The 2020 Maine Drought and Agriculture Report

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Overview

Climate change is already affecting growers in the Northeast, leading to changes in temperature and precipitation (Wolfe et al. 2018). Climate scientists anticipate that these changes will intensify in coming decades. Of particular importance to agriculture is the degree to which water availability will align with water demand throughout the growing season. Past research suggests that Northeast states such as Maine are likely to see increasingly wet and cold springs, potentially leading to disrupted field operations (Fernandez et al. 2020), in addition to high evapotranspiration rates that lead to a greater crop water demand (McDonald and Girvetz 2013).

Recent events, such as the regionally widespread agricultural drought of 2016, have negatively affected agriculture in our region. In their survey of New York agricultural producers, Sweet et al. (2017) documented that even farmers with access to water and irrigation equipment experienced significant yield loss during such periods. In 2016, vegetable growers in Sweet's study lost an estimated 40% of their crops, fruit producers lost an estimated 47%, pasture producers lost an estimated 40%, and field crop producers lost an estimated 31%. The most common cause of loss was inadequate irrigation capacity or water supply (surface and groundwater). In 2020, much of the Northeast was again affected by agricultural drought, including the state of Maine.

The United States Drought Monitor began tracking Maine drought conditions in 2000. Since monitoring began, the most intense drought lasted 110 weeks, from June 2001 – July 2003. The most intense period of drought (when 61% of the state was affected) occurred in July 2002 (NIDIS 2020). The recent 2020 growing season was also characterized by widespread drought across the state. While the severity of the 2020 drought did not reach that of the 2001-2003 event, producers across a range of agricultural sectors struggled. In response, the USDA Farm Service Agency (FSA) activated permissions for emergency haying and grazing of acres normally set aside through the Conservation Reserve Program (CRP) (USDA-FSA 2020a). In September, FSA additionally designated Aroostook County (home to Maine's potato industry) as a primary national disaster area, opening the door for producers in Aroostook, Penobscot, Piscataquis, Somerset, and Washington Counties who were negatively impacted by the drought to access federal emergency loans (USDA-FSA 2020b).

This report documents the experiences of agricultural producers from a variety of sectors in Maine, specifically their experiences with drought and its effects in 2020 and the five years prior. The purpose of our study is to identify approaches for drought resistance and resilience in Maine agriculture, drawing from the experiences and perspectives of Maine farmers. First, we report on the results of a producer survey conducted in the winter of 2020-2021. Second, we make targeted recommendations for outreach, education, technical service, and (when possible) financial assistance. Our findings support recent calls for updating existing state programs, policies, and financial incentives to address climate change effects and mitigation, as stated in the *Maine Won't Wait* report (Maine Climate Council 2020, 78)**.**

Key findings

1. The majority of survey respondents reported that, in most years, they typically have enough water to meet their farm's needs. However, only one-third reported that this was true in 2020. In fact, *over half reported that they did not have sufficient water to meet their farms' needs during the 2020 drought.*
2. All producer groups who responded to this survey reported higher than normal losses in 2020. Lowbush blueberry producers were hardest hit, both in terms of percentage of producers reporting losses, and the percentage of crop yield lost.
3. Following the 2020 drought, a notable proportion of respondents indicated an interest in expanding their water use for various purposes, including for irrigation, milk processing, and livestock watering. Other drought adaptation approaches reported by farmers include mulching, cover cropping, changing the timing of key management activities, using high tunnels, greenhouses, or other covered structures, and changing crop or variety types in response to drier conditions.
4. There are many respondents who use one water source for both household and farm purposes. Reduced water supply during times of drought not only affects farm operations, but also basic household functions.
5. To improve water access, respondents are interested in investing in soil health, irrigation, building additional ponds, expanding electrical access for pumps, and drilling additional wells. There is a need for additional information, technical assistance, and financial assistance for practices such as water quality assessments, soil moisture monitoring, navigating surface and groundwater regulations, measuring the volume of water needed for agricultural purposes, and ensuring sufficient water access to meet production needs. There is an opportunity to connect more farmers with Extension and USDA-NRCS and FSA programs to further develop on-farm practices that support soil health and efficient water use on farms, and make financial support available to farmers when needed (i.e., disaster assistance, crop insurance).
6. Changing weather patterns associated with climate change are having negative effects on Maine agriculture. Respondents report concern about reduced crop quality, poor crop and cover crop germination, and increased labor needs associated with irrigation. Respondents also noted that extreme weather events make it more difficult to access their fields, increases erosion and soil loss, and have negative effects on crew health and

wellbeing. An overwhelming majority of respondents reported concern about climate change in general *and* changing weather patterns.

Approach

A survey was conducted in the winter of 2020-2021, targeting Maine's highest grossing commodities (potatoes, wild blueberries) and other important agricultural sectors (diversified vegetable and small fruit, tree fruit, maple, hemp, livestock and dairy, and nurseries). The survey instrument was collaboratively developed by a team of agricultural advisors and service providers from the Maine Department of Agriculture, Conservation, and Forestry (MDACF), the University of Maine Extension, the University of Maine School of Food and Agriculture, and the Maine Organic Farmers and Gardeners Association (MOFGA). Additional review of the survey instrument was provided by collaborators with the United States Department of Agriculture Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA). The survey instrument was tested by five farmers prior to deployment, and adjustments made based on their feedback. University of Maine IRB provided human subjects review and approval for the project.

As in many states, there is no publicly available database of Maine farmers. Therefore, we conducted our survey using a non-probability sampling approach (AAPOR 2016). This means that the results presented in this report represent the experiences and perspectives of survey respondents, but should not be generalized to the larger population of Maine agricultural producers. Specifically, invitations to anonymously complete the survey were sent out through the University of Maine Extension Dairy list, the MOFGA JourneyPerson list, the Maine Vegetable and Berry Listserv, the MOFGA Farmer Programs Newsletter, the University of Maine Spudline Listserv, the MDACF Horticulture Listserv, MDACF Hemp Listserv, the University of Maine Tree Fruit list, and the University of Maine Wild Blueberry Newsletter. Sampling began in December 2020, and concluded at the end of January 2021. The survey was deployed using Qualtrics, an online survey platform that allows for branching logic and anonymous submissions, but which can prevent respondents from submitting more than one response (based on IP address). Data were downloaded and analyzed using R (R Core Team 2018).

Demographic summary

We received 165 complete survey responses and 88 partial responses (total n = 253). Partial responses were included in analysis. The best represented category of respondents was vegetable producers, followed by potato and poultry producers (figure 1). Respondents reported farming in most Maine counties, with Aroostook County being best represented in the sample (39 respondents, figure 2). Respondents managed between 0.5 and 10,000 acres (median acres farmed = 55.0; median acres irrigated = 1.0).

The average age of respondents was 52 years old. The majority of respondents identified as male (74.3%), 25.7% identified as female. Six-percent of respondents reported holding a high-school diploma or an equivalent degree, 5.8% reported having vocational training, 11.7% reported holding an associate's degree, 37.0% reported holding a bachelor's degree, 12.3% reported attending some college, and 13.6% reported holding a master's degree. Ninety-seven percent of respondents reported their race and ethnicity as white/non-Hispanic, while one respondent reported identifying as Indigeounous American or Alaska Native.

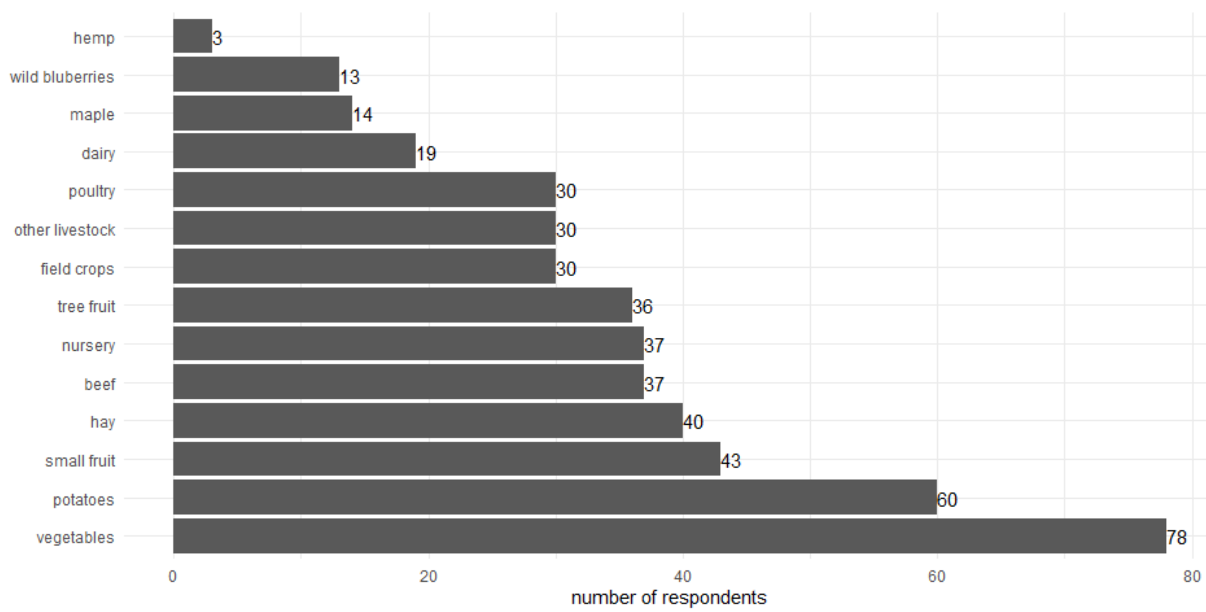

Figure 1: Survey respondents by production category. Total N = 253. Note: respondents could indicate production in more than one category.

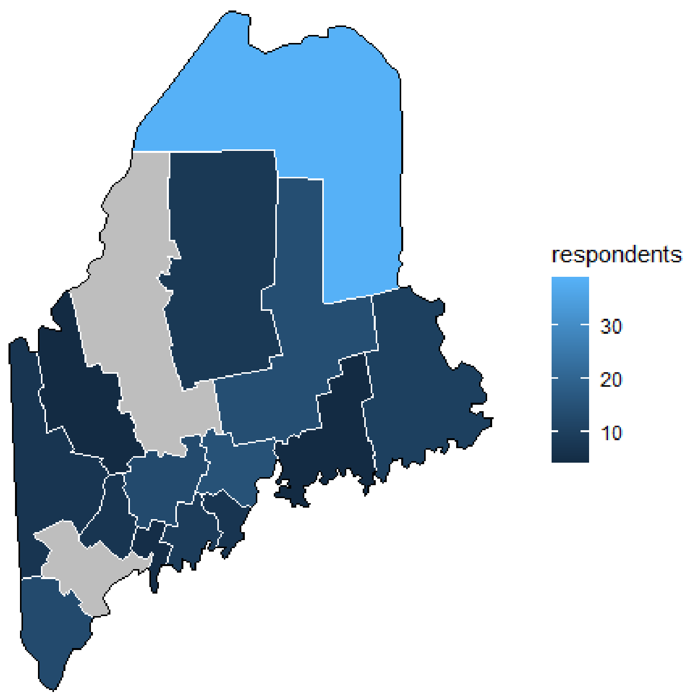

Figure 2: Survey respondents by county.

Yield loss due to drought

Producers were asked to report if they had experienced yield loss due to drought, either in 2020 or in the past five years. In all product categories, a larger percentage of respondents reported losses due to drought in 2020 than in the 2015-2019 period (figure 3). For example, 43% of respondents who grow potatoes reported drought-related yield loss in 2015-2019, while 67% reported losses in 2020. Among wild blueberry growers, 61% reported drought-related loss in 2015-2019, while 100% reported losses in 2020. Among respondents who reported any drought-related losses in the 2015-2019 period, the median number of years that losses occurred was three.

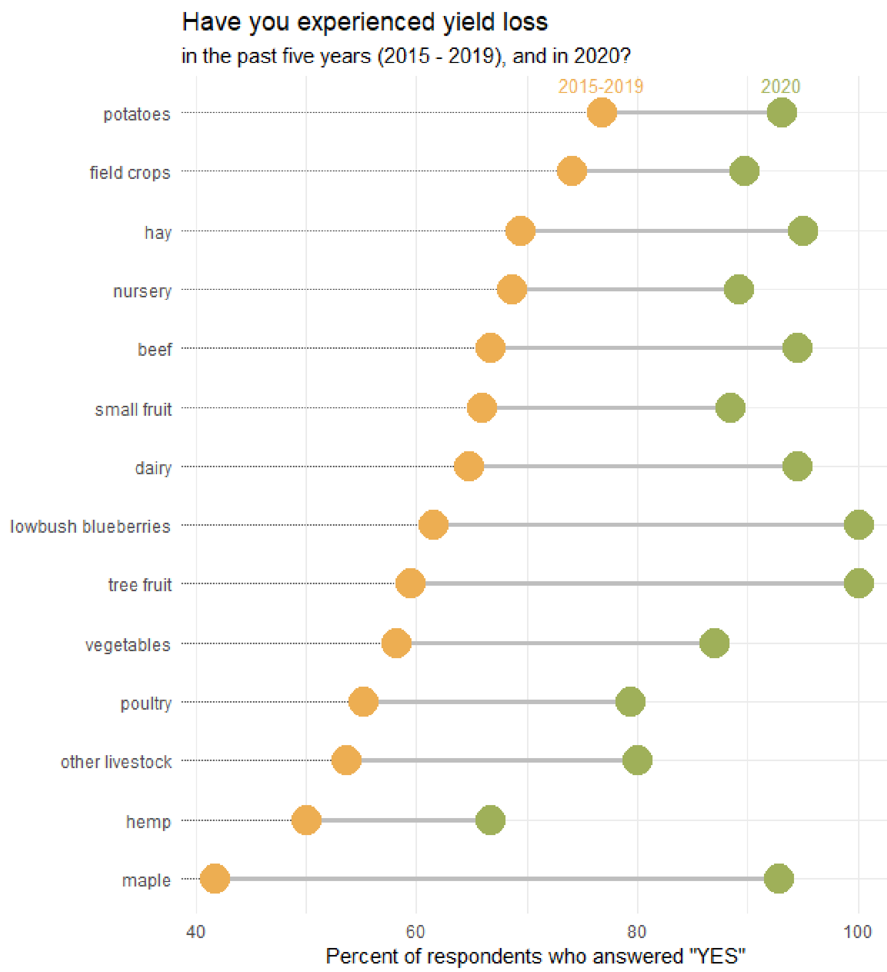

Figure 3: Respondent reports of yield loss due to drought in two time periods (2015-2019, and 2020).

If survey respondents reported that they had experienced yield losses in 2020, they were asked to estimate these losses as a percentage of their typical yield. While the effects of drought on yield of some products (such as beef) can be difficult to assess, the percentages in figure 4 represent respondents' best estimates. Among those agricultural sectors hardest hit by the 2020 drought, low bush blueberries reported the most notable impact, followed by hay, beef, dairy, maple, and potatoes.

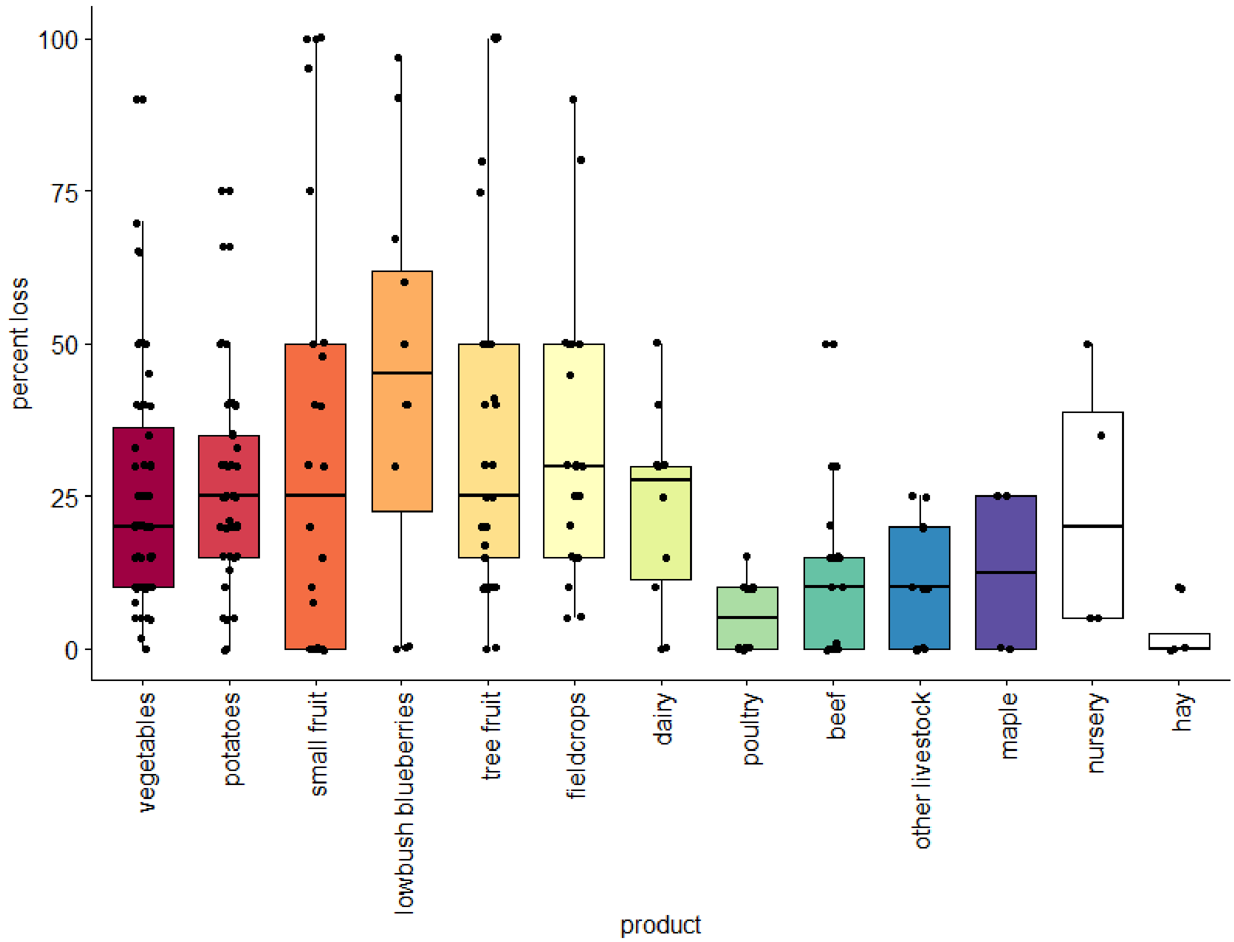

Figure 4: Producer estimated losses relative to expected yield, due to the 2020 drought or other causes.

Water source, reliability, and use

Water source failure during droughts and dry periods can have negative effects on farm operations. Respondents were asked to report both their primary and secondary water sources, how they used water on their farms and in their households, and whether they had experienced source failure. The majority of respondents reported that drilled wells served as their primary water source (n = 95), followed by ponds with natural recharge (n = 48). Dug wells were the most commonly cited secondary source (n = 28), followed by ponds with natural recharge (n = 22) and rivers/streams (n = 18) (figure 5). Respondents reported an average of 15.5 G/min pumping capacity for dug wells (median = 5 G/min), and an average of 25.7 G/min for drilled wells (median = 10). The average reported drilled well depth was 271.2 feet (median = 216.0 feet).

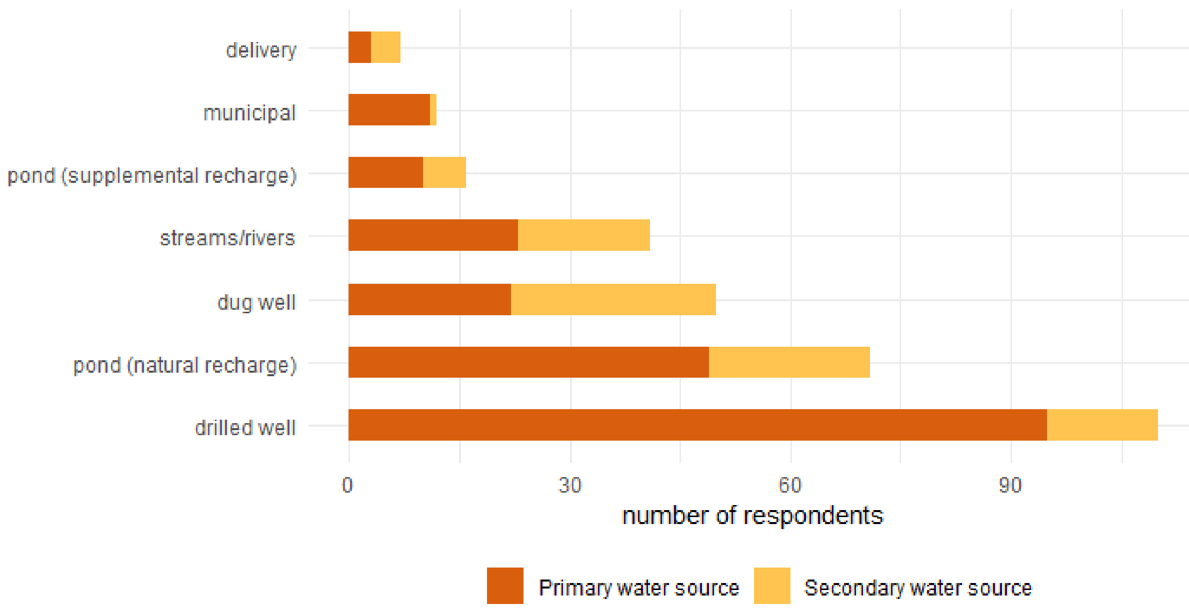

Figure 5: Respondents' reports of primary and secondary water sources, sorted by number of respondents using each source.

Of the 44 respondents who reported using a dug well either as a primary or secondary source, 23 (52.3%) reported that their well had run dry at some point in the past. Among the few respondents who reported using a dug well as their primary water source (n = 20), 40% reported their dug well had failed at some point. More than half (52.3%) of respondents who reported using a dug well, either as a primary or secondary source, reported that the well ran dry in 2020 (figure 6). Of the 107 respondents who reported using a drilled well either as a primary or secondary source, 26 (24.3%) reported that their well had run dry at some point in the past. A minority (18.9%) reported that the well ran dry in 2020. Twenty-percent of respondents who reported using a drilled well as their primary water source reported this water source failing at some point in the past, with 14.8% reporting failure in 2020. This demonstrates the relative resistance of drilled wells to drought conditions, compared to dug wells.

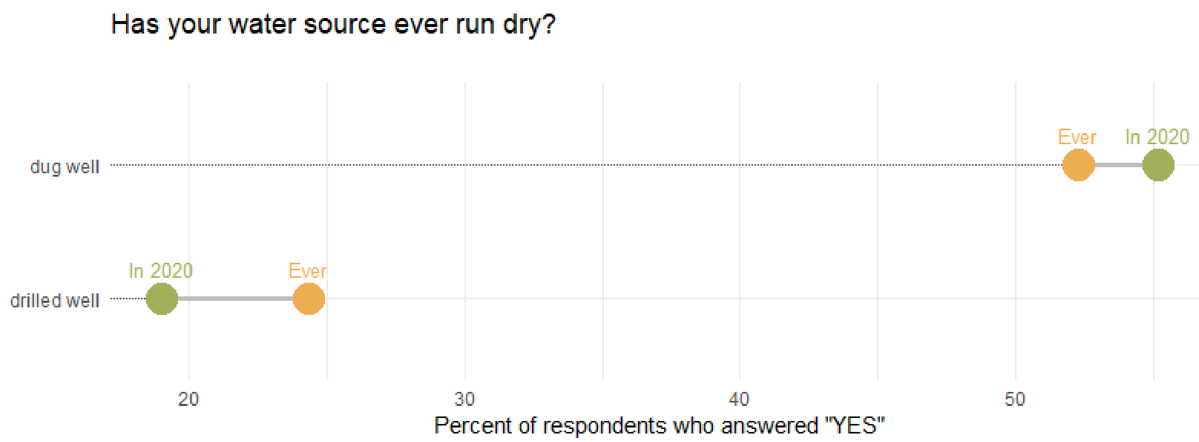

Figure 6: Respondent experiences with dug and drilled well failure.

Among respondents who reported using water from ponds, streams, or rivers, more than half (55.6%) reported that these sources had reduced levels or flows that prevented drawing from using this source in 2020. Twenty-three respondents reported using surface waters as their primary farm water source, with 47.8% of these respondents reporting reduced flows that interrupted water use in 2020. The majority of respondents (65.7%) reported that in most years they typically have enough water to meet their farm's needs. However, only 33% reported that this was true in 2020. The majority (57.6%) reported that they *did not* have sufficient water to meet their farms' needs in 2020.

Respondents were asked to report how they used water on their farm. The most frequently cited uses were household use (n = 131) and irrigation (n = 116), with other frequent uses including vegetable and fruit washing and processing (n = 91) and livestock watering (n = 81). Respondents reported using water for purposes like heat stress reduction (n = 37) and frost protection (n = 17) less often. Write-in responses revealed several additional water uses including seedling production, grain processing, chemical mixing, hydroponic production, cleaning, dye processing, cut flower arranging, commercial kitchen use, washing equipment/tractors, etc.

Respondents were also asked to report their intentions to increase water consumption for specific uses in the future, decrease water use, or invest in new equipment and/or supplies (figure 7). Few reported that they planned to decrease water use in any category, with the exception of those who intend to decrease water use for frost protection. Of the respondents who reported using water for frost protection, 17.6% strongly agreed that they intended to decrease water use for this purpose. This intention to decrease sprinkler use for frost protection could be due to farmer preferences for alternative frost-protection approaches (such as floating row-cover) for small fruit.

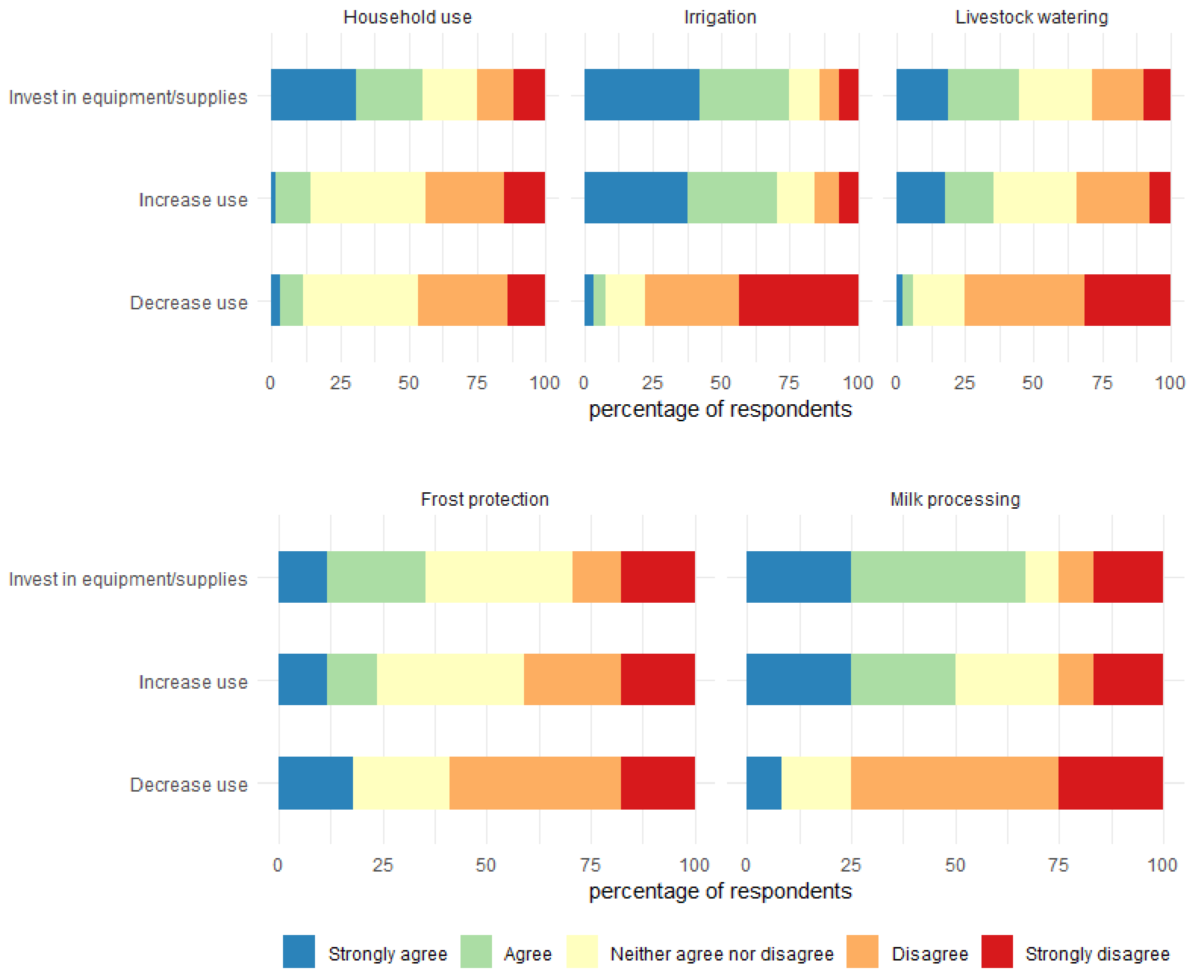

Figure 7: Intentions for future water use.

A notable proportion of respondents indicated their interest in expanding their water use for various purposes, including 70.2% of those who use water for irrigation, 50% of those who use water for milk processing, and 35.4% of those who use water for livestock watering. Many respondents indicated their interest in making improvements, including investments in equipment and supplies. Of the respondents who reported using water for irrigation currently, the majority (74.6%) indicated that they were interested in investing in new irrigation equipment and supplies (e.g., pumps, pivots, drip irrigation). Forty-five percent of respondents who reported using water for livestock agreed or strongly agreed that they are interested in investing in new equipment/supplies for this purpose, while 66.0% of those who use water for milk processing reported a similar interest in investing in new equipment. As only 12 milk processors responded to this survey, the latter result should be interpreted conservatively.

Among respondents who reported using water for household use, 55.0% agreed or strongly agreed that they are interested in securing a new source of water for household use, or investing in new equipment and supplies for household water use (e.g., new wells, improved plumbing). Additionally, 23.4% of respondents who use water for household use reported that they are interested in securing a new source of water for non-household use, specifically to reduce farm reliance on their household water source. This finding indicates that there are many who use one water source for both household and farm purposes. Reduced access during times of drought not only has an effect on farm operations, but also on basic household functions.

Many respondents indicated that they are interested in making specific investments in their farm's water use capacity in the future. Respondents' most commonly cited interest in making investments was in soil health to improve soil water holding capacity (88.1% indicated this was true for them). Many respondents are also interested in investing in equipment and infrastructure for irrigation, such as pumps, piping, delivery heads, etc. (68.9%), building additional ponds (48.2%), expanding electrical access for pumps (46.3%) and drilling additional wells (41.6%) (figure 8).

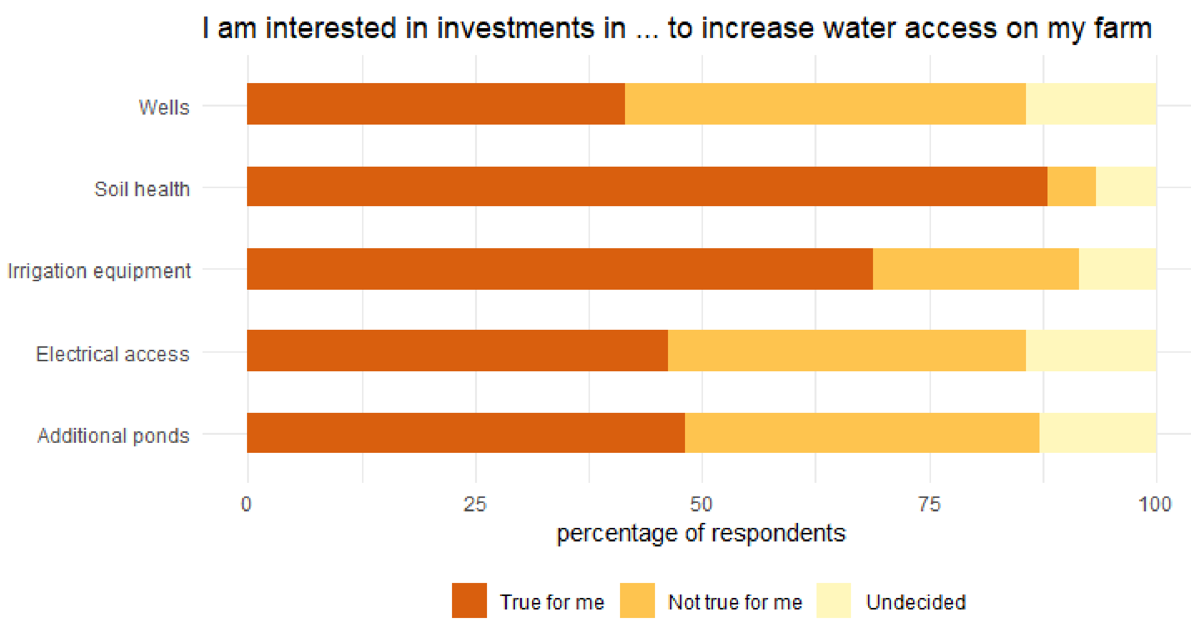

Figure 8: Respondent interest in specific water-related investments.

The following section will describe the perceived opportunities of key management changes, as well as some barriers to implementing these changes as reported by respondents.

Drought adaptation

Farmers are actively adapting to drought through farm management strategies. The most commonly cited approach was to increase soil coverage through mulching, cover cropping, or other practices (73.4% of respondents report using this practice specifically to deal with drought). A majority of respondents (57.3%) report changing the timing of management activities, and 61.4% report reducing tillage to adapt to dry conditions. The majority (56%) of vegetable producers reported using high tunnels, greenhouses, or other covered structures for protection, an approach that allows for more precise water applications to crops, if water is available and irrigation systems are in place. Vegetable producers also reported changing crop types or varieties in response to drier conditions (47.2% reported they had taken this approach), pointing to need and opportunity to broaden selection of drought-resistant vegetable crop options for Northeast growers. Less frequently cited approaches included selecting livestock types or breeds better suited for dry conditions (only 7% of beef producers and 4% of other livestock producers reported taking this approach). There are opportunities for further research and outreach on the efficacy of these practices.

Water-related investments

Soil health

The most popular water-related investment that producers who responded to this survey are interested in making is improving soil health to improve soil water holding capacity (figure 8). Among respondents who indicated interest in this approach, 83.0% reported that they would pursue this action in the near future (figure 9). The majority (71.9%) reported that they possess the technical knowledge, while 25.4% reported that they require additional information before committing to the practice. Fifty-six percent indicated that they were confident building soil health would improve on-farm water utilization. Most respondents (79.1%) indicated that they knew where to seek technical assistance on the topic. Forty-six percent reported that they had the financial resources available to implement soil health practices.

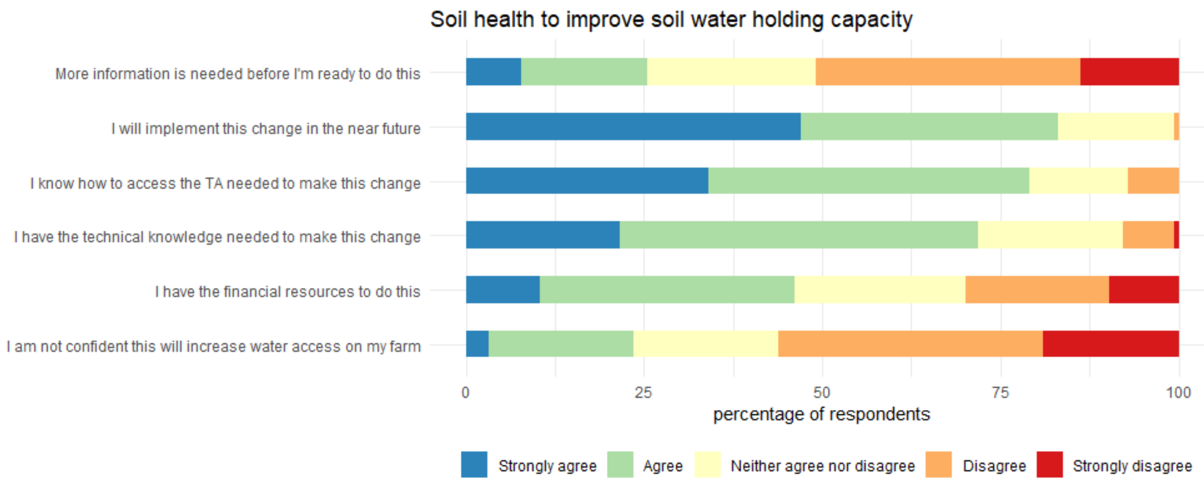

Figure 9: Respondent intentions to use soil health to improve soil water holding capacity (n = 153).

Irrigation

Many participants indicated their intention to invest in additional equipment and infrastructure for irrigation, such as pumps, piping, delivery heads, etc. Of those who indicated interest, 68.3% reported that they intended to make these investments in the near future (figure 10). Respondents were generally confident that this type of investment will change how they are able to use water on their farm, with a small proportion of respondents indicating a lack of confidence that this would be the case (21.6%). Many respondents (57.9%) reported that they already have the knowledge needed to make this investment, though 46.0% reported additional information was needed. This indicates a base level of knowledge about irrigation among many farmers, with opportunities for further education and technical assistance in specific areas or related to specific practices. Only 13.5% percent of respondents reported that they did not know where to go for technical assistance related to irrigation investments, showing that past educational and outreach efforts have been successful. Of the respondents who indicated interest in expanding their use of irrigation, over 50% reported that they do not have the financial resources needed for these investments.

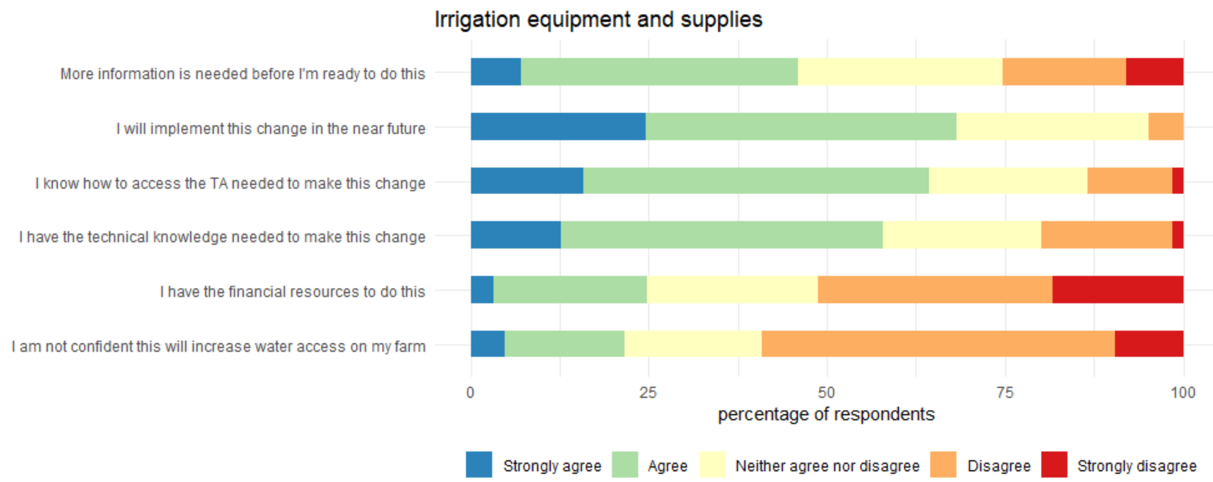

Figure 10: Respondent intentions to expand use of irrigation equipment and supplies (n = 125).

Ponds

Among those who reported that they were interested in building additional ponds to increase their access to water (n = 99), 53.5% reported that they agreed or strongly agreed that they would do so in the near future, and 49.0% reported that they possessed the technical knowledge to do so (figure 11). Respondents were generally confident that pond installation would increase their ability to access water, or would change how they were able to use water on their farm. However, 40.0% reported that they disagreed or strongly disagreed with the statement "I know how to access technical support I need" to make this change, and 71.0% agreed or strongly agreed that they needed more information before they were willing to make a decision to install additional ponds. This indicates that even though many respondents believe they possess knowledge and technical skills needed to install additional ponds, they likely still have questions about some aspects of pond construction. An additional factor adding to producer uncertainty is the perceived potential for regulatory limitations on pond installation. This points towards a need for additional technical support and outreach around pond development. Additionally, only 15% of respondents who answered this question reported that they have the financial resources to make this change.

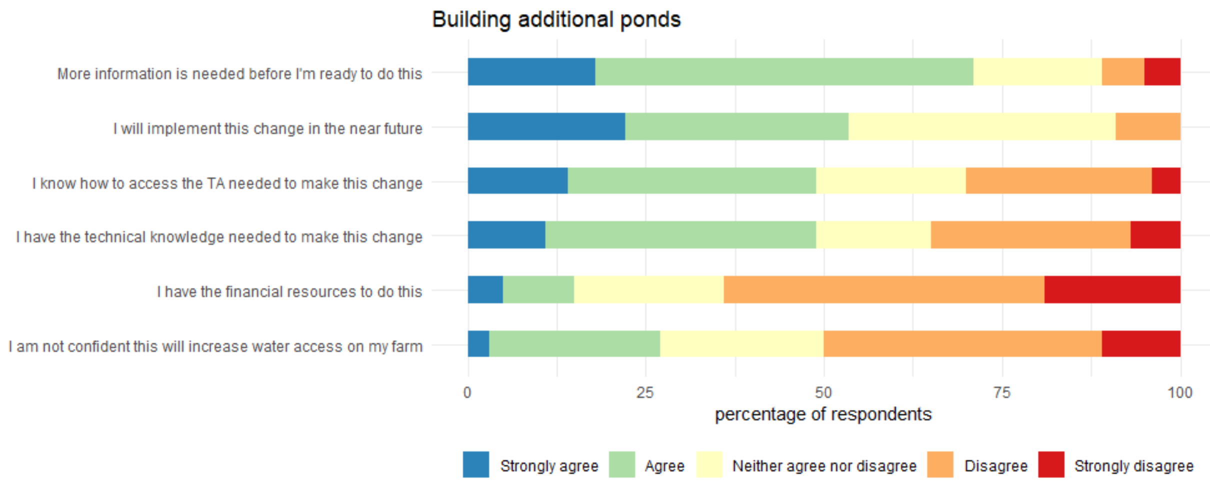

Figure 11: Respondent intentions to build additional ponds to increase water access (n = 99).

Expanding electrical access for pumps

Among respondents who reported an interest in expanding electrical access for pumping (n = 94), 39.0% reported that they were interested in doing so in the near future (figure 12). Forty-one percent reported they possess the knowledge necessary to implement this change, but 65.2% reported that more information was needed before they were ready to do so. Just under half (43.6%) reported that they knew where to seek technical assistance on this topic. Thirty-five percent indicated they were confident that this change would help them improve their ability to access water. Only 11.5% of respondents reported that they have the financial resources to make this change.

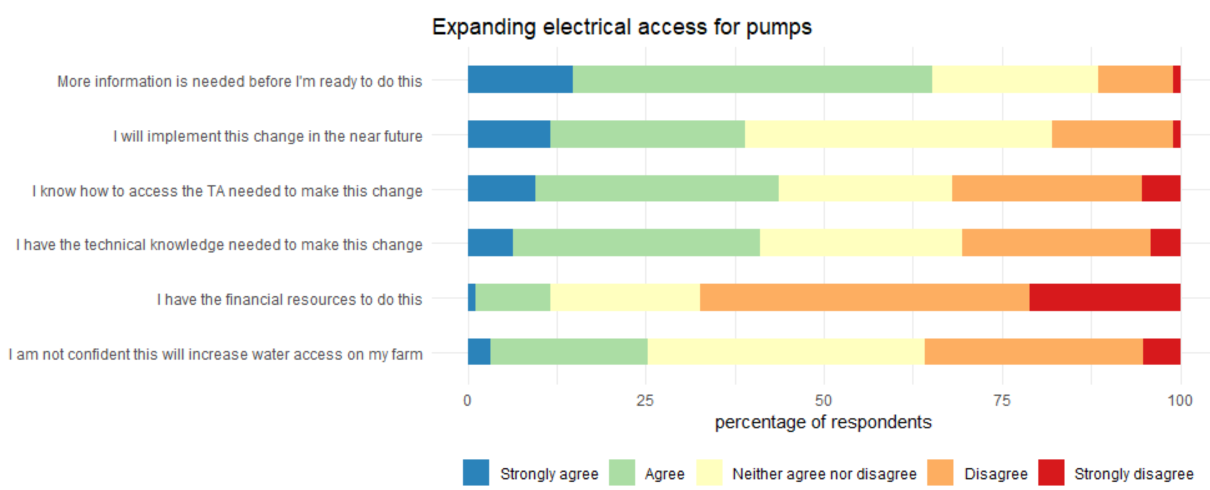

Figure 12: Respondent intentions to expand electrical access for pumps (n = 94).

Drilling additional wells

Among those who reported an interest in drilling new wells to increase their access to water, 36.3% agreed or strongly agreed that they intended to do so in the near future (figure 13). Forty-percent of respondents who answered this question reported that they had the technical knowledge to make this change, though 67.0% reported that they needed more information before they were ready to make the decision to drill additional wells. Just under half (48.8%) reported that they know how to access the technical support they need to drill wells, if they decided to move ahead with this decision. While 25.6% of respondents indicated they did not have confidence that installing additional wells would help them improve their access to water, 40.7% reported they were confident that this approach would improve their water access. Over a third of respondents to this question (36.8%) reported that they do not have the financial resources to make this change.

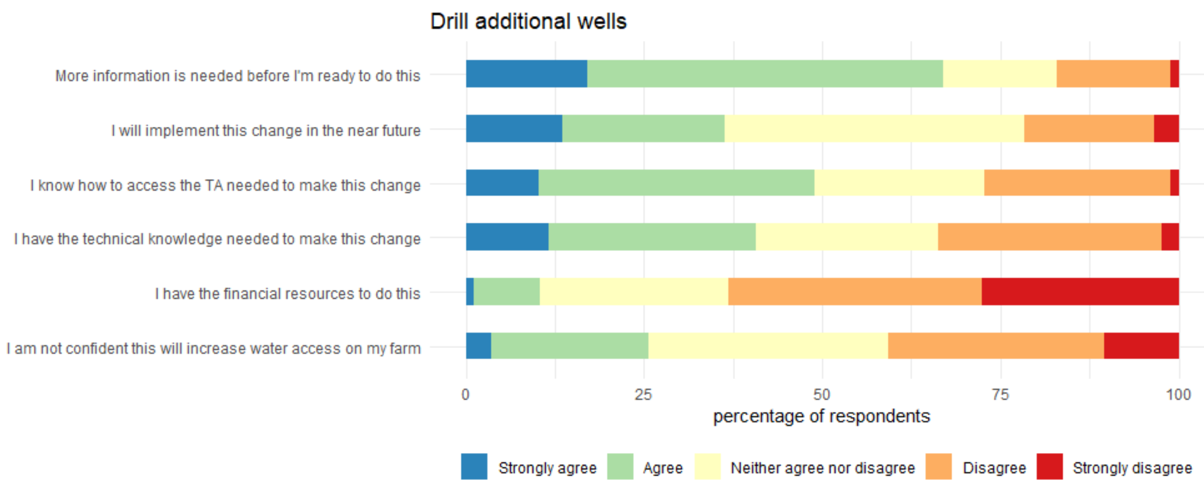

Figure 13: Respondent intentions to drill additional wells to increase water access (n = 88).

Opportunities to provide information, technical, and financial assistance

All respondents were asked to report what kind of support they would like (information, technical assistance, financial assistance, or no assistance) for a range of other drought-adaptive practices (figure 14). In this context, *information* is general descriptions of a practice or improvement (e.g., the reasons behind using a practice, scientific evidence supporting efficacy of the practice, or examples of successfully implemented practices or improvements), while *technical assistance* is site-specific guidance on implementation (siting, sizing, materials, etc.)

Respondents indicated that they are interested in receiving additional information about water quality assessments, soil moisture monitoring, pond installation and design, and navigating surface water pumping regulations, among other topics. They indicated less need for information on topics such as *planning or adjusting planting schedules*, *installing hoop houses or high tunnels*, and *acquiring new land with water in mind*. Respondents reported desiring technical assistance on a range of practices, including *ensuring sufficient water to meet crop needs*, *pond installation and design*, and *installing/designing irrigation systems*. Respondent desire for financial assistance was cited for *deep well installation*, *ditch work and water redirection*, *pond installation and design*, and *installing and designing irrigation systems*, among other practices. Many respondents reported that they did not require additional assistance related to *acquiring new land with water in mind*, *addressing too much water* (e.g., saturated soils, washouts), *adopting conservation tillage* (including no-till) or *cover cropping*.

Figure 14: Types of assistance that respondents reported would be useful to them, by practice.

Farmer engagement with FSA / NRCS programs

All respondents were asked to report whether or not they participated in USDA programs designed to provide support for agriculturalists facing a variety of production, market, or natural resource challenges, including drought. Few respondents reported participating in the selected USDA Farm Service Agency programs (FSA). However, more than half (55.0%) of respondents reported that they had filed a crop acreage report with FSA in 2020, which cues FSA to notify farmers if they are eligible for drought-related assistance programs.
Of the few respondents reporting participation in FSA programs, the largest reported participation was in the Livestock Forage Program (LFP) (9% of respondents), which provides compensation for grazing losses related to drought. Among those who reported not using this program, the largest barriers were perceived lack of eligibility (51.1%), followed by lack of interest (29.3%), and lack of awareness (19.5%). The next most utilized program was the Emergency Conservation Program (ECP) (7% of respondents), a program that provides cost sharing for emergency water for livestock and existing irrigation systems for orchards and vineyards. Among those who did not use the program, the largest group again were those who reported that they did not believe they were eligible (41.1%), with equal numbers of respondents reporting a lack of awareness (29.5%) and a lack of interest (29.5%).

Among the least utilized programs were the Emergency Loan Program (ELP), the Tree Assistance Program (TAP) and the Disaster Set-Aside Program. ELP provides low interest loans for farmers to rebuild or recover from drought (55.5% of respondents reported lack of interest, 23.5% reported lack of eligibility, and 21.0% reported lack of awareness); TAP provides compensation for replanting or rehabilitating trees (28.9% respondents reported lack of interest, 31.2% reported lack of eligibility, and 35.9% reported lack of awareness); and the Disaster Set-Aside Program provides extra payments for farmers who have existing FSA loans (47.2% of respondents reported lack of interest, 31.5% reported lack of eligibility, and 35.3% reported lack of awareness). There are clear opportunities for further outreach and education about FSA programs, considering the number of respondents who reported being unaware of FSA offerings.

Respondents were also asked about their participation in programs facilitated by the USDA Natural Resources Conservation Service (NRCS). Specifically, respondents were asked to report on their participation in the Environmental Quality Incentives Program (EQIP) and the Agricultural Management Assistance Program (AMA). More than half of survey respondents (53.4%) reported participating in EQIP, which can provide technical and financial assistance to address a range of natural resources concerns, including water efficiency. Of those who did not report participating, 40.9% reported that this was due to a lack of awareness, 27.3% a lack of eligibility, and 31.8% a lack of interest. A smaller percentage of respondents reported participating in AMA (25.7%), which can be used for technical and financial assistance to construct new, or modify existing, irrigation systems. The most common reason given for not participating in AMA was lack of awareness (51.2%), followed by lack of interest (30.2%), and lack of eligibility (18.6%). NRCS field staff are trained to assist farmers evaluate their farm resource concerns, and will help direct farmers into appropriate programs if the farmers are eligible. Support for both NRCS and FSA outreach would likely boost program participation among farmers who are currently unaware of what these agencies have to offer.

Extreme weather

When asked about the other impacts of weather extremes, respondents reported that the most common negative impacts experienced were reduced crop quality (84.3% of respondents indicated they had experienced this), poor crop and cover crop germination (74.7%), and increase labor for irrigation which took away from other tasks (59.1%) (figure 15). Respondents also noted that extreme weather made it more difficult to access their fields (43.4% reported experiencing this), led to more erosion and soil loss (40.5%), as well as negative effects on crew health and wellbeing (29.4%). Some farms reported running out of water for home (11.8%) and farm (29.8%) use. Other effects of extreme weather cited by respondents included weed control issues, loss of pasture leading to an increased need to purchase livestock feed, decreased yield and/or crop value, increased deer pressure (due to lack of wild forage), water seepage into buildings, wind damage, power outages, poor pollination, decreased herbicide efficacy, and overall anxiety and stress.

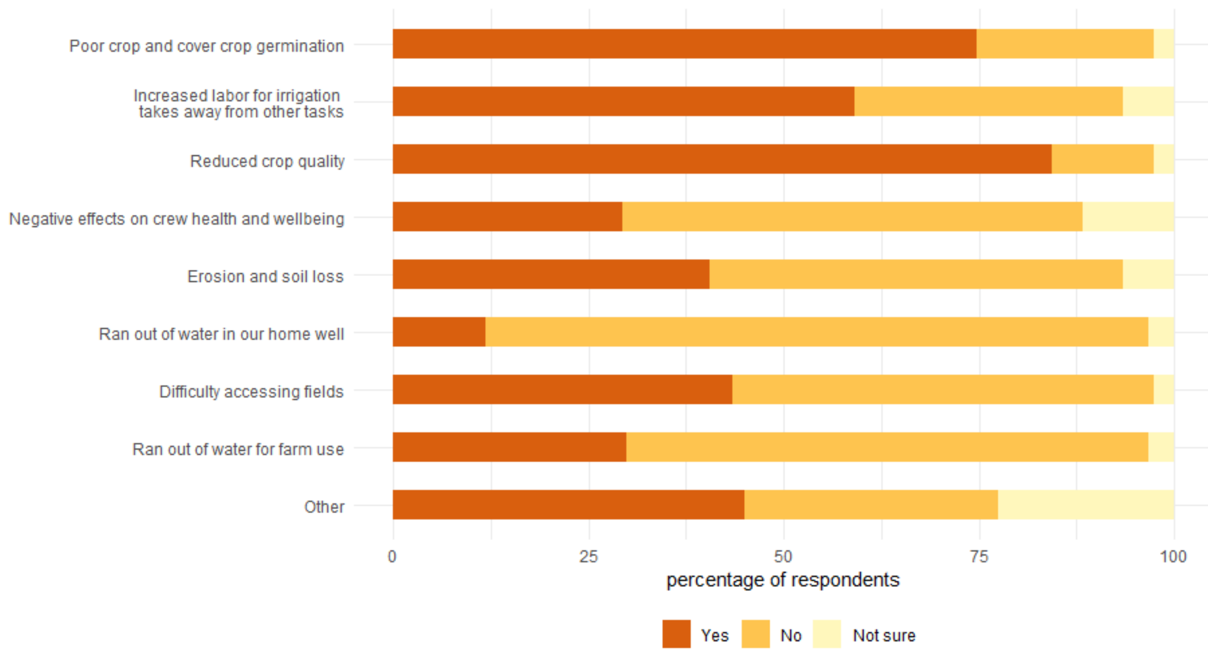

Figure 15: Effects of extreme weather reported by respondents.

When asked what weather and climate changes posed the greatest risk to their farm operations (figure 16), respondents reported that drought was the most significant (61.5% reported drought posed “a great deal of risk” to their farm, an additional 35.9% reported it posed “some risk”). Changes in water availability (44.7% reported this posed “a great deal of risk”) and higher pest, weed, or disease pressure (45.2%) were also perceived as presenting a high degree of risk. Respondents also demonstrated concern about high wind events (92.8% of respondents reported that this would pose a great deal or some risk), extreme precipitation events (96.0%), climate change in general (96.0%) and changing weather patterns in general (97.3%). There was little concern among respondents when it came to saltwater intrusion (88.2% reported this posed no risk to their farm). There was also low concern about water contamination, compared to other potential risks.

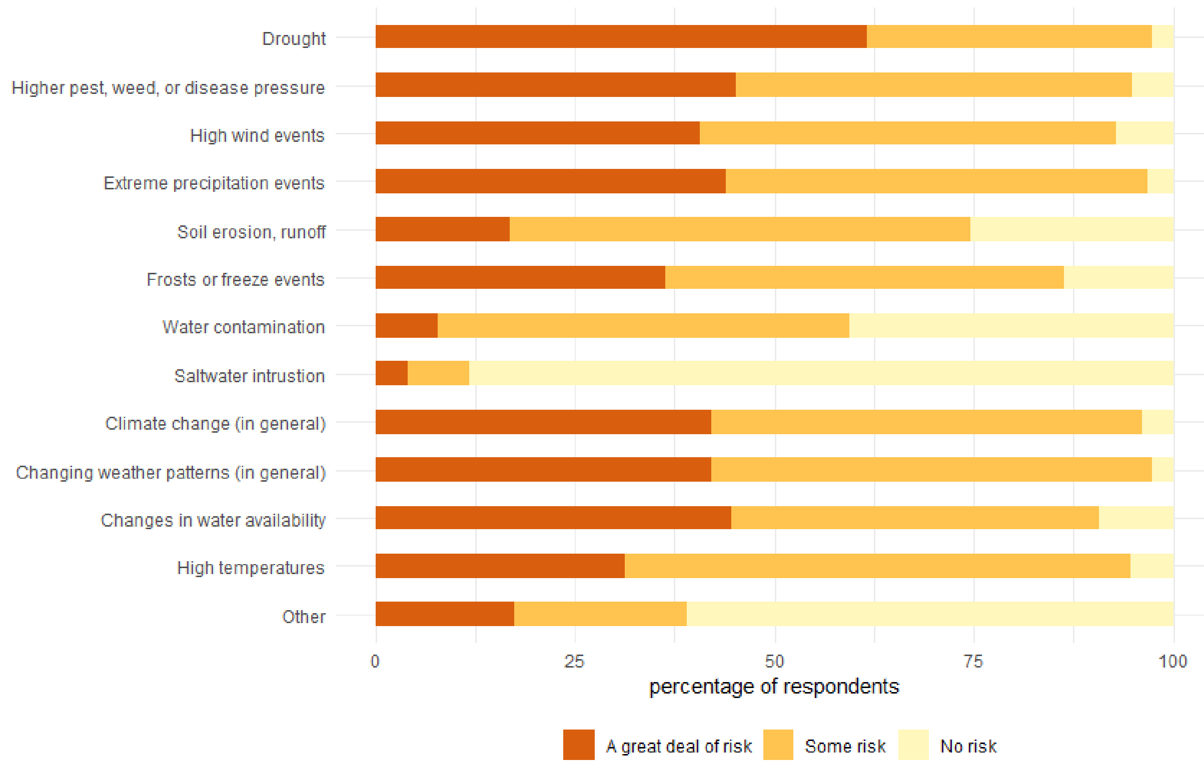

Figure 16: Respondents perceived risks to their farm.

Potatoes

Potato growers who responded to the survey (n = 60) reported producing for table markets (34.4%), seed (17.2%), and processing (39.1%). In addition, 9.4% of potato producers reported marketing directly to customers on a small scale, often as part of a diversified vegetable operation. Growers reported on their use of rotations (between potatoes and small grains or cover crops): 22.6% reported using a one-year rotation strategy, 20.8% reported a two-year rotation, and 32.1% reported a 3-year rotation. Almost a quarter of respondents (24.5%) reported using other rotation strategies, including 5-year rotations, 10-year rotations with other mixed vegetables, integration of corn into the rotation, and incorporation of green manures or fall seeding of cover crops. Respondents were also asked if they would irrigate their non-potato rotation crops: 39.2% reported that they would do so, 33.3% reported they would not, and 27.5% reported that they do not have the capacity to irrigate.

When asked to describe the quality of their potato crop in 2020 as compared to a typical year, the majority of respondents (66.7%) reported that color was about the same. Just under half (48.1%) reported that disease pressure and/or physiological disorders (hollow heart, etc.) was about the same, while 36.5% reported that disease conditions were lower than in a typical year. Many respondents (64.8%) reported potatoes were generally smaller than normal (figure 17). Respondents were also asked to consider when they would prioritize irrigation if, in the future, irrigation water was scarce: 48% reported they would prioritize watering during the tuber bulking stage of development, while 52% reported they would prioritize watering during tuber initiation.

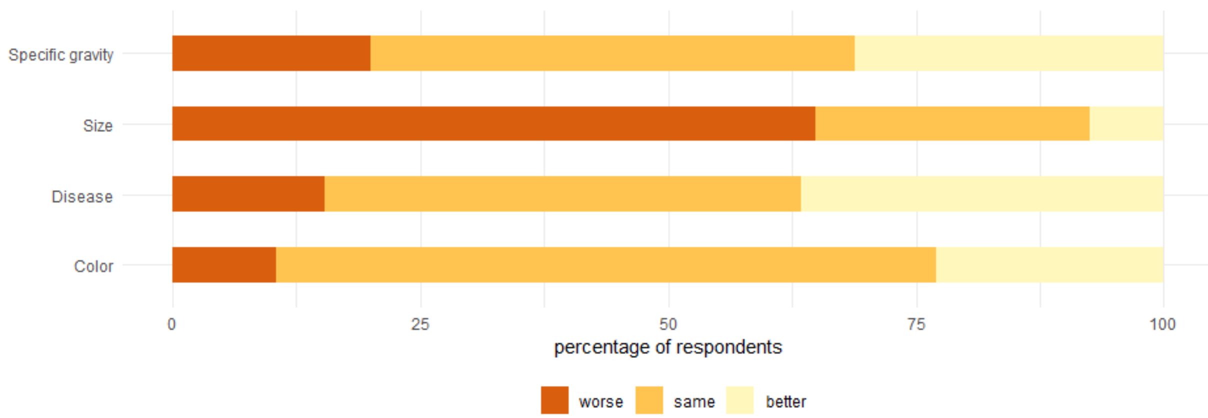

Figure 17: Crop quality in 2020, compared to a typical year.

The most common practices used by potato growers to deal with drought include under-sowing grains (64.2% report doing this) and under-sowing with grains that allow clover or grass to grow the following year (59.3%). Less common approaches to dealing with drought include practicing no-till in years between potato crops (37.0% report doing this practice) and rotating land with other farmers to lengthen the number of years between potatoes (26% of respondents report doing this).

A common problem many potatoes growers face is *dying complete*, a combination of verticillium wilt and nematodes. The most frequently cited approach for dealing with this challenge among survey respondents was extended rotations (2+ years, 74.5% of respondents reported using). Irrigation was also a frequently cited approach (58.7% reported using for this purpose). Less frequently reported approaches included biofumigation with high glucosinolate mustards, shorter rotations (1-year), and fumigation with Chloropicrin or Metamsodium. Among those who reported fumigating, most respondents reported that fumigated fields produced higher yields, ranging from 50-150 cwt. One respondent noted no yield difference between fumigated and non-fumigated acres.

Wild Blueberries

Thirteen wild blueberry growers responded to this survey. Among those blueberry growers who reported irrigating their crops (n = 7), one respondent reported using overhead sprinklers (for 15% of their production area), and two reported using overhead gun irrigation (one respondent reported using it on 100% of their production area, the other reported using it on 35% of their production area). One respondent reported using above ground irrigation piping on 75% of their production area, laying the pipe out when necessary. The last time this individual reported using this approach was in 2016, though they reported that this approach was effective in the context of their operation. No other irrigation approaches were noted. Only one wild blueberry grower who responded to this survey reported using irrigation for frost protection purposes.

As previously discussed, wild blueberry growers were greatly affected by drought conditions in 2020. Estimated production losses in 2020 due to drought or other causes ranged from 0.5% of normal yield to 97.0% (average percent loss = 43.7%; median percent losses = 45.0%). Among those growers who reported irrigating, 85.0% reported an interest in expanding the number of acres they irrigate. Sixty-six percent of wild blueberry respondents indicated they would like additional technical assistance and information about installing and designing irrigation systems, while 58.0% reported they would like financial assistance.

When asked if they were planning on doing anything differently moving forward, wild blueberry grower respondents reported:

> "If I had assistance to set up for irrigation, I would definitely do that."
>
> "Increased capital spending on new irrigation installation and R&D Innovation."
>
> "Irrigate if cost allows."

Livestock

Respondents that produced dairy (n = 19), poultry (n = 30), beef (n = 37), or other livestock (n = 30) were asked how the drought of 2020 affected their forage yields. The majority of these respondents reported that the drought compromised yields (81.6% reported damage) and quality (60.8% reported damage; figure 18). Respondents reported that in a typical year, they produced on average 76% of their farm's forage needs (median 100%). In 2020, respondents were able to produce only 59% of their farm's forage needs (median 60%). This represents a 22.4% decrease in average forage production needs (40% median decrease). This indicates that many farms are able to produce all of their own feed in a typical year, with a small number of farms typically buying-in a significant percentage of their forage needs. However, the similarity between the average and median forage yields in 2020 suggests that most livestock operations were challenged to produce their own forage during the drought. The ability to grow feed on-farm is an important strategy for ensuring profitability in livestock production. Dry conditions that challenge this strategy are a significant hurdle for livestock producers to overcome.

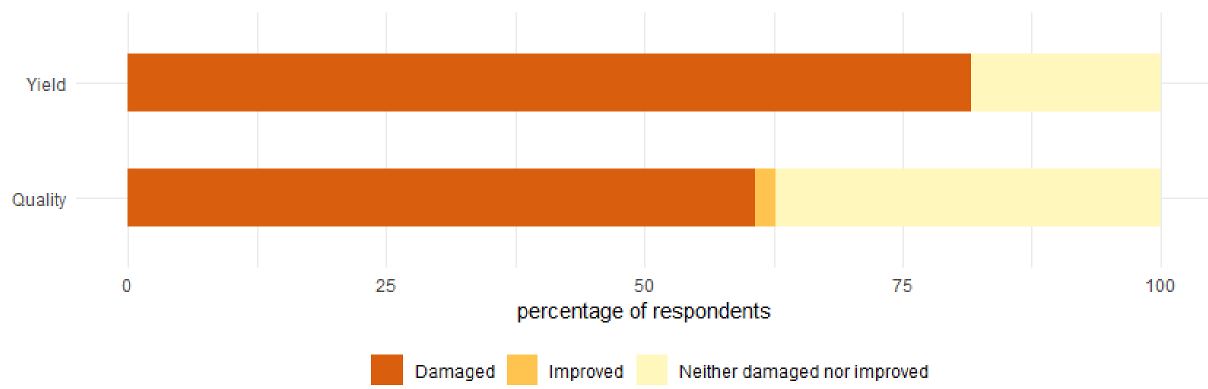

Figure 18: Effects of the 2020 drought on forage yields and quality.

When asked if they planned to change their 2021 crop management for summer annuals (corn silage, sorghum, sorghum sudan, or millet) as a result of the drought, 26.4% of livestock producer respondents indicated that they would, 56.6% indicated they would not, and 17.0% were unsure. When addressing whether they would change their pasture management strategy because of the 2020 drought, 44.4% reported that they will make changes, 38.9% reported that they would not, while 16.7% were unsure.

Livestock producers were also asked if the drought offered any opportunities that were not possible during the wet year of 2019, and what those opportunities were. Examples of opportunities reported by respondents include the ability to move animals on to areas that were typically too wet for grazing, taking advantage of more grazing days in the spring, planting earlier in the season, harvesting feed earlier in the year, reseeding wet fields, clearing additional land, and increasing the depth of livestock watering ponds. It should also be noted that several respondents indicated that 2019 was not a wet year for them, or that 2020 did not offer any opportunities worth noting.

Vegetables, small fruits, hemp, nursery/greenhouse, and tree fruit

Vegetable (n = 78), small fruit (other than wild blueberry, n = 43), hemp (n = 3), nursery/greenhouse (n = 37), and tree fruit producers (n = 36) were asked a series of common questions, with tree fruit growers asked a small number of industry specific questions. Specifically, growers in these sectors who reported using irrigation were asked about what tools would help them improve irrigation management. There was not a notable difference between the perceived usefulness of the tools, with the majority of respondents indicating that site-specific precipitation forecasts, site-specific evapotranspiration forecasts, 1- and 2-month soil moisture forecasts would all be at least moderately useful. The same group of growers was asked to report on whether they use a variety of weather forecasts when determining crop water needs (figure 19). The most frequently used weather forecast is precipitation (97.6% report using), followed by temperature (95.0%) and wind (91.2%). Fewer growers use sunlight (54.2%), relative humidity (56.4%), and evaporation forecasts (17.4%), though a notable percentage of grower notes that they would use evapotranspiration forecasts if they had access to them (31.9%). This points to opportunities for outreach and education around how to find and interpret a range of weather forecast tools.

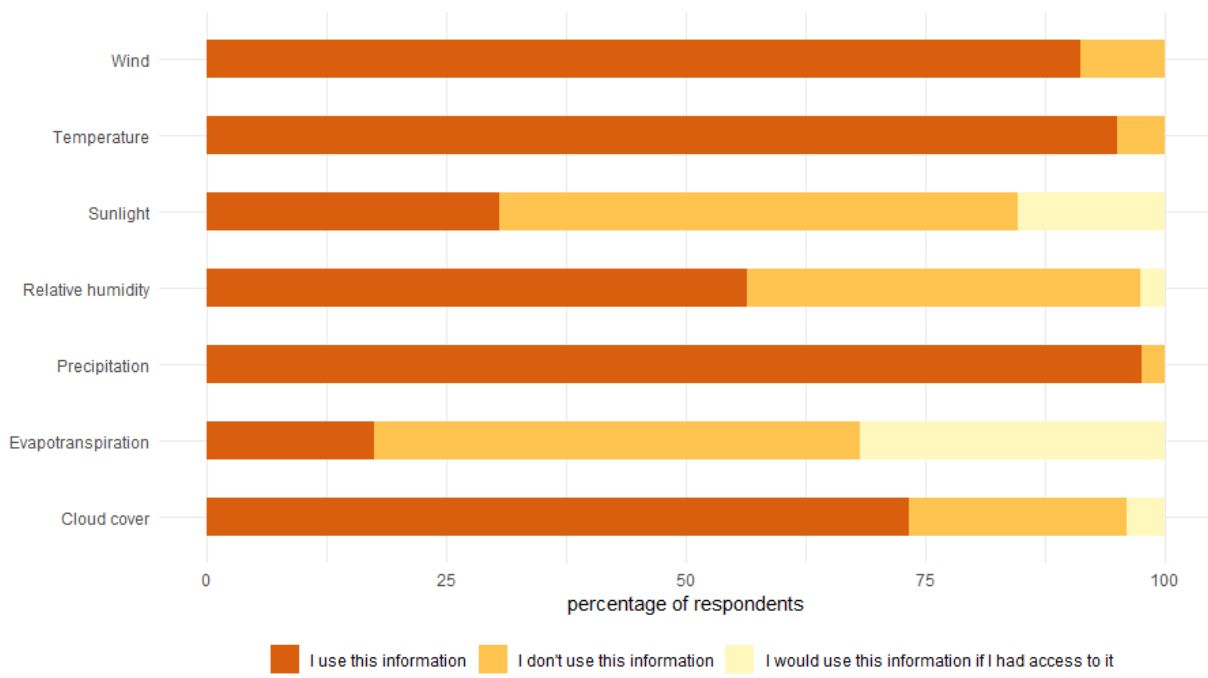

Figure 19: Producer use of weather forecast tools.

When nursery and greenhouse operators were asked what percentage of their production space is irrigated by overhead, drip, and no irrigation, those who reported using irrigation, indicated that drip irrigation is the most commonly used approach. The average percent of production areas (in sq ft) irrigated under drip was 49.7% (median = 33.0%). The mean percent of production area (in sq ft) irrigated by these growers using overhead irrigation was 16.4% (median = 0%).

Vegetable, tree fruit, and small fruit (other than wild blueberry) producers were similarly asked how they irrigated their production acres. The mean percentage of acres per operation irrigated by overhead and drip are reported in table 1. It should be noted that there is a large variation within sectors when it comes to acres irrigated. Tree fruit growers were also asked what percentage of their *total production* was irrigated by each method. The distinction between *total acreage* and *total production* is useful when assessing irrigation practices in apple orchards, where modern high-density plantings have become more common but orchards planted on semi-dwarf or standard rootstock are still in production. In tree fruit orchards planted on standard rootstocks, irrigation has long been viewed as optional. However, irrigation is a necessity in modern, high-density, high-investment plantings. While apples trees grafted onto dwarf rootstock in high-density plantings come into production sooner and produce more fruit per acre, they are also more sensitive to drought. Tree fruit grower survey respondents reported that, on average, 56.9% of their new plantings are irrigated (median = 75.0%); many of these new plantings are likely high-density production systems.

Table 1: Irrigation method by crop sector.

	Overhead	Drip	No irrigation
	Mean (SD)	Mean (SD)	Mean (SD)
Vegetables (n = 78)			
Crop acres	20.2 (32.8)	26.8 (32.6)	19.7 (35.9)
Tree fruit (n = 36)			
Crop acres	10.0 (25.1)	25.4 (32.7)	23.5 (37.3)
Total production	11.9 (26.1)	30.7 (34.0)	20.3 (34.0)
Small fruit* (n = 43)			
Crop acres	14.4 (29.3)	28.9 (35.8)	19.4 (34.4)
Hemp (n = 3)			
Crop acres	33.0 (n/a)	35.8 (n/a)	34.0 (n/a)

** other than wild blueberry; SD = standard deviation*

Moving forward

When all respondents were asked *if they had known about the 2020 drought in advance, what (if anything) they would have done differently*, respondents reported a variety of ideas. These included not planting drought sensitive crops, selecting different varieties, planting more cover crops, planting less overall, planting larger transplants, planting less during dry periods, or planting crops on different locations (e.g., on heavier soil, under pivot irrigation). Some respondents reported they would have invested more in water source development for irrigation (e.g., ponds, wells), installed back-up water sources (e.g., cisterns, rainwater collection systems, other holding systems), or collected water during low-activity hours. Several respondents reported that if they had they known about the drought in advance, they would have invested in irrigation equipment (pumps, etc.), sought funding to support irrigation, installed drip irrigation on long-season crops at the time of planting, irrigated during seed germination, and watered more earlier in the season. They also reported that they would have reduced early tillage or tilled less overall; purchased more livestock feed, sold less, or reduced their herd size; changed harvest schedule for vegetables, fruits, hay, and berries; processed beef earlier in the season; fed bees more aggressively; used more mulch; planned for additional labor hours to accommodate irrigation needs; conserved water; or taken the summer off.

When asked *what they plan to do differently moving forward*, specifically to prepare for future droughts, respondents noted that they would like to increase their water access and improve efficiency for irrigation (crop and pastureland), processing, and livestock watering. Specific improvements cited by respondents included installation of underground piping and additional pumps, reels, and drip systems; source development (e.g., dig wells, ponds, cisterns), and updating existing sources (e.g., pumps); and using soil moisture monitoring systems to improve irrigation efficiency. Respondents also cited intentions to reduce tillage or acquire more land; increase soil organic matter and improve soil water retention; alter cover crop termination schedules; extend rotations; change when water is applied during the season, target irrigation timing to ensure sufficient crop water during germination and tuber initiation stages (for potatoes). There is an interest among growers in drought-resistant crops and varieties. Also some reported their intention to increase legume content of perennials in forage, plant more annual forages, rest pasture between grazings or lengthen resting periods; reconsider the size of their herds, and stockpile feed. While some respondents reported that they intend to scale-back their operation because of the drought, others intend to scale-up.

Conclusion and recommendations

The 2020 drought in Maine affected agricultural producers across the state. Across all agricultural sectors, respondents to this survey reported that the drought affected their ability to conduct normal farm operations and, in some cases, severely decreased crop yield and/or quality. In response to the drought, Maine producers have indicated their interest in:

1. adjusting their water use, including expanding irrigated acres;
2. investing in new water ponds and wells; and
3. separating household and farm water sources.

While many practices are already in place that help producers adapt to drought conditions, farmers are concerned about future droughts and the potential negative effects they may have.

Survey respondents reported several areas in which additional information, technical assistance, or financial assistance would be of value to them. These include:

1. water quality assessments;
2. soil moisture monitoring;
3. helping them to navigate surface and groundwater regulations;
4. measuring the volume of water needed for agricultural purposes; and
5. ensuring sufficient water access to meet production needs.

This presents an opportunity to connect more farmers with Extension and other service providers, NRCS, and FSA programs to enhance on-farm practices that support soil health and efficient water use on farms, and facilitate farmer access to financial support when needed. Additionally, existing partnerships between state, federal, non-profit, industry organizations, and university collaborators (i.e., the Maine Water Board, the Maine Drought Task Force) are critical for leveraging needed resources. The continued collaborations of these groups is important for the long term resilience of Maine's agricultural industries, and protection of the state's natural resources.

Additionally, the state of Maine should actively incorporate science-based expectations for escalating risks of future droughts in state rules and regulations pertaining to water access. Legal scholars have anticipated future conflicts surrounding water resources because of climate change, even in regions that have historically had sufficient water resources (Dellapenna 1999). Recent assessments of scarcity provisions in the Northeast point towards a need to assess current rules and enforcement practices in anticipation of accelerating competition for water resources among agricultural, industrial, recreational, and municipal users (Schattman et al. 2020). For example, to protect running surface water resources that are essential for healthy ecosystems and recreation, resources can be directed to assist farmers develop on-farm water sources (i.e., ponds and wells) where possible. Additionally, water efficiency practices could be further incentivized among all water users, including agricultural producers. The spirit of these recommendations aligns with those made by the Maine Climate Council, specifically to protect natural and working lands and waters (Maine Climate Council 2020). By proactively addressing potential resource conflicts and anticipating future agricultural water needs, Maine can ensure equitable access to and protection of this critical natural resource.

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