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Climate Change Resilience on Vermont Farms: A Research Report for Service Providers

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Key findings

1. Vermont farmers rely on best management practices to reduce risk in their farm businesses. Some of these practices are useful in limiting the farm-scale risks producers may face because of climate change.

2. Key strategies for limiting risks associated with climate change at the farm scale include (1) diversity of markets, production, household income and land base, (2) sustainable soil management, including water management in soils, and (3) innovative cropping systems.

3. Technical service providers can assist farmers to address the continuing challenges associated with climate change by:

   - ♦ Educating themselves about the most current climate projections
   - ♦ Better understanding the potential on-farm impact that rising atmospheric temperatures, changing rainfall, drought conditions, and frequency of extreme weather events may have on Vermont farms.

Background

Global climate change will lead to increasing average and extreme global temperatures, rising sea levels, and decreasing snow and ice cover, both within the next 50 to 100 years, and beyond (Archer, 2007). While there will be geographic differences in how regions are affected, people everywhere are concerned about how changes will impact their homes, businesses, and communities. According to the Intergovernmental Panel on Climate Change (IPCC), increasing global temperatures will have numerous effects on both natural and human systems, including those associated with food and agriculture (Walthall et al. 2012). Of concern are changes in precipitation averages and extremes, air and water temperature, and frequency of extreme weather events that will impact global public health, economies of all scales, and ecosystems.

In the future, the risks faced by farmers because of climate change will vary depending on geographic region, market stability, access to financial and social capital, and many other factors (Smith et al. 2008, Tubiello et al. 2008). In the northeastern United States, climate change is expected to present significant challenges to rural populations and farming communities (Lal, Alavalapati, and Mercer 2011). Climate change impacts in the northeastern United States include an increase in the number of heavy storms and floods, changes in the suitability for growing traditional northeastern crops (e.g. apples, blueberries and cranberries), changes in insect and plant communities, and decreases in milk production due to hotter summers (Frumhoff et al. 2007, Wolfe et al. 2007).

The first statewide climate assessment in the United States was completed for the state of Vermont by Galford et al. (2014). This assessment predicts warming seasonal average temperatures, which may result in later first-fall freeze and earlier last-spring freeze dates, an extended growing season, increased weed pressure, agricultural disease outbreaks and pest infestations. The authors of the assessment also note that extreme variations in year to year productivity may lead to economic challenges for Vermont producers.

Farmers can take precautions to mitigate the risks associated with climate change. Producers already rely on many practices that have the potential for climate change mitigation and adaptation (Wall and Smit 2008), but it is less clear which practices have the greatest potential to increase resilience for particular farms. The Vermont Agricultural Resilience in a Changing Climate Initiative (VAR) is a University of Vermont (UVM)-based program that brings diverse stakeholders together to address climate change resiliency on Vermont farms. Our team is composed of researchers from many disciplines, a professional advisory committee that includes farmers and other collaborators, farmers who cultivate a wide range of products, and policy makers. Through this participatory action research (PAR) approach, we work with diverse stakeholder groups to (1) identify the agricultural best management practices (BMPs) that best help farmers adapt to climate change now and in the future, (2) provide information on how farmers can contribute to greenhouse gas (GHG) mitigation, (3) work with outreach professionals and policy makers to incentivize and deliver information about these practices to a broad community of farmers and other professionals, (4) assess the future needs related to climate change of stakeholders in the Vermont ag-

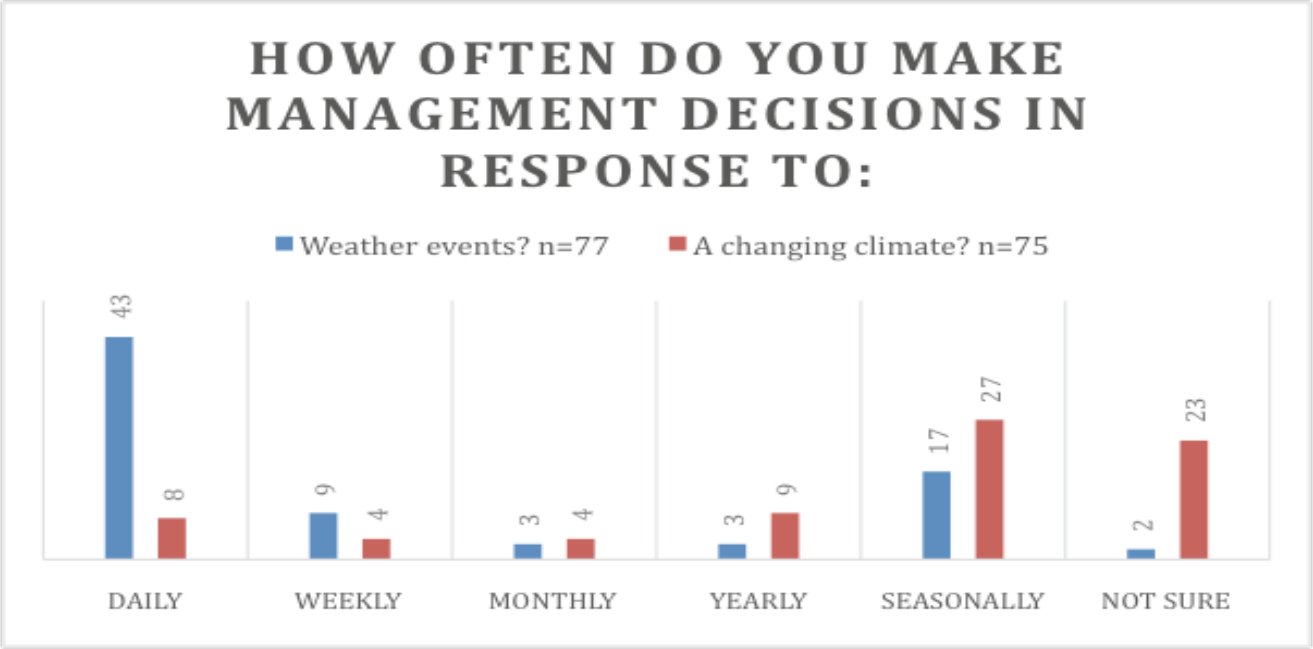

Figure 1: Frequency of farmer management decisions based on weather and climate, reported in 2013 survey.

rifood system, and (5) create and utilize tools to inform policy and governance that are specifically related to climate change and agriculture issues. This paper draws on findings from:

- 16 interviews with Vermont farmers conducted in 2013 and 2014.
- 12 interviews with agricultural technical services providers conducted in 2013 and 2014.
- A survey of Vermont farmers in the Lamoille and Missisquoi watersheds, conducted by the VAR team in 2013.

Farmer interview participants were sorted by type of farm (dairy, meat, vegetable or diversified.) Participant farms qualified for our study if they grossed more than $10,000 in 2011, and if they used one or more of the following best management practices (BMPs): reduced tillage or no tillage, cover crops/ green manures, wetlands conservation, storm water run-off management, riparian or other conservation buffers, and rotational grazing. These were a small selection of the BMPs considered in the interviews themselves, but were used during the selection process in order to ensure that participant farmers would also be able to work with other members of our on-farm research team. Agricultural service provider interview participants were identified by key informants and members of our Advisory Committee.

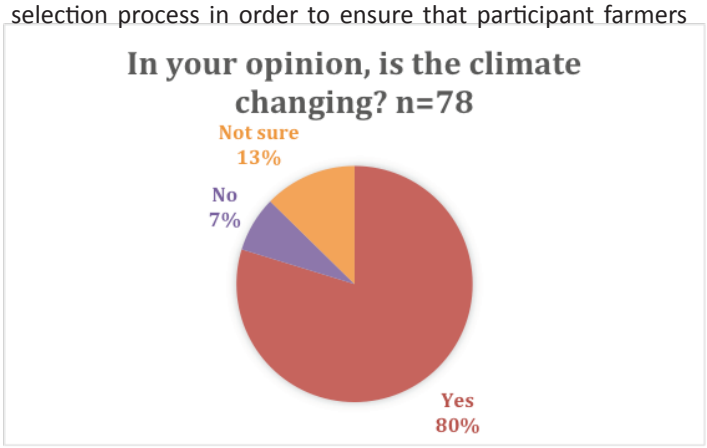

Figure 2: Farmer perceptions of climate change, reported in 2013 survey.

The survey of Vermont farmers in the Lamoille and Missisquoi watersheds was conducted in 2013. All farms with more than $10,000 gross sales were included in the sample. Farms were identified by the National Agricultural Statistical Service (NASS) by zip code. NASS administered the survey on behalf of our team, beginning with a short screening survey mailed to 1,104 farms. Following the screening survey, full length surveys were mailed to those farms who indicated interest. There were 81 completed surveys, (confidence interval of 10.49 percent with a 95 percent confidence level). Survey data was coded and checked for integrity by our team.

In this brief, we discuss three categories of BMPs that were both frequently cited by the farmers we interviewed, and which were addressed by multiple farmers. We also discuss farmer perceptions of climate change, and the perceived impact that climate related changes will have on their farms. While this is not representative of all farmers throughout Vermont, we hope it lends insight into some of the approaches Vermont farmers are taking to increase resiliency and limit the risks they face due to a changing climate.

Findings

Based on our survey of Vermont farmers in the Lamoille and Missisquoi watersheds, most farmers (80%, n=78) believe that the climate is changing, but a smaller number of respondents believe that climate change will negatively impact their farm (55%, n=69). A greater percentage of respondents are unsure of how climate change would impact their farm (30%, n=69), indicating that many farmers are unsure about the specific consequences of climate change or how these conditions will affect them.

Vermont farmers already rely on many best management practices (BMPs) to manage risk on the farm. Three examples drawn from our interviews highlight best management practices that farmers currently use to limit risk, whether they think that risk is associated with climate change or not: (1) diversification, (2) improvement of soil health, including water management to this end, and (3) new cropping systems. In the following section, we detail what farmers in our study had to say about these practices, how and why they use them.

1. Diversification

Agricultural producers practice diversification in many ways. In this study, farmers report diversifying markets, products, sources of household income, and land-base. First, the threat of crop failure, associated with climate change or otherwise, is addressed by some farmers through development of specific market channels. Farms that rely on market diversification practiced a combination of direct-to-consumer marketing (at farmers' markets, through community supported agricultural –CSA– arrangements, etc.) and wholesale (through commodity markets or third party distributors.) There are also hybrid arrangements, such as the vegetable grower who works with a small number of other growers and a third party in the Boston area to develop an adapted CSA outside of Vermont. CSA programs, where a customer purchases a subscription at the beginning of the season and receives periodic shares of whichever crops are available, can help farmers avoid sales losses normally associated with crop failure.

> *"The more farms can be diversified, the better chance they stand of weathering weird climate years."*
>
> -Technical Service Provider

Farms also report diversifying their production, which reduces the revenue they depend upon from a single crop. This applies to both farms that produce several types of food products (e.g. meat, vegetables, hay) and farms that use marginal crop land for energy production (e.g. solar farms, biofuel production.) For example, a dairy producer interviewed for this initiative reports a long-term lease arrangement with a solar production firm that guarantees rental income over several decades. At the termination of the lease, he has the option to renew, or to decommission the solar arrays and return the land to agricultural use.

Diversification of household income also helps farmers manage the risks of climate change and potential income loss resulting from decreased production. This can include a variety of on-farm activities, including production of commodity and non-commodity products, value added processing, or agritourism, or could encompass employment off farm by the primary farm operator or other members of the farm household. The range of these activities is termed pluriactivity by Evans and Ilbery (1993). The farmers we interviewed often cite off-farm income brought into the household by either themselves or a partner as being an important strategy for maintaining the farm. Off-farm employment cited during the interviews was both agricultural (building fences, working for other farmers) and non-agricultural (e.g. state government employees, paralegal professionals, photographers, educators, and many more.)

Lastly, both farmers and agricultural technical service providers interviewed for this initiative address diversity of land base as a key strategy for limiting climate change risk. Farmers discuss renting or purchasing additional acres to expand the types of land they have access to (e.g. clay versus sand soils, river-bottom land versus high-elevation land, crop versus grazing land). One farmer stated clearly that purchasing of additional grazing land helps him to insure his business against droughts that would limit forage production. Other interviewees discussed their decision to move their businesses entirely, citing frequent flooding as the primary driver in their decision to look for new land. The uncertainty of climate change impacts has led some farms to prefer leasing agreements of five years or less as opposed to purchasing land or entering into long-term leases.

2. Improvement of soil health (water management in the context of soil health)

Most farmers who participated in our interviews were highly aware of the role that climate change plays in changes of both average rainfall amounts and frequency of extreme rain events (precipitation or drought.) Many cite a concern about the effect that these changes will have on the health of agricultural soils in the future. Managing water flow, and by proxy nutrient flows, on the farm was a frequently discussed topic.

The need for water on vegetable and diversified farms was addressed by several producers. One farmer noted the need for irrigation in fields and hoop houses and wash water for vegetables as being significant factors in her farm's plan to dig an irrigation pond. Livestock watering is an additional concern for many who rely on rotational grazing as a critical part of their production plan. A technical service provider notes that while many vegetable farms did not use irrigation 15 years ago, many now do. This shift is due, in part, to the growing awareness among producers that there are more frequent and longer stretches of dry, hot weather in summer, and that vegetable crop quality is improved by consistently applied amounts of irrigation water.

Farmers are very aware about how wet conditions impact a crop's ability to thrive and metabolize soil nutrients. In addition to water management, farmers also cite management of soil organic matter (OM) as a key concern, though not exclusively in the context of climate change. This is likely due to a lack of information available to farmers about how climate change will influence OM on their farms. A meta-analysis of the effect of increasing atmospheric temperatures on OM conducted by Conant et al. (2011) proposes that not all OM will react the same to climate change, but variation will result from how different microbial communities are affected, and by extension, on OM's susceptibility to decomposition. This was confirmed by field studies that found that OM's reaction to climate change is dependent upon both microbial communities and substrate quality (Frey, Lee, Melillo, & Six, 2013).

Erosion is also of concern to many farmers interviewed. Cover cropping and green manures were cited as strategies for not just adding OM to production areas, but also for increasing root penetration, increasing water absorption, and reduc-

Table 1: Diversification strategies reported in farmer interviews

Markets	"We do several different kinds of marketing. We do some wholesale, CSAs certainly help with risk management a lot. If you have a crop failure or anything like that, you can still make up the value of the share with other crops and not lose that market because you didn't have a specific crop or maybe a specific time of year you didn't have enough because of weather disasters of whatever." (Diversified farm produced vegetables, meats and eggs.)
Products	"It is not all just vegetables, I guess that is another way we have diversified too. We have year round income because of egg collection and hoop houses. We sell vegetables and shares year round so if I lose everything in the main growing season it would be hard but it is not the end." (Diversified producer.) "Also when it comes to managing risks faced by pests/diseases. If one crop gets hammered, you are not so specialized that you can't make up the income with another crop." (Diversified veggie farm that grows 30+ crops.)
Household income	"I build high tensile electric fence on other farms. A lot of times through local state, federal or watershed groups. Trying to exclude cows from rivers, stuff like that. And [anonymous] does a little off farm work as a photographer working with advocacy groups for people with disabilities. She works for a non-profit foundation. I would say that's 25% of our total income." (Dairy and meat producer.) "(Anonymous) worked for 22 years. That paid the mortgage and let us invest in a lot of things for the farm. I think we put $100,000 just into our barns to keep them up. You have to have an off-farm job to keep that up if you are an organic farmer. (Dairy producer.)
Land-base	"I guess if that was the only piece of land that you had and you were at risk of flooding every year I would probably think differently. Because we have a couple pieces, I know that if I lose the crops on that piece one year, I am still going to have other income because we have livestock too." (Diversified producer.) "We will not stay. It's hard … in the state of Vermont you're either in a mountain range or in a valley, and there's very little topsoil in the state in general. We have to base the future of our farm on what might happen 10 years down the line." (Diversified producer.)

ing erosion. In areas or at times of year when cover cropping is not able to be incorporated into production cropping systems, strategies such as buffer strips or river reconstruction to slow flood waters are used. Grazing and sub-soiling were also cited as BMPs that can help to address erosion. Tile drainage was indicated as a practice that has great potential, but could be improved upon. Farmers want more control over the release of water out of tile drainage systems, and better technical advice about when installing a drainage system would be effective.

3. New/modified agricultural management systems

Farmers respond to a variety of influences when deciding what practices to use on their farm. The influence of peers, learning about innovative new practices, and problem solving support from technical service providers all inform farmers' decisions about when and how to adopt new practices. In the context of climate change, the farmers interviewed in this study cited several practices that were either new to the farming community or new to their farm.

Vegetable growers cited plastic mulch and unheated hoop houses (also called high tunnels) as especially helpful in managing cultivation timing in wet fields. Farmers can lay beds of black plastic during dry periods and leave the beds prepped for planting for several weeks even if heavy rains fall. If beds are not covered in plastic, the farmer would have to cultivate in the field again prior to planting in order to limit weed pressure. This can lead to increased soil compaction and decreased soil health. Using black plastic as a mulch is seen as a way to hedge the farmer's risk related to heavy rainfall in the pre-planting period, though it does lead to increased production of on farm waste. Hoop houses enable growers to extend the growing season, produce certain crops in cold seasons, control water application and limit certain plant diseases. Despite the potential reduction of risk associated with water supply and climate change, producers note that hoop houses are not without risk. Especially for those growers located in high-wind areas, plastic covered structures are vulnerable to extreme weather events. All things considered, there has been a significant increase in recent years in the number of hoop houses used by Vermont growers. This is likely due, not only to their production benefits, but to grant programs administered through the Natural Resource Conservation Service (NRCS).

Many growers showed interest in experimenting with new crops that are either suited to warmer climates, longer growing seasons, or which are resilient to flooding. Grapes and asparagus are examples noted by producers, as were tree crops and

other perennials. Of great concern to growers is the likelihood of flooding, and which crops can either sustain short periods of water saturated soils or can be replanted in a timely manner. In the period following Tropical Storm Irene, many growers who experienced flooding were required to dispose of crops that appeared to be undamaged but which may have been contaminated by point source pollution upstream of their fields. Food safety regulations related to flooding now state that food that is grown, held or packed under unsanitary conditions where it may have become contaminated with flood waters is considered adulterated and cannot be introduced to the human or animal food supply (U.S. Government Printing Office, 2010). To address this current climate of regulatory shifts, growers must be strategic in their planting, choosing either varieties that will not be touched by flood waters under predictable circumstances, or by planning for rotations of crops that can follow each other in quick succession thereby allowing them to generate income from crop land at multiple points in the season.

Lastly, dairy producers interviewed in this project highlighted several key production innovations that help them to limit the production risks associated with climate change. To increase efficiency and reduce feed requirements across the herd, robotic milking was cited as a key step forward. This approach helps dairy producers increase feed efficiency on the farm, as less feed is needed per unit of milk produced. In part, this is due to increased milking frequency (from two to three milking times a day per cow) and a reduction in the amount of labor needed to complete each milking. Additionally, new approaches to feed storage (such as wrapped silage bales) and feed harvesting (harvesting selected parts of the plant) allow dairy producers greater control over the quality of feed available to their herds, and the length of time this feed can be held, often over a year. All of these things help producers spread their need for feed production or purchase out over a longer period of time, insulating them from the uncertainty of extreme weather events related to climate change.

What can technical service providers do?

Technical service providers can assist farmers to address the continuing challenges associated with climate change by educating themselves about the most current climate projections and understanding the impact that rising atmospheric

Table 2: Strategies for improving water management in the context of soil health, reported in farmer interviews

Nutrient management	"I'm convinced that soil health is key, and it's not just about NPK. I did a lot of broad spectrum remineralizing a few years ago, like I but a bunch of different rock dusts down and humates. I applied about 50 yards to the acre of wood chips. (Vegetable producer.)
Irrigation	"We are doing a pond for irrigation, we have been irrigating from our well—drip (irrigation)—so we have never had any overhead irrigation. But because we are also getting not only saturation, not flooding but saturation, we also get extreme drying events and I think there are times when we will go weeks without rain instead of having our steady one inch a week. I think also we have learned more, you can almost never put on too much water. If you can put it on in a controlled way, things always do better." (Vegetable producer.) "I've given up trying to improve wet soils. I need to do better with my drier (soil) and hope that I can manage a drought. Droughts would be really annoying, but it's possible to get water in from sprinklers. It's not really possible to make it stop raining." (Diversified hay and vegetable producer.)
Organic matter management	"For our perennials, we do a lot more mulching. The nice thing about our perennials is that we can do it all no-till. We aren't big fans of the tillage because we think that just chews up the organic matter once you aerate the soil and get the oxygen in there. The microbes go nuts and we are losing organic matter that way." (Diversified fruit and vegetable producer.) "This summer has been this crazy, crazy, wet summer. I planted greens every week as soon as the snow was off like I do every year. I plant once, cover it, cut once, till it in. My whole financial life is based on sowing a hundred pounds of greens a week, and I had to call my accounts every week and say "I don't have anything" because there was standing water between the raised beds all the time. (The crop) couldn't, couldn't metabolize any of the organic matter, they couldn't take up any nitrogen and everything was just stunted and purple." (Diversified vegetable and hay producer.)
Erosion control	"We didn't have any flooding, but we had rain every day. We had erosion in the fields but they didn't go beyond the buffers we had." (Dairy producer.) "The riverbank was rebuilt after (Tropical Storm) Irene, and it was rebuilt in a way that would theoretically slow the flood waters…We planted a lot a lot of shrubs along that creek, so as soon as those things build up, that will be secure." (Vegetable producer.)

Table 3: Innovative production strategies reported in farmer interviews

Plastic mulch	"I foresee huge increases in the use of plastic. Greenhouses, hoop houses, and all sorts of tunneling, all sorts of plastic. When we grow things in—not under but on plastic—we can get into fields that we wouldn't otherwise might not have. And plus it deals with weeds. It is a little bit of a concern, because it is a fossil fuel product… (But) the wet weather wreaks havoc on our cultivation schedule." (Diversified vegetable and hay producer.)
Hoop houses (high tunnels)	"Given my soil and given the climate here, I am not incentivized to grow much outside. I don't really see a reason to. Whatever I have put outside does so much worse than anything I put underneath the (hoop) house. It's shocking, the difference. It's amazing. Not in every crop, but in a lot… The high tunnels are the most efficient system on our farm." (Diversified vegetable and dairy producer.) "We have been doing hoop houses over the past couple of years (and) we have been investing in more robust structures and putting in more permanent footers. We do have one mobile house but after we did that one we thought about others and we just said no. We didn't want to go in that direction because they are just too risky. Especially in a high wind area." (Diversified vegetable, meat and egg producer.)
Robotic milking	"We do need more feed per acre and we utilize more local inputs to grow our feed. What we are doing is, once we had the (robotic milking system) we decreased the number of cows we milk and made more milk (per cow). So there was less feed consumed, especially corn silage." (Dairy producer.)
New crops	"If I did own the property, the areas that were flooded would probably be put into perennial crops. Asparagus is what I would do. I would not grow tillage crops in the flood-plane." (Vegetable producer.) "Certain crops are more flood tolerant in one way or another. Maybe its extra tall varieties of sweet corn, so that if the bottom two feet get flooded, we can still harvest the ears because their four or five feed off the ground. Or maybe it's looking at more tree crops in valleys. For instance, we're looking at the more flood-prone land for biomass crops that then we could use to fuel our greenhouses. Some crops, there's a lower pre-harvest cost. Let's do a ton of high value stuff that cycles through really quickly like bunched herbs and baby salad mix and baby greens like arugula, radishes, baby turnips and all these kind of things that take you know 28, 30, 45 days. If you lose it, if it all gets wiped off the map, you turn around you replant and you're back in business four weeks later." (Vegetable producer.)

temperatures, changing rainfall and drought conditions, and frequency of extreme weather events may have on Vermont farms. Some service providers we interviewed reported reticence about raising the topic of climate change with the farmers with whom they worked. When asked if they discussed the topic with producers, one interviewee stated "I don't broach the subject unless a farmer brings it up. Some people don't think it's real, and then you get into a political argument about it. I don't have the capacity to do that." However, most service providers we interviewed stated that the farmers they work with are believers in climate change, and that thinking proactively is something farmers must do in order to protect themselves from its effects. This is supported by findings from our survey and from our interviews with farmers. Others argued that farmers are knowledgeable about climate change, but make management decision based more often on short to medium term considerations (such as weather.) This is also supported by our survey, which shows a greater level of willingness among farmers to make decisions based on weather than on climate. Farmers interviewed for this research reported that they received their most valuable technical assistance from organizations focused on outreach and education and their fellow farmers. It seems that service provider knowledge of climate change would best serve the farmers if integrated into all aspects of technical assistance. In other words, the service provider could bring climate change information to the table when discussing other topics with farmers so as to avoid ignoring the impacts climate change will have on farms. Another way to help farmers respond to climate change is to help them identify and how to better manage farm areas or practices that can be most affected by climate change. For example, identifying the areas of the farm that are more drought and flood prone and defining strategies on how best to cope with these threats.

To better familiarize themselves with the potential impacts of climate change on farms in the northeastern United States, we strongly recommend that technical service providers seek out professional development opportunities that provide up-to-date climate change information. The Vermont Agricultural Resilience in a Changing Climate Initiative is holding a pilot ser-

vice provider training in 2014/2015 that will work with a small group of participants to better understand climate change, the likely impact on Vermont farms, and what farms can do to increase resiliency. (For more information, http://www.vtfarmresilience.org) Once service providers complete this training, or other professional development trainings as they become available, there may be more opportunities to bring this information to farms. Just as importantly, we hope to learn more from farmers who experience the effects of climate change in their businesses. By engaging in this reiterative process of question asking and knowledge development, we hope to limit the risk faced by producers at the farm scale, with regional benefits for us all.

Want more information about Vermont agriculture and climate change?

- **Considering Vermont's future in a changing climate: The first Vermont climate assessment** by Galford et. al (2014) is available at http://vtclimate.org/. This is the first state-level climate assessment in the United States, and provides useful information about anticipated climate changes and their impact on agriculture.
- The official website for the **Intergovernmental Panel on Climate Change** (IPCC) is available at http://www.ipcc.ch/. The IPCC provides concise summary reports on scientific findings related to climate change, as well as in-depth information. The most current report on the IPCC website is the Fifth Assessment Report, or AR5.
- The **U.S. Environmental Protection Agency** (EPA) provides a summary on their website about the impact of climate change on agriculture in the United States, including crops, livestock, and fisheries. http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html
- **USDA Climate Hubs** is a new, multi-agency effort that will bring research-based information to farmers, ranchers, and forest landowners. The Northeastern Regional Climate Hub is based in Durham, NH. http://www.usda.gov/oce/climate_change/regional_hubs.htm
- **Climate Communication** is a group that specializes in connecting scientists and journalists around climate change. Their website (http://www.climatecommunication.org/) is a useful resource for understanding how climate change will have variable impacts around the globe. They have some useful tips for talking about climate change with people who are not scientists.

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