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**Research
Brief #15**

Grower and Worker Perspectives in a Dynamic Regulatory Environment for California's Strawberry Industry

— Julie Guthman¹ and Madison Barbour,² University of California, Santa Cruz

EXECUTIVE SUMMARY

This publication reports the findings of a research project that set out to investigate how the phase out of methyl bromide and increasing restrictions on other soil fumigants have affected the California strawberry industry. The goals of this research were to gain insight into industry stakeholders' perspectives, including farmworkers, on the current regulatory apparatus surrounding soil fumigants, and to learn how California strawberry growers are navigating the loss of a critical chemical. This report, based on three years of qualitative research on the California strawberry industry, details grower and worker perspectives on the current suite of pesticide use regulations.

Key findings include:

1) Growers maintain a wide range of perspectives on the current suite of soil fumigant regulations. Some growers felt that the regulations were too strict and threatened their economic viability, while others defended the regulations as reasonable and in place to protect public safety. Others expressed frustration at the difficulties of compliance given the complexity of the application protocols, but felt the premise of the regulations was reasonable. There is no strong consensus among growers regarding the efficacy and validity of the current application protocols and mitigation measures.

2) Though growers' perspectives on the validity of the current suite of regulations varies along a spectrum, growers widely expressed frustration at the seemingly contradictory nature of their enforcement and the complexity of compliance. Growers called for greater transparency and more even enforcement of regulations across counties, in addition to the more rational allocation of chemicals subject to use restrictions.

3) Growers are significantly more concerned about the current labor shortage than the increasing restrictions on fumigant use. When asked about the main challenges they face, few growers cited increasing regulatory burdens as a main challenge, while a majority of growers mentioned the labor shortage.

4) This research found that growers were relatively mixed in their evaluations of the necessity of fumigants to the viability of their operations and to the viability of the strawberry industry as a whole. Some growers said that they would be unable to stay in business if fumigants were phased out, while others were nonplussed by the prospect of an eventual phase-out, arguing that growers will innovate and adapt to the new realities of production.

5) Growers' adoption of alternatives to chemical soil fumigants remains limited. We found that a significant number of growers are engaging in experiments with alternative methods of soil disinfection, but that growers' use of these alternatives is still largely experimental and limited to small-scale trials.

6) There is a wide consensus both among growers and other industry stakeholders about the future trajectory of the strawberry industry. Most growers and industry figures agreed that innovative growers will be able to successfully navigate the challenges of a post methyl-bromide strawberry industry, while limited-resource, undercapitalized growers will be pushed out by the combined challenges of drought, labor shortage, land costs, and a limited range of alternatives to methyl bromide.

7) Growers and fieldworkers do not see eye to eye on safety in the field. Most growers asserted that pesticides are safe as long as they are not handled improperly, while workers regarded the chemicals they work with as dangerous and potentially harmful to their health regardless of whether application protocols are followed. In general, growers feel that fieldworkers' exposure to pesticides is not a problem, and that the only workers at risk of significant and health-damaging exposures are pesticide mixers and applicators. While the persistent, low-dose exposures commonly endured by fieldworkers may not appear to be of immediate concern to growers, this research found that the health effects of exposure to pesticides are certainly of concern to fieldworkers.

¹Professor, Division of Social Sciences, Community Studies Program, UCSC; ²Politics Department, UCSC

CALIFORNIA STRAWBERRY INDUSTRY AT A CROSSROADS

The California strawberry industry is at a crossroads. In recent years, heightened restrictions have been placed on a class of pesticides called soil fumigants that strawberry farmers rely on to disinfect their fields of soil pathogens, along with weeds and nematodes, before planting. The phase out of the soil fumigant methyl bromide under the Montreal Protocol and the withdrawal of its replacement chemical methyl iodide has given new urgency to the search for effective alternative methods of soil disinfestation. Predictions that the loss of methyl bromide would spell doom for the industry have not been borne out, however. Our review of pesticide use data from 2004 to 2011 found that growers have compensated for the loss of methyl bromide by using higher rates of chloropicrin (see figure 1). But restrictions on methyl bromide's two most economically viable chemical

alternatives—1,3-D chloroprene and chloropicrin—are also increasing, and the industry's reliance on these fumigants may be untenable in the long-term (CDPR, 2013). In 2013, the California Department of Pesticide Regulation published a Non-fumigant Production Plan to bolster the search for alternatives to traditional soil fumigants. This plan called for the eventual phase out of fumigants in order to protect community and farmworker health. These developments signal the increasing curtailment of fumigants and perhaps the eventual phase out of the chemical class in California. The increasingly strict regulatory environment surrounding fumigants and the prospect of an eventual phase-out have wide-ranging implications for California strawberry growers.

Several studies have examined the impacts of increasing fumigant use regulations on grower viability and the potential economic impacts of the loss of methyl bromide on the

strawberry industry (Goodhue et al., 2016; Carter et al., 2005; Carpenter et al., 2000; Norman 2005). Goodhue et al. (2016) found that increasingly stringent spatially-defined pesticide use regulations, such as buffer zones, affect growers unevenly based on their farm location. Carter et al. (2005), in their study of the economic impacts of the phase out of methyl bromide on the California strawberry industry, predicted that industry revenues would decline moderately and that these declines would vary by region. Models used by Carpenter et al. (2000) found that higher berry prices would compensate for the increased costs of production associated with the use of fumigant alternatives. Norman (2005) predicted that cost increases to growers incurred by the loss of methyl bromide would be balanced by rising berry prices as these additional costs are passed on to strawberry consumers. Since these studies were based on economic models, less is known about California strawberry growers' own perspectives on how the current trajectory of increasing fumigant use regulations affect their viability and that of the industry.

On top of an increasingly challenging regulatory environment, growers are contending with the effects of an unprecedented drought, unusual labor shortages, rising costs, the emergence of new soil pathogen problems, and limited land availability (Hertz and Zahniser 2013; Lloyd et al., 2016). In this context, low-resource growers subsisting at the margins of production are the most likely to be significantly impacted by increasing regulatory burdens. The USDA has made the viability of limited-resource growers a priority and offers an array of programs and services to small and mid-sized growers, from provisioning credit to distributing grants. These efforts demonstrate that safeguarding the viability of small and limited-resource producers is a clear policy priority. Yet, little attention has been given to the particular challenges facing limited-resource California strawberry growers in a changing regulatory context.

Figure 1. Pounds of fumigants applied for nine counties, 2004-2013

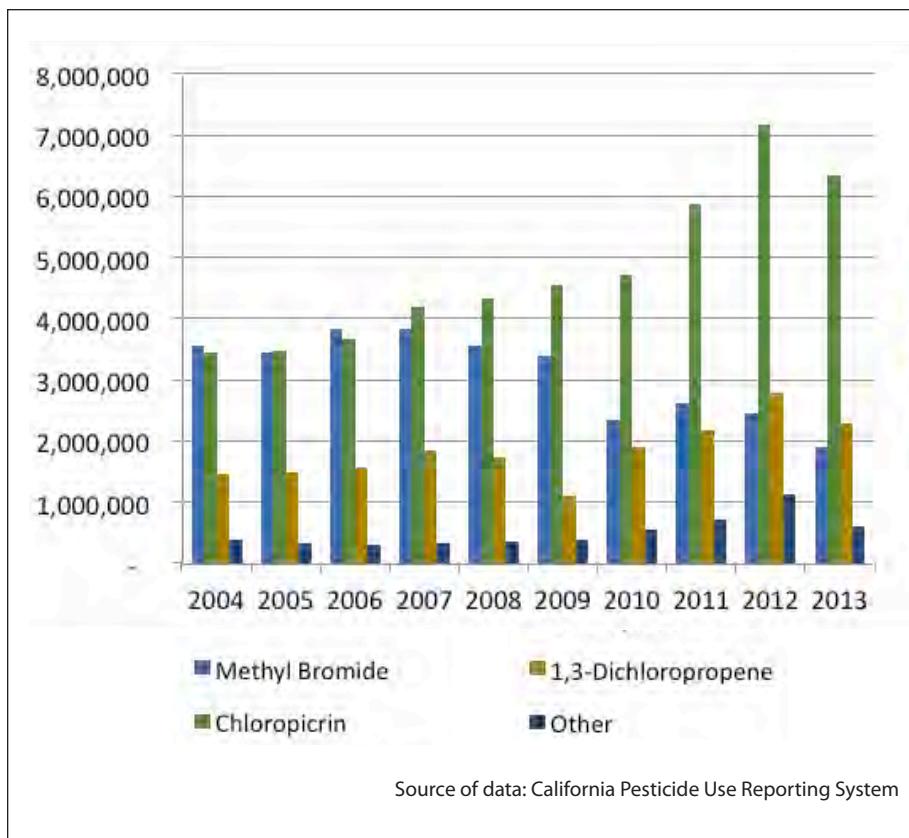


Table 1: Description of grower sample

County of operation*	Monterey (n=22)	Santa Barbara (n=9)	Santa Cruz (n=19)	Ventura (n=24)	
Strawberry acreage	Under 20 (n=6)	21-50 (n=9)	51-100 (n=8)	100+ (n=47)	Unknown (n=4)
Organic conventional	All conventional (n=36)	Mixed/Transitioning (n=31)	All organic (n=6)	Unknown (n=1)	

*Some growers operate in multiple counties

The object of this research was to document the response of growers and the industry to the changing regulatory environment surrounding fumigants. This report will also elucidate some of the specific issues affecting limited resource strawberry growers in this shifting regulatory context.

METHODS

This research involved qualitative interviews with 74 strawberry growers and 55 workers in Monterey, Santa Cruz, Santa Barbara, and Ventura counties. An additional 50 interviews were conducted with industry figures, extension agents, and strawberry researchers.

Grower interviewees were identified through pesticide application data provided by county agricultural commissioners. Using the contact information contained in these reports, members of the research team contacted growers by phone and arranged interviews with those willing and available to participate. The grower sample is somewhat skewed toward larger, more established growers, because the contact information of these growers tended to be more available and accurate in the pesticide use data provided by county agricultural commissioners. Yet, the research team was still able to talk to several growers who had recently left the business and enough low-resource growers to obtain reasonable saturation. Interviews with growers were semi-structured and covered a wide range of topics, but interviewers consistently asked questions about growers' perspectives on the current suite of fumigant regulations, the implications of further regulation for the viability of their operations and the industry as a

whole, and their experiments with and perspectives on alternative methods of soil disinfestation. Grower interviews averaged about half an hour, with considerable range. Table 1 describes the grower sample.

Recruiting worker research subjects presented a more difficult set of challenges, especially because the project team did not want to upset growers by recruiting at the work place. Instead,

four members of the research team travelled to farmworker labor camps and community gatherings where they canvassed for interviews with strawberry workers, incentivized with a modest payment. Interviews with workers were also semi-structured and consistently included questions about workers' experience with pesticide exposure, workers' use of self-protective practices at work, and workers' perceived risk from exposure to pesticides. Interviews with workers averaged about a half hour in length. Due to the sensitive nature of questioning subjects about their immigration status, the citizenship status of a high proportion of workers interviewed is uncertain. These interviews were conducted in Spanish by fluent speakers, and the recorded interviews were transcribed and translated into English by a native speaker. Table 2 describes the worker sample.

Table 2: Description of worker sample

County	Monterey (n=21)	Santa Barbara (n=3)	Ventura (n=14)	Santa Cruz (n=17)
Native Language	Spanish (n=47)	Mixteco (n=5)	Zapoteco (n=1)	Unknown (n=2)
Gender	Female (n=25)	Male (n=28)	Unknown (n=2)	
Immigration Status	Documented (n=22)	Undocumented (n=17)	Unclear (n=16)	
Length of time in the U.S.	Less than 2 years (n=2)	2-5 years (n=5)	5-10 years (n=8)	Over 10 years (n=39) Unknown (n=1)



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Interviewing a strawberry grower in Santa Barbara County.

All interviews were conducted in accordance with a human subjects' research protocol approved by UCSC's Institutional Review Board, which among other things, allowed research participants to decline to answer any question. In addition, not all research participants were able to every question due to time constraints and the open-ended nature of the interviews. By the same token, for some questions interviewees could provide multiple answers. Therefore, the number of responses for some questions do not add up to the sample size. Data were analyzed using standard social science research methods, which involved distilling relevant themes from qualitative data contained in interviews and quantitative analysis of survey data. This analysis was facilitated by the use of NVivo, a qualitative data analysis software.

FINDINGS

Growers are not unified in their perspectives on fumigant use regulations.

While it might be assumed that growers unanimously read pesticide use regulations as overly strict, given the burdens of compliance and their potential effects on growers' bottom line, this research revealed that strawberry growers are not unified in their perspectives on the current regulations governing the use of soil fumigants. In interviews, growers were asked to evaluate whether they felt the current mitigation measures in place, such as buffer zones and limits on the amount of acreage that can be fumigated at any given time, were reasonable regulations. Their responses are represented in Table 3.

As Table 3 shows, growers range in their support of mitigation measures. Responses ranged from support of the mitigation measures (they are "necessary to protect the public") to dismissal of their necessity ("buffer zones address a problem that doesn't exist"). Though there was no consensus on the validity of the regulations, growers generally interpreted them as onerous, and most growers registered at least some complaints about the regulations. One grower, echoing the

Table 3: Grower responses to the question "Do you think that the mitigation measures currently in place are reasonable?"

Response	# of responses
Reasonable but problematic in practice	8
Unreasonable, implemented for reasons other than public safety	13
Reasonable, necessary measures to protect environment, public health	8

sentiments of several others, lamented that "it's gotten to the point where...I spend more time doing that [ensuring that he is complying with the regulations] than actually farming."

Growers complained that the allocation of 1,3-D in areas subject to township caps on a "first come, first serve" basis is irrational and "unfair." One grower noted that this system of allocation disproportionately advantages early-season growers, who "grab up all the permits" to use 1,3-D. This grower suggested that permits to use 1,3-D should be allocated by percent-

age of growers' acreage rather than being distributed on a first come , first served basis: "If you can only do 20% of this township, can everybody have 20%?" Others say it should be allocated on the basis of need. Past scholarship has corroborated that growers are not well served by current policy, which allows fumigation companies to distribute 1,3-D to growers on a "first come, first served" basis (Carpenter et al., 2001). Enhanced restrictions on the use of 1,3-D are set to go into effect in January of 2017 and will likely increase the difficulties of growers who rely on 1,3-D products. Given experiences with methyl bromide, in which allowable amounts appeared to go to favored growers, pesticide applicator control over the allocation of even more limited supplies of 1,3-D may appear unfair for growers as they navigate the restricted availability of 1,3-D under the newly released rules.

Growers often charged that mitigation measures are unevenly interpreted and enforced across counties. One grower described the unevenness of the mitigation measures across the state's major strawberry growing regions: "Santa Barbara's considered pretty high profile enforcement. I think Ventura County's a lot more

Table 4: Growers' main challenges (up to 3 responses)

Response	# of responses	% of responses
Labor shortage	38	58%
Soil pathogens or other pests	7	11%
Water availability	6	9%
Regulations	5	8%
Land availability	4	6%
Increasing costs	2	3%
Other	4	6%
Total	66	100%

*figures do not add up to 100% due to rounding

relaxed. From the growers that come up here, they've come up from here and said god, we didn't have to do that. Same in Monterey County, and then you go across the river to Santa Cruz County, it gets tightened up there. So it just depends on who your Ag Commissioner is." Other growers corroborated the sentiment that the language of the mitigation measures are sufficiently vague to allow varied interpretations by agricultural commissioners, resulting in differences in enforcement across counties. For the many growers who operate in multiple counties, the uneven regulatory environment across growing regions can pose an additional burden on compliance. Another grower summarized the difficulties of operating in an uneven regulatory context: "Because of some of the vagueness within some of the buffer zone language, the local governing bodies can have different interpretations where, on this side of the river it's this way, on that side of the river it's that way...The buffer zones, they get really complicated... The interpretation needs to stay consistent."

A few growers lamented that mitigation protocols, particularly the increasing size of buffer zones, are limiting the amount of available strawberry land and are "dictating where you can grow." This is a problem for the strawberry industry in particular, as berries are often the "last crop before the suburbs." Given that land availability is one of the most pressing challenges facing California strawberry growers, the possibility that widening buffer zones are further limiting where strawberries can be grown is alarming to growers (also Lloyd et al., 2016).

One grower charged that the growing complexity of the regulations presents a technical barrier to compliance for limited-resource growers and argued that outreach to help growers understand and comply with increasing regulatory burdens is limited. Several growers discussed feeling overwhelmed by the technical intricacy and sheer volume of the regulations. One grower described the additional burdens that the increasing complexity of the regulations places on

his operation: "You're almost having to hire someone...what I'm calling a compliance director. Someone that can learn the county procedures, someone that can learn the Water Board's, someone can learn the OSHA's. There's so many regulations and regulation companies it's just impossible to keep up with it." Another grower noted that increasingly complex regulations serve as a technical barrier to entry for new strawberry growers. "There's lots of burden but no help or information to keep up with the rules," one grower asserted.

The introduction of totally impermeable film (TIF) tarps to control the emissions from fumigation, which reduces the size of growers' buffer zones, seems to have assuaged some growers' concerns about complying with increasingly strict mitigation measures. As one grower put it when asked whether the mitigation measures are reasonable, "the TIF film...that's saved us." Several growers questioned whether the mitigation measures, particularly buffer zones, were too stringent or even necessary in light of the industry's adoption of TIF tarps, suggesting that TIF's enhanced control of emissions is tantamount to safety. Some growers complained about additional county requirements to use TIF given the additional expense of the film, but others noted that the price of

the tarp is coming down and that the use of TIF saves water: "you are saving money, and the price has come way down...before it was pretty expensive, 100 dollars an acre...now it's more like 10 or 15 dollars."

Growers also frequently suggested that limits on the amount of acreage that can be fumigated at any given time increase the number of fumigation equipment hookups required to treat a field, which increases the risk of accidents. From the growers' perspective, these limits also increase the complexity and cost of treating a field, even as they limit emissions from a safety perspective.

Growers view the current labor shortage as a greater threat to their economic viability than increasing regulatory burdens.

California strawberry growers appear to be experiencing an unusual labor shortage. The shortage owes to both heightened militarization of the border since 2001 and the pull of less arduous jobs in other crops and other industries. Growers widely complain about a lack of labor (Hertz and Zahner 2013; Tourte et al., 2016). One of the more interesting findings of this research is that the current agricultural labor shortage is much more concerning to strawberry growers than increasing regulations on soil



Dirt used to hold down protective tarps.

JULIE GUTHMAN



JULIE GUTHMAN

Workers maintaining a bed fumigation.

fumigants. Table 4 shows growers' responses to an interview question about their main challenges. When growers were asked to identify the main challenges to the viability of their operations, virtually every grower who gave a response mentioned the labor shortage, while comparatively few identified increasing regulatory burdens as one of their main challenges. This suggests that the labor shortage is a significantly more pressing concern for growers than increasingly strict mitigation measures or the potential phase out of soil fumigants. One grower's comments summarized the sentiments of several others: "The problem has nothing to do with fumigation. It's a labor shortage...there's not enough people to pick."

A few growers (4) reported that widening buffer zones were taking valuable land out of production on their operations, but many growers (14) reported having to abandon significant amounts of acreage due to the labor shortage, with some growers reporting huge losses of 60 to 90 acres. Other growers discussed plans to shrink production or halt expansion in response to the shortage. Even growers who reported that their operations had not suffered due to a lack of labor often mentioned neighboring growers whose farms had. One grower estimated that "a lot, a lot, a lot, about 80 percent [of grow-

ers] have had problems with lack of staff." Strawberry growers' high per acre investments mean that the loss of even a few acres of production due to the inability to find harvest labor can be devastating (Wells, 1996).

We found that growers are using a variety of strategies to manage the effects of the labor shortage. Growers have been increasing compensation, particularly per box rates, in order to attract and retain workers; some reported increasing their per box rates by 10 to 15 cents to attract workers. Some growers have adjusted the balance of piece rates and wages over the duration of the season, paying more in hourly wages when the harvest wanes to retain workers.

Other growers tried more novel strategies to attract and maintain workers. One reported offering cash incentives for workers to recruit others. Another grower said he began his season early to retain workers, and another said he retained additional workers during the slow season to encourage loyalty. Yet another discussed diversifying his operation to provide off-season employment and retain workers. Interestingly, many growers told of prospective workers who came to their ranches to inspect the fields before seeking employment. Growers said that these potential workers were examining field conditions such

as plant health, berry size and row quality, all factors that can affect the amount of berries a worker can pick and the pace of work. Given that many workers are paid by piece-rate, these field conditions may matter considerably to a picker's ability to maximize their income during the harvest. In this context, many growers are attending to their field conditions and making adjustments such as selecting high-yielding, easy to pick varieties to help attract and retain workers. Growers also adjusted plant and row spacing; one grower reported that he had spaced his rows farther apart and decreased plant density to enhance ease of picking. Another grower described the importance of making such adjustments in the context of a labor shortage: "We have workers come to our field and want to walk it before they'll let us know they're gonna work for us... If you have good fields, we get more labor than the next guy."

Still other growers are turning to H2A contracting services to meet their labor needs, although many complained that H2A was a costly and burdensome undertaking, particularly considering the requirement that growers must provide housing for workers. This requirement makes guest workers more expensive than hiring domestic labor. One grower observed that the housing provision of H2A would burden him with the additional responsibilities of a landlord: "I'm letting somebody else be that guinea pig... People used to do that more; people used to have labor camps. Once you agree to take care of people outside of the workplace, you're becoming a landlord, you're becoming a service-type organization for people, and now you've got 5 other different regulatory agencies that want to look over your shoulder." However, growers who used H2A argued that this option was still considerably less expensive than losing a field to lack of labor.

Growers are mixed in their perspectives on the necessity of chemical soil fumigants to the viability of the industry.

This research found that growers were relatively mixed in their evaluations of the necessity of fumigants to the viability of their operations and to the viability of the strawberry industry as a whole. Some growers said that they would be unable to stay in business if fumigants were phased out, while others were nonplussed by the prospect of an eventual phase-out, arguing that growers will innovate and adapt to the new realities of production. Still others noted the difficulties of transitioning to alternatives but held that an industry-wide transition to alternative methods is achievable. Growers' perspectives on the necessity of fumigants are represented in Table 5.

Table 5: Growers' perspectives on the necessity of fumigants

Response	# of responses
Growers will be doomed without fumigants	11
Phase-out would be difficult but doable	6
Growers will innovate if fumigants are phased out	4

Strawberry growers' adoption of alternative methods of soil sterilization remains limited.

Of the growers we interviewed, 27 reported experimenting with soil fumigant alternatives. The types of alternatives these growers experimented with are represented in Table 6.

Anaerobic Soil Disinfestation (ASD), substrate (soilless) growing medium, and steam sterilization are a few of the alternatives that growers are currently experimenting with. ASD involves the use of water and soil amendments such as rice bran to create anaerobic conditions in order to disinfect soil. Steam sterilization involves the treatment of soil with hot steam to kill harmful pathogens. Some growers are using substrate production systems in which berries are grown in a sterile,

Table 6: Grower experiments with alternatives

Alternatives	# of responses
Aerobic Soil Disinfestation (ASD)	16
Substrate	6
Steam	1
Proprietary tech/other	4

soilless medium such as coconut coir or peat. Growers' experimentation with alternatives was largely limited to small-scale research trials, although 3 growers had scaled up and reported using ASD as their primary method of soil sterilization on their organic plots. Research and support of ASD trials has been spear-headed by UCSC researchers, Joji Muramoto and Carol Shennan.

Growers' evaluations of the efficacy of alternatives were mixed. Some were enthusiastic about the results and had scaled up their use of the technology (3); others were cautiously optimistic but hesitant to scale up (5); and still others found them to be ineffective (4). There was a general consensus that

the existing alternatives to traditional soil fumigants were not yet developed enough for widespread adoption on a commercial scale. The cost and complexity of administering these treatments emerged in interviews as a clear barrier to scaling up the use of alternatives. One research participant summarized the hesitation felt by many growers in scaling up the use of alternatives: "my acreage is limited, and I need to maximize it." Even growers who observed promising results from their alternative trials often lamented that the technologies were too costly to scale up.

On the whole, conventional growers continue to opt for traditional chemical fumigants in lieu of implementing more agro-ecological and integrative approaches. Our review of pesticide use data from 2004 to 2011 shows that rather than scaling up their use of these alternative technologies, growers are generally choosing to increase their rates of chloropicrin application to compensate for the loss of methyl bromide. Growers are hesitant about scaling up the use of what they see as technologies still in the development rather than the commercial adoption phase, particularly in the context of challenges like lack of labor and drought that constrain their capac-



Anaerobic soil disinfection (ASD) trial plots.

JOJI MURAMOTO

ity to take risks and innovate. These constraints are particularly stark for low-resource growers, whose limited access to technical resources, low degree of capitalization, and often disadvantageous land context further limit their capacity to experiment with alternatives.

Industry predicts shakeout of low-resource, undercapitalized growers.

Through the course of our interviews a clear consensus about the future trajectory of the industry emerged. Growers predicted that the current trajectories of increasing regulations on fumigants and growing costs will result in a smaller strawberry industry as low-resource growers exit production. Growers' opinions about this trajectory of consolidation were mixed—3 growers felt that the industry needed to shrink, and 7 expressed concern about the prospect. More (11) were neutral towards the changing structure of the industry. Growers' perspectives on the future of the strawberry industry are represented in Table 7.

Many growers observed a trend toward industry consolidation in which small growers will be pushed out by the suite of challenges facing the industry—labor shortages, increasing regulations, lack of fumigant alternatives, new pathogen problems, lack of water, and rising costs. Low-resource growers are viewed as the most vulnerable to the nexus of challenges currently facing the industry. Squeezed by the growing cost of inputs and land

and a lack of readily available labor, low-resource growers have little room for the innovation that will be crucial to maintaining the viability of their operations as future years see greater restrictions on the use of traditional soil fumigants. Growers who take out high amounts of debt to go into business operate on thin margins and will have limited capacity to take the risks and make the innovations necessary to maintain viability in the next decade. These growers face high initial and growing debts as they continue to borrow money to pay off their loans, maintain good credit and stay in business when their operations lose money. One such grower operating in Oxnard, a particularly beleaguered strawberry region, described his predicament:

“We don’t know what is going to happen when we go to the bank...we don’t want to keep losing, losing, and losing [money] because then it’s not a business if we keep losing. So if it’s going to be like that, then it is going to be difficult.”

Burdened by debt and operating on tight profit margins, these growers do not have the capital to invest in alternative methods of soil fumigation and make the needed innovations to their production systems. If integrative growing practices are really the “new reality” of strawberry production, these precarious growers will be least poised to meet the demands being placed on the industry.

During our review of pesticide use data, we found evidence of a shakeout

of low-resource growers, many of whom are Latino. Comparing grower listings from pesticide use reports between 2012 and 2013, we found a high turnover rate of permittees, many of which were operations of ten or fewer acres or had Hispanic surnames. Furthermore, when members of the research team attempted to contact growers for interviews in 2014 and 2015, we found even more who had gone out of business. Again, the majority of these growers who were no longer in business had small acreage operations and/or Hispanic surnames. Those who we were able to interview confirmed our suppositions: resource-poor growers are already being pushed out of business by the nexus of unfavorable trends facing the California industry, and this trend is likely to continue.

Well-financed and innovative growers already engaging in experimentation with alternative methods of soil sterilization are viewed as more likely to maintain viability in a post-fumigant strawberry industry. Reflecting the opinion among some growers that the most innovative will survive, one grower concluded that “the better growers are gonna strive over this. The growers that are dependent on fumigants...they’re the ones that are gonna struggle.” Growers' perspectives are corroborated by existing research, which suggests that innovation and adoption of alternatives, particularly the use of integrated approaches to production, will be important to maintaining viability in the post-methyl bromide industry (Carpenter et al., 2000; CDPR 2013). One strawberry extension agent aptly described growers' imperatives to innovate and adopt integrative growing practices: “this is the new reality and the new strawberry production regime is going to have to include many tools in the kit. People who understand that and move in that direction will be the only ones to survive.” Growers generally recognize that the future availability of soil fumigants may be limited and that maintaining viability will depend on their ability to innovate and meet the challenge of the state's demands.

Table 7: Perspectives on the future of the industry

Response	# of responses	% of responses
Small growers will get hurt	23	50%
Industry will move elsewhere	9	20%
Innovators will survive	6	13%
Industry will be fine	5	11%
Industry needs to shrink	3	7%
Total	46	100%

*figures do not add up to 100% due to rounding.

Some growers welcomed the prospect of a shrinking strawberry industry, suggesting that the current state of overproduction depressed berry prices and that many growers would benefit from the exit of less competitive, economically marginal growers in the form of higher berry prices. Several raised the specter of an industry move to Mexico, where costs are lower, land is cheaper, and regulations are far less stringent. However, wholly shifting production to Mexico is an unlikely solution to the challenges vexing the California strawberry industry because of the competitive advantages offered by the state's agricultural landscape. Mexico's water shortages pose a particularly significant problem (Lopez 2016). Currently, production in Mexico is best suited to the winter months only.

Growers and workers do not see eye to eye on safety in the field.

Soil fumigants are some of the most highly toxic and readily volatilizing pesticides used in agriculture, meaning that they are difficult to control and pose a potentially serious health risk to applicators (CDPR, 2013). These health risks include respiratory illness from acute exposure and increased cancer risks from long-term exposure (CDPR, 2010). Incidents of fumigant drift with the potential to sicken workers, community residents, and bystanders can occur even when products are applied according to the label.

Growers and workers differ in their perspectives on safety from exposure to pesticides in the field. How growers and workers regard the chemicals they work with affects their perspectives on pesticide exposure. Most growers believe that pesticides are safe and do not pose health risks if used according to the label, and generally believe that fieldworker exposure to pesticides is a marginal concern, as pesticide mixers and applicators face the greatest risks of accidental exposures, a finding corroborated by (Quandt, 1998). Growers' perspectives on the safety of pesticides are represented below in Table 8.

Fieldworkers, by contrast, view the pesticides used at their worksites as



Warning sign at the edge of a fumigation.

JULIE GUTHMAN

potentially dangerous to their health regardless of whether protective measures are in place. A majority of workers (64%) who participated in the study felt that pesticides posed a danger to their own health or that of their families. This stands in contrast to the perspective of growers, who generally held that pesticides pose little or no risk to human health if handled and applied correctly. Growers, of course, are concerned about safety, but generally believe that the workplace protective measures and pesticide application protocols are adequate enough to ensure worker safety. One grower suggested that even pesticide applicators are not at risk of harmful exposure because of the extensive protective measures in place. Discussing the risks of worker exposure to soil fumigants in particular, one grower said: "Sure it's a safety issue if you put your head under the tarp, but when it's [chloropicrin] used properly, it's tear

gas, you know? It's supposed to make you go away."

For fieldworkers, safety from exposure to pesticides is not simply a matter of properly handling and applying the chemical, as growers view it, because it is common for these workers to labor in recently treated fields where they are exposed to chemical residues on plant matter and/or vapors in the air. 36% of workers interviewed reported experiencing pesticide-related illness, and 45% reported knowing someone who had become sick from exposure to pesticides. This despite the fact that nearly every worker who reported experiencing pesticide-related illness from exposure in the field received pesticide safety training and wore protective equipment. Of the 20 workers who reported experiencing pesticide-related illness at work, only 5 stated that their employer did not respect the restrictions on field re-entry required after pesticide applications. Thus, for workers, exposure to pesticides and its related ailments occur regardless of whether protective measures are adequately followed. One woman dismissed the frequent allergic reactions on her hands from contact with pesticide residues as "part of the work.". Many workers mentioned that they were hesitant to report suspected pesticide use violations or experiences of pesticide-related illness, believing

Table 8: Growers' perspectives on the safety of pesticides

Response	# of responses
Safe with caution	17
Completely safe	3
Dangerous, shouldn't use	1

that this type of activity would put them at risk of firing or deportation in the case of undocumented workers. While growers view the current regulations as sufficiently protective of farmworker health, fieldworker accounts of pesticide exposure contest this view and suggest that the current measures in place may offer inadequate protection from exposure in the field.

CONCLUSIONS AND POLICY

IMPLICATIONS

While some in the industry predicted economic disaster after the phase-out of methyl bromide, such concerns have largely subsided as growers get by using higher rates of chloropicrin. But the industry still faces serious challenges, one of which is grappling with a trajectory of increasingly strict pesticide regulation. Growers are not unified in their perspectives on this trajectory, with some supporting the regulations and others fearing they will squeeze growers out of business. But there was a consensus among growers that the regulations are complex and sometimes unevenly implemented and contradictory. In this uneven regulatory context, the future viability of growers will hinge on a number of factors, from land location to ability to secure allocations of chemicals with limited availability (Goodhue et al., 2016). Regulations that affect growers unequally, such as buffer zones based on spatial proximity to certain structures, can create winners and losers as some growers are able to avoid the regulations and garner a competitive advantage (Goodhue et al., 2016). It is important for DPR to consider that the design of particular regulations, such as buffer zones used in chloropicrin mitigation and township caps on the allocation of 1,3-D, can affect growers unevenly and have implications for their viability that may vary by region, farming context, degree of capitalization, and other factors. In an uneven and rapidly changing regulatory context that generates winners and losers and demands innovation, it is clear that low-resource growers—who operate at the margins of production, often in disadvantageous locations—will be those most affected by continuing restrictions on the use of fumigants.

In addition to the insight that low-resource growers are particularly vulnerable within a changing regulatory context, our interviews revealed that growers have a number of concerns about the current regulations. The purpose of reporting grower complaints is to share the perspective of growers with regulatory officials. It is not to make explicit recommendations about what DPR should do, but rather to suggest that the issues that came up in interviews are areas that may warrant reconsideration, based on grower input. We suggest that the following areas could be revisited by policymakers at DPR:

- Reconsider the system by which 1,3-D is allocated in areas subject to township cap restrictions. Currently, private companies control the allocation of 1,3-D and distribute the chemical to growers on a “first come, first served” basis. Our interviews with growers corroborate previous scholarship, which suggests that this system of allocation may not serve growers or agricultural communities as well as other mechanisms of distribution (Carpenter et al., 2001). Growers suggested that private control over the allocation of restricted-use chemicals poses an additional burden for growers that rely on 1,3-D. In light of the recently released enhanced restrictions on the use of 1,3-D products, it is likely that this system of allocation will continue to pose an additional challenge to California strawberry growers who use 1,3-D to fumigate their fields and therefore merits reevaluation.
- Ensure that limits on the amount of acreage that can be fumigated at any given time are sufficiently health-protective measures. Growers suggest that these limits increase the amount of fumigation rig hookups required to treat a field and thus increase the risks of accidental exposure and drift. DPR should consider the risks posed by additional equipment hook-ups when evaluating whether the limits on the amount of acreage that can be fumigated at a given time are sufficiently health-protective.
- Given that many growers operate in multiple counties, we suggest that the existing coordinated framework,

including the California Agricultural Commissioners and Sealers Association (CACSA), be strengthened to encourage discussion and cooperation among county agricultural commissioners in the major strawberry growing regions. This will promote more even interpretation and enforcement of pesticide use regulations across counties. This will reduce the difficulties of compliance for growers who operate in multiple counties.

This research also highlights the need for greater attention to the issue of fieldworker exposure to pesticides. While growers are correct that pesticide mixers and applicators are more vulnerable to acute exposure than fieldworkers, accounts of pesticide-related illness among strawberry fieldworkers and their associates suggest that this exposure is both frequent and concerning to fieldworkers. To this end, both the California DPR and the U.S. EPA have laudably strengthened worker protections with the release of an updated Worker Protection Standard in 2016, providing enhanced protection for fieldworkers from the hazards of workplace pesticide exposure. While providing workers with more safety information is a step in the right direction, our interviews with workers suggest these efforts may not be enough to truly enhance worker safety. Often, the problem of worker safety from pesticide exposure is not simply a matter of inadequate safety information, but a problem of reporting and enforcing violations of pesticide use. California farmworkers, a majority of whom are undocumented, often do not feel that they are in a position to contest pesticide safety violations. Without addressing the legal barriers like citizenship status that prevent farmworkers from reporting violations and exposure incidents, simply providing workers with more safety information may prove an inadequate approach to reducing pesticide exposure among farmworkers.

That growers generally do not believe that the increasing regulation of fumigants will be the demise of their own operations or the industry bodes well for DPR as it considers increasing restrictions on existing fumigants in

order to protect public health and weighs their potential effects on grower viability. Growers are more alarmed by the current labor shortage than the prospect of increasing restrictions on the availability of fumigants. This suggests that generally, even from growers' perspectives, claims that the phase-out of fumigants would be the demise of the strawberry industry in California are overstated. It would be more accurate to say that growers see increasing restrictions on the use of soil fumigants, combined with the other challenges facing the industry, as being one of the many contributing factors that will push low-resource growers out of production and shrink the industry. Some growers see this development as positive, noting an exit of uncompetitive growers would improve berry prices. But if the continued viability of low resource growers is in the public interest as USDA policy suggests, steps must be taken to help these growers navigate the demands of a rapidly changing industry.

DPR has already identified the need for greater public investment in the research and development of alternative soil sterilization methods in order to protect community and farmworker health (CDPR, 2013). This research reaffirms the necessity of greater state investment in the development of these methods in support of these goals, and suggests that particular attention should be given to research projects that seek to identify solutions for low-resource growers interested in transitioning to alternatives. In addition, this research suggests that limited-resource California strawberry growers would benefit most from alternative soil sterilization research projects that include a significant educational and outreach component designed to disseminate the study's findings and help low-resource growers apply the results. Thus the institutions which provide funding for research projects focused on developing alternative methods of soil sterilization, like the California DPR and the California Strawberry Commission, might consider the particular needs of

limited-resource strawberry growers in choosing which projects to fund, if keeping them in business remains a policy goal.

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