Report of the 2017-2018

New England Adaptation Survey

for Vegetable and Fruit Growers

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The 2017-2018 New England Adaptation Survey for Vegetable and Fruit Growers: Preliminary Results

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Contents

Introduction

This report presents a summary and preliminary statistical analysis of the results of the New England Adaptation Survey. In partnership with farmer networks and organizations across the region, 193 fruit and vegetable growers participated in the survey between November 2017 and March 2018. Drawing upon the experience of producers in the region, this survey explores emerging adaptive management strategies, perceived climate related risks, and adaptive capacity. Recently updated projections for the Northeastern US forecast increasingly severe and erratic precipitation events which pose significant risks to every sector of agricultural production in the region. Summer water deficits and droughts are also projected to intensify. Vegetable and berry farmers are among the most vulnerable to the impacts of severe precipitation and drought due to the intensive soil and crop management strategies which characterize of this kind of production.

Recent experiences with drought in 2016, and a number heavy precipitation events, such as Tropical Storm Irene in 2011, have forced producers in the region to adapt to the water extremes associated with climate change in the Northeastern US. This report highlights the adaptive strategies which producers have already used, and are planning to use, for managing these two climate risks of high concern. This survey also aimed to draw out the experience of farmers who are innovating new farm management ideas to account for increasingly extreme weather. The results of the survey link these adaptive management strategies to specific climate impacts and site characteristics, allowing growers who read this report to better understand what their peers with similar farm characteristics are doing. The report does not assess the efficacy of these strategies, but hopes to inform the growing conversation about what information and resources could be most useful in supporting diversified vegetable and berry farmers at this unique time.

Approach

This survey is part of a two-year project at the University of Vermont called "The New England Adaptation Survey". The project is funded by USDA SARE and supported by an ongoing partnership between UVM and the USDA Northeast Climate Hub. The New England Adaptation Survey was developed in collaboration with farmer groups to provide usable information about adaptive management for vegetable and berry farmers across the Northeastern US region. The survey draws upon the knowledge and experience of farmers in the region to identify information on adaptive management and then share results back in the second year via collaborating organizations in Vermont, New Hampshire, Maine and Massachusetts. Collaborating organizations include UVM Extension, MOFGA, NOFA VT, VVBGA, NOFA NH, Rural Vermont, CISA, NEVFC, NEVBGA, Maine Fruit Growers List, and ACORN. These established farmer organizations facilitate the interface between research and stakeholders, and offer valuable interpretation and framing of the results for key audiences.

Summary of results

- Farmers in the Northeast are actively managing for, adapting to and planning for extreme weather events.
- More than 60% of respondents reported using cover crops and soil heath strategies to manage for the risks of heavy precipitation and drought.
- There are *many* emerging, innovative and promising ideas which farmers are using, thinking about and testing.
- Understanding of the flow of water on a site and using a whole systems perspective on farm planning informs long-term adaptation to drought and heavy precipitation.
- The site and soil characteristics of a farm influence some of the adaptive management strategies a farm uses. The survey results reflect this with statistical significance.
- Adaptive management strategies for heavy precipitation and flooding highlight the use of raised beds, investments in storm water management, adjusted locations of crops based on site and soil characteristics, new high tunnels, perennial plants, reduced tillage, and soil building.
- Adaptive management strategies for drought highlight the importance of water harvesting, efficient irrigation systems, mulch, soil health, reduced tillage, and crop planning.
- The climate change impacts which farmers are most concerned about are unpredictable spring temperatures, increased incidence of drought, new pest and disease pressures, and loss of nutrients due to heavy and abundant precipitation.
- Most farmers are confident that they understand the vulnerability of their farmland to extreme weather conditions, yet the majority of growers believe that they do *not* have the financial capacity, knowledge or technical skills to deal with the expected level of weather-related threats to the viability of their farm operation.

Profile of respondents

To date, 193 respondents have completed the survey. Respondents primarily represented states in the Northeast, plus six responses which came from Canadian provinces. Basic demographic characteristics of the sample differ from national demographic means. We encourage readers not to infer conclusions beyond the sample because it has not been weighted appropriately to represent all growers in the region. The average age of respondents was 46, positioning the sample as younger than the national average age of farm operators, 58.3 in 2012 (USDA NASS, 2012). Our sample also presents itself as more gender balanced than the national statistics for farmers, which was 70% male in 2012 (USDA NASS, 2012). The majority of the sample is comprised of diversified vegetable farmers and primary decision-makers.

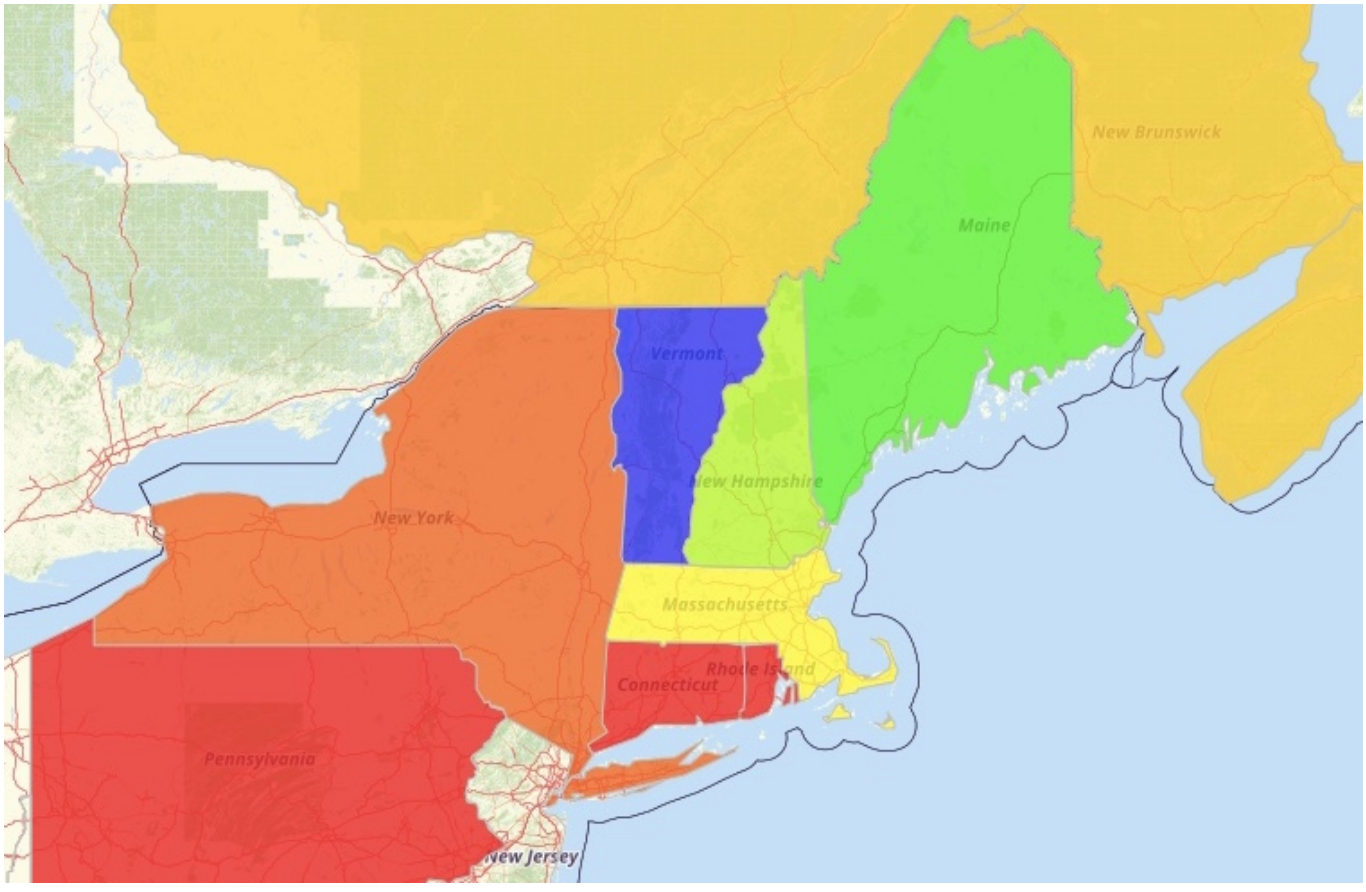
Photo by Greg Noble

Demographic of sample

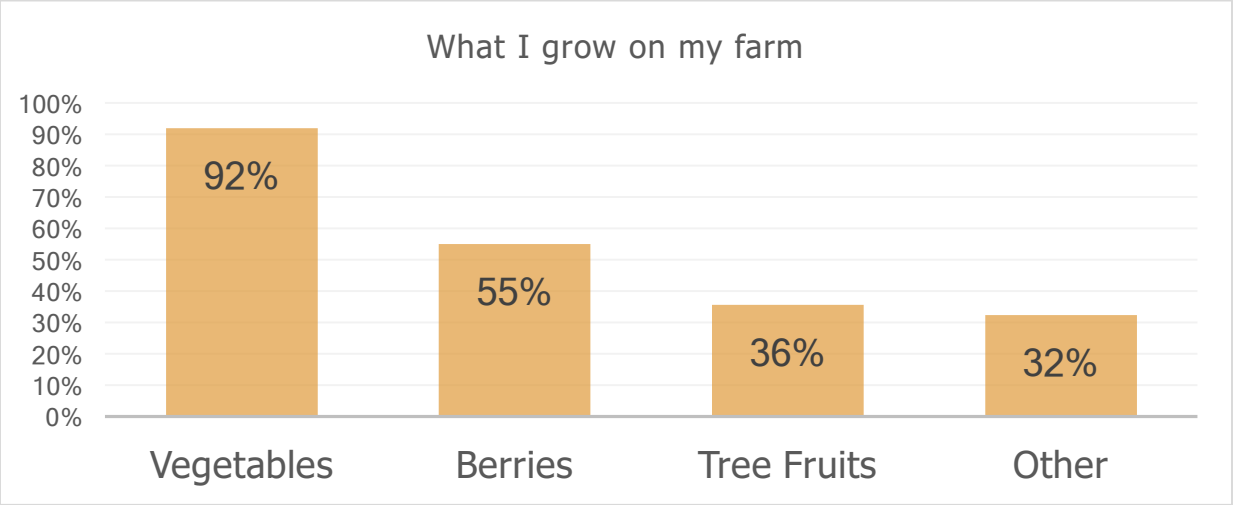
Average Age	47
Gender	54% Male, 44% Female, 2% Other
Average total farm acreage in production	27.6 acres
Average years as a decision maker on a farm	13 years
% of participants who grow organic	45%

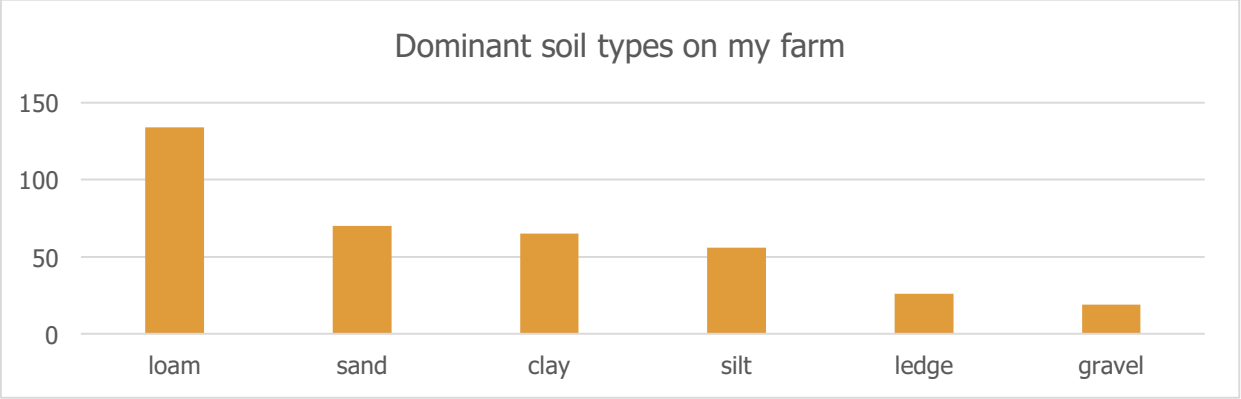
Geographic range of respondents

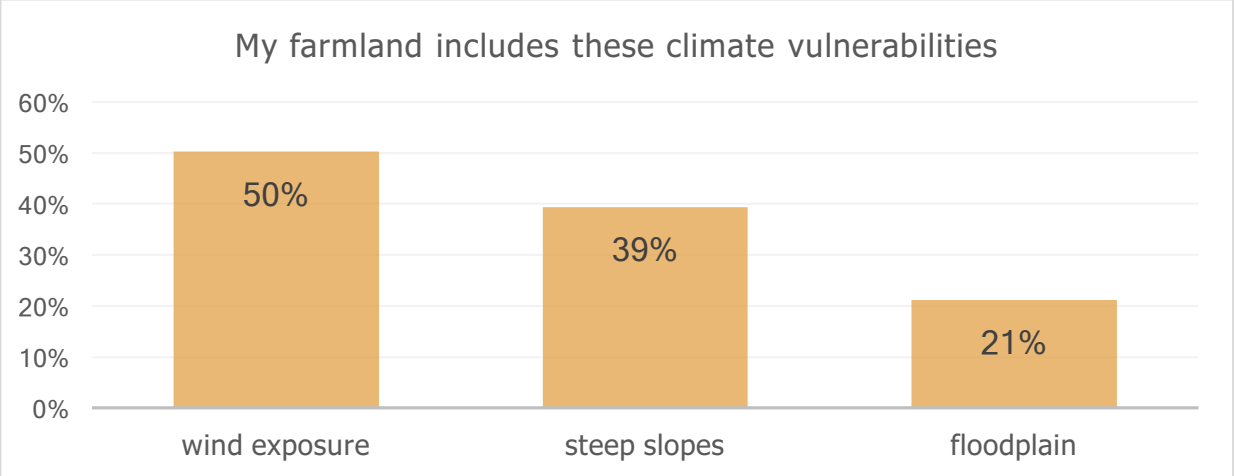
193 producers responded to the survey, the majority being from between Pennsylvania and New Brunswick. Six respondents were from Canadian provinces and one respondent was from Alaska.



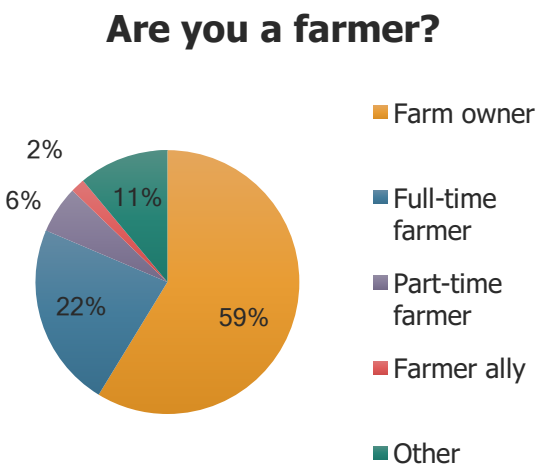
Profile of respondents

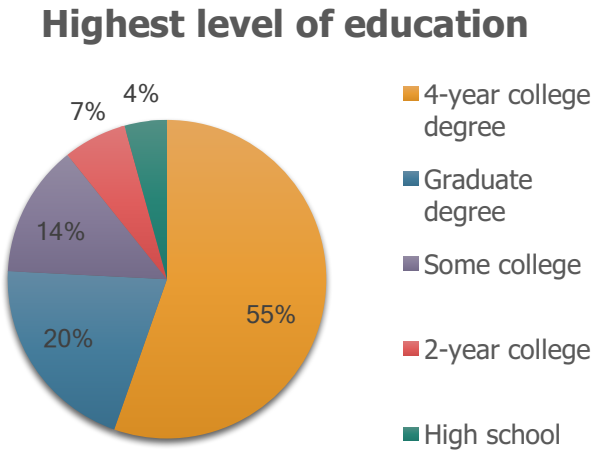


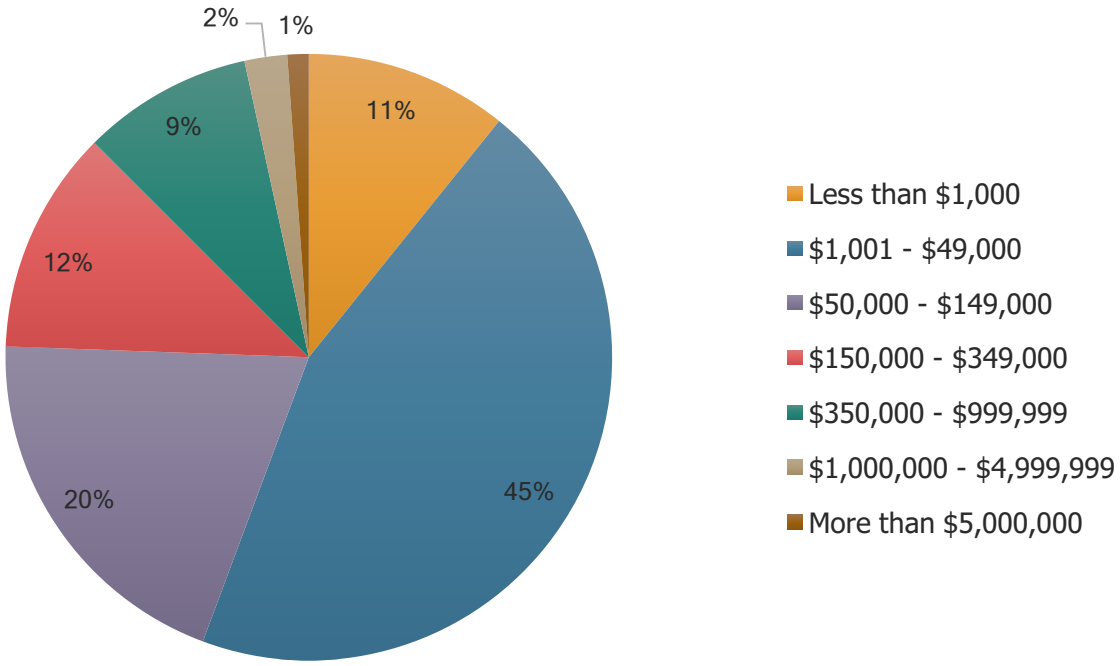




Profile of respondents



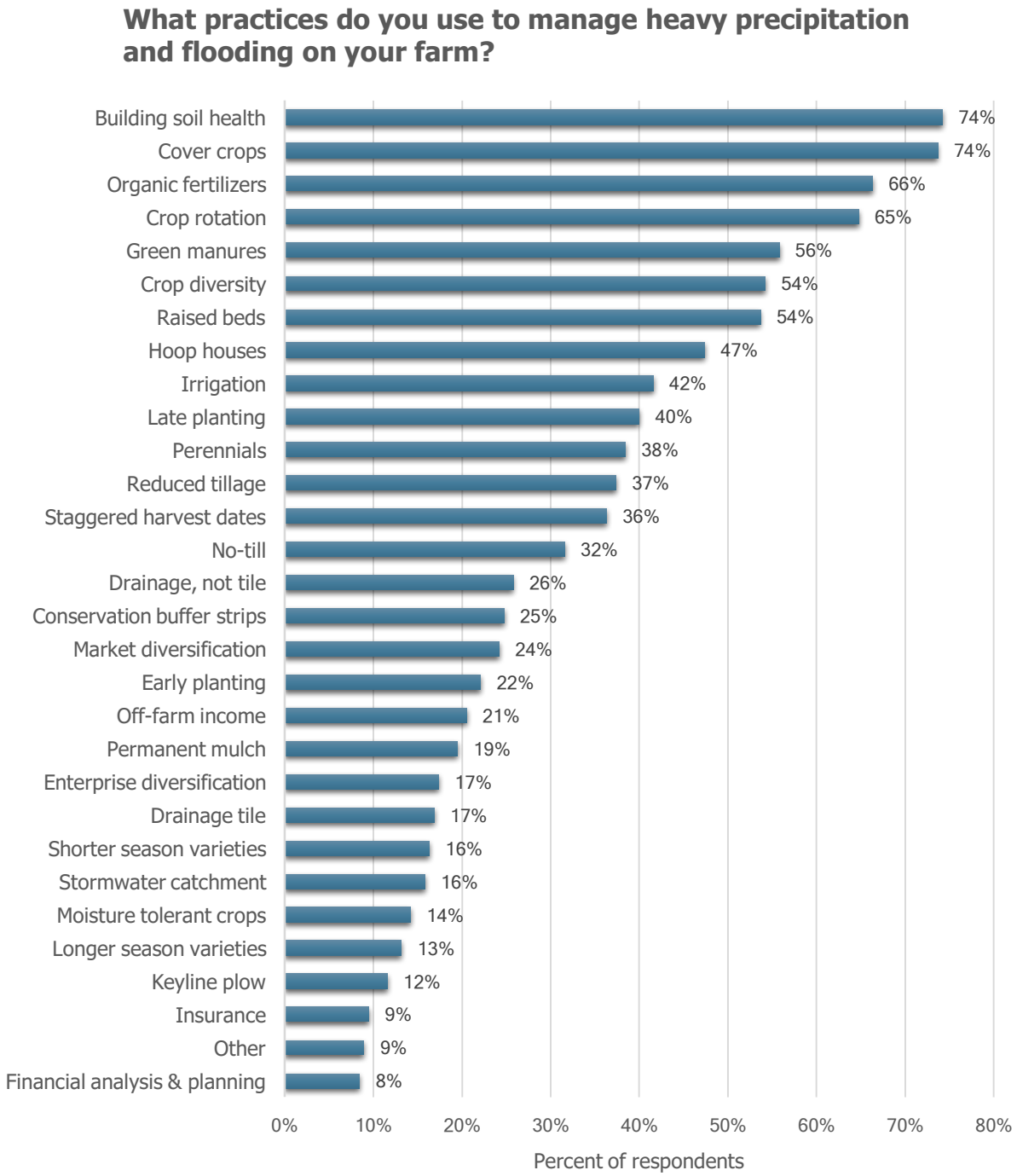




Results

Adapting to heavy precipitation & flooding

Producers were first asked a multiple-choice question about which strategies and practices they already use to manage for weather related risks. The options which they could select were based on previously conducted surveys and studies in the region.



Adapting to heavy precipitation & flooding

72% of participants have made changes on their farm because of an experience with, or concern about, heavy precipitation or flooding

61% of participants are planning to make changes that will help manage for the risk of heavy precipitation or flooding

Producers were asked three open-ended questions about adapting to the increased incidence of heavy precipitation and flooding:

- *What changes have you made on your farm because of this experience with heavy precipitation or flooding?*
- *What changes are you planning to make in the near future which will help you manage for the risk of heavy precipitation or flooding?*
- *In your opinion, what is the most promising, interesting or innovative strategy for adapting to heavy precipitation and flooding that you have heard about?*

The responses to these questions were analyzed by our research team and then grouped into themes. The results are shared in the following summary and table.

Storm water management. Many survey participants dug new or deepened ditches to control the flow of water across their site. Producers also reported trying increased or new drainage strategies to improve water infiltration and flow through their soils, such as deep tillage. Some growers specifically mentioned using subsoil plow implements in their wheel tracks to counter soil compaction and allow water infiltration between raised beds. Others said they had installed swales, terraces, berms, trenches or pond systems to slow, control and catch water movement across their landscape.

Site planning for heavy soil and flood risks. Many growers reported paying closer attention to how their site and soil characteristics interacted with heavy precipitation and flooding. Some farmers reported transitioning flood prone fields and heavy soils to perennial plants, pasture, reduced tillage or permanent cover crops. Others reported planting lower value crops, short duration crops or "vegetables that tolerate poor drainage in the sections of our fields that flood."

Another grower reported that they stopped cropping in areas of their field which was poorly drained.

Raised or permanent beds. Raised beds were one of the most highly reported changes that farmers made in response to an experience with heavy precipitation or flooding. Some farmers have adopted permanent or semi-permanent raised beds. Others reported purchasing a bed hiller or modifying their own equipment to re-raise beds and maintain shoulders. One farmer noted that they also "orient the beds to reduce runoff erosion."

Protection. Farmers mentioned adopting mulch or reduced tillage to protect soil from heavy precipitation or flooding risks. Uncultivated "idle strips" or sod are increasingly being left between plots and beds where they can protect soil from erosion. Many respondents also reported investing in high tunnels, greenhouses, hoop houses and caterpillar tunnels to protect plants and soil from rain and moisture. Responses also often noted that this strategy has tradeoffs, in terms of investment costs and irrigation needs, but offers additional protection from cold weather.

Soil health. Improving soil characteristics was one of the most highly reported changes, primarily though using cover crops, incorporating organic matter and keeping the soil covered. Respondents also mentioned reduced and no-till strategies. Keyline plowing, or subsoiling on contour, was mentioned as a strategy to increase water infiltration into soil and slow erosion.

Perennial plantings. Many farmers noted that they have started to grow more perennial plants, both as primary crops and as perennial borders or buffers around fields. It was often noted that perennial crops were planted in areas which would have left annuals more vulnerable, such as on slopes and areas prone to more moisture or flooding. Agroforestry was mentioned broadly as a good strategy, as well as the inclusion of more trees and deep-rooted perennials. Specific agroforestry cropping systems were also mentioned, such as "intersperse rows of perennial + nursery crops with annuals."

Crop planning. In addition to a trend towards more perennial plants, growers reported many cropping changes to help them deal with the increased incidence of extreme precipitation and flooding. Cover crops were a highly reported strategy considered by growers in crop planning--used in idle areas, interplanted among crops and planted to protect soil before and after crops. Growers also reported making multiple plantings, alley cropping, strip cropping, and "planned succession in case of failures." Many growers have changed the location of some crops due to heavy soils that are prone to staying saturated, or places prone to heavy flooding. Others reported using smaller sized blocks in their plot layout to account for the size of low and waterlogged areas of fields.

Crop timing. From general planting date changes to very precise planting dates based on the locations of beds, growers reported many changes to their cropping calendars. This included later planting dates due to wet soils, cooler wetter weather, and flood risk. Some crops are also being planted early when grown under protection of hoop houses. Farmers also noted the benefit of planning in staggered harvest dates.

Plant selection. Growers reported changing crops and diversifying crops, and expressed interest in species and cultivars that are more tolerant of extreme weather conditions and excess moisture. Crops that are native, moisture tolerant, and even "suitable for heavy rains" are increasingly considered by growers because these plants could thrive through challenging climate conditions.

Some farmers noted that they have reduced crops that ”expose bare ground for too long, such as potatoes,” and added crops that consume a lot of water.

Whole system planning and community.
Some growers stressed the importance of looking at their farm through a holistic, systems level lens, using terms such as regenerative agriculture, agroecology and permaculture. They stressed the importance of "thinking", "rethinking," "being prepared by a long-term policy," "always looking for better ideas" and making space for education and farmer-to-farmer talks about climate change. Specific examples of systems-level changes that came up in the survey responses include using "maps based on flooding", enterprise diversification, microgreens production, planting on contour, "using the landscape," and "working with nature as much as possible." In addition to direct mentions of permaculture design, the survey results included the lexicon of ideas popular in permaculture communities, from keyline to hugelkulture, as well as berms, swales and earthworks.

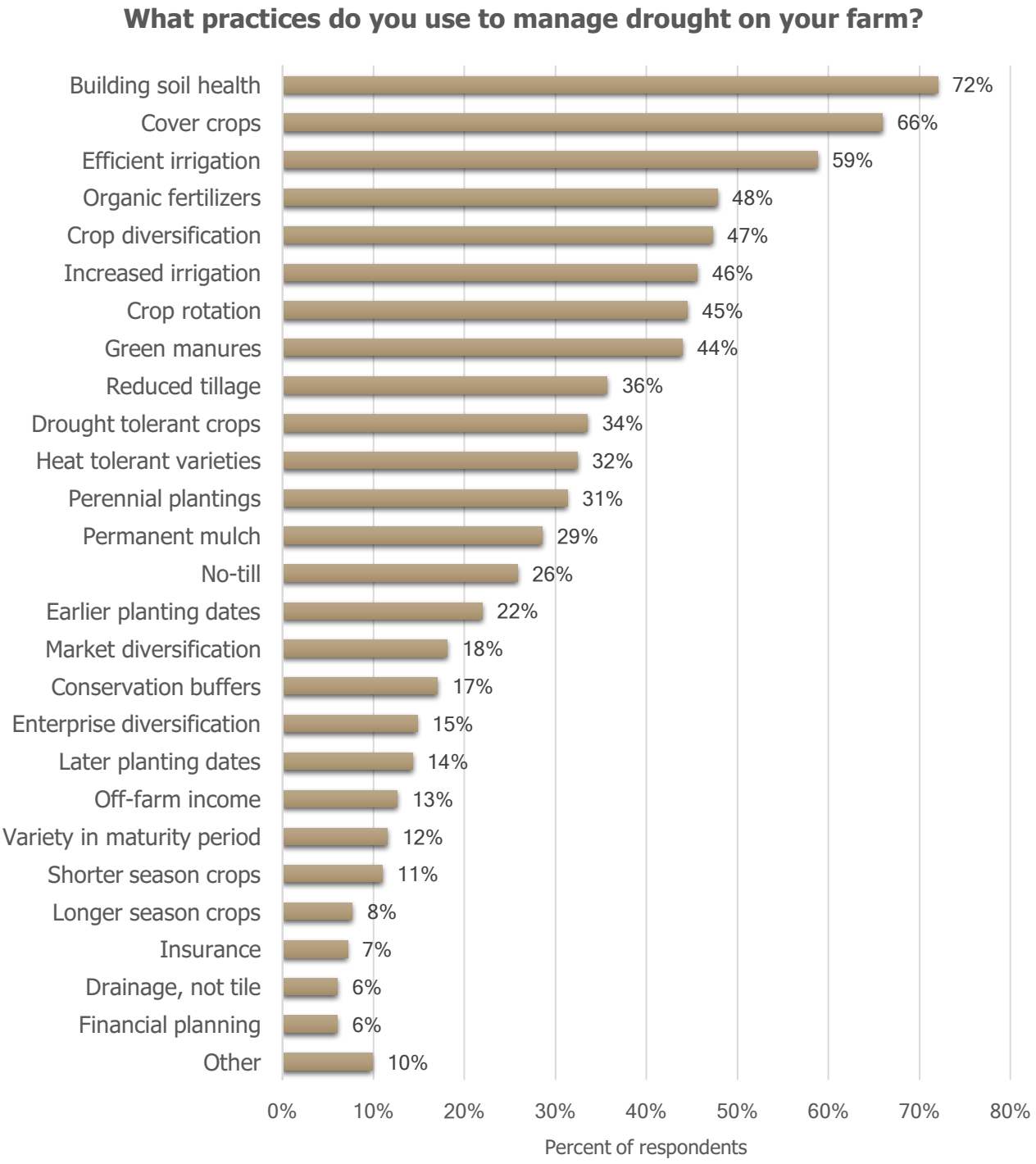
Adaptive management themes for heavy precipitation and flooding, by question and number of mentions from survey participants

Adaptive response		*Adaptive planning*		*Innovative adaptations*	
Changes made due to an experience with extreme precipitation or flooding		**Planned changes to manage for increased incidence of extreme precipitation or flooding**		**Innovative and promising strategies for adapting to extreme precipitation and flooding**	
raised beds	30	hoop house or high tunnel	22	no till	21
site selection	27	storm water management	14	cover crop	18
ditching	23	ditching	13	crop planning (general)	13
changed location of crops	20	perennial plantings	12	raised beds	12
drainage	17	raised beds	11	mulch	11
cover crop	16	drainage	10	improved soil physical characteristics	10
hoop house or high tunnel	20	cover crop	9	storm water management	9
changing planting dates	11	no till	8	reduced till	9
mulch	10	pond	6	covering soil	8
changed crops	8	water collection and conservation	6	soil building	8
storm water management	8	swales	5	keyline	7
deep and subsoil tillage	6	improving soil physical characteristics	5	swales	7
improving soil physical characteristics	6	changed location of crops	4	hoop house or high tunnel	7
no till	6	caterpillar tunnels	4	increasing soil organic matter	7
reduced till	6	reduced till	5	perennial plantings	6
drainage tile	6	crop planning (general)	3	drainage	6
better water holding capacity in soils	6	hugelkulture	3	permaculture	6
perennial plantings	5	site selection	3	agroforestry	5
regrading	5	terraces	3	water collection and conservation	5
soil management	5	change row orientation	3	ditching	5
covering soil	5	soil building	3	site selection	4
pond	5	gutters	3	pond	4
water collection and conservation	5			buffers	4
buffers	4			changed location of crops	3
crop planning (general)	4			protected culture	3
land management	4			earthworks	3
planning and strategizing	4			deep and subsoil tillage	3
deep rooted plants	3			drainage tile	3
tolerant crops	3			crop diversification	3
swales	3				
living mulch in pathways	3				
low or caterpillar tunnels	3				

The table only includes themes that came up *three or more times* in each question about adapting to heavy precipitation and flooding

Adapting to drought

Producers were first asked a multiple-choice question about which strategies and practices they already use to manage for weather related risks. The options which they could select were based on previously conducted surveys and studies in the region.



Adapting to drought

66% of participants have made changes on their farm because of an experience with, or concern about, drought.

39% of participants are planning to make changes that will help manage for the risk of drought.

Producers were asked three open-ended questions about adapting to the increased incidence of drought:

- *What changes have you made on your farm because of an experience with drought?*
- *What changes are you planning to make in the near future which will help you manage for the risk of drought?*
- *In your opinion, what is the most promising, interesting or innovative strategy for adapting to drought that you have heard about?*

The responses to these questions were analyzed by our research team and then grouped into themes. The results are shared in the following summary and table.

Drought tolerant plants. Farmers mentioned selecting drought tolerant crops as a promising and adaptive strategy. Many phrased it as crops that would not only tolerate it, but *thrive* in drought conditions. One grower said, "we need to get our plants use to IT by not spoiling the plants." This sage advice is often used strategically in more drought prone climates where growers use conservation irrigation strategies to train roots to go deep for water, i.e. dry farm grapes and tomatoes in California. Growers also mentioned efforts to save seed and select for locally adapted varieties

Crop planning. Some farmers mentioned that they were trying to plant things earlier to take advantage of soil moisture during critical establishment periods. Others mentioned that they stopped growing drought-sensitive crops, or reconsidered expanding orchard plantings due to limited water availability. One grower described planting taller crops to shade sensitive salad greens. Others reported that they grow a diversity of cultivars and crops as insurance against extreme weather and drought. Many growers have installed perennial plantings as a drought adaptation, and noted the value of biodiversity and agroforestry as an adaptation for drought.

Water source development. Growers reported investing in additional water sources, including additional on-farm wells. Many noted that they have already or are planning to invest in infrastructure to access water from existing ponds, nearby springs, rivers and waterways. Many farmers have recently created new retention ponds, and many are planning to install retention ponds in the near term. Growers reported adjusting their water source to pond-water instead of well-water. Many farmers highlighted how ponds could be strategically integrated with landscape level storm water flows and irrigation infrastructure.

Water harvesting. Growers reported rainwater collection using roofs, gutters, rain barrels, swales, ditches and retention ponds. Some growers noted the potential to catch storm water from roofs and redirect it towards garden beds. Farmers also identified the value of site level keyline planning to collect and divert water into storage ponds for use during drought. One respondent even described an innovative and promising system for collecting dew and atmospheric moisture.

Water storage and access. Growers reported investing in increasing their water storage capacity and placing it in new locations around the farm or near fields. In addition to ponds, water storage containers mentioned by farmers included tanks, 55 gallon drums, bins, and cisterns.

Improved water delivery systems. New, updated and expanded irrigation systems were the most highly reported strategies for adapting to drought. Growers reported investing in new buried mains, valves, timers, more hoses, water reels, and larger capacity equipment, including new well pumps. Drip was one of the most popular systems mentioned, but growers also mentioned overhead sprinkler systems, gravity-fed water delivery, and the importance of streamlined systems for time efficiency. Importantly, land tenure was named as a major constraint for growers who wanted to invest in irrigation infrastructure.

Using water wisely: water conservation & drip irrigation. Responses reflect a significant awareness of many ways to conserve water on site or in the soil, from watering during strategic times, to keeping residue on soil surface longer to conserve water in the soil, and using water judiciously. Many people mentioned spot or drip irrigation strategies which use less water, and an interest in buried drip irrigation lines. Growers also expressed an interest in how wash and pack areas could use water more efficiently and recycle water. The creation of shade was an interesting theme that came up to conserve water, both in the practice of setting up large shade cloths over plants, or planting more trees into the landscape strategically.

Soil building. Growers mentioned soil building strategies for adapting to drought as a general strategy, but also through specific practices like the use of cover crops, reduced tillage, incorporating residues, and other organic matter sources. In regards to drought adaptations, soil building was primarily linked to the goal of increasing the natural water holding capacity of soil. Growers' comments show that farmers keenly understand that good soil structure and organic matter content improve the capacity for soil to absorb and store water for crops. Hugelkulture was one innovative strategy mentioned with these soil building and moisture retention benefits. As growers say, "better quality soil is more resilient!"

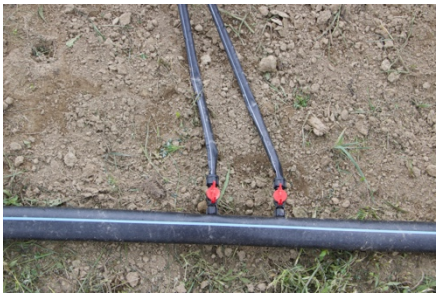
Low and no till. Reduced tillage and no-till are practices which many farmers use, plan to adopt and consider to be promising and innovative for adapting to drought. Notably, survey respondents expressed interest in learning how to use low and no till practices for vegetables and within organic systems. Growers often mentioned the importance of reduced tillage and consistent soil cover to limit the evaporation of moisture from bare soil. Permanent bed systems with mown paths was considered as a promising strategy to reduce tillage and bare soils.

Mulch. Mulching with organic materials or with plastic mulch was widely mentioned as a promising strategy that conserves water by protecting soil moisture from evaporation, keeps weeds down, and builds or protects soil organic matter. Living mulch in pathways was also considered adaptive for managing drought.

Systems level water planning. Respondents reported taking a bigger picture perspective on their farm landscape and water flows with the goal of understanding how to make sure water was conserved and available when needed. This was a theme that was reiterated across the survey responses. Growers emphasized the importance of paying attention to soils and contours and using them to manage water availability on site. A systems level perspective on how much water is available across the farm benefits both the passive water delivery systems and pump powered irrigation systems. Farmers value low-cost and effective investments in irrigation infrastructure that create a streamlined system to make better use of their time in the long term. One farmer mentioned the practice of measuring water as a promising and innovative strategy.

Adaptive management themes for drought, by question and number of mentions from survey participants						
	Reactive adaptation		*Proactive adaptation*		*Innovative adaptation*	
	Changes made dues to an experience with extreme precipitation or flooding		**Planned changes to manage for increased incidence of extreme precipitation or flooding**		**Innovative and promising strategies for adapting to extreme precipitation and flooding**	
	irrigation (general)	68	updated irrigation	30	soil building	23
	updated irrigation	40	drip irrigation	14	mulch	20
	drip irrigation	30	pond	14	irrigation (general)	19
	mulch	24	mulch	13	water collection and conservation	19
	wells	16	rainwater collection	11	tolerant crops	17
	new irrigation	15	irrigation (general)	10	no till	14
	water collection and conservation	13	wells	10	drip irrigation	12
	pond	12	no till	8	increased soil organic matter	12
	drought tolerant crops	8	crop planning (general)	7	reduced till	10
	planning and strategizing	8	drought tolerant crops	7	cover crop	9
	reduced till	8	reduced till	7	planning and strategizing	8
	changed crops	7	soil building	6	drought tolerant crops	6
	crop planning (general)	7	water storage - water tank	6	water holding capacity	6
	increased irrigation capacity	7	perennial plantings	4	rainwater collection	5
	cover crop	6	conservation irrigation	4	conservation irrigation	5
	site selection	6	increased irrigation capacity	4	improving soil physical	5
	soil building	6	covering soil	4	pond	5
	perennial plantings	5	planning and strategizing	4	crop diversification	4
	water storage - water tank	5	hoop house or high tunnel	3	swales	4
	changing planting dates	4	pump	3	covering soil	4
	pump	4	hugelkulture	3	water management - direct	4
	conservation irrigation	4	site selection	3	water conservation	4
	hoop house or high tunnel	3	swales	3	water sprinkler system	4
	earthworks	3	increased soil organic matter	3	agroforestry	3
	living mulch in pathways	3			biodiversity	3
					Changed crops	3
					hoop house or high tunnel	3
					site selection	3
					living mulch in pathways	3
					holistic site & farm planning	3

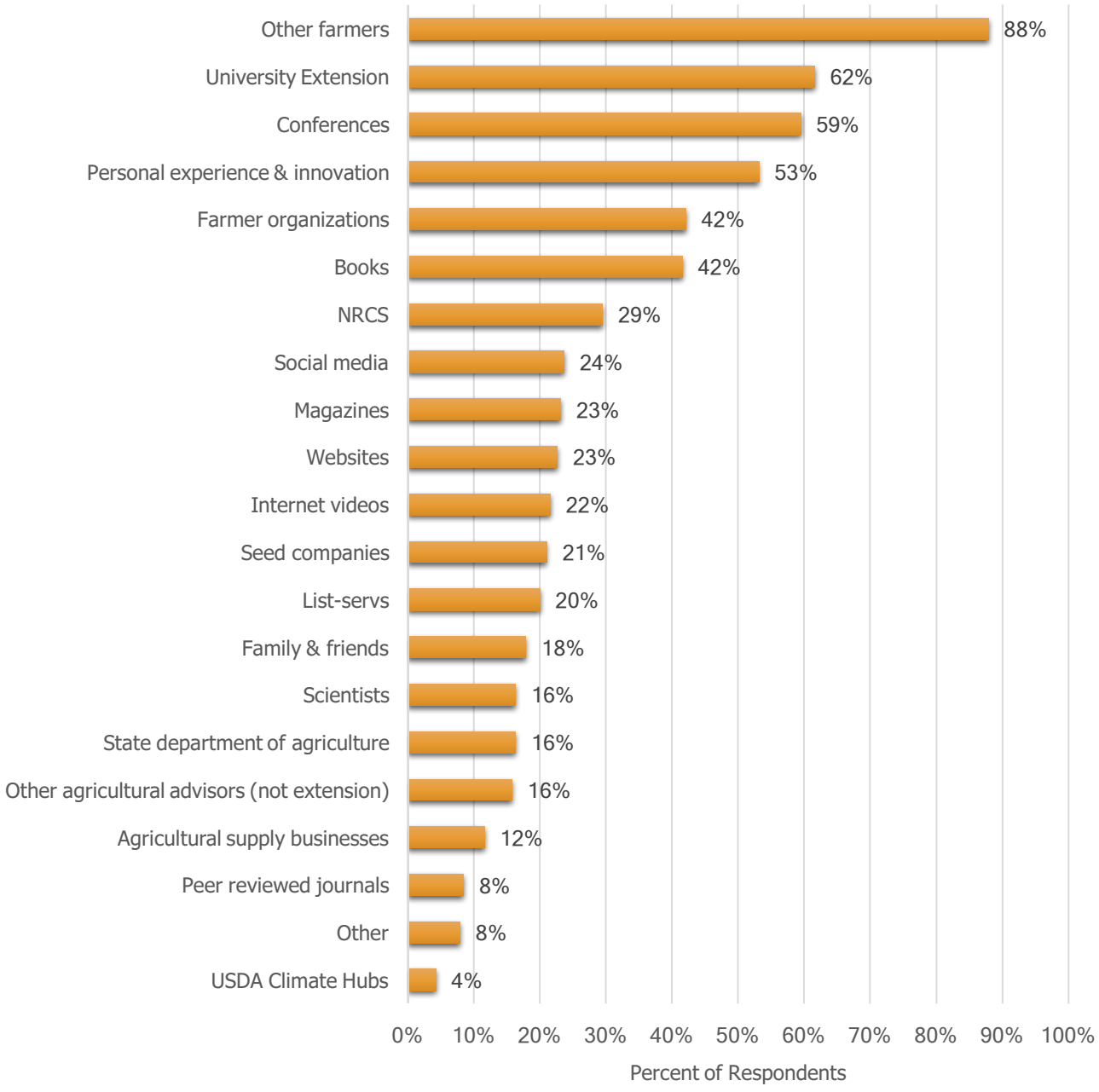
The table only includes themes that came up *three or more times* in each question about adapting to drought.



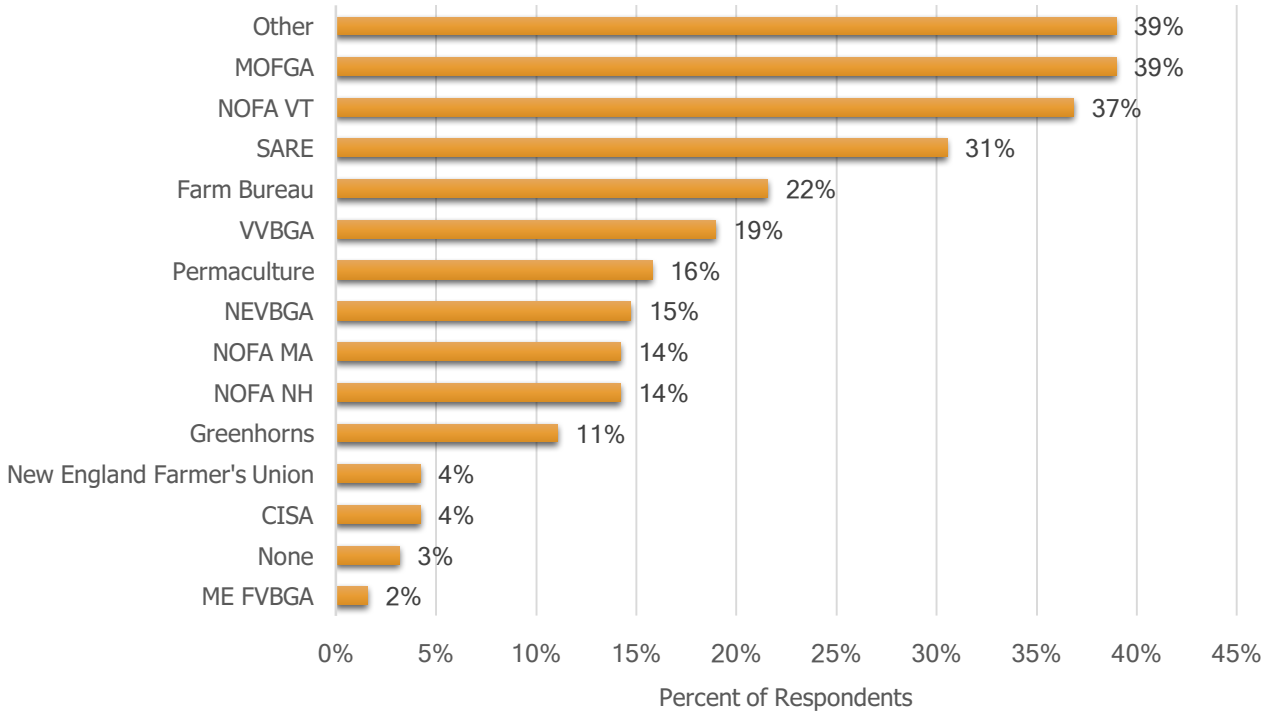
Pond and catchment photos by Mark Krawczyk

Questions about networks and information

In your experience, what are the best sources of information on innovative and adaptive approaches to new challenges you encounter on your farm?



What farming groups and networks are you a member of, or get information from?



Growers were asked to identify information networks they participate in or use. Most respondents selected multiple information networks. Those who selected "Other" were provided space to specify other networks which were not on our list. This included:

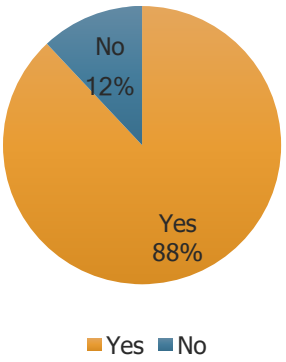
- National and Local Young Farmers Coalition groups (11)
- Cooperative Extension (includes Cornell, UVM UMASS, UMAINE and Waldo County) (9)
- NRCS (8)
- ACORN (Canada) (6)
- Instagram and Facebook Groups (7)
- NOFA NY (5)
- Rural Vermont (3)
- NOFA RI (3)
- SEMAP (2)
- PASA (Penn) (2)
- Canadian National Farmer's Union (2)
- NOFA CT (2)
- Maine Pomological Society (2)
- CRAFT (2)
- Demeter & Biodynamic Association (3)
- Cornell Small Farmers Program
- Pemberton Farmers Institute
- North American Strawberry Growers Association (NASGA)
- Perrenia (Nova Scotia)
- NH VBGA
- Composting Association of Vermont
- Growing for market
- Draft animal power network (DAPNet)
- NAFTMA
- National Farmer's Union
- NCAT-ATTRA
- Certified Naturally Grown
- Champlain Valley Farmer's Coalition
- Vermont Beekeepers Assoc.
- North Berkshire Beekeepers Assoc.
- NOFA NJ
- Deep Root Organic Co-op
- Le Cape, CTAB, COABC
- North American Fruit Explorers
- Persimmon Growers
- RAFEDS fig group
- Northern Nut Growers
- Northern Berkshire Beekeepers Association
- Beginning women's farmer network
- Veterans to Farmers
- Club Consul Agro
- Organic Ecocert certification
- Vermont Farmers Food Center
- Westchester Farmers Alliance
- Bionutrient Food Association
- New York State berry growers
- NAC
- ICRAF
- IPCC

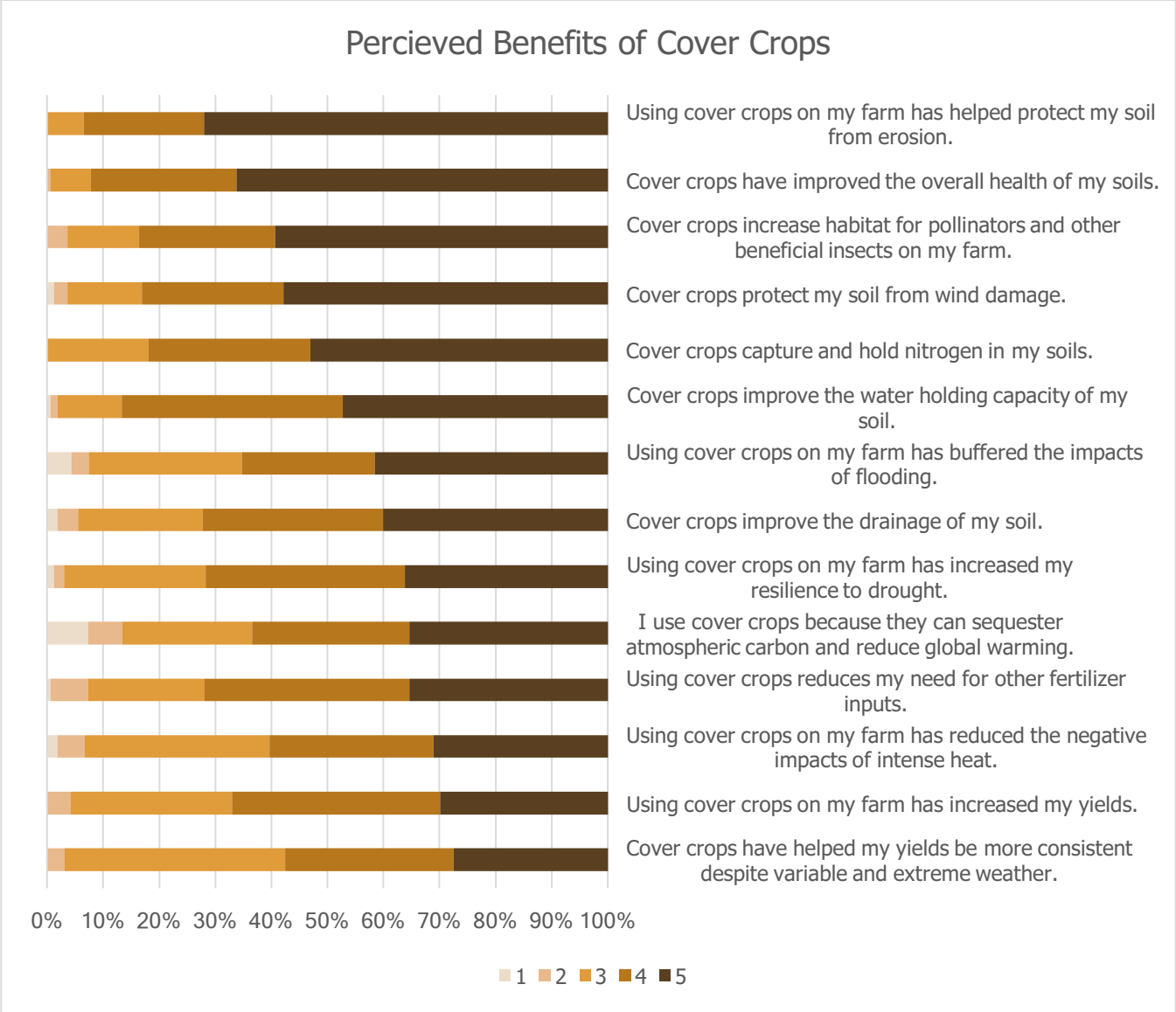
Questions about cover crops

Cover crops are considered a best practice for farmers, which also offer many climate resilience benefits. The survey asked producers about some of the climate-related benefits and drawbacks of using cover crops.

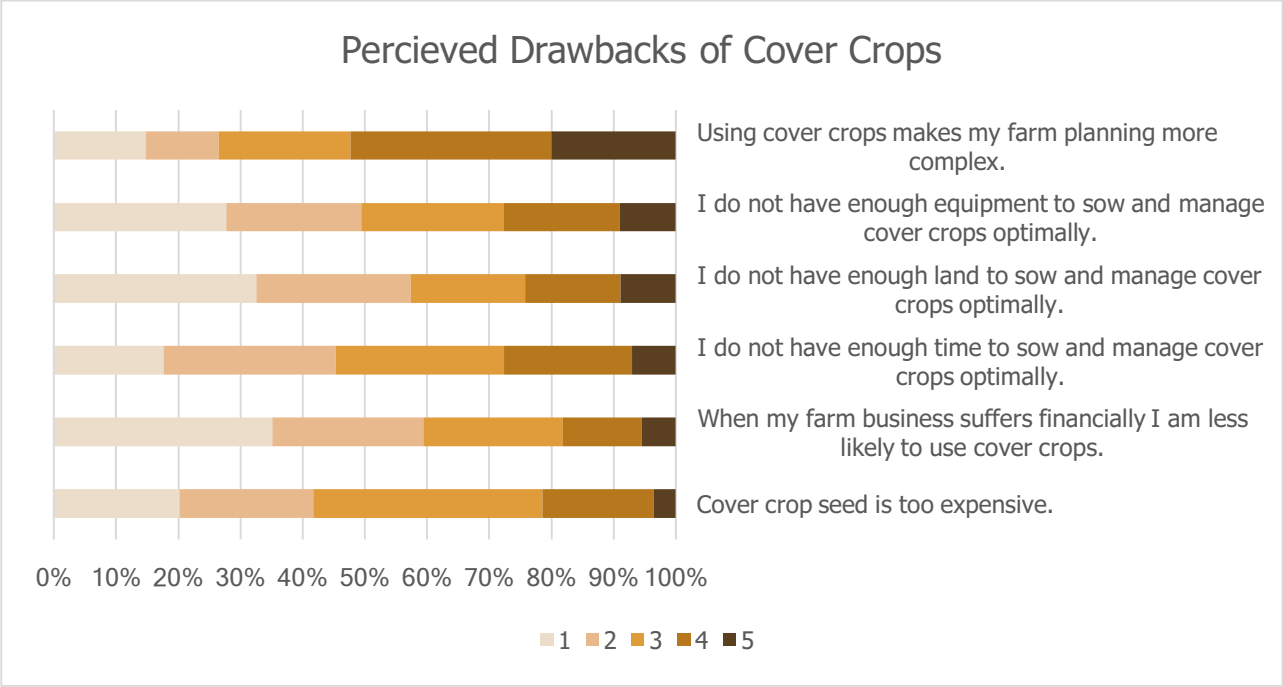
Participants were asked to indicate their level of agreement with the following statements on a scale of 1-5, where 5 represents "strongly agree" and 1 represents "strongly disagree". In the figures below, the darker colors below represent stronger levels of agreement.

Do you use cover crops?





Participants were asked to indicate their level of agreement with the following statements on a scale of 1-5, where 5 represents "strongly agree" and 1 represents "strongly disagree". In the figures below, the darker colors below represent stronger levels of agreement.



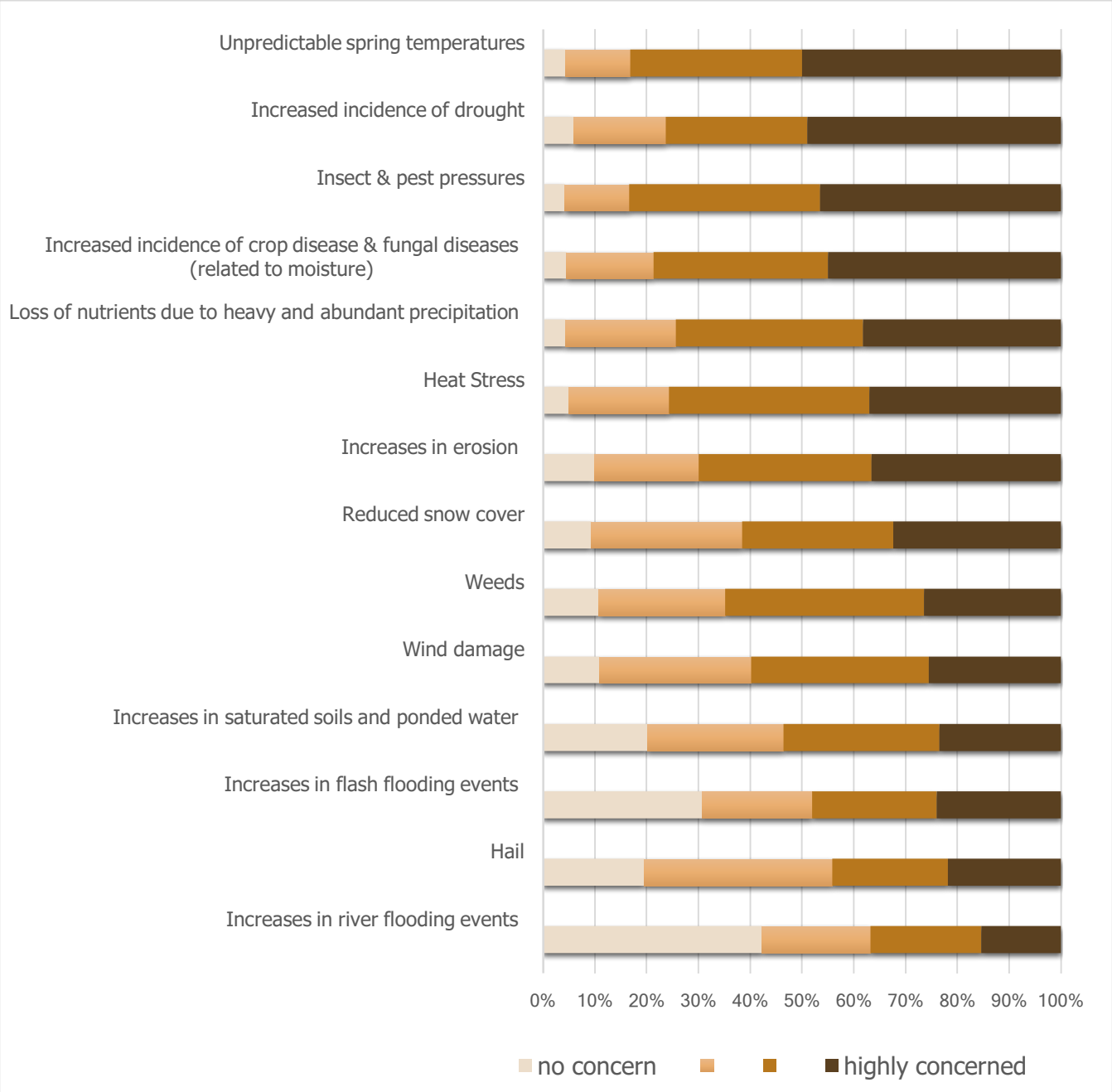
I would use more cover crops if…

Producers were also asked to answer an open-ended prompt, "I would use more cover crops if…" The major themes of these responses include:

- … I had more land.
- … I had more time.
- … I had better equipment.
- … I had more knowledge about how to plan them into my unique cropping system.
- … they were free or cost less.
- … I had a seed drill or a no-till drill.
- … I had a longer growing season.
- … organic certification did not require organic seed, or more organic varieties were available.
- … I had more evidence of benefits.
- … I had more farm workers who know how to help.
- … I could save and clean my own cover crop seed.
- I cover crop to the max, so this question does not apply to me!

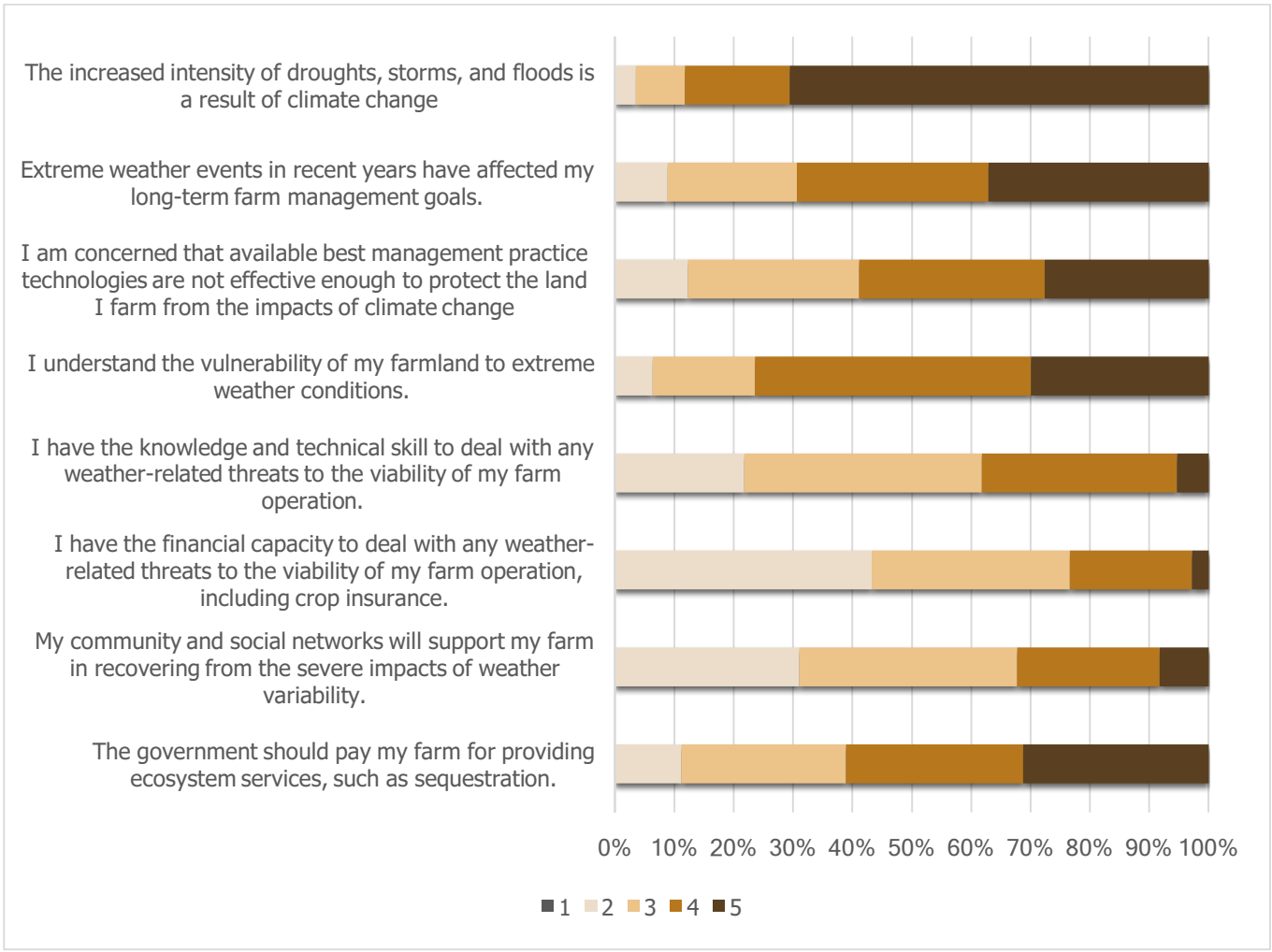
Concern about extreme weather

The following is a list of some weather challenges that farms in the northeast have experienced. The survey asked growers the following question, "*When you think about the impact they have had on your own farm, how concerned are you about these challenges?"*

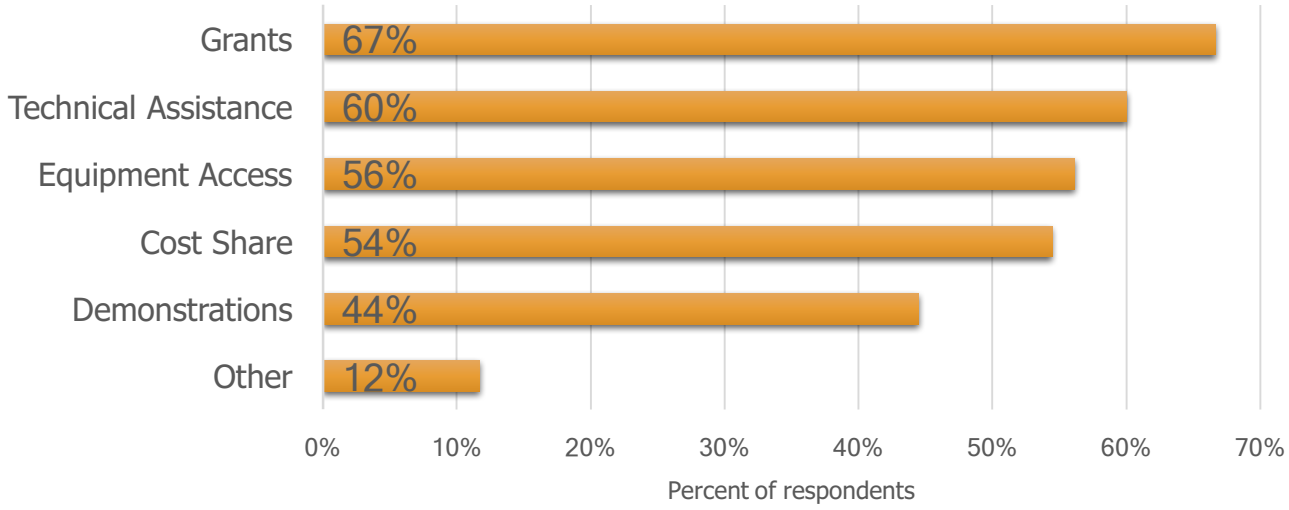


Resources and Capability

Participants were asked to indicate their level of agreement with the following statements on a scale of 1-5, where 5 represents "strongly agree" and 1 represents "strongly disagree". In the figures below, the darker colors below represent stronger levels of agreement



What incentives and resources would most help you make the changes you think you need to make to manage for the risks of extreme weather?



Other incentives and resources which growers suggested include:

- Training, workshops and networking
- Grants for me to teach other farmers
- Info on water monitoring and working with kids to make data about changes + get them out interviewing and exchanging with older growers
- Farmer to Farmer discussion
- Information geared to small, diversified farms.
- Stop use of fossil fuels
- Subsidized cover crop seed
- Land security
- Governmental support & recognition of climate change & costs
- Programs through Extension
- Focused, easily accessible education
- Field help
- Learn to depend on your self
- I guess more programs for small farmers helping keep us alive and producing.
- Education on methods
- Remove legal risk to improvements
- A property tax system that took into account footprint
- On farm consultations
- One-on-one advice

Results by Site Characteristics

Adaptations are influenced by site characteristics

Among the open survey responses, farmers often mentioned their soil type or site characteristics, and linked them to the adaptive management strategies and practices they use. Our goal was to support farmers in understanding how other growers with similar conditions are adapting their management for extreme weather conditions. Thus, we organized our data by site and soil characteristics to look at trends in adaptive management by site characteristic. We also ran a series of statistical tests to look for relationships between site characteristics and adaptive management strategies. We initially ran chi-squared tests, and then used binomial logistic regressions to identify the site characteristic variables which predicted management practices.

What emerges is that some strategies and practices, such as soil health and covers crops, are broadly adaptive and useful for all site and soil conditions. There are some practices and strategies though, like the use of raised beds, which appear to be used for managing climate related risks more in some types of sites than in others.

Decision making for each farm is different, and there are many things that shape what makes sense for each farmer. Site characteristics and soil type are not the only things that influence adaptive management, but they present important opportunities and challenges for managing water on site. Understanding how famers with similar land features and exposure are dealing with extreme weather can shed light on new opportunities for adaptation.

The following tables include two things:

- First, they show the ten most reported strategies or practices for each weather impact and site characteristic.
- Second, they include the practices and strategies which have statistically significant relationships to that site or soil characteristic.

Clay soils	
Climate impact:	*Adaptation strategies and practices:*
Heavy precipitation & flooding	Ten highest reported strategies & practices • Soil Health • Organic Fertilizers • Cover Crops • Crop Rotation • Raised Beds • Green Manure • Crop Diversification • Hoop Houses • Late Planting Dates • Perennial Plantings Statistically relevant to clay soils in particular: • Raised beds
Drought	Ten highest reported strategies & practices • Soil health • Cover crops • Efficient irrigation • Green manure • Organic fertilizers • Crop diversity • Crop rotation • Increased irrigation • Permanent mulch • Reduced tillage Statistically relevant for clay soils in particular: • Crop diversification • Variety in maturity period

Silty soils	
Climate impact:	*Adaptation strategies and practices:*
Heavy precipitation & flooding	Ten highest reported strategies & practices • Cover Crops • Soil Health • Crop Rotation • Green Manure • Crop Diversification • Organic Fertilizers • Raised Beds • Perennial Plantings • Irrigation strategies • Late Planting Dates
Drought	Ten highest reported strategies & practices • Soil health • Efficient irrigation • Cover crops • Crop diversity • Crop rotation • Organic fertilizers • Green manure • Increased irrigation • Drought tolerant crops • Perennial plantings Statistically relevant for silty soils in particular: • Reduced tillage • Efficient irrigation • Enterprise diversification

Sandy soils	
Climate impact:	*Adaptation strategies and practices:*
Heavy precipitation & flooding	Ten highest reported strategies & practices • Soil Health • Cover Crops • Crop Rotation • Organic Fertilizers • Crop Diversification • Green Manure • Raised Beds • Late Planting Dates • Hoop Houses • Irrigation strategies Statistically relevant for sandy soils in particular: • Later planting dates • Crop insurance • Shorter season varieties
Drought	Ten highest reported strategies & practices • Efficient irrigation • Soil health • Cover crops • Crop diversity • Organic fertilizers • Crop rotation • Increased irrigation • Green manure • Reduced tillage • Perennial plantings Statistically relevant for sandy soils in particular: • Reduced tillage • Efficient irrigation • Crop diversification • Variety in maturity period • Perennial plants

Soils with gravel or ledge

Climate impact:	*Adaptation strategies and practices:*
Heavy precipitation & flooding	Ten highest reported strategies & practices • Soil Health • Organic Fertilizers • Cover Crops • Crop Rotation • Raised Beds • Green Manure • Perennial Plantings • Irrigation strategies • Late Planting Dates • Crop Diversification Statistically relevant for rocky soils in particular: • Organic fertilizers
Drought	Ten highest reported strategies & practices • Crop diversity • Permanent mulch • Cover crops • Increased irrigation • Drought tolerant crops • Perennial plantings • Crop rotation • Green manure • Conservation buffer strips • Later planting dates Statistically relevant for rocky soils in particular: • Shorter season crops • Efficient irrigation • Drought tolerant crops

Floodplain	
Climate impact:	*Adaptation strategies and practices:*
Heavy precipitation & flooding	Ten highest reported strategies & practices • Soil Health • Crop Rotation • Cover Crops • Organic Fertilizers • Crop Diversification • Irrigation strategies • Hoop Houses • Green Manure • Late Planting Dates • Raised Beds Statistically relevant for the floodplain in particular: • Permanent mulch • Crop rotations • Staggered harvest dates • Irrigation strategies • Financial planning • Diversify markets & enterprises
Drought	Ten highest reported strategies & practices • Soil health • Cover crops • Efficient irrigation • Crop diversity • Crop rotation • Organic fertilizers • Green manure • Increased irrigation • Drought tolerant crops • Heat tolerant crops Statistically relevant for the floodplain in particular: • Crop diversification • Crop rotations • Later planting dates

Steep slopes	
Climate impact:	*Adaptation strategies and practices:*
Heavy precipitation & flooding	Ten highest reported strategies & practices • Cover Crops • Soil Health • Organic Fertilizers • Green Manure • Raised Beds • Perennial Plantings • Crop Rotation • Crop Diversification • Hoop Houses • Reduced Tillage Statistically relevant for steep slopes in particular: • Raised beds • Permanent mulch • Reduced till • Cover crops • Perennial plantings
Drought	Ten highest reported strategies & practices • Soil health • Cover crops • Efficient irrigation • Crop diversity • Organic fertilizers • Green manure • Crop rotation • Increased irrigation • Perennial plantings • Permanent mulch Statistically relevant for steep slopes in particular: • Buffer plantings • Perennial plants • Enterprise diversification

Windy sites	
Climate impact:	*Adaptation strategies and practices:*
Heavy precipitation and flooding	Ten highest reported strategies & practices • Cover Crops • Soil Health • Crop Rotation • Organic Fertilizers • Green Manure • Crop Diversification • Raised Beds • Hoop Houses • Late Planting Dates • Irrigation strategies
Drought	Ten highest reported strategies & practices • Soil health • Cover crops • Efficient irrigation • Crop diversity • Organic fertilizers • Crop rotation • Green manure • Increased irrigation • Heat tolerant crops • Drought tolerant crops Statistically relevant for windy sites in particular: • Crop diversification • Crop rotations • Earlier planting dates

Methods

Administering the survey

The New England Adaptation Survey was developed in fall 2017 with input from farmers and collaborating farmer networks to optimize the questionnaire's readability, usability and response rate. Researchers referenced five prior surveys on similar themes when writing survey questions. Six farmers trialed the survey and the survey was revised based on their feedback. Collaborating farmer networks and organizations informed the delivery approach for the survey, resulting in a tailored, mixed-mode survey design (Dillman et al., 2014). Survey responses were solicited in-person at eight farmer network events, and via email through four farmer list-servs between November 2017 and March 2018. The survey instrument contained 77 questions, including both closed and open-ended questions about 1) practices already used to manage for drought and extreme precipitation, 2) promising strategies for managing drought and extreme precipitation at multiple scales, 3) perceived barriers and tradeoffs associated with these strategies, 4) in-depth information about the of use of cover crops, 5) perceptions of vulnerability and capability, 6) production context and 7) demographic information.

Analysis

Reported adaptive management strategies were compiled, sorted and reported as percentages of total responses using Excel. To identify how adaptive management strategies differ by site specific

characteristics, individual Pearson's Chi Squared Test for goodness of fit were run in R Studio. We then ran binomial logistic regressions for each management strategy, using site and soil characteristics as predictor variables.

Qualitative data from open-ended questions was analyzed by the well-established qualitative methods of grounded theory and constant comparative analysis. These methods ensure that emergent theories are first anchored by patterns in the data reflected across the survey, and continually evolve as additional data is collected and analyzed (Lindloff and Taylor, 2011). We used open coding to draw out themes and concepts from the dataset. Further review of the data revealed intensity and recurrence of themes, which were then grouped into a coding tree. Keywords and specific phrases were integrated to develop a set of axial codes, which reflected the emergent patterns of categories of meaning. We ensured inter-coder reliability by coding independently and then cross-checking emerging trends.

About the project

The survey was first conceived as a SARE Graduate Student Grant by Alissa White in the spring of 2017 in response to conversations with extension professionals and farmers about the need for more specific and tailored information about climate resilience. The USDA Northeast Climate Hub has been a central point of support for this project, and has invested time and resources into making it a success.

About the team

The project is coordinated by Alissa White, who is a graduate student in the Department of Plant & Soil Science at the University of Vermont. The project would not have been possible without mentorship and faculty support from Dr. Joshua Faulkner and Dr. V. Ernesto Mendez at the University of Vermont. A team of undergraduate students at the University of Vermont were selected based on their experience working on farms in the Northeast. This includes Sarah Sims, Phoebe Tucker, Kyle Weatherhogg, and Ben Fisher, who have contributed to data collection, data processing, analysis and outreach.

Pictures

Pictures by Alissa White unless otherwise noted. Additional photos by Greg Noble and Mark Krawczyk.

Acknowledgements

The project has received support and sponsorship from many colleagues and donors, without whom it would not have been possible. *Thank you to farmers and partner organizations for working with me.* Thank you to my advisors Joshua Faulkner and V. Ernesto Mendez the inspiration and for guiding the work. Thank you to Erin Lane and Sarah Heiss for the support and encouragement to do this! Thank you to my dedicated undergraduate research team, Sarah Sims, Phoebe Tucker and Kyle Weatherhogg, who contributed to data collection, data entry and coding the qualitative dataset, and to Ben Fisher for supporting data collection. Feedback and invaluable advice was offered by David Conner, Becky Madden, Alisha Utter, Janica Anderzen, Rachel Schattman, the entire Agroecology and Livelihoods Collaborative, Natalia Salazar, John Hadden, Meredith Niles, E. Carol Adair, Paul Schwartzkopf and many, many farmers. Some of the survey questions were replicated from a previous survey with permission of J. G. Arbuckle. Product donations for participant incentives were provided foremost by Bee's Wrap, as well as Brio Coffeeworks, Wild Faith Herbal Wellness, Primitive Threads, and Burton Snowboards. Thank you to the UVM Department of Plant and Soil Science and NE SARE for the opportunity, and the NE Climate Hub for solidarity and support.

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