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Farm resilience during the COVID-19 pandemic: The case of California direct market farmers

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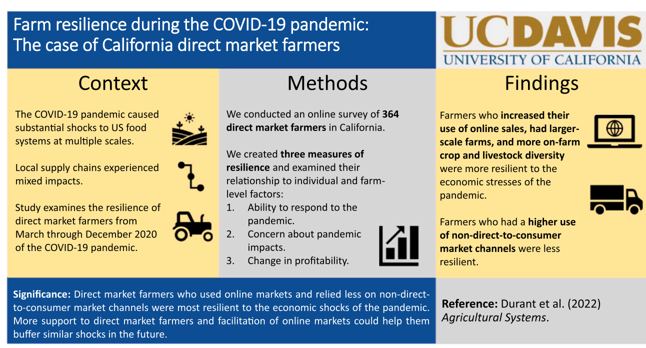
HIGHLIGHTS

- We surveyed 364 direct market farmers in California to assess their resilience to the COVID-19 pandemic in 2020.
- Farmers that increased their use of online sales and marketing were more resilient to the impacts of the pandemic.
- Farmers with larger-scale farms and more on-farm crop and livestock diversity were also more resilient.
- Greater use of non-direct-to-consumer market channels (e.g., wholesale) was associated with less resilience to the pandemic.
- Policies and programs can help direct market farmers, especially direct-to-consumer farmers, strengthen resilience to crises.

GRAPHICAL ABSTRACT



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ABSTRACT

CONTEXT: The COVID-19 pandemic caused significant shocks to U.S. food systems at multiple scales. While disturbances to long-distance supply chains received substantial attention in national media, local supply chains experienced mixed impacts. As broad closures of schools, restaurants, and other businesses sourcing from local farmers removed key marketing channels for many direct market farmers, consumer interest in Community Supported Agriculture (CSA), farmers markets, and on-farm and online direct farm sales increased.
OBJECTIVE: In this paper, we examine the resilience and vulnerability of farmers during the March 2020 through December 2020 period of the COVID-19 pandemic. We focus on California farmers and ranchers engaged in direct market sales.
METHODS: Through a widely disseminated survey, we collected responses from 364 farmers and used these data to answer the following questions about direct market farmers in California: 1) What were direct market farmers' experiences of the pandemic from March 2020 through December 2020? 2) Which factors (e.g., relationships, institutions, market channels) did farmers report enhanced their resilience during the pandemic? 3) Which

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individual and operational factors were significantly associated with resilience during the pandemic? And finally, 4) how do the farmer-reported factors compare to the statistically significant factors associated with resilience? We created three dependent variables—ability to respond to the pandemic, concern about pandemic impacts, and change in profitability—to operationalize several aspects of resilience and examine their association with individual and operational characteristics through a series of ordered logistic regression models.

RESULTS AND CONCLUSIONS: Across both the quantitative models and the farmer reported factors, we found that farmers who increased their use of online sales and marketing during the first year of the pandemic, had larger-scale farms, and had more on-farm crop and livestock diversity were more resilient to the shocks of the pandemic. We also found that greater use of non-direct-to-consumer market channels was associated with less resilience. The characteristics of the farming operations played a relatively larger role in predicting resilience compared to the individual characteristics of the farmers surveyed.

SIGNIFICANCE: This study gives a detailed picture of how California direct market farmers fared during the pandemic and the characteristics associated with greater resilience. As short and long-term disruptions become increasingly common in agriculture, policies and programs can leverage support to direct market farmers, particularly direct-to-consumer farmers, as a strategy to strengthen farmer resilience.

1. Introduction

In 2020, as a result of worldwide shutdowns and restrictions put in place to control the spread of the COVID-19 pandemic, the global food system began experiencing a myriad of unprecedented shocks in the U.S. with uncertain long term repercussions (Darnhofer, 2020; Johansson et al., 2020; Weersink et al., 2021). The numerous pandemic-related disruptions exposed vulnerabilities in the food system, particularly the fragility of the industrialized agricultural and concentrated food processing systems that underpin much of global food production (Altieri and Nicholls, 2020; Montenegro de Wit, 2021; Robinson et al., 2021). The uncertainties about the stability of global supply chains during the onset of the pandemic also led to an apparent shift in consumer preference for locally-and regionally produced food (Hiller, 2020; Peyton, 2020).

Concerns over personal health, food safety, and food availability motivated consumer interest in receiving food directly to their door or neighborhood to lessen their risk of COVID-19 exposure (Danovich, 2020a; Pretty, 2020). Farmers and ranchers (hereafter collectively referred to as "farmers") that used direct market channels, which we refer to as direct market farmers, were well poised to reap the benefits of this shift in demand. Direct market farmers sell their products without intervening brokers, buyers, or distributers, either directly to the final consumers (e.g., through farmers' markets, Community Supported Agriculture subscriptions, or farm stands), or through direct sales to businesses and institutions (e.g., restaurants, grocery stores, schools, hospitals) (Low et al., 2015; UC SAREP, 2017; USDA NASS, 2016).

In the Northern Hemisphere spring of 2020, as shelves went empty in grocery stores, many direct market farmers involved in their local and regional food systems were able to pivot to new market channels by leveraging established relationships in local food supply chains (Thilmany et al., 2020). Community Supported Agriculture (CSA) memberships saw significant expansions in enrollment (Bachman et al., 2021; Danovich, 2020b; Ricker, 2020; Thilmany et al., 2020). Many direct market producers also turned to the internet to sell their products to reach this growing customer base (Lamb, 2020; Meuwissen et al., 2021; Schreiber et al., 2022; Thilmany et al., 2020; Weersink et al., 2021). Online food sales reached records heights in the early months of the pandemic (Fairhurst, 2020; Wiggers, 2020). These shifts appeared to build on trends documented by the U.S. Department of Agriculture's (USDA) Economic Research Service, which noted a 35% increase in sales through direct market channels from 2019 to 2020 (Whitt et al., 2021).

While some direct market farmers experienced increased demand, supply chain dynamics also introduced new challenges that may have left direct market farmers vulnerable to the disruptions of the pandemic. Prior to the pandemic, direct market farmers were already challenged by the increasingly centralized power of agribusiness and food processing companies (Holt-Giménez and Altieri, 2013; Horst and Marion, 2019; Patel, 2013) and economic hardships from competing with large-scale industrial agriculture (Akram-Lodhi and Kay, 2010a, 2010b; Galt, 2013; van der Ploeg, 2018). While direct market farmers may have benefited from a nimble ability to pivot to new market channels, such as shifting to online sales, these changes also complicated operational logistics, adding to administrative workloads (Bachman et al., 2021). Social distancing also added new challenges for direct market farmers, particularly those who sold through farmers markets, where some producers saw significant reductions in sales, funding, and access to casual workers (O'Hara et al., 2021; Taylor et al., 2021). Small and medium scale producers and socially disadvantaged farmers were also less likely to receive federal pandemic aid (Rappeport, 2022; USDA FSA, 2021), deepening pre-existing inequities between these farm types and large-scale agriculture.

Research is still emerging about how the pandemic affected and continues to affect direct market farmers in various global contexts, so it will take time to have a robust picture of how farmers have fared during this global crisis. Though some have argued that the U.S. food sector largely returned to "normal or near-normal" operations by the end of 2020 (Weersink et al., 2021, p. 2), questions remain about how actors throughout the food system coped, and what factors enabled some producers to remain resilient throughout the first year of the pandemic.

Direct market farmers have much potential to contribute to food production during economic shocks such as those experienced during the pandemic, and may play an increasingly important role in food production in coming years. Direct market farmers can help support sustainable agriculture through increased farmer profits, support for local economies, and by providing higher quality products to consumers (UC SAREP, 2017). Their experience during the pandemic is thus important to examine to understand how to support and encourage their resilience.

California is a uniquely important state to examine direct market farmers in this context. California is the largest producer of agricultural products (crops and livestock) in the U.S. (USDA ERS, 2021) and has the highest percentage of direct market sales in the country, accounting for about a third of the U.S. total (USDA NASS, 2016). Yet, despite California's prominence in agricultural production and its robust direct markets, the pandemic's disruptions deeply affected agricultural supply chains and producers, causing an estimated direct impact on California agriculture of between \$5.9 and \$8.6 billion in 2020 (ERA Economics, 2020). Given these factors, California provides an important case study to understand how U.S. direct market farmers fared during the COVID-19 pandemic.

To this end, we asked the following questions about direct market farmers in California: 1) What were direct market farmers' experiences during the first year of the COVID-19 pandemic (March 2020 through December 2020)? 2) Which factors (e.g., relationships, institutions, market channels) did farmers report enhanced their resilience? 3) Which individual and operational factors were significantly associated with resilience during the pandemic? And finally, 4) how do farmer-reported factors compare to the statistically significant factors associated with resilience? We focused on direct market farmers (those who sell directly to consumers and directly to businesses and institutions, such as restaurants, schools, or hospitals) rather than solely those who use direct-to-consumer market channels (e.g., farmers markets, CSAs, farm stands), because we wanted to track how farmers fared who sold through a variety of market channels as a result of the pandemic's social distancing restrictions and subsequent economic stresses.

Multiple frameworks exist to understand resilience and vulnerability in modern agri-food systems, and to contextualize farmers' ability to respond to both short- and long-term disruptions (Cabell and Oelofse, 2012; Darnhofer, 2014). Vulnerability, resilience, and adaptive capacity are interrelated and often contested concepts used in these frameworks (Gallopín, 2006; Petersen-Rockney et al., 2021), and they describe both the susceptibility of a farm system to disruptions, as well as its ability to respond (Petersen-Rockney et al., 2021). Farm resilience addresses aspects of vulnerability, sensitivity, and exposure, with particular focus on a farm's ability to respond to internal and external stresses (Tittonell et al., 2021).

In this paper, we understand resilient farmers as those able to “integrate and balance” three capabilities: 1) respond to short term stresses through coping or “buffering” capabilities (Darnhofer, 2014, p. 467); 2) respond to longer-term or larger scale stress through “adaptive” capabilities (p. 468), and 3) transform their operations to address major stresses (e.g., climate change) (p. 468). All three of these capabilities can help farmers respond to sudden shocks and unexpected events (Darnhofer, 2014; Darnhofer et al., 2010), such as a wildfire or the effects of the COVID-19 pandemic. Given the shorter time scale of the first ten months of the pandemic (compared to long-term adaptation required by climate change), in this paper we focus on farmers' coping and adaptive capabilities.

Our study adds to a developing body of literature on the impacts of the COVID-19 pandemic by focusing on the experiences and responses of direct market farmers in California. The highly disruptive first year of the pandemic offers an unparalleled opportunity to examine the resilience of farmers and their operations. Bringing our data into dialogue with previous studies on direct market farming can help identify approaches to support transitions to more resilient and equitable food systems that are capable of withstanding future shocks and disasters.

1.1. Study site overview

California had 70,521 farmers in 2017 and is the state with the highest value of agricultural goods production in the United States, worth $45.1 billion in 2017 (USDA NASS, 2017a). Despite being a powerhouse of industrial and export-oriented agriculture that feeds into national and international food systems, as noted above, California also accounts for nearly a third of all direct market sales in the U.S. (USDA NASS, 2016). In 2017, direct marketing was a $5 billion industry in California, accounting for one-ninth of all agricultural product sales in the state. The 2017 USDA Census of Agriculture reported that 7623 farms (10.8% of all California farms) sold $782 million worth of food directly to consumers, and that 4301 farms (6.1% of all California farms) sold $4.4 billion worth of food directly “to retail markets, institutions, and food hubs for local or regionally branded products” (USDA NASS, 2017a, p. 10). These numbers underscore the scale of direct market sales in California.

California is also a geographically and socially diverse state. While it contains areas across a range of different growing conditions (e.g., the temperate salad bowl of the Salinas Valley versus the summer heat of the Central Valley), due to its Mediterranean climate, most of its low elevation growing environments can support year-round produce growth and production. Farmer-consumer relationships within the state are also diverse; Rural Northern Californian CSA farmers are most likely to be satisfied with their work, while Southern Californian CSA farmers are least likely to be satisfied (Galt and Munden-Dixon, 2019). This variation could be an important factor in understanding how regional geographies and consumer dynamics might have impacted farm resilience during the first year of the pandemic.

2. Methods

2.1. Survey design and implementation

We conducted an online survey of direct market farmers in California to understand their resilience to economic and social disruptions experienced during the first year of the pandemic. The survey was designed and administered through Qualtrics online survey software and was available in both English and Spanish. The survey gathered data on farmer demographic characteristics (e.g., age, race/ethnicity, gender, years of farming), farm operation characteristics (e.g., size, location, type of production), responses to the impacts of the COVID-19 pandemic (e.g., changes in market channels and production as well as collaboration with other actors), and enabling and constraining factors to their response to the impacts of the COVID-19 pandemic (e.g., institutional or community support). The questions were focused on farmers' experiences of and responses to the first ten months of the pandemic (March 2020 through December 2020). Due to the relatively small proportion of direct-to-consumer and direct-to-retail/institutions farmers in the state (10.8% and 6.1%, respectively) (USDA NASS, 2017a), a random sample of all California farmers would have been insufficient to capture an adequate sample size of the target population. Instead, we used a purposeful sampling technique to target direct market farmers through several sources.

The survey was sent to farmers through three routes: 1) the California Department of Food and Agriculture's (CDFA) Certified Farmers Market Producers, which contains contact information for all farmers who are certified to participate in the state's certified farmers markets; 2) organic farmers certified by the non-profit California Certified Organic Farmers (CCOF) and engaged in direct marketing (CCOF maintains data on the market channels used by each farmer it certifies); and 3) California farmers listed on LocalHarvest, an online directory of direct market farmers. For the first two lists we were able to distribute the survey directly to farmers' email addresses, while LocalHarvest sent the survey link internally to their farmer listserv. This sampling strategy allowed us to calculate response rates for each list and calculate an overall estimated response rate. Given our dissemination channels, farmers selling through farmers markets and farmers that are certified organic are likely over-represented in our sample relative to all direct market farmers in the state.

Participants were first contacted via email on January 19, 2021 and invited to participate in the online survey. Four reminder emails were sent between February 25th and March 17, 2021, and the survey was closed on April 19, 2021. We offered a $20 Amazon e-gift certificate incentive to survey respondents who completed the survey. The incentive was offered based on previous research that indicates that cash incentives increase participation, retention, and the quality of responses (Göritz, 2010).

A total of 364 farmers completed the survey and met the inclusion criteria, with a total response rate of 16.1% based on the three distribution lists we used.[1] We received 360 completed surveys in English and four in Spanish. Our analysis includes direct market producers that met the following criteria: an owner-operator, partner, or hired manager in a farming operation in California in 2020; sold through direct market channels in 2020; and produced crops (including produce, nuts, flowers, fiber, and feed) or raised livestock (including bees). While the farmers in this sample sold their products through a variety of market channels, including non-direct market channels (i.e., wholesale), we label them all as "direct market farmers" for the purposes of this study since all use at least one form of direct marketing.

To ensure our survey sample was representative, and therefore generalizable to the broader direct market farmer population of California, we compared our sample to the population of direct-to-consumer farmers in California from the USDA Census of Agriculture.[2] We focused on geographical and ethnoracial representation, two factors for which we had directly comparable data between the sample and the USDA Census of Agriculture.

Fig. 1 shows the geographical representation of California farms selling directly to consumers from the 2017 Census of Agriculture (USDA NASS, 2017a), compared to our 2020 sample of direct market farmers. Appendix A shows the comparison in more detail. Overall, our sample was relatively representative of the geographic dispersion of direct market farmers in the state. There was a geographical affinity bias given our affiliation with UC Davis: we have higher than proportional numbers for many Northern California counties (especially Yolo, Sonoma, and Humboldt Counties) and lower than proportional numbers for counties in the southern part of the San Joaquin Valley (Fresno and Tulare Counties) and some Southern California areas (Ventura and San Diego Counties). Lower than proportional numbers in the San Joaquin Valley likely means that we did not reach many of the Hmong and Latinx growers there. Despite not being proportional at the county level for all counties, we do consider our sample large enough to generalize about the experiences of direct market farmers in California, and for robust comparisons between Southern California ($n = 41$) and the rest of the state.

The ethnoracial demographic characteristics of survey respondents are displayed in Table 1 and generally reflect the population of direct market farmers in California. This indicates a lack of response bias vis-a-vis race and ethnicity and indicates good overall representativeness of the direct market farmers in the state.

[1] Response rate was calculated as follows. First, before sending the survey, we removed duplicate emails between the distribution lists to ensure farmers received the survey only once. To determine the number of survey recipients, we counted the number of direct market farmers included in each list, then removed individuals that had an email that bounced (this resulted in 894 for the CDFA list and 638 for the CCOF list). Since we did not have access to emails for the LocalHarvest list, we estimated overlap between LocalHarvest and CDFA, and between LocalHarvest and CCOF, to determine the number of farmers who received the survey twice (and would have then been double counted in our survey recipient number). We estimated this overlap using our survey question about whether farmers had a LocalHarvest account and determined that 15.2% of farmers from the CDFA list and 6.1% of the CCOF list had a LocalHarvest account. We then multiplied these percentages by the response numbers from the CDFA and CCOF lists and removed these numbers from the LocalHarvest survey recipient number, reducing it from 898 to 723. Summing the unique recipients from each list (894 CDFA +638 CCOF +723 LocalHarvest) resulted in 2255 total survey recipients, of which 364 responded, resulting in an overall response rate of 16.1%. While a higher response rate is desirable, getting farmers to respond in the midst of a pandemic was a challenge, and we consider this high enough to be representative of the population.

[2] We compared direct-to-consumer farmers in the USDA Census of Agriculture to direct market farmers in our sample because we believe there is sufficient overlap between the two groups for comparison.

2.2. Analysis

Data analysis was conducted using *R* software (version 4.0.3). We created a series of three ordered logistic models to understand the factors associated with self-reported resilience during the pandemic. Ordered logistic regression was chosen due to the ranked ordering of the categories composing the dependent variables. Independent variables were chosen based upon relevant hypotheses and available literature on farm resilience, including gray literature and news reports during the months of the pandemic, and refined through a bi-directional stepwise selection procedure to find the best model fit according to the lowest Akaike Information Criterion (AIC). The independent variables we chose to predict resilience, their hypothesized relationship with resilience, and the literature that supports this hypothesis, are included in Table 2.

Whether a farmer received federal pandemic assistance was used as a control variable in all the regressions to help isolate the relationship between gross sales and the dependent variables, and the dependent variable *increase in profitability* and its relationship with the independent variables. We grouped the independent variables according to farmers' individual characteristics and operational characteristics to evaluate the roles of each separately. We then examined individual and operational characteristics combined. Providing three model specifications for each dependent variable helps to identify the differences across individual and operational variables, and to test the robustness of statistically important variables across models.

We calculated AIC values of each model to compare the strength of the various sets of independent variables (individual, operational, combined) to explain the dependent variables. The AIC is useful in selecting the most explanatory model relative to those included in the set, which is appropriate for logistic regression with no R^2 value.

2.2.1. Dependent variables

To measure resilience during the pandemic, we used three measures of farmer-reported operational resilience. For the first two measures, farmers were asked to rate their agreement with the following statements: 1) "Overall, our operation was able to respond to the pandemic," which became the dependent variable *ability to respond to the pandemic*, and 2) "I am concerned with how the pandemic has impacted our operation," which became the dependent variable *concern about pandemic impacts*. Agreement for both was measured through a modified Likert scale containing three responses: disagree, neither agree nor disagree, and agree (coded as 1, 2, and 3, respectively). A positive coefficient indicates a likely increase in the likelihood that a farmer would report agreement and a negative coefficient indicates a likely increase in the likelihood of reporting disagreement. The third measure of resilience is *change in profitability*, derived from a question asking, "From March 2020 through December 2020, how did your operation's profitability change overall?" Responses were on a modified Likert scale of: decreased, no change, and increased (coded as 1, 2, and 3, respectively). For this variable, a positive coefficient indicates a greater likelihood of reporting increased profitability while a negative coefficient indicates a greater likelihood of reporting decreased profitability.

2.2.2. Independent variables

2.2.2.1. Individual characteristics. Individual characteristics included in the models below are: *race is white*, *gender is male*, *under 55 years old*, *first-generation farmer*, and *online farmer network participant*. Each was coded as a binary variable (yes = 1, no = 0). Participation in an online farmer network was derived from a question asking whether an online farmer network helped them respond to the challenges of the pandemic. We assumed a respondent that checked this option was involved in the network, and therefore used it as a proxy for participation in an online farmer network. Facebook groups are listed in the survey as an example of online networks. Other examples include listservs and group chats,

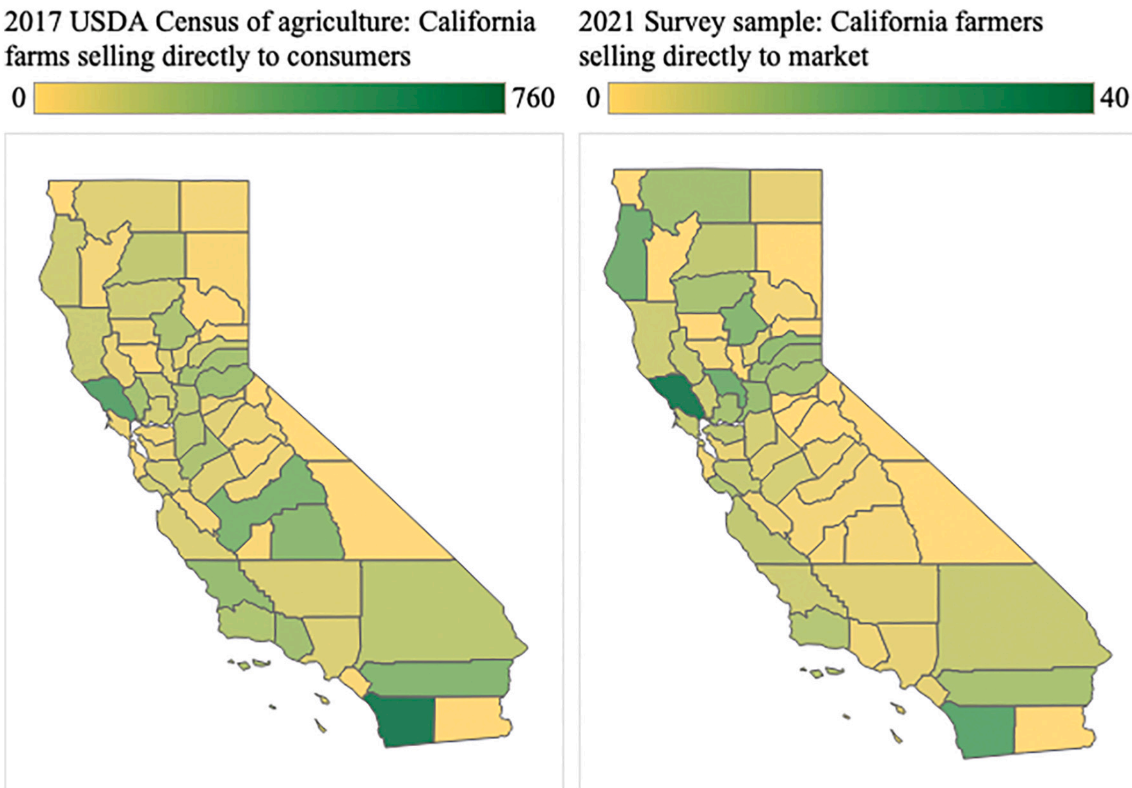

Fig. 1. Geographical representativeness of the survey sample compared to the 2017 USDA Census of Agriculture Source: authors' data and USDA NASS (2017a).

Table 1
Survey sample of California direct market farmers compared to the population of direct-to-consumer (DTC) farmers.

	Survey respondent demographics		Demographics for all California DTC producers (USDA)	
	Number*	Percentage[a]	Number**	Percentage[a]
American Indian and Alaska Native	13	4.3%	301	3.9%
Asian	19	6.6%	604	7.9%
Black or African American	6	2.3%	84	1.1%
Latino or Hispanic	39	12.8%	1320	18.1%
Native Hawaiian and Other Pacific Islander	1	0.3%	68	0.9%
White (non-Hispanic)	263	85.9%	6463[b]	88.4%
Prefer not to answer	16	5.6%	–	–
Other	16	5.3%	–	–
Total size	364		7623***	

[*] Number columns do not add up to their total size since categories are not mutually exclusive.

[**] Calculated from the proportion of the total number of California famers by race/ethnicity who "sell directly to consumers" (USDA NASS, 2017b). For example, California had 2153 farms with American Indian or Alaska Native producers (USDA NASS, 2017b, p. 1), of which 14% sell directly to consumers (USDA NASS, 2017b, p. 2).

[***] Total from U.S. Census of Agriculture (USDA NASS, 2019, p. 88).

[a] Percentage columns not total to 100% since categories are not mutually exclusive.

[b] White (non-Hispanic) numbers are estimated from the overall California 2017 Census of Agriculture data; 13,148 Latino/Hispanic producers identify as white racially, which we used to calculate the proportion of the 113,717 white-identifying producers in California who identify as Latino/Hispanic (the result is 11.6%). Using that percentage, an estimated 845 white Hispanic DTC producers were taken out of the original 7308 white category, resulting in 6463 white (non-Hispanic) producers.

and more organized networks such as FarmsReach (www.farmsreach.com) that provide online tools, support, and connection opportunities for farmers to communicate with each other, find suppliers, and expand their networks.

2.2.2.2. Farm characteristics. Farm characteristics included in the models are: *farm age*, whether the operation was *organic certified*, whether the farm *used unpaid family labor,* a *crop and livestock diversity index*, *gross farm sales*, *percentage direct market sales*, *farm resources index*, two market channel indices—a *direct-to-consumer market channels index* and a *non-direct-to-consumer market channels index, change in use of online sales* (during the pandemic), farming *region is Southern California* and *received pandemic assistance* from government agencies or NGOs. Farm characteristics are defined below.

Farm age measured the number of years since the operation was established. We use farm age as opposed to "multigenerational farm" as the majority of survey respondents were first generation farmers. *Organic certified* was marked yes if any part of the operation was certified organic in 2020. *Used unpaid family labor* was marked yes if the operation used any unpaid family labor from March 2020 through December 2020. We originally planned to use *number of year-round employees* as a variable, however it was strongly correlated with *gross farm sales*. Thus, we could not include it in multiple regression models.

The *crop and livestock diversity index* is a composite index of the number of crop and livestock types produced and raised on the operation in 2020. Crop types include: vegetables, fruit, nuts, wine grapes, grains and pulses, oil crops, fiber crops, animal feed, flowers/ornamentals, seed crops, nursery stock, and other. Livestock types include: chickens (layers), chickens (boilers), hogs and pigs, sheep and lambs, goats and kids, dairy cattle, beef cattle, llamas or alpacas, bees, and other. Each crop or livestock type selected was scored as a one and the resulting index is a sum of the scores, ranging from 0 to 22 possible crop and livestock types.

Gross farm sales includes all revenues from the farm operation,

Table 2
Independent variables expected to predict farmer resilience to the COVID-19 pandemic included in the ordered logit regression models, with expected relationship.

	N	Mean	St. Dev.	Expected relationship with resilience	Supporting literature
Race is white (Yes = 1)	339	0.78	0.42	+	(Bowens, 2015; Minkoff-Zern and Sloat, 2017; Ricker, 2020; Taylor et al., 2022)
Gender is male (Yes = 1)	339	0.46	0.50	+	(Fraser et al., 2005; Jones-Bitton et al., 2020)
Under 55 years old (Yes = 1)	334	0.55	0.50	+/−	(Darnhofer, 2010; Mase et al., 2017; Peerlings et al., 2014)
First generation farmer (Yes = 1)	340	0.68	0.47	−	(Holt-Giménez, 2002; Munden-Dixon et al., 2018)
Online farmer network participant (Yes = 1)	341	0.06	0.24	+	(Carlisle, 2016; Šūmane et al., 2018)
Farm age	331	20.13	22.47	+	(Darnhofer, 2010; Holt-Giménez, 2002; Kautsky, 1988; Mann and Dickinson, 1978)
Crop and livestock diversity index (0–22)	344	3.17	2.13	+	(Bowles et al., 2020; A. S. Davis et al., 2012; Maggio et al., 2018; Perrin et al., 2020; Petersen-Rockney et al., 2021; Tamburini et al., 2020)
Gross farm sales (1–8)	263	4.86	2.34	+	(Hamann, 2021; Ramgopal and Lehren, 2020; Whitt et al., 2021)
Organic certified (Yes = 1)	362	0.44	0.50	+	(Brzezina et al., 2016; Perrin and Martin, 2021; Perrin et al., 2020)
Percent direct market sales (1–6)	266	4.89	1.57	+	(Galt, 2013; Low et al., 2015; Marusak et al., 2021)
Region = Southern California	362	0.17	0.37	−	(Galt and Munden-Dixon, 2019)
Farm resources index (0–5)	363	2.05	1.30	+/−	(Low et al., 2015; O'Connell et al., 2021)
Used unpaid family labor (Yes = 1)	352	0.38	0.49	+	(Aguilar et al., 2022; Alpízar et al., 2020; Galt, 2013; Suryanata et al., 2021)
Direct-to-consumer market channels index (0–5)	358	1.43	0.91	+	(Galt, 2013; Kloppenburg et al., 1996; Low et al., 2015; Marusak et al., 2021)
Non-direct-to-consumer market channels index (0–7)	358	1.18	1.23	−	(Galt, 2013; Kloppenburg et al., 1996; Low et al., 2015; Marusak et al., 2021)
Change in use of online sales and marketing (1–3)	359	2.34	0.62	+	(Bachman et al., 2021; Erjavec et al., 2021; Hsiao and Tuan, 2021; Schreiber et al., 2022)

Notes: Gross sales is measured as less than \$2500 = 1; \$2500–\$4999 = 2; \$5000–\$9999 = 3; \$10,000–\$24,999 = 4; \$25,000–\$49,999 = 5; \$50,000–\$99,999 = 6; \$100,000–\$499,999 = 7; \$500,000 or more = 8. Percent direct market sales is measured as 1–10% = 1; 11–25% = 2; 26–50% = 3; 51–75% = 4; 76–90% = 5; 91–100 = 6. Change in use of online sales and marketing is measured as decreased =1; no change =2; increased =3.

including sales of goods and services, in 2020. Though both acres farmed and gross sales can serve as metrics for farm scale (Whitt et al., 2021), we used gross farm sales rather than acres operated as a measure of scale of the operation in order to compare scale across crop and livestock operations that have vastly different acreages. *Percentage direct market sales* was the percentage of gross farm sales from direct-to-consumer, direct-to-retail, and direct-to-institution market channels in 2020. The data was collected on an ordinal scale where *gross farm sales* included categories of less than \$2500 to \$500,000 or more, summed for an index ranging from one to eight and *percentage direct market sales* included categories of 1–10% and 91–100%, summed for an index ranging from one to six.

The *farm resources index* was compiled using a series of questions asking about the resources the operation had access to from March 2020 through December 2020. Resources included processing equipment, packaging equipment, non-refrigerated storage for raw products, large scale refrigeration capacity, and vehicles to transport products. Each resource selected was summed for a final index score ranging from zero to five.

Market channels used by respondents at any time in 2020 (including the months prior to the pandemic) were disaggregated into two indices according to the type of marketing: *direct-to-consumer market channels index* and *non-direct-to-consumer market channels index. The direct-to-consumer market channels index* includes sales to Community Supported Agriculture (CSA), farmstands, you-pick, farmers markets, and nurseries. The *non-direct-to-consumer market channels index* includes direct-to-retail, −restaurants, −universities, −schools, and -non-educational institutions (e.g., hospitals, prisons); wholesale; and services and other non-farm good sales (e.g., event rentals, Airbnb, or other agrotourism).

Change in use of online sales and marketing measures whether a farmer's use of online sales and marketing decreased, increased, or saw no change from March 2020 through December 2020. The variable was coded as decreased =1, no change =2, and increased =3.

Farming *region is Southern California* is categorized as Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, Santa Barbara, and Ventura Counties. All other 50 counties are included in Northern California. Two farmers that produced in both Southern and Northern California were given an NA for this variable.

3. Results

Our results proceed as follows. We begin by discussing the characteristics of our sample of direct market farmers and their operations, the market channels they used and how those changed during the pandemic, and their reported experience during the pandemic. We then discuss factors statistically associated with resilience according to our multivariate regression analysis, and factors that farmers reported helped them withstand the challenges of the first year of the COVID-19 pandemic.

3.1. Summary statistics

The majority of direct market farmers within the survey sample identified as white and were first generation farmers (78% and 68%, respectively) (Table 2). About half of farmers identified as male (46%) and were under 55 years of age (55%). Six percent of farmers participated in an online farmer network.

Most farms in the sample were located in Northern California (83%). The average age of the farms studied was 20 years, and 44% of the operations were organically certified. The average score for crop and livestock diversity across operations was 3.17. In other words, out of the 22 types listed, the average operation cultivated or raised slightly over three types of crops or livestock.

In terms of on-farm economics, the average farm in the sample brought in gross sales between $25,000–$49,999. Of gross farm sales, on average 76–90% were from direct market sales. Operations had access to an average of two out of the five resources listed, which included vehicles, refrigeration, dry storage, processing equipment, and packaging equipment. Thirty-eight percent of respondents used unpaid family labor on their operation (Table 2).

The dependent variables, which were related to farmers' experiences during the first year of the pandemic, are displayed in Table 3. They show varied opinions of, and responses to, the March 2020 through December 2020 portion of the pandemic. The majority of respondents (68%) felt that they were able to respond to the pandemic during March 2020 through December 2020. At the same time, 60% were concerned about how the pandemic had impacted their operation. Thirty percent of respondents reported increases in profitability, while 43% reported decreases in profitability (with no change reported by 27%).

When asked about their marketing channels, 86% of farmers answering this question reported using at least one direct-to-consumer channel and 62% reported using at least one non-direct-to-consumer channel. Farmers overall reported greater use of direct-to-consumer channels compared to non-direct-to-consumer channels during 2020. The average farmer in the sample reported using one of the five direct-to-consumer channels listed (CSA, farmstands, you-pick, nurseries, and farmers markets) and two of the seven non-direct-to-consumer marketing channels (direct-to-retail, −restaurants, −universities, −schools, and -non-educational institutions (e.g., hospitals, prisons); wholesale; and services and other non-farm good sales) (Table 2).

Forty-six percent of our respondents reported using online marketing channels during March 2020 through December 2020. Fifty percent of those farmers who reported using online market channels during that time reported no change in their use of online sales, 42% reported increasing their use of online sales, and 8% reported decreased use. The number of direct market farmers involved in online marketing in our sample is substantially higher than reported by a 2015 study of direct market farmers, which found that only 8% used online marketing (O'Hara and Low, 2020), suggesting a possible upward trend towards the use of online markets among direct market farmers.

One of the largest shocks to farmers during the first few months of the pandemic was disruptions to market channels (Johansson et al., 2020; Ransom et al., 2020; Yaffe-Bellany and Corkery, 2020). Fig. 2 shows the changes that farmers made in the market channels they used between March 2020 through December 2020. The market channels that had the largest number of farmers adding them during the pandemic were online sales and CSAs (Fig. 2). In contrast, the channels that farmers reported losing the most were farmers markets and restaurants. Farmers markets and farmstands saw both substantial overall growth *and* loss. The net change of additions and losses across all market channels was positive 2%,[3] signifying that while there were certainly losses across all market channels, there were gains in others that kept participation across the various market channels relatively stable.

3.2. Factors associated with resilience

The following paragraphs summarize results from farmer perceptions of factors that enabled them to withstand or even prosper during the challenges of the pandemic (Tables 4–5) and from the *combined* regression models (Table 6). Table 6 describes the results of a series of ordered logistic regressions estimating the relationships between the characteristics of producers and their operations and each measure of resilience. Several tests were performed to improve confidence in our model selection. A test of parallel lines found no indication that the effect of the independent variables varied for different levels of the dependent variables, except for the *direct-to-consumer channels index* ($p < 0.05$) in Model 4, *first generation farmer* ($p < 0.05$) and *direct-to-consumer channels index* ($p < 0.01$) in Model 7 and *farm age* in Model 8 ($p < 0.05$) (Brant 1990). Given that proportional odds held for 92 of the 96 independent variables across the nine models fitted, we believe that the dependent variables are more appropriately treated as ordinal compared to nominal. An examination of correlation coefficients and variance inflation factors (VIFs) showed no signs of multicollinearity among the independent variables; all independent variables had a variance inflation factor score of 2.0 or less. Finally, a Hosmer-Lemeshow and Lipsitz test indicated a good fit of the data to the ordinal logistic models (Fagerland and Hosmer, 2016).

The pseudo R^2, a measure of the predictive power of a model appropriate for logistic regression, is 0.45 for Model 7 measuring *ability to respond to the pandemic,* 0.36 for Model 8 measuring *concern about pandemic impacts*, and 0.29 for Model 9 measuring *change in profitability*. The best model fit among the various models is signified by the lowest AIC value, with a difference of two between models' AICs considered substantial (Burnham and Anderson, 2002). A comparison of each model's AIC shows that operational variables (Models 4–6) are the most important for predicting resilience (AIC = 367.20–475.93) compared to the individual variables (Models 1–3) (AIC = 558.16–705.12). The combined models (Models 7–9) that consider both individual and operational factors have the best model fit indicated by the lowest AIC values (AIC = 366.37–466.49).

3.3. Individual characteristics

3.3.1. Race

Reports surfaced during the pandemic showing that BIPOC farmers (Black, Indigenous, and people of color) were more vulnerable to its disruptions (Rappeport, 2022; Ricker, 2020; Taylor et al., 2022), and several of our models show a similar effect of race. *Race is white* emerged as an important, positive predictor of resilience in the individual characteristic models: *change in profitability* was positive and significant at the >1% level and *ability to respond to the pandemic* at the 6% level. These results align with the inequities BIPOC farmers experience in the U.S. agrifood system (Bowens, 2015; Minkoff-Zern and Sloat, 2017). However, when holding operational factors constant in our combined models, *race is white* becomes non-significant ($p > 10\%$) in each model, although the direction of the relationships remains the same. When operational characteristic variables are added into the model, they reduce the effects of *race is white*. However, since operational characteristics such as farm scale (represented by *gross farm sales*) are partially determined by race (from structural racism in U.S. agriculture, see Discussion), these models should not be interpreted to mean that racial

[3] This was calculated from the average of farm-level net changes in market channels during the pandemic (channels gained minus channels lost).

Table 3
Dependent variables indicating farmer resilience to the COVID-19 pandemic included in the ordered logit regression models.

	DI	NAD	AG	DC	NC	IN	N	Mean	St. Dev.	Min	Max
Overall, our operation was able to respond to the pandemic (*ability to respond*)	45	70	244				359	2.55	0.71	1.00	3.00
I am concerned with how the pandemic has impacted our operation (*concern about pandemic impacts)*	53	90	216				359	2.45	0.74	1.00	3.00
From March 2020 through December 2020, how did your operation's profitability change overall? (*Change in profitability*)				155	95	109	359	1.87	0.85	1.00	3.00

Notes: DI = disagree; NAD = neither agree nor disagree, AG = agree; DC = decreased; NC = no change; IN = increased.

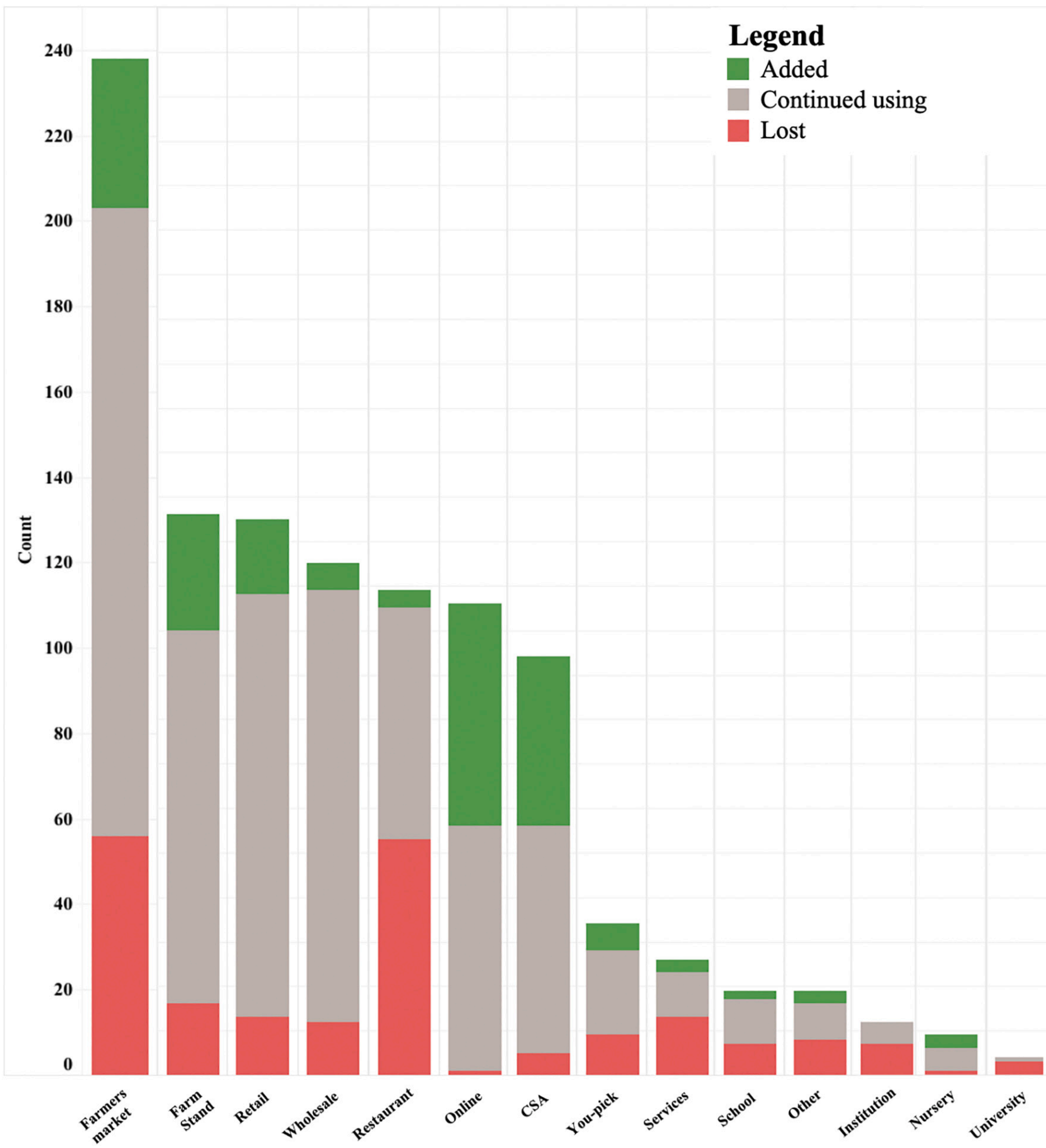

Fig. 2. Number of farmers reporting changes in use of each market channel, March 2020 through December 2020.

inequalities in pandemic effects and response do not exist. This is evidenced by the correlation between *race is white* and *gross farm sales* ($r = 0.2$, $p = 0.0008$). Even though this correlation does not approach the level that creates a problem of multicollinearity, the correlation is consistent with how racialization influences important farm characteristics through structural racism.

3.3.2. Gender

Gender is male was not significantly associated with resilience in any of the models. Unlike race, it was not significant in the farmer characteristic models, and this did not change with the inclusion of farm characteristics. This finding countered research indicating that the stresses of farming (e.g., unpredictable weather, animal disease, economic stresses, overwork, burden of paperwork/bureaucracy, media

Table 4
Farmer-reported relationships and institutions that helped farmers respond to pandemic-related challenges.

	N	Percent	St. Dev.
Family	341	63%	0.48
Customers	341	46%	0.50
Employees	341	29%	0.45
Farmers market management	341	28%	0.45
Farmers	341	23%	0.42
Government pandemic assistance	341	23%	0.42
Nonprofit	341	14%	0.35
Volunteers	341	13%	0.34
Restaurants	341	8%	0.27
Online farmer network	341	6%	0.24
UC Cooperative Extension	341	3%	0.17
Farm coop	341	3%	0.16
Marketing boards	341	1%	0.12
Other	341	7%	0.25
None of the above	341	5%	0.22
Prefer not to answer	341	1%	0.09

Notes: Yes = 1 for all items.

Table 5
Farmer-reported operational attributes that helped farmers respond to pandemic-related challenges.

	N	Percent	St. Dev.
Market channels	342	55%	0.50
Production diversity	342	44%	0.50
Size of the farm (acres cultivated)	342	34%	0.48
Crop varieties	342	33%	0.47
Ability to sell products online	342	28%	0.45
Number of employees	342	19%	0.39
Land tenure	342	17%	0.38
Access to equipment	342	16%	0.37
Labor arrangement	342	15%	0.35
Types of livestock	342	9%	0.28
Ability to expand cultivation	342	7%	0.25
None of the above	342	10%	0.30
Prefer not to answer	342	5%	0.21

Notes: Yes = 1 for all items.

criticism, and social isolation) tend to affect women more than men in general farming populations (Booth and Lloyd, 1999; Brumby et al., 2013; Fraser et al., 2005; Jones-Bitton et al., 2020). It also countered pandemic-specific international studies on both the general farming population and small-holder farmers indicating that women farmers were more vulnerable than their male counterparts to the stresses of the pandemic (de Paz et al., 2020; Kantamneni, 2020; Parry and Gordon, 2020). However, our findings do align with research highlighting the specific benefits of direct market farming for women farmers such as empowerment, gender equality, and caring for the community, environment, and oneself, that has led to a higher prevalence of satisfaction in farming for female direct market farmers (Jarosz, 2011; Tijani and Yano, 2007; Wells and Gradwell, 2001; Zirham and Palomba, 2016). These benefits may have translated to greater resilience to the impacts of the pandemic for women direct market farmers and suggests that women direct market farmers in California may have been similarly capable of adapting to the pandemic's challenges.

3.3.3. Farmer age

Similar to other studies that found that younger farmers are more capable of adaptation (Darnhofer, 2010; Mase et al., 2017; Peerlings et al., 2014), farmers under 55 years of age were associated with a greater likelihood of reporting that they were able to respond to the challenges of the pandemic ($p = 0.04$). Other studies show that younger farmers were more able to pivot to digital commerce during the pandemic (Erjavec et al., 2021), which were a helpful tool in responding to the pandemic's disruptions (Meuwissen et al., 2021; Tittonell et al., 2021).

3.3.4. First generation farmer

While limited research on new and first-generation farmers shows that they are more vulnerable to stressors (Holt-Giménez, 2002; Munden-Dixon et al., 2018), we found that they were more likely to report being less concerned about the impacts of the pandemic ($p = 0.06$).

3.3.5. Online network participation

Farmers that were involved in an online farmer network were more likely to report feeling less concern about the pandemic impacts ($p = 0.07$) and were more likely to report no change or an increase in profitability during the pandemic ($p = 0.02$), most likely given the benefits of connectivity to other farmers and their knowledge and resources (Carlisle, 2016; Šūmane et al., 2018).

3.4. Operational characteristics

3.4.1. Farm age

While we expected older farms to have more established market channels, community support systems, lines of credit, and accumulated on-farm capital that would help them to respond (Darnhofer, 2010; Holt-Giménez, 2002; Kautsky, 1988; Mann and Dickinson, 1978), when controlling for all other variables in the model, farm age was not associated with any measure of resilience.

3.4.2. Production diversity

The *crop and livestock diversity index* was positively associated with *ability to respond to the pandemic* ($p = 0.03$) and *change in profitability* ($p = 0.06$) from March 2020 through December 2020. In other words, farmers with a greater diversity of crops and livestock were more likely to agree that they were able to respond to the pandemic and report no change or an increase in profitability compared to farmers with fewer types of crops and livestock. These findings from the regression models were supported by farmer perceptions. Forty-four percent of farmers listed production diversity as an operational attribute they felt helped them respond to pandemic-related challenges, the second most frequent attribute selected (behind market channels) (Table 5). Our results confirm the growing literature on the benefits of on-farm diversity (Bowles et al., 2020; A. S. Davis et al., 2012; Tamburini et al., 2020), including in the context of farmers responding to disturbances (Maggio et al., 2018; Perrin et al., 2020; Petersen-Rockney et al., 2021).

3.4.3. Gross farm sales

Gross farm sales was positively associated with *ability to respond to the pandemic* ($p = 0.10$) and *change in profitability* ($p < 0.00$), and negatively associated with *concern about pandemic impacts* ($p = 0.08$), controlling for whether the farm received federal pandemic assistance. Larger-scale operations were thus significantly more likely to withstand or benefit from the shocks caused by the pandemic, presumably because of their larger buffering capacity in the form of capital to allocate to new problems. This aligns with studies indicating that small-scale, diversified farmers were less likely to be eligible for federal pandemic relief funds, and larger-scale farms received a greater share of pandemic assistance, making it more difficult for smaller-scale operations to recover from the financial challenges of the pandemic (Hamann, 2021; Ramgopal and Lehren, 2020; Whitt et al., 2021).

3.4.4. Organic certification

Whether a farm was *organic certified* did not emerge as an important operational characteristic in any of the models, despite studies indicating that organic farms can have greater resilience due to production diversity, increased input autonomy, and access to high-end markets (Brzezina et al., 2016; Perrin and Martin, 2021; Perrin et al., 2020). The greater diversity of production typical on organic farms may have been captured by the production diversity index while the higher-value

Table 6
Ordered logistic regression models predicting resilience to the COVID-19 pandemic according to individual-level, farm-level and combined individual-farm-level variables.

	Dependent variable:								
	Ability to respond to the pandemic	Concern about pandemic impacts	Change in profitability	Ability to respond to the pandemic	Concern about pandemic impacts	Change in profitability	Ability to respond to the pandemic	Concern about pandemic impacts	Change in profitability
	Model	Model	Model	Model	Model	Model	Model	Model	Model
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Race is white	0.524*	−0.448	0.809***				0.452	−0.229	0.465
	(0.276)	(0.281)	(0.262)				(0.360)	(0.360)	(0.336)
	p = 0.058	p = 0.111	p = 0.003				p = 0.210	p = 0.525	p = 0.167
Gender is male	−0.098	0.174	−0.255				0.213	−0.168	−0.186
	(0.239)	(0.224)	(0.211)				(0.336)	(0.302)	(0.291)
	p = 0.682	p = 0.439	p = 0.227				p = 0.527	p = 0.579	p = 0.524
Under 55 years old	0.669***	−0.308	0.581***				0.726**	−0.279	0.463
	(0.239)	(0.224)	(0.212)				(0.343)	(0.314)	(0.291)
	p = 0.006	p = 0.168	p = 0.007				p = 0.035	p = 0.375	p = 0.112
First generation farmer	0.007	−0.226	0.160				0.413	−0.675*	0.487
	(0.258)	(0.244)	(0.227)				(0.354)	(0.352)	(0.322)
	p = 0.980	p = 0.356	p = 0.481				p = 0.244	p = 0.055	p = 0.131
Online farmer network participant	0.445	−0.876**	1.012**				0.404	−1.005*	1.440**
	(0.529)	(0.435)	(0.452)				(0.703)	(0.560)	(0.610)
	p = 0.400	p = 0.044	p = 0.026				p = 0.567	p = 0.073	p = 0.019
Farm age				−0.003	0.006	−0.009	0.002	0.004	−0.005
				(0.007)	(0.008)	(0.007)	(0.008)	(0.009)	(0.007)
				p = 0.651	p = 0.439	p = 0.191	p = 0.792	p = 0.680	p = 0.463
Crop and livestock diversity index				0.189**	0.008	0.117*	0.215**	−0.016	0.132*
				(0.091)	(0.070)	(0.068)	(0.096)	(0.073)	(0.070)
				p = 0.037	p = 0.914	p = 0.088	p = 0.025	p = 0.830	p = 0.061
Gross farm sales				0.173**	−0.146*	0.245***	0.153*	−0.151*	0.251***
				(0.088)	(0.082)	(0.079)	(0.092)	(0.085)	(0.082)
				p = 0.048	p = 0.075	p = 0.002	p = 0.096	p = 0.077	p = 0.003
Organic certified				0.152	0.317	0.108	0.156	0.427	0.205
				(0.359)	(0.314)	(0.309)	(0.369)	(0.335)	(0.325)
				p = 0.671	p = 0.314	p = 0.727	p = 0.672	p = 0.203	p = 0.528
Percent direct to market sales				0.079	−0.176*	0.121	0.052	−0.128	0.075
				(0.098)	(0.098)	(0.089)	(0.101)	(0.102)	(0.094)
				p = 0.421	p = 0.073	p = 0.177	p = 0.608	p = 0.208	p = 0.426
Region = Southern California				−0.617	0.268	−1.032***	−0.487	0.142	−0.908**
				(0.396)	(0.387)	(0.393)	(0.409)	(0.396)	(0.404)
				p = 0.120	p = 0.489	p = 0.009	p = 0.234	p = 0.719	p = 0.025
Farm resources index				−0.248*	0.240**	−0.132	−0.242*	0.241**	−0.113
				(0.131)	(0.120)	(0.111)	(0.135)	(0.123)	(0.115)
				p = 0.060	p = 0.047	p = 0.236	p = 0.073	p = 0.050	p = 0.323
Used unpaid family labor				−0.031	−0.059	−0.248	0.008	−0.127	−0.283
				(0.334)	(0.293)	(0.286)	(0.352)	(0.306)	(0.299)
				p = 0.927	p = 0.841	p = 0.387	p = 0.982	p = 0.677	p = 0.345
Direct-to-consumer channels index				−0.081	−0.043	0.135	−0.119	−0.021	0.141
				(0.178)	(0.168)	(0.155)	(0.184)	(0.174)	(0.162)
				p = 0.650	p = 0.798	p = 0.383	p = 0.518	p = 0.904	p = 0.384
Non-direct-to consumer channels index				−0.132	0.335**	−0.347***	−0.199	0.419***	−0.437***
				(0.142)	(0.142)	(0.128)	(0.146)	(0.149)	(0.135)
				p = 0.353	p = 0.019	p = 0.007	p = 0.175	p = 0.005	p = 0.002
Change in use of online sales				0.871***	−0.536**	1.123***	0.785***	−0.389	0.888***
				(0.275)	(0.251)	(0.250)	(0.291)	(0.260)	(0.262)
				p = 0.002	p = 0.033	p = 0.00001	p = 0.008	p = 0.136	p = 0.001
Observations	334	334	334	236	236	236	234	234	234
Pseudo R^2 (McFadden's)	0.10	−0.02	−0.14	0.44	0.34	0.26	0.45	0.36	0.29
AIC	558.16	628.19	705.12	368.69	428.99	476.22	367.91	425.36	467.28

Note: AIC stands for Akaike information criterion. Standard errors are listed in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

markets of organics were likely overshadowed by the demand for local products, regardless of certification status.

3.4.5. Percent direct market sales

The *percent direct market sales* was not significant in any of the combined models, suggesting that a diversity of market channels that included intermediary and wholesale channels may have been important. This finding may have been different had we measured percent direct-to-consumer sales distinct from direct market sales broadly, given that direct-to-consumer marketing has been associated with higher farm survival rates in local food systems than other non-direct-to-consumer market channels (Low et al., 2015). However, our study did allow us to differentiate use of direct-to-consumer and non-direct-to-consumer market channels, as discussed in the *market channel diversity* paragraphs below.

3.4.6. Regional differences

Region is Southern California was significantly and negatively associated with *change in profitability* ($p = 0.03$). This means that farmers operating in Southern California were more likely to experience a decrease in profitability during the pandemic compared to those in Northern California counties. This corresponds well with a California regional analysis showing that CSA farmers in Southern California felt less supported by their members than those in Northern California, and that Southern California grocery shoppers rank lowest (out of the four regions used) in positive attitudes towards direct marketing and highest in their valuing of organic (Galt and Munden-Dixon, 2019). Because organic systems in California can be large-scale industrialized production systems (using primarily wholesale and intermediated markets), they may not be embedded in the same socio-economic systems that define local and regional food systems (Brinkley, 2017; Brinkley et al., 2021; Cabell and Oelofse, 2012; Guthman, 2014; Trivette, 2019). We suspect that direct market farm products in Southern California may not have received the same interest as in Northern California, although further research is needed to draw strong conclusions.

3.4.7. Farm resources index

The variable *farm resources index* was associated with less resilience during the pandemic. Greater access to farm resources was negatively associated with the ability *to respond to the pandemic* ($p = 0.07$) and positively associated with greater *concern about pandemic impacts* ($p = 0.05$). Farmers echoed this finding; only 16% listed equipment as an important operational attribute that helped them respond to pandemic challenges. While a surprising finding, multiple factors may be operative here. On the one hand, direct market farmers that owned more on-farm resources may have been over-leveraged by credit taken out to purchase those resources (e.g., farm equipment loans) (Low et al., 2015) and subsequently more vulnerable to the economic shocks they may have experienced during the first year of the pandemic. On the other hand, farmers who had to shift their operation during the pandemic to acquire additional storage, vehicles, or packaging equipment likely had to manage extra expenses and stress associated with finding these resources. Further research would be needed to understand this in more depth.

3.4.8. Family support

While difficult to measure quantitatively in our models, the majority of respondents (63%) said that their families helped them through the pandemic (Table 4). Family was also the most selected response to the relationships and institutions that helped farmers respond to pandemic-related challenges, which supports existing research on the benefits of unpaid family (Aguilar et al., 2022; Alpízar et al., 2020; Galt, 2013; Suryanata et al., 2021). Following these findings, we expected the variable *used unpaid family labor* to be important to resilience in the ordered logistic regressions. However, it was not found to be significant across any measure of resilience, suggesting that other forms of familial support—emotional, household work, childcare, elder care, etc. and even paid work on the farm—were likely important for farmers but were not captured in our regression models.

3.4.9. Market channel diversity

While previous research suggested that farms with a higher number of direct-to-consumer market channels would fare better during the pandemic (Galt, 2013; Low et al., 2015; Marusak et al., 2021), our results proved more complex. We found no significant associations between a higher score on the *direct-to-consumer market channels index* and resilience. However, the *non-direct-to-consumer market channels index* emerged as strongly associated with less resilience. Use of a greater number of non-direct-to-consumer channels such as wholesale, retail, and institutions were positively associated with concern about the pandemic impacts ($p < 0.01$) and negatively associated with change in profitability ($p < 0.00$). This indicates that while multiple marketing channels may have been difficult for farmers to juggle during the pandemic, those that were direct-to-consumer fared better than non-direct-to-consumer channels.

Types of market channels were also important according to farmers. When asked to select the top five attributes that most helped their operation respond to the pandemic, 55% of farmers chose the market channels their operation used; this was also the most selected response (Table 5).

3.4.10. Online sales and marketing

Change in use of online sales and marketing is positively associated with *ability to respond to the pandemic* ($p < 0.01$) and *change in profitability* ($p < 0.00$). In other words, farmers who reported an increase in online sales and marketing were more likely to agree with the statement that their operation was able to respond to the pandemic and report an increase in profitability. This is in line with other pandemic research indicating that online sales played a central role in supporting farm resilience during the pandemic (Bachman et al., 2021; Erjavec et al., 2021; Hsiao and Tuan, 2021; O'Connell et al., 2021; Schreiber et al., 2022). Specifically, when direct-to-consumer market channels were shut down due to pandemic-related restrictions, online platforms and social media acted as a key intermediary between farmers and consumers (Danovich, 2020a; Lamb, 2020; Meuwissen et al., 2021; Pretty, 2020).

Within the sample, 42% of farmers reported increasing their use of online sales and marketing during the pandemic. When asked in a separate question to select the five operational attributes that most helped them respond to the pandemic, 26% selected their ability to sell products online (Table 5).

4. Discussion

The COVID-19 pandemic provides an opportunity to increase our understanding of the factors that support farm resilience, particularly farming operations' ability to cope with and adapt to short- and medium-term disruptions. Despite substantial news coverage of booming CSA memberships, the most common response from farmers was that they experienced a decrease in profitability during the early stages of the pandemic (43%, compared with 30% who reported increases in profitability) and most (60%) expressed concern about the impacts of the pandemic, underscoring the challenges many farmers faced during the first ten months of the pandemic (Table 3). Though farmers added or increased sales through some direct market channels such as farm stores, CSAs, and grocery stores, they also reported declines in sales to more public-facing channels such as farmers markets and restaurants that closed or reduced operations due to public health mandates. Overall, this created little net change across all market channels (a 2% net increase), but likely created a new set of logistical stresses and/or challenges for farmers who had to navigate these changes. Additionally, multiple farmers wrote in open survey responses that labor and input shortages, increased costs of operating to meet safety measures and sell in individual quantities, and a lack of USDA meat processing facilities all led to reductions in profitability.

Still, out of the 364 farmers who participated in our online survey, the majority of our respondents (68%) felt able to respond to the challenges that the pandemic posed and 56% of our respondents either saw no change (27%) or experienced an increase in profits (30%) (Table 3), suggesting some level of overall resilience to its impacts. Our analysis shows that several factors were particularly important to a farmer's response to the pandemic: market channels, online sales and marketing, farm scale, and on-farm diversity. Each of these were in the top five most highly ranked operational attributes that farmers said helped them to respond to the pandemic (Table 5) and statistically significant at the 5% level or lower across multiple measures of resilience in our regressions (Table 6).

The farmers in our study reported that the most important operational attribute that helped them respond to the challenges of the pandemic was their market channels. However, our findings revealed a complex relationship between market channel diversity and farmer resilience to economic shocks like the pandemic. We found that the number of non-direct-to-consumer market channels a farmer used was one of the most statistically significant variables across our combined models (Models 8–9) and highly significantly associated with less resilience to the pandemic. In other words, the more non-direct-to-consumer market channels a farmer used, the less resilient they were to the impacts of the pandemic.

We also found that, on average, farmers in the sample gained most of their income from direct market sales. However, interestingly, direct market channel diversity was not statistically significantly associated with resilience as we expected. Farmers explained in open responses on the survey that this was because expanding into new market channels added to operational logistics and required a greater investment of time and resources to manage, a phenomenon detailed by Bachman et al. (2021). As noted by Esquivel et al. (2021), each market channel came with its own buyer requirements in terms of food safety protocols. These varying standards were likely exacerbated during the pandemic when greater sanitation protocols were put in place. With fewer intermediaries, direct-to-consumer channels including CSA, farmstands, online sales, you-pick, and nurseries, had fewer requirements to meet. Overall, these findings suggest that having a higher diversity of direct market channels might not support farm resilience during periods of disruption because the logistical pivots required to adjust a farm's operation to meet the demands of the new channel can be challenging for farmers to manage.

Online sales, while not selected as frequently as market channels, were also reported by farmers as important to responding to the pandemic and were highly significantly associated with resilience in our models. An increase in the use of online sales and marketing meant that farmers were likely to feel more able to respond to the challenges of the pandemic and report an increase in profitability. This aligns with other research on direct market or small-scale farms during the pandemic that found that online resources were helpful to overcome barriers to public vending (Danovich, 2020a; Lamb, 2020; Meuwissen et al., 2021; Pretty, 2020). However, online tools for sales and marketing require resources (e.g., a stable internet connection) that not all farmers have access to. One farmer explained in the survey: "We are in desperate need of rural bandwidth to utilize online resources. We have little to no cell coverage, and spotty and unreliable satellite internet service. This hampers our ability to increase sales outlets online." Moreover, farmers indicated that online sales involved more work to manage, package, and ship products. This suggests that while some farmers benefited from an increased use of online sales and marketing, others may have been at a disadvantage due to their lack of access to the internet and time and labor constraints.

Farm scale and production diversity were also important to farmers and associated with resilience in our regressions, although less statistically significant compared to market channels and online sales and marketing. Larger-scale operations, measured by acres cultivated in farmer reported factors and gross farm sales in our regressions, may have had a greater ability to withstand shocks due to economies of scale and eligibility for and share of federal disaster relief (Rappeport, 2022; USDA FSA, 2021). Production diversity, or the number of crop and livestock types raised on the farm, may have allowed farmers to pivot to alternative market channels and address new product demands during the pandemic, as detailed by (Måren et al., 2022). These findings on production diversity align with research suggesting that higher levels of on-farm diversification support greater farm resilience (Altieri, 1998; Ebel et al., 2022).

Despite the general importance of operational characteristics, two farmer characteristics were statistically significant in the combined models with 5% significance or greater: farmers who were under 55 and those involved in online farmer networks were both statistically significantly more resilient to the impacts of the pandemic. Studies on farmer resilience during the COVID-19 pandemic found that collaborating with other farmers (Prosser et al., 2021), participating in a locally embedded food system (Perrin and Martin, 2021), and/or having high interconnectivity with other food systems actors (Coopmans et al., 2021) contributed to risk mitigation and resilience. Other pandemic-specific research indicates that younger farmers used digital market channels most frequently during the pandemic (Erjavec et al., 2021), which also aligns with our findings and existing literature.

While not significant in the combined models, we still believe that race is important to resilience because of the likelihood that its significance was absorbed by other variables, such as gross farm sales, that have been strongly influenced by structural racism in agrifood systems. As noted in the Results section (3.3. Individual characteristics), *race is white* was a significant predictor of resilience in the individual characteristic models (1–3). This finding is similar to a recent study of young farmers under forty that found that BIPOC farmers experience challenges with farming (e.g., access to capital, land, and federal programs) at heightened rates compared to their white counterparts (Ackoff et al., 2022). Land and capital access and operation size are strongly impacted by legacies of structural racism in U.S. agriculture that overwhelmingly benefitted white farmers, through, for example, the genocide of Native Americans, the enslaving of millions of Africans forced to labor in U.S. agriculture, the 1868 Homestead Act (Sherraden, 2005), USDA's documented racial discrimination (Gilbert et al., 2002), and Japanese and Japanese American internment (Minkoff-Zern et al., 2011) to name but a few. Thus, race in the U.S. is structurally tied to operational size and resources. Not surprisingly, adding operational characteristics to the combined model reduces the significance of race, but this needs to be interpreted with the knowledge that structural racism deeply influences the distribution of land and resources in agriculture (Calo and De Master, 2016; Horst and Marion, 2019; Minkoff-Zern, 2018; White, 2018).

4.1. Policy implications

Taken together, these findings have interesting implications for policies and practices aimed at supporting long-term resilience in the agrifood system. Given the strong negative association between resilience and non-direct-to-consumer market channels, more effort can be made by industry, extension, NGO, and/or government programs to support direct-to-consumer markets. Local procurement policies for governments and businesses of all scales could also provide stronger support for direct market farmers. One promising recent example of this is USDA's $400 million in funding to support Regional Food Business Centers, announced September 2022 (USDA, 2022a). These centers will provide technical assistance, coordination, and capacity building to small and mid-size food and farm businesses, with the goal of creating a "more resilient, diverse, and competitive food system." While this program will provide much-needed funding to support local and regional food systems, it will require considerable coordination with regional support networks, including extension specialists, farm lending institutions, and other local government and NGO actors to provide the necessary support and realize the goals of the program.

Increased research to better understand the role that direct market farmers play in increasing farmer well-being and ecological and economic resilience could further the development of direct-to-consumer markets. Direct market farmers may provide important environmental services through their often diversified and regenerative farming practices (Björklund et al., 2009). Efforts to quantify the benefits of these practices would help to support a shift to carbon taxes or subsidies for socially and ecologically regenerative practices and help level the playing field for diversified, direct market farmers.

The use of online sales and marketing was identified as a helpful response strategy to the disruptions of the pandemic in several studies (Meuwissen et al., 2021; Tittonell et al., 2021) as well as our own. Given that the pandemic may have induced a long-term or permanent shift towards online sales (Coresight Research, 2021; Danovich, 2020a; Held, 2020; Lamb, 2020; Marvar, 2021; Pretty, 2020), efforts to 1) train farmers on how to set up their own or tap into existing online retail platforms, 2) provide farmers with startup funds to establish an online presence or set up an online storefront, and 3) invest in infrastructure that increases rural broadband internet capacity could help farmers access online markets and networks. This can in turn support their resilience in the face of future shocks. Farmers in rural areas who lack reliable access to an internet connection, farmers with fewer financial resources, and immigrant farmers who may need language assistance when navigating online sales and marketing platforms will be particularly important to support in this area, though further research is needed to understand which communities need the most support and the forms of support that are needed.

Finally, increased efforts could be made to support young and underserved farmers. Our results that farmers under 55 years of age were more resilient to the impacts of the pandemic, coupled with recent findings that 86% of farmers under 40 adopted regenerative farming practices (Ackoff et al., 2022), suggest that continued efforts can be made to invest in the next generation of farmers to support their access to land and resources. Efforts such as USDA's NEXTGEN funding opportunity do so by supporting the training of the next generation of food and agriculture professionals at minority-serving institutions (USDA NIFA, 2022). Our results on BIPOC farmers and extensive research on BIPOC and other underserved producers indicate that they need more support to be resilient to disruptions and thrive in the food system. A recent $300 million USDA funding opportunity to partner with organizations that increase access to land, capital, and markets for vulnerable farmers is a promising start (USDA, 2022b), though localized efforts at the state and county levels will also be needed. Additional steps to support these efforts are detailed by other scholars (Calo, 2020; Carlisle et al., 2019).

4.2. Limitations and areas for future research

Despite our survey's relative representativeness (Fig. 1, Table 1), we suspect that the experiences of certain types of farmers were omitted. Most prominently, our survey was distributed through email and administered through an online instrument, which means that farmers without easy access to online technologies were likely underrepresented in our findings. Secondly, more time-constrained farmers, for example those with small children or other time-consuming caretaking responsibilities, might not have taken our survey. Third, immigrant and/or marginalized farming communities may not have found the survey accessible (e.g., because of language barriers beyond Spanish, or a lack of access to the internet or computers and smartphones to take an online survey). Future research should target these groups to ensure that their experiences are represented in pandemic-related research.

Our findings also indicated that gender was not a statistically significant variable in our combined models. However, it is possible that our survey did not reach some of the most vulnerable and/or struggling women farmers during the pandemic because they either did not have internet access, did not have time to take the survey, or did not participate in the listservs we used for distribution. Further research, particularly with BIPOC women farmers, could confirm or add nuance to these results.

Additionally, this study is cross-sectional and captures farmers' experience during only one part of the pandemic. Longitudinal research studies could capture farmers' experience over time as the impacts of the pandemic continue to unfold. As of this writing, farmers are still experiencing the effects of the pandemic on local, national, and global supply chains (Gayman, 2021; Johansson, 2021; Mitchell, 2022; Tomascik, 2021). This underscores the periodicity of the pandemic (i.e., the pre-vaccine period, post-vaccine period, and the surges of variants), as well as its geographic variability due to varied restrictions and market impacts. Pairing quantitative research with qualitative interview-based research would also help provide a more granular understanding of farmers' experiences during the pandemic.

While this study looks at resilience within direct market farmers, it would be helpful to conduct comparative studies on how direct market farmers fared relative to those with only intermediary market channels, and whether the type of product produced by direct market farmers (e.g., non-perishable commodity crops compared to fresh produce or value-added products) impacted operational resilience differently during the pandemic or other exogenous shocks.

5. Conclusion

The pandemic's impact has been experienced globally, its time frame ambiguous and unpredictable, and its initial stressors from multiple directions. Farmers have had the formidable task of responding to these multiple stressors all at once, each with varying degrees of impact, rather than adapt to one sudden, short-term crisis or slow-building issue over time. Because it was unknown whether the shocks in 2020 would be long term or not, farmers had to decide whether to focus on short-term shifts to buffer the pandemic's impacts (e.g., having family and volunteer labor help with labor shortages, using less external-input intensive production practices) or longer-term adaptive changes that involved at least partial transformations of the operation's business model (e.g., a shift to more diversified production systems, expanding to online market channels for the foreseeable future).

Given this unprecedented context, understanding which underlying factors were associated with direct market farm resilience to the pandemic's disruptions can help guide larger transitions towards sustainable and resilient regional food systems that can buffer, adapt to, and even transform these operations in response to short- and long-term crises. Because this study focused on California direct market farmers, who represent over a third of U.S. direct market farmers (USDA NASS, 2016), these findings can offer important insight on how U.S. direct market farmers fared during the first ten months of the pandemic.

Our combination of findings on the role of certain farm and farmer characteristics in strengthening resilience largely aligns with the literature on resilience, coping, and adaptive capacity, while adding nuance particular to local food systems and exogenous shocks. Specifically, we found that for California's direct market farms, those that were more resilient to the shocks of the pandemic had: 1) direct-to-consumer (rather than through intermediary) market channels, 2) greater use of online sales and marketing, 3) larger-scale farms, and 4) more on-farm crop and livestock diversity. While farming operation characteristics played a relatively larger role in predicting resilience compared to the individual characteristics of the farmers surveyed, we did find that farmers under 55 years of age and those involved in online farmer networks were both more resilient to the impacts of the pandemic. Additionally, white farmers fared better than BIPOC farmers as shown in our farmer characteristic models (1–3). This inequality will hopefully be addressed by continued USDA priorities around promoting next-generation farmers from underrepresented races and ethnicities in U.S. agriculture but will need to be addressed by state and county-level policy and non-governmental support as well.

Our research also suggests that direct markets alone were not enough to ensure on-farm resilience, despite long-standing and widespread celebration of the social embeddedness of alternative food networks acting to blunt the rough edges of commodity markets (Feagan and Morris, 2009; Galt, 2013; Hinrichs, 2000). Percentage of sales through direct markets did not strongly influence any of the dependent variables used as proxies for resilience. In other words, direct market farmers still faced numerous problems despite being socially embedded through their direct market relationships.

Taken together, these findings suggest that direct market farmers were generally able to respond to the impacts of the first ten months of the pandemic, but also experienced a number of challenges that might have been alleviated by increased policy, market, and extension/educational support, as well as increased access to cellular and internet services. Large-scale disruptions are becoming increasingly common as extreme weather and climate are accompanied by social disruptions (Swanson et al., 2014). Additionally, future pandemics appear inevitable (M. Davis, 2005; Mayer and Lewis, 2020). The advantage of shorter supply chains and diversified farming systems that help farmers buffer and adapt to these disruptions are substantial. Policy and other institutional support for all farmers to enhance farm-level agrobiodiversity and short supply chains through direct market farming, with an additional focus to support BIPOC farmers because of the disadvantages they have faced, will be important to create a more resilient and equitable food system in the years to come.

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Author contributions

JD led the research study, contributed to the survey design, writing, and analysis, revisions, and managed the collaborative research process among the co-authors. LA contributed to the survey design, writing, revisions, and conducted the statistical analysis, graphing, and mapping. RG provided guidance on the research process throughout, ran the survey distribution, contributed to the survey design, analysis, writing, revisions, and provided funding. SP contributed to the survey design, writing and translated the survey instrument into Spanish. GM contributed to the survey design, dissemination, and citations and provided formatting, comments, and edits to the manuscript. NP provided feedback throughout the project and provided citations, comments, and edits to the manuscript. All authors contributed to the article and approved the submitted version.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Survey respondents by county, compared with all farms selling directly to consumer in the 2017 Census of Agriculture

	Farms selling directly to consumers, 2017 Census of Agriculture^		Respondents, 2021 statewide survey^^		Sample Disproportionality
County	Number	Percentage of total DTC farmers in CA	Number	Percentage of total survey respondents	Difference in Percentage
Alameda County	73	1.0%	4	1.0%	0.0%
Alpine County	0	0.0%	0	0.0%	0.0%
Amador County	69	0.9%	0	0.0%	-0.9%
Butte County	215	2.8%	17	4.2%	1.4%
Calaveras County	94	1.2%	0	0.0%	-1.2%
Colusa County	35	0.5%	3	0.7%	0.3%
Contra Costa County	60	0.8%	9	2.2%	1.4%
Del Norte County	19	0.2%	0	0.0%	-0.2%
El Dorado County	253	3.3%	12	3.0%	-0.4%
Fresno County	347	4.6%	2	0.5%	-4.1%
Glenn County	72	0.9%	1	0.2%	-0.7%
Humboldt County	137	1.8%	20	4.9%	3.1%
Imperial County*	14	0.2%	0	0.0%	-0.2%
Inyo County	10	0.1%	0	0.0%	-0.1%
Kern County	110	1.4%	5	1.2%	-0.2%
Kings County	35	0.5%	2	0.5%	0.0%
Lake County	75	1.0%	8	2.0%	1.0%
Lassen County	36	0.5%	0	0.0%	-0.5%
Los Angeles County*	105	1.4%	4	1.0%	-0.4%
Madera County	58	0.8%	3	0.7%	0.0%
Marin County	69	0.9%	8	2.0%	1.1%
Mariposa County	35	0.5%	3	0.7%	0.3%
Mendocino County	141	1.8%	7	1.7%	-0.1%
Merced County	92	1.2%	6	1.5%	0.3%
Modoc County	37	0.5%	4	1.0%	0.5%
Mono County	4	0.1%	1	0.2%	0.2%
Monterey County	107	1.4%	9	2.2%	0.8%
Napa County	231	3.0%	7	1.7%	-1.3%
Nevada County	140	1.8%	15	3.7%	1.9%
Orange County*	34	0.4%	4	1.0%	0.5%
Placer County	232	3.0%	13	3.2%	0.2%
Plumas County	22	0.3%	2	0.5%	0.2%
Riverside County*	331	4.3%	12	3.0%	-1.4%
Sacramento County	175	2.3%	14	3.5%	1.2%
San Benito County	45	0.6%	3	0.7%	0.2%
San Bernardino County*	179	2.3%	8	2.0%	-0.4%
San Diego County*	760	10.0%	24	5.9%	-4.0%
San Francisco	0	0.0%	6	1.5%	1.5%
San Joaquin County	187	2.5%	6	1.5%	-1.0%
San Luis Obispo County	278	3.6%	7	1.7%	-1.9%
San Mateo County	48	0.6%	3	0.7%	0.1%
Santa Barbara County*	203	2.7%	10	2.5%	-0.2%
Santa Clara County	113	1.5%	8	2.0%	0.5%
Santa Cruz County	137	1.8%	11	2.7%	0.9%
Shasta County	170	2.2%	9	2.2%	0.0%
Sierra County	2	0.0%	1	0.2%	0.2%
Siskiyou County	98	1.3%	13	3.2%	1.9%
Solano County	123	1.6%	12	3.0%	1.3%
Sonoma County	480	6.3%	40	9.9%	3.6%
Stanislaus County	214	2.8%	5	1.2%	-1.6%
Sutter County	92	1.2%	1	0.2%	-1.0%
Tehama County	137	1.8%	12	3.0%	1.2%
Trinity County	45	0.6%	0	0.0%	-0.6%
Tulare County	309	4.1%	2	0.5%	-3.6%
Tuolumne County	61	0.8%	1	0.2%	-0.6%
Ventura County*	250	3.3%	3	0.7%	-2.5%
Yolo County	136	1.8%	20	4.9%	3.2%
Yuba County	89	1.2%	5	1.2%	0.1%
California	7623	100.0%	405	100.0%	—

*County included in Southern California region in our analysis.
^NASS 2017a, pp. 280–284.
^^The sum is >364 since 31 respondents farm in more than one county.

References

Ackoff, S., Flom, E., Garcia Polanco, V., Howard, D., Manly, J., Mueller, C., Wyatt, L., 2022. Building a Future with Farmers. National Young Farmers Coalition. Retrieved from. https://www.youngfarmers.org/resource/building-a-future-with-farmers-ii/.

Aguilar, F.X., Hendrawan, D., Cai, Z., Roshetko, J.M., Stallmann, J., 2022. Smallholder farmer resilience to water scarcity. Environ. Dev. Sustain. 24 (2), 2543–2576. https://doi.org/10.1007/s10668-021-01545-3.

Akram-Lodhi, A.H., Kay, C., 2010a. Surveying the agrarian question (part 1): unearthing foundations, exploring diversity. J. Peasant Stud. 37 (1), 177–202. https://doi.org/10.1080/03066150903498838.

Akram-Lodhi, A.H., Kay, C., 2010b. Surveying the agrarian question (part 2): current debates and beyond. J. Peasant Stud. 37 (2), 255–284. https://doi.org/10.1080/03066151003594906.

Alpízar, F., Saborío-Rodríguez, M., Martínez-Rodríguez, M.R., Viguera, B., Vignola, R., Capitán, T., Harvey, C.A., 2020. Determinants of food insecurity among smallholder farmer households in Central America: recurrent versus extreme weather-driven events. Reg. Environ. Chang. 20 (22) https://doi.org/10.1007/s10113-020-01592-y.

Altieri, M.A., 1998. Ecological impacts of industrial agriculture and the possibilities for truly sustainable farming. Mon. Rev. 50, 60–71. https://doi.org/10.14452/MR-050-03-1998-07_5.

Altieri, M.A., Nicholls, C.I., 2020. Agroecology and the reconstruction of a post-COVID-19 agriculture. J. Peasant Stud. 881–898 https://doi.org/10.1080/03066150.2020.1782891.

Bachman, G.H., Lupolt, S.N., Strauss, M., Kennedy, R.D., Nachman, K.E., 2021. An examination of adaptations of direct marketing channels and practices by Maryland fruit and vegetable farmers during the COVID-19 pandemic. J. Agric. Food Syst. Comm. Dev. 10 (4), 283–301. https://doi.org/10.5304/jafscd.2021.104.010.

Björklund, J., Westberg, L., Geber, U., Milestad, R., Ahnström, J., 2009. Local selling as a driving force for increased on-farm biodiversity. J. Sustain. Agric. 33 (8), 885–902. https://doi.org/10.1080/10440040903303694.

Booth, N.J., Lloyd, K., 1999. Stress in farmers. Int. J. Soc. Psychiatry 46 (1), 67–73. https://doi.org/10.1177/002076400004600108.

Bowens, N., 2015. The Color of Food: Stories of Race, Resilience and Farming. New Society Publishers, Gabriola, BC. Retrieved from. https://newsociety.com/books/c/the-color-of-food.

Bowles, T.M., Mooshammer, M., Socolar, Y., Calderón, F., Cavigelli, M.A., Culman, S.W., Grandy, A.S., 2020. Long-term evidence shows that crop-rotation diversification increases agricultural resilience to adverse growing conditions in North America. One Earth 2 (3), 284–293. https://doi.org/10.1016/j.oneear.2020.02.007.

Brinkley, C., 2017. Visualizing the social and geographical embeddedness of local food systems. J. Rural. Stud. 54, 314–325. https://doi.org/10.1016/j.jrurstud.2017.06.023.

Brinkley, C., Manser, G.M., Pesci, S., 2021. Growing pains in local food systems: A longitudinal social network analysis on local food marketing in Baltimore County, Maryland and Chester County, Pennsylvania. Agric. Hum. Values 38, 911–927. https://doi.org/10.1007/s10460-021-10199-w.

Brumby, S., Kennedy, A., Chandrasekara, A., 2013. Alcohol consumption, obesity, and psychological distress in farming communities-an Australian study. J. Rural. Health 29 (3), 311–319. https://doi.org/10.1111/jrh.12001.

Brzezina, N., Kopainsky, B., Mathijs, E., 2016. Can organic farming reduce vulnerabilities and enhance the resilience of the European food system? A critical assessment using system dynamics structural thinking tools. Sustainability 8 (10), 971. https://doi.org/10.3390/su8100971.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach, 2nd ed. Springer, New York. https://doi.org/10.1007/b97636. Retrieved from.

Cabell, J., Oelofse, M., 2012. An indicator framework for assessing agroecosystem resilience. Ecol. Soc. 17 (1), 18. https://doi.org/10.5751/ES-04666-170118.

Calo, A., 2020. "Who has the power to adapt?" frameworks for resilient agriculture must contend with the power dynamics of land tenure. Front. Sustain. Food Syst. 4 (December), 1–7. https://doi.org/10.3389/fsufs.2020.555270.

Calo, A., De Master, K.T., 2016. After the incubator: factors impeding land access along the path from farmworker to proprietor. J. Agric. Food Syst. Comm. Dev. 6 (2), 111–127. https://doi.org/10.5304/jafscd.2016.062.018.

Carlisle, L., 2016. Factors influencing farmer adoption of soil health practices in the United States: A narrative review. Agroecol. Sustain. Food Syst. 40 (6), 583–613. https://doi.org/10.1080/21683565.2016.1156596.

Carlisle, L., de Wit, M.M., DeLonge, M.S., Calo, A., Getz, C., Ory, J., Press, D., 2019. Securing the future of US agriculture: the case for investing in new entry sustainable farmers. Elementa 7 (1). https://doi.org/10.1525/elementa.356.

Coopmans, I., Bijttebier, J., Marchand, F., Mathijs, E., Messely, L., Rogge, E., Wauters, E., 2021. COVID-19 impacts on Flemish food supply chains and lessons for Agri-food system resilience. Agric. Syst. 190, 103136 https://doi.org/10.1016/j.agsy.2021.103136.

Coresight Research, 2021, May 20. US online grocery survey 2021: post-surge consumer behaviors. In: Coresight Research. Retrieved from. https://coresight.com/research/us-online-grocery-survey-2021-post-surge-prospects/.

Danovich, T., 2020, April 2. Is this the start of a CSA boom? As home cooks practice social distancing, farm produce that skips the store makes sense. In: Eater. Retrieved from. https://www.eater.com/2020/4/2/21200565/csa-trend-coronavirus-covid-19-stay-at-home-delivery-groceries.

Danovich, T., 2020, November 16. With COVID-19, CSAs Are Trending as Way to Shop. Eater. Retrieved from. https://www.eater.com/2020/4/2/21200565/csa-trend-coronavirus-covid-19-stay-at-home-delivery-groceries.

Darnhofer, I., 2010. Strategies of family farms to strengthen their resilience. Environ. Policy Gov. 20 (4), 212–222. https://doi.org/10.1002/eet.547.

Darnhofer, I., 2014. Resilience and why it matters for farm management. Eur. Rev. Agric. Econ. 41 (3), 461–484. https://doi.org/10.1093/erae/jbu012.

Darnhofer, I., 2020. Farm resilience in the face of the unexpected: lessons from the COVID-19 pandemic. Agric. Hum. Values 37, 605–606. https://doi.org/10.1007/s10460-020-10053-5.

Darnhofer, I., Fairweather, J., Moller, H., 2010. Assessing a farm's sustainability: insights from resilience thinking. Int. J. Agric. Sustain. 8 (3), 186–198. https://doi.org/10.3763/ijas.2010.0480.

Davis, M., 2005. The Monster at our Door: The Global Threat of Avian Flu, 1st ed. The New Press.

Davis, A.S., Hill, J.D., Chase, C.A., Johanns, A.M., Liebman, M., 2012. Increasing cropping system diversity balances productivity, profitability and environmental health. PLoS One 7 (10), e47149. https://doi.org/10.1371/journal.pone.0047149.

de Paz, C., Muller, M., Boudet, A.M.M., Gaddis, I., 2020. Gender Dimensions of the COVID-19 Pandemic. World Bank Group. Retrieved from. https://openknowledge.worldbank.org/bitstream/handle/10986/33622/Gender-Dimensions-of-the-COVID-19-Pandemic.pdf?sequence=1&isAllowed=y.

Ebel, R., Ahmed, S., Warne, T., Moxley, A., Grimberg, I., Jarchow, M., Menalled, F.D., 2022. Perceptions and responses of diversified farm producers in the northern Great Plains to the early stage of the COVID-19 pandemic. Front. Sustain. Food Syst. 6, 8. https://doi.org/10.3389/FSUFS.2022.668335/BIBTEX.

ERA Economics, 2020. Economic Impacts of the COVID-19 Pandemic on California Agriculture. ERA Economics LLC. Retrieved from. https://www.cfbf.com/wp-content/uploads/2020/06/COVID19_AgImpacts.pdf.

Erjavec, K., Janžekovič, M., Kovač, M., Simčič, M., Mergeduš, A., Terčič, D., Klopčič, M., 2021. Changes in use of communication channels by livestock farmers during the COVID-19 pandemic. Sustainability 13 (18), 10064. https://doi.org/10.3390/su131810064.

Esquivel, K.E., Carlisle, L., Ke, A., Olimpi, E.M., Baur, P., Ory, J., Bowles, T.M., 2021. The "sweet spot" in the middle: why do mid-scale farms adopt diversification practices at higher rates? Front. Sustain. Food Syst. 5, 734088 https://doi.org/10.3389/fsufs.2021.734088.

Fagerland, M.W., Hosmer, D.W., 2016. Tests for goodness of fit in ordinal logistic regression models. J. Stat. Comput. Simul. 86 (17), 3398–3418. https://doi.org/10.1080/00949655.2016.1156682.

Fairhurst, M., 2020, May 28. U.S. Online Grocery Continues to Set New Records - $6.6B in Sales for May 2020. Retrieved from. https://www.mercatus.com/newsroom/online-grocery-sales-may/.

Feagan, R.B., Morris, D., 2009. Consumer quest for embeddedness: a case study of the Brantford Farmers' market. Int. J. Consum. Stud. 33 (3), 235–243. https://doi.org/10.1111/j.1470-6431.2009.00745.x.

Fraser, C.E., Smith, K.B., Judd, F., Humphreys, J.S., Fragar, L.J., Henderson, A., 2005. Farming and mental health problems and mental illness. Int. J. Soc. Psychiatry 51 (4), 340–349. https://doi.org/10.1177/0020764005060844.

Gallopín, G.C., 2006. Linkages between vulnerability, resilience, and adaptive capacity. Glob. Environ. Chang. 16 (3), 293–303. https://doi.org/10.1016/j.gloenvcha.2006.02.004.

Galt, R.E., 2013. The moral economy is a double-edged sword: explaining farmers' earnings and self-exploitation in community-supported agriculture. Econ. Geogr. 89 (4), 341–365. https://doi.org/10.1111/ecge.12015.

Galt, R.E., Munden-Dixon, K., 2019. Comparing embeddedness of place-based agrifood systems: a regional analysis of community supported agriculture (CSA) in California. In: ASFS/AFHVS Annual Conference 2019. The Association for the Study of Food and Society (ASFS), The Agriculture, Food, & Human Values Society (AFHVS), Anchorage, Alaska. Retrieved from. https://afhvs.wildapricot.org/resources/Documents/Conferenceprograms/2019-ASFS-AFHVS-Conference-Final-Program(1).pdf.

Gayman, D., 2021, October 25. Supply chain crunches affecting agriculture — From farm to table. In: Nebraska Today. Retrieved from. https://news.unl.edu/newsrooms/today/article/supply-chain-crunches-affecting-agriculture-from-farm-to-table/.

Gilbert, J., Sharp, G., Felin, M., 2002. The loss and persistence of black-owned farms and farmland: A review of the research literature and its implications. J. Rural Soc. Sci. 18 (2). Retrieved from. https://egrove.olemiss.edu/jrss/vol18/iss2/1.

Göritz, A.S., 2010. Using lotteries, loyalty points, and other incentives to increase participant response and completion. In: Advanced Methods for Conducting Online Behavioral Research. American Psychological Association, Washington, DC, US, pp. 219–233. Retrieved from. https://psycnet.apa.org/record/2009-10640-014?errorCode=invalidAccess.

Guthman, J., 2014. Agrarian Dreams: The Paradox of Organic Farming in California, 2nd ed. University of California Press, Oakland, California. Retrieved from. https://www.ucpress.edu/book/9780520277465/agrarian-dreams.

Hamann, E., 2021, April 8. USDA reopens COVID relief program for farmers, with pledge to address inequity. Sacram. Bus. J. Retrieved from https://www.bizjournals.com/sacramento/news/2021/04/08/usda-reopens-covid-relief-program-for-farmers.html.

Held, L., 2020, April 2. The local food revolution goes online — for now. In: Eater. Retrieved from. https://www.eater.com/2020/4/2/21203608/farmers-markets-small-farms-offer-online-orders-because-of-coronavirus.

Hiller, S., 2020, May 21. COVID-19 Sparks a Rebirth of the Local Farm Movement. YES! Magazine. Retrieved from. https://www.yesmagazine.org/environment/2020/05/21/coronavirus-food-local-farm-movement.

Hinrichs, C.C., 2000. Embeddedness and local food systems: notes on two types of direct agricultural markets. J. Rural. Stud. 16 (3), 295–303. https://doi.org/10.1016/S0743-0167(99)00063-7.

Holt-Giménez, E., 2002. Measuring farmers' agroecological resistance after hurricane Mitch in Nicaragua: a case study in participatory, sustainable land management impact monitoring. Agric. Ecosyst. Environ. 93 (1), 87–105. https://doi.org/10.1016/S0167-8809(02)00006-3.

Holt-Giménez, E., Altieri, M.A., 2013. Agroecology, food sovereignty, and the new Green Revolution. Agroecol. Sustain. Food Syst. 37 (1), 90–102. https://doi.org/10.1080/10440046.2012.716388.

Horst, M., Marion, A., 2019. Racial, ethnic and gender inequities in farmland ownership and farming in the U.S. Agric. Hum. Values 36 (1), 1–16. https://doi.org/10.1007/s10460-018-9883-3.

Hsiao, C.Y., Tuan, C.L., 2021. How recreational farm operators use dynamic capabilities to respond to COVID-19 pandemic. J. Outdoor Recreat. Tour. 100460 https://doi.org/10.1016/j.jort.2021.100460.

Jarosz, L., 2011. Nourishing women: toward a feminist political ecology of community supported agriculture in the United States. Gend. Place Cult. 18 (3), 307–326. https://doi.org/10.1080/0966369X.2011.565871.

Johansson, R., 2021, July 29. America's farmers: Resilient throughout the COVID pandemic. In: US Department of Agriculture. Retrieved from. https://www.usda.gov/media/blog/2020/09/24/americas-farmers-resilient-throughout-covid-pandemic.

Johansson, R., Hungerford, A., Sewadeh, M., Effland, A., 2020. Unprecedented crisis calls for unprecedented policy responses. Appl. Econ. Perspect. Pol. 43 (1), 120–131. https://doi.org/10.1002/aepp.13128.

Jones-Bitton, A., Best, C., MacTavish, J., Fleming, S., Hoy, S., 2020. Stress, anxiety, depression, and resilience in Canadian farmers. Soc. Psychiatry Psychiatric Epidemiol. Psych. Epidemiol. 55, 229–236. https://doi.org/10.1007/s00127-019-01738-2.

Kantamneni, N., 2020. The impact of the COVID-19 pandemic on marginalized populations in the United States: A research agenda. J. Vocat. Behav. 119, 103439 https://doi.org/10.1016/j.jvb.2020.103439.

Kautsky, K., 1988. The Agrarian Question, Volume 1. Pluto Press, London; Winchester, Mass. Retrieved from. https://www.plutobooks.com/9781853050237/the-agrarian-question-volume-1/.

Kloppenburg, J., Hendrickson, J., Stevenson, G.W., 1996. Coming in to the foodshed. Agric. Hum. Values 13, 33–42. https://doi.org/10.1007/BF01538225.

Lamb, C., 2020, April 1. Harvie's Customizeable D2C farm sales platform could help local growers survive. In: The Spoon. Retrieved from. https://thespoon.tech/harvies-customizeable-d2c-farm-sales-platform-could-help-local-growers-survive/.

Low, S.A., Adalja, A., Beaulieu, E., Key, N., Martinez, S., Melton, A., Jablonski, B.B.R., 2015, January. Trends in U.S. Local and Regional Food Systems: A Report to Congress: Administrative Publication No. 68. US Department of Agriculture; Economic Research Service. Retrieved from. https://www.ers.usda.gov/publications/pub-details/?pubid=42807.

Maggio, G., Sitko, N., Ignaciuk, A., 2018. Cropping system diversification in eastern and southern Africa: identifying policy options to enhance productivity and build resilience. In: FAO Agricultural Development Economics Working Papers. FAO, Rome, Italy. Retrieved from. https://www.fao.org/publications/card/en/c/CA1562EN/.

Mann, S.A., Dickinson, J.M., 1978. Obstacles to the development of a capitalist agriculture. J. Peasant Stud. 5 (4), 466–481. https://doi.org/10.1080/03066157808438058.

Måren, I.E., Wiig, H., McNeal, K., Wang, S., Zu, S., Cao, R., Marsh, R., 2022. Diversified farming systems: impacts and adaptive responses to the COVID-19 pandemic in the United States, Norway and China. Front. Sustain. Food Syst. 6 (June), 1–17. https://doi.org/10.3389/fsufs.2022.887707.

Marusak, A., Sadeghiamirshahidi, N., Krejci, C.C., Mittal, A., Beckwith, S., Cantu, J., Grimm, J., 2021. Resilient regional food supply chains and rethinking the way forward: Key takeaways from the COVID-19 pandemic. Agric. Syst. 190, 103101 https://doi.org/10.1016/j.agsy.2021.103101.

Marvar, A., 2021, August 23. The Farmers Market is Moving Online. The Verge. Retrieved from. https://www.theverge.com/22618396/farmers-market-online-local-food-distribution-platforms.

Mase, A.S., Gramig, B.M., Prokopy, L.S., 2017. Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. crop farmers. Clim. Risk Manag. 15, 8–17. https://doi.org/10.1016/j.crm.2016.11.004.

Mayer, J.D., Lewis, N.D., 2020. An inevitable pandemic: geographic insights into the COVID-19 global health emergency. Eurasian Geogr. Econ. 61 (4–5), 404–422. https://doi.org/10.1080/15387216.2020.1786425.

Meuwissen, M.P.M.M., Feindt, P.H., Slijper, T., Spiegel, A., Finger, R., de Mey, Y., Reidsma, P., 2021. Impact of COVID-19 on farming systems in Europe through the lens of resilience thinking. Agric. Syst. 191, 103152 https://doi.org/10.1016/j.agsy.2021.103152.

Minkoff-Zern, L.-A., 2018. Race, immigration and the agrarian question: farmworkers becoming farmers in the United States. J. Peasant Stud. 45 (2), 389–408. https://doi.org/10.1080/03066150.2017.1293661.

Minkoff-Zern, L.-A., Sloat, S., 2017. A new era of civil rights? Latino immigrant farmers and exclusion at the United States Department of Agriculture. Agric. Hum. Values 34, 631–643. https://doi.org/10.1007/s10460-016-9756-6.

Minkoff-Zern, L.-A., Peluso, N.L., Sowerwine, J., Getz, Christy, 2011. Race and regulation: Asian immigrants in California agriculture. In: Alkon, A.H., Agyeman, J. (Eds.), Cultivating Food Justice: Race, Class, and Sustainability. MIT Press, Cambridge, Massachusetts.

Mitchell, S., 2022, January. Labor Shortages Mean Trouble for Ag. The Collegian. Retrieved from. https://sdsucollegian.com/22410/news/labor-shortages-mean-trouble-for-ag/.

Montenegro de Wit, M., 2021. What grows from a pandemic? Toward an abolitionist agroecology. J. Peasant Stud. 48 (1), 99–136. https://doi.org/10.1080/03066150.2020.1854741.

Munden-Dixon, K., Tate, K., Cutts, B., Roche, L., Munden-Dixon, K., Tate, K., Roche, L., 2018. An uncertain future: climate resilience of first-generation ranchers. Rangeland J. 41 (3), 189–196. https://doi.org/10.1071/RJ18023.

O'Connell, C., Gay, R., McDonald, N., Tayal, S., 2021. COVID connections: lessons from adaptations to COVID-19 as strategies for building food system resilience. Culture Agric. Food Environ. 43 (2), 123–136. https://doi.org/10.1111/cuag.12276.

O'Hara, J.K., Low, S.A., 2020. Online sales: A direct marketing opportunity for rural farms? J. Agric. Appl. Econ. 52 (2), 222–239. https://doi.org/10.1017/aae.2019.44.

O'Hara, J.K., Woods, T.A., Dutton, N., Stavely, N., 2021. COVID-19's impact on farmers market sales in the Washington, D.C., area. J. Agric. Appl. Econ. 53 (1), 94–109. https://doi.org/10.1017/aae.2020.37.

Parry, B.R., Gordon, E., 2020. The shadow pandemic: inequitable gendered impacts of COVID-19 in South Africa. Gend. Work. Organ. 28 (2), 795–806. https://doi.org/10.1111/gwao.12565.

Patel, R., 2013. The long Green Revolution. J. Peasant Stud. 40 (1), 1–63. https://doi.org/10.1080/03066150.2012.719224.

Peerlings, J., Polman, N., Dries, L., 2014. Self-reported resilience of European farms with and without the CAP. J. Agric. Econ. 65 (3), 722–738. https://doi.org/10.1111/1477-9552.12062.

Perrin, A., Martin, G., 2021. Resilience of French organic dairy cattle farms and supply chains to the COVID-19 pandemic. Agric. Syst. 190, 103082 https://doi.org/10.1016/j.agsy.2021.103082.

Perrin, A., Milestad, R., Martin, G., 2020. Resilience applied to farming: organic farmers' perspectives. Ecol. Soc. 25 (4), 5. https://doi.org/10.5751/ES-11897-250405.

Petersen-Rockney, M., Baur, P., Guzman, A., Bender, S.F., Calo, A., Castillo, F., Bowles, T., 2021. Narrow and brittle or broad and nimble? Comparing adaptive capacity in simplifying and diversifying farming systems. Front. Sustain. Food Syst. 5 (March), 1–30. https://doi.org/10.3389/fsufs.2021.564900.

Peyton, N., 2020, April 30. Farmers Prosper in Pandemic as Americans Shop Local. Reuters. Retrieved from. https://www.reuters.com/article/us-health-coronavirus-farming-trfn-idUSKBN22C2YX.

Pretty, J., 2020. New opportunities for the redesign of agricultural and food systems. Agric. Hum. Values 37, 629–630. https://doi.org/10.1007/s10460-020-10056-2.

Prosser, L., Thomas Lane, E., Jones, R., 2021. Collaboration for innovative routes to market: COVID-19 and the food system. Agric. Syst. 188, 103038 https://doi.org/10.1016/j.agsy.2020.103038.

Ramgopal, K., Lehren, A.W., 2020, August 9. Small Farmers Left Behind in COVID-19 Relief Package. NBC News. Retrieved from. https://www.nbcnews.com/business/economy/small-farmers-left-behind-trump-administration-s-covid-19-relief-n1236158.

Ransom, E., DuPuis, E.M., Worosz, M.R., 2020, April 23. Why farmers are dumping milk down the drain and letting produce rot in fields. In: The Conversation. Retrieved from. http://theconversation.com/why-farmers-are-dumping-milk-down-the-drain-and-letting-produce-rot-in-fields-136567.

Rappeport, A., 2022, February 21. Black Farmers Fear Foreclosure as Debt Relief Remains Frozen. The New York Times. Retrieved from. https://www.nytimes.com/2022/02/21/us/politics/black-farmers-debt-relief.html.

Ricker, H., 2020, December 14. California farmers of color need more support during the pandemic. In: Can Private Efforts Help? Civil Eats. Retrieved from. https://civileats.com/2020/12/14/california-farmers-of-color-need-more-support-during-the-pandemic-can-private-efforts-help/.

Robinson, J.M., Mzali, L., Knudsen, D., Farmer, J., Spiewak, R., Suttles, S., Babb, A., 2021. Food after the COVID-19 pandemic and the case for change posed by alternative food: A case study of the American Midwest. Glob. Sustain. 4 https://doi.org/10.1017/sus.2021.5.

Schreiber, K., Soubry, B., Dove-McFalls, C., MacDonald, G.K., 2022. Diverse adaptation strategies helped local food producers cope with initial challenges of the COVID-19 pandemic: lessons from Québec, Canada. J. Rural. Stud. 90, 124–133. https://doi.org/10.1016/j.jrurstud.2022.02.002.

Sherraden, M.W., 2005. Inclusion in the American Dream: Assets, Poverty, and Public Policy. Oxford University Press, New York, NY.

Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Rios, I., Des, I., Ashkenazy, A., 2018. Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. J. Rural. Stud. 59, 232–241. https://doi.org/10.1016/j.jrurstud.2017.01.020.

Suryanata, K., Mostafanezhad, M., Milne, N., 2021. Becoming a new farmer: agrarianism and the contradictions of diverse economies. Rural. Sociol. 86 (1), 139–164. https://doi.org/10.1111/ruso.12355.

Swanson, D., Hiley, J., Venema, H.D., Grosshans, R., 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability: Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York, NY. Retrieved from. https://www.ipcc.ch/report/ar5/wg2/.

Tamburini, G., Bommarco, R., Wanger, T.C., Kremen, C., van der Heijden, M.G.A., Liebman, M., Hallin, S., 2020. Agricultural diversification promotes multiple ecosystem services without compromising yield. Sci. Adv. 6 (45) https://doi.org/10.1126/sciadv.aba1715.

Taylor, D.E., Lusuegro, A., Loong, V., Cambridge, A., Nichols, C., Goode, M., Pollvogt, B., 2021. Racial, gender, and age dynamics in Michigan's urban and rural farmers markets: reducing food insecurity, and the impacts of a pandemic. Am. Behav. Sci. https://doi.org/10.1177/00027642211013387.

Taylor, D.E., Farias, L.M., Kahan, L.M., Talamo, J., Surdoval, A., McCoy, E.D., Daupan, S. M., 2022. Understanding the challenges faced by Michigan's family farmers: race/

ethnicity and the impacts of a pandemic. Agric. Hum. Values. https://doi.org/10.1007/s10460-022-10305-6.
Thilmany, D., Canales, E., Low, S.A., Boys, K., 2020. Local food supply chain dynamics and resilience during COVID-19. Appl. Econ. Perspect. Pol. 43 (1), 86–104. https://doi.org/10.1002/aepp.13121.
Tijani, S.A., Yano, I., 2007. The direct farmer's market: a tool for rural female empowerment. Direct Mark. Int. J. 1 (4), 195–210. https://doi.org/10.1108/17505930710836979.
Tittonell, P., Fernandez, M., El Mujtar, V.E., Preiss, P.V., Sarapura, S., Laborda, L., Cardoso, I.M., 2021. Emerging responses to the COVID-19 crisis from family farming and the agroecology movement in Latin America – A rediscovery of food, farmers and collective action. Agric. Syst. 190, 103098 https://doi.org/10.1016/j.agsy.2021.103098.
Tomascik, J., 2021, October 22. Agriculture continues to feel impact of COVID-19 pandemic. In: Texas Farm Bureau. Retrieved from. https://texasfarmbureau.org/agriculture-continues-to-feel-impact-of-covid-19-pandemic/.
Trivette, S.A., 2019. The importance of food retailers: applying network analysis techniques to the study of local food systems. Agric. Hum. Values 36, 77–90. https://doi.org/10.1007/s10460-018-9885-1.
UC SAREP, 2017. Direct marketing. In: What is Sustainable Agriculture? Sustainable Agriculture Research and Education Program. UC Division of Agriculture and Natural Resources. Retrieved from. https://sarep.ucdavis.edu/sustainable-ag/direct-marketing.
USDA, 2022a. USDA Announces $400 Million in Funding Available to Create USDA Regional Food Business Centers. Retrieved September 15, 2022, from. https://www.usda.gov/media/press-releases/2022a/09/07/usda-announces-400-million-funding-available-create-usda-regional.
USDA, 2022b. USDA Announces Up to $550 Million in American Rescue Plan Funding for Projects Benefiting Underserved Producers and Minority Serving Institutions that Create Career Development Opportunities for Next Generation Leaders. Retrieved September 14, 2022, from. https://www.usda.gov/media/press-releases/2022b/08/24/usda-announces-550-million-american-rescue-plan-funding-projects.
USDA ERS, 2021, January 4. Agricultural Production and Prices. US Department of Agriculture; Economic Research Service. Retrieved from. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/agricultural-production-and-prices/#:~:text=U.S.Agriculturalproductionoccursineachofthe50States&text=Intermsofsalesvalue,the2012CensusofAgriculture.
USDA FSA, 2021, March 24. After Identifying Gaps in Previous Aid, USDA Announces 'Pandemic Assistance for Producers' to Distribute Resources More Equitably. Retrieved from. https://fsa.usda.gov/news-room/news-releases/2021/after-identifying-gaps-in-previous-aid-usda-announces-pandemic-assistance-for-producers-to-distribute-resources-more-equitably.
USDA NASS, 2016. Direct Farm Sales of Food: Results from the 2015 Local Food Marketing Practices Survey (ACH12–35). US Department of Agriculture, National Agricultural Statistics Service. Retrieved from. https://www.nass.usda.gov/Publications/Highlights/2016/LocalFoodsMarketingPractices_Highlights.pdf.
USDA NASS, 2017a. California State Census Data 2012 and 2017: Market Value of Agricultural Products Sold Including Landlord's Share, Food Marketing Practices, and Value-Added Products. US Department of Agriculture, National Agricultural Statistics Service. Retrieved from. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/California/st06_1_0002_0002.pdf.
USDA NASS, 2017b. Race/Gender/Ethnicity Profile: California Farms with American Indian or Alaska Native Producers. US Department of Agriculture, National Agricultural Statistics Service. Retrieved from. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Race,_Ethnicity_and_Gender_Profiles/California/cpd06000.pdf.
USDA NASS, 2019. California State and County Data. 2017 Census of Agriculture. United States Department of Agriculture, National Agricultural Statistics Service. Retrieved from. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/California/.
USDA NIFA, 2022. From Learning to Leading: Cultivating the Next Generation of Diverse Food and Agriculture Professionals (NEXTGEN). Retrieved September 14, 2022, from. https://www.nifa.usda.gov/grants/funding-opportunities/learning-leading-cultivating-next-generation-diverse-food-agriculture.
van der Ploeg, J.D., 2018. The New Peasantries: Rural development in times of globalization (Second). Routledge, London; New York. Retrieved from. https://www.routledge.com/The-New-Peasantries-Rural-Development-in-Times-of-Globalization/Ploeg/p/book/9781138071315.
Weersink, A., von Massow, M., Bannon, N., Ifft, J., Maples, J., McEwan, K., Wood, K., 2021. COVID-19 and the Agri-food system in the United States and Canada. Agric. Syst. 188, 103039 https://doi.org/10.1016/j.agsy.2020.103039.
Wells, B.L., Gradwell, S., 2001. Gender and resource management: community supported agriculture as caring-practice. Agric. Hum. Values 18 (1), 107–119. https://doi.org/10.1023/A:1007686617087.
White, M.M., 2018. Freedom Farmers: Agricultural Resistance and the Black Freedom Movement. University of North Carolina Press, Chapel Hill. Retrieved from. https://uncpress.org/book/9781469663890/freedom-farmers/.
Whitt, C., Todd, J.E., Keller, A., 2021. America's Diverse Family Farms, 2016 edition. US Department of Agriculture; Economic Research Service. Retrieved from. https://www.ers.usda.gov/webdocs/publications/102808/eib-231.pdf?v=8640.4.
Wiggers, K., 2020, May 21. How Instacart remade its systems to handle a 500% jump in order volume. In: VentureBeat. The Machine. Retrieved from. https://venturebeat.com/2020/05/21/how-instacart-remade-its-systems-to-handle-a-500-jump-in-order-volume/.
Yaffe-Bellany, D., Corkery, M., 2020, April 11. Dumped Milk, Smashed Eggs, Plowed Vegetables: Food Waste of the Pandemic. The New York Times. Retrieved from. https://www.nytimes.com/2020/04/11/business/coronavirus-destroying-food.html.
Zirham, M., Palomba, R., 2016. Female agriculture in the short food supply chain: a new path towards the sustainability empowerment. Agric. Agric. Sci. Proc. 8, 372–377. https://doi.org/10.1016/J.AASPRO.2016.02.032.