

The Impact of Climate Change on Agriculture: Harvard, Massachusetts: APPENDICES

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Prepared for the Town of Harvard



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Image Credit: Harvard Alpaca Ranch

Appendix A: Agricultural Community Survey

As noted above in Section 1, part of the planning process for the Agricultural Workshop, the MVP Core Committee worked with Harriman to develop a questionnaire for distribution to those who were producing agricultural products and those interested in agriculture. This section contains the questions and results. Note that the respondents were self-selected; the members of the MVP Core Group attempted to reach as many people who were related to agriculture as possible, but the results should be treated as a snapshot of the community rather than a scientific survey.

There were some clear differences in the responses that were also apparent in the workshops. Respondents differed in the scale of their operations (large/small), the type of operations (commercial/noncommercial), the structure (income-producing/hobby), whether the farms were crop-based, animal-based or a mixture, and whether the farms were organic/non-organic. These differences have implications for climate change in that the vulnerabilities to climate change, the potential mitigation or adaptation actions, the resources available to undertake those actions, and the implications for failure differ based on farm type, operations, and goal.

This is the raw data from the survey, and, other than formatting the tables for legibility, has not otherwise been altered.

1 How much land do you have in production during your growing season? (Select one.)

Answer Choices	Number of Responses	Percentage of Responses
Less than 1 acre	27	38.57%
1 to 2.9 acres	13	18.57%
3 to 4.9 acres	4	5.71%
5 to 9.9 acres	4	5.71%
10 to 14.9 acres	7	10.00%
15 to 29.9 acres	7	10.00%
30 to 49.9 acres	5	7.14%
50+ acres	3	4.29%

2 What do you produce and how many acres are devoted to that crop? (Animals and Animal Products)

	Less than 1								
	acre	1	1 to 2.9 acres		3 to 4.9 acres		5 to 9.9 acres		
Cattle and calves	2.27%	1	0.00%	0	0.00%	0	0.00%	0	
Milk from cows	0.00%	0	0.00%	0	0.00%	0	0.00%	0	
Hogs and pigs	2.38%	1	0.00%	0	0.00%	0	0.00%	0	
Sheep, goats, wool, mohair, and milk	0.00%	0	6.38%	3	0.00%	0	4.26%	2	
Horses, ponies, mules, burros, and donkeys	0.00%	0	2.08%	1	6.25%	3	4.17%	2	
Poultry and eggs	22.22%	12	3.70%	2	1.85%	1	0.00%	0	
Aquaculture (Fish)	0.00%	0	0.00%	0	0.00%	0	0.00%	0	
Apiculture (Beekeeping)	10.20%	5	2.04%	1	2.04%	1	2.04%	1	
Other animals and animal products (please specify)									

3 What do you produce and how many acres are devoted to that crop? (Field Crops and Grains)

	Less than 1 acre		1 to 2.9 acres		3 to 4.9 acres		5 to 9.9 acres		
Hay	1.82%	1	9.09%	5	5.45%	3	5.45%	3	
Corn	7.14%	3	0.00%	0	2.38%	1	0.00%	0	
Wheat	2.50%	1	0.00%	0	0.00%	0	0.00%	0	
Grains, oilseeds, dry beans, and dry peas	10.00%	4	0.00%	0	0.00%	0	0.00%	0	
Other field crops and grains (please specify)									

Please specify:

- Pumpkins 1.5 acres
- Corn land leased to Pickard
- Personal Garden
- Perennials, fresh produce, bedding plants, annuals, winter-hardy shrubs. Considering commercial hemp and possibly cannabis.
- Mostly vegetables, herbs, flowers for myself
- Corn, squash, apples
- Basic veggie garden

	10 to 14.9 acres		15 to 29.9 acres		30 to 49.9 acres		50+ acres		Unknown		Not applicable		Total
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	97.73%	43	44
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	41	41
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	97.62%	41	42
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	89.36%	42	47
	4.17%	2	4.17%	2	0.00%	0	0.00%	0	0.00%	0	79.17%	38	48
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	72.22%	39	54
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	42	42
	2.04%	1	2.04%	1	0.00%	0	0.00%	0	0.00%	0	79.59%	39	49
													0

	10 to 14.9 acres		15 to 29.9 acres		30 to 49.9 acres		50+ acres		Unknown		Not applicable		Total
	10.91%	6	1.82%	1	1.82%	1	0.00%	0	0.00%	0	63.64%	35	55
	2.38%	1	2.38%	1	0.00%	0	0.00%	0	0.00%	0	85.71%	36	42
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	97.50%	39	40
	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	90.00%	36	40
													7



Image Credit: Westward Orchards

4 What do you produce and how many acres are devoted to that crop? (Fruits, Vegetables, and Other Hort)

	Less than 1 acre		1 to 2.9 acres		3 to 4.9 acres		5 to 9.9 acres	
Berry crops	64.41%	38	1.69%	1	1.69%	1	0.00%	0
Grapes	34.15%	14	0.00%	0	0.00%	0	0.00%	0
Tree fruits	40.38%	21	7.69%	4	3.85%	2	3.85%	2
Cool-weather vegetables (ex. lettuce, spinach, kale)	52.83%	28	3.77%	2	0.00%	0	0.00%	0
Warm-weather vegetables (ex. tomatoes, peppers) and melons	61.82%	34	1.82%	1	0.00%	0	1.82%	1
Root vegetables (ex. potatoes, sweet potatoes, carrots, parsnips)	50.00%	26	3.85%	2	0.00%	0	0.00%	0
Herbs	61.82%	34	0.00%	0	0.00%	0	1.82%	1
Nursery, greenhouse and floriculture	14.63%	6	2.44%	1	0.00%	0	0.00%	0
Other fruits, vegetables or horticultural products (please specify)								

Please specify:

- Assume you want to know about large scale production and not family garden.
- Trees
- Squash
- Rhubarb

5 What do you produce and how many acres are devoted to that crop? (Forest and Related Products)

	Less than 1 acre		1 to 2.9 acres		3 to 4.9 acres		5 to 9.9 acres	
Fire wood	20.31%	13	6.25%	4	7.81%	5	7.81%	5
Lumber	2.08%	1	0.00%	0	2.08%	1	2.08%	1
Christmas trees	4.35%	2	0.00%	0	0.00%	0	0.00%	0
Maple syrup	18.37%	9	2.04%	1	0.00%	0	0.00%	0
Other horticultural products (please specify)								

Please specify:

- Hot pepper jam and fruit jams
- home use only
- trees
- Specialty horticultural such as Clivia.
- Have access to other acreage to cut firewood

Agricultural Products)

10 to 14.9 acres	15 to 29.9 acres	30 to 49.9 acres	50+ acres	Unknown	Not applicable	Total
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	32.20% 19	59
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	65.85% 27	41
0.00% 0	0.00% 0	1.92% 1	1.92% 1	0.00% 0	40.38% 21	52
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	43.40% 23	53
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	34.55% 19	55
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	46.15% 24	52
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	36.36% 20	55
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	82.93% 34	41
						4

10 to 14.9 acres	15 to 29.9 acres	30 to 49.9 acres	50+ acres	Unknown	Not applicable	Total
4.69% 3	1.56% 1	3.13% 2	0.00% 0	0.00% 0	48.44% 31	64
2.08% 1	2.08% 1	2.08% 1	0.00% 0	0.00% 0	87.50% 42	48
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	95.65% 44	46
0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	79.59% 39	49
						5

6 What do you produce and how many acres are devoted to that crop? (Techniques)

	Less than 1 acre		1 to 2.9 acres		3 to 4.9 acres		5 to 9.9 acres	
Hydroponics	3.77%	2	0.00%	0	0.00%	0	0.00%	0
Aquaponics	1.96%	1	0.00%	0	0.00%	0	0.00%	0
Other techniques (please specify)								

Please specify:

- We are actively considering hydroponics and aeroponic systems.

7 If you sell your products, who do you sell them to? (Check all that apply.)

Answer Choices	Responses	
I don't sell my products	52.86%	37
Direct to consumers (e.g., farmers' market, you-pick, farm stand, CSA program)	35.71%	25
Wholesale	12.86%	9
Processing	4.29%	3
Other (please specify)	17.14%	12

Please specify:

- Have plans to sell next season
- My horses eat the hay
- Neighboring Farms
- Lumber mill
- We only sell eggs
- Forest land: haven't needed to sell in a while.
- We trade our hay to the farmer for cutting it.
- Donate products to non profits to sell as fund raisers
- Horses are sold to client and other outside customers. Hay is consumed by stock
- Direct to consumers, through word-of-mouth, pick-up is at our home
- I do not grow anything for sale
- Hay is baled by a local farmer

10 to 14.9 acres		15 to 29.9 acres		30 to 49.9 acres		50+ acres		Unknown		Not applicable		Total
0.00%	0	0.00%	0	0.00%	0	0.00%	0	1.89%	1	94.34%	50	53
0.00%	0	0.00%	0	0.00%	0	0.00%	0	1.96%	1	96.08%	49	51

8 Please estimate the amount of your total household income supported by your farm or orchard (Select one.)

Answer Choices	Responses	
None	54.93%	39
Almost none	29.58%	21
Less than half	9.86%	7
Most	1.41%	1
All	4.23%	3



Image Credit: Westward Orchards

9 Which of the following have the largest impacts on your success? (Use the numbers 1 to 5 to rank each)

	1 - Most important		2 - Important		
Land use regulations, such as zoning	39.29%	22	21.43%	12	
Labor regulations	3.70%	2	11.11%	6	
Food safety regulations	11.54%	6	11.54%	6	
Pesticide notification laws	16.36%	9	14.55%	8	
Pest control	22.22%	12	31.48%	17	
Extreme and variable weather	51.72%	30	34.48%	20	
Weekend weather conditions	16.98%	9	32.08%	17	
Market volatility	3.64%	2	12.73%	7	
Crop failure	24.53%	13	26.42%	14	
Insecure land tenure	1.92%	1	9.62%	5	
Local tax structure	25.00%	14	26.79%	15	
Equipment purchasing and/or maintenance	11.11%	6	33.33%	18	
Increased operation costs (e.g., fuel, electricity, hourly wage, insurance)	12.73%	7	18.18%	10	
Cost of mitigation (e.g., irrigation, row covers/hoop houses, increased use of pesticides and/or fertilizers)	7.27%	4	25.45%	14	
Succession planning	5.56%	3	12.96%	7	
Full-time labor shortages	1.89%	1	5.66%	3	
Part-time labor shortages	3.70%	2	7.41%	4	
Recruitment, retention, and training of seasonal employees	0.00%	0	5.66%	3	
Other (please specify)					

Please specify:

- Increased deer pressure, including because commercial orchards qualify for fencing grants and I don't. Also can see impact of road salting on edge of orchard
- Indiscriminate pesticide use
- Availability of water.
- I do not have a commercial operation

impact in terms of importance, with 1 being most important, and 5 being not important.)

	3 - Neutral		4 - Less important		5 - Not important		Total	Weighted Average
	14.29%	8	1.79%	1	23.21%	13	56	2.48
	14.81%	8	3.70%	2	66.67%	36	54	4.19
	15.38%	8	7.69%	4	53.85%	28	52	3.81
	16.36%	9	10.91%	6	41.82%	23	55	3.47
	20.37%	11	7.41%	4	18.52%	10	54	2.69
	6.90%	4	0.00%	0	6.90%	4	58	1.76
	18.87%	10	3.77%	2	28.30%	15	53	2.94
	18.18%	10	5.45%	3	60.00%	33	55	4.05
	11.32%	6	11.32%	6	26.42%	14	53	2.89
	11.54%	6	5.77%	3	71.15%	37	52	4.35
	8.93%	5	3.57%	2	35.71%	20	56	2.98
	18.52%	10	5.56%	3	31.48%	17	54	3.13
	21.82%	12	12.73%	7	34.55%	19	55	3.38
	20.00%	11	14.55%	8	32.73%	18	55	3.4
	20.37%	11	9.26%	5	51.85%	28	54	3.89
	15.09%	8	5.66%	3	71.70%	38	53	4.4
	18.52%	10	7.41%	4	62.96%	34	54	4.19
	20.75%	11	3.77%	2	69.81%	37	53	4.38
							4	



Image Credit: Dunroven Farm

10 What could the Town of Harvard do to support your viability?

- Stop salting roads and Help stop Devens-Barnum Road area in particular and other abutting areas especially the major Train Cargo/Truck Distribution area and the Output of Waste, Gases, Noise, Pollution
- Tax breaks for farms less than five acres in size
- Clarify regulations related to the use of home kitchens vs commercial kitchens for the sale of products like hot pepper/fruit jam. Is this regulated by state or local jurisdiction. Rules are not easy to find or decipher
- Work to preserve water for households and agriculture over lawns. Minimize salt use on roads whenever possible
- Property taxes in Harvard are a big expense for us as an agricultural business. Not sure if there are ways the town could create a different tax structure that would lessen this burden. While we do have land listed in chapter 61A, we also have a farm store, storage buildings, seasonal labor camp and several residences that management reside in year round. The current (and predicted future) tax rate is not something that will sustain an agricultural business. It is something we have great concerns about when thinking about the town of Harvard and our viability
- Ban neonicotinoids
- Allow farm use buildings & not make them commercial use
- Not build a new school
- The 61A tax relief is nice, those support farmers well. It is tough to be a farm in a town that has gotten more and more developed, urban, and progressive. Example - laws regulating things like the particular size/dimensions of a driveway. Makes sense in an urban setting, not on a farm. Driveways aren't permanent on land that is farmed, they get moved to go around farming activities
- Keep on the steady course that they are currently on
- Nothing
- Reduce property taxes
- Keep my forestland as Chapter 6
- Limit or ban pesticides harmful for pollinators
- Help people who have less than five acres with tax incentives
- continue carbon footprint reduction
- Tax breaks, year round signage, tractor crossing signs, advertising local farms, make conservation land available farmers, free water testing of ponds and wetlands (water we use for irrigation)
- We, as a small farm, must be included in the town's agritourism overlay district. This is mission-critical for our farm's viability. We also would like to receive strengthened town elder support for both commercial hemp and cannabis
- Implement town-wide water use guidelines, specifically banning lawn irrigation when drought conditions occur, setting vehicle idling limits (in front of The General Store, or at Prospect Hill pull-over)
- Less stringent regulations on land use
- Help finance a shallow well in the Community Garden on Littleton Rd
- Give permission to firewood folks to harvest selected trees on conservation properties

- Continue to understand that horses are, or can be, a viable agricultural product. In addition it keeps lands in agricultural usage which could change to other products (ie..food products) over time but without this current usage that hold the land open then the land might fall into development which would forever remove those options
- Do not require Farm Stands to be subject to § 125-39, Site standards. Allow small agricultural operations to have roadside stands not subject to standard setbacks
- Lower our taxes
- Have tree warden consult for proper management of woodland/farming balance
- Offer water testing recommendations because of the weird water in Harvard--what is “normal” here
- Offer tips for gardening and lawn management without pesticides or limited pesticide use. Set goals so town residents can aim for those targets
- Maintain what we have in laws and reg[ulations] that make it easy to do this without unreasonable restriction or limits
- Lower my taxes
- Assure zoning is compatible with continued - and even expanded - agricultural uses
- Mitigate snowmobile use on conservation land as this type of pollution (noise and air) contributes to the destabilization of the natural environment supporting the whole ecosystem that makes farming possible in Harvard
- Decrease unwarranted land use regulation
- Cull the deer. Encourage foxes to kill the voles



Image Credit: Westward Orchards

11 The following is a list of some weather challenges that farms and orchards in the Northeast have experienced. Rank each challenge in terms of concern, with 1 being the least concern and 4 being the most concern.

	1 - No Concern		2 - Little Concern		
More frequent saturated soils and ponded water	13.56%	8	13.56%	8	
More frequent river flooding events	49.12%	28	15.79%	9	
More frequent flash flooding	37.50%	21	23.21%	13	
More frequent erosion	28.57%	16	32.14%	18	
Loss of nutrients due to heavy and abundant precipitation	17.86%	10	16.07%	9	
More frequent crop diseases related to weather	14.04%	8	7.02%	4	
Longer dry periods or drought	12.28%	7	8.77%	5	
More frequent heat stress on my crops	16.36%	9	12.73%	7	
More frequent or new pest pressures related to weather (e.g., insects, fungus, disease)	16.95%	10	3.39%	2	
More frequent or new weed/invasives pressure related to weather	15.79%	9	10.53%	6	
More frequent stress/runtime on cold storage/refrigeration due to increased temperatures	55.56%	30	25.93%	14	
Reduced winter snow cover	26.32%	15	22.81%	13	
More frequent unpredictable seasonal temperatures (early bud break, early or late frosts)	12.28%	7	12.28%	7	
Wind damage	21.05%	12	24.56%	14	
Hail and ice storm damage	22.03%	13	16.95%	10	



Image Credit: Westward Orchards

rienced. When you think about the impact they have had on your own farm or orchard, how concerned are being no concern, and 4 being highly concerned.)

	3 - Some Concern		4 - Highly Concerned		Total	Weighted Average
	50.85%	30	22.03%	13	59	2.81
	26.32%	15	8.77%	5	57	1.95
	25.00%	14	14.29%	8	56	2.16
	26.79%	15	12.50%	7	56	2.23
	46.43%	26	19.64%	11	56	2.68
	43.86%	25	35.09%	20	57	3
	38.60%	22	40.35%	23	57	3.07
	41.82%	23	29.09%	16	55	2.84
	27.12%	16	52.54%	31	59	3.15
	35.09%	20	38.60%	22	57	2.96
	12.96%	7	5.56%	3	54	1.69
	40.35%	23	10.53%	6	57	2.35
	38.60%	22	36.84%	21	57	3
	35.09%	20	19.30%	11	57	2.53
	32.20%	19	28.81%	17	59	2.68



Image Credit: Westward Orchards

12 Have you made any changes on your farm or orchard because of an experience with, or concern about, any of these weather challenges? (Select one.)

Answer Choices	Responses	
Yes	34.48%	20
No	65.52%	38

13 If yes, what changes have you made?

Drainage

- None made to date/Not at this time/Not as of now.../None now/None yet
- No (six responses)
- Increased electrical supply for animals during winter months for water. Purchasing more hay to lay down over mud to allow animals dry areas to stand and lay
- To maintain fields, increased rotation and resting of fields
- We put in a well at the home farm this year with the help of a grant through NRCS
- Hay requires dry weather once cut until baled. No way to change that
- Trying to obtain more disease resistant varieties of trees
- Placement of crops to avoid spots where wind is bad
- More serious pruning. Rainwater storage (cisterns)
- Added more hives to make up for lost volume due to erroneous effort in eliminating plants that we introduced to support pollinators
- Increase in fungicide application to fruit trees
- Put energy into other on farm activities to bring in a profit
- Water drainage systems and the investigatory work to assess a new deep well and new aquaponics and aeroponic systems
- I'm very mindful of water use
- Using more compostables in my garden plot and raising beds to be above water that collects from heavy rains
- Improved drainage overall, increased mulching for water retention during dry times to decrease need for watering
- Changed where we garden and added water filtration to outside water lines. More often test soil quality
- Revised planting schedule. Variety selection
- Had to plant new plum trees bc of increased pest invasion killed trees
- No longer growing brassicas given need to frequently treat plants due to increased presence of cabbage moths
- Tree harvests have been delayed for months at a time due to weather issues (ground not freezing as it used to)

14 Are there any changes you are planning to make?

- Tree maintenance is expensive. Need a forestry plan. Hard work fighting the bittersweet, grapevine and poison ivy. Trying to selectively cull and removing be invasives.
- Drainage
- Attempting to clear more land at an increased elevation to allow better water drainage during rainy months.
- We are planning to scale down our apple production in 2019 due to the lack of financial return we have seen over the past couple years. We do plan to plant more vegetable crops, and have certain plots put into rotation.
- Down-size wholesale production due to falling price returns
- If we continue to eradicate pollen producing plants, we will be forced to quit
- Currently the orchard is planted with a variety of tradition peach trees. The white peaches were attacked by bugs and disease this year. I am currently researching to find more disease resistant species and will plant 6 - 10 trees in the spring
- Spray even more
- Installation of a greenhouse with aeroponic or aquaponic system along with a new deep well being dug.
- More raised beds
- Treat bees with medications I do not like to use. I have been organic for several years but hive losses not sustainable without treatments. One three pound nuc with queen coats \$125 plus.
- More cover crop use during the growing season. Grow more disease resistant varieties.
- We have considered eliminating more pine trees on property because they do not deal well with stress. All the elm trees died. So, we are looking at different kinds of trees to replace. This changes where we might place livestock on the property and where we garden
- Drip irrigation
- We're waiting for availability of low impact logging equipment in New England. Areas in the south have already adapted high flotation/low impact harvesters, feller-butchers, etc, but not locally



Image Credit: Westward Orchards

15 What changes would you like to make but can't?

- Likely will be restricted in what we will accomplish due to cost / we are not running a business and have not put land into forestry - we pay a high land cost even though land is not subdividable
- None at this time/No/None (2 responses)/NA
- Build a large barn to house animals with running water and electricity
- 1) reduce CO2 levels to 280 ppm (currently > 400 ppm); 2) remove all invasive fauna/flora (not counting humans!)
- Irrigation
- We need to do some farm maintenance projects, and update some mechanical equipment to more energy efficient models to help lesson our energy expenses
- Weather
- Get a profitable return on a per acre basis
- Solar panel installation
- Allow loosestrife, black locust, and knotweed etc. to exist in controlled areas or beekeeping will be lost
- Move forward to take advantage of the new agritourism overlay district
- Nothing comes to mind
- Easier access to water
- Additional help
- Cost of logging has gone up and ability to sell low quality wood for biomass fuel has gone down due to regulations barring or limiting biomass energy plants



Image Credit: Westward Orchards

16 Extreme weather events in recent years have affected my long-term farm/agricultural/forestry management goals. (Select one)

Answer Choices	Responses	
Not at all	20.00%	11
Somewhat	50.91%	28
Moderate	16.36%	9
Frequent	10.91%	6
Extreme	1.82%	1
Comment:		12

Comment:

- The ice storm caused a ton of damage to the trees and clean up is expensive. Last year wind and storms took down mature trees. Keeping up with forest maintenance is difficult
- No experience as we have been living in Harvard for only 1 year
- Increased rain caused us to not be able to split as much firewood as we needed. And our felled trees were covered in fungus and are not burning well due to the wet fall season this year
- Crop loss due to late April freeze. Crop loss due to Aug 4 hail storm. Presence of fire blight. Note -- abandoned orchards can harbor fire blight which can infect commercial and home orchards
- Every season we have to adapt on the fly when it comes to weather
- More tree blow down than before. Firewood from blown over or down trees than from harvested trees is a much higher percentage of my total crop
- Apple trees (Herman Macs) don't hold apples in You Pick seasons. Had to be cut down.
- More frequent ice/wind storms & less stable root systems have caused loss of large oaks, maples & pines
- Just a hobby, not goal oriented
- The drought alone 2 summers ago cost us over \$5500 with no state, or other, relief
- It has changed the water availability for our turn outs and the pasture turnouts grow less grass therefore requiring more supplied feed
- As I am not financially dependent on my crop, I can experiment with new techniques and risk losing a harvest

17 Is there anything else you'd like to share related to the content of this survey?

- I believe pond on property is used by Fire Dept for filling tanker. Neighbors have been drawing water from pond without prior permission. I may install gate to limit access in future.
- Decline in bee (native and honey) populations. Perhaps a school project to build native bee houses? Have you discussed safety of pick your own orchards from tick-borne disease? (maybe because most spray the populations are controlled -- education for visitors?) Outreach/education to town re protecting water supply (dangers of spraying, of flushing meds, of not caring for septic systems).
- It is a lovely sentiment to be looking into the effects of weather on farms/agriculture in town. I don't see the town being able to help agricultural businesses when it comes to weather related impacts, but this survey could be a good ice breaker for some bigger conversations.
- No (5 responses)
- We have seen great changes in our forest over the last 18 years. The hemlocks are mostly dead. A lot of trees have come down and continue to in bad weather. The soil is eroding and since we live on the pond, we fear more will end up in the pond and harming it. The loss of trees lets in more of the heat from the sun in the summer thus increasing energy use for air conditioning. We do have solar panels to help offset that need the best it can. Mostly, it is sad to see how much of the forest we are losing. The few apple trees we do have were diseased the last few years and we are not sure if they will come back and if climate change is the reason.
- Weather is causing more damage & increases in insect infestations.
- The Right-To-Farm policy is really not oriented to helping farms. It is used to protect the town. We need a major effort to help farms with the agritourism overlay district opportunity as well as embracing the cannabis cultivation and hemp cultivation market opportunities.
- Lastly, historic or heritage farms should also be supported from a cultural perspective which adds additional clout for agritourism effort.
- We need water use guidelines codified in Harvard!
- Over population of deer coupled with orchard fencing is driving deer to invade vegetable gardens. They are eating green bean plants and tomato plants. They are also carriers of ticks which is quite serious for outside workers.
- Happy you are doing this for our community!
- Resilience is important.
- Thanks for the opportunity to respond. There are several bee keepers in Harvard you should be aware of.
- Agriculture has always been a necessity in modern society, but it will be even more vital due to the effects of climate change. It's great to see that the town of Harvard is concerned what these effects are having and will continue to have on farmers and other agricultural operations in the future. I look forward to further steps the town plans to take to not only preserve, but to encourage and increase agricultural stewardship.
- These are good questions but it's important to take into consideration the broader landscape and what's adjacent to farms, downstream and downwind.
- I would have liked to see more questions related to how this particular town deals with agriculture and farming, not just climate related. Making it easier for farmers and forest owners to operate in an increasingly regulated environment would be welcomed.

Appendix B: All Community-Sourced Vulnerabilities and Actions

This section is a summary of the input received from both workshops. The raw material is provided in *Appendix E: Workshop 1: CRB Participatory Mapping* and *Appendix F: Both Workshops: CRB Matrices and Actions*. The agendas and presentations are provided in *Appendix D: Workshop Agendas and Presentations*.

Agricultural Workshop #1

Hazards

All Hazards Identified by Participants

- Excessive moisture/flood
- Extreme storm events
- Storm event timing
- Temperature variability
- Increased precipitation
- Weather extreme
- Temperature variation
- Pests! (Deer, gypsy moth)
- Invasive vegetation
- Inconsistent temperatures
- Precipitation Extremes
- Fire

Priority Hazards

- Variability and extremes in temperature
- Variability and extremes in precipitation

Strengths and Vulnerabilities

Vulnerabilities Related to Climate Change

- Above ground utilities/ Lower energy resilience
- Public Health
- Water quality (wetlands, water resources)
- Plant threats (invasives, leaf canopy, blight extension)
- Insect threats (invasives, pests, pollinators)

- Disease threats (blight, stress, animal diseases)
- Wildlife (increased predators, dispersers, climate status)
- Better road design/engineering
- Reduced production
- Contaminants (runoff and applications)
- Varietals not viable
- Crops
- Livestock

Existing Vulnerabilities, Not Related to Climate Change

- Lack of town water
- Well depth/water quality
- Lack of awareness
- Municipal fiscal sustainability/local tax structure
- Regulatory (assessing, zoning)
- Economic (tourism, limits to, local goods/services)
- Agricultural use of conservation lands
- Development surrounding
- Trees
- Tree undergrowth
- Storage
- Increase in minimum wage by 2023

Post-Meeting Survey

Did you find today's workshop helpful?

- Yes (5)
- Yes very much so
- Good Start!
- Yes: a good insight into issues that others are concerned about
- Yes helps sort out your thoughts
- Yes but frustrating
- Interesting
- Yes!

What did you learn that you didn't know?

- How forests are impacted and how they impact surrounding land
- That a lot of people have concerns that I do
- Deer population is 50% above level
- Agricultural use of conservation land an option?

- Good discussion of impacts to animal husbandry
- Some
- Specifics about the degree, kind, and location of farms in Harvard
- How different issues can interact
- Interconnectedness
- Little forest business in Harvard
- Maple sugar affected by deer
- Takes me time to get thoughts together! I'll email.
- A lot! The graphics were awesome from the survey. Discussion very informative.
- Temp graphics pictures and precipitation projections.

What did you want to learn that you did not?

- That it is going to be tough to resolve most issues
- More about helpful regulation for small commercial farms. Bylaws, regulations difficult to find
- What crop/varieties resources are there to accommodate climate change
- Actions to be done

What else would you like us to think about as we prepare for the next workshop?

- Help guide the discussion by framing the categories with some examples
- Narrow the concerns
- Drinking water supply threats?
- Financing
- I think we need several different maps that can be compared/contrast/analyzed to identify challenges/opportunities/resources here in Harvard
- Education and outreach to entire Town. How to teach Town about role of agriculture in Town's fabric/history?
- Ticks and mosquito risks for farm workers; heat risks, etc.; climate change and health risks for farm workers
- Any outside of Harvard entities that are stakeholders should be included. Sudbury Valley Trustees (SVT) and maybe Oxbow rep?
- Educate the Town government and Town citizens

Follow-up Calls with Farmers

Vulnerabilities Related to Climate Change

- Limited irrigation
- Standing water/soaked pastures
- Variability of temperatures in a single season
- Quality of hay, other feed

Existing Vulnerabilities, Not Related to Climate Change

- Decreasing margins
- Few distributors
- Increase in price of supplies (hay, packing boxes, etc.)
- Labor – supply, cost of
- Local regulations
- Property taxes
- Restrictions on agritourism
- State building codes
- Financing for mitigation/adaptation
- Need people to buy product
- Succession planning

Agricultural Workshop #2

What Are We Missing?: Vulnerabilities to Climate Change

- Disappearance of insects.
- Weather impacts when spraying can occur.

What Are We Missing?: Other Vulnerabilities

- Disconnect between new residents and existing population (social change)
- Shared information base and community understanding.
- Understanding of farm practices by new residents.
- Groundwater quality for agriculture and community health (Devens)
- Devens stewardship to leverage opportunities for Harvard.

Vulnerabilities, Strategies, and Partners

Temperature

Vulnerability		Strategies	Partners	Total Votes
A.	Disease threats to plants, animals (difference between organic and non-organic)	IPM	UMASS	1
B.	Reduced production Varietals not viable	Education	UMASS	

Vulnerability		Strategies	Partners	Total Votes
C.	Invasives – plants, wildlife, pests (difference between organic and non-organic) W.I. ticks (regional problem), mice	Systems Education, deer fencing- comprehensive regional strategies land stewardship- collective, No bird feeders near homes	Town, Individual Owners, States	6
D.	Threats to/loss of pollinators Outside companies spraying for mosquitoes, ticks	Regulations- don't allow during day (timing) Public Education - Neonix awareness of context-day-year. Pollinator Gardens – school program native bee houses.		7
E.	Stress from heat/ cold variation within a single season	Smudge pot for small farms		
F.		Regional Education Strategy	Communities	4
G.	Abandoned Apple Trees harbor disease/pests	Education monitor		
H.		Settlement patters/ hazards, Collate strategies for small N.E. Towns.	State	7
I.		Burdens/Challenges as opportunities (Ayer Road)		6

Precipitation

Vulnerability		Strategies	Partners	Total Votes
A.	Disease threats to plants, animals (difference between organic and non-organic)	Soil health, Inter-planting		8
B.	Runoff of contaminants into water supply/wetlands	Tamper roads, Vegetative buffers, Stone vs log erosion control	Town	3
C.	Reduced production – amount and quality varieties not viable	Education		
D.	Super-saturated fields/ pastures	Raised beds		
E.	Lack of water at the right time (limited irrigation, well-depth)			

Vulnerability		Strategies	Partners	Total Votes
F.	Stress from drought/flooding at different times of the year	Community water bank, AG. Liaison for expert consult	NRCS, UMASS Extension, Local Experts	3
G.	Weather impacts on spraying			
H.	Erosion			
I.	Invasive species impact water pumping			
J.	Shorter planting season	Adjust crop according to growing period, Hoop house, Apples – Craft Southern Varieties, Nutrient sprays – Maganese – helps calcium uptake micro nutrients		
K.	<10 Acres Join forces	Forest management for CO2, Sequestration integration of management plans	Town, Public/private partnerships, UMASS, Amherst?, DAR/DEM	12

Economic/Market

Vulnerability		Strategies	Partners	Total Votes
A.	Labor – availability and cost	Visa flexibility, lobbying to feds (quotas, review times) Knowledgeable local labor, schools		1
B.	Reduced margins	Value-added products	Producers, partnerships	
C.	Increasing supply costs	Value-added products		
D.	Limited distributors/distribution channels	Limits to uses re: zoning, local networking/marketing.	Municipal	1
E.	People need to buy products	Agritourism (opportunities) buy local program % of local products? Consortium/Farm Business Association	State, supermarkets, school	3
F.	Property taxes/property assessment/difference between taxes on land vs. buildings	Land bank -> Preservation. Re-couple residential, commercial, R.E. Tax (exchange) rates and don't tax ag. Assets as commercial.	Local	9
G.	Financing	Dedicated % of tax		2

Vulnerability		Strategies	Partners	Total Votes
H.	Need to diversify income streams	Agritourism (zoning) (as economic development initiative) NVCC ??? Accommodations/hospitality integration where are commercial kitchens?	Local, producers, new group, chamber	
I.	Market Fragmentation	Agritourism/NVCC		3

Regulatory

Vulnerability		Strategies	Partners	Total Votes
A.	Local regulations (ex. Erosion control, zoning)	Bylaws w/ appropriate due diligence better sign bylaws – sign working group.	Town other specialty groups.	2
B.	Applicability of building codes to agricultural buildings (health)	Lobbying state for more reasonable ag. Regs.		5
C.	Agritourism – state or local control?	Bylaws -> state to local information flow and communication local lobbying - local to state.	Local – State – Resident population	7
D.	Need to preserve land in productive use			
E.	Lack of accessible information for producers	Make information available via typical channels (web, social media)	Local	2
F.	DEP regulations on farm stands (serving food)	Lobbying state		4
G.	Enforcement of bylaws (lighting)	Capt. America		

Other

Vulnerability		Strategies	Partners	Total Votes
A.	Succession planning	Transfer of development rights * open space design development. Holding land values down Chapter 61A enhance the economics.	Schools Municipal	4
B.	Lack of awareness about agriculture/agricultural needs in Harvard	Education/Outreach	Schools, Town, Ag. Comm.	6

	Vulnerability	Strategies	Partners	Total Votes
C.	Groundwater quality for agriculture (and others!)	Retain local H2O locally regulatory land stewardship education/awareness (leveraging, protective)		1
D.	Understanding of farm practices by new residents.	Facilitation, connecting community	Schools/town	
E.	Lack of shared information base about agriculture for the entire community.	Facilitation connecting community		5
F.	Devens stewardship to leverage opportunities for Harvard			1
G.	Largely volunteer town government.	Staffing and volunteer continuity (retreats) build a base of information, tools, etc. Build volunteer base		1

Post-Meeting Survey

Did you find today's workshop helpful?

- Yes
- Yes - what individual can do to reduce vulnerability; networking
- Yes, interesting
- Yes
- Yes /No. Conversation was okay. Sometimes relatable/relevant
- Yes

What did you learn that you didn't know?

- Regulations [?] our farmers
- Tips for better soil health, links to resources. Very important.
- I didn't know about the MVP program.
- A better understanding of vulnerability issues of concern to the community
- Not [?]. We already implement examples/suggestions presented
- Learned perspective/opinions/needs from farms that are different in size

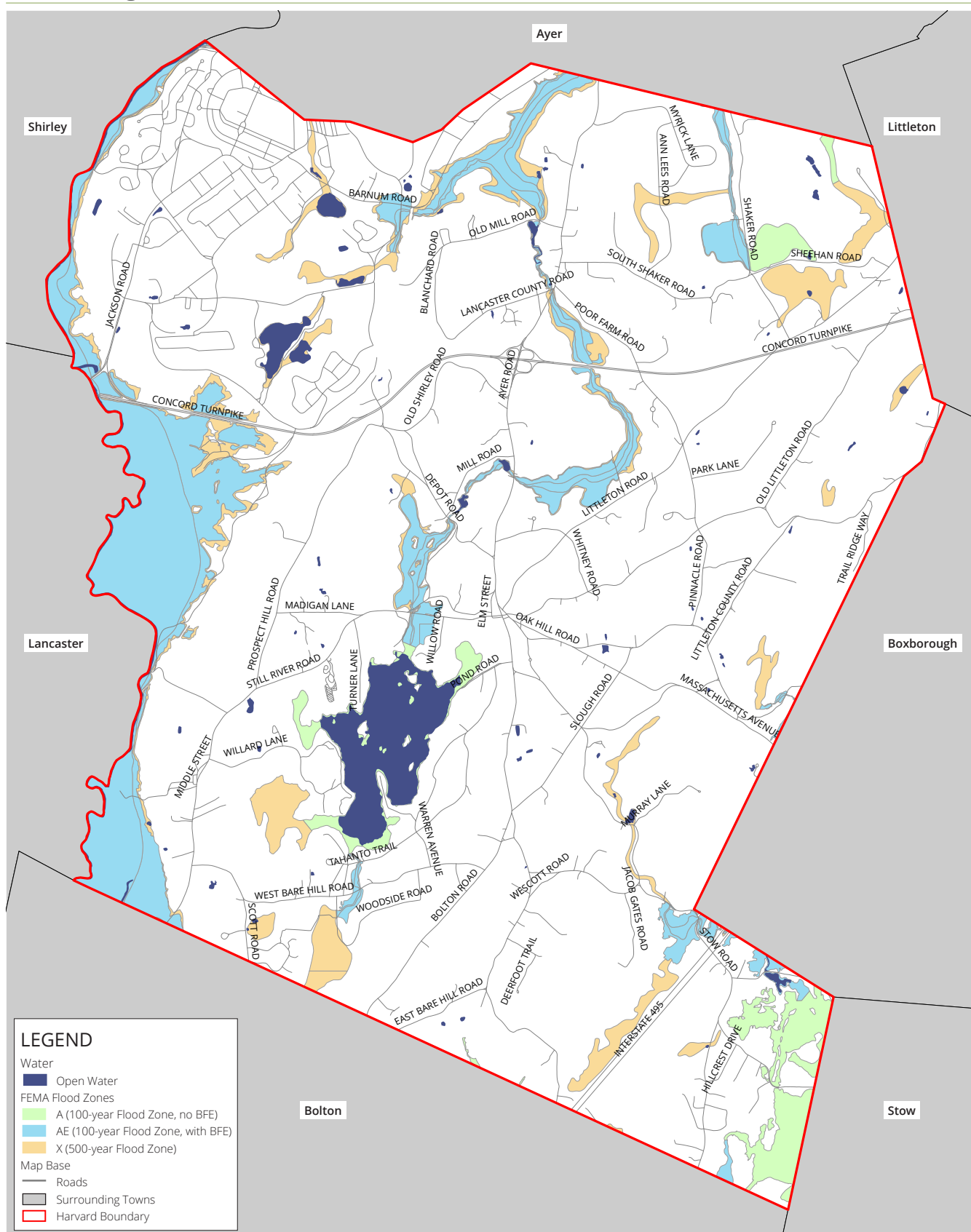
What did you want to learn that you did not?

- More info [on] water management as it relates to wetland.
- Actions that State of MA plans to take (what is in discussion?)
- More direct cost/successful implementations that are new/available

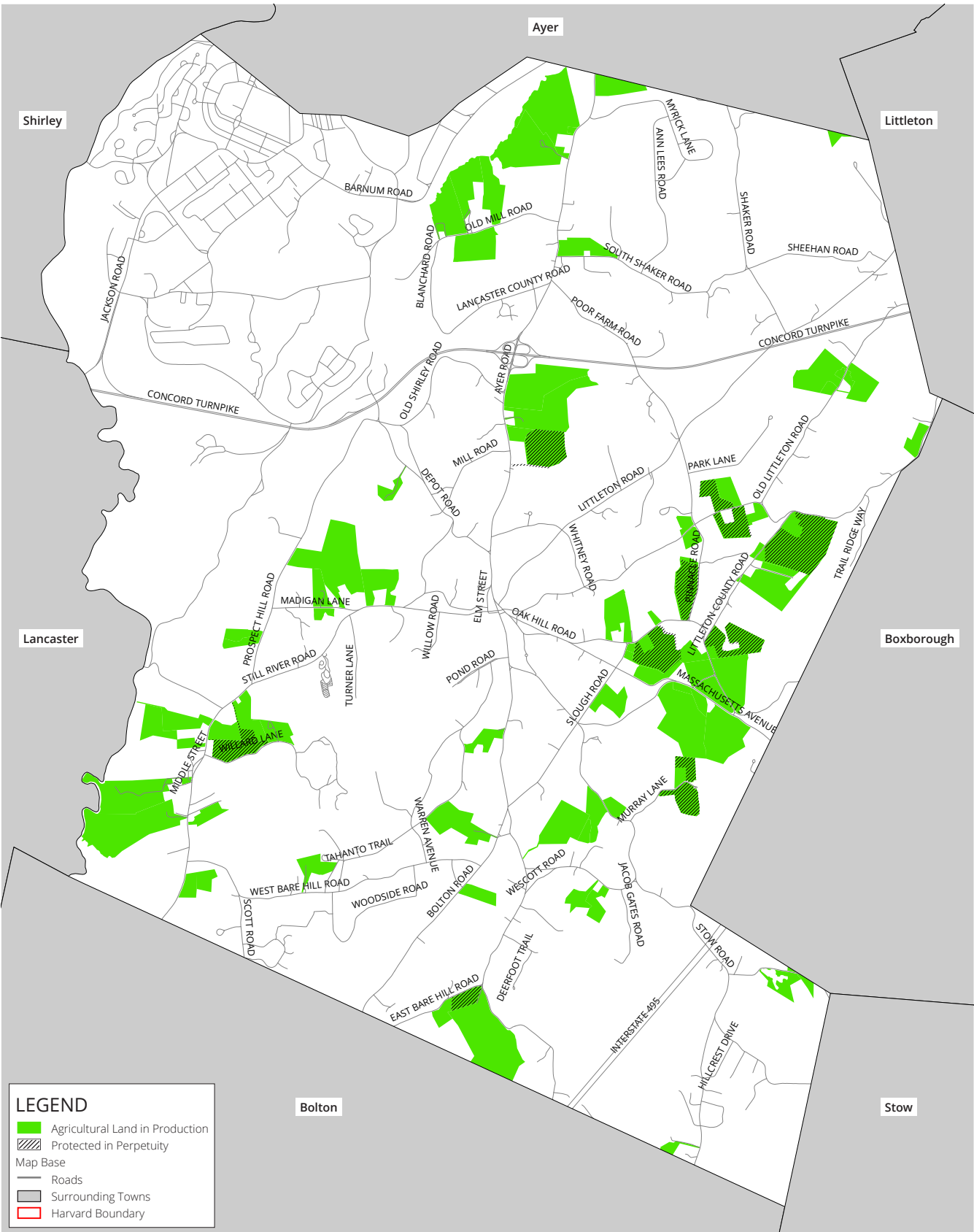
Appendix C: Preparatory Information

The following two maps are the base maps used during the first Agricultural Workshop.

Existing Conditions: Water and FEMA Zones



Existing Conditions: Agricultural Properties



Appendix D: Workshop Agendas and Presentations

This appendix contains the agendas and presentations for both agricultural workshops.



**Municipal Vulnerability Preparedness (MVP) Workshop
Agricultural Workshop #1
Agenda**

February 2, 2019

- 8:30 Registration
- 9:00 Welcome and Introductions
- 9:05 MVP Overview, Agricultural Workshop Process
- 9:20 Overview of Climate Change, Agriculture and Harvard
- 9:50 Questions and Answers
- 10:00 Small Group Exercise Introduction
- 10:10 Small Group Discussions
 - Introductions, identify person for report out
 - Characterize the hazards
 - Identify Harvard's vulnerabilities and strengths
- 10:45 Break
- 11:00 Continue Small Group Discussion
- 12:00 Small Group: Report Outs
- 12:20 Wrap up and Introduce Workshop #2

46 HARRIMAN DRIVE
AUBURN, ME 04210
207.784.5100

123 MIDDLE STREET
PORTLAND, ME 04101
207.775.0053

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PORTSMOUTH, NH 03801
603.626.1242

170 MILK STREET, SUITE 5
BOSTON, MA 02109-3438
617.426.5050

www.harriman.com



Harvard Municipal Vulnerability Preparedness Agricultural Workshop 1

February 2, 2019

HARRIMAN

February 2, 2019



Workshop Agenda

- 9:00 Welcome and Introductions
- 9:05 MVP Overview, Agricultural Workshop Process
- 9:20 Overview of Climate Change, Agriculture and Harvard
- 9:50 Questions and Answers
- 10:00 Small Group Exercise Introduction
- 10:10 Small Group Discussions
 - Introductions within the team, identify person for report out
 - Characterize the hazards
 - Identify Harvard's vulnerabilities and strengths
- 10:45 Break
- 11:00 Continue Small Group Discussion
- 12:00 Small Group: Report Outs
- 12:20 Wrap up and Introduce Workshop #2

February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Introductions

- MVP Core Group
 - Christopher Ryan, Director of Community and Economic Development
 - Liz Allard, Land Use Administrator/Conservation Agent
 - Eric Broadbent, Energy Advisory Committee
 - Justin Brown, Planning Board
 - Kerri Green, Agricultural Advisory Commission
 - Sharon McCarthy, Board of Health
 - Kara Minar, Select Board
- Harriman
 - Emily Keys Innes, Associate and Senior Urban Planner
 - Katie Moore, Urban Planner
- University of Massachusetts-Amherst
 - Professor Dan Cooley

February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop



Municipal Vulnerability Preparedness (MVP) Program Overview

What is the MVP Program?

- A component of MA Executive Order 569 (2016)
- Grant funding for technical support to
 - Complete vulnerability assessments
 - Develop action-oriented resiliency plans

Why is the Town Participating?

- Increasingly more unpredictable and severe weather is occurring
- Agriculture is a significant part of the town's composition and identity
 - Dedicated MVP component focusing on agriculture
- Completion qualifies Harvard for access to further grant funding

February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Workshop Process

- Prepare for the Workshop
- Characterize Hazards
- Identify Community Vulnerabilities and Strengths
- Identify and Prioritize Community Actions
- Determine the Overall Priority Actions
- Put it All Together
- Move Forward

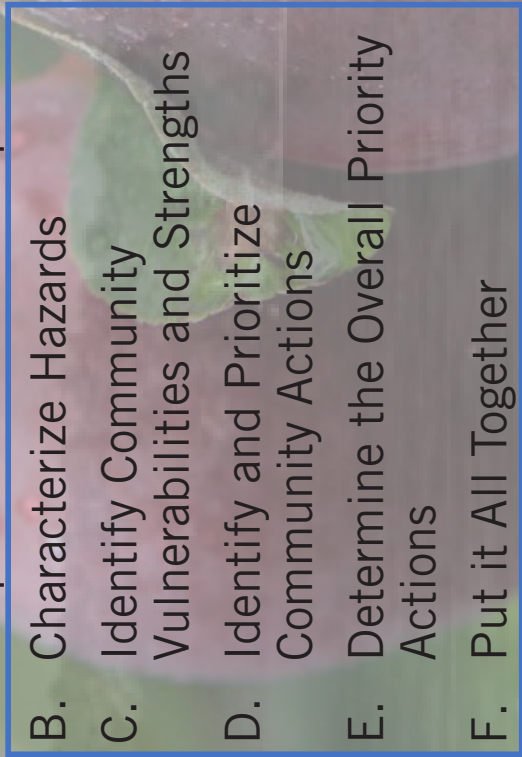
Community Resilience Building
WORKSHOP GUIDE

www.CommunityResilienceBuilding.com

Community Resilience Building Risk Matrix						Top Priority Hazards (roads, floods, wildfire, hurricanes, earthquakes, drought, sea level rise, heat waves, etc.)			
						PRIORITY	TIME	SEVERITY	LIKELIHOOD
						H-H-L	H-H-L	H-H-L	H-H-L
Features									
Infrastructure									
Social									
Environmental									

February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

- 
- B. Characterize Hazards
 - C. Identify Community Vulnerabilities and Strengths
 - D. Identify and Prioritize Community Actions
 - E. Determine the Overall Priority Actions
 - F. Put it All Together

[illegible]

Overview of Climate Change

- Climate change
 - A change in the state of the climate ... whether due to natural variability or as a result of human activity
- Natural hazard
 - Natural events that threaten lives, property, and other assets
 - Often can be predicted; they tend to occur repeatedly in the same geographical locations because they are related to weather patterns or physical characteristics of an area
- Risk
 - The potential for an unwanted outcome resulting from a hazard event
- Vulnerability
 - The propensity or predisposition to be adversely affected
 - A function of exposure, sensitivity, and adaptive capacity

A hazard is the sun.
The risk is sunburn.
The vulnerability includes the length of exposure to the sun, how sensitive the skin is to it.

Definitions from the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan*, 2018

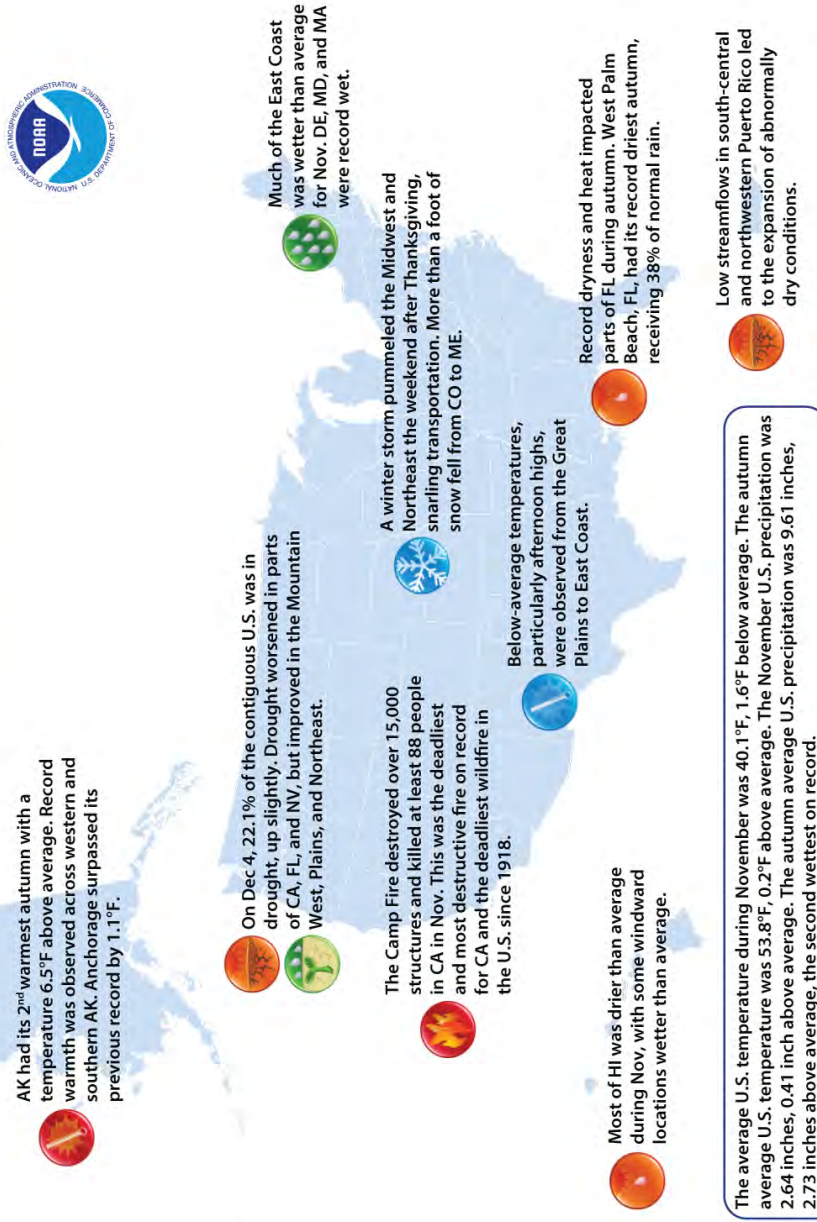
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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Overview of Climate Change - US

November 2018 was the 407th consecutive month with global temperatures above the 20th century average

U.S. Selected Significant Climate Anomalies and Events for November and Autumn 2018



Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: <http://www.ncdc.noaa.gov/sotc>

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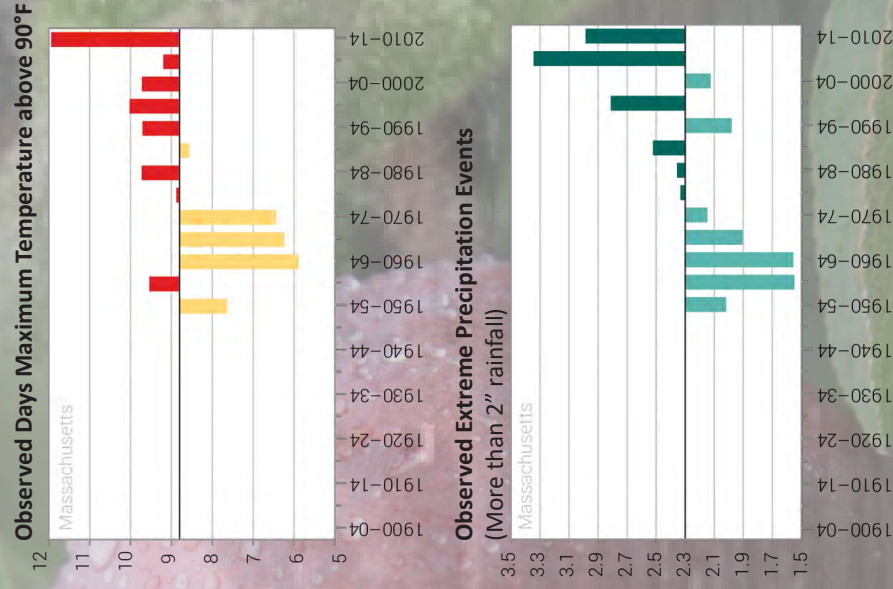
Overview of Climate Change - MA

- Average annual temperatures increased almost 3°F between 1900-2014
- Number of days maximum temperature was above 90°F has been consistently above average since the 1990s
- All precipitation metrics have been highest during the most recent decade of data (2005-2014)

Source: NOAA Technical Report NESDIS 149-MA, 2017

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop



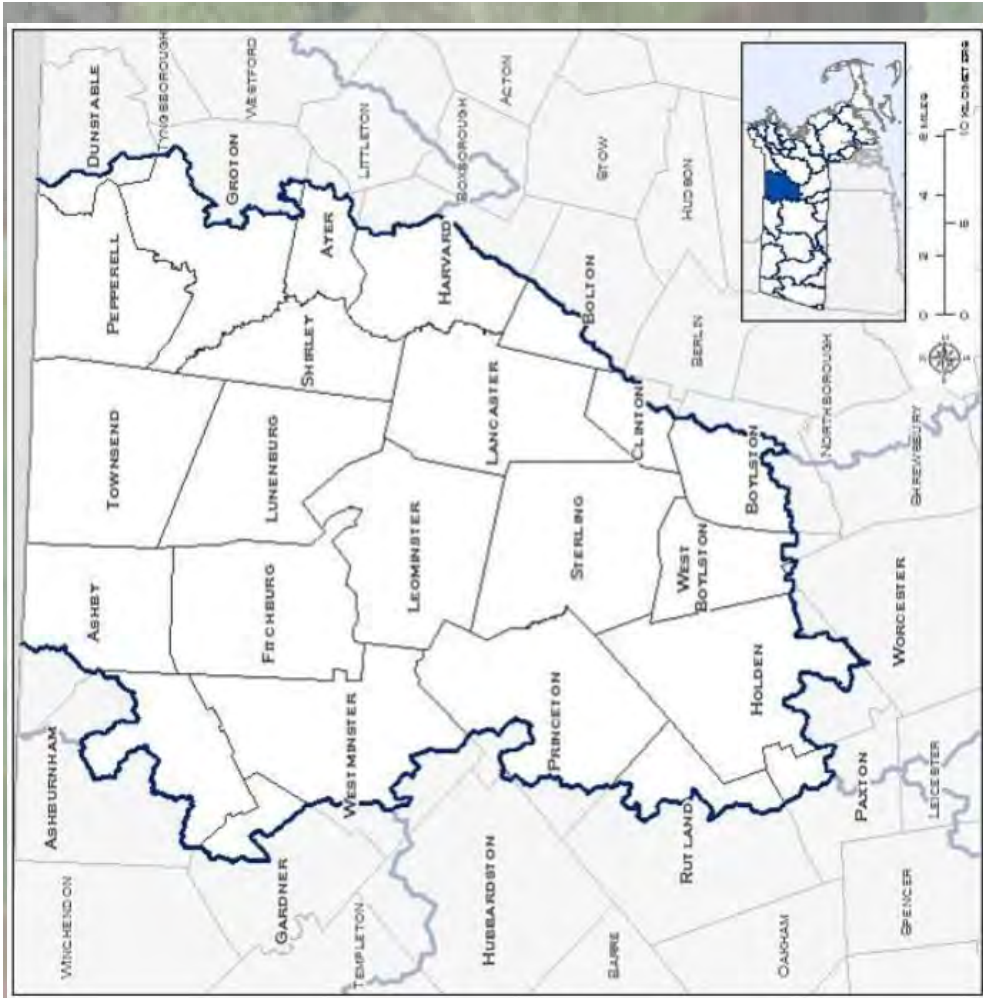
Overview of Climate Change - MA

- MA Executive Office of Energy and Environmental Affairs created a clearinghouse of climate science maps, data, documents (resilientMA.org)
- Projections from Northeast Climate Adaptation Science Center (e.g., temperature, precipitation)
 - “Downscaled” to major watershed basin (Harvard is in the Merrimack, Nashua, and Sudbury-Assabet-Concord (SuAsCo) Basins)
 - Temperature projections are more certain than precipitation

February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Overview of Climate Change – Nashua Basin



February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Overview of Climate Change – Nashua Basin

- Increased average, maximum, and minimum temperatures
 - Increased seasonal temperatures; winter is expected to see greater increases
- More days with extreme heat (daily maximum temperatures over 90°F)
- Fewer days with daily minimum temperatures below 32°F

	Baseline (1971-2000)	Mid-century (2050s)	End of Century (2090s)
Average annual temperature (°F)	46.8°F	+ 3.0 to 6.4°F	+ 3.9 to 11.0°F
Annual days max temperature >90°F	4 days	9 to 30 more days	13 to 70 more days
Annual days min temperature <32°F	156 days	19 to 38 fewer days	23 to 64 fewer days

Source: resilient MA, 2018

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Overview of Climate Change – Nashua Basin

- Number of days receiving over 1” precipitation are variable; winter is expected to see the highest increase
- Winter is expected to see the greatest change in precipitation (increase 2-22% by 2050s, increase 6-39% by 2090s)
- Fall and summer are expected to continue to have the most consecutive dry days

February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Agriculture and Harvard



February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop



Small Groups

1. Team introductions: Name, organization/department
2. Identify a spokesperson (not the facilitator)
3. Characterize the *top 4 priority hazards* for agriculture in Harvard
4. Identify *community vulnerabilities and strengths*
 - “Features” in each category of infrastructure, society, and environment.
 - List of key assets and infrastructure applicable to each category
 - Describe location for each asset and infrastructure
 - Identify ownership
 - Identify each “Feature” as a vulnerability or strength.

Identify Community Vulnerability and Strengths

- Infrastructural
- Societal
- Environmental

Community Resilience Building Workshop Risk Matrix						
H, M, L priority for action over the Short or Long term (and Ongoing)						
V = Vulnerability, S = Strength						
Features	Location	Ownership	V or S	Top 4 Hazards (tornado, floods, wildfire, hurricanes, snow/ice, drought, sea level rise, heat wave, etc.)		
				Coastal Flooding SLR/Storm Surge	Inland Flooding and Rain Events	Ice and Snow Wind
Infrastructural						
Town Campus	Specific	Town	V			
Evacuation Routes - Roads	Town-wide	Town/State	V			
Nursing Homes/Elderly Care Facilities	Multiple	Private	V			
Homeowners Associations/Neighborhoods	Town-wide	Town/Private	V			
Electrical Distribution System	Multiple	CL&P/Town	V			
Dams (Inland and coastal)	Multiple	Private	V			
Railway and State Bridges	Multiple	Ambak/State	V			
Septic Systems	Town-wide	Private	V			
State Roads/Intersections	Town-wide	State/Town	V			
Wharves and Shore Infrastructure	Shore	Town/State-Private	V			
Waste Water Treatment Facility	Specific	Town	V			
New Ambulance Center	Specific	Town	S			
Zoning Regulations (maintain large lot size)	Multiple	Town	S			
Business District (power generators)	Specific	Town/Private	S			

Report Out from Small Teams



February 2, 2019

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Next Steps

Workshop #2

March 2, 9:00am-12:45pm

- Review related experiences of agriculture in other areas
- Develop actions that further reduce the impact of hazards and increase resilience across and within Harvard
- Prioritize the actions

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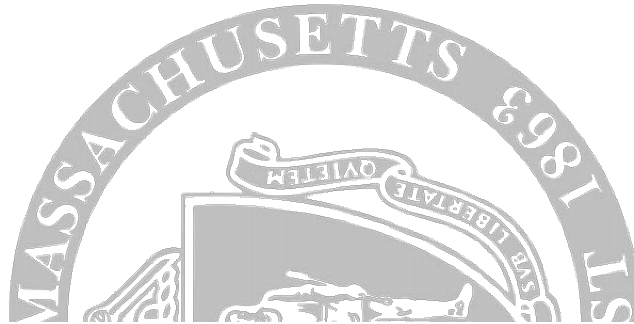
Harvard Municipal Vulnerability Preparedness (MVP) Workshop

Climate Change and Agriculture in Harvard MA

Harvard Municipal Vulnerability Preparedness Agricultural Workshop I

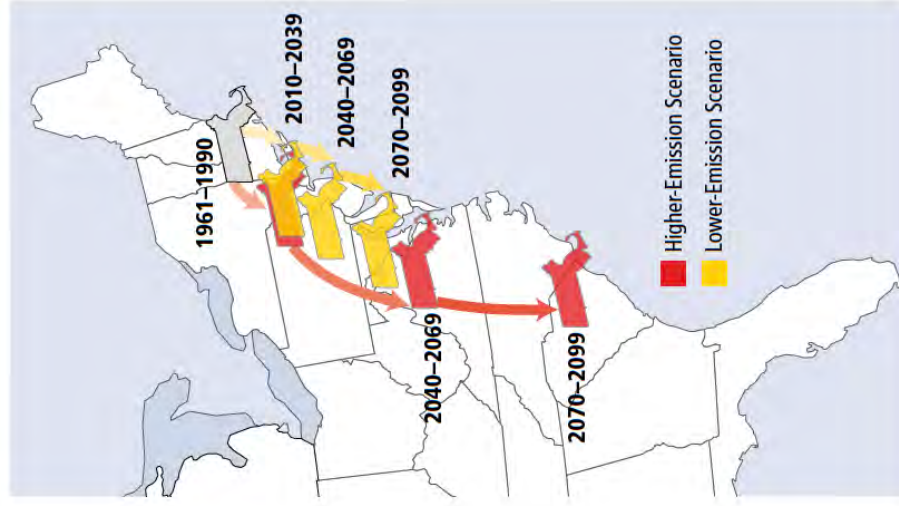
February 2, 2019

Daniel Cooley
Stockbridge School of Agriculture
University of Massachusetts Amherst



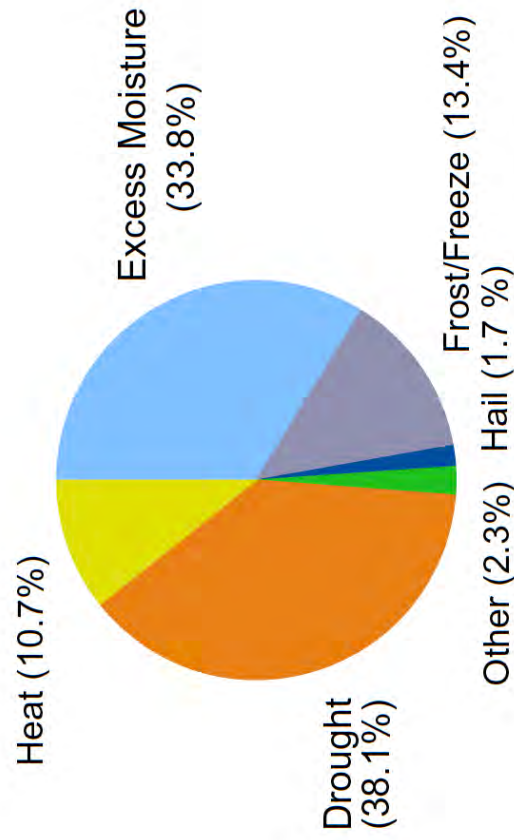
The basic problem

- Climate is changing
- Impacts average temperatures and precipitation
- Impacts weather patterns – more extremes
- Both will impact what we grow and how well we grow it in MA
- Not as simple as switching from apples to oranges



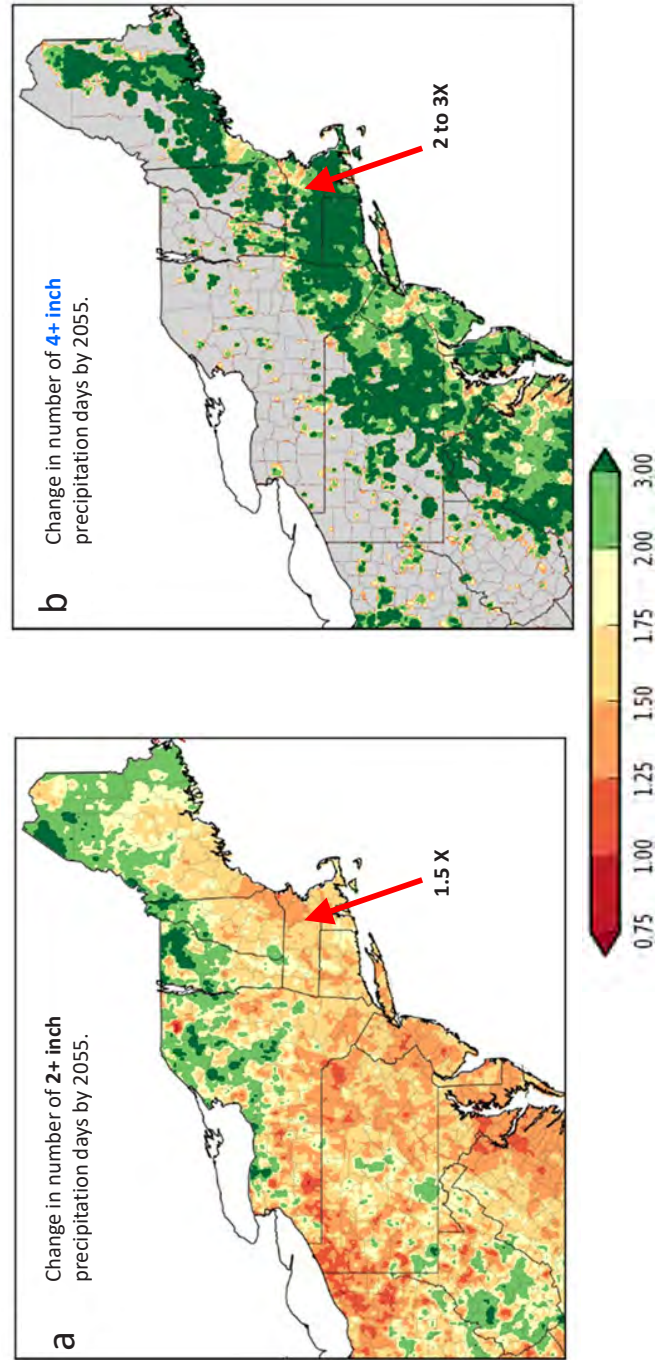
Climate change impacts on Northeast agriculture

- 2013-16 snapshot of weather-related crop loss
- About 1/3 of losses caused by excess precipitation
- An increase of 71% in extreme precipitation events since mid-1990s.



Weather-related crop loss reported to USDA for all crops in the Northeastern US 2013 – 2016. From Wolfe et al 2018.

More extremes in precipitation



1.00 = no change. 1.50 = 50% more days. 2.00 = Twice as many days.

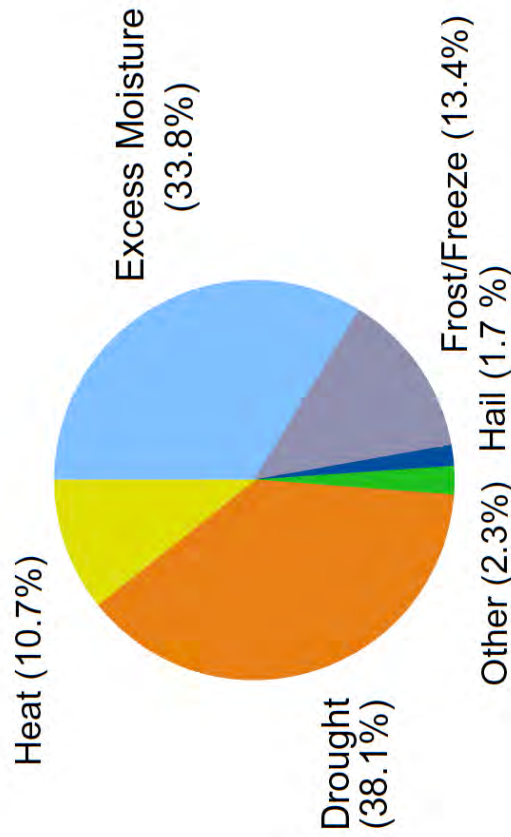
More extreme rainfall

- Root suffocation
- Increased root diseases from fungi
- More crop diseases e.g. potato and tomato late blight, apple scab
- Soil erosion
- Runoff of sediment, chemicals, animal manure to surface water
- Planting delays due to wet soil - shortens the growing season even if “frost-free periods” lengthen
- Requires more drainage, other mitigation for soil and surface water



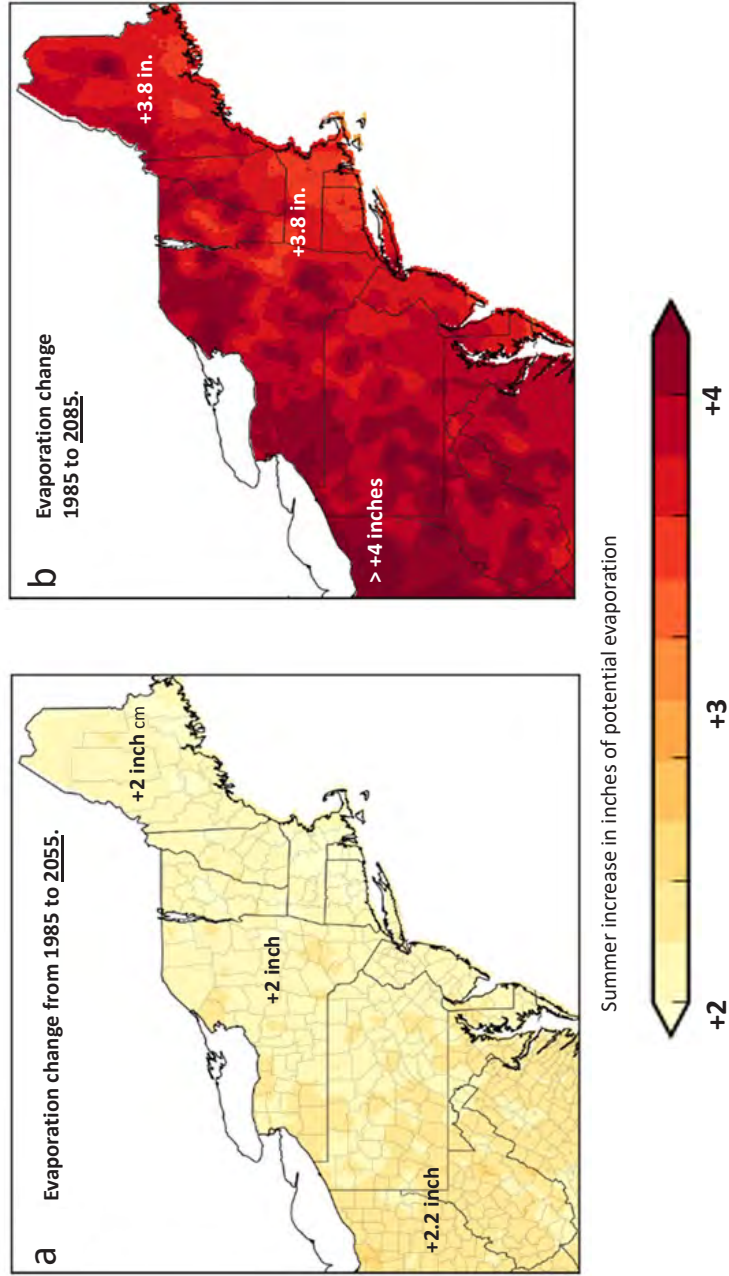
Drought

- About 40% of crop loss in 2013-16 caused by drought – data skewed by severe 2016 drought
- High-value fruit, vegetables and ornamentals already require irrigation
- Projected higher evapotranspiration, plus steady or decreased summer precipitation, plus precipitation concentrated in high-rainfall events would increase the need for water storage and irrigation



Weather-related crop loss reported to USDA for all crops in the Northeastern US 2013 – 2016. From Wolfe et al 2018.

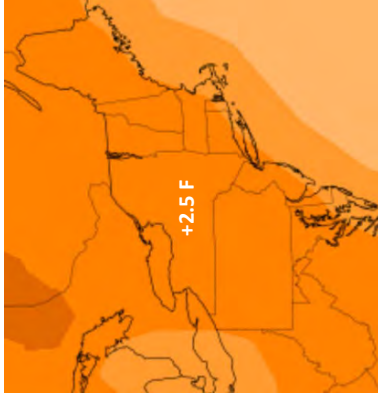
Increased risk of short-term drought



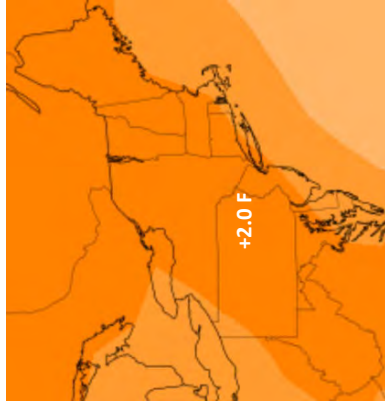
Summer heat stress

- About 11% of losses in study related to heat, including higher night temps, as well as extremes
- Higher night temps > lower yields
- Projected 3 to 4°C (5.5 to 7°F) increase in summer max and min
- Warmer temps change quality of some fruit and vegetables, e.g. firmness decreases, more grainy texture
- May allow insects, diseases to survive better

Change in seasonal average temperature, from 2017 to 2047



Summer Jun., Jul. Aug.



Fall Sept., Oct., Nov.

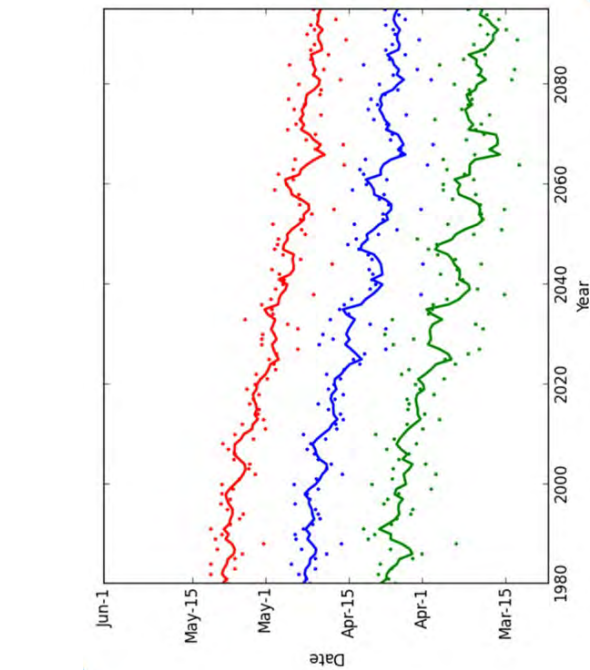
Frost and freeze damage

- Warmer winters and springs will lead to earlier bloom in perennial crops, e.g. apples, peaches, grapes
- For example, 2012 apple bloom 3 to 4 weeks earlier than historical norms – followed by several frosts
- After warm weather in Jan. and Feb. 2016, severe freeze killed peach crop in southern New England



Frank Carlson surveys lost peach crop from Feb. 2016 freeze. Frost damaged flowers on apple above right, and flower bud killed by freezing left.

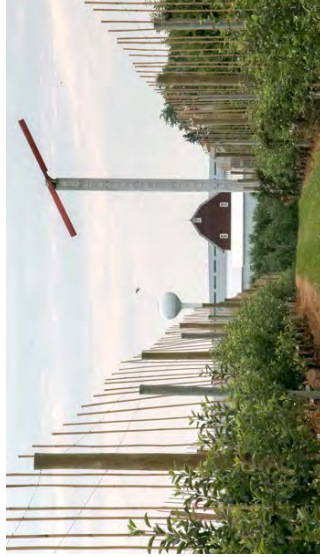
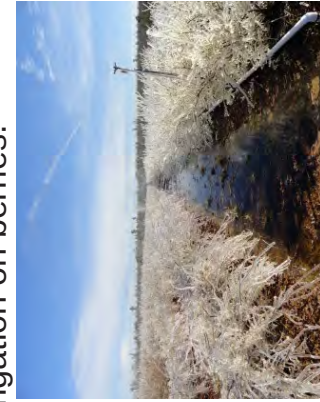
Complicated relationship between chilling, early season, frost



Oil-soaked hay bales also used for frost. Overhead irrigation on berries.

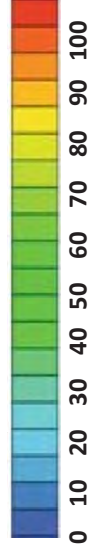
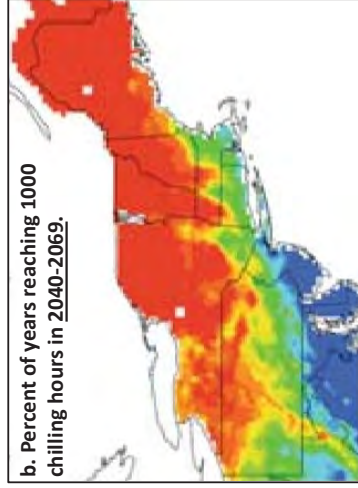
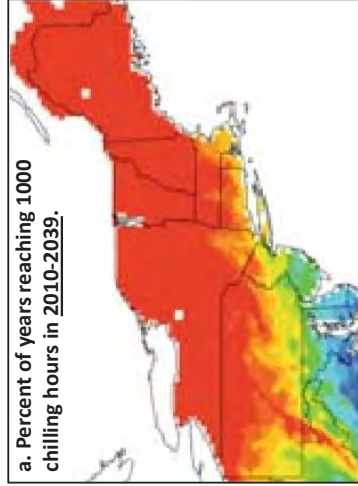


In some frosts, mixing air using a wind machine or helicopter helps. Maybe drones? Tractor mounted heater can also be used.



Change in chilling hours

- Perennial crops require cold during their winter dormancy
- Once fulfilled, they can lose cold tolerance
- If not fulfilled, they won't grow normally
- Southern New England now gets 900 to 1000 hours, but this is projected to drop significantly > changes in varieties, maybe crops



Projected percentage of years during 2010-2039 when a 1000 hour winter chill requirement will be met. Adapted from Wolfe et al. 2008.

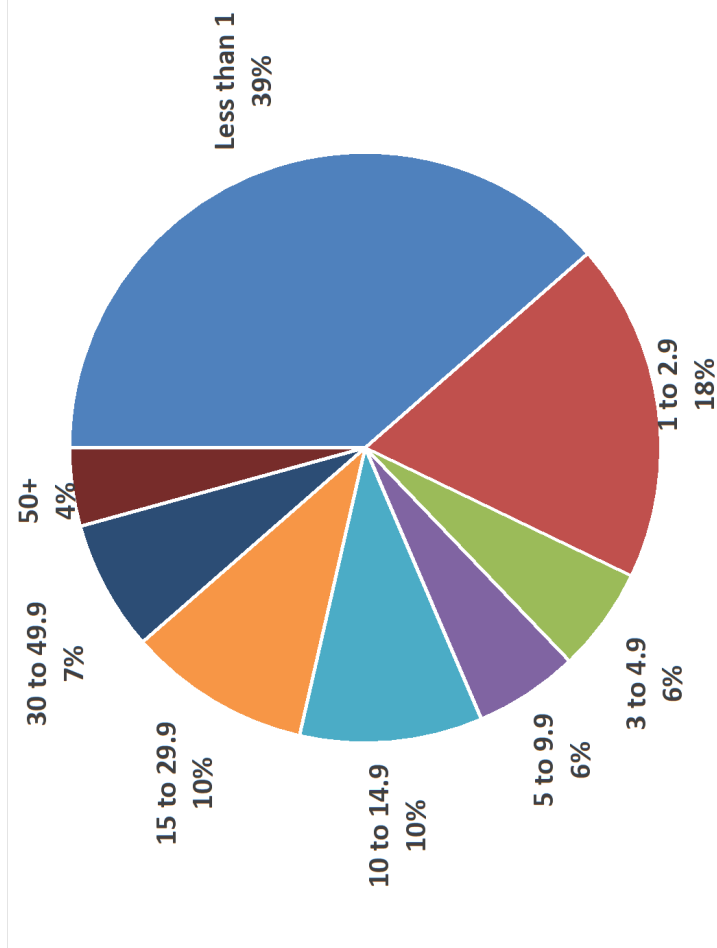
Harvard agricultural survey

- Gather information about who is involved in agriculture in Harvard
- What is being produced
- What are the issues related to agriculture, particularly climate-related issues, as far as farmers are concerned



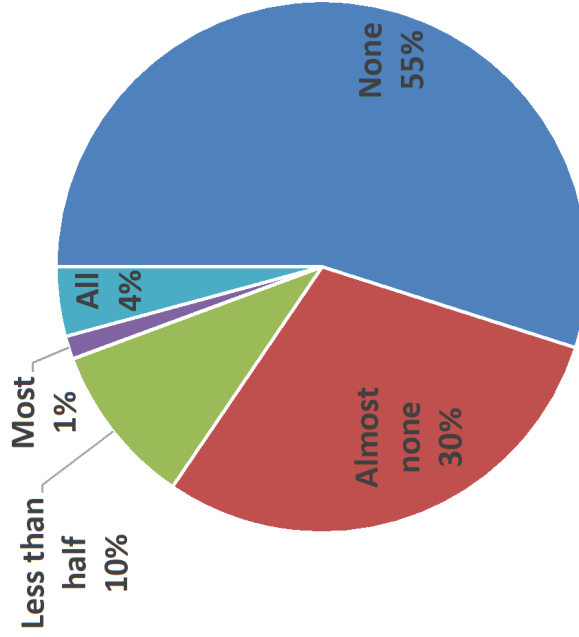
How many acres do you have in production during your growing season?

- Of 70 responding:
- Highest category less than 1 acre, 39%
- Most production on less than 3 acres, 57%
- Lowest category 50 acres or more, 4%
- About a third of production on parcels over 10 acres, 31%



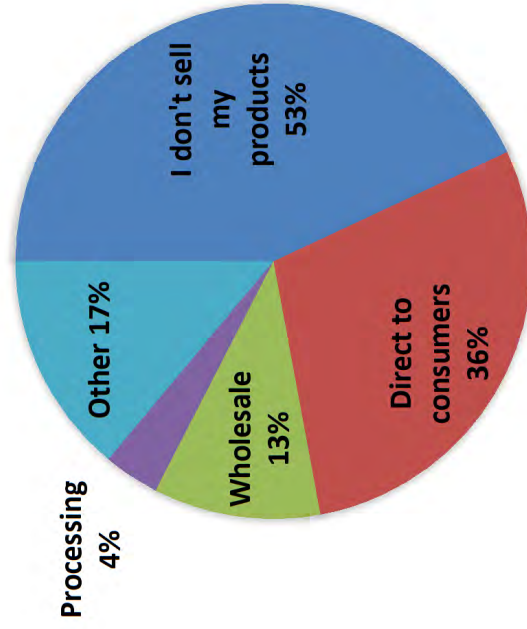
Amount of total household income supported by farm or orchard

- Of 70 responding:
- Over half report none, 55%, and 85% report none to almost none.
- Only 5% report most or all.
- Conclusion: most respondents are doing small-scale, hobby farming



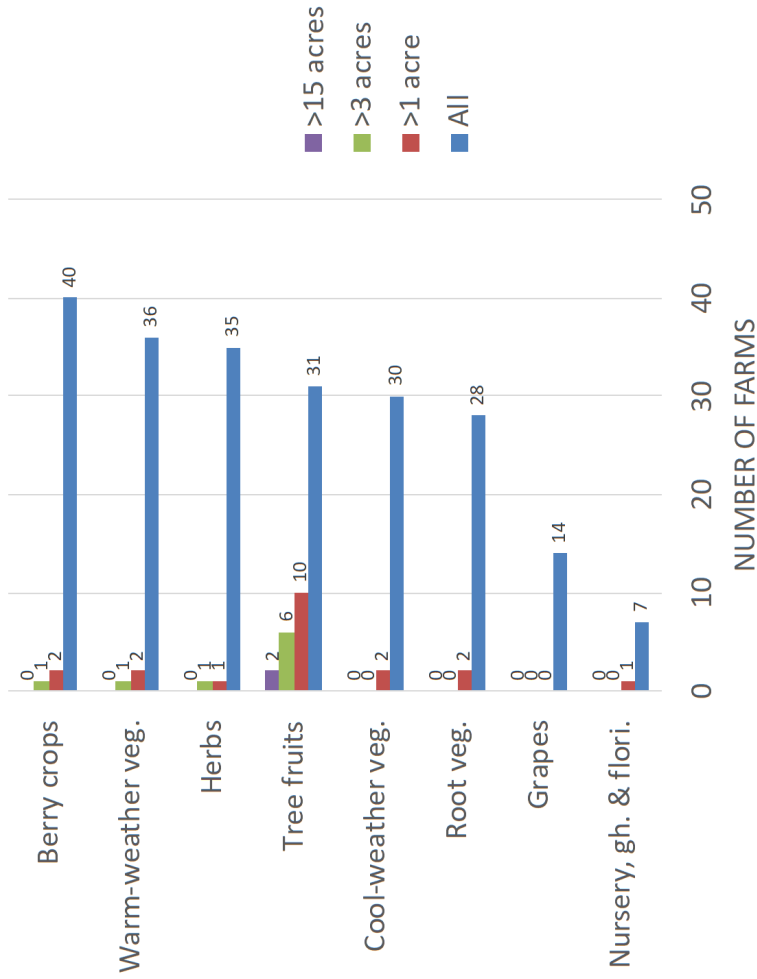
How do you sell your products

- Of 70 responding:
- Over half report don't sell products
- Direct sales are most important for those who do
- Other
 - Use hay for feed or have another farmer use it
 - Haven't needed to sell wood
 - Personal use, give away



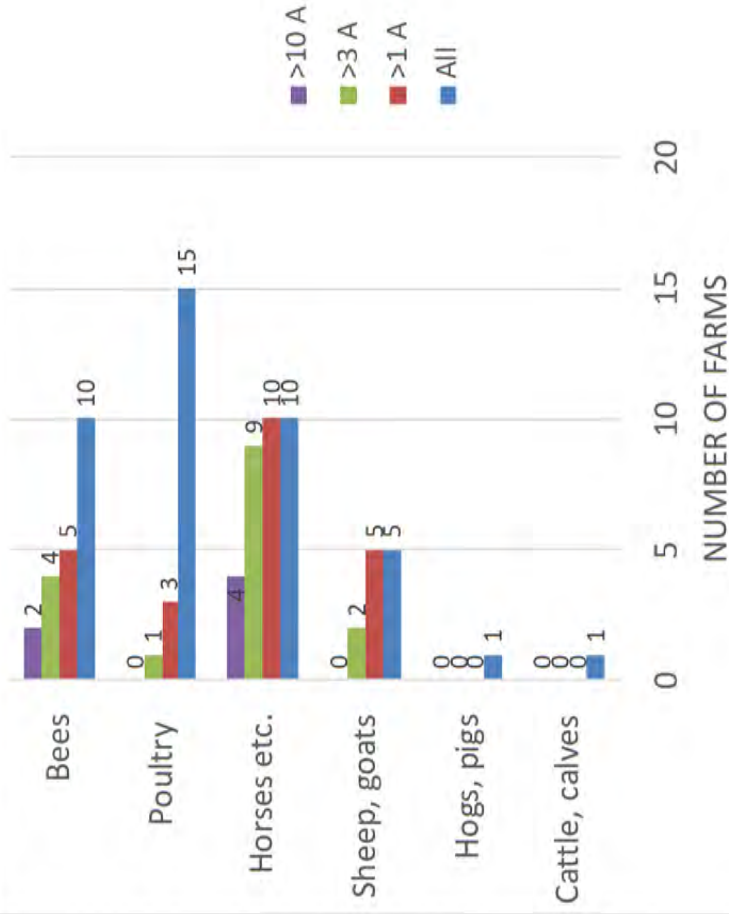
Acres of fruits, vegetables and other horticultural products

- Most respondents produce berry crops, warm-weather vegetables such as tomatoes, herbs, tree fruit and other vegetables
- Most larger farms produce tree fruit
- Production over 3 acres limited to tree fruit, warm-weather vegetables, berries and herbs.



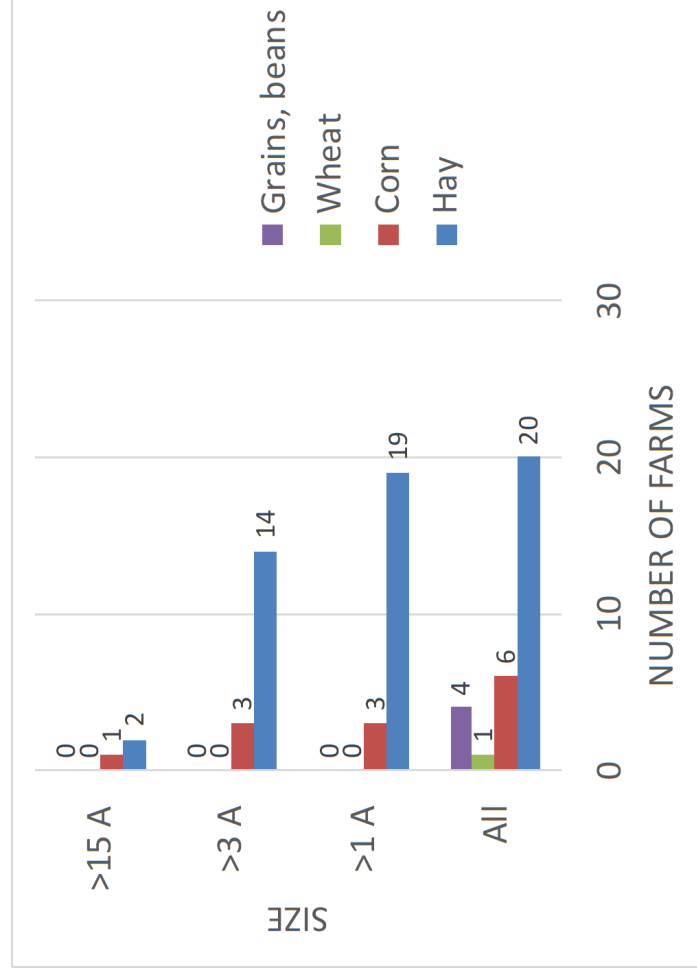
Animal agriculture

- Chickens, horses, sheep & goats, and bees are most important
- Horses dominate in farms over 30 acres
- No animal agriculture over 30 acres
- So horse farms are between 3 and 30 acres



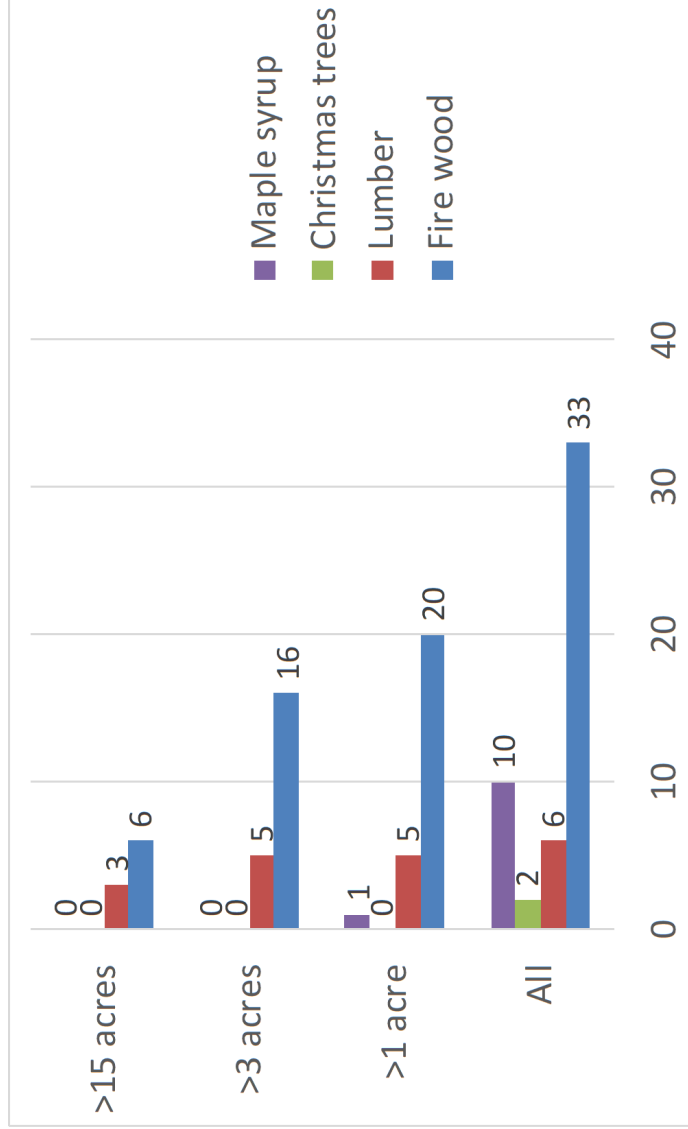
Field crops

- Most in hay and corn
- None over 50 acres
- Three over 15 acres



Forest related products

- A total of 33 respondents, all of whom produced firewood
- Larger acreage parcels produced lumber
- Small scale maple syrup and Christmas trees

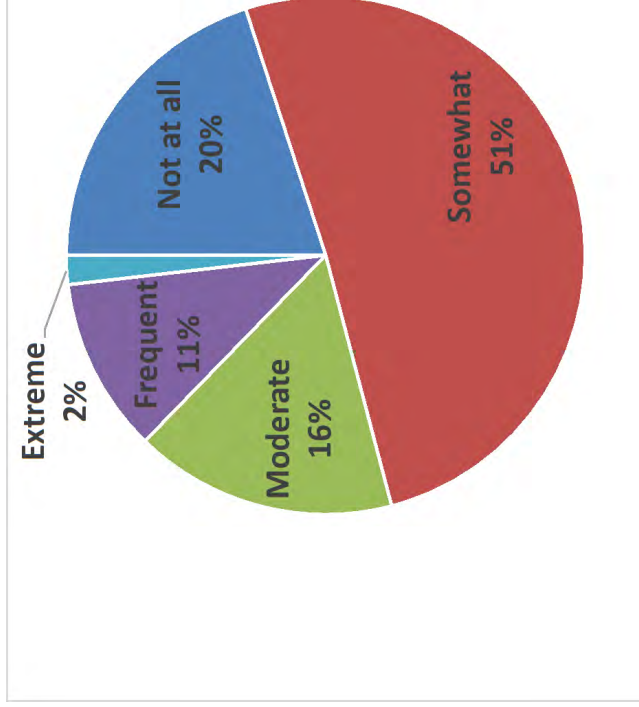


What could the Town of Harvard do to support your viability?

- Taxes – 6
 - Lower
 - Lower taxes on farms < 5 acres
- Land use regulations - 6
 - Decrease
 - Don't use suburban regs. on farms
 - Fewer regs. on farmstands, farm buildings
 - Clarify home kitchen vs. commercial
- Classify more land as farmland - 5
 - Horses should be agriculture
 - Increase ag. land zones
 - Include small farms in ag. overlay
 - Allow farming on conservation land
 - Allow firewood harvest on cons. land
- Water - 5
 - Free water testing, esp. for irrigation
 - Priority for farm irrigation vs. residential
 - Well for community garden
- Wildlife and bees -3
 - Cull deer, encourage foxes
 - Pesticide regs. to help pollinators
- Keep on the present course – 2
- More support for hemp, cannabis - 1

Recent extreme weather events have affected my long-term farm/ agricultural/ forestry management goals

- Of 55 responding:
- Over half said somewhat
- One fifth said not at all
- About one third said moderate to extreme
- Ice storm
- Wind
- Too much rain
- Freeze
- Drought



How concerned are you about potential impact of the following?

More frequent or new pest pressures related to weather (e.g., insects, fungus, disease)	3.2
Longer dry periods or drought	3.1
More frequent crop diseases related to weather	3.0
More frequent unpredictable seasonal temperatures (early bud break, early or late frosts)	3.0
More frequent or new weed/invasives pressure related to weather	3.0
More frequent heat stress on my crops	2.8
More frequent saturated soils and ponded water	2.8
Loss of nutrients due to heavy and abundant precipitation	2.7
Hail and ice storm damage	2.7
Wind damage	2.5
Reduced winter snow cover	2.4
More frequent erosion	2.2
More frequent flash flooding	2.2
More frequent river flooding events	2.0
More frequent stress/runtime on cold storage/refrigeration due to increased temperatures	1.7

Which of the following have the largest impacts on your success?

Extreme and variable weather	1.76
Land use regulations, such as zoning	2.48
Pest control	2.69
Crop failure	2.89
Weekend weather conditions	2.94
Local tax structure	2.98
Equipment purchasing and/or maintenance	3.13
Increased operation costs (e.g., fuel, electricity, hourly wage, insurance)	3.38
Cost of mitigation (e.g., irrigation, row covers/hoop houses, increased pesticides and/or fertilizers)	3.4
Pesticide notification laws	3.47
Food safety regulations	3.81
Succession planning	3.89
Market volatility	4.05
Labor regulations	4.19
Part-time labor shortages	4.19

Summary

- People are concerned that climate change will have a negative impact on horticulture and agriculture in Harvard
- Largest concerns relate to extreme weather events, drought and other water-related issues, excessive heat and consequent increases in pest problems (insects, diseases and weeds).
- Most people who responded are not farming commercially and are managing small areas.
- Most larger parcels farmed for tree fruit, vegetables, berries, herbs horses, hay, corn, firewood and lumber.
- Suggestions for town changes to encourage ag. are varied, with most common being tax changes, land use regulation and classifying more land as farmland.



Harvard Municipal Vulnerability Program
Agricultural Workshop #2
Climate Change and Agriculture in the Northeast – A Brief List of Resources
Prepared by Daniel R. Cooley
Stockbridge School of Agriculture
University of Massachusetts Amherst

Adaptation Workbook – web site to work through Forests, Urban Forests and Agriculture. Need to register. <https://adaptationworkbook.org>

Climate Change Adaptation Workshops: A Planning Guide for Local Govt. Need to register.

<https://www.cakex.org/tools/climate-change-adaptation-workshops-planning-guide-local-government-staff>

Climate change adaptation in New England agriculture. A fact sheet overview. Produced by the Manomet Center for Conservation Science. https://www.manomet.org/wp-content/uploads/old-files/Agriculture_fact_sheet%205-13.pdf

Climate change and pests. Northeast Reg. IPM Center. Resources related to pest management and climate change in the Northeast. <https://www.northeastipm.org/about-us/signature-programs/climate-change-and-pests/>

Climate Smart Farming. <http://climatechange.cornell.edu/our-mission/climate-smart-farming/> Part of the Cornell Institute for Climate Smart Solutions. Access decision tools here: <http://climatesmartfarming.org>

Comprehensive Assessment of Soil Health. Cornell Univ. Analyzes the health of soils and makes recommendations to improve soil health. <https://soilhealth.cals.cornell.edu>

AUBURN

Janowiak, Maria K.; Daniel N. Dostie, Michael A. Wilson, Michael J. Kucera, R. Howard Skinner, Jerry L. Hatfield, David Hollinger, and Christopher W. Swanston. Adaptation Resources for Agriculture: Responding to Climate Variability and Change in the Midwest and Northeast. U.S. Department of Agriculture, Washington, DC Technical Bulletin 1944. 2016.

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<https://www.climatehubs.oce.usda.gov/sites/default/files/AdaptationResourcesForAgriculture.pdf>

PORTSMOUTH

Hristov, A. N. et al. 2016. Climate change effects on livestock in the Northeast US and strategies for adaptation. Climatic Change (2018) 146:33–45. A scientific journal article describing just what it says.

Magdoff, F. and H. van Es. Building Soils for Better Crops. Sustainable Soil Management. 3rd edition. Sustainable Agriculture Research and Education (SARE), USDA, 2009. http://bit.ly/Build_Healthy_Soil

harriman.com



USDA Climate Hubs. <https://www.climatehubs.oce.usda.gov> . A wealthy of resources developed by a collaboration of USDA and Land Grants. There are Regional Hubs, one in the Northeast.

UMass Center for Agriculture, Food & Environment. UMass Extension. A wealth of resources for managing crops and livestock more sustainably. Includes IPM information, irrigation in general and for specific areas.

<http://ag.umass.edu/resources/agriculture-resources>

Wolfe, D., J. Beem-Miller, L. Chambliss, A. Chatrchyan, H. Menninger. 2011. Farming Success in an Uncertain Climate. Cornell eCommons.

https://ecommons.cornell.edu/bitstream/handle/1813/54950/CornellClimateChange_Farming-Success-in-an-Uncertain-Climate_FINAL-2l8vftg.pdf?sequence=1

U.S. Climate Resilience Toolkit - Northeastern agriculture. General information on potential impacts of climate change. Part of a national set of resources.

<https://toolkit.climate.gov/regions/northeast/ecosystems-and-agriculture>



Municipal Vulnerability Preparedness (MVP) Workshop – Agricultural Workshop #2 Agenda

March 9, 2019

- 8:30 Registration
- 9:00 Welcome and Introductions
- 9:05 MVP Overview
 - Agricultural Workshop #1 and Farmer Interviews
 - Group Discussion: Vulnerabilities
- 9:30 Strategies for Climate Change: Mitigation and Adaptation
- 10:15 Group Discussion: Strategies and Questions and Answers
- 10:45 Break
- 11:00 Strategies and Priorities
- 12:30 Report Outs and Next Steps

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Planning for Climate Change: Municipal Vulnerability Preparedness Program Town of Harvard

Agricultural Workshop 2

March 9, 2019

Workshop Agenda

- 9:00 Welcome and Introductions
- 9:05 MVP Overview
 - Agricultural Workshop #1 and Farmer Interviews
 - Group Discussion: Vulnerabilities
- 9:30 Strategies for Climate Change: Mitigation and Adaptation
- 10:15 Group Discussion: Strategies and Questions and Answers
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- 11:00 Strategies and Priorities
- 12:30 Report Outs and Next Steps

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Introductions

- MVP Core Group
 - Christopher Ryan, Director of Community and Economic Development
 - Liz Allard, Land Use Administrator/Conservation Agent
 - Eric Broadbent, Energy Advisory Committee
 - Justin Brown, Planning Board
 - Kerri Green, Agricultural Advisory Commission
 - Sharon McCarthy, Board of Health
 - Kara Minar, Select Board
- Harriman
 - Emily Keys Innes, AICP, LEED AP ND, MSVP TSP Associate and Senior Urban Planner
 - Steve Cecil, AIA, ASLA Principal
 - Jessica Wilson *Urban Designer/Planner*
- University of Massachusetts-Amherst
 - Dan Cooley *Professor of Plant Pathology*

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Municipal Vulnerability Preparedness (MVP) Program Overview

What is the MVP Program?

- A component of MA Executive Order 569 (2016)
- Grant funding for technical support to
 - Complete vulnerability assessments
 - Develop action-oriented resiliency plans

Why is the Town Participating?

- Increasingly more unpredictable and severe weather is occurring
- Agriculture is a significant part of the town's composition and identity
 - Dedicated MVP component focusing on agriculture
- Completion qualifies Harvard for access to further grant funding

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Overview of Climate Change

- Climate change
 - A change in the state of the climate ... whether due to natural variability or as a result of human activity
- Natural hazard
 - Natural events that threaten lives, property, and other assets
 - Often can be predicted; they tend to occur repeatedly in the same geographical locations because they are related to weather patterns or physical characteristics of an area
- Risk
 - The potential for an unwanted outcome resulting from a hazard event
- Vulnerability
 - The propensity or predisposition to be adversely affected
 - A function of exposure, sensitivity, and adaptive capacity

Definitions from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 2018

Risk/Risk Management

- Defining risk, understanding risk, and managing risk
 - Rational actor paradigm: making the optimal choice based on an understanding of maximizing the benefit and minimizing the losses
 - Behavioral economics: studies why people don't always make the rational choice
- Define your risk by understanding where/how you are vulnerable
- Understand the strategies that can reduce your vulnerability
- Identify the cost of implementing the strategy vs. the cost of doing nothing
- **Know that you will never have perfect information, and that reducing vulnerability/risk is a series of actions over time, not a single decision**

- **Resources**

- Risk, Uncertainty and Rational Action; Carlo C. Jaeger, Thomas Webler, Eugene A. Rosa, Ortwin Renn
- The Resilience Dividend: Being Strong in a World Where **Things Go Wrong**, Judith Rodin
- Antifragile: Things that Gain from Disorder, Nassim Nicholas Taleb

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: February 2

- Purpose
 - Introduce the impacts of climate change in the local watersheds (state data provided by watershed)
 - Introduce the impacts of climate change on agriculture (crops and livestock)
 - Review the results of the agriculture survey
 - Identify hazards and vulnerabilities



Agricultural Workshop #1: February 2

- Discussion goals (state process)
 - Identify top hazards to agriculture from climate change
 - Identify related vulnerabilities in terms of impacts to infrastructure, society, and environment



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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Findings

- Small Group Discussions
- Comments Cards from meeting
- Follow-up interviews with farmers
 - Frank Carlson, Carlson Orchards
 - Chris Green, Westward Orchards
 - Linda Hoffman, Old Frog Pond
 - Laura McGovern, Dunroven Farm
 - Paul Willard, Willard Farm
- Waiting to talk to Pam Lawson of Doe Orchards

Agricultural Workshop #1: Small Groups

• Top Four Hazards

- Excessive moisture/flood
- Extreme storm events
- Storm event timing
- Temperature variability

- Increased precipitation
- Weather extreme
- Temperature variation

- Pests! (Deer, gypsy moth)
- Invasive vegetation
- Inconsistent temperatures
- Precipitation Extremes
- Fire

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Small Groups

- Top Four Hazards

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- Increased precipitation
- Weather extreme
- Temperature variation

- Pests! (Deer, gypsy moth)
- Invasive vegetation
- Inconsistent temperatures
- Precipitation Extremes
- Fire

Agricultural Workshop #1: Small Groups

- Top Hazards
- **Temperature:** extremes and variability
- **Precipitation:** extremes and variability

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Small Groups

Vulnerabilities: Identified by Groups

- Lack of town water
- Above ground utilities/ Lower energy resilience
- Well depth/water quality
- Lack of awareness
- Municipal fiscal sustainability/local tax structure
- Regulatory (assessing, zoning)
- Economic (tourism, limits to, local goods/services)
- Agricultural use of conservation lands
- Development surrounding
- Public Health
- Water quality (wetlands, water resources)
- Plant threats (invasives, leaf canopy, blight extension)
- Insect threats (invasives, pests, pollinators)
- Disease threats (blight, stress, animal diseases)
- Wildlife (increased predators, dispersers, climate status)
- Better road design/engineering
- Trees
- Tree undergrowth
- Storage
- Reduced production
- Increase in minimum wage by 2023
- Contaminants (runoff and applications)
- Varietals not viable
- Crops
- Livestock

Agricultural Workshop #1: Small Groups

Vulnerabilities: Potential Impacts from Climate Change

- Lack of town water
- Above ground utilities/ Lower energy resilience
- Well depth/water quality
- Lack of awareness
- Municipal fiscal sustainability/local tax structure
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March 9, 2019

Agricultural Workshop #1: Small Groups

Vulnerabilities: Unrelated to Climate Change

- **Lack of town water**
- Above ground utilities/ Lower energy resilience
- **Well depth/water quality**
- **Lack of awareness**
- **Municipal fiscal sustainability/local tax structure**
- **Regulatory (assessing, zoning)**
- **Economic (tourism, limits to, local goods/services)**
- **Agricultural use of conservation lands**
- **Development surrounding**
- Public Health
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- Contaminants (runoff and applications)
- Varietals not viable
- Crops
- Livestock

Agricultural Workshop #1: Follow-up Calls

Vulnerabilities: All

- Limited irrigation
- Decreasing margins
- Few distributors
- Standing water/soaked pastures
- Increase in price of supplies (hay, packing boxes, etc.)
- Labor – supply, cost of
- Local regulations
- Property taxes
- Variability of temperatures in a single season
- Restrictions on agritourism
- State building codes
- Financing for mitigation/adaptation
- Need people to buy product
- Quality of hay, other feed
- Succession planning

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Follow-up Calls

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Agricultural Workshop #1: Follow-up Calls

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Follow-up Calls

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 - **Financing for mitigation/adaptation**
 - **Need people to buy product**
 - Quality of hay, other feed
 - **Succession planning**

Agricultural Workshop #1: Small Groups

Vulnerabilities: What are we missing?

Climate Change?

Other, Agriculture-Specific?

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Comment Cards

• 12 responses

- Did you find today's workshop helpful?
- What did you learn that you didn't know?
- What did you want to learn that you did not?
- What else would you like us to think about as we prepare for the next workshop?

12

Agricultural Workshop #1: Saturday, February 2, 2019

Thank you for attending today's workshop. Please take the time to fill out the short survey below and return it to the presenters.

Did you find today's workshop helpful? Yes

What did you learn that you didn't know? I got the graphs. I was really surprised.

What did you want to learn that you did not? Save the world. I was really surprised.

What else would you like us to think about as we prepare for the next workshop?

Please put additional comments on the back.

Agricultural Workshop #1: Comment Cards

- Did you find today's workshop helpful?
 - Yes (5)
 - Yes very much so
 - Good Start!
 - Yes: a good insight into issues that others are concerned about
 - Yes helps sort out your thoughts
 - Yes but frustrating
 - Interesting
 - Yes!

Agricultural Workshop #1: Saturday, February 2, 2019

Thank you for attending today's workshop. Please take the time to fill out the short survey below and return it to the presenters.

Did you find today's workshop helpful? Interesting

What did you learn that you didn't know? Some specific about the degree kind and location of farms in Harvard

What did you want to learn that you did not? What crop/varieties issues are there to accommodate climate change

What else would you like us to think about as we prepare for the next workshop? I think we need several different maps that can be overlaid to compare/contrast/analyze challenges/opportunities/issues here in Harvard.

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Comment Cards

- **What did you learn that you didn't know?**
 - How forests are impacted and how they impact surrounding land
 - That a lot of people have concerns that I do
 - Deer population is 50% above level
 - Agricultural use of conservation land an option?
 - Good discussion of impacts to animal husbandry
 - Some
 - Specifics about the degree, kind, and location of farms in Harvard
 - How different issues can interact
 - Interconnectedness
 - Little forest business in Harvard
 - Maple sugar affected by deer
 - Takes me time to get thoughts together! I'll email.
 - A lot! The graphics were awesome from the survey. Discussion very informative.
 - Temp graphics pictures and precipitation projections.

Agricultural Workshop #1: Saturday, February 2, 2019

Thank you for attending today's workshop. Please take the time to fill out the short survey below and return it to the presenters.

Did you find today's workshop helpful? Good start!

What did you learn that you didn't know? Agricultural use of conservation land an option?

What did you want to learn that you did not? More about helpful regulations for small commercial farms. Bylaws, regulations.

What else would you like us to think about as we prepare for the next workshop? Ticks + mosquito risks for farm workers; heat risks etc. climate change + health of farm workers.

Please put additional comments on the back.

Agricultural Workshop #1: Comment Cards

- What did you want to learn that you did not?
 - That it is going to be tough to resolve most issues
 - **More about helpful regulation for small commercial farms. Bylaws, regulations difficult to find**
- What crop/varieties resources are there to accommodate climate change
- Actions to be done

Agricultural Workshop #1: Saturday, February 2, 2019

Thank you for attending today's workshop. Please take the time to fill out the short survey below and return it to the presenter.

Did you find today's workshop helpful? YES VERY MUCH SO

What did you learn that you didn't know?
THAT A LOT OF PEOPLE HAVE CONCERNS
THAT I DO

What did you want to learn that you did not?
THAT IT IS GOING TO BE TUGH TO RESOLVE WHAT
WHAT ELSE WOULD YOU LIKE US TO THINK ABOUT AS WE PREPARE FOR THE NEXT WORKSHOP ISSUE'S

EDUCATE THE TOWN GOV. &
TOWN CITIZENS

Please put additional comments on the back.

Harriman + Professor Daniel Cooley

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Agricultural Workshop #1: Comment Cards

- **What else would you like us to think about as we prepare for the next workshop?**
 - Help guide the discussion by framing the categories with some examples
 - Narrow the concerns
 - **Drinking water supply threats?**
 - **Financing**
 - I think we need several different maps that can be compared/contrast/analyzed to identify challenges/opportunities/resources here in Harvard
 - **Education and outreach to entire Town. How to teach Town about role of agriculture in Town's fabric/history?**
 - **Ticks and mosquito risks for farm workers; heat risks, etc.; climate change and health risks for farm workers**
 - **Any outside of Harvard entities that are stakeholders should be included. Sudbury Valley Trustees (SVT) and maybe Oxbow rep?**
 - **Educate the Town government and Town citizens**

Introduction to Climate-Change Strategies

Switch to Climate Change and Agriculture in Harvard: Adaptation Strategies, Tactics, and Tools

Harriman + Professor Daniel Cooley

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Small Group Discussion/Continued Focus Group

Temperature	Precipitation	Economic/ Market	Regulatory	Other

Small Group Discussion/Continued Focus Group

Temperature	Precipitation	Economic/ Market	Regulatory	Other
Vulnerabilities: How are you vulnerable to these pressures?				

Harriman + Professor Daniel Cooley

Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Small Group Discussion/Continued Focus Group

Temperature	Precipitation	Economic/ Market	Regulatory	Other
Strategies: How could you mitigate/adapt to these pressures?				

Small Group Discussion/Continued Focus Group

Temperature

Precipitation

Economic/
Market

Regulatory

Other

Partners: Whose help do you need and what is that help?

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Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Small Group Discussion/Continued Focus Group

Temperature	Precipitation	Economic/ Market	Regulatory	Other
Prioritize: What are the five most important strategies to you?				

Next Steps

- Write up notes for this meeting!
- Main MVP workshop scheduled for March 21 and April 4
 - These will follow the state format using the grid and steps we began last time
- Report for review by the MVP Committee
- Public Listening Session (not yet scheduled)
- Comments from the listening session added as an appendix to the report
- Submission to state for review

Harriman + Professor Daniel Cooley

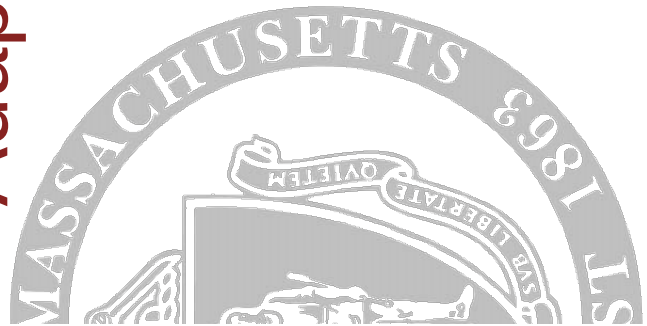
Harvard Municipal Vulnerability Preparedness (MVP) Workshop

March 9, 2019

Climate Change and Agriculture in Harvard: Adaptation Strategies, Tactics and Tools

Harvard Municipal Vulnerability Preparedness
Agricultural Workshop II
March 9, 2019

Daniel Cooley
Stockbridge School of Agriculture
University of Massachusetts Amherst



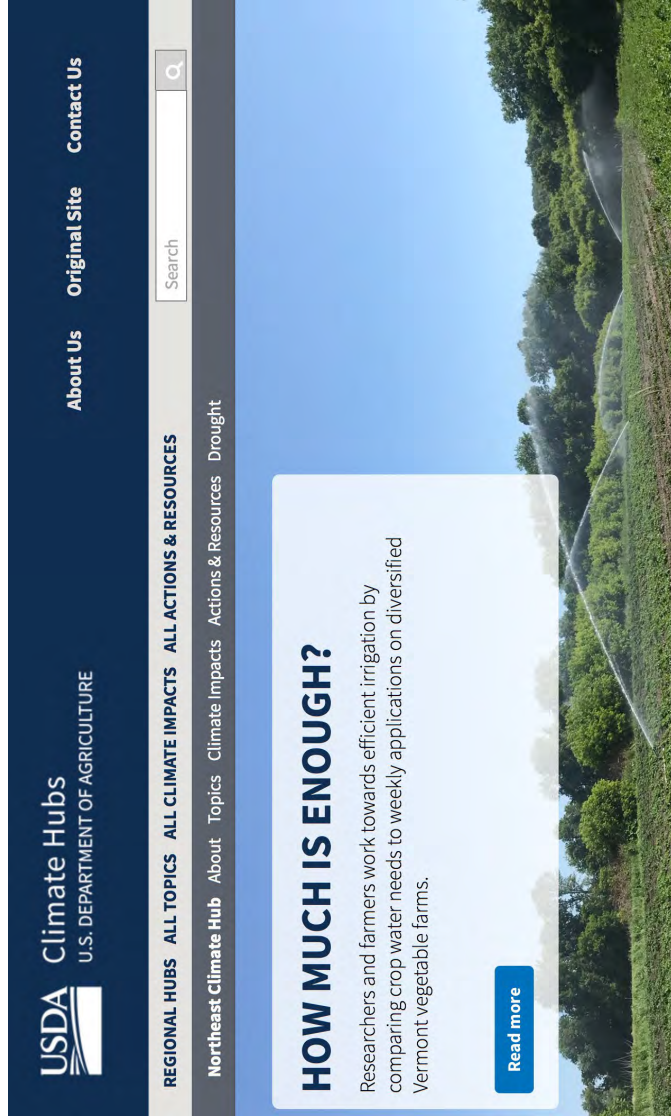
Today

- Potential adaptation strategies, tactics and tools – ways to address climate change in agriculture
- Precipitation variability and extremes – focus on soil health
- Overview of irrigation
- Erosion case study
- Temperature variability and extremes
 - Frost and heat
 - Growing-season length
 - Chilling
- Challenges in pest management - IPM
- Planning specific adaptation tactics



General Resources

- USDA Climate Hubs > Northeast Climate Hub
- <https://www.climatehubs.northeast.usda.gov/hubs/northeast>
- Resources and research dealing with agriculture, forestry and climate change



Northeast Climate Hub

- A compilation of many resources to educate about climate change and adapt to it.
- Collaborators in USDA and Land Grant Universities
 - Agricultural Research Service
 - Forest Service
 - Natural Resources Conservation Service
 - Farm Service Agency
 - Risk Management Agency

Lessons learned from Urban Forestry Vulnerability Assessment: Chicago



UVM Dairy Farming Research



Woodman Horticultural Research Farm at UNH



UMASS Permaculture



Irrigation Research at UD



SARE Resource: Cultivating Climate Resilience on Farms and Ranches



Cornell Biochar and Compost Facilities



Living Shorelines



UDC Urban Farm

General Resources

- UMass Center for Agriculture, Food and the Environment > UMass Extension
- <http://ag.umass.edu/resources/agriculture-resources>
- Many agricultural resources though not specific to climate change adaptation
- Individual areas such as vegetables, fruit, livestock



Integrating research and outreach education from UMass Amherst

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Search the Center for Agriculture, Food and the Environment Search this site Search



Resources

Agriculture & Commercial Horticulture

Agriculture & Commercial Horticulture Resources

This section presents informational and educational resources for agricultural producers and commercial horticulture professionals.

[View a listing of services from UMass Extension of interest to producers.](#)

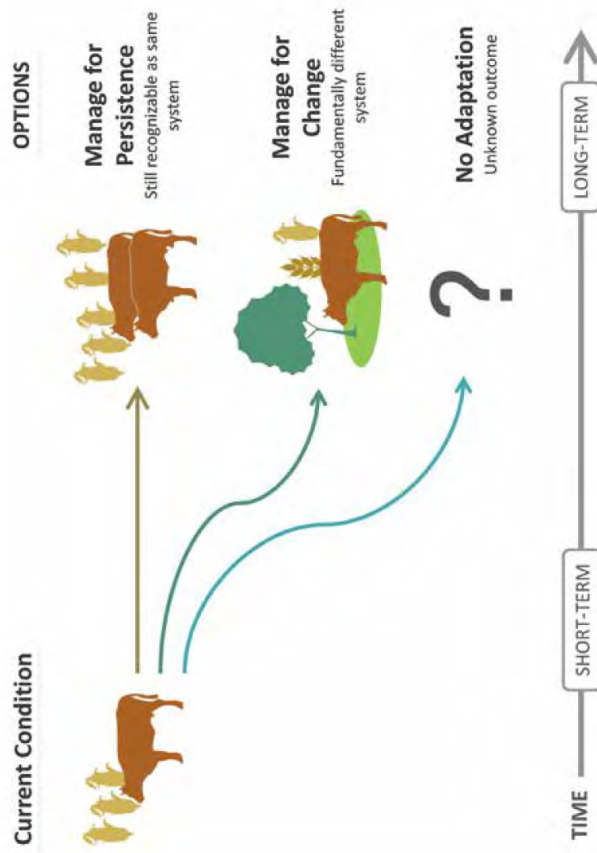
Best Management Practices (BMPs) Sets of voluntary practices for agricultural and horticultural operations designed to maximize productivity and sustainability. Nutrient Best Management Practices These recommended practices are intended to assist agricultural and horticultural operations in Massachusetts in staying up to date with changing nutrient management requirements. Management Guides Seven comprehensive guides on management practices for topics including pests, soils, and nutrients in Massachusetts and New England. Pest Alerts/ Messages Brief periodic communications from Extension agricultural and horticultural programs on timely issues of interest.	Food Safety for Farmers Information resources on good agricultural practices to ensure that risk of on-farm microbial contamination is minimized. Information on the Food Safety Modernization Act (FSMA), USDA's Good Agricultural Practices (GAP) certification and the Massachusetts Commonwealth Quality Program certification. Business Resources for Farmers A comprehensive guide to business resources for all farmers—both existing and beginning—in Massachusetts. Sections on: Starting to Plan; Finances and Taxes; Regulations and Laws; Other Resources. Beginning Farmer Resources This section provides information on educational resources and programs at	Farms Specific FAQs Find answers by Extension agricultural experts to common questions specific to different types of farms. These include: apple orchards; bees and honey; Christmas trees; field grown cut flowers; forest management; goats and sheep; greenhouse crops; horses; maple sugaring; nursery production; vegetable production; vineyards. Commonwealth Quality Information for farmers on becoming part of the state's Commonwealth Quality Program. The Commonwealth Quality Seal serves to identify locally sourced products that are grown, harvested, and processed right here in Massachusetts using practices that are safe, sustainable and don't harm the environment. Massachusetts Agricultural Data
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Key points from the survey

- People believe climate change will have a negative impact on horticulture and agriculture in Harvard.
- Largest concerns relate
 - Extreme weather events
 - Drought, flooding and other water-related issues
 - Excessive heat and cold damage, frosts
 - Increased pest problems - insects, diseases and weeds
- Most larger parcels farmed for tree fruit, vegetables, berries, herbs horses, hay, corn, firewood and lumber.
- Most people who responded are not farming commercially and are managing small areas but want to make changes to adapt to climate change

Short-term and long-term

- Short-term changes, 1 to 5 years.
- Long-term changes, 5 to 20 years or more
- Managing for persistence – tactics in the same basic system
- Managing for change – using a fundamentally different system
- Today – focus on short-term changes managing for persistence



Precipitation: managing soils and water to adapt to climate change

- Soil and water are basic – start with them
- Focus on soil health
- Manage water resources and water risks



Soil and water concerns from survey

- > Longer dry periods or drought
- > More frequent saturated soils and ponded water
- > Loss of nutrients due to heavy and abundant precipitation
- > Reduced winter snow cover
- > More frequent erosion
- > More frequent flash flooding, river flooding

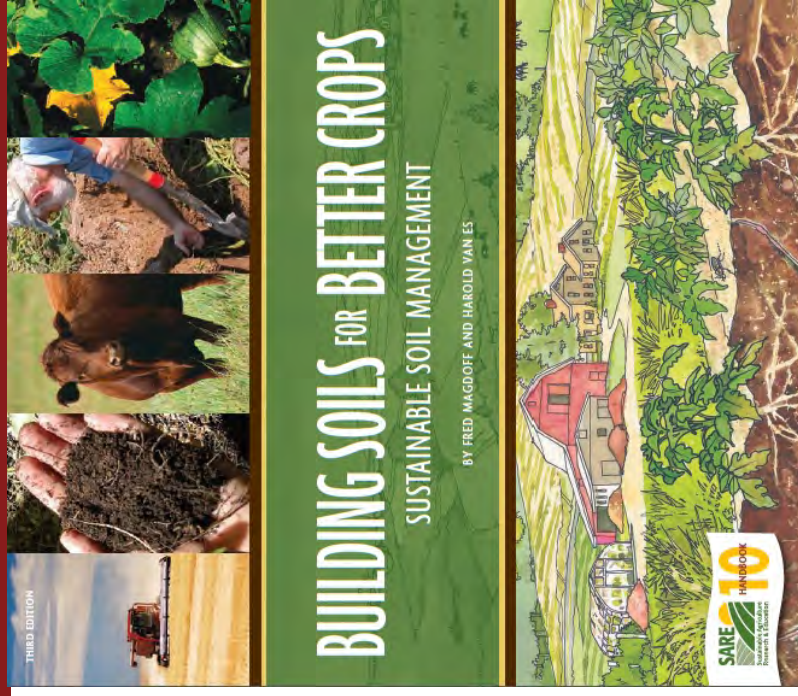
Soil health

- Overall recommendation – build soil health to buffer precipitation extremes
- Modern agriculture tends to think of soils as inert, something to hold roots and fertilizers
- Healthy soils are “living” soils
- Contain enough organic matter
- Good farming regardless of climate change, but
- Protects against both dry and wet precipitation extremes

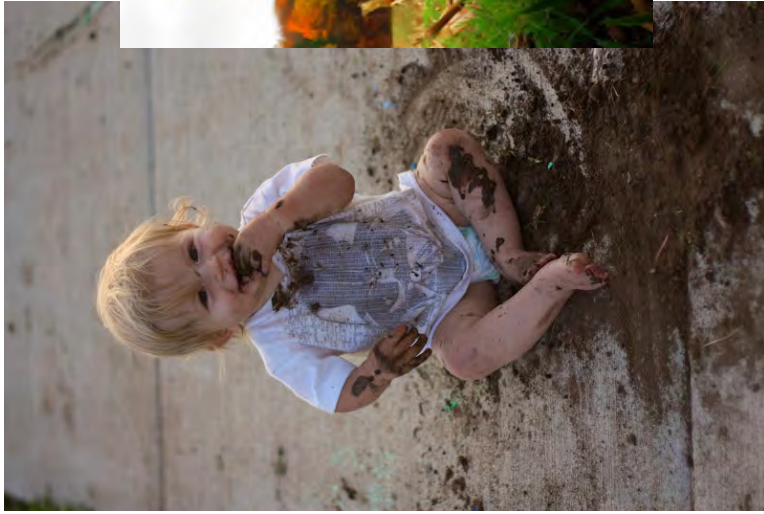


Building healthy soils

- Specific problems addressed:
 - > Longer dry periods or drought
 - > More frequent saturated soils and ponded water
 - > Loss of nutrients due to heavy and abundant precipitation
- Free book to help understand and solve the problem
- http://bit.ly/Build_Healthy_Soil
- Site also has other resources, and an interactive graphic to help understand soil health



Measuring your soil's health



- Soil health is composed of many factors, but it can be measured!
- Cornell Comprehensive Assessment of Soil Health.
- <https://soilhealth.cals.cornell.edu>
- [Comprehensive Assessment of Soil Health Training Manual](https://blogs.cornell.edu/healthysoil/training-manual/)
- <http://blogs.cornell.edu/healthysoil/training-manual/>



A soil quality/health index

- Inputs several types of data such as soil hardness, pH, surface hardness, water capacity
- Determines which are below levels needed for a healthy soil
- Gives an overall rating for soil health
- Makes specific recommendations for changes that will improve that soil



Measuring soil hardness with a penetrometer.

Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. <http://soilhealth.cals.cornell.edu>



- Background info

- Address

- Location

- Crop history

- Soil texture

- Cost

- Basic \$60
- Standard \$110
- Extended \$170

Grower:

Bob Schindelbeck
306 Tower Rd.
Ithaca, NY 14853

Sample ID: LL8

Field ID: Caldwell Field- intensive management

Date Sampled: 03/11/2015

Given Soil Type: Collamer silt loam

Crops Grown: WHT/WHT/WHT

Tillage: 7-9 inches

Agricultural Service Provider:

Mr. Bob Consulting
rrs3@cornell.edu

Measured Soil Textural Class: **silt loam**

Sand: **2%** - Silt: **83%** - Clay: **15%**

- (2) Measured indicator
- (3) Indicator value
- (4) Rating
- (5) Constraints
- (6) Overall quality score

Measured Soil Textural Class: **silt loam**

Sand: **2%** - Silt: **83%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.14	37	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	15.7	19	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.5	28	
biological	ACE Soil Protein Index	5.1	25	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	288	12	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	20.0	100	
chemical	Extractable Potassium	150.6	100	
chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100	

Overall Quality Score: **51** / Medium

Recommendation

- Available Water Capacity Low
- Short term
 - Add stable organic materials, mulch
 - Add compost or biochar
 - Incorporate high biomass cover crop
- Long term
 - Reduce tillage
 - Rotate with sod crops
 - Incorporate high biomass cover crop

Sand: 2% - Silt: 83% - Clay: 15%

2

3

4

Group	Indicator	Value	Rating
physical	Available Water Capacity	0.14	37
physical	Surface Hardness	260	12
physical	Subsurface Hardness	340	35
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biological	Organic Matter	2.5	28
biological	ACE Soil Protein Index	5.1	25
biological	Soil Respiration	0.5	40
biological	Active Carbon	288	12
chemical	Soil pH	6.5	100
chemical	Extractable Phosphorus	20.0	100
chemical	Extractable Potassium	150.6	100
Constraint	Long Term Management Suggestions		100
Available Water Capacity Low	Short Term Management Suggestions	• Add stable organic materials, mulch • Add compost or biochar • Incorporate high biomass cover crop	• Reduce tillage • Rotate with sod crops • Incorporate high biomass cover crop
Surface Hardness High	Short Term Management Suggestions	• Perform some mechanical soil loosening	• Shallow tilled conservation cover

Recommendation

- Surface Hardness Very High
- Short term
 - Perform some mechanical soil loosening (strip till, aerators, broadfork, spader)
 - Use shallow-rooted cover crops
 - Use a living mulch or interseed cover crop
- Long term
 - Shallow-rooted cover/rotation crops
 - Avoid traffic on wet soils, monitor
 - Avoid excessive traffic/tillage/loads
 - Use controlled traffic patterns/lanes

Sand: 2% - Silt: 83% - Clay: 15%

Group	Indicator	Value	Rating
physical	Available Water Capacity	0.14	37
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chemical	Extractable Potassium	150.6	100
chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100

Recommendation

- Aggregate Stability Very Low
- Active Carbon Very Low
- Very similar recommendations
- Short term
 - Incorporate fresh organic materials
 - Use shallow-rooted cover/rotation crops
 - Add manure, green manure, mulch
- Long term
 - Reduce tillage
 - Use a surface mulch
 - Rotate with sod crops and mycorrhizal hosts
 - Cover crop whenever possible

Sand: 2% - Silt: 83% - Clay: 15%

Group	Indicator	Value	Rating
physical	Available Water Capacity	0.14	37
physical	Surface Hardness	260	12
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chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100



Soil is meant to be covered



Masoud Hashemi

Cover crops and mulch impact everything in soil!

- [illegible]

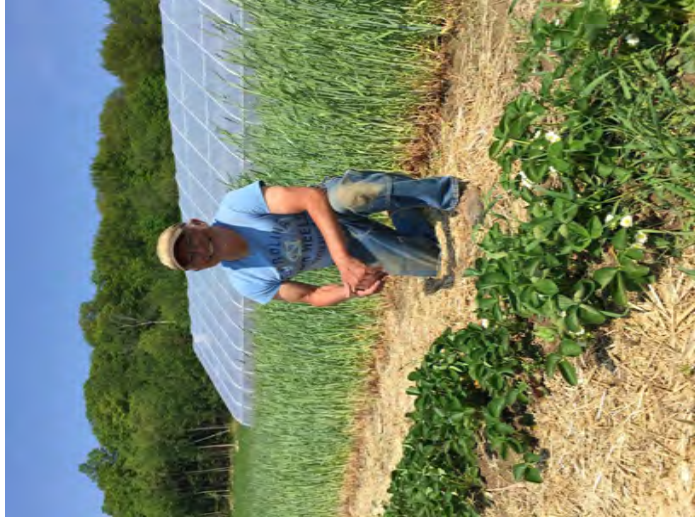
Managing water

- More intense rainfall events > running, erosion, ponding, and nutrient leaching
- More prolonged dry periods and higher temperatures > drought stress
- Excess water management
 - Reduce flow rates using for ex. cover crops, organic mulch, diversions and grade stabilization structures,
 - Reduce ponding and flooding impacts using for ex. raised beds, tile drainage
- Drought stress
 - Improved soil water holding capacity
 - Improved irrigation capacity and efficiency
 - Improved water storage capacity



Erosion management – Last Resort Farm, Monkton, VT

- Dairy until 1986. Presently 15 acres under produce cultivation, 80 acres of hay and 1,200 maple taps – farm stand, CSA, farmers markets
- “Storms have been worse, causing soil erosion. In June 2015, we had 20 inches of rain.”
- Increased gully erosion, nutrient pollution in streams.
- Farm partnered with many groups to reduce the amount of sediment leaving the gullies.
 - Local conservation group, their contracted engineering firm, USDA Natural Resources Conservation Service (NRCS) and the Vermont Department of Environmental Conservation
- Used two mitigation approaches



Hard engineering solution

- Rip rap, stones
- Advantages
 - Tried and tested
 - Potentially longer life-span
 - Less frequent maintenance
- Disadvantages
 - Higher cost
 - Heavy equipment for construction
 - Potential soil compaction

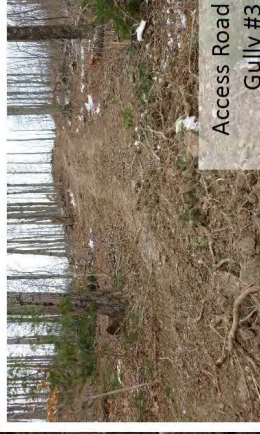
Project Design & Construction

Gullies #3 and #4



NRCS Rock-lined Waterway

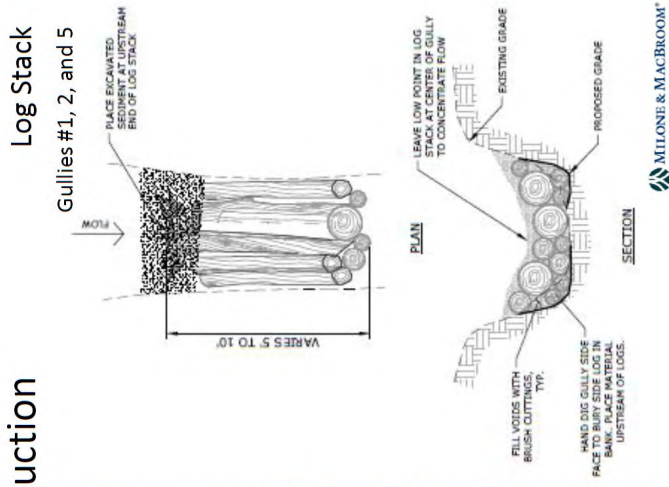
- 12" stone and 24" stone over geotextile fabric
- Treats full length of gully regardless of degree of erosion
- Installed with excavator
- Separate access road through forest to move rock



Soft engineering solution

- Engineered log and wood placement with minimal rock use
- Advantages
 - Mostly on-site materials
 - Lighter impact on environment
- Disadvantages
 - Likely higher maintenance
 - Likely shorter life span
 - More manual labor

Project Design & Construction



Benefits

- Farmer benefit - avoided costs due to loss of productivity caused by continued gully erosion
- Public benefit - less sediment in Lewis Creek and Lake Champlain. Sedimentation has negative effects on water treatment, recreation, fisheries, and navigation.

BENEFIT CATEGORIES	LOW BENEFIT (NET TO FARMER)	HIGH BENEFIT (NET TO FARMER AND PUBLIC)
GULLY SOIL	\$500	\$4,200
FIELD SOIL	\$2,200 - \$8,600	\$80,600
HAY	\$0 - \$700	\$1,100
MAPLE SAP	\$0 - \$1,000	\$2,000
TOTAL	\$2,700 - \$10,800	\$87,900

Raised beds

- Keeps plant root zones above the water level after heavy rain
- Bed-shapers
- Can also be used for flood irrigation



Improved water efficiency

- Healthy soils absorb and hold more water
- Mulches reduce evaporation
- Soil type – sandy soils may need shorter, more frequent irrigation
- Irrigation – use the most efficient possible
- Micro-irrigation, usually drip or trickle – 90 to 95% efficient vs. 70 to 75% for overhead sprinklers
- Sub-surface irrigation
- Can't use for frost protection!



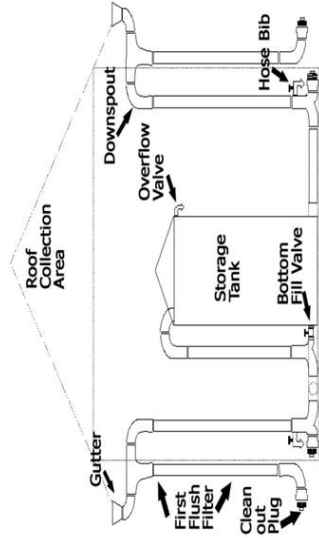
Multiple factors determine irrigation need

- | | | | | | | | | |
|---|--|--------------|-------------|----------|----------------------|---------------|--------------------|--|
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| | Irrigating Vegetable Crops | | | | | | | |
| | <p>Efficient conservation, management, and use of irrigation water are critical to successful vegetable production, especially under drought conditions. Frequently, extremely hot and dry conditions can reduce production over large areas of the region, thereby limiting vegetable supplies and driving prices up. Profit opportunities exist for the producer with a well-organized water management plan when these conditions occur.</p> | | | | | | | |
| | Crop Requirements and Responses | | | | | | | |
| | <p>Vegetable crop water requirements range from about 6" of water per season for radishes to 24" for tomatoes and pumpkins. Irrigation requirements can be predicted by knowing the crop's root system depth and effective soil water volume. Lack of water during the growing period results in reduced plant vigor and yield. Drought stress causes plants to shed leaves and close stomata, which has a direct effect on photosynthesis. The effects of drought include increased plant stress in relation to the stage of growth. Nearly all vegetable crops are sensitive to drought during two periods: during harvest and two to three weeks before harvest. More than 30 different vegetable crops are grown commercially. Although all vegetables benefit from irrigation, each class responds differently.</p> | | | | | | | |
| Leafy vegetables | | | | | | | | |
| Cabbage, lettuce, and spinach are generally planted at or near field capacity. Being shallow rooted, these crops benefit from frequent irrigation throughout the season. As leaf expansion relates closely to water availability, these crops, especially cabbage and lettuce, are particularly sensitive to drought stress during the period of head formation through harvest. Overwatering or irregular watering can result in burst heads. | | | | | | | | |
| Broccoli and cauliflower | | | | | | | | |
| Although not grown specifically for their leaves, broccoli and cauliflower respond to irrigation much as the leafy vegetables do. They are both sensitive to drought stress at all stages of growth, responding to drought with reduced growth and premature heading. | | | | | | | | |
| Root, tuber, and bulb vegetables | | | | | | | | |
| Sweet potato, potato, carrot, and onion crop yields depend on the production and translocation of carbohydrates to the root or bulb. The most sensitive stage of growth generally occurs as these storage organs enlarge. Carrots require an even and abundant supply of water throughout the season. Stress causes small, woody, and poorly flavored roots. Uneven irrigation can lead to misshapen or split roots in carrots. Second growth in potatoes, and early bulbing in onions. | | | | | | | | |
| Flowering vegetables | | | | | | | | |
| Cucumbers, melons, pumpkins and squashes, lima beans, snap beans, peas, peppers, sweet corn, and tomatoes are most sensitive to drought stress at flowering and as fruits and seeds develop. Fruit set on these crops can be seriously reduced if water becomes limited. An adequate supply of water during the period of fruit enlargement can reduce the incidence of fruit cracking and blossom-end rot in tomatoes. Irrigation is often reduced as fruit and seed crops mature. | | | | | | | | |
| Plant growth stage also influences the susceptibility of crops to drought stress. Irrigation is especially useful when establishing newly seeded or transplanted crops. Irrigation after transplanting can significantly increase the plant survival rate, especially when soil moisture is marginal and the evapotranspiration rate is high. Irrigation can also increase the uniformity of emergence and final stand of seeded crops. For seeded crops, note the rate of | | | | | | | | |

Improve storage capacity

- Irrigation ponds - NRCS
- Deeper wells
- Rainwater harvest from buildings, greenhouses



Heat and cold issues

- Temperature mitigation is difficult
- Length of the season changes
- High temperatures
- Frosts
- Issues with chilling requirement
- Livestock stress



Temperature concerns from survey

- > More frequent unpredictable seasonal temperatures (early bud break, early or late frosts)
- > More frequent heat stress on my crops
- > More frequent stress/runtime on cold storage/refrigeration due to increased temperatures

High temperatures

- Select longer growing-season, heat-resistant, or drought-resistant varieties of crops
- Adjust planting time to avoid mid-summer heat – earlier in spring or later in summer
- For livestock, provide shelter and shade
- Insure water sources are adequate
- Rotate grazing more frequently

Heat and Drought Tolerant Plants

Sandy Feather, extension educator in Allegheny county, has prepared this list of trees, shrubs, annuals and perennials that don't just survive but will thrive in our long, hot summers.

 ARTICLES | UPDATED: SEPTEMBER 13, 2017

Trees

- White Fir (*Abies concolor*)
- Hedge Maple (*Acer campestre*)
- Italian Alder (*Alnus cordata*)
- Devil's Walking Stick (*Aralia spinosa*)
- Hackberry (*Celtis occidentalis*)
- Yellowwood (*Cladrastis kentukea*)
- Kentucky Coffeetree (*Gymnocladus dioica*)



Black-eyed Susan (*Rudbeckia* spp.)

- Ginkgo (*Ginkgo biloba*)
- Goldenrain tree (*Koeleruteria paniculata*)
- American Sweetgum (*Liquidambar styraciflua*)

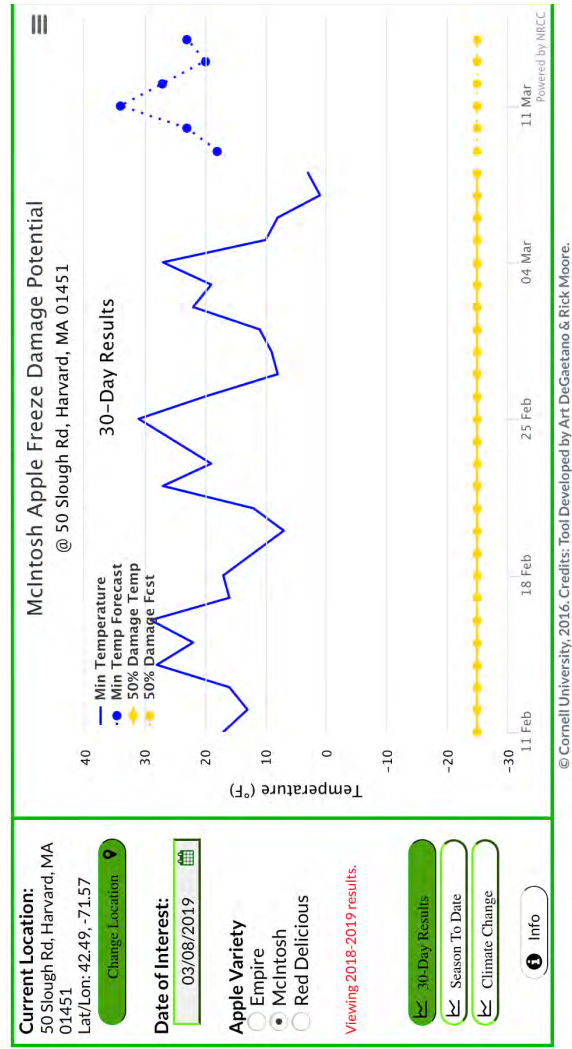
Frosts

- Most severe at low levels
- Allow air to drain from fields on a slope – cut holes in hedgerows
- Floating row covers – small-scale or large scale hoops
- Overhead or under plant sprinklers
- Supplemental heat – machines, burning material
- Helicopters or wind machines



Climate Smart Farming

- Cornell site with tools that give probabilities of freeze damage for some crops such as apples and grapes
- So far apples haven't lost hardiness levels – tolerant down to -25 F.



Pests and climate change

- Reduce pest stresses on crops and animals
- Use Integrated Pest Management – IPM
- Monitor crop, weather and pests
- Stay aware of new pests



Pest management concerns from survey

- > More frequent or new pest pressures related to weather (e.g., insects, fungus, disease) – #1
- > More frequent crop diseases related to weather
- > More frequent or new weed/invasives pressure related to weather

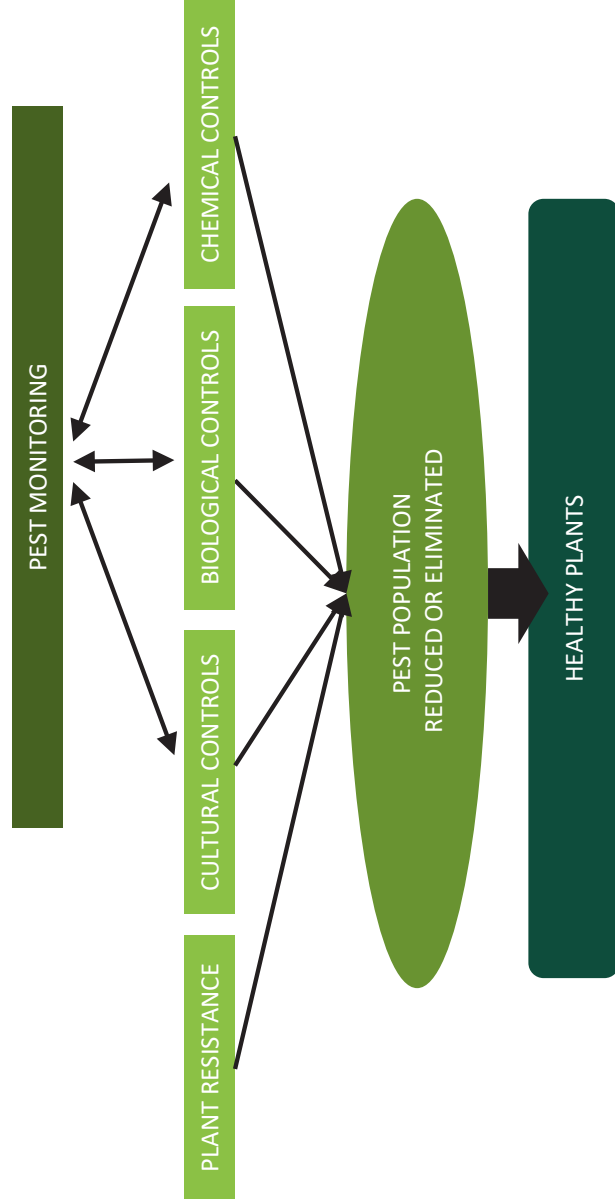
Integrated Pest Management

- IPM - **ecosystem-based strategy**
- Uses **combination of techniques**: resistant varieties; modification of cultural (growing) practices; biological controls; and chemicals
- Pesticides used only when **monitoring** indicates a need according to established guidelines – **thresholds**
- Monitoring means
 - Keeping track of crop development
 - Getting daily weather data and forecasts
 - Using traps, observations on crop to see of pests, diseases, weeds are present



IPM tactics for plant diseases

- Start from a base of plants and animals that resist pests
- Use production systems (planting mixes, densities, locations) that suppress rather than encourage pests
- Use biocontrols, biopesticides if available
- Choose chemicals with low non-target toxicity
- Use only when needed



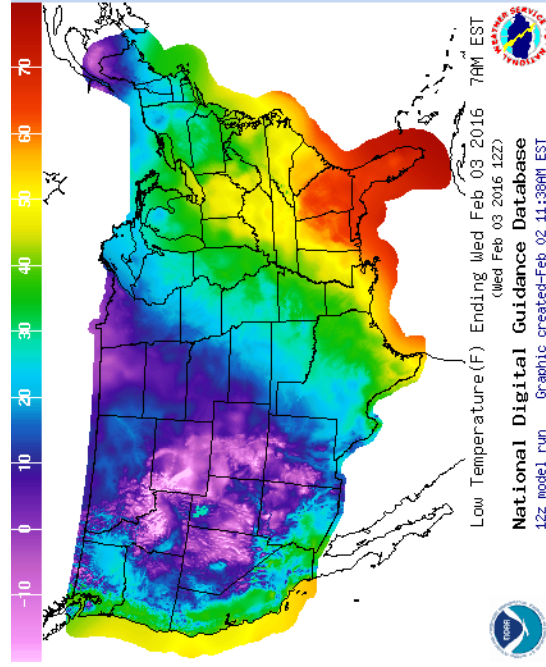
Weather monitoring

- Basically two sources
- Buy and maintain an on-site weather station
- Must be ***well-calibrated and maintained***
- Purchase a subscription to a virtual weather service



Alternative to weather stations

- Gridded data generated from observations, used in past data and forecasts
- 1 km² grids – improving resolution
- Public – US National Weather Service
- Private services, e.g. MeteoBlue
- Gridded data definitely the future



Decision Support - NEWA

- Weather stations can be connected to decision support systems
- Most common in MA and eastern US is NEWA – Cornell
- <http://newa.cornell.edu>

Search Cornell

Website status:
No issues reported
3/3/2019 5:51:25 PM

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Click on a map marker to go Sweet Corn's home page.

Map

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Applies
Grapes
Onions
Potato
Tomato
Sweet Corn

National Weather Service Forecast

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Resources

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UMass Extension Programs

Below are links to individual UMass Extension program sites within the [Center for Agriculture, Food and the Environment](#) that will provide more resources on particular areas of interest.

- [Cranberry](#)
- [Crops, Dairy, Livestock & Equine](#)
- [Greenhouse Crops & Floriculture](#)
- [Fruit](#)
- [Landscape Nursery & Urban Forestry](#)
- [Pesticide Education & Analysis](#)
- [Turf](#)
- [Vegetable](#)

<https://ag.umass.edu/integrated-pest-management/umass-extension-programs>

Vegetable Program page



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Program



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What's New

Events

Current Newsletter: Vegetable Notes 2019 Vol. 31:3

 February 14, 2019 [Vegetable Notes](#)

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2018 Vegetable Program Survey

The UMass Extension Vegetable Program looking for your feedback! Your response to our Vegetable Program Survey will help us adapt the program to better meet your needs as growers, farm workers, ag service providers, and home gardeners. The survey should take about 10 minutes to complete.

Related Websites

Beginning Farmer Resources

Crops, Dairy, Livestock & Equine

Cranberries

Crop Insurance/Risk Management

Fruit

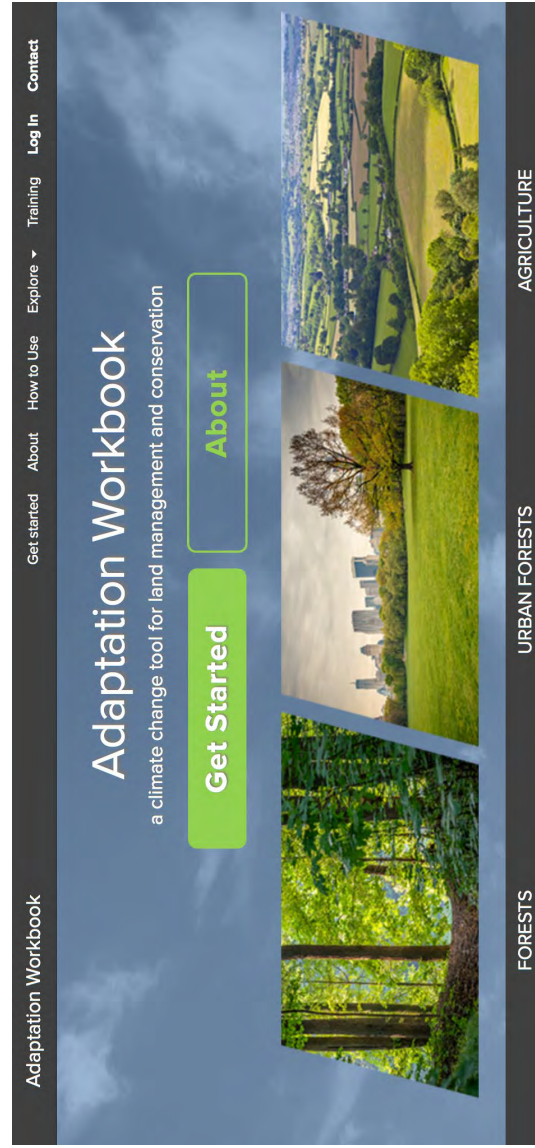
Greenhouse Crops & Floriculture

Home Gardening

Integrated Pest Management

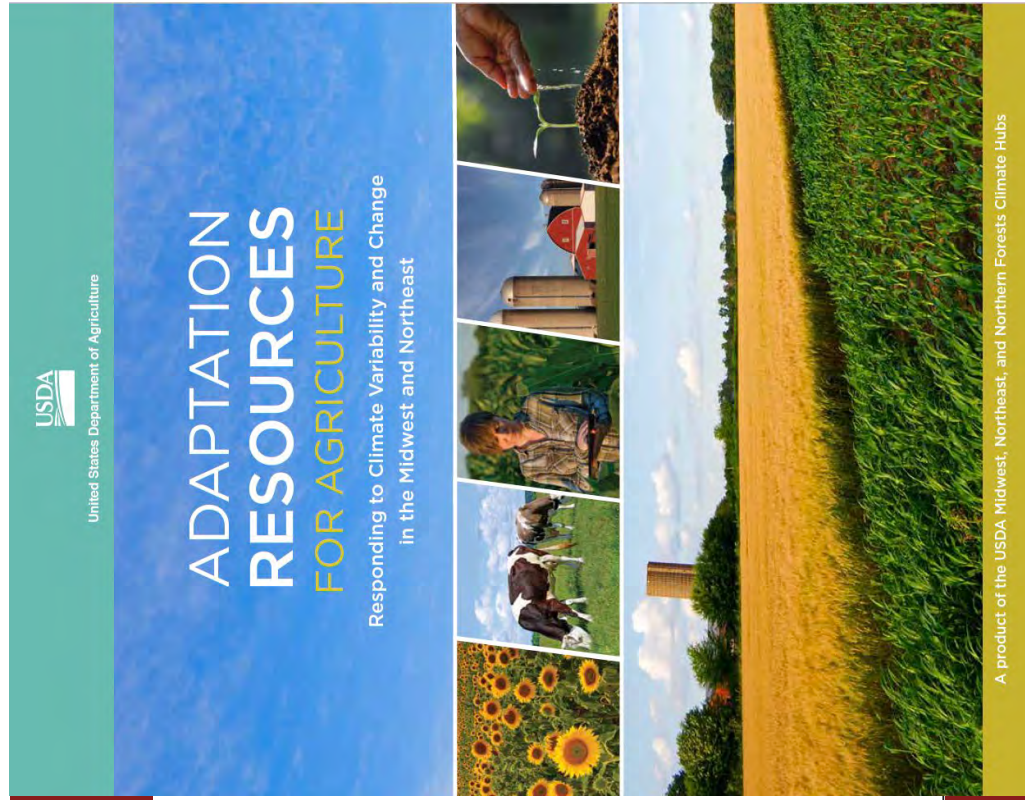
Planning your adaptation tactics

- Adaptation Workbook
- Hard copy and web site
- Web - <https://adaptationworkbook.org>

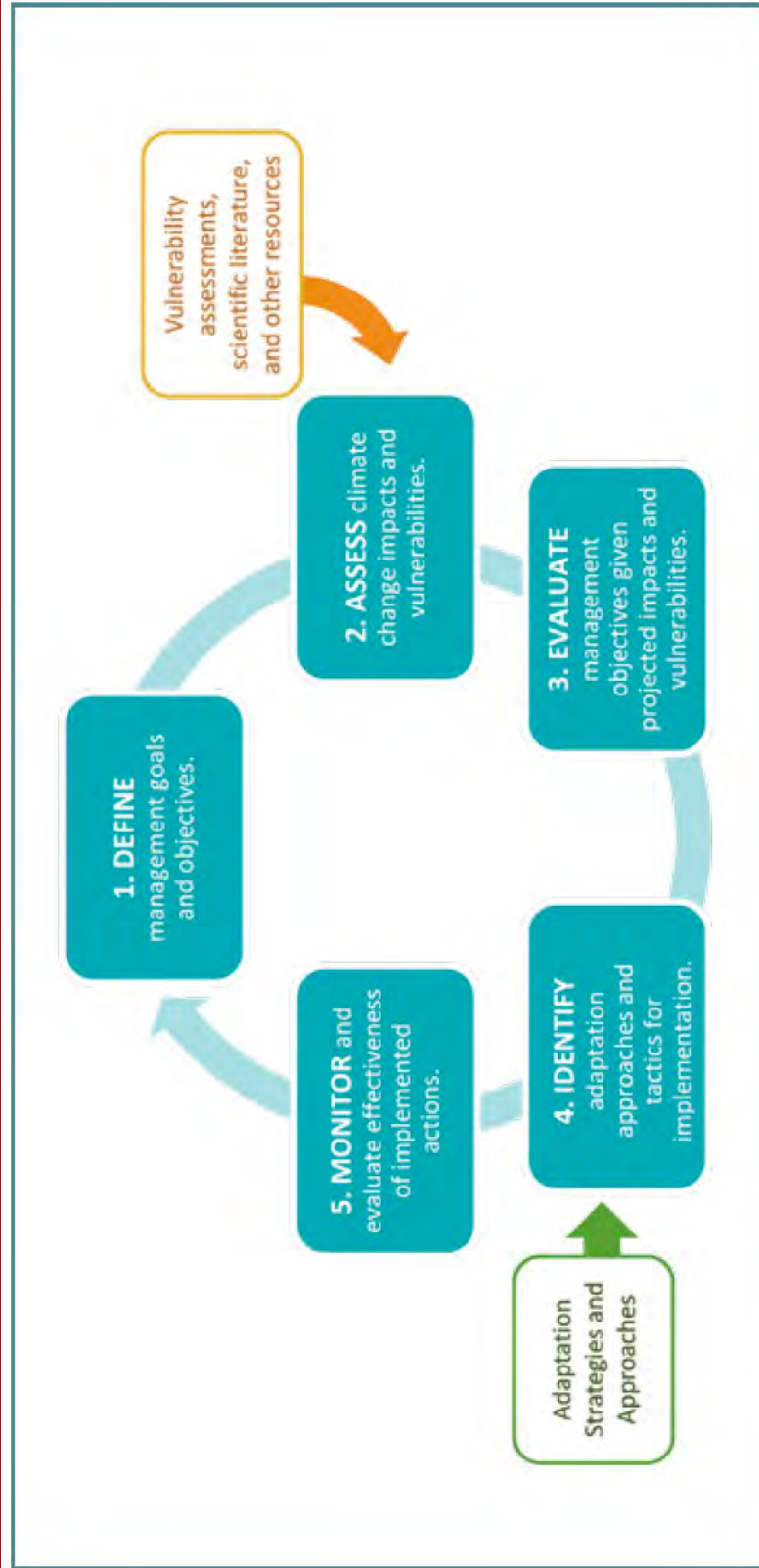


Planning your adaptation tactics

- Adaptation Workbook
- Hard copy and web site
- Web - <https://adaptationworkbook.org>
- Book:
<https://www.climatehubs.oce.usda.gov/sites/default/files/AdaptationResourcesForAgriculture.pdf>



Process



Changing your system

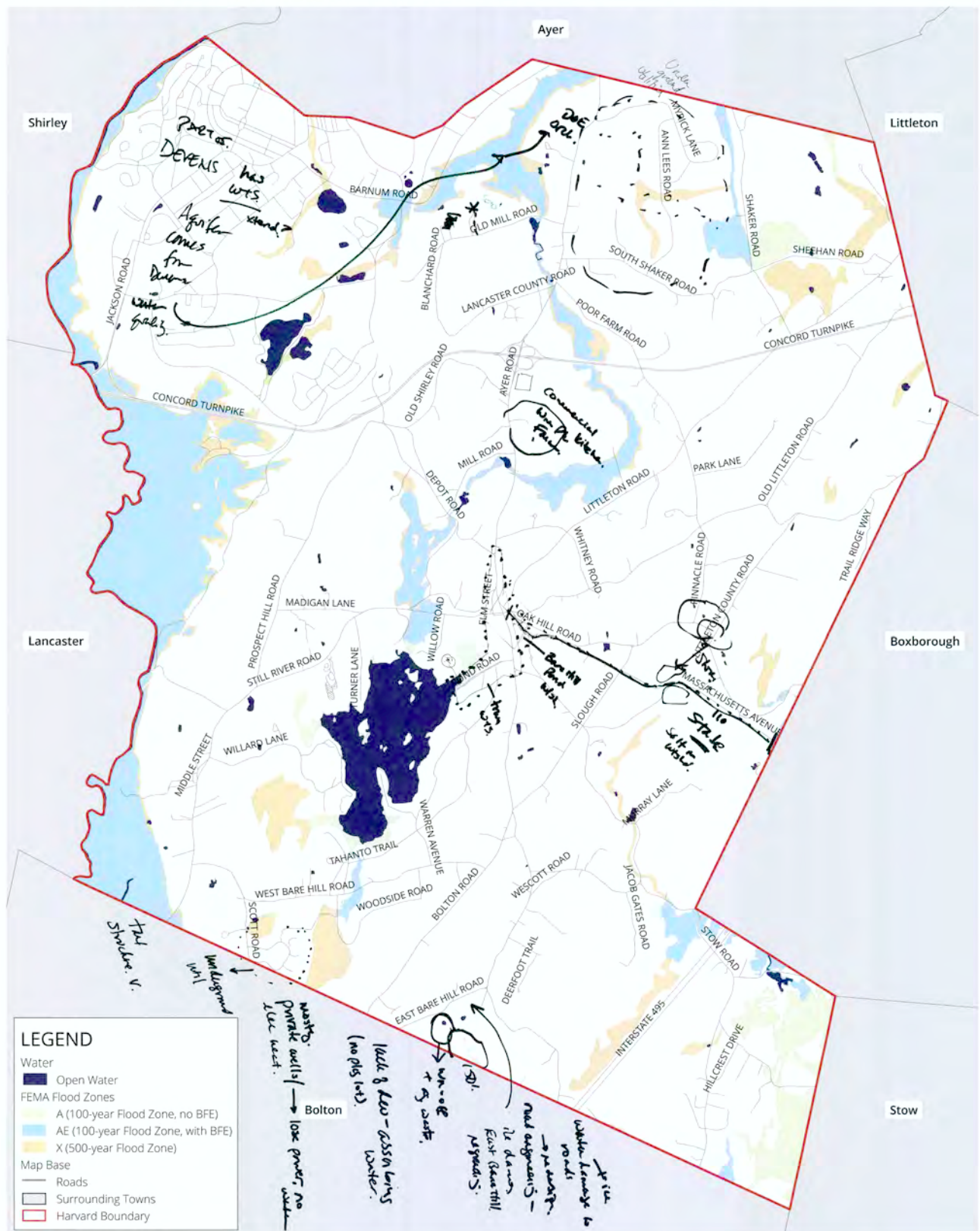
- Diversify production – spreads risk
- Extreme example of diversification: permaculture
- Presently best suited to small-scale, subsistence gardens
- UMass Permaculture –
- What is permaculture?



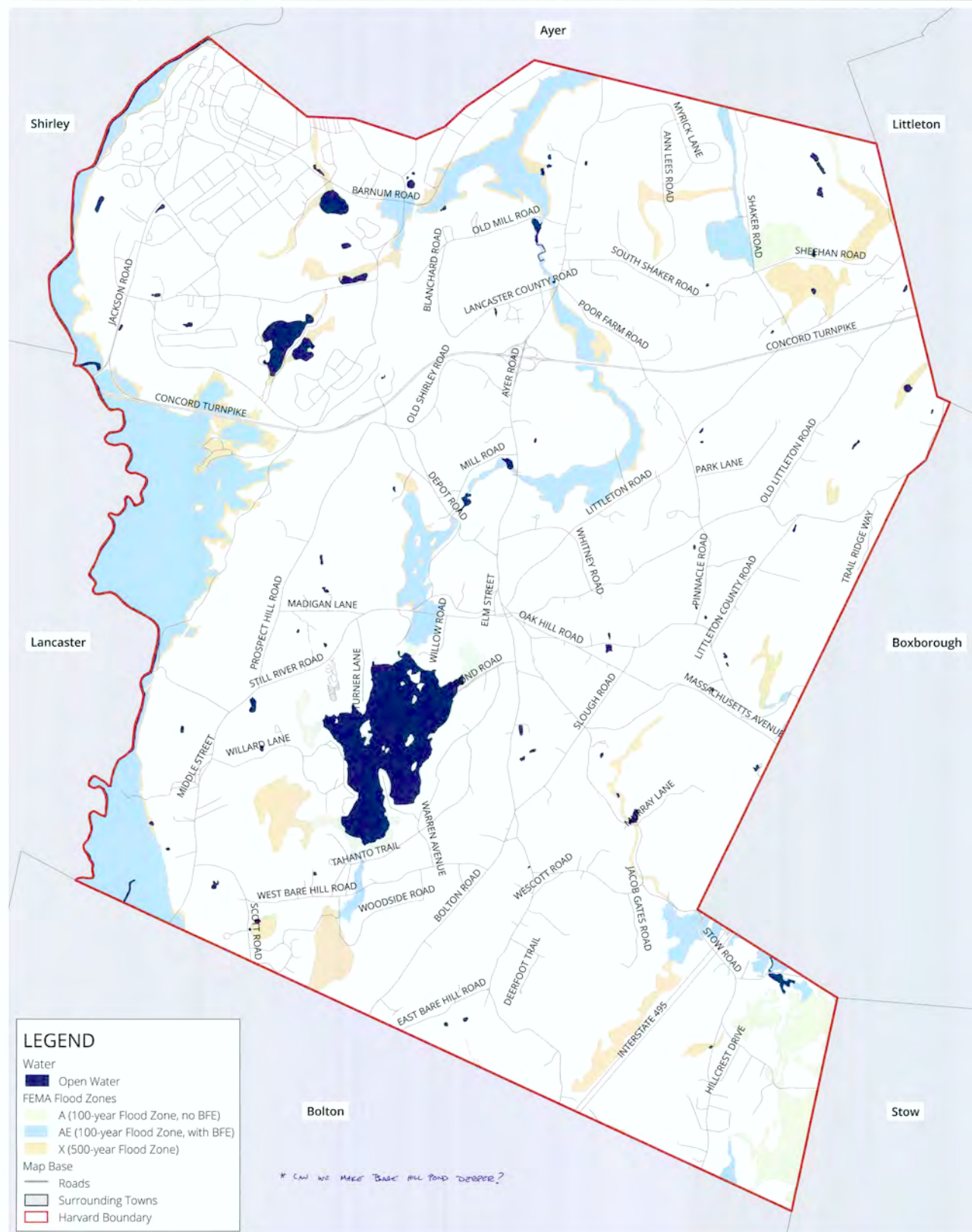
Appendix E: Workshop 1: CRB Participatory Mapping

This appendix contains the map produced during the two agricultural workshops.

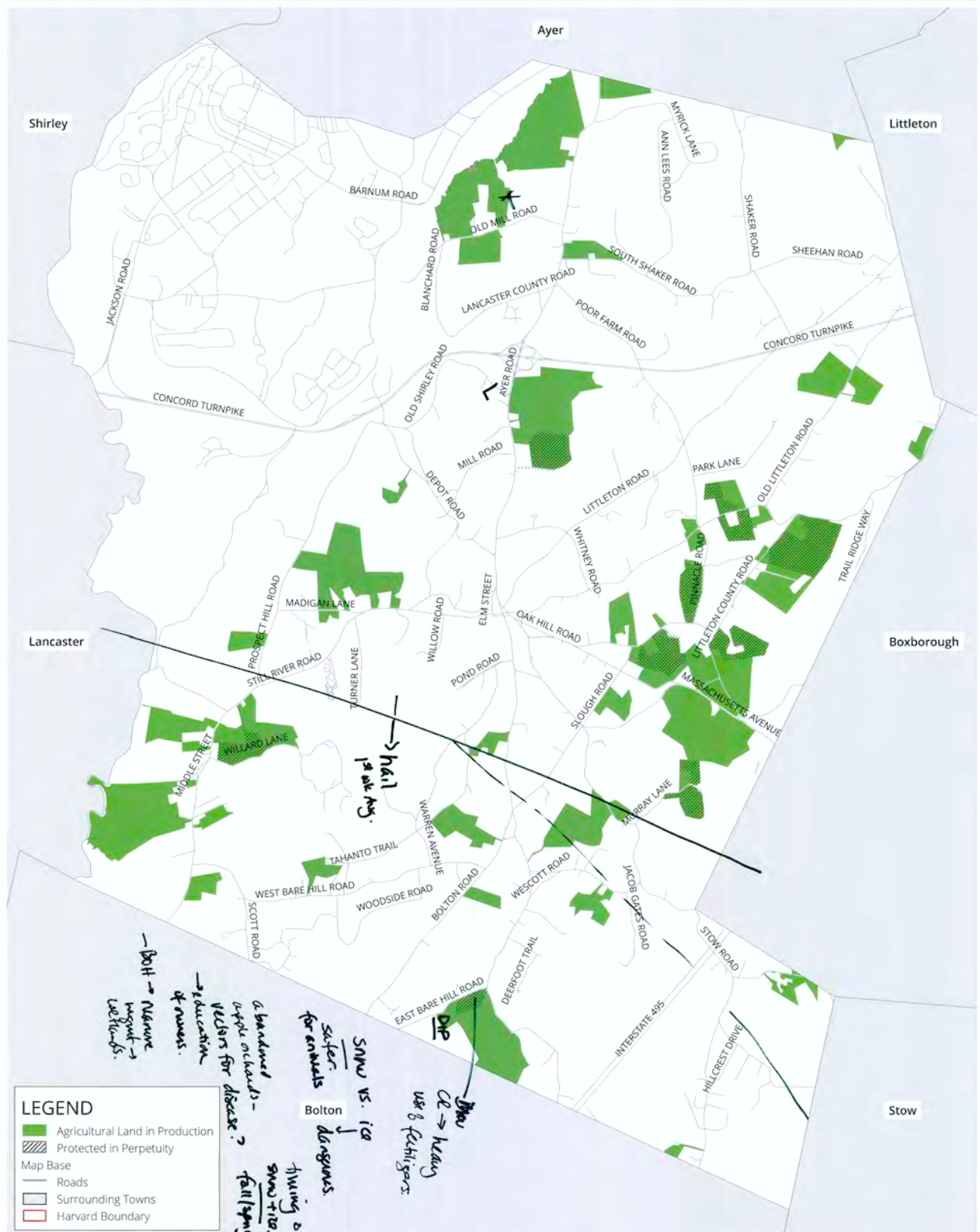
Existing Conditions: Water and FEMA Zones



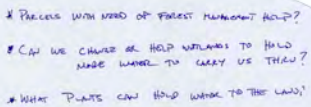
Existing Conditions: Water and FEMA Zones



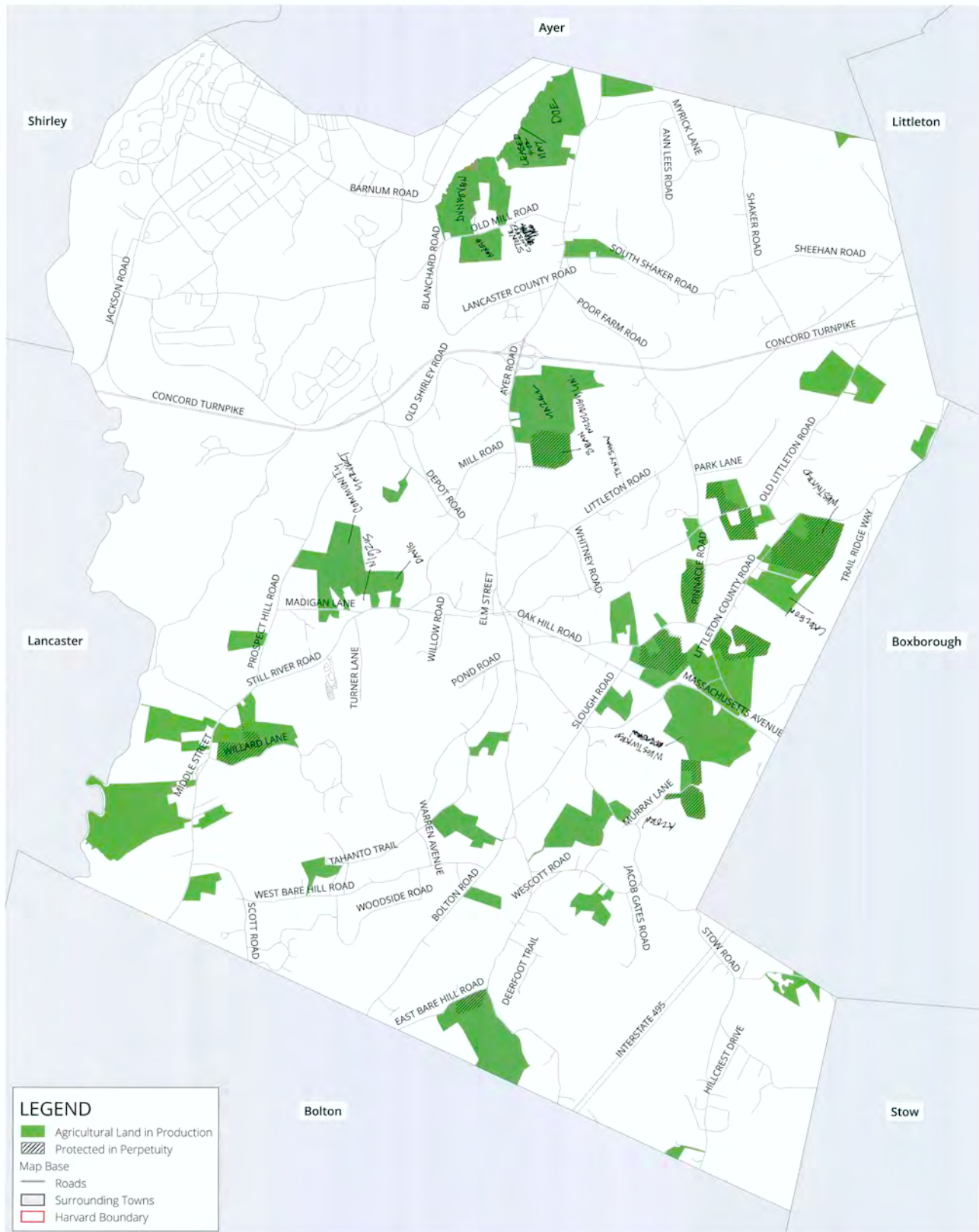
Existing Conditions: Agricultural Properties



2



Existing Conditions: Agricultural Properties



Appendix F: Both Workshops: CRB Matrices and Actions

This appendix contains the matrices produced during the two agricultural workshops.

Community Resilience Building Risk Matrix		www.CommunityResilienceBuilding.org							
Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)									
H-M-L priority for action over the Short or Long term (and Ongoing)									
V = Vulnerability S = Strength									
Features	Location	Ownership	V or S	Excessive Moisture/Flood	Extreme Storm Events	Storm Event Timing	Temperature Variability	Priority	Time
H - M - L									
Short Long Ongoing									
Infrastructure									
Lack of Development			S						
Lack of Town Water			V						
Above Ground Utilities / Energy Resilience			V						
Better Road Design / Eng.			V						
Well Depth / Water Quality			V						
Societal									
Reduced Production (weed, apple, honey, etc.)			V						
Lack of Awareness (local culture, ag, etc.)			V						
Muni Fiscal Sustainability / Local Tax Structure			V						
Regulatory (Assessing, Zoning)			V						
Economic (tourism, limits to, local goods / services)			V/S						
Environmental									
Wetlands, other water resources									
Contaminants (both runoff and applications)									
Plant Threats / Vulnerabilities (invasive, leaf canopy extension)									
Insect Threats / Vulnerabilities (invasive, pests, pollinators)									
Disease Threats (blight, stress, animal diseases)									
Wildlife (invasive species, dispersal, introduction of species)			V/S						

HARRIMAN HARVARD MVP WORKSHOPS FEBRUARY 2019

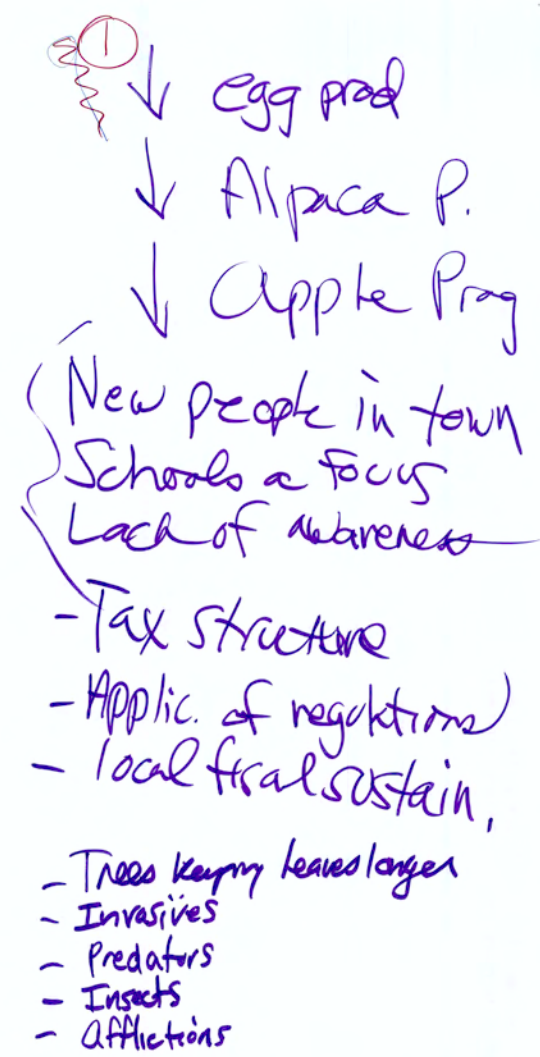
Community Resilience Building Risk Matrix		www.CommunityResilienceBuilding.org				
3		Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)				
H-M-L priority for action over the Short or Long term (and Ongoing)		Priority				
V = Vulnerability S = Strength		H - M - L				
Features	Location	Ownership	V or S	INC. PREP. P. UP.	WATER- EFFICIENT	TEMP. TOLERANT
Infrastructural						
STORAGE	LARGE OP.	ALL COM.	V	INC. ENERGY COST		
OPEN SPACE			S			
Societal						
TAXES	ALL	ALL	V	RES. / COM. SAME	PROTECT VALUE (DON'T KEEP A WILDFIRE TAXED NO COM.)	AG. BUILDINGS EQUIP. TAXED
AG USE OF CON. LANDS	SOME	TOWN	V			
DEVELOP. SURROUNDING	ANYWHERE	DOE	V			
MIN. WAGE UP BY 2023	ALL COM	ALL COM	V			
Environmental						
INCR. RAIN	ALL	ALL	V/S	PEST / DISEASE	CROP FAIL	
INCR. TEMPS	ALL	ALL	V	VARIETIES NOT Viable	HEAT STRESS	

3

2014-2015
2016-2017

2018-2019
2020-2021
2022-2023
2024-2025

2026-2027
2028-2029
2030-2031



2026-2027

Agricultural Workshop #2: What are We Missing?: Vulnerabilities to Climate Change

A

DISAPPEARANCE OF INSECTS

B

WEATHER IMPACTS WHEN SPRAYING CAN OCCUR

C

D

E

F

G

H

I

J

K

L

- A Disconnect between new residents and existing population (social change)
- B Shared information base and community understanding
- C Understanding of farm practices by new residents
- D Groundwater quality for agriculture and community health (Devens)
- E ^{Stewardship} ~~responsibility~~ to leverage opportunities for Harvard
- F
- G
- H
- I
- J
- K
- L

Agricultural Workshop #2: Climate Change: Temperature Extremes and Variability

Vulnerability		Strategies	Partners	TOTAL
A	Disease threats to plants, animals Difference between organic and non-organic	IPM	UMASS	1
B	Reduced production Varietals not viable	EDUCATION	UMASS	
C	Invasives - plants, wildlife, pests Difference between organic and non-organic WOOLLY AWOOLLY TKS MECE (REGIONAL PROBLEM)	(SYSTEMS) EDUCATION DEER FENCING - COMPREHENSIVE REGIONAL STRATEGIES LAND STEWARDSHIP - COLLECTIVE NO BEED FEEDERS NEAR HOMES	TOWN INDIVIDUAL OWNERS STATE	6
D	Threats to/loss of pollinators OUTSIDE COMPANIES SPRAYING FOR MOSQUITOES, TICS PUBLIC	REGULATIONS - DON'T ALLOW DURING DAY (TOWN) EDUCATION - AWARENESS OF CONTEXT POLLINATOR - SCHOOL PROGRAM NATIVE BEE HOUSES SMUDGE POT FOR SMALL FARMS		7
E	Stress from heat/cold variation within a single season			
F		REGIONAL EDUCATION STRATEGY	COMMUNITIES	4
G	ABANDONED APPLE TREES HARBOR DISEASE/PESTS	EDUCATION MONITOR		
H		SETTLEMENT PATTERNS / HAZARDS → LOCATE STRATEGIES FOR SMALL NE. TOWNS	STATE	7
I		BURDENS/CHALLENGES AS OPPORTUNITIES (AYER RD.)		6
J				
K				
L				

Agricultural Workshop #2: Climate Change: Precipitation Extremes and Variability

Vulnerability		Strategies	Partners	TOTAL
A	Disease threats to plants, animals <i>Difference between organic and non-organic</i>	SOIL HEALTH INTER-PLANTING		8
B	Runoff of contaminants into water supply/ wetlands	TAMPER ROADS VEGETATIVE BUFFERS STONE VS. LOG EROSION CONTROL	TOWN 	3
C	Reduced production – amount and quality Varietals not viable	EDUCATION		
D	Super-saturated fields/pastures	RAISED BEDS		
E	Lack of water at the right time (limited irrigation, well-depth)			
F	Stress from drought/flooding at different times of the year	COMMUNITY WATER BANK AG. LIAISON FOR EXPERT CONSULT	NRCS UMASS EXTENSION LOCAL EXPERTS (VOLUNTEERS) 	3
G	<i>Weather Impacts on Spraying</i>			
H	EROSION			
I	INVASIVE SPECIES IMPACT WATER PUMPING			
J	SHORTER PLANTING SEASON	ADJUST CROP ACCORDING TO GROWING PERIOD HOOP HOUSE APPLES-GRAFT SOUTHERN VARIETIES NUTRIENT SPRAYS MANGANESE-HELPS CALCIUM UPTAKE MICRO NUTRIENTS		1
K				
L	< 10 ACRES JOHN FORCES	FOREST MANAGEMENT FOR CO2 SEQUESTRATION INTEGRATION OF MANAGEMENT PLANS	TOWN UMASS EXTENSION UMASS AMHERST? DAR/DEM 	12

March 2019

Town of Harvard: Municipal Vulnerability Program Planning Workshop

HARRIMAN + Daniel Cooley, Ph.D. Professor of Plant Pathology
UMass Amherst

Agricultural Workshop #2: Economic/Market

[illegible]

Agricultural Workshop #2: Regulatory

	Vulnerability	Strategies	Partners	TOTAL
A	Local regulations (ex. erosion control, zoning)	Bylaws w/ appropriate due diligence - Better sign bylaws - sign working group	town other specific groups	●●
B	Applicability of building codes to agricultural buildings → Health	Lobbying state for more reasonable ag. regd.	●●●●	●●●●
C ②	Agritourism - state or local control?	Bylaws → state to local Info. flow and communication Local lobbying local to state	local, state resident pop.	●●●●
D	Need to preserve land in productive use			
E	Lack of accessible info. for producers	Make info. available via top channels Web, social media	local	●●
F	DEP regs. on farmsteads (serving food)	Lobbying state		●●●●
G	Enforcement of bylaws (lighting)	Capl. America		
H				
I				
J				
K				
L				

March 2019

Town of Harvard: Municipal Vulnerability Program Planning Workshops

HARRIMAN + Daniel Cooley, Ph.D. Professor of Urban Technology
Urban Analytics

Agricultural Workshop #2: Other

Vulnerability		Strategies	Partners	TOTAL
A	Succession planning	*Transfer of Development Rights *Open Space Design Devel. *Holding land values down *Chap. 61A *Enhance the economics	Schools Municipal	●●●●
B	Lack of awareness about agriculture/agricultural needs in Harvard	Education/outreach	Schools, town, ag.comm.	●●●●
C	Groundwater quality for agriculture (and others!)	Retain local M2D locally regulatory land stewardship Education/awareness (leveraging, proactive)		
D	Understanding of farm practices by non-residents	Facilitation, connecting community	Schools → town	
E	Lack of shared information base about agriculture for the entire community			●●●●
F	Deleves stewardship to leverage opportunities for Harvard			
G	Largely volunteer town govt.	Staffing and volunteer contracts (Retreats) Build a base of information, tools, etc. Build volunteer base		●
H				
I				
J				
K				
L				

