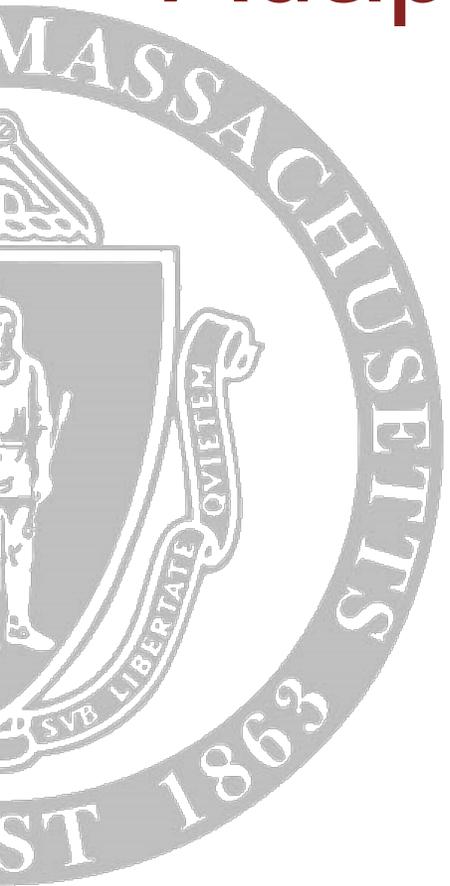


# Climate Change and Agriculture in Harvard: Adaptation Strategies, Tactics and Tools



**Harvard Municipal Vulnerability Preparedness  
Agricultural Workshop II  
March 9, 2019**

Daniel Cooley  
Stockbridge School of Agriculture  
University of Massachusetts Amherst

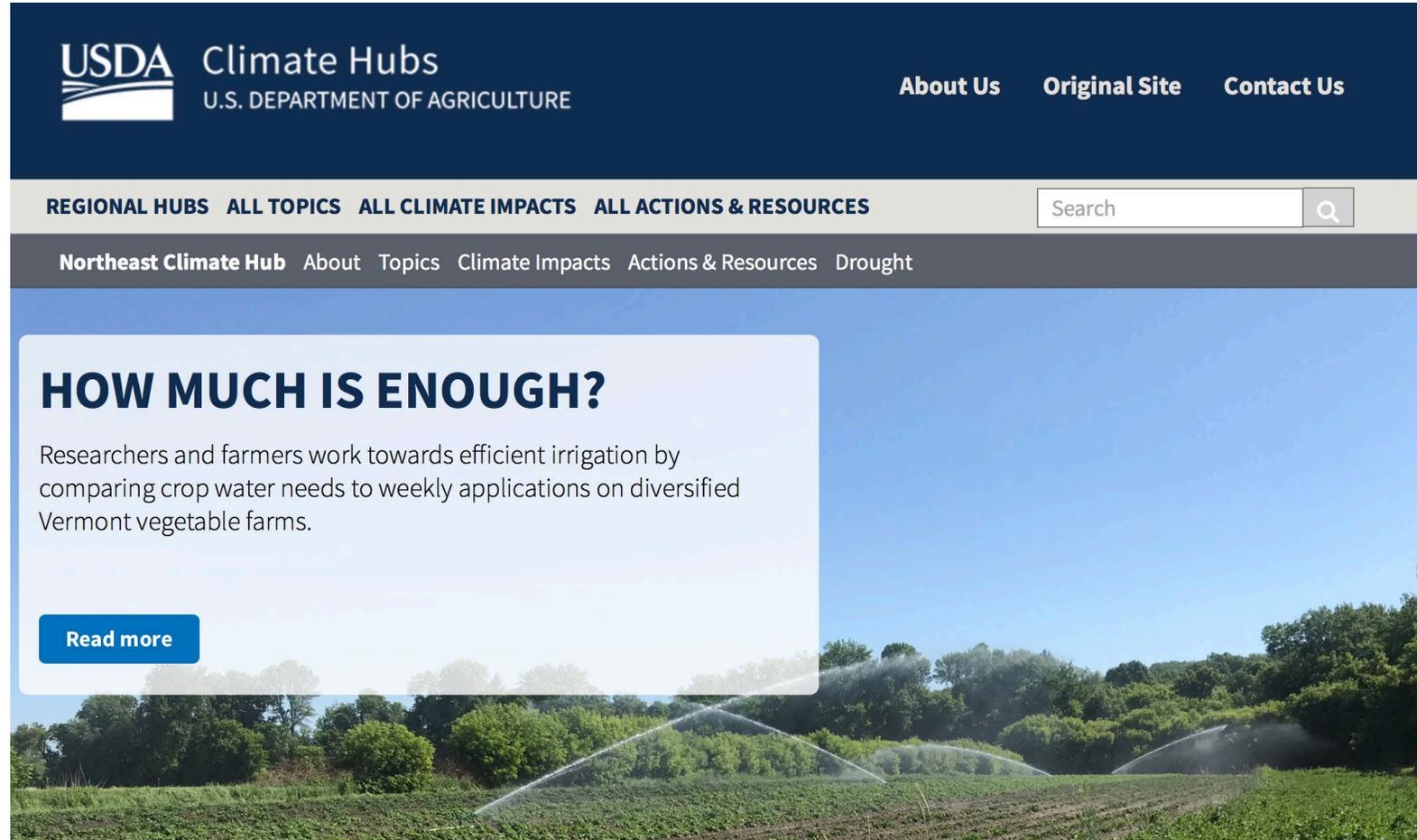
# Today

- 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.oce.usda.gov/hubs/northeast>
- Resources and research dealing with agriculture, forestry and climate change



The screenshot displays the USDA Climate Hubs website. The top navigation bar includes the USDA logo, 'Climate Hubs U.S. DEPARTMENT OF AGRICULTURE', and links for 'About Us', 'Original Site', and 'Contact Us'. Below this is a secondary navigation bar with 'REGIONAL HUBS', 'ALL TOPICS', 'ALL CLIMATE IMPACTS', and 'ALL ACTIONS & RESOURCES', along with a search box. The main content area features a 'Northeast Climate Hub' breadcrumb and a featured article titled 'HOW MUCH IS ENOUGH?' with a 'Read more' button. The background image shows a field being irrigated by a center pivot system under a clear blue sky.

USDA Climate Hubs  
U.S. DEPARTMENT OF AGRICULTURE

About Us Original Site Contact Us

REGIONAL HUBS ALL TOPICS ALL CLIMATE IMPACTS ALL ACTIONS & RESOURCES

Search

Northeast Climate Hub About Topics Climate Impacts Actions & Resources Drought

## HOW MUCH IS ENOUGH?

Researchers and farmers work towards efficient irrigation by comparing crop water needs to weekly applications on diversified Vermont vegetable farms.

Read more

# 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

UMassAmherst Links ▾ Search UMass 🔍

The Center for Agriculture, Food and the Environment Integrating research and outreach education from UMass Amherst

For Faculty and Staff | Contact Info

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Home About Extension Outreach Research Resources Services Farms & Facilities News & Events

Search the Center for Agriculture, Food and the Environment  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.

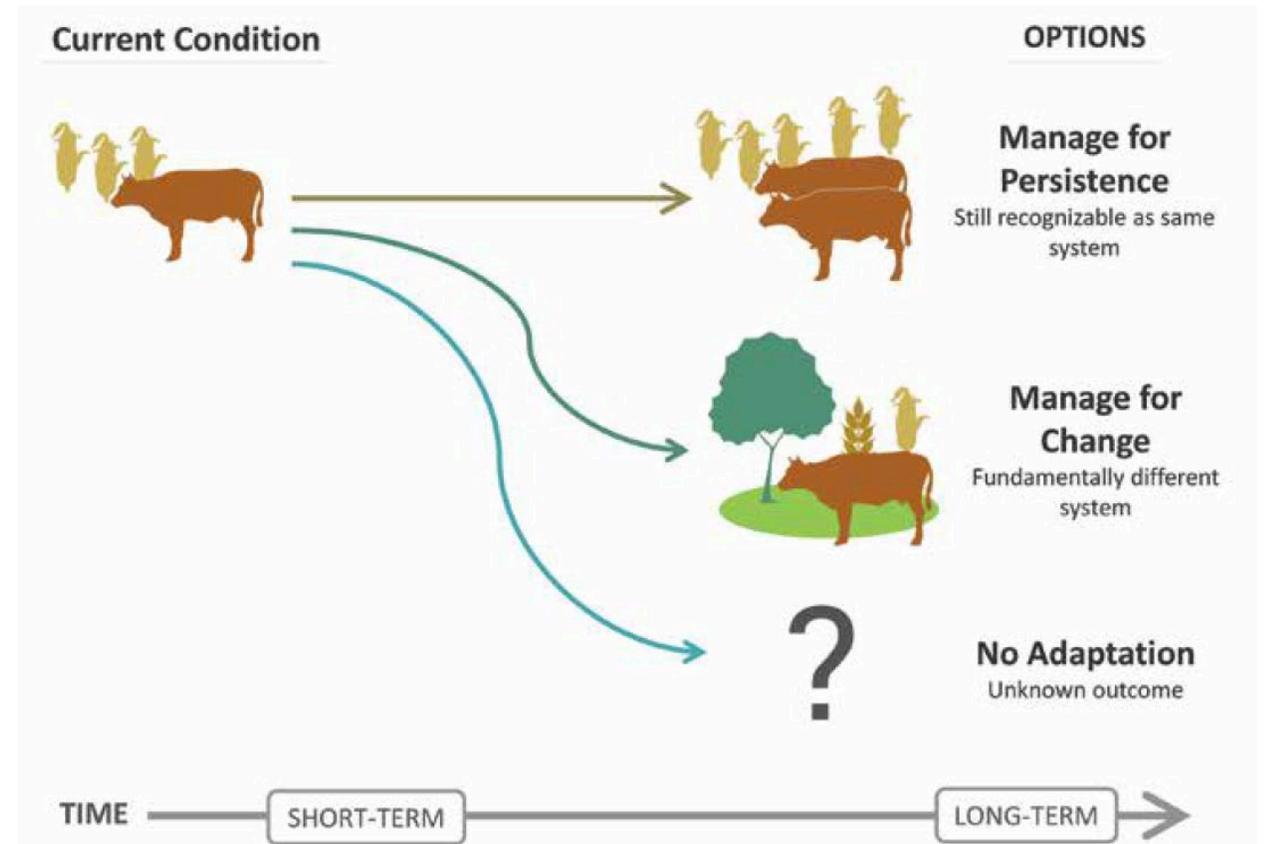
#### Massachusetts Agricultural Data

# 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

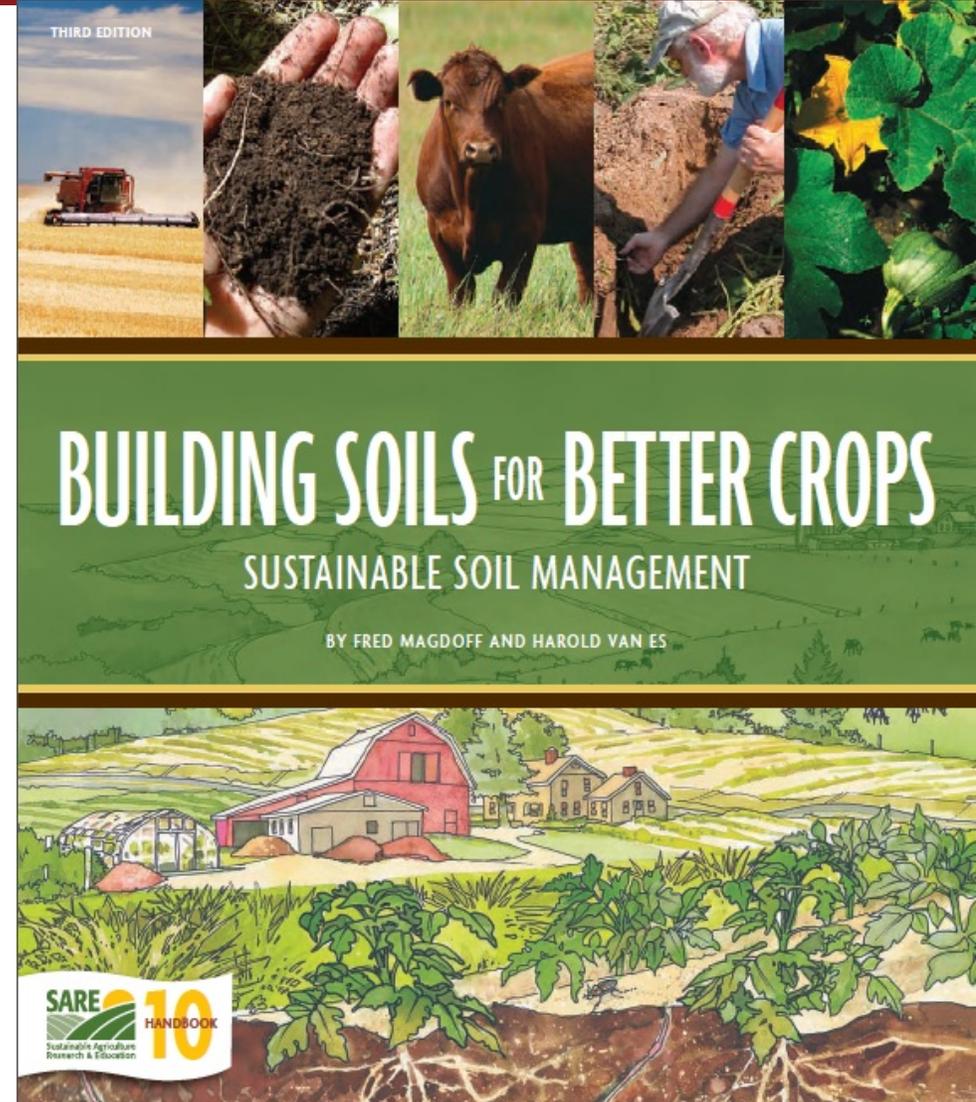
# Soil health

- 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

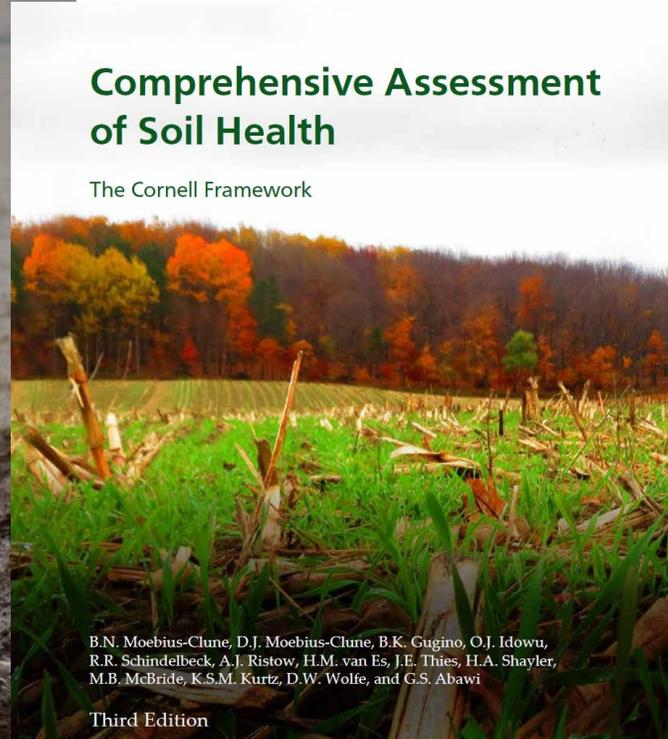


# Building healthy soils

- 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](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](#)
- <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.

- Background info
- Address
- Location
- Crop history
- Soil texture
- Cost
  - Basic \$60
  - Standard \$110
  - Extended \$170

## 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>



Grower:  
Bob Schindelbeck  
306 Tower Rd.  
Ithaca, NY 14853

Agricultural Service Provider:  
Mr. Bob Consulting  
rrs3@cornell.edu

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

Measured Soil Textural Class: **silt loam**

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

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

Group	Indicator <b>2</b>	Value <b>3</b>	Rating <b>4</b>	Constraints <b>5</b>
<i>physical</i>	Available Water Capacity	<b>0.14</b>	<b>37</b>	
<i>physical</i>	Surface Hardness	<b>260</b>	<b>12</b>	<b>Rooting, Water Transmission</b>
<i>physical</i>	Subsurface Hardness	<b>340</b>	<b>35</b>	
<i>physical</i>	Aggregate Stability	<b>15.7</b>	<b>19</b>	<b>Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff</b>
<i>biological</i>	Organic Matter	<b>2.5</b>	<b>28</b>	
<i>biological</i>	ACE Soil Protein Index	<b>5.1</b>	<b>25</b>	
<i>biological</i>	Soil Respiration	<b>0.5</b>	<b>40</b>	
<i>biological</i>	Active Carbon	<b>288</b>	<b>12</b>	<b>Energy Source for Soil Biota</b>
<i>chemical</i>	Soil pH	<b>6.5</b>	<b>100</b>	
<i>chemical</i>	Extractable Phosphorus	<b>20.0</b>	<b>100</b>	
<i>chemical</i>	Extractable Potassium	<b>150.6</b>	<b>100</b>	
<i>chemical</i>	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		<b>100</b>	

**6**

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%

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	Active Carbon	288	12
chemical	Soil pH	6.5	100
chemical	Extractable Phosphorus	20.0	100
chemical	Extractable Potassium	150.6	100
			100

Constraint	Short Term Management Suggestions	Long Term Management Suggestions
Available Water Capacity Low	<ul style="list-style-type: none"> <li>• Add stable organic materials, mulch</li> <li>• Add compost or biochar</li> <li>• Incorporate high biomass cover crop</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce tillage</li> <li>• Rotate with sod crops</li> <li>• Incorporate high biomass cover crop</li> </ul>
Surface Hardness High	<ul style="list-style-type: none"> <li>• Perform some mechanical soil loosening</li> </ul>	<ul style="list-style-type: none"> <li>• Shallow rooted cover/rotation crops</li> </ul>

# 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

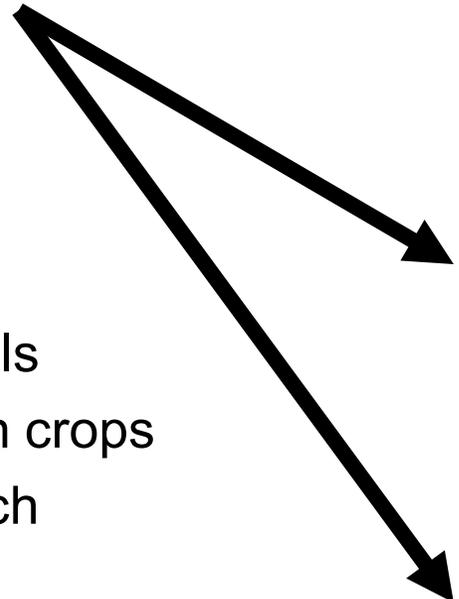


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Group	Indicator	Value	Rating
<i>physical</i>	Available Water Capacity	<b>0.14</b>	<b>37</b>
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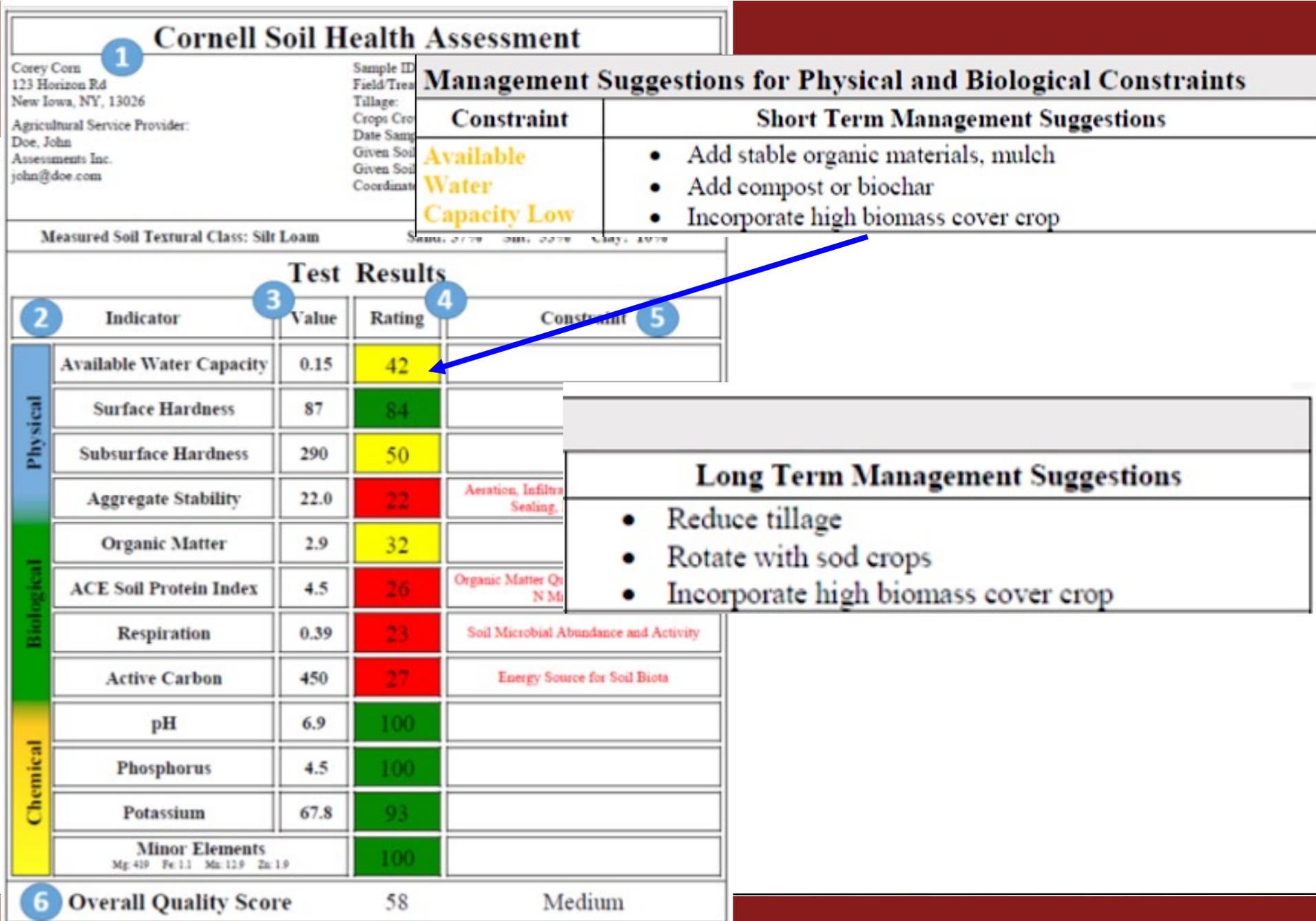
# Recommendation

- 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%**

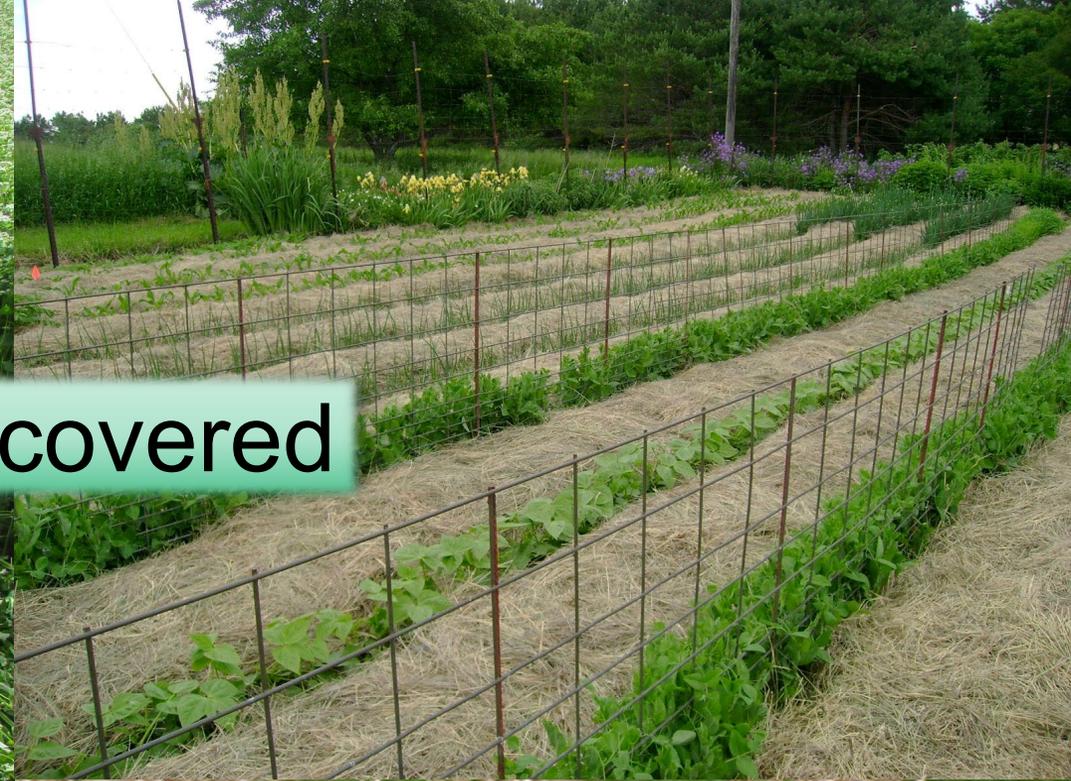
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**FIGURE 2.53.** Sample Soil Health Assessment Report with (1) Background info, (2) Measured indicator, (3) Indicator value, (4) Rating, (5) Constraints, and (6) Overall quality score.

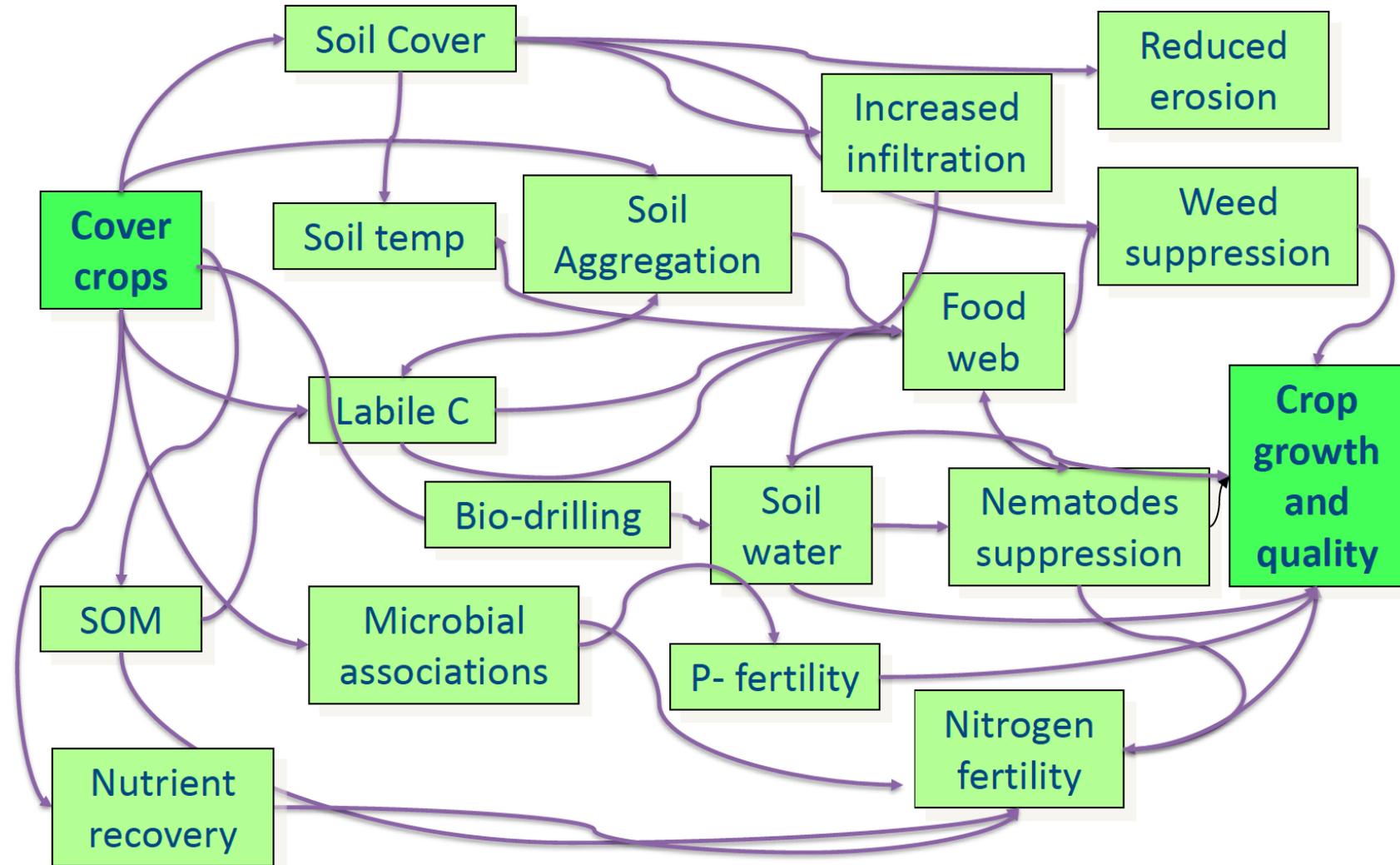


Soil is meant to be covered



# Cover crops and mulch impact everything in soil!

- Using mulches and cover crops, intercropping, so that the soil is left bare and fallow for as little time as possible is one of the most important things that can be done to mitigate climate change impacts.
- No-till
- Polycultures



# 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

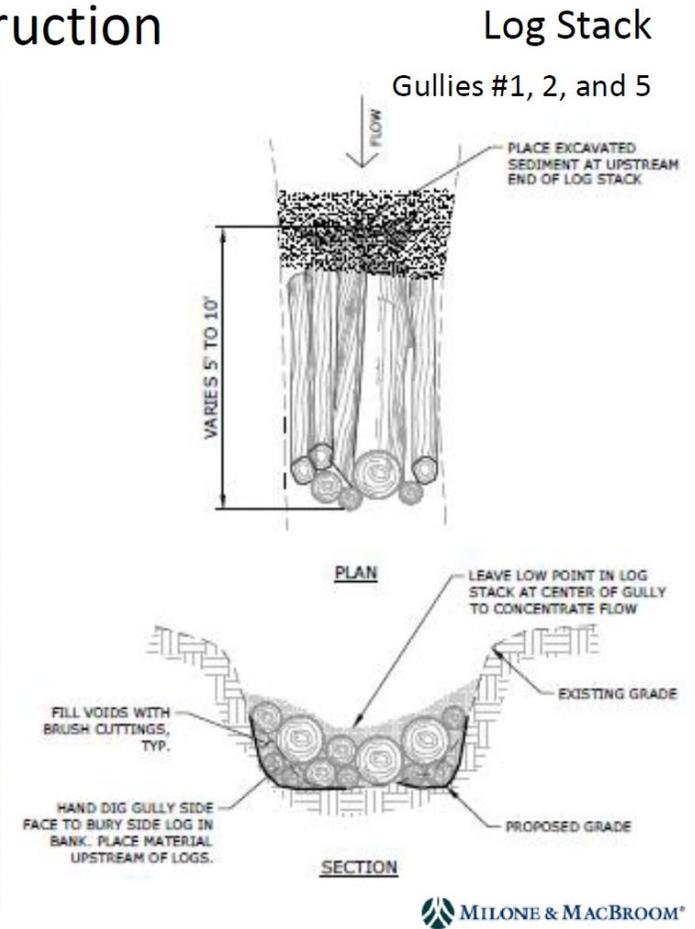
- 12" stone and 24" stone over geotextile fabric
- Treats full length of gully regardless of degree of erosion
- Installed with excavator
- Separate access road through forest to move rock



# 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.

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

# 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

- Apply the correct amount of water at the right time – become familiar with irrigation principles
- For ex. UMass “Irrigating Vegetable Crops”  
<https://ag.umass.edu/vegetable/fact-sheets/irrigating-vegetable-crops>
- Time irrigation by need – measure rain, soil moisture - tensiometer, soil moisture block
- Measure irrigation output

The screenshot shows the UMass Amherst website for the Center for Agriculture, Food and the Environment. The page is titled "Irrigating Vegetable Crops" and is part of the UMass Extension Vegetable Program. The navigation menu includes "Vegetable Home", "About", "Publications", "Fact Sheets", "Projects", "Resources & Services", "News & Events", and "Make a Gift". The main content area is divided into two columns. The left column contains a "Fact Sheets" section with a list of topics: "View All Fact Sheets", "Vegetable Crops", "Diseases", "Insects and Mites", "Business Management", "Cultural Practices", "Soil & Nutrient Management", "Food Safety", "Weeds", and "Wildlife". Below this is a "Search CAFE" box with a search input field and a "Search" button. At the bottom of the left column, there is a "Connect with UMass Extension Vegetable Program" section with a Facebook icon and a link to the "UMass Vegetable & Fruit IPM Network". The right column contains the main article text, which discusses the importance of efficient irrigation water use and provides detailed information on "Crop Requirements and Responses", "Leafy vegetables", "Broccoli and cauliflower", "Root, tuber, and bulb vegetables", and "Fruiting vegetables".

UMassAmherst Links Search UMass

The Center for Agriculture, Food and the Environment

Vegetable Home About Publications Fact Sheets Projects Resources & Services News & Events Make a Gift

UMass Extension Vegetable Program

## Irrigating Vegetable Crops

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.

### Crop Requirements and Responses

Vegetable crop water requirements range from about 6" of water per season for radishes to 24" for tomatoes and watermelons. Precise irrigation requirements can be predicted based on crop water use and effective precipitation values. Lack of water influences crop growth in many ways. Its effect depends on the severity, duration, and time of 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.

#### 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 leaf 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 from the leaf 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.

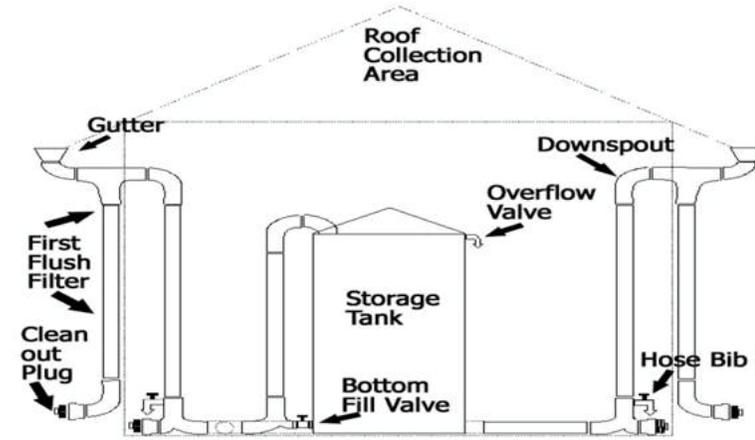
#### Fruiting vegetables

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, reduce 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



PennState Extension

HOME | HEAT AND DROUGHT TOLERANT PLANTS

## 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



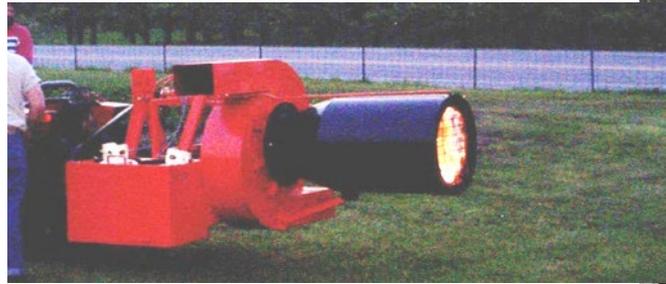
Black-eyed Susan (*Rudbeckia* spp.)

### 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 dioicus*)
- Ginkgo (*Ginkgo biloba*)
- Goldenraintree (*Koelreuteria paniculata*)
- American Sweetgum (*Liquidambar styraciflua*)

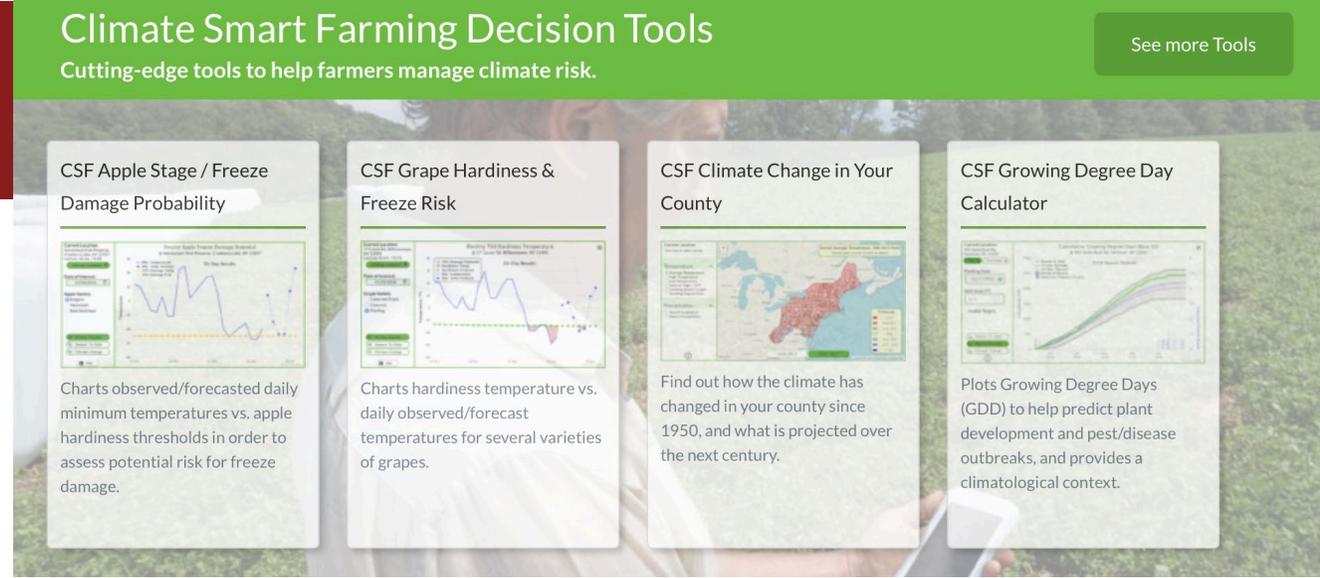
# Frosts

- 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.



**Current Location:**  
50 Slough Rd, Harvard, MA 01451  
Lat/Lon: 42.49, -71.57  
[Change Location](#)

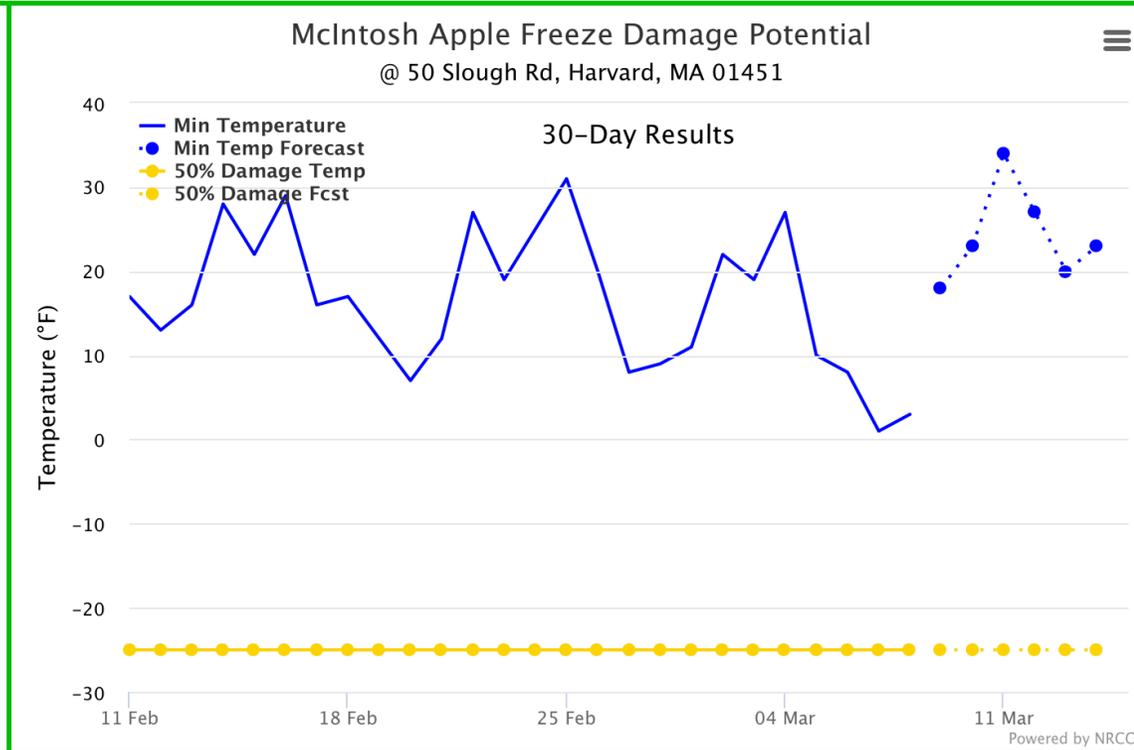
**Date of Interest:**  
03/08/2019

**Apple Variety**  
 Empire  
 McIntosh  
 Red Delicious

*Viewing 2018-2019 results.*

[30-Day Results](#)  
[Season To Date](#)  
[Climate Change](#)

[Info](#)



# 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

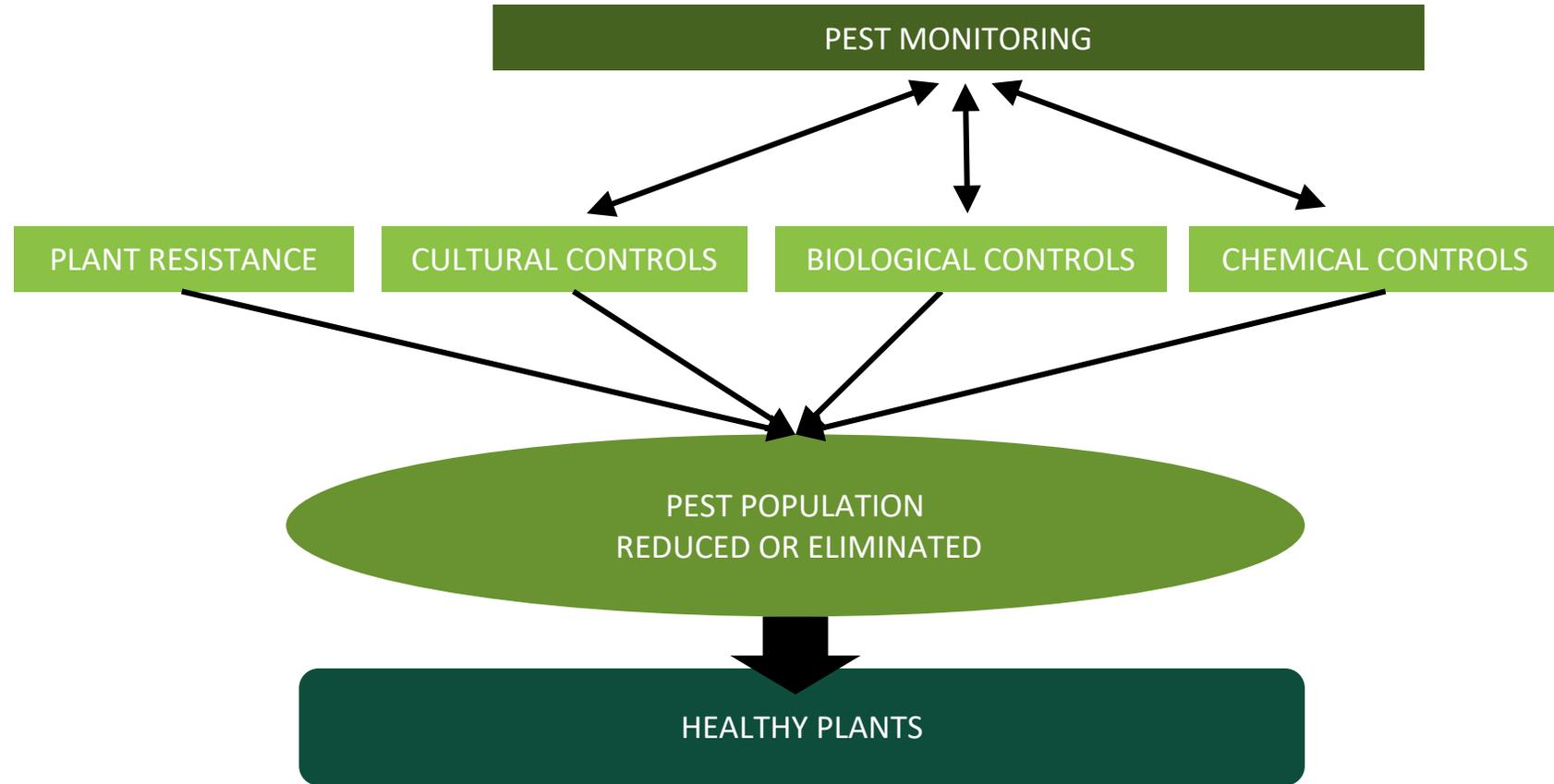
# Integrated Pest Management

- 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 if 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



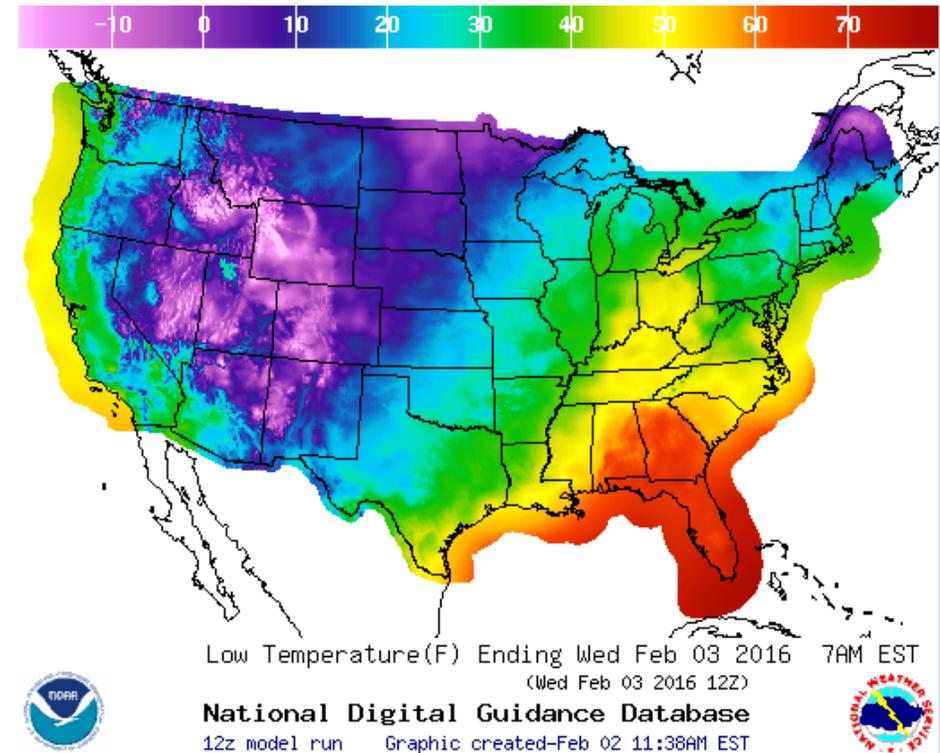
# Weather monitoring

- 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 km<sup>2</sup> 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>

The screenshot displays the NEWA website interface. At the top left is the Cornell University logo. The main header includes the text "New York State Integrated Pest Management Program" and "NEWA Network for Environment and Weather Applications". A "Website status" box in the top right corner reports "No issues reported" as of "3/3/2019 5:51:25 PM". A blue navigation bar contains links for "Weather Data", "Pest Forecasts", "Station Pages", "Crop Management", "Crop Pages", "Weather Stations", and "Help". Below this, a green box contains the text "Welcome to the NEWA Home Page". A search bar prompts users to "Enter 'City, ST' or 'zip code'" with a "Go" button. A sidebar on the left lists "About NEWA" (with links for About NEWA, Contact Us, NEWA Press Releases & Reports, Vision Statement, and Your NEWA Blog) and "Other Weather Data Sources" (with links for 6-10 Day Outlook (NWS), National Doppler Radar Sites, National Weather Service, NWS Graphical Forecasts, NWS State Data, Weather Activity Planner, Weekly Weather & Crop Bulletin (USDA), and About Other Weather Data Sources). Another sidebar lists "Other Pest Forecast Tools" (with links for Cucurbit Downy Mildew Forecasting, Fusarium Head Blight Prediction Center, Soybean Rust ipmPIPE, and About Other Pest Forecast Tools). The main content area features a map of the Northeast United States and parts of Canada, with a "Map" dropdown menu and a "Click on a map marker to go to the station's home page." instruction. A dark overlay on the map lists crop types: Apples, Grapes, Onions, Potato, Tomato, and Sweet Corn. The map shows numerous green circular markers representing weather stations, with airplane icons indicating airport locations. The map data is attributed to ©2019 Google.

# UMass Extension resources

UMassAmherst

Links ▾

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IPM by Commodity

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## UMass Extension

Integrated Pest  
Management  
Program



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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>

## Resources

### UMass Extension Programs

Regional Partners

Outside New England

# Vegetable Program page

[Vegetable Home](#)[About](#)[Publications](#)[Fact Sheets](#)[Projects](#)[Resources & Services](#)[News & Events](#)[Make a Gift](#)

UMass  
Extension

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Program



Search the Center for Agriculture, Food and the Environment

## What's New [Events](#)

### Current Newsletter: Vegetable Notes 2019 Vol. 31:3

 [February 14, 2019 Vegetable Notes](#)

[Subscribe to Vegetable Notes »](#)

[View past Vegetable Notes »](#)

### 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>



United States Department of Agriculture

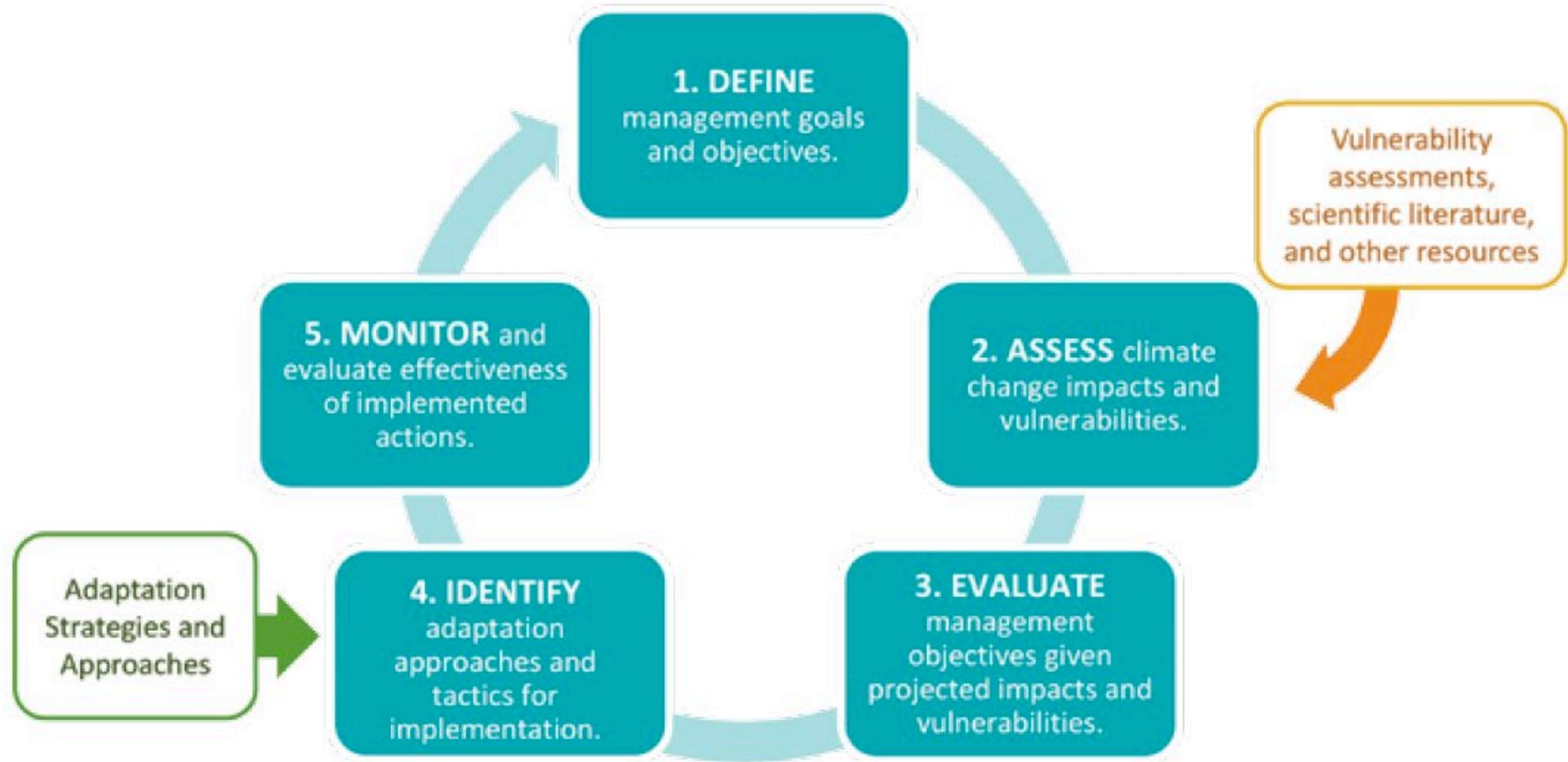
## ADAPTATION RESOURCES FOR AGRICULTURE

Responding to Climate Variability and Change  
in the Midwest and Northeast



A product of the USDA Midwest, Northeast, and Northern Forests Climate Hubs

# 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?

