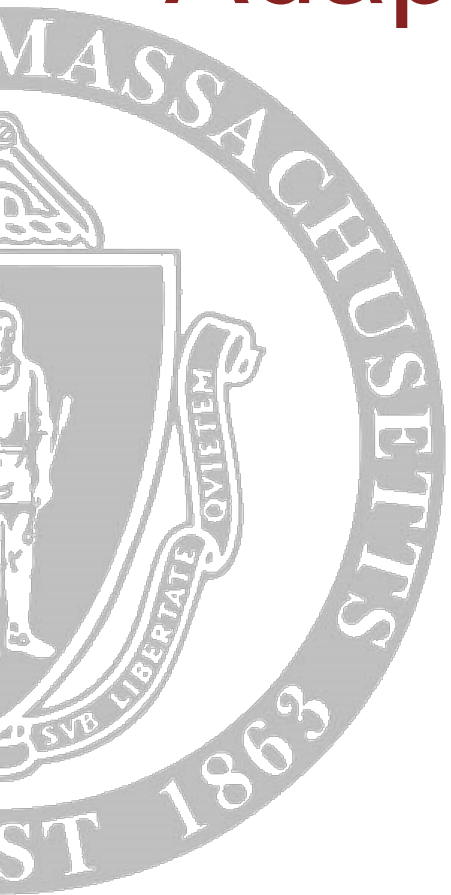
UMassAmherst

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

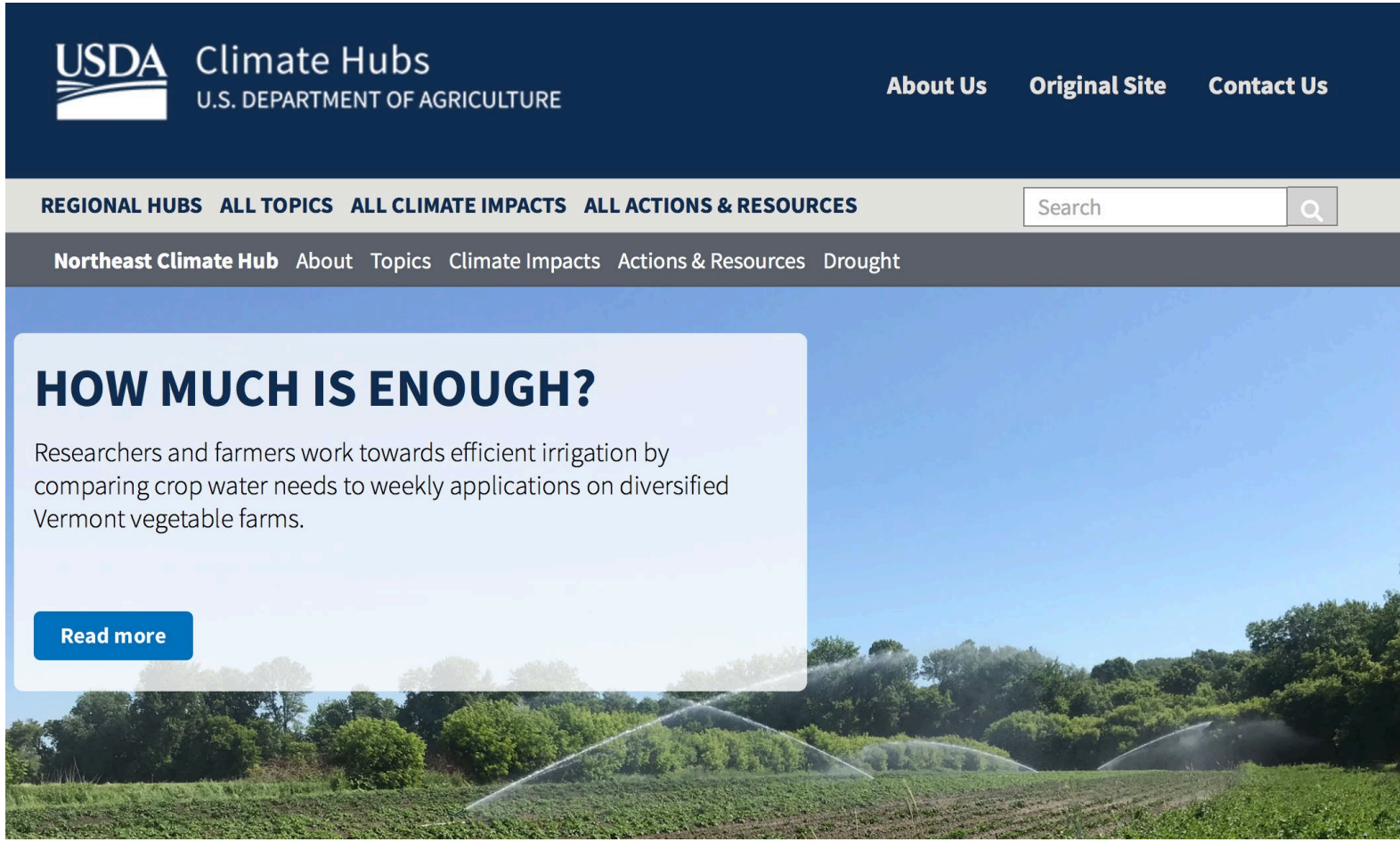
- Potential adaptation strategies, tactics and tools – ways to address climate change in agriculture
- Precipitation variability and extremes – focus on soil health
- Overview of irrigation
- Erosion case study
- Temperature variability and extremes
  - Frost and heat
  - Growing-season length
  - Chilling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


KUBOTA
M6040


FORD
1710

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



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 Sustainable Agriculture Research & Education www.sare.org

SARE Resource: Cultivating Climate Resilience on Farms and Ranches

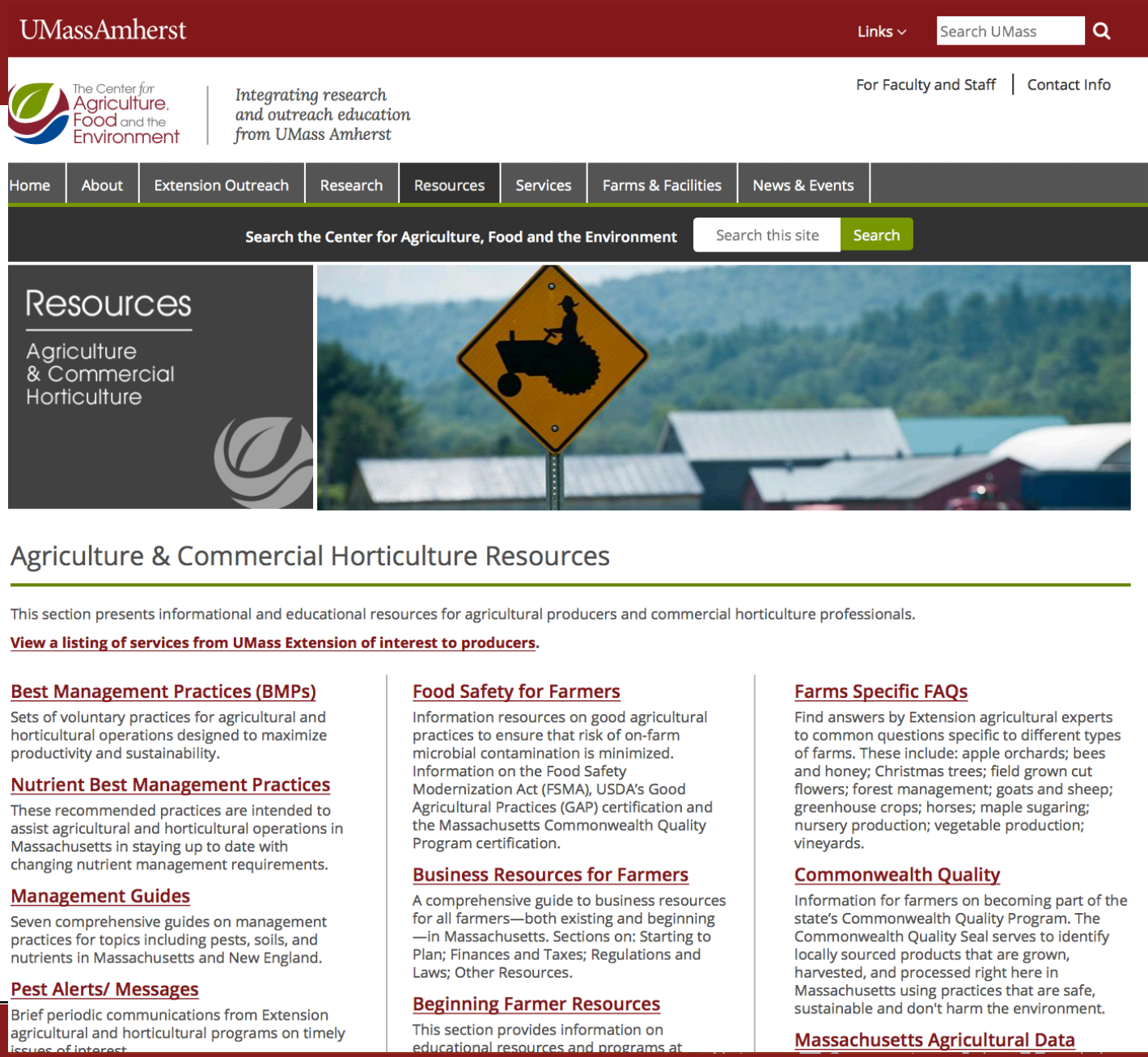
Cornell Biochar and Compost Facilities

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

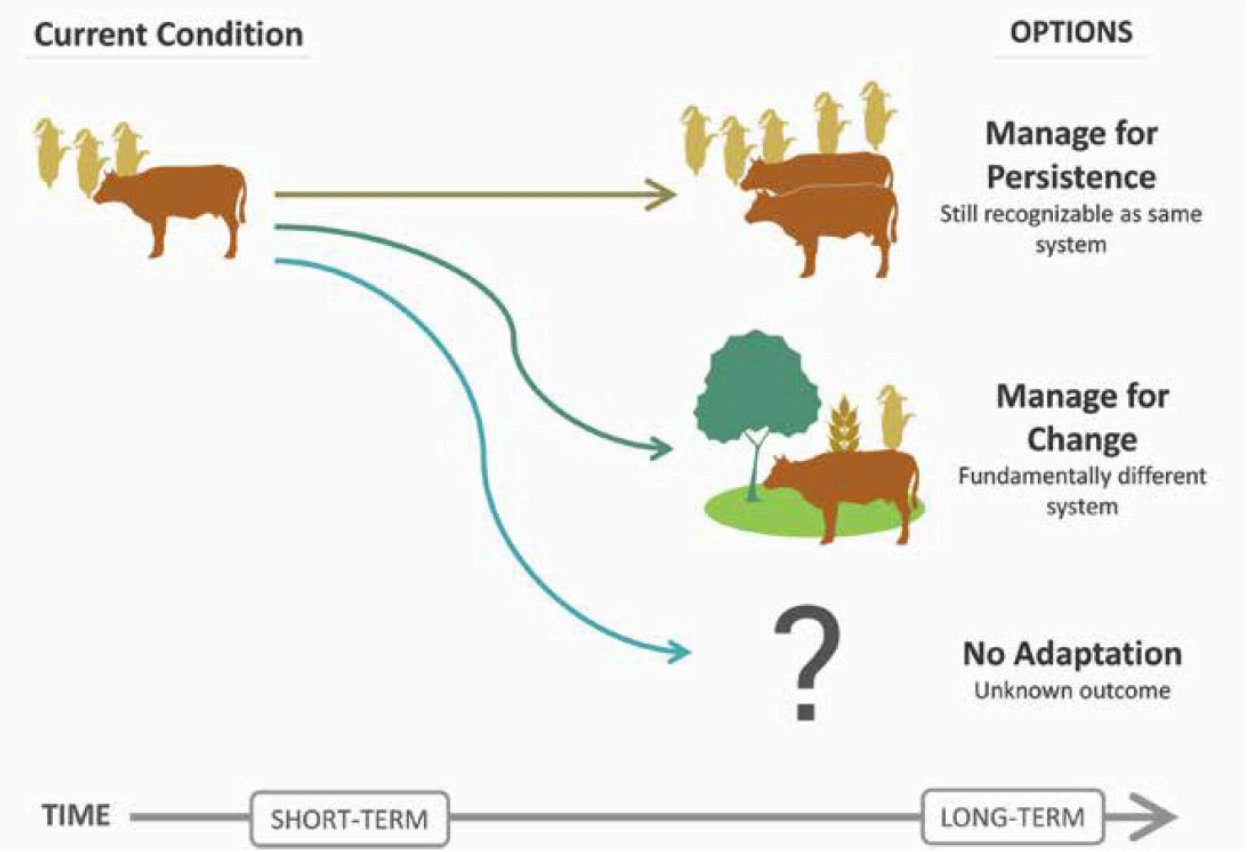


Key points from the survey

- 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

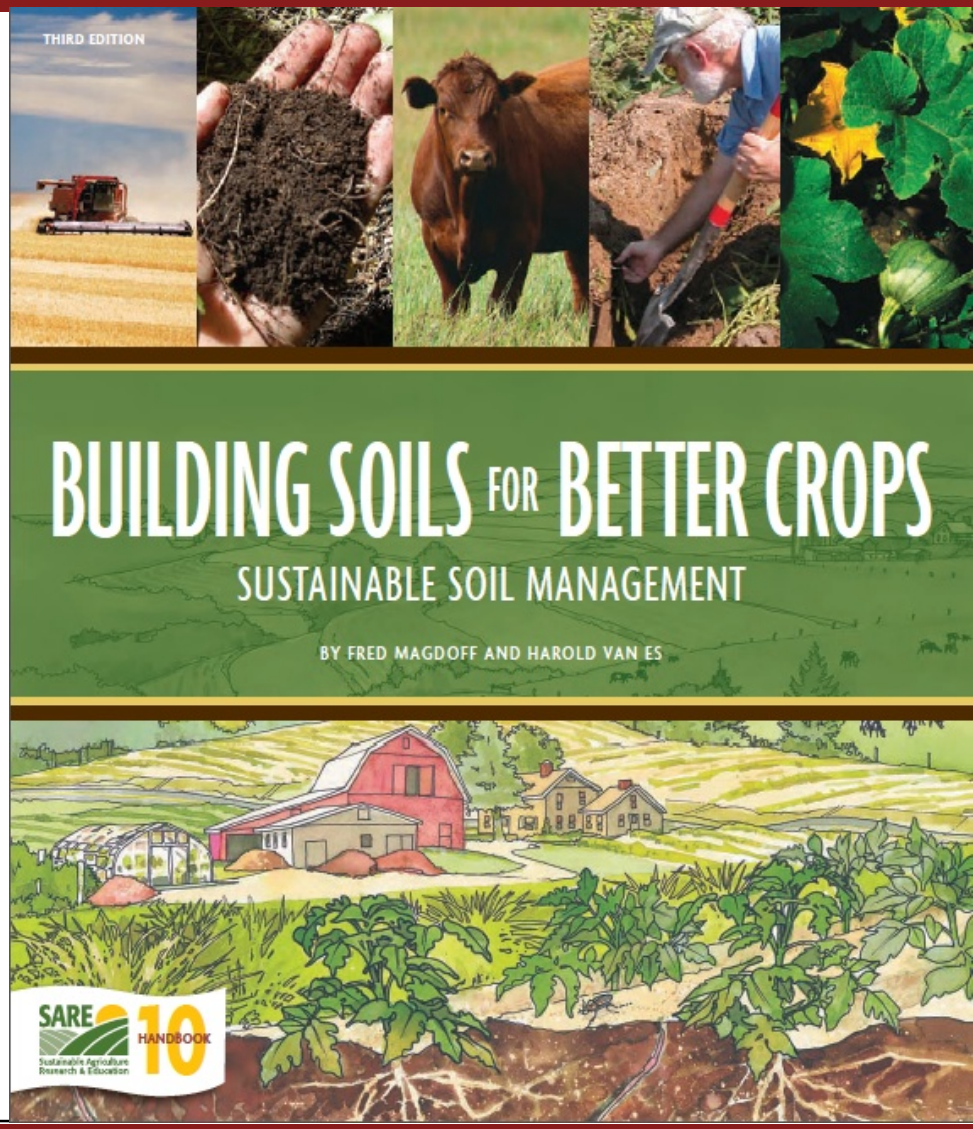
Soil health

- 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

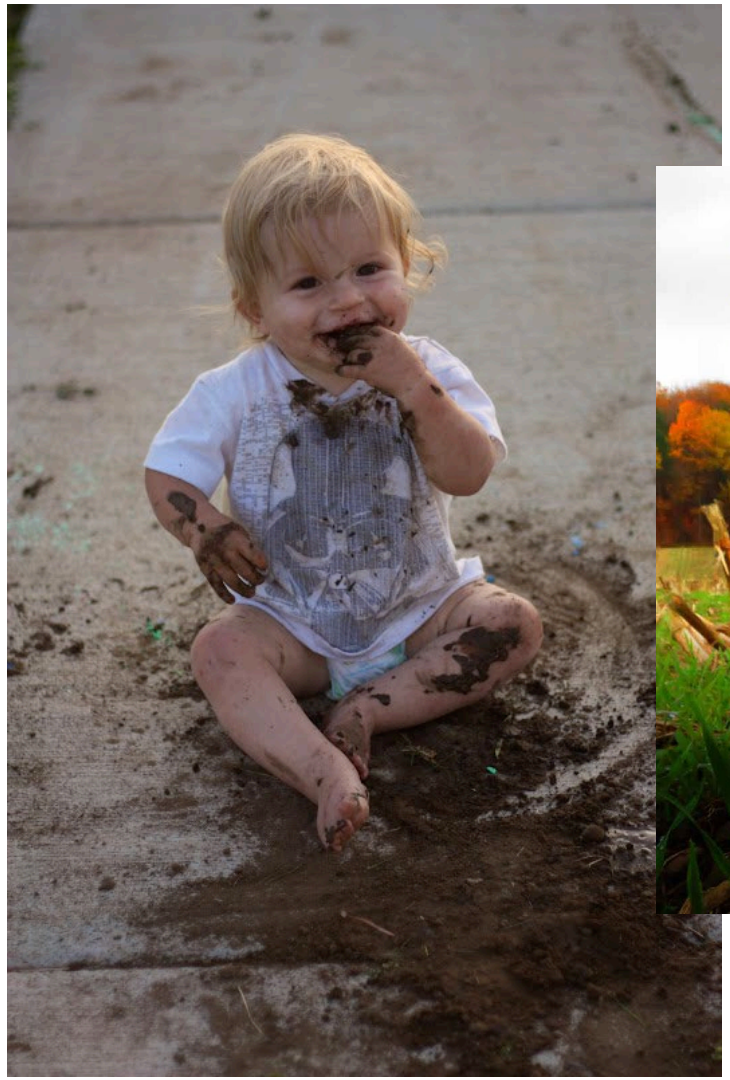
Building healthy soils

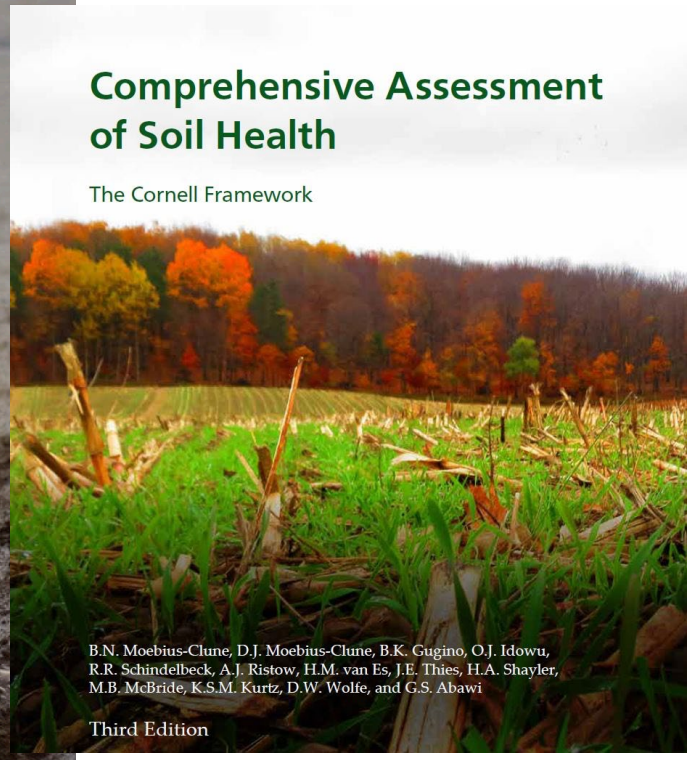
- Specific problems addressed:
  - > Longer dry periods or drought
  - > More frequent saturated soils and ponded water
  - > Loss of nutrients due to heavy and abundant precipitation

- 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
- 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%**

- (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: **[illegible]%**

Group	Indicator (2)	Value (3)	Rating (4)	Constraints (5)
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**	

(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: **[illegible]%**

Group	Indicator	Value	Rating
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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	• 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	• Perform some mechanical soil loosening	• Shallow-rooted cover/rotation crops

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: **[illegible]%**

Group	Indicator	Value	Rating
physical	Available Water Capacity	**0.14**	**37**
physical	Surface Hardness	**260**	**12**
physical	Subsurface Hardness	**340**	**35**
physical	Aggregate Stability	**15.7**	**19**
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**
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: **[illegible]%**

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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chemical	Extractable Potassium	**150.6**	**100**
chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		**100**

Cornell Soil Health Assessment

1

Corey Corn
123 Horizon Rd
New Iowa, NY, 13026

Agricultural Service Provider:
Doe, John
Assessments Inc.
john@doe.com

Sample ID
Field/Trea
Tillage:
Crops Cro
Date Samp
Given Soil
Given Soil
Coordinate

Measured Soil Textural Class: Silt Loam

Test Results

	2 Indicator	3 Value	4 Rating	5 Constraint
Physical	Available Water Capacity	0.15	42	
Physical	Surface Hardness	87	84	
Physical	Subsurface Hardness	290	50	
Physical	Aggregate Stability	22.0	22	Aeration, Infiltra Sealing,
Biological	Organic Matter	2.9	32	
Biological	ACE Soil Protein Index	4.5	26	Organic Matter Qu N Mi
Biological	Respiration	0.39	23	Soil Microbial Abundance and Activity
Biological	Active Carbon	450	27	Energy Source for Soil Biota
Chemical	pH	6.9	100	
Chemical	Phosphorus	4.5	100	
Chemical	Potassium	67.8	93	
Chemical	Minor Elements Mg: 419 Fe: 1.1 Mn: 12.9 Zn: 1.9		100	
6	Overall Quality Score	58	Medium	

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.

Management Suggestions for Physical and Biological Constraints

Constraint	Short Term Management Suggestions
Available Water Capacity Low	• Add stable organic materials, mulch • Add compost or biochar • Incorporate high biomass cover crop

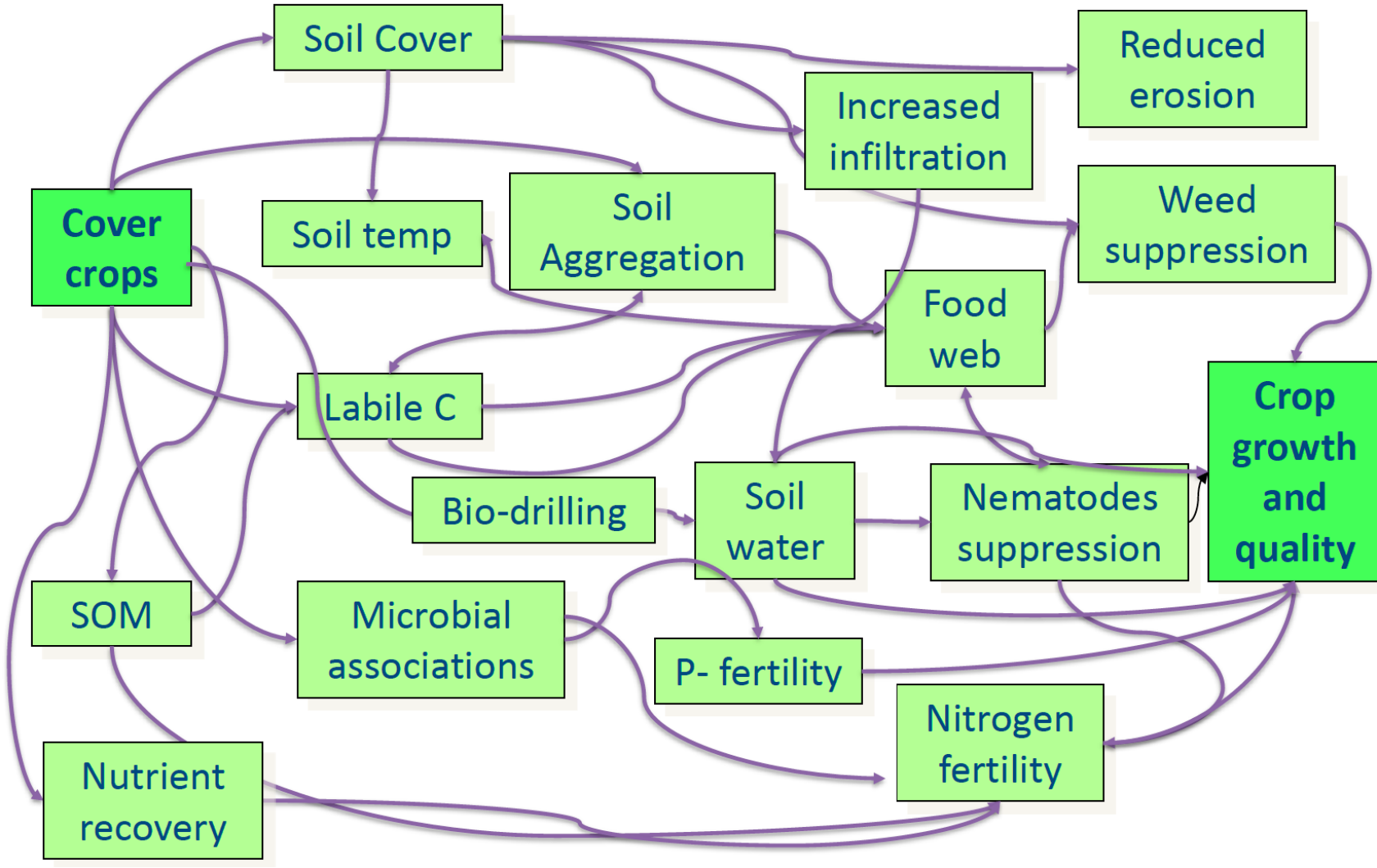
Long Term Management Suggestions

- Reduce tillage
- Rotate with sod crops
- Incorporate high biomass cover crop


Soil is meant to be covered
Masoud Hashemi

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 stablilization 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


Gully #3

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


Access Road
Gully #3

Soft engineering solution

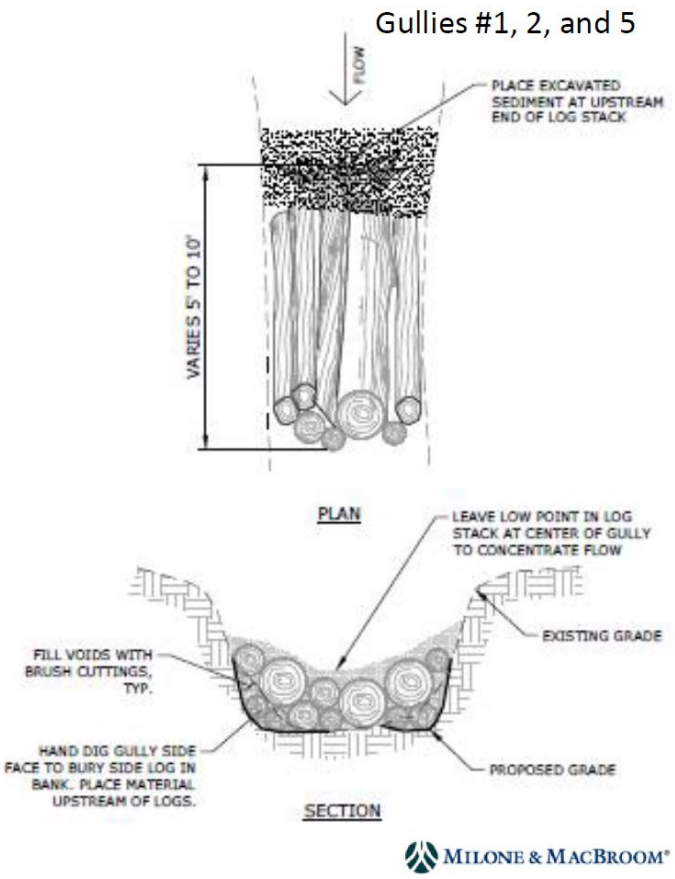
- Engineered log and wood placement with minimal rock use
- Advantages
  - Mostly on-site materials
  - Lighter impact on environment
- Disadvantages
  - Likely higher maintenance
  - Likely shorter life span
  - More manual labor

Project Design & Construction


Gully #1

Log Stack

Gullies #1, 2, and 5



MILONE & MACBROOM®

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

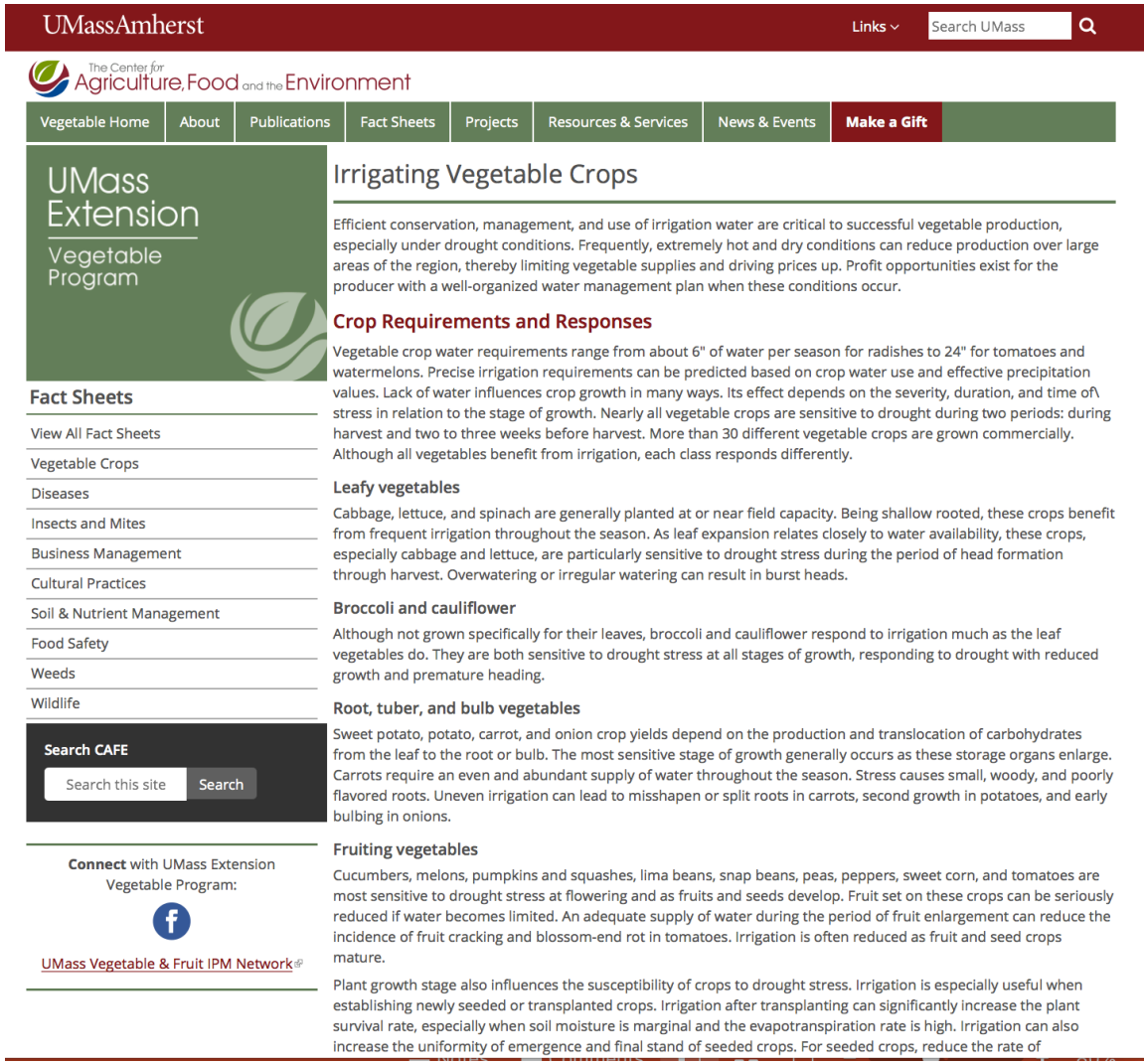
- Keeps plant root zones above the water level after heavy rain
- Bed-shapers
- Can also be used for flood irrigation

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!

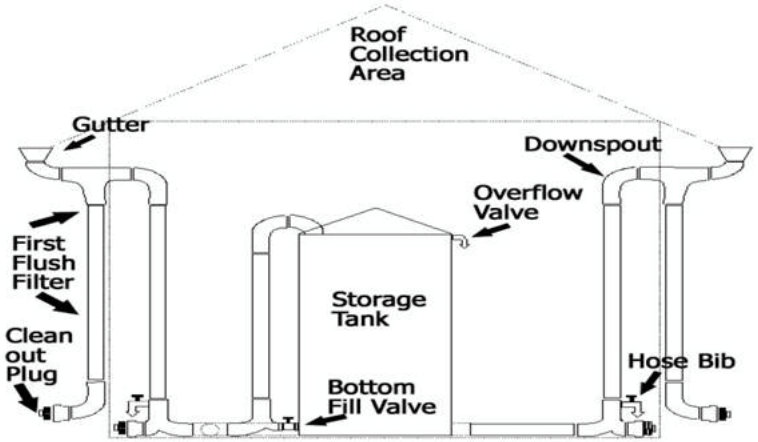
Multiple factors determine irrigation need

- 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



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

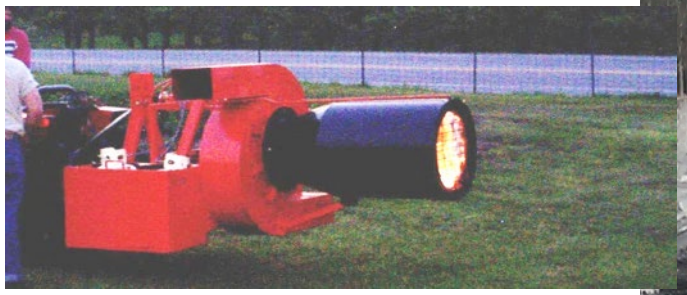
Black-eyed Susan (Rudbeckia spp.)

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*)

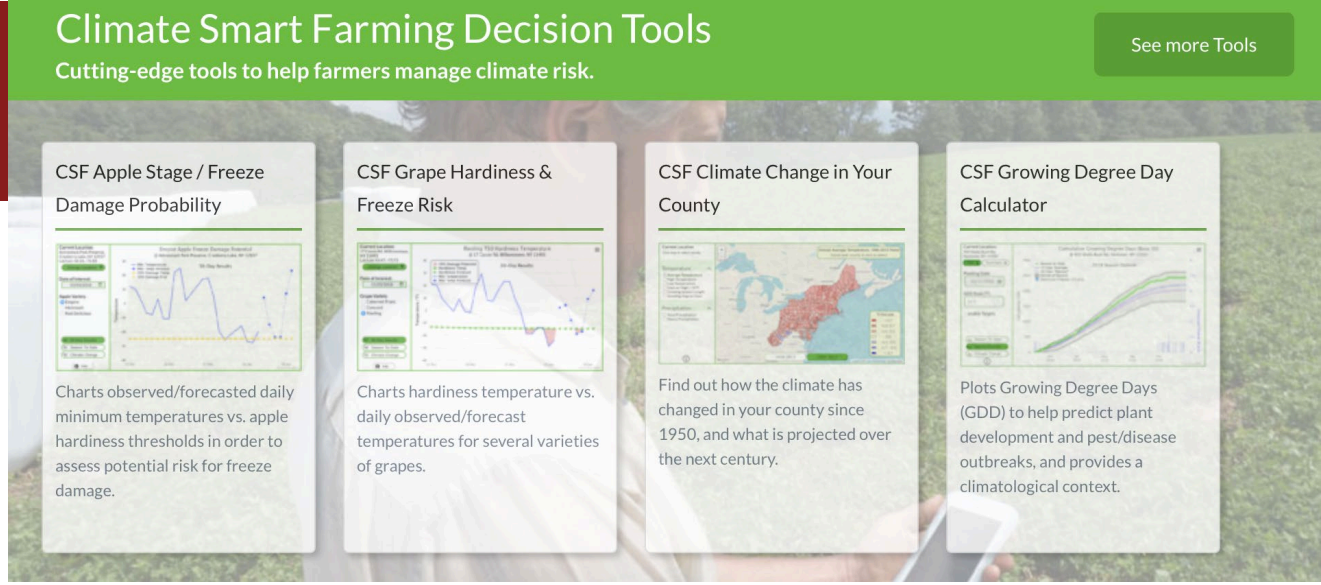
Frosts

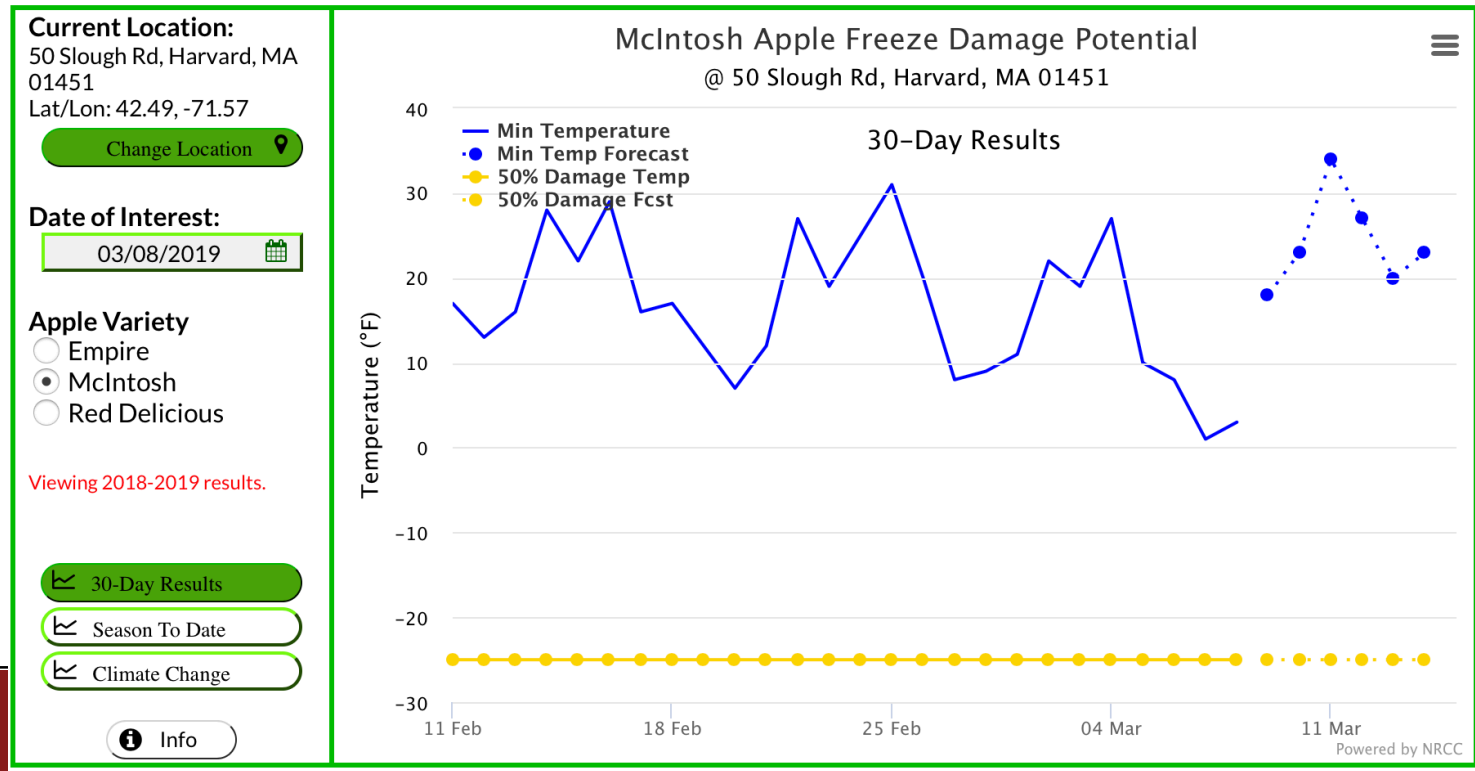
- Most severe at low levels
- Allow air to drain from fields on a slope – cut holes in hedgerows
- Floating row covers – small-scale or large scale hoops
- Overhead or under plant sprinklers
- Supplemental heat – machines, burning material
- Helicopters or wind machines



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.





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

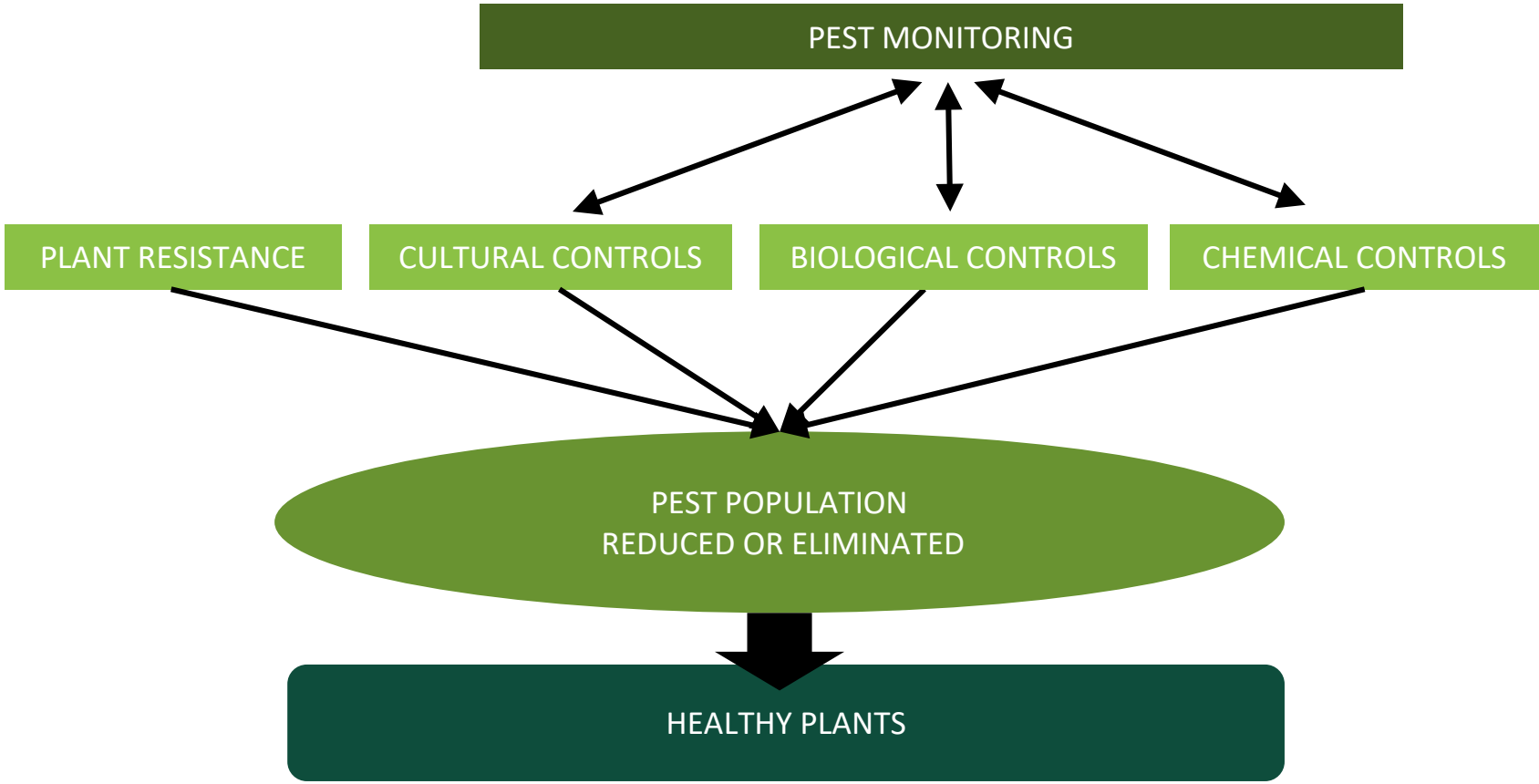
> More frequent or new weed/invasives pressure related to weather

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

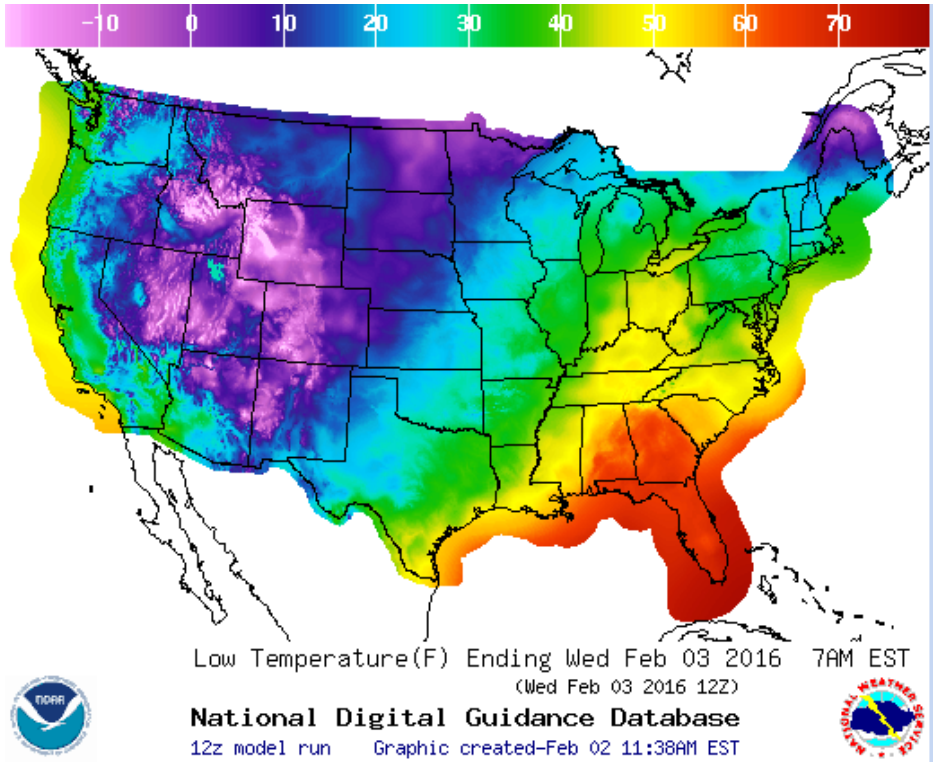


Weather monitoring

- 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

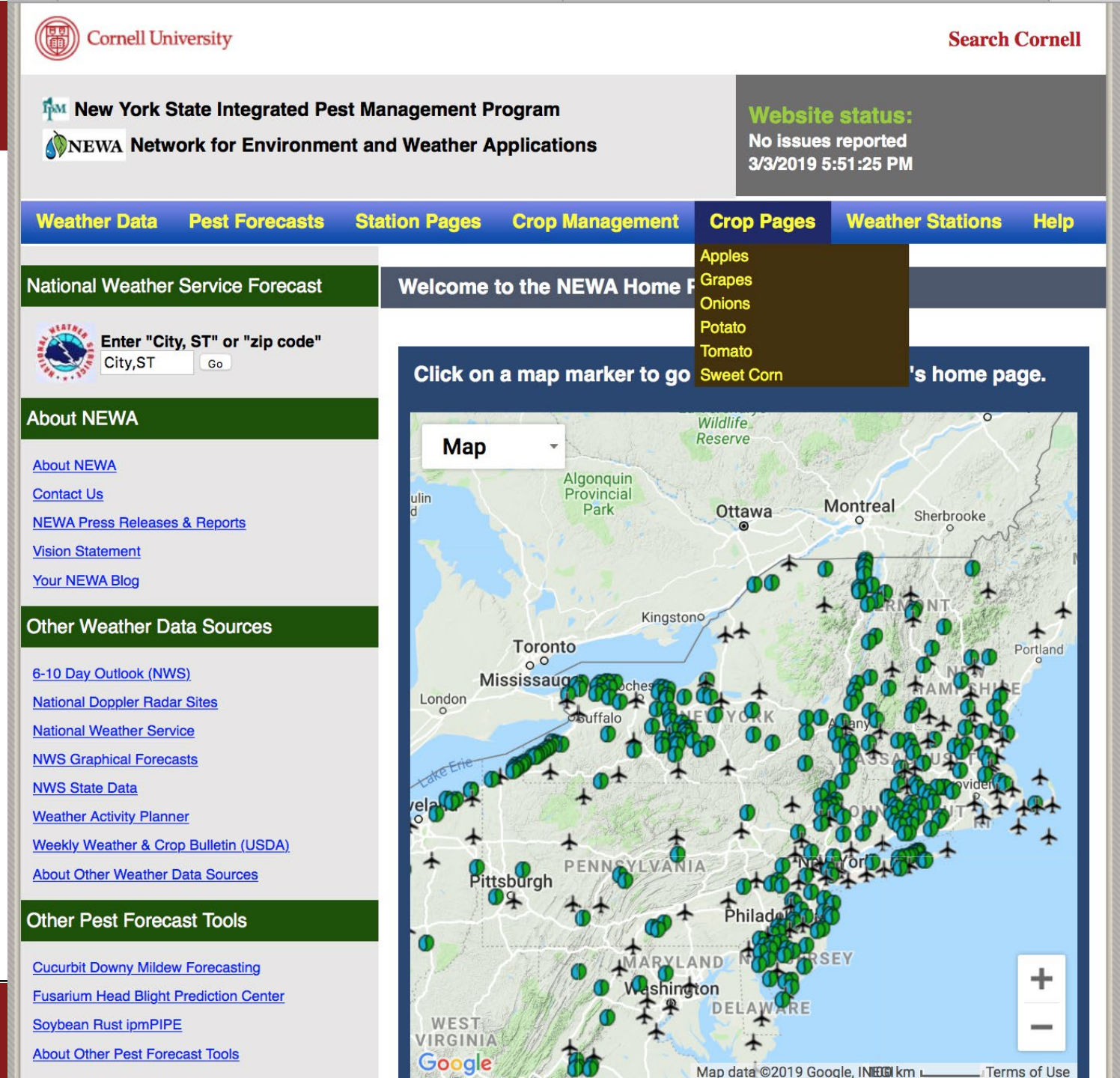
Alternative to weather stations

- Gridded data generated from observations, used in past data and forecasts
- 1 km^2 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



UMass Extension resources

UMassAmherst

Links Search UMass

The Center for Agriculture, Food and the Environment

IPM Home | About | IPM by Commodity | Featured Pests | Publications | Resources | News & Events | Contact

UMass Extension

Integrated Pest Management Program

Search CAFE

Search this site Search

Resources

- **UMass Extension Programs**
- Regional Partners
- Outside New England

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

The Center for Agriculture, Food and the Environment

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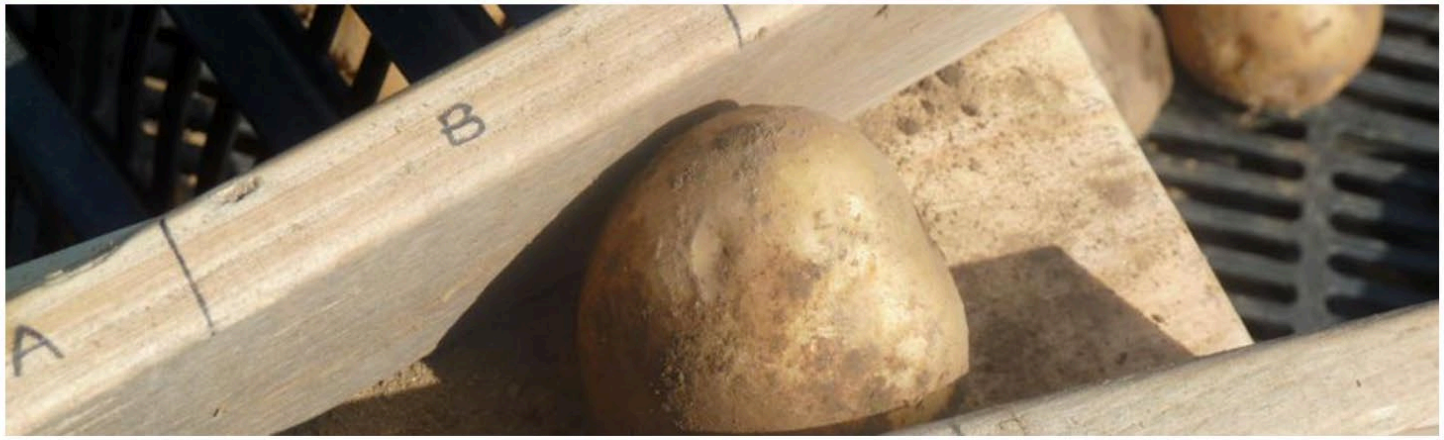
UMass Extension
Vegetable Program



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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

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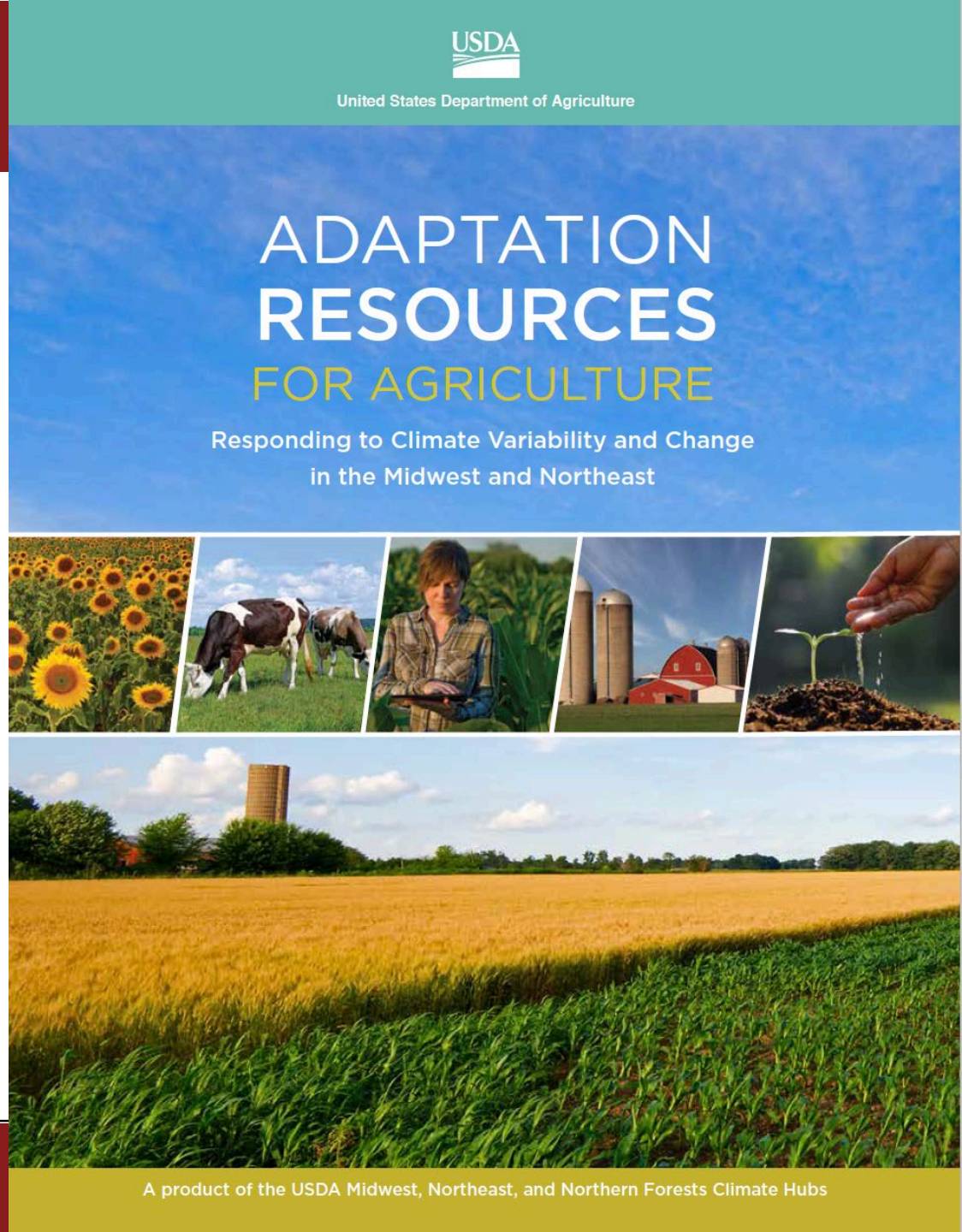
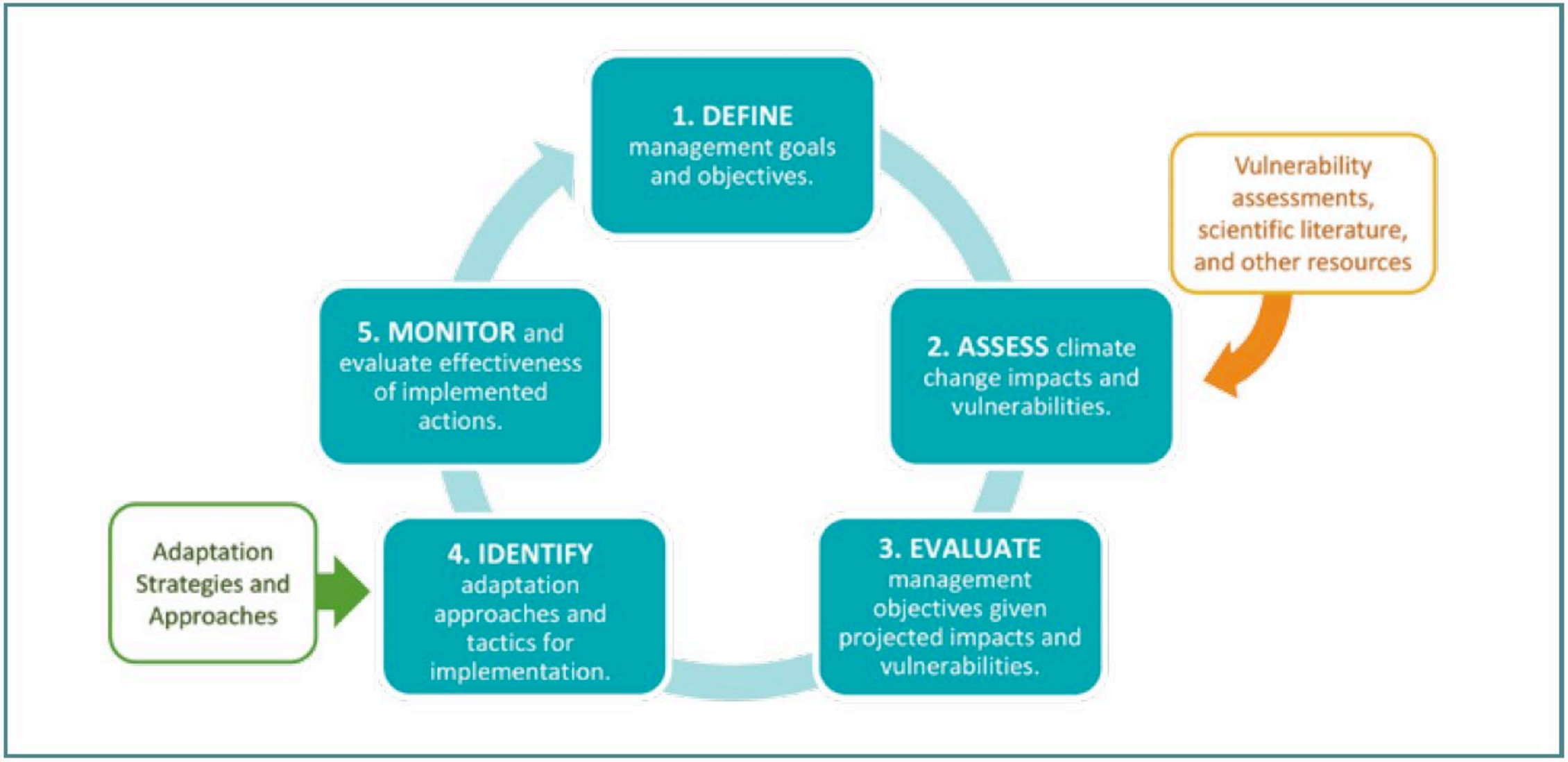


Process


1. DEFINE management goals and objectives.
2. ASSESS climate change impacts and vulnerabilities.
3. EVALUATE management objectives given projected impacts and vulnerabilities.
4. IDENTIFY adaptation approaches and tactics for implementation.
5. MONITOR and evaluate effectiveness of implemented actions.
Vulnerability assessments, scientific literature, and other resources
Adaptation Strategies and Approaches

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?