, availability of workers, and significant changes to their markets. When the pandemic began, we built on an ongoing interdisciplinary research project with organic vegetable farmers on the California Central Coast to track how those growers adapted to the crisis. We conducted surveys in April 2020 and January 2021 to determine impacts on farmers and how farm size, market channels, and management strategies influenced a farm's ability to adapt to and recover from pandemic-induced disruptions. We found that mid-sized farmers with flexible and diverse marketing channels could navigate changes from the pandemic with minimal losses and, in some cases, economic gains. By contrast, smaller farmers with limited resources, especially those with disadvantaged backgrounds and limited access to technology, experienced more drastic impacts, including lost markets, labor shortages, and increased childcare needs. The lessons learned can inform a transition toward more sustainable, resilient agroecological systems.

In March 2020, the COVID-19 pandemic began to disrupt life in California, including the food system. Tracking this disruption, we wanted to learn how organic vegetable growers on the California Central Coast experienced challenges, as well as how they adjusted to dramatic changes in markets. Our research explored how farming scale, diversity of crops, and diversity of markets influenced farm resilience.

The Diversified Farming Systems group at the University of California, Berkeley, has worked with 18 organic vegetable farmers in the Central Coast region since 2018. The farmers span a range of social backgrounds and farming models. They operate farms with varied sizes, farming practices, labor practices, and markets (Esquivel et al. 2021). To varying degrees, they use diversification practices such as cover cropping, crop rotations, multiple crops, hedgerows and other practices that nourish soils and biodiversity. Before the pandemic, we had begun building a large dataset of soil, ecological and social conditions on each farm to investigate whether higher diversification is

Flower border on a farm in Monterey County. UC Berkeley researchers surveyed Central Coast farmers about the impacts of the pandemic and the changes they made to production and marketing. Being able to quickly adapt to new market opportunities was helpful for farmers in overcoming uncertainty and market interruption. *Photo*: rightdx, iStock.

associated with healthier soils and richer on-farm biodiversity. We have also studied how organic vegetable farmers in this particular region decide to engage in diversification practices (Carlisle et al. 2022; Esquivel et al. 2021). These practices became important to surviving the pandemic.

In 2020, with the pandemic abruptly creating major hardships for the farmers with whom we were working, we decided to leverage our existing project to conduct a rapid response study exploring the challenges and opportunities the pandemic created for organic vegetable farmers. Our objective was to learn why some farms exhibited more resilience during pandemic conditions. We asked farmers in our core sample group to share their experiences via two rounds of surveys in April–May 2020 and December–January 2021. Our findings provide insight not only into whether and how more diversified farmers were better situated to adapt to the pandemic, but also to coping with ongoing challenges such as climate change. Finally, our work underlines the need for researchers to adapt during a systemic shock that also disrupts their field studies.

Central Coast organic farms

California is integral to U.S. agricultural production and has the highest farm sales of any state (CDFA 2021). Key commodities produced in California include milk, nuts, lettuce, fruit and other vegetables (CDFA 2021). The average farm size in California is 349 acres, although farm size in the state varies greatly (CDFA 2021). The farmers we surveyed are located in Santa Cruz County and Monterey County along the California Central Coast, the leading region for production of strawberries, lettuce and many other vegetables. In 2020, Monterey County ranked fourth statewide for highest commodity production value ($4 billion) (CDFA 2021). Although a leader in production for nationwide and export markets, California, and the Central Coast in particular, also has a robust local food system with strong demand for direct-to-consumer markets. During the pandemic, consumer demand for local agriculture grew, as seen in increased participation in community supported agriculture (CSA) memberships (Thilamany et al. 2020).

Farms in Monterey County had an average size of 1,214 acres in 2017, according to the U.S. Agricultural Census. About 46% of Monterey County farms had fewer than 50 acres and 20% had over 1,000 acres. This variety represents a mixture of small-scale family farms, mid-sized farms, and very large commercial farms (USDA 2017). By contrast, in Santa Cruz County, the average farm size was 102 acres, while 81% of Santa Cruz County farms were under 50 acres, considerably smaller than the state average (USDA 2017). Farms in our study ranged from less than an acre to 5,000 acres.

Organic agriculture has expanded rapidly in California, with sales from California in 2020 representing 36% of the U.S. total of organic farm products (CDFA 2021). Monterey County and Santa Cruz County are in the top five California counties for overall gross sales of organic products (CDFA 2021). Certified organic acreage represents 6.6% of harvested acreage in Monterey County and 12% of farmland in Santa Cruz County (CDFA 2021; County of Santa Cruz 2021). Organic farmers in California range from highly diversified operations to large-scale, intensive systems resembling conventional fields with few crops (Guthman 2000; Tscharntke et al. 2021). Marketing practices among organic growers vary greatly and include working with local cooperative food hubs; selling directly to consumers at farm stands, farmers markets, and CSAs; contracts with institutions such as schools and hospitals; and nationwide contract and wholesale sales to restaurants and shippers. In general, California farmers, including organic farmers, face tremendous pressure for rapid, high-volume production dictated by buyer preferences, high land rents, and high labor and production costs (Calo et al. 2021; Carlisle et al. 2022).

Diversified farms use practices such as planting diverse crop mixes, cover cropping, and applying compost to keep soil healthy, as well as planting non-crop plants like hedgerows to attract beneficial insects and birds. These practices foster biodiversity and can provide ecosystem services, such as pollination and flood protection, that benefit the surrounding environment (Kremen and Miles 2012; Tamburini et al. 2020). Large organic farms are less likely to use agroecological practices (Liebert et al. 2022). Prior research suggests that diversified farms may be more resilient during times of environmental and socioeconomic stress (Darnhofer 2010; Darnhofer et al. 2016). Resilience refers to the ability of farmers to navigate a natural or economic cycle by creating a buffer against shocks, responding to changing conditions, and transforming activities where necessary (Berkes 2007).

Farmers can use several strategies to increase the resilience of their farm, such as diversifying their crops, income sources, and productive activities. Diversity expands the options for managing shocks and creates new opportunities for farm survival (Berkes 2007). Darnhofer et al. (2016) note: "For those farmers growing a limited number of field crops, adaptability and thus resilience can be increased by introducing new crops or by combining several marketing channels." Organic farmers report financial viability and diversification as key factors in being able to respond to disturbances (Perrin et al. 2020). Emerging research provides evidence that farms that are both biologically diversified and diversified in their marketing strategies had increased resilience during the early COVID-19 crisis (Durant et. al. 2023 on CSA operations in California; Mastronardi et al. 2022 on multi-functional farms in Italy; Darnhofer 2020, on family farms in Austria).

This greater resilience may be associated with having a farming model that enables farmers to achieve greater biological diversity and maintain an economically viable operation. Previous research from our

group categorized farmers into three distinct farming models: limited resource, mid-sized and large operations (Esquivel et al. 2021). Based on our main interview data (not part of this study), we observed that each model had a typical farm size range: limited resource (small-scale, 0–20 acres), mid-sized (mid-scale, 21–350 acres) and large operations (large-scale, over 350 acres). Throughout our paper, we describe farms based on farm size using the following categories: small-scale, mid-scale and large-scale. These categories are rooted in the larger farm model typology described by Esquivel et al. (2021). These farm models and, thus, farm sizes, may vary in other regions. They also reflect the high-intensity and high-value cropping conditions in the California Central Coast (Carlisle et al. 2022; Esquivel et al. 2021).

We hypothesized that organic farmers in the California Central Coast region experienced both challenges and opportunities related to the pandemic, and that the ability of farms to adapt to the shock of the pandemic was related to the different levels of diversification and size of the farm. Many of the small-scale farmers in our sample (< 21 acres) are highly diversified, growing 15 crops or more at once. However, they tend to struggle to implement sustainability practices, particularly because of limited access to labor and equipment. In contrast, mid-sized farmers (between 21 and 350 acres) often have more flexibility and diversity in their markets and enough resources to adopt farming practices that support ecological diversity, such as cover cropping. Finally, large-scale farmers (over 350 acres, or the California average farm size) tend to sell to wholesale buyers or grow under contract. They are less likely to adopt ecologically diversified practices for reasons such as inflexible production schedules and food safety requirements (Esquivel et al. 2021).

Surveys during the pandemic

Our research reflects the initial shocks that arose during the pandemic's first year. Many of these conditions and responses have shifted considerably since the reopening and lifting of restrictions in California. While our sample captures only a fraction of the diverse pandemic-related experiences of California farmers, we offer a unique snapshot of how organic vegetable growers on the Central Coast experienced and responded to rapid market shifts, labor volatility, and uncertain regulatory and working conditions.

In addition, the process through which we gathered data reflects our own ongoing adaptation to the research limitations imposed by the pandemic. Our university locked down field research for many months until safety protocols were introduced. We could only use telephone calls and online surveys to gather data during 2020, which affected our ability to reach farmers and to ask questions and verify answers. We chose to sample the California Central Coast organic vegetable farmers in our larger project on ecological diversification in organic lettuce production. This choice was made for two reasons: the region's importance to California's lettuce and vegetable production and our existing research relationships with individual farmers.

We gathered data via two surveys, a COVID-19 questionnaire (referenced in this paper as COVID-19 Survey #1) and another farmer survey (Survey #2) that contained a subset of the COVID-19 questions. In total, we received 29 responses from 22 unique farmers from both surveys (see table 1).

We sent the COVID-19 Survey #1 as an online Qualtrics questionnaire to the 18 growers in our research sample in May 2020 (see online supplemental material 1). Questions focused on shocks to farmers markets, production and labor, as well as actions farmers were taking to adapt. We asked growers to check off the impacts and responses that applied to them.

TABLE 1. Farmer sample and attributes

	Small-scale (1–20 acres)	Mid-scale (21–350 acres)	Large-scale (350+ acres)
Number of farmers in sample	12 (9 primary Spanish speaking)	3	7
Number of crops	15 or more Primary crops: lettuce, mixed vegetable, herbs, flowers	15 or more Primary crops: lettuce, mixed vegetable, herbs, flowers	10 or less Primary crops: lettuce, strawberries, broccoli
Markets	Local markets	Local markets National markets	National markets Local markets
Organic status	Certified organic	Certified organic	Certified organic, certified organic and conventional mixed
Diversified practices used	Cover cropping Compost Diverse crop rotation	Cover cropping Compost Diverse crop rotation Hedgerows Planting perennials Animal integration on farm	Compost Cover cropping on a small portion of acreage Some floral strips
Farm sales*	Less than $25,000 (4 farmers) $25,000–100,000 (5 farmers)	Not available	Not available

* Economic data was only collected from the Spanish-speaking farmers in our study and is unavailable for the rest of our sample.

We also asked for qualitative examples and reflections in open answers. The questionnaire was available in English and Spanish, and respondents filled it in on their own.

A project advisor who works with beginning farmers suggested that non-English-speaking farmers might be faring worse during the pandemic. Therefore, we decided to expand our sample to include seven more Spanish-speaking, small-scale growers. We added questions to capture other potential impacts, such as lost childcare and regulatory pressures. We collected the responses over the telephone from the Spanish-speaking farmers and entered it into the online form. The COVID-19 Survey #1 received 16 responses.

The project was already planning a December 2020–January 2021 online Qualtrics survey of field management practices to gather information for the soil and biodiversity analysis. We integrated additional pandemic-specific questions in this Survey #2 (see supplemental material 2). This strategy minimized the time commitment from growers during a difficult period. The questions in Survey #2 were a subset of the COVID-19 Survey #1. Survey #2 contained fewer questions related to COVID-19; it was a way to increase our sample size while asking only the most pressing questions from the first survey. Both multiple-choice questions and open-response boxes were used. We received 13 responses to the questions in this survey that pertained to impacts from the pandemic (seven responses were from farmers who had also completed the COVID-19 Survey #1).

We analyzed the data by qualitatively coding for themes such as "market access," "labor availability" and "worker precautions." We then evaluated trends within each theme based on farm scale, farm marketing strategy, and farmers' primary language. We decided to use farm size (acres) as a proxy for scale because farmers in our sample expressed reluctance to share financial data. We chose the scale cutoffs for small, medium and large-scale farms to match those established by Esquivel et al. (2021) for farmers representing much of the same sample and farming region. These size cutoffs represent the acreages that corresponded to the farming models (limited resource, mid-sized diversified, and large wholesale) that were identified through interview data (Esquivel et al. 2021).

Given the small sample and uneven response rates, we primarily report our findings through quotes and summaries instead of quantitative analysis. In table 2, we provide raw data counts and simple statistics on the percentage of farmers who experienced different types of pandemic-related challenges. We analyzed the data using linear regression and t-tests for figures 1 and 2.

Juggling many challenges

Farmers in our sample vary greatly in their levels of crop diversity and marketing diversity. They also varied greatly in their ability to adapt to the pandemic conditions. Most of the small-scale growers in our sample farm on fewer than 10 acres. At the time of the study, they were all certified organic and grew a diverse range of crops, herbs and flowers to sell in local markets through farmers markets, farm stands, and some contracts with restaurants and schools (table 1). Around half of the farmers in our small-scale category are immigrants, non-English-speaking, and beginning farmers who may face additional barriers. Farmers under 20 acres described how having limited resources impacted overall farm function. Examples of these resource limitations include difficulty with labor costs and not

TABLE 2. Type and magnitude of challenges experienced by farmers according to farm size

Type of challenge	Small-scale (1–20 acres)	Mid-scale (21–350 acres)	Large-scale (350+ acres)
Market interruption	Major challenge (5, 42%)* Minor challenge (4, 33%) Not a challenge (3, 25%) *n* = 12	Major challenge (1, 33%) Minor challenge (1, 33%) Not a challenge (1, 33%) *n* = 3	Major challenge (4, 57%) Minor challenge (1, 14%) Not a challenge (2, 28%) *n* = 7
Procuring PPE	Major challenge (5, 42%) Minor challenge (6, 50%) Not a challenge (1, 8%) *n* = 12	Major challenge (0, 0%) Minor challenge (2, 67% Not a challenge (1, 33%) *n* = 3	Major challenge (1, 14%) Minor challenge (2, 29%) Not a challenge (4, 57%) *n* = 7
Uncertainty about food safety	Major challenge (7, 64%) Minor challenge (2, 18%) Not a challenge (2, 18%) *n* = 11	Major challenge (1, 33%) Minor challenge (1, 33%) Not a challenge (1, 33%) *n* = 3	Major challenge (2, 29%) Minor challenge (5, 71%) Not a challenge (0, 0%) *n* = 7
Labor shortage due to illness	Major challenge (4, 57%) Small challenge (1, 14%) Not a challenge (2, 29%) *n* = 7	Major challenge (0, 0%) Minor challenge (1, 33%) Not a challenge (2, 67%) *n* = 3	Major challenge (0, 0%) Minor challenge (3, 43%) Not a challenge (4, 57%) *n* = 7
Lost income from non-farm work	Major challenge (6, 67%) Minor challenge (2, 22%) Not a challenge (1, 11%) *n* = 9	N/A	N/A

* Parentheses represents: (Number of farmers, % of farmers in size category).

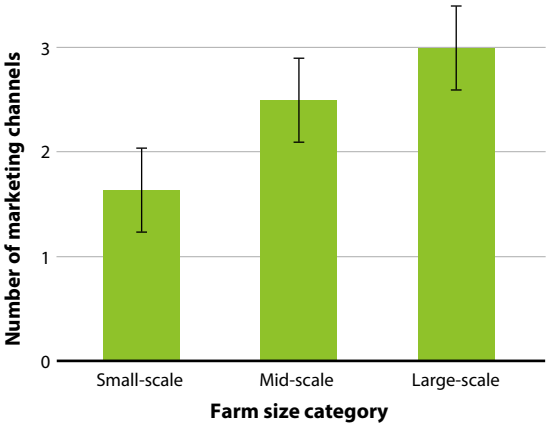

FIG. 1. Mean number of marketing channels (±1 SD) for small-, mid- and large-scale farms. Linear regression shows an increased number of marketing channels with increased farm size ($n = 15$, $P = 0.008$). None of the three pairwise comparisons of the number of marketing channels between small-scale, mid-scale and large-scale farms are significant [large-scale vs. mid-scale]: $P = 0.037$, [mid-scale vs. small-scale]: $P = 0.39$, [large-scale vs. small-scale]: $P = 0.021$. The Bonferroni alpha for three comparisons is 0.017.

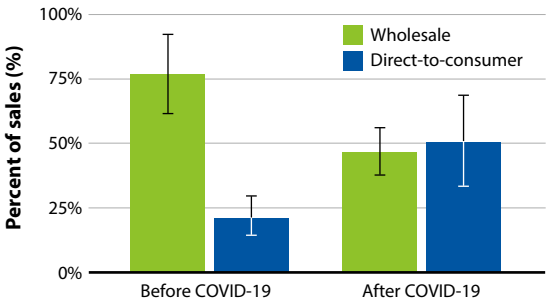

FIG. 2. Change in marketing practices due to COVID-19 market shifts among small-scale farmers ($n = 12$). A t-test shows that the percent of direct-to-consumer sales for small farms increased significantly in the period after COVID-19 ($P = 0.014$, t = 2.65, df = 22).

being able to afford investments in farm conservation practices such as planting hedgerows.

The mid-scale farmers were highly diverse in the number of crops grown, and their additional size and resources allowed for diversification practices such as the planting of hedgerows and perennials. These farmers demonstrated greater economic viability than the small-scale farmers, as evidenced by being able to pay for workers' health insurance and specialized farm equipment. One of the mid-scale farms in our sample reported growing over 60 different varieties of vegetables and fruit each year. Like small-scale farmers, mid-scale farmers sold their produce in local markets via farmers markets, local food distributors, and contracts with restaurants and institutions. In addition, they reported selling into national distribution channels.

The large-scale growers ranged from 400 to 5,000 acres and tended to grow fewer crops than the small and mid-scale growers. For example, one large-scale farmer in our sample had the majority of acres planted with lettuce, and then devoted a small part of acreage towards other crops such as broccoli. The large-scale growers often had both certified organic and conventional production. Their main distribution was through contracts and nationwide wholesale channels (table 1).

Farmers had to juggle numerous concerns at once in response to the pandemic. We saw evidence of a multidimensional decision-making challenge. The challenges were not simply about plummeting demand in some markets or lack of protective equipment. There were concerns about food safety, labor shortages, shifting markets for agricultural products, and balancing new demands for family, illness and childcare. We also saw tremendous variation in the ability of farmers to respond to the shock of the pandemic and adapt their marketing strategies, labor requirements, and farm organization.

Interrupted access to markets

Interrupted market access caused by the COVID crisis was the largest challenge reported by farmers in our sample. They ranged in their level of marketing diversification. Some of the smallest farmers reporting only one marketing channel, while some mid-scale and large-scale farmers reported multiple avenues, including contracts, wholesale buyers, processing plants, and directly to consumers, including farmers markets and farm stands (fig. 1). We sorted farm size into small-, mid- and large-scale based on the size categories from table 1. Linear regression demonstrates that larger farm sizes have significantly more marketing channels ($P = 0.008$).

We asked participants in both surveys to rate the severity of market interruption. Forty-five percent of all respondents reported market interruption as a major challenge (table 2). Farmers who had contracts with schools, restaurants, food service, and other institutions that stopped purchasing during the pandemic experienced lost revenue and difficulties in planning which crops to grow. In some cases, with no buyers, farmers decided to till their crops back into the soil. One small-scale farmer explained, "We had a lot of fear, uncertainty about how much of the product, if any, we could sell." Many of these small-scale farmers sold the majority of their products wholesale via food hubs, and did not have other marketing channels such as contract sales or processing sales. With a great decrease in wholesale demand early in the pandemic, these farmers were faced with a need to develop new markets, especially direct-to-consumer sales. Figure 2 shows that these small-scale growers anticipated a shift from an average of 22% of direct-to-consumer sales before COVID-19 to over 50% after COVID-19. A t-test shows that the percentage of direct-to-consumer sales for small farms increased significantly in the period after COVID-19 ($P = 0.014$). One small-scale farmer reported: "We have had to shift our sales outlets and

Workers cut and package lettuce in the Salinas Valley. Many farmers were already experiencing significant labor shortages before the pandemic, and this was exacerbated by illness and new safety precautions. *Photo*: rightdx, iStock.

develop new ones (delivering directly to individual customers). We lost a weekly delivery that went to Stanford [University] when they shut down on-campus classes. [We lost] many weekly restaurant orders."

Several farmers in our sample, notably the small-scale farms, relied on farmers markets, which were closed early in the pandemic. Meanwhile, many consumers shifted from restaurant food to local meal and grocery delivery services (Goldy et al. 2020). This move toward direct-to-consumer sales created new market opportunities, which most farmers in our sample pursued by expanding internet sales, working with food hubs, and providing door-to-door delivery.

Large-scale and mid-sized growers in our sample tended to have multiple marketing channels in place before the pandemic (fig. 1). This diversification of marketing channels helped reduce the need for these growers to quickly develop new markets. Mid- and large-scale growers sold the majority of products via contract sales and on the wholesale market, and they planned only modest shifts (5% of sales) away from wholesale toward direct-to-consumer sales.

However, some of these large-scale farmers and shippers (who may own or have contracts with several farms) experienced market collapse. One farmer explained, "Agriculture was deemed an essential industry, thus we never stopped our jobs; however, the initial collapse of the food service sector did impact many of our shippers and thus our farmers." A large-scale farmer commented: "We are faring better because we are retail oriented. Those who sell to schools or restaurants are having problems. Our sale volume is actually up a lot but prices are awful because all the other farmers are flooding the market. I hope we break even." This farmer portrays the financial insecurity farmers faced even when their market channels remained open.

Farmers on the Central Coast were already facing challenges before the pandemic. As described by one large-scale farmer, "At the same time the pandemic occurred, we had our own pandemic in the lettuce industry with new plant viruses that are still ongoing. In the meantime, California vegetable farmers are facing increased competition by the importation of produce from Mexico more and more every year which is collapsing our markets year after year." A different large-scale farmer confirmed the impact on farmers from decreased sales to institutional buyers: "When it first started things got cut back a lot because school contracts from one of our shippers came to a halt."

A major challenge for farmers of all sizes was coping with unpredictable swings in demand that made it difficult to plan crop plantings. Farmers in our sample typically planned crop plantings and rotations many months beforehand. With extreme market volatility, farmers faced a challenge in knowing how much to produce and what to plant. One large-scale farmer explained the difficulty caused by "unprecedented bounces in demand up and down," particularly "the uneven flow of orders. Fields are planted months in advance, so product is being lost. You cut acres and when that product is ready, demand can be high." Another small-scale farmer explained the decision to reduce plantings: "We have scaled back plantings that we were unsure of whether there would be a market for [those crops] due to COVID-19 restaurant/company closures."

Implementing worker precautions

Farmworkers suffered disproportionately high rates of illness early in the pandemic, an issue made more problematic by a lack of sufficient guidance from government officials about what workers or farm employers should do when workers became sick (Knight 2020; Mora et al. 2022). Farmers in our sample reported that they felt uncertain about best practices for worker protections and food safety. Still, they supplied workers with masks and gloves, performed temperature checks, enforced distance among field and processing factory workers, and increased hand washing. Some of the mid-scale and large-scale farms reported precautions such as extra sick time for ill employees, a practice more feasible for farms with robust resources and stable labor. While a few farmers reported difficulty in obtaining and providing personal protective equipment (PPE), most reported encountering only minor challenges in obtaining PPE — some even had access to an abundance of masks and gloves. This finding contrasts with early pandemic accounts that portrayed PPE availability as a significant difficulty for farmers (Allington 2020).

Farmers had to reorganize staff work arrangements to maintain social distancing and to meet new needs, such as marketing and packing CSA boxes. Although some farmers reported that this was not a major challenge, others said that these changes resulted in lost

productivity and higher production costs. One large-scale farmer described some changes: "One harvest person is in charge solely of cleaning for the duration of their shift. We're running double the harvest machinery and setting out twice as many break tables to ensure nobody has to be in close contact." Another farmer described how these kinds of precautions have allowed the farm to "continue to work but less productively."

Farmers also pointed to an often-overlooked challenge: managing a complex regulatory landscape where occupational rules and guidance changed frequently, as California and federal regulators tried to adjust to the pandemic. In a 2022 follow-up interview with a large-scale wholesale farmer, the management of regulations continued to present challenges: "It was challenging to navigate the constant regulatory changes, i.e., wage supplementation, Cal-OSHA laws, workers compensation reporting, etc. . . . I do not believe we are back to 'normal' because illnesses are still occurring and the laws are still changing."

Labor shortage

Many farmers were already experiencing significant labor shortages before the pandemic, and this was exacerbated by illness and new safety precautions. One mid-scale farmer commented: "[Workers] missed days because of the precaution of not working when sick, [we are] down a lot of workers sporadically." As lockdowns began, farmers were uncertain about how many people would be available to work. One farmer remarked that workers were afraid to come. "Workers are afraid and this impacts productivity." One small-scale farmer even said that a crop that had already been harvested could not be cleaned due to lack of labor, and therefore was lost.

Other farmers who shifted toward more direct-to-consumer sales suddenly needed more labor for packing CSA boxes and making deliveries. One small-scale farmer had to take employees away from field work to meet needs for packing and distribution, stressing an already short-staffed production system.

Family needs and money worries

Labor challenges related to family needs and illness were magnified for small-scale family-run farms. These farmers were affected greatly by school closures. Both farmers and farmworkers had to care for children while maintaining their operations and distributing produce. One farmer with about 20 acres described the shift required to balance family and farming needs:

> *As a sole farm proprietor, I used to work full time in the day-to-day operation and management of the farm. Now my kids are home from school and daycare, and I'm having a lot of trouble not only keeping up with my previous relatively stable responsibilities to run the farm, but also now all the added work and time trying to completely change our business due to the dramatic market and consumer demand changes. My time is now spent 50% delivering CSA boxes, with kids in the truck, instead of previous tasks or homeschooling. As a parent, I personally struggled to do my work for the farm while caring for my kids home from daycare and school.*

In addition to new needs for child and elder care, farmers and farmworkers faced added pressure from lost off-farm jobs. A farm advisor described the impact on the small-scale farmers they work with: "Most of the farmers' spouses [who would otherwise work off farm] have to stay at home taking care of the kids who are not going to school and are too young to work on the farm. Other farmers have lost their part-time jobs like the ones that work in non-essential places like hair salons and clothing stores." This further constrained their already low resource availability.

Some farmers became ill with COVID-19 or had employees experience this illness. The effects of illness, as well as the worry and stress that the pandemic created, took a physical and psychological toll on farmers and farmworkers. The smallest farms in our sample reported experiencing large impacts from illness-related labor shortages (table 2). A small-scale farmer commented, "My own health has been impacted." Especially for small family-run farms without other income sources, the challenge of balancing farmwork, product distribution, illness, and family needs caused great financial stress.

A major challenge for farmers of all sizes was coping with unpredictable swings in demand that made it difficult to plan crop plantings.

Resources for adaptation

COVID-19 caused a ripple effect of lockdown, supply chain disruptions, and shifting labor availability due to illness and child/elder care needs. For some farmers, this shock created an enormous burden. Other growers, in contrast, seemed to be more resilient and took advantage of new market opportunities. Examining differences in farmer adaptive capacity, we found that these appeared to match our earlier findings (derived from a similar sample) that organic vegetable growers on the Central Coast fall into one of three farming models (limited resource, mid-sized and large-scale), which influence their ability to use diversified farming practices (Esquivel et al. 2021).

While all farmers we spoke with were affected by pandemic shocks, we observed that small-scale farms (< 21 acres) mostly lacked the resources to quickly make changes needed to adapt. Mid-scale farmers (21–350 acres) with diverse market channels reported fewer large impacts. The large-scale farms (> 350 acres,

Organic sungold tomatoes from Opal Creek Farm in Davenport. *Photo*: Joanna Ory.

Farmers with more diversity in crops and over 20 acres were more resilient and able to create new markets and local distribution opportunities.

the California average farm size) often suffered sizable financial losses due to canceled contracts. Similar to findings by Durant et al. (2023), we found that farmers with more diversity in crops and over 20 acres were more resilient and able to create new markets and local distribution opportunities.

Farmers with limited resources encountered particularly high levels of uncertainty, anxiety and financial stress. With new needs for family care and lost sales to restaurants and farmers markets, these farmers struggled to accomplish the daily tasks needed to run their operations. These hardships were particularly difficult for the non-English-speaking, immigrant farmers who mainly relied on themselves and family members as the labor source for the farm. They found it harder to devote scarce time and labor to developing new direct markets. One commented: "I would like to sell more to the consumer like in CSA boxes, direct to the consumer, maybe food hub and online store. Also sell in street stalls." Despite such barriers, many limited-resource growers expanded their direct markets by identifying online platforms such as Facebook, which they used to reach potential customers.

Minority farmers with small farms faced even greater challenges. Spanish-speaking farmers were more likely to report a lack of reliable internet access as a major challenge. Some farmers wanted to increase direct-to-consumer sales but lacked the English language skills needed to easily market online. As one farmer said, "[I'd like to] find new ways to make more sales and earn more money. I've also tried to sell more online, but I don't speak English." Still, many Spanish-speaking farmers in our sample reported creating new market opportunities by selling CSA boxes, selling door to door, advertising on Facebook and delivering directly to individual customers.

Many small-scale farmers were able to pivot toward direct market channels, despite limitations in language, internet access, networks, family care, and financial resources. The creativity and nimbleness with which this group acted to expand markets demonstrates that, with greater policy and technical support, these growers could have more easily overcome these marketing challenges and suffered less stress.

Large wholesale growers had the language, internet, networks and financial resources to branch out and adapt. However, they were constrained by rigid production contracts, high land rents, and an industrial monoculture model that limited their options to diversify their crop portfolio.

In contrast, the mid-scale farmers who already had multiple distribution channels (e.g., restaurants, CSAs, farm stalls, retailers), or who had the ability to quickly gain access to new markets, fared better. These growers benefited from existing economic diversification and diverse crop production. For example, one grower reported a shift from 60% to 90% direct-to-consumer sales. These farmers could create or use existing food delivery services, as well as farm stands. Mid-scale growers had the financial means, language facility, technology skills, internet access, and existing marketing channels to more easily shift sales toward stable or growing market channels.

With only three farmers in the mid-scale category, we also looked along a continuum of our sample and found evidence of a trend that farms above 10 acres were better positioned to make changes and suffer fewer setbacks from the COVID-19 crisis than the smallest farms in our sample (those of 1–2 acres). For example, we observed that small farms closer to 20 acres had more resources and were more likely to shift marketing strategies in response to pandemic changes than farms with only two acres.

This pattern suggests that the ability of farmers to use diversified farming practices and diverse markets is closely related to their capacity to adapt to disturbances (see also Petersen-Rockney et al. 2021). Moreover, organic growers vary considerably in their adaptive capacity. Growers who are already more skilled in managing complex decisions can more easily plan to adapt to unexpected changes to the food system.

Our research experience allowed us to recognize the need for researchers to strengthen our capacity to rapidly adapt existing projects to respond to emerging needs. In principle, rapid research could have helped small-scale farmers with challenges related to language capacity or technical marketing know-how (e.g., how to set up an online store) and also assisted all growers to keep better abreast of continuously updating rules, guidance and best practices. Another potential role for researchers during a crisis is to support and facilitate peer-to-peer networks for sharing information. However, the research community faces its own resource limitations and institutional barriers to rapid response. For example, funds are frequently tied to particular projects with predetermined questions and methods. Researchers cannot necessarily shift funding from existing projects to meet questions raised by emerging crises. Developing more flexible funding mechanisms and research regulations, such

as human subjects protocols, would support rapid response research.

Lessons learned

Looking forward, farmers in California will continue to deal with the ongoing aftershocks of the COVID-19 pandemic. They will also experience shocks to agricultural production in the future, such as new pandemics, drought, flooding, extreme heat, and labor shortages (Petersen-Rockney et al. 2021). Based on our exploratory research, a major lesson appears to be that farmers who can quickly shift what they grow, where they sell, and to whom they sell will have an advantage over those trapped in rigid growing contracts or unable to enter new marketing channels. More broadly, having access to enough land and capital, diversified production systems, a sufficient and reliable labor force, and diversified market channels could give farmers greater adaptive capacity and resilience. Further research is needed to confirm the relationship between adaptive capacity and pandemic responses that we have identified in other agricultural regions and for other crop types.

To better equip farmers to adapt to shocks, policies need to address the structural disadvantages in adaptive capacity that both small-scale and large-scale growers face (Carlisle et al. 2022). Policies also need to nurture the emergence and survival of organic, smaller-scale, diversified farmers. For example, technical, marketing and financial support can help farmers build multiple market channels and ecological farming knowledge. Incentives for companies to make production schedules more flexible to accommodate diversified farming practices can also benefit growers. Government and extension assistance can be provided in diverse languages and formats to disadvantaged growers. Strengthening public programs that support organic and diversified farming practices, like the USDA Organic Cost Share Program and the CDFA Healthy Soils Program, can help boost the resilience of these farmers. Additionally, making emergency financial aid readily available for farmers, including assistance with procuring such financial aid, can help in moments of crisis. CA

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