



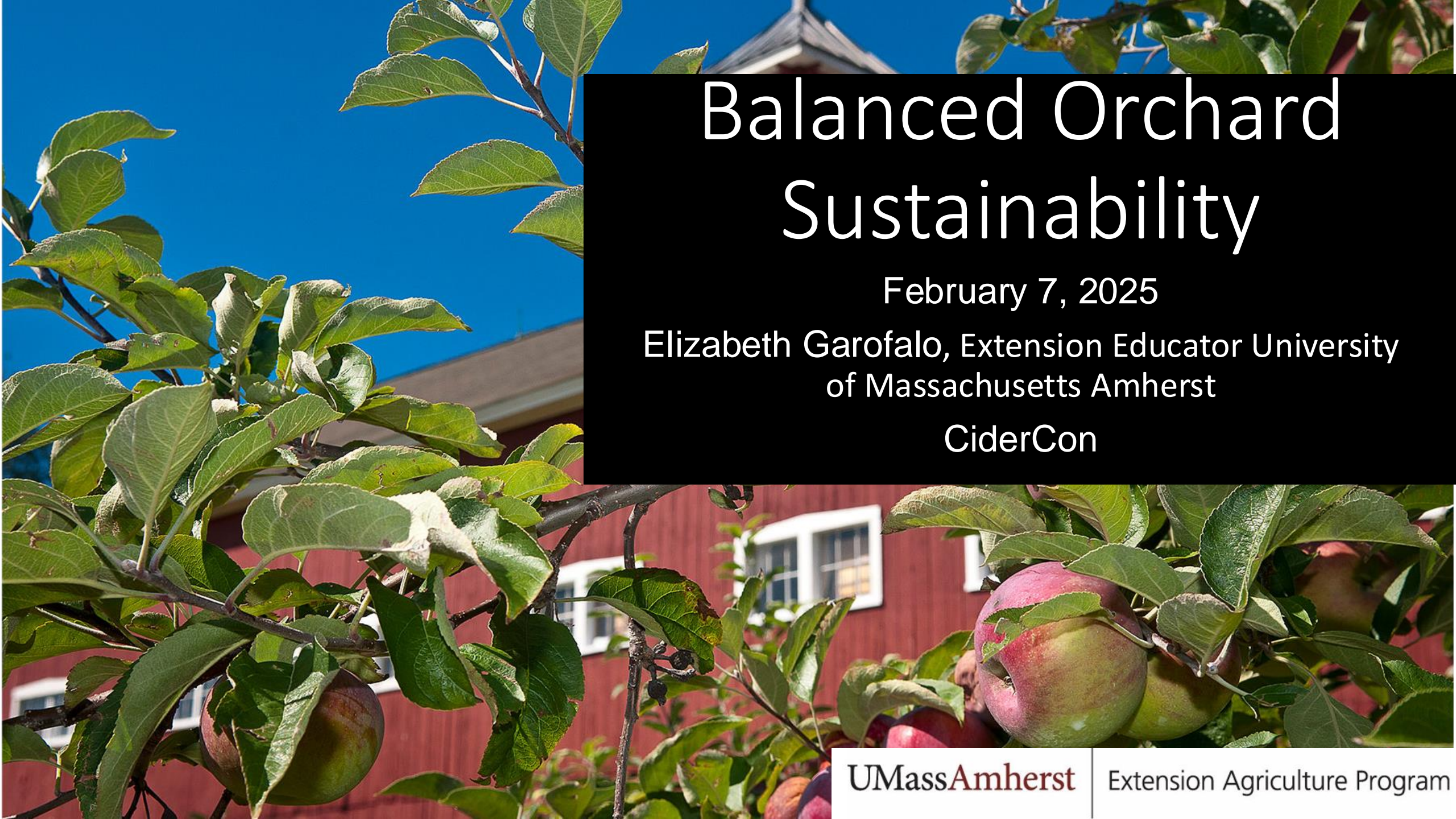
AMERICAN
CIDER
ASSOCIATION

Balanced Orchard Sustainability Through IPM

PRESENTED BY:

Elizabeth Garofalo





Balanced Orchard Sustainability

February 7, 2025

Elizabeth Garofalo, Extension Educator University
of Massachusetts Amherst

CiderCon

UMassAmherst

Extension Agriculture Program

AGENDA

- 1 Understanding Sustainability
- 2 Why it all Matters
- 3 Probably Some Painfully Corny Jokes
- 4 Deep Dive Into IPM; Insect & Disease
- 5 Lotsa Puns
- 6 Pithy Conclusion



BMW concept a 'sustainable car of the future'

Paul McVeigh
Automotive News

TWEET SHARE in SHARE EMAIL

REPRINTS PRINT



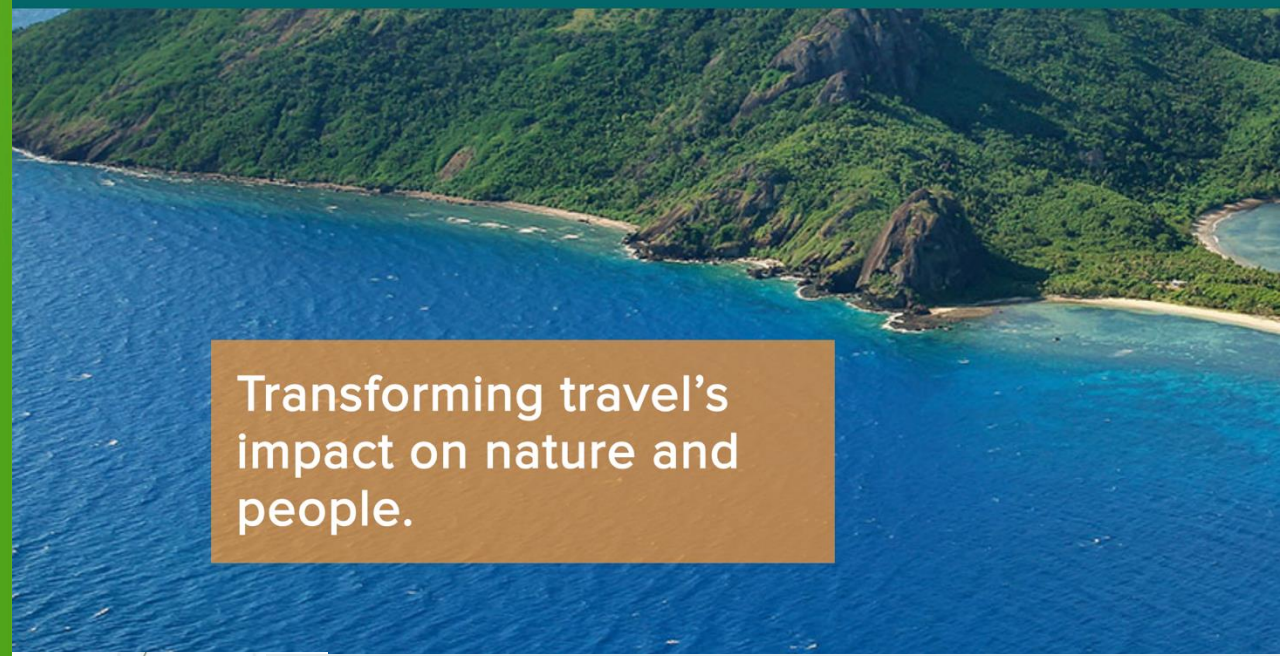
BMW AG

BMW would use unpainted recycled plastic in the lower bumper area of its i Vision Circular car, resulting in a "marbled" look to the part.

Buy a new and sustainable home on the Costa del Sol



INDIVIDUALS BUSINESSES DESTINATIONS



Transforming travel's impact on nature and people.

eco nappii™
SUSTAINABLE BAMBOO
plant based diaper

Size 2
3-6 kg

32 Nappies

Up To 40% Less Plastic Bio Bag

- Hypoallergenic
- Ultra Dry Protection
- Soft & Flexible for Comfort

100% Bamboo pulp & Super Absorbent core

100% Recycled Paper

FSC

TÜV AUSTRIA S1094

OK Biobased

SUSTAINABLE FASHION

- Eco-friendly & Green
- CIRCULAR FASHION
- Upcycle & Recycle
- SLOW FASHION
- Thrifting Swapping & Renting
- ETHICAL FASHION
- Vegan & Cruelty-free
- CONSCIOUS FASHION

STARBUCKS SUSTAINABILITY COMMITMENT

AREAS OF FOCUS

- Plant-based menu options
- Reusable packaging
- Regenerative agriculture, reforestation, forest conservation and water replenishment
- Managing our waste
- Eco-friendly stores, operations, manufacturing, delivery

Indigenous Agricultural Knowledge & Practices

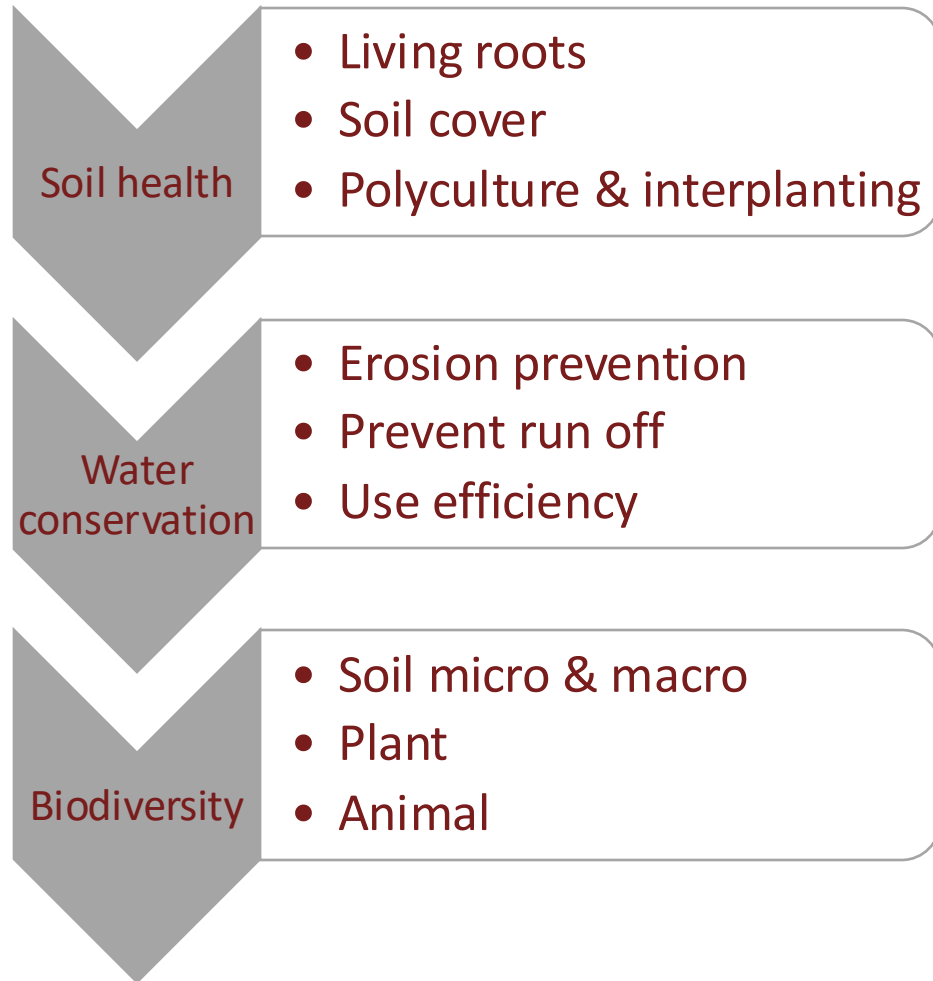


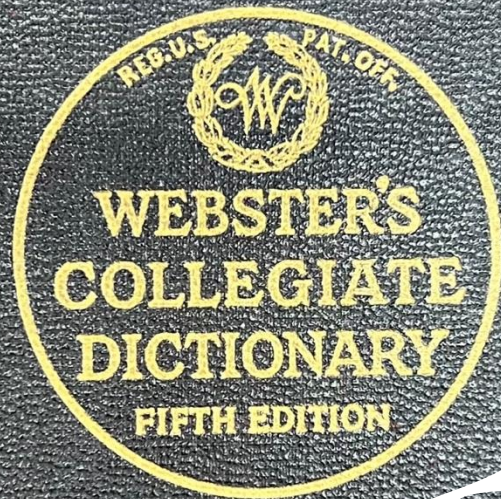
Illustration: Anna Juchnowicz, Wikipedia

So, What IS Sustainability??

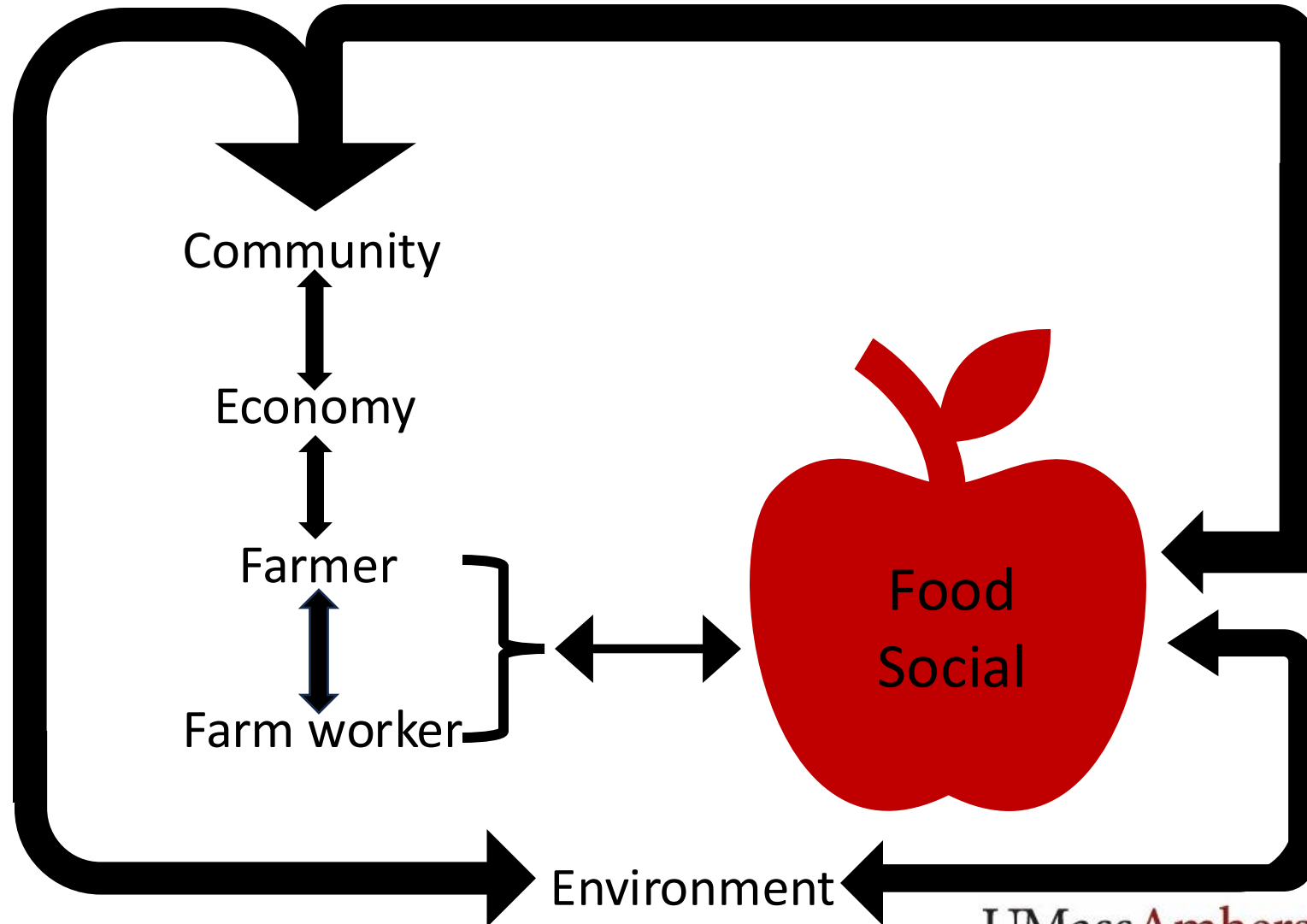
- Sustain (*L.sustinere* ~ to hold):

**TO ENDURE
WITHOUT
FAILING**

-Webster's Collegiate Dictionary- 5th Edition



Elements of Sustainability



Economy

- 2022 USDA Census of Ag.
- Total of ~411,260 acres
 - ~363,000A in production
- Total of ~9,975,000,000 pounds
 - A total value of ~\$3,158,311,245*
 - *As interpreted by the US Apple association



An Example: Organic Honeycrisp

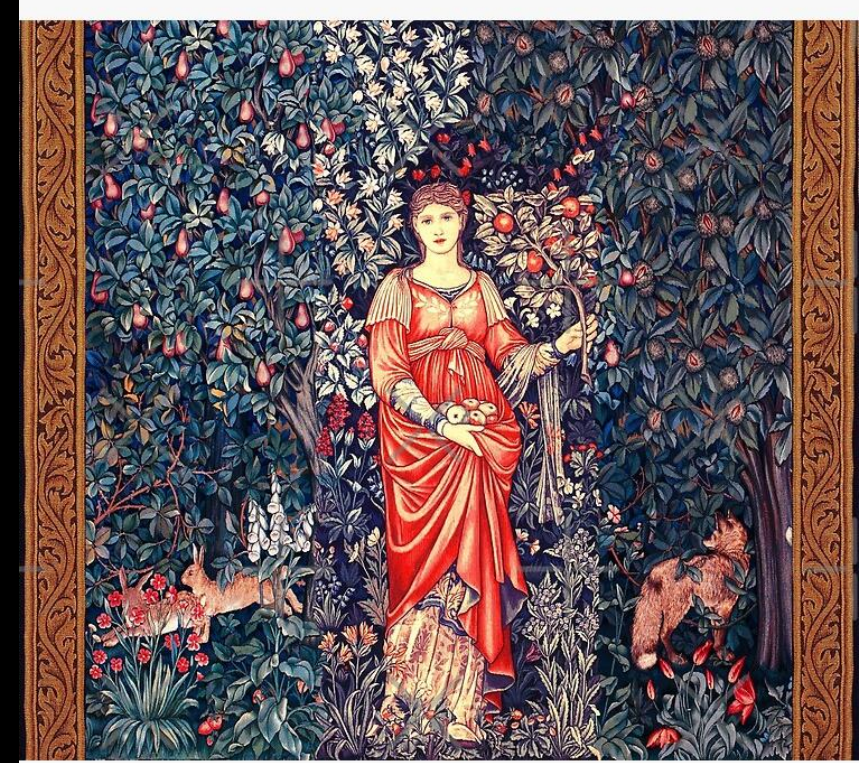
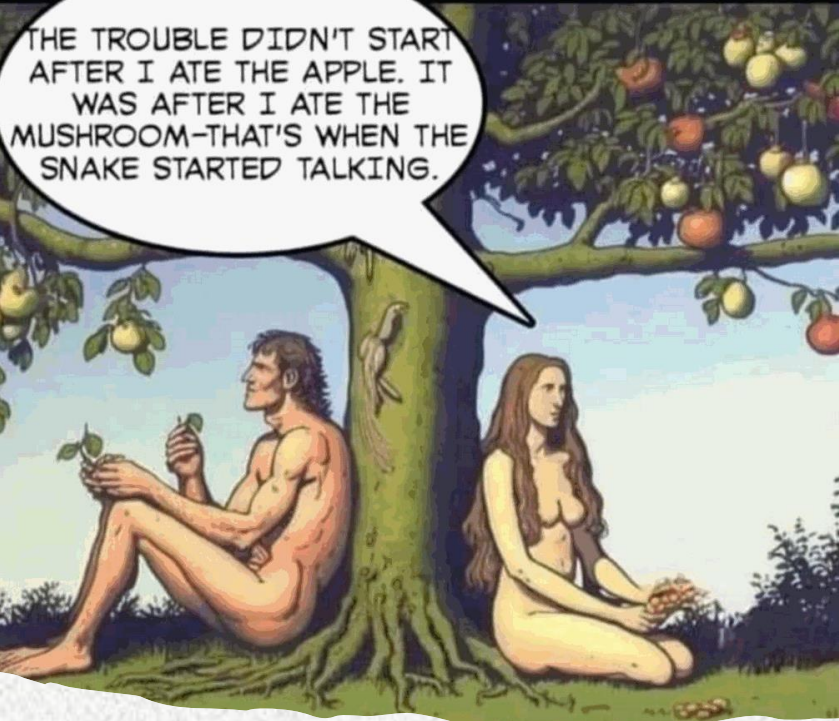
- Washington, 2021-2022
 - Based on mature production
- Total variable cost/acre
 - \$28,433
- Total fixed cost/acre
 - \$10,290
- Total cost/acre
 - \$38,723
- Total return/acre
 - \$45,680
- Net return/acre
 - \$6,957



Gallardo, R. K., & Pedroso-Galinato, S. (2023). *2022 cost estimates of producing and packing organic Honeycrisp apples in Washington (no. TB91E)*. Washington State University Extension.

Social

THE TROUBLE DIDN'T START
AFTER I ATE THE APPLE. IT
WAS AFTER I ATE THE
MUSHROOM-THAT'S WHEN THE
SNAKE STARTED TALKING.



Apple in Human History



- It has sustained us for thousands of years
 - Evidence of "crab" apples at Neolithic sites (Switzerland, Scotland)
- Pomona, Idun, Eve

The Luscious Apple



SOCIAL MEDIA





I mean...

Food



Community

- Social activity
- Sense of community
- Open space protection
 - Bonus if that open space is accessible to others

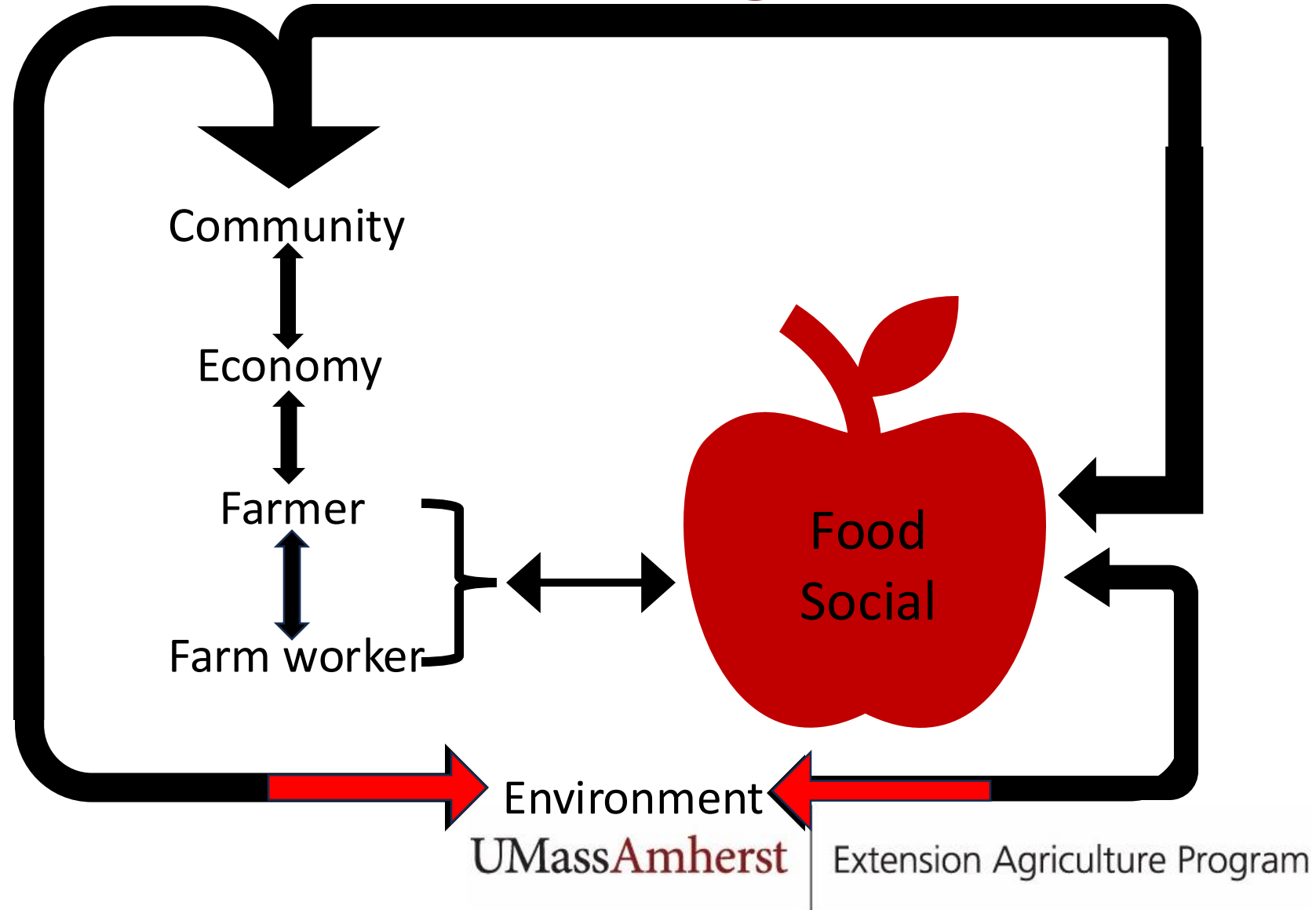


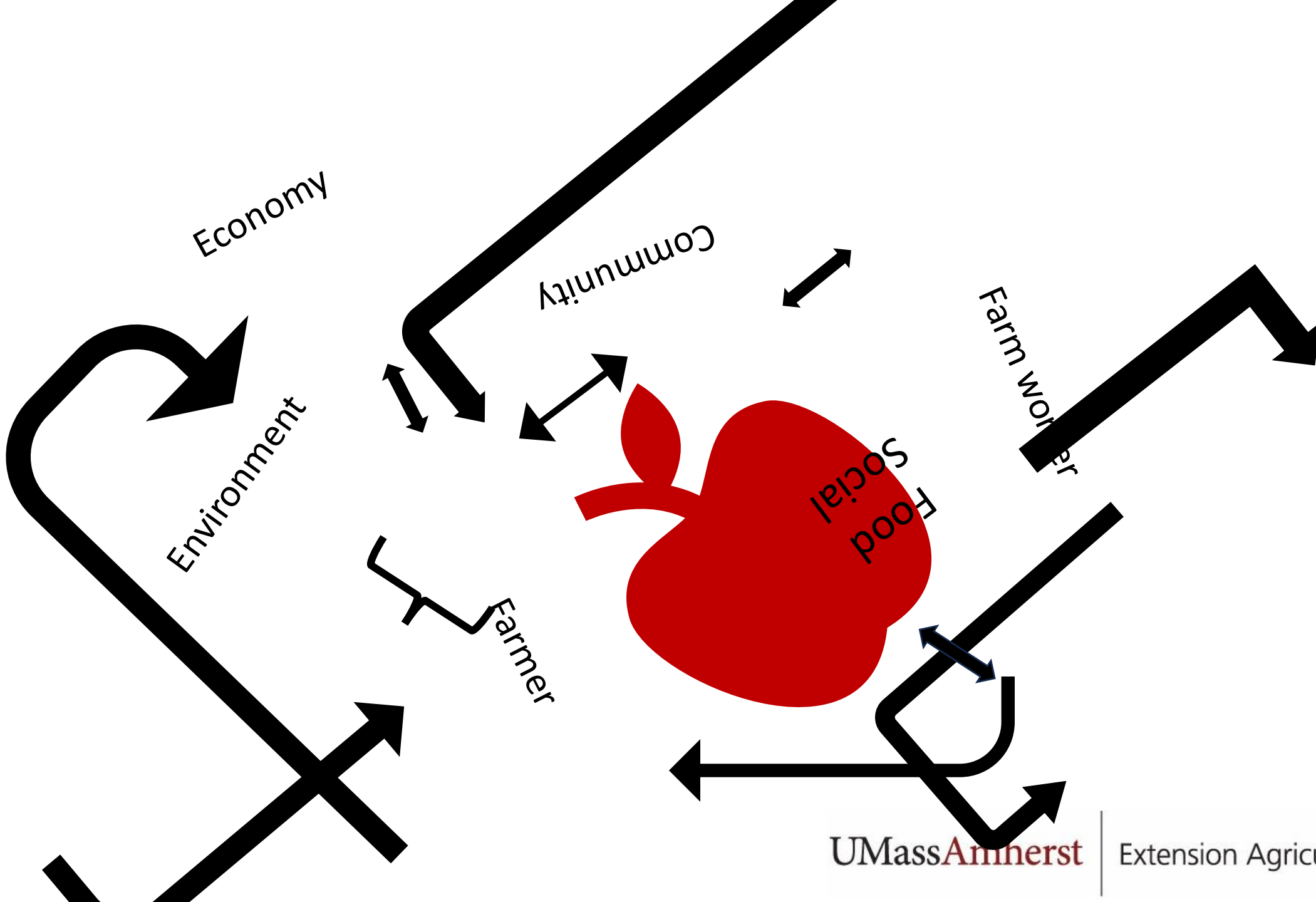
The Farm Producer- 2022 USDA Ag Census

Producers	2022	2017		2022	2017
Total #	3,374,044	3,399,834	-25,790		

The Environment- Our Surroundings

- The weather
- Undeveloped land
 - Beautiful vistas
- Environmental services
- Learning opportunities





The Art of War

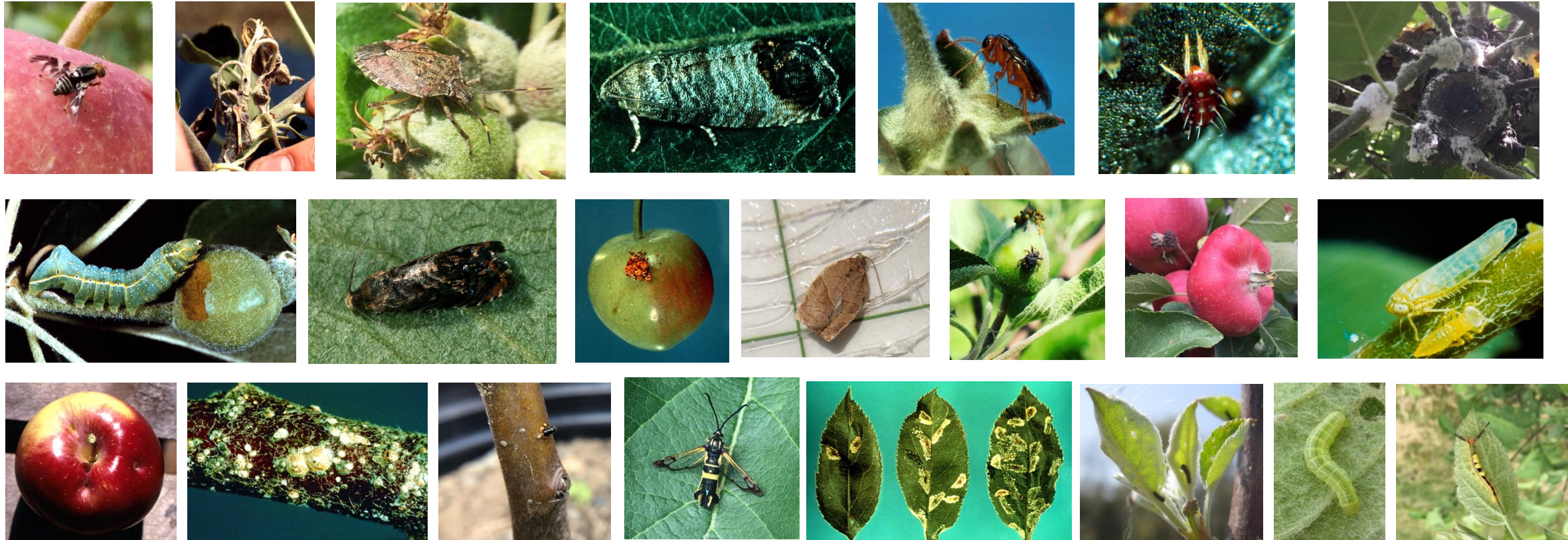
Know thyself, know thy enemy and fear not the outcome of 100 battles.

-Sun Tzu, 5th century B.C.



A Gallery of Rogues

- MSU lists ~40 insect pests of apple



The Rotten Facts

- MSU lists ~40 diseases that affect apple



A Gallery of Rogues Identified

- Top row (left to right):
 - Apple maggot fly¹, damage caused by apple pith moth larvae², brown marmorated stink bug³, codling moth⁴, European apple sawfly⁵, European red mite⁶, wooly apple aphid⁷, damage caused by tarnished plant bug feeding⁸
- Middle row (left to right):
 - Humped green fruitworm⁹, lesser apple worm¹⁰, damage caused by oriental fruit moth larvae¹¹, oblique banded leafroller¹², plum curculio adult¹³, damage cause by rosy apple aphid feeding¹⁴, potato leaf hopper adult and nymph¹⁵
- Bottom row (left to right):
 - San jose scale¹⁶, black stem borer¹⁷, dogwood borer¹⁸, damage caused by leaf miner larvae¹⁹, spongy moth larvae²⁰, winter moth larvae²¹, tussock moth larvae²²

Insect Photo Credits

- ¹E. Garofalo, ²Alan Eaton, Univ. of NH, ³E. Garofalo, ⁴NY State Ag Experiment Station, ⁵NY State Ag Experiment Station, ⁶MSU Extension, ⁷E. Garofalo, ^{8,9,10, 11}NY State Ag Experiment Station, ^{12, 13,} ¹⁴E. Garofalo, ¹⁵Mid-Atlantic Orchard Monitoring Guide, ¹⁶Alan Eaton, Univ. of NH, ^{17, 18}E. Garofalo, ¹⁹NY State Ag Experiment Station, ^{20,} ²¹Heather Faubert, URI Extension, ²²E. Garofalo

Rotten Facts Identified

- Top row (left to right):
 - Cedar apple rust symptoms on eastern red cedar¹, nectria twig blight², apple scab³, fireblight⁴, bitter rot⁵, powdery mildew⁶, crown gall⁷, sooty blotch flyspeck⁸
- Middle row (left to right):
 - Marssonina⁹, apple mosaic virus¹⁰, black rot/frog eye¹¹, blister spot¹², dry eye/blossom end rot¹³, alternaria leaf blotch¹⁴
- Bottom row (left to right):
 - White rot¹⁵, bitter pit, brooks fruit spot¹⁶, mucor rot¹⁷, nectria canker¹⁸, moldy core¹⁹, apple union necrosis²⁰, blue mold²¹

Disease Photo Credits

- 1, 2, 3, 4, 5, 6 E. Garofalo, 7MSU Extension, 8, 9, 10E. Garofalo, 11William Turechek, USDA-ARS, 12Wayne Wilcox, Cornell Univ., 13E. Garofalo, 14Turner Sutton, NC State Univ, 15Mid-Atlantic Orchard Monitoring Guide, 16Poliana Francescato, 17Mid-Atlantic Orchard Monitoring Guide, 18Themis Michailides, Univ. of California, 19Alan Jones, MSU, 20Mike Ellis, OSU, 21Mid-Atlantic Orchard Monitoring Guide, 22Dave Rosenberger, Cornell Univ.

We Got 99 Problems...



A Solid Foundation

- Site selection
 - No wet feet
 - Full sun
- Reduce stress
 - Ensure adequate H₂O
 - Balanced vigor



Integrated Pest Management

- A decision-based process involving coordinated use of multiple tactics for optimizing the control of all classes of pests (insects, pathogens, weeds, vertebrates) in an ecologically and economically sound manner.

-Dr. Ronald Prokopy, 2003

- Decrease overall input
- Increase efficacy of applications
- Minimize off target impact
- Grower confidence in adoption

What's in Your IPM Toolbox?

- Scouting
 - observations of pest population or damage occurring directly on the host
- Trapping
 - use of a device, typically consisting of a sticky coated surface, often baited with a lure
- Monitoring
 - checking your site to identify which pests are present, how many there are, or what damage they've caused
- Forecast models
 - We'll get into this later...



Economic Injury Level (EIL)

- “The lowest population density of a pest that will cause economic damage; or the amount of pest injury which will justify the cost of control.”

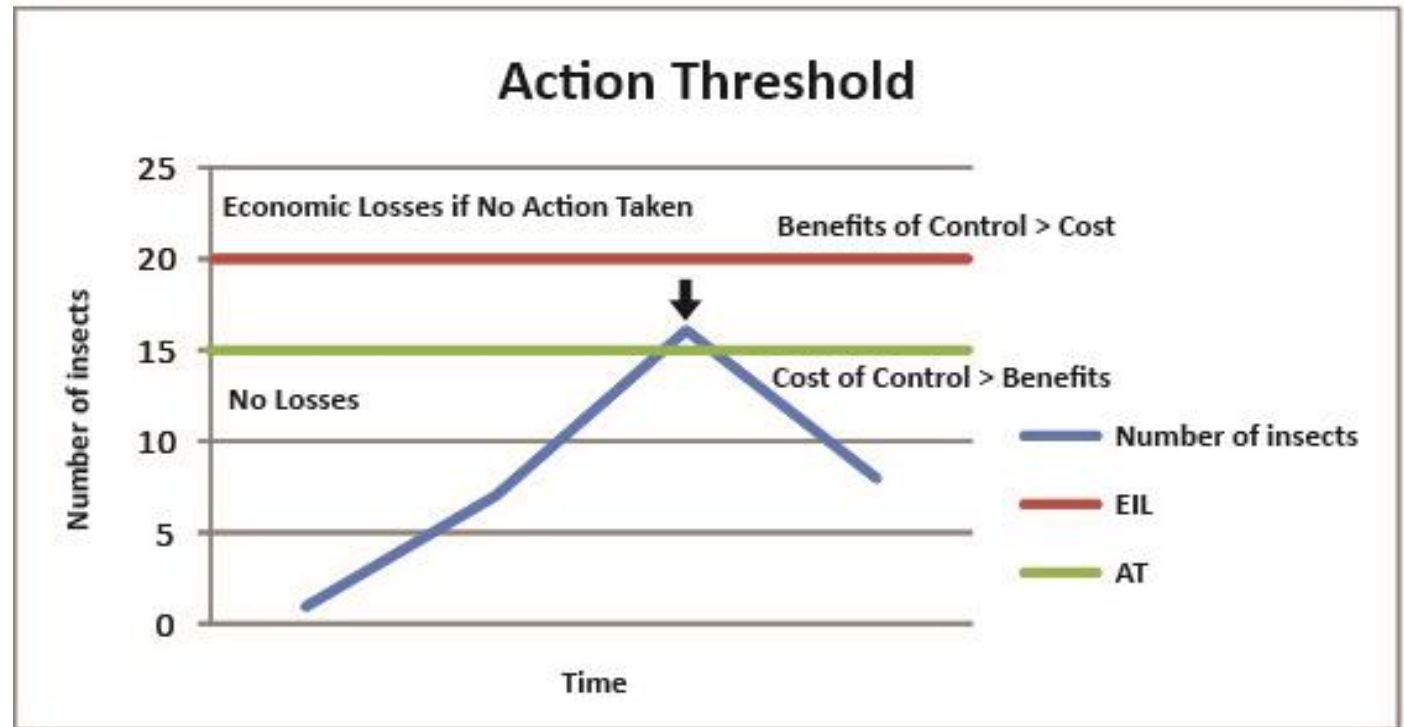
-Stern et al., 1959



Economic Threshold (aka *Action* Threshold)

- “The pest density at which control measures should be *implemented* to prevent it from reaching the Economic-injury Level (point where economic loss occurs).”

-Stern et al., 1959



What is IPM?

Integrated Pest Management is a science-based approach that combines a variety of techniques. By studying their life cycles and how pests interact with the environment, IPM professionals can manage pests with the most current methods to improve management, lower costs, and reduce risks to people and the environment.

IPM tools include:

- Alter surroundings
- Add beneficial insects/organisms
- Grow plants that resist pests
- Disrupt development of pest
- Prevention of pest problem developing
- Disrupt insect behaviors
- Use pesticides

1 IDENTIFY/MONITOR

Determine the causal agent and its abundance (contact your local extension agent for help).

2 EVALUATE

The results from monitoring will help to answer the questions: Is the pest causing damage? Do we need to act? As pest numbers increase toward the economic threshold further treatments may be necessary.

3 PREVENT

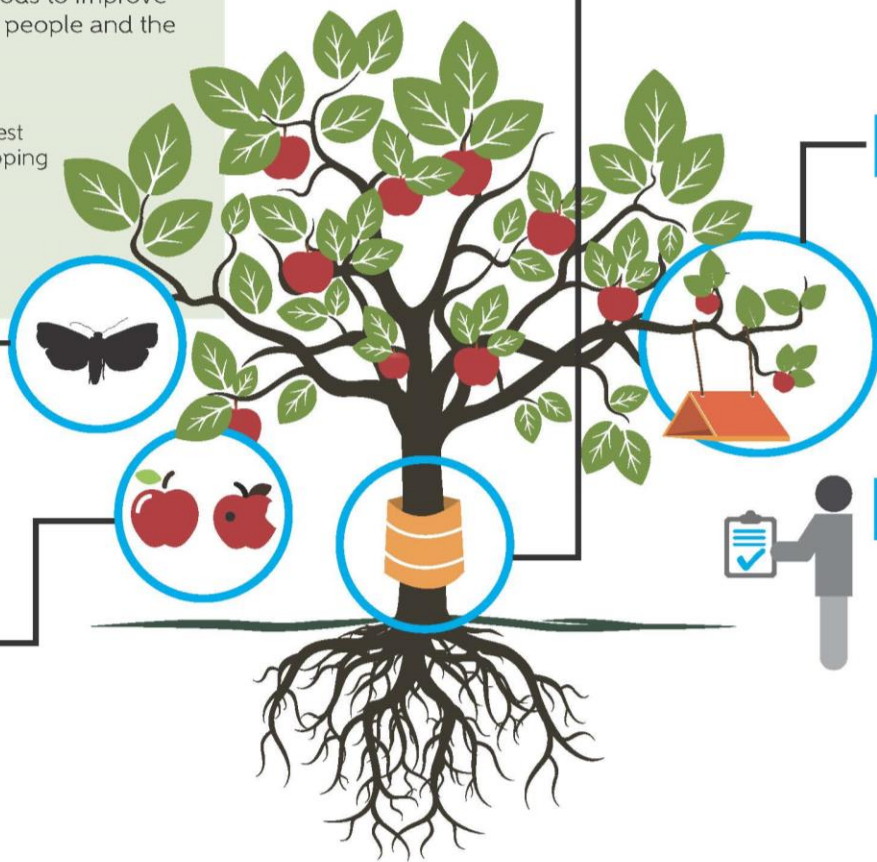
Some pest problems can be prevented by using resistant plants, planting early, rotating crops, using barriers against climbing pests, sanitation, and sealing cracks in buildings.

4 ACTION

IPM uses multiple tools to reduce pests below an economically damaging level. A careful selection of preventive and curative treatments will reduce reliance on any one tactic and increase likelihood of success.

5 MONITOR

Continue to monitor the pest population. If it remains low or decreases, further treatments may not be necessary, but if it increases and exceeds the action threshold, another IPM tool should be used.



Sharin ~ Insect Science Globally

WHERE CAN YOU PRACTICE IPM?



Buildings and Homes:

Inspect, identify pests, keep pests out, clean to deny pests food and water, vacuum, trap, or use low-risk pesticides.



Farms:

Check for pests/pest damage regularly, identify accurately, choose pest-resistant plant varieties, encourage/introduce beneficial insects, time planting to avoid pests, and if needed use low-risk pesticides.



Managed Natural Systems:

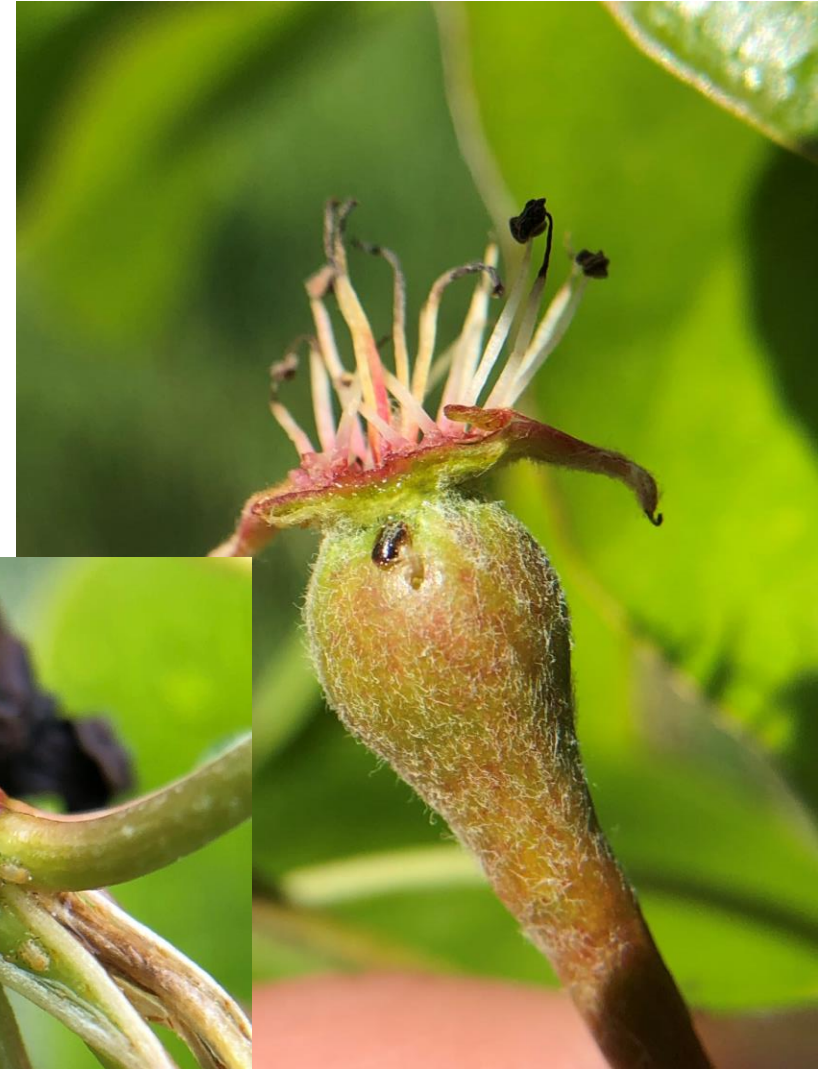
Identify the pest and use management options that have minimal risks to pollinators, humans, and pets.



The Entomological Society of America is the largest organization in the world serving the needs of entomologists and other insect scientists. ESA stands as a resource for policymakers and the general public who seek to understand the importance and diversity of earth's most diverse life— insects. Learn more at www.entsoc.org.

Scouting: Insects


Plum curculio



Pear psylla



Scouting: Insects

- Pear psylla (incomplete metamorphosis)
 - Overwinters as adult
 - Early egg laying
 - Multiple overlapping generations
 - Action threshold
 - 25 spurs & terminals
 - One nymph per three leaves
- 



Trapping: Insects

- "Whoever is first in the field and awaits the enemy will be fresh for the fight." –Sun Tzu, Art of War

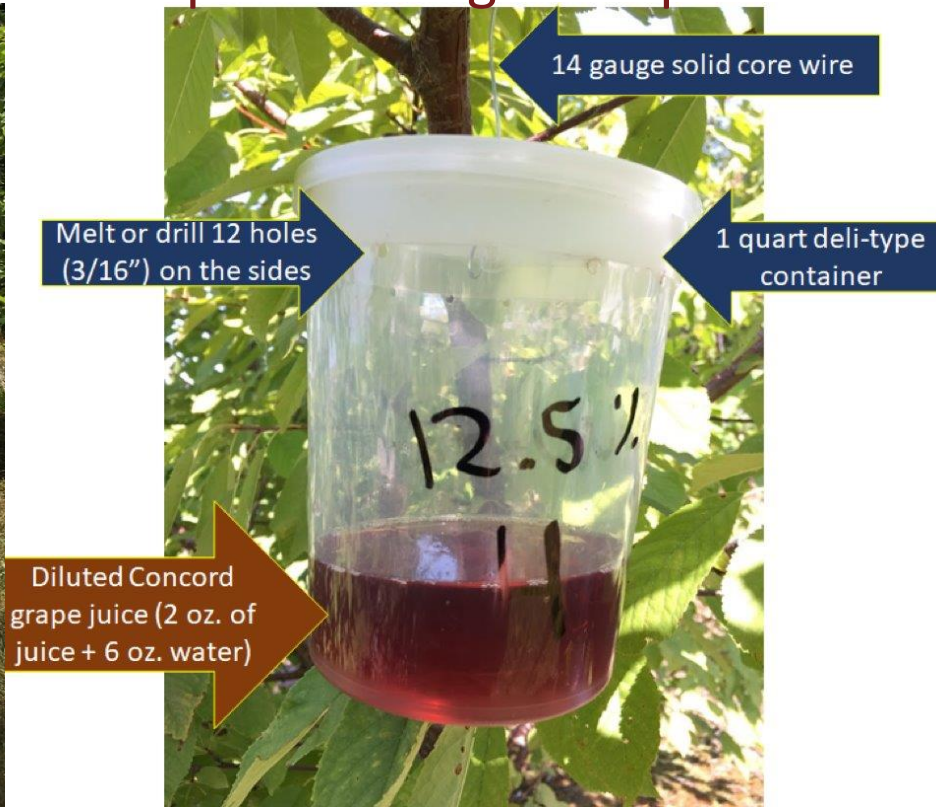
Multiple flying pests



Multiple crawling pests



Spotted wing drosophila




Apple Maggot Fly



Red Sticky Sphere

- The “attract” in attract and kill
- Deploy in mid-June
- Mainly a visual cue
 - Can be paired w/an olfactory “bait”
- Action threshold
 - Unbaited 1-2
 - Baited 5
- Trap out
 - 1 unbaited trap per tree
 - Ex. Arbico Organics

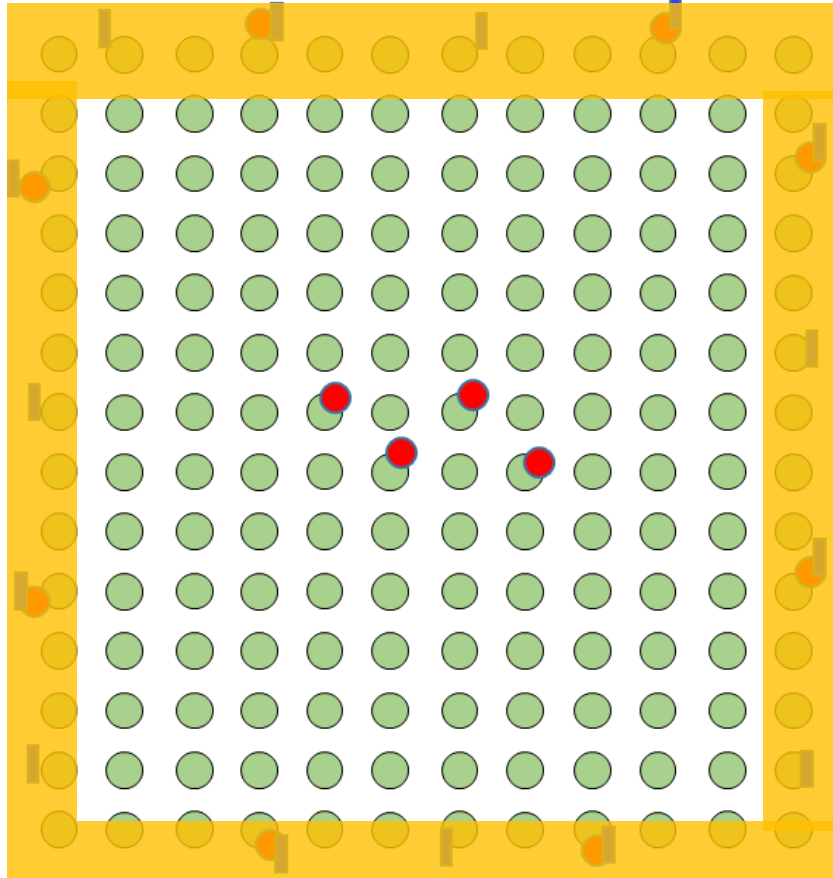




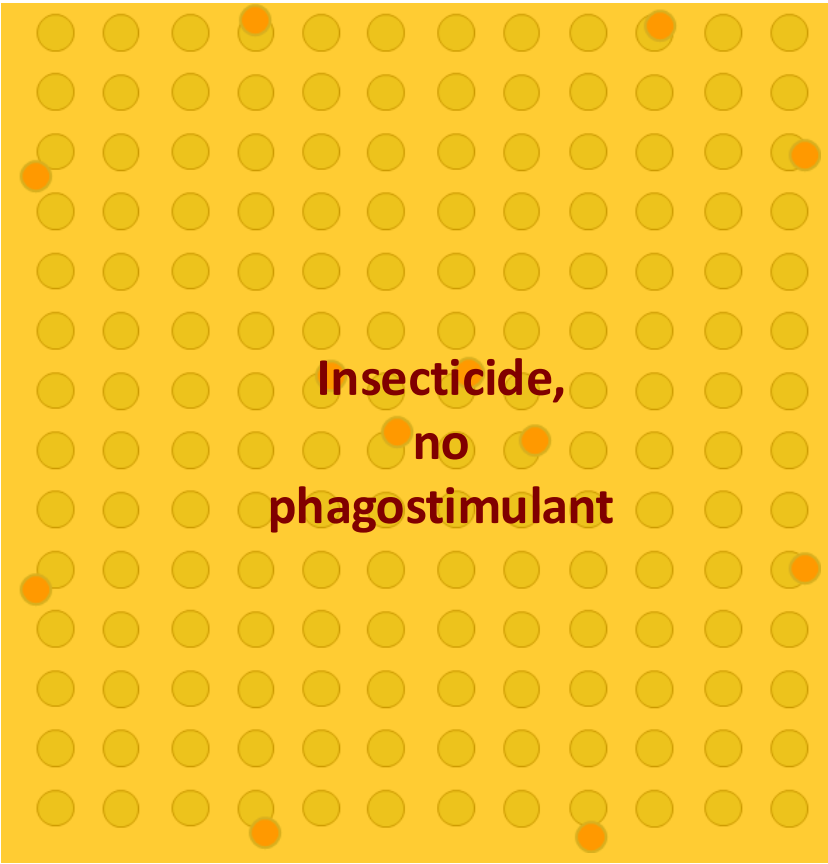
From 2019 to 2021, apple growers who implemented an attract-and-kill strategy for apple maggot reduced their insecticide use between 64% and 75%.

■ = AMF lures
● = Monitoring sticky sphere

Attract-and-kill



Grower standard



Insecticide +
feeding
stimulant

Insecticide,
no
phagostimulant

- Over a 3-year period and across 26 commercial orchards across MA, NH, and ME, the new A-K system developed controlled apple maggot fly successfully.
- Amount of insecticide used in A-K blocks was reduced by 75%, 64.7%, and 64.2% in 2019, 2020, and 2021, respectively,



Journal of Economic Entomology, XX(XX), 2024, 1–6
<https://doi.org/10.1093/je/toae253>
Research



Horticultural Entomology

Multi-year evaluation of an attract-and-kill strategy for apple maggot fly (Diptera: Tephritidae) in New England commercial apple orchards

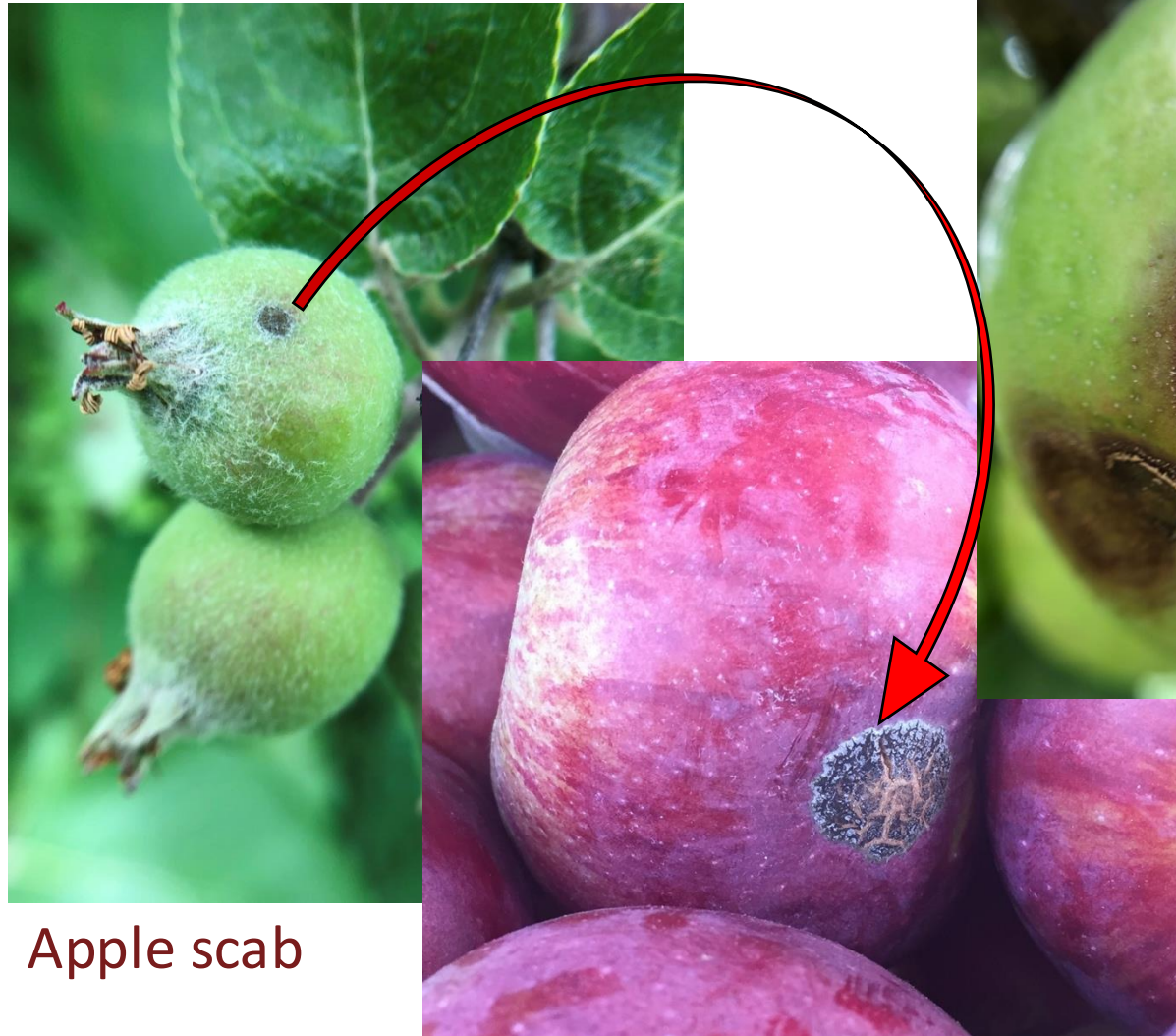
Jaime C. Piñero^{1,*}, Heriberto Godoy-Hernandez¹, Tracy C. Leskey²

¹Stockbridge School of Agriculture, University of Massachusetts, Amherst, MA, USA, ²USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV, USA *Corresponding author, email: jpinero@umass.edu

Subject Editor: Nik Wiman

Received on 3 June 2024; revised on 1 October 2024; accepted on 12 October 2024

Scouting: Diseases



Apple scab

Bitter rot



Black rot





Disease Trapping? Yeah... But

Skill, time, equipment and patience.

Disease IPM

- Disease = the abnormal functioning of an organism.
- Scab, black spot, mildew, anthracnose, mold, blight, leaf spot, rot, rust, canker...



Know thy enemy!

Abiotic

VS

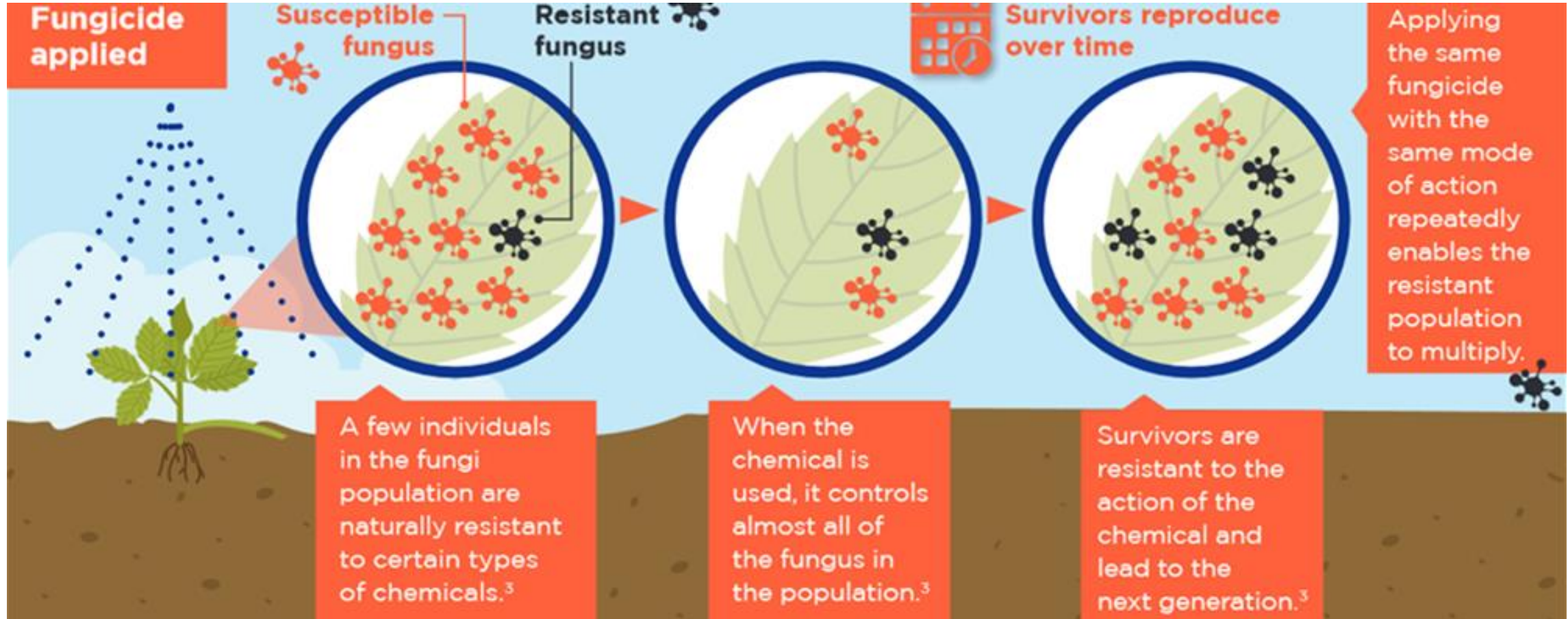
Biotic

Tract blight

VS

Fireblight



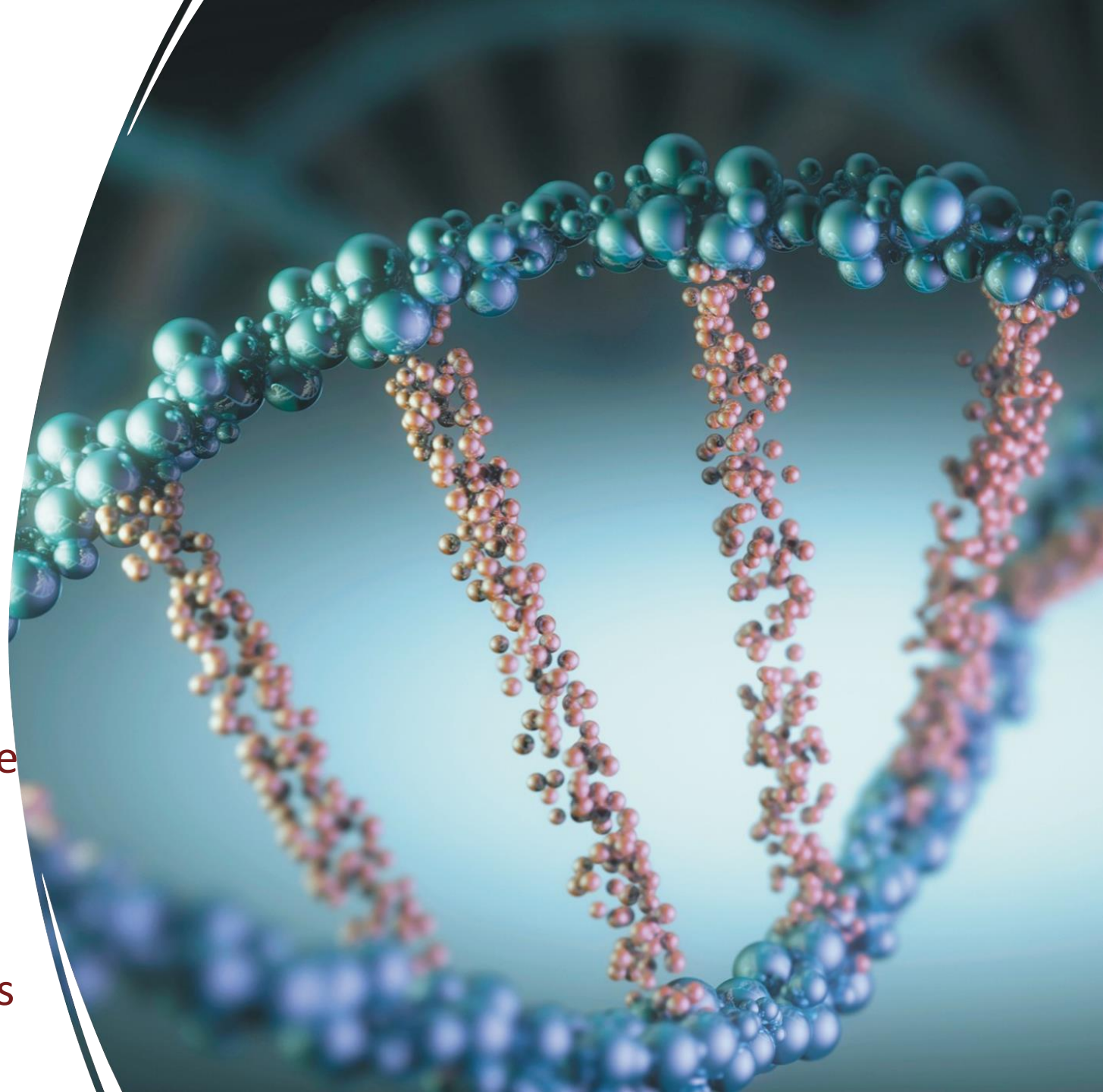


Resistance

- Influenced by many factors
 - Cropping system
 - Pathogen
 - Fungicide
 - Climate
 - Farmers' ability and willingness to use resistance management strategies

Resistance Management

- "Do not repeat the tactics which have gained you one victory but let your methods be regulated by the infinite variety of circumstances."
–Sun Tzu, Art of War
- Host genetics
 - First step in preventing fungicide resistance
- ~57,000 genes contained w/in the apple genome
 - More than twice that of humans



Cultural Controls

- Manage canopy density
- Rootstock selection
- Maintain healthy crops
- Cultivar mixtures (interplanting)
- Prune out infected tissue
- (crop) Host eradication
- Sanitation
- Alternate host removal
- Crop rotation



Alternate Host Removal

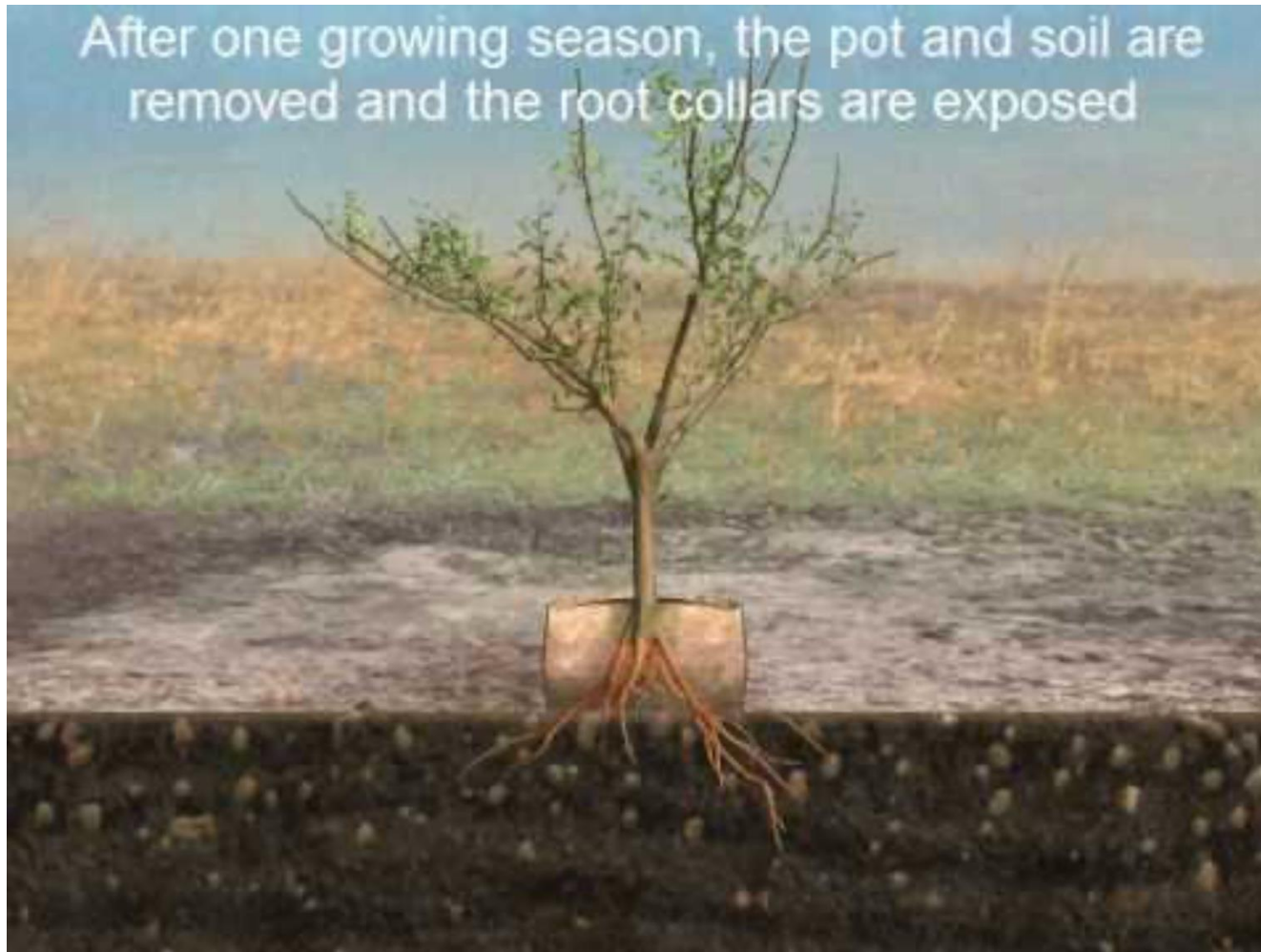
- Cedar apple rust
 - Eastern red cedar (*Juniperus virginiana*)

Sanitation



- Apple scab
 - Leaf chopping
 - Urea

Walking Peach Trees



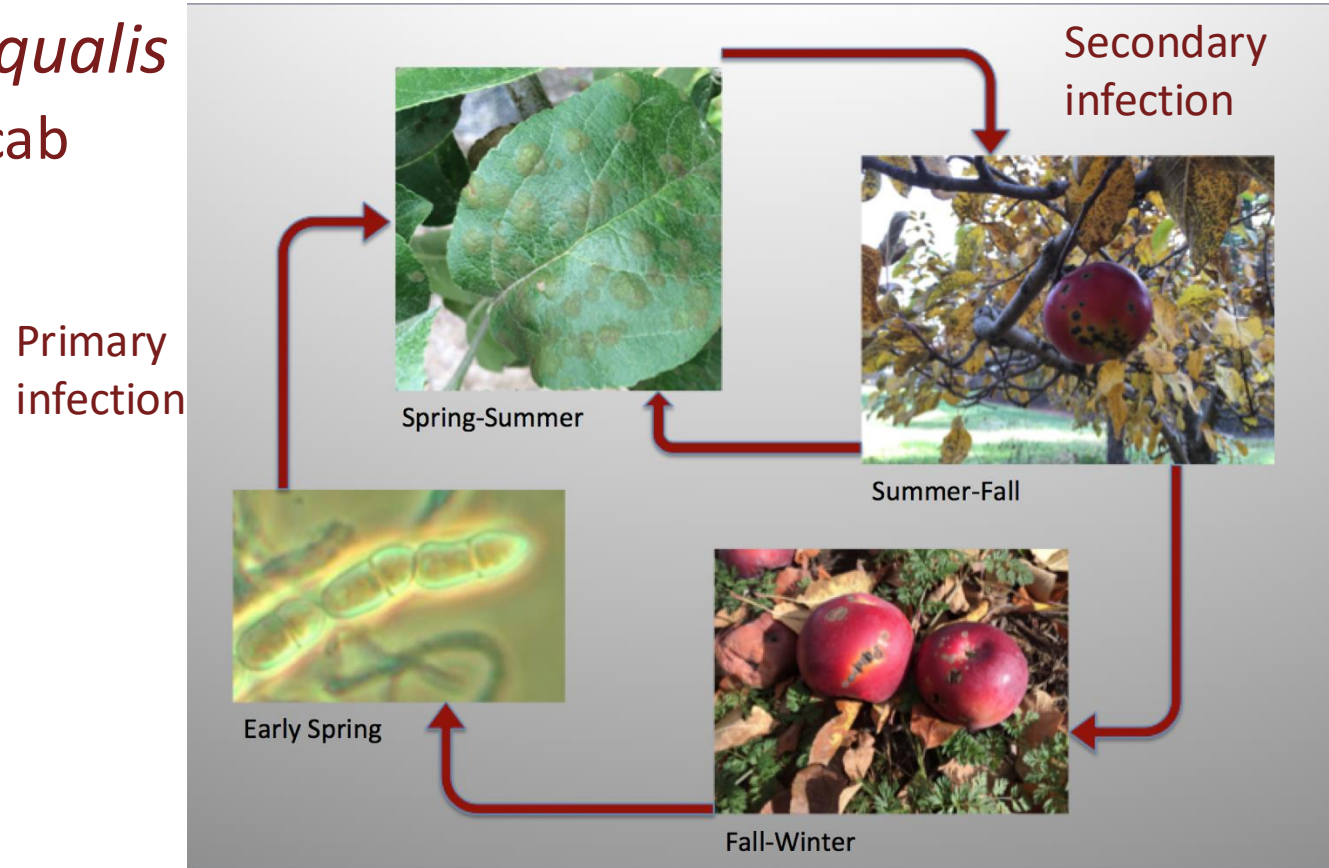
Clemson Cooperative Extension

All Boxes ✓

- Three choices for further disease management
 - 1: Cross your fingers and hope really, really hard
 - 2: Spray fungicides willy nilly and hope you hit something accidentally on purpose
 - 3: Make a targeted fungicide application
 - Efficient, effective

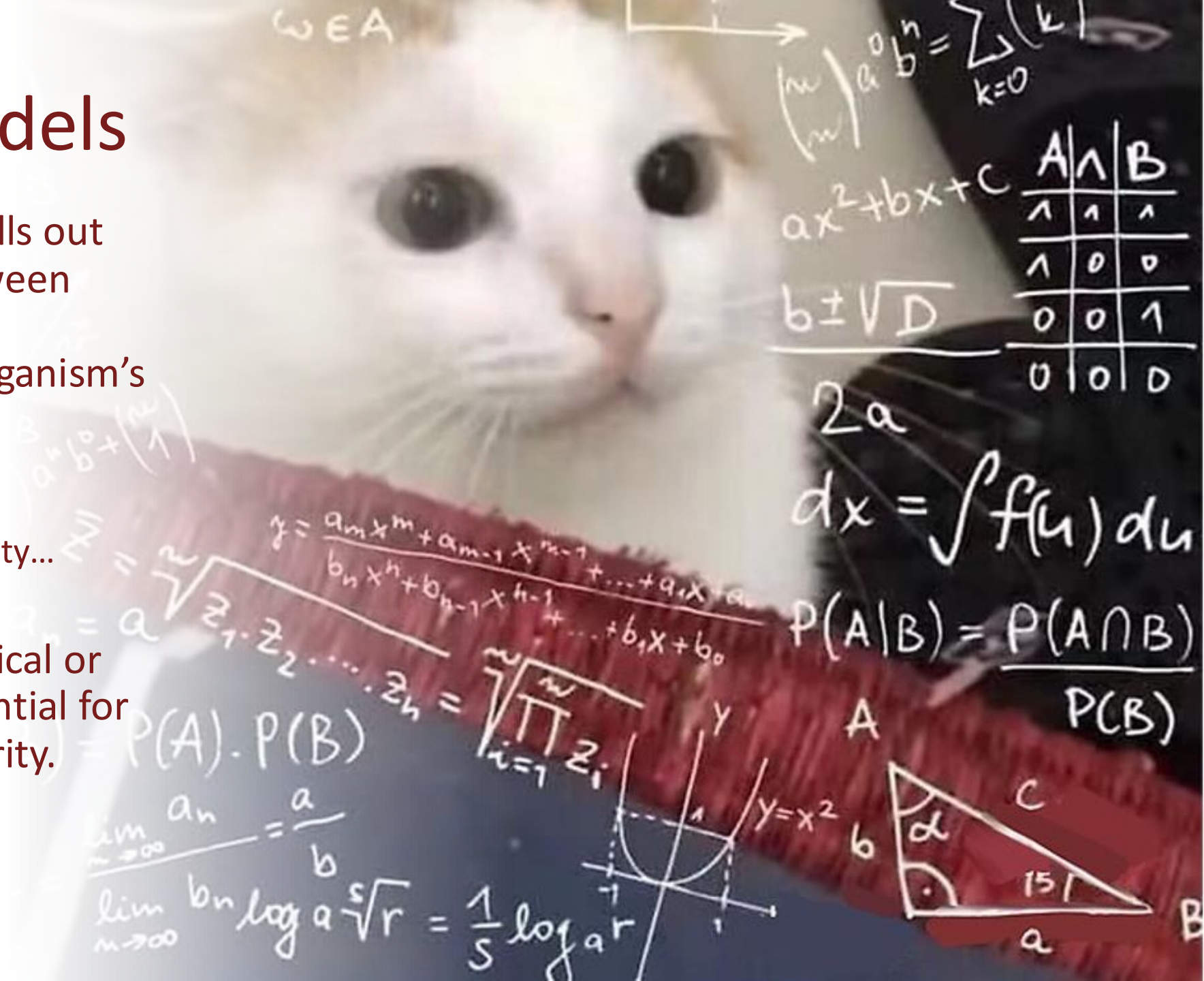
Know Thy Enemy

- *Venturia inaequalis*
 - Aka apple scab



Forecast Models

- An equation that spells out the relationship between factors that effect an organism and that organism's response.
 - Temperature, light intensity/duration, precipitation, humidity...
- Used to describe the likelihood of a biological or climatic event's potential for occurrence and severity.

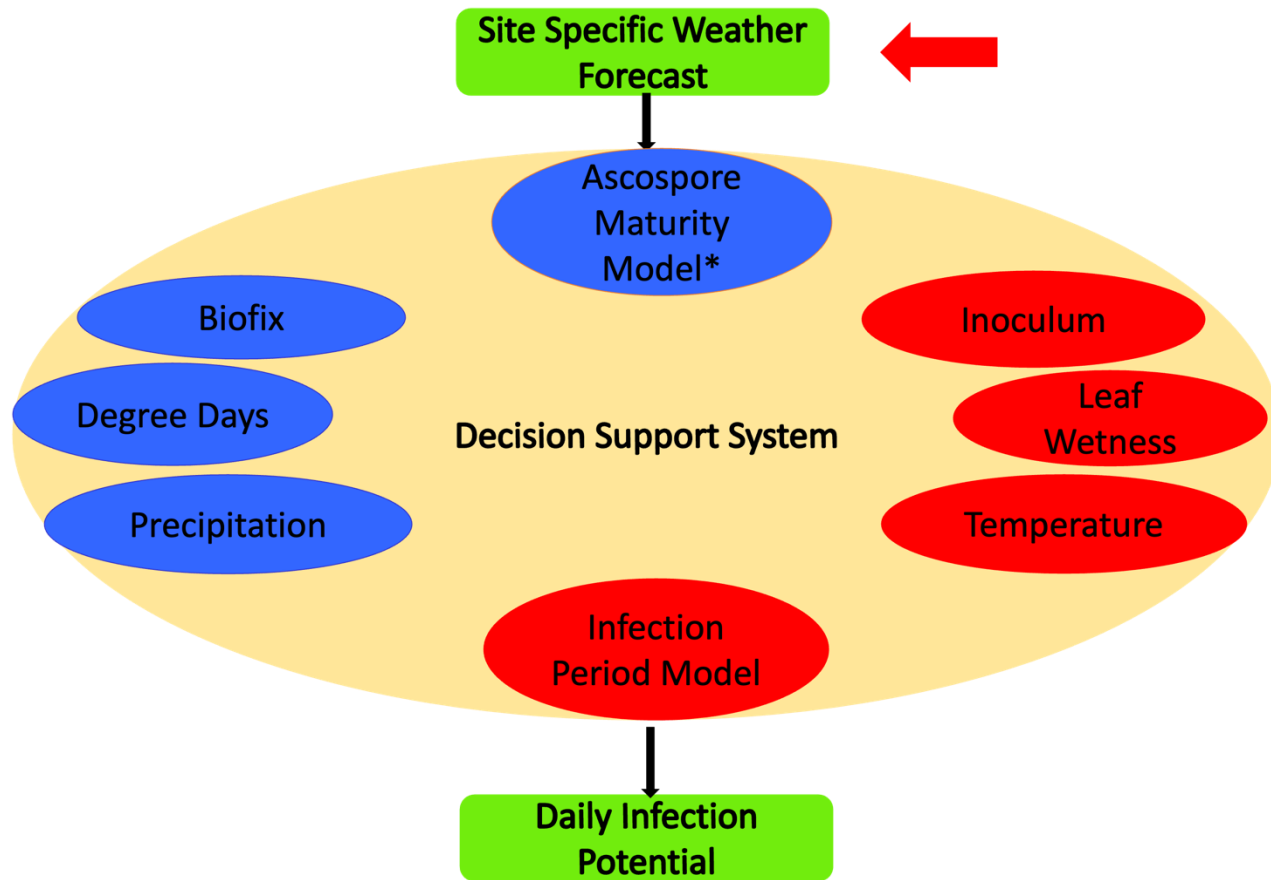


Decision Support Systems (DSS)

- Decision Support Systems (DSS) are online tools meant to provide information for effective, timely and efficient crop production decisions.
- Each DSS contains many different models. Often, risk forecast is determined by multiple models working in conjunction with one another.
- Models contained in these DSS range from pest forecasting to horticultural activity timing.

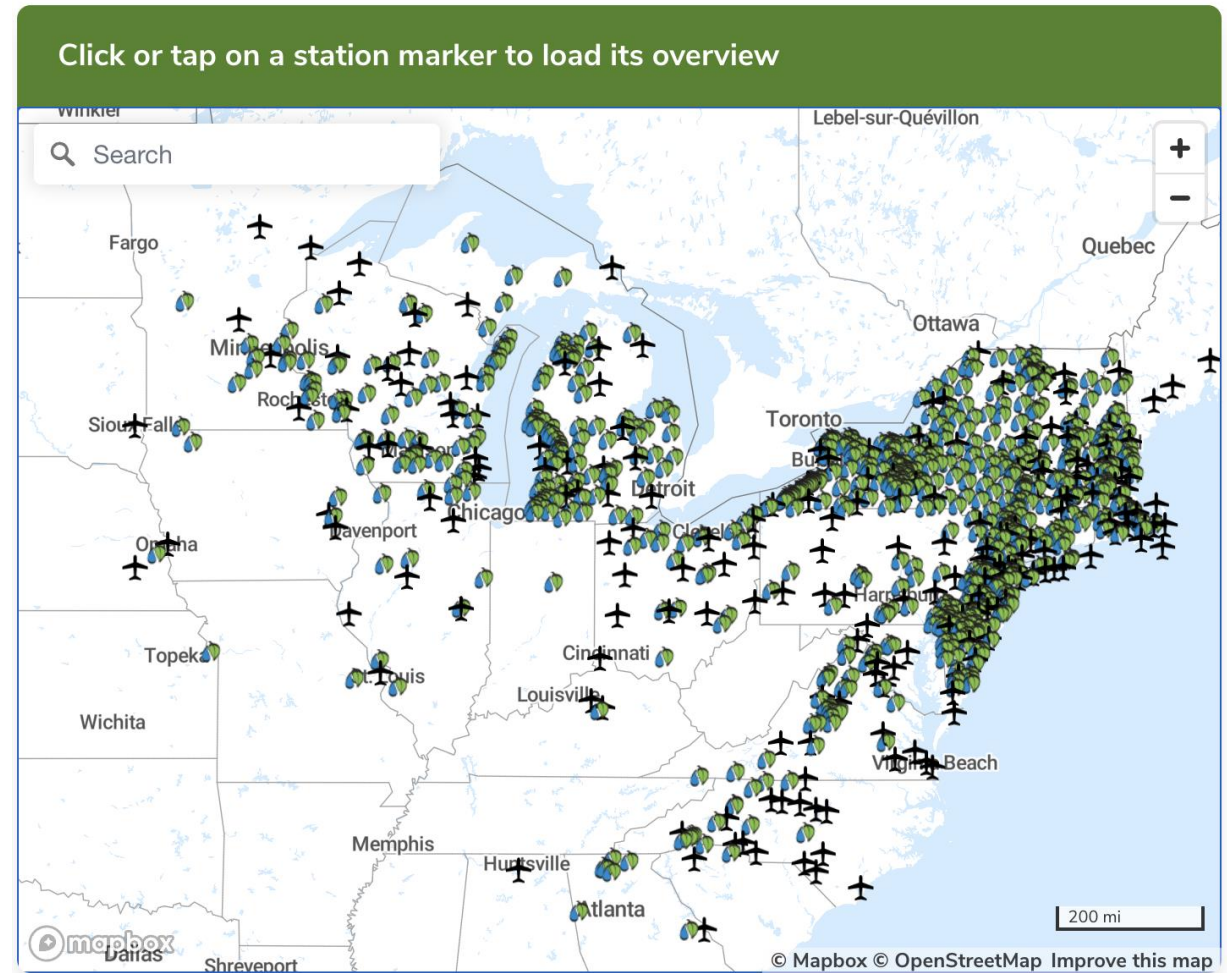
Anatomy of a DSS

- Example: apple scab



NEWA

- NEWA.cornell.edu
- Free...ish
- Set up your account (free)
- Identify
 - Favorite weather stations
 - Preferred tools
- Cache biofix data
- Retrospective assessments



Forecast Model: Apple Scab

- NEWA

Ascospore Maturity Summary

Model 1 Daily Discharge Thresholds: ≥ 10% > 20%

Date	Ascospore Maturity	Daily Ascospore Discharge	Cumulative Ascospore Discharge
Apr 1	1%	<1%	<1%
Apr 2	1%	<1%	1%
Apr 3	2%	0%	1%
Apr 4	2%	0%	1%
Apr 5	2%	0%	1%
Apr 6	3%	<1%	1%
Apr 7	3%	0%	1%
Apr 8	3%	0%	1%



Biofix: green tip,
McIntosh 4/02/23

Infection Events Summary

Model 2 Events: Dry Wet

Date (2023)	Infection Events	Average Temp (°F) for wet hours	Leaf Wetness (hours)	Hours > 90% RH	Rain Amount
Apr 1	no	44	18	18	0.5
Apr 2	no	41	2	0	0
Apr 3	no	-	0	0	0
Apr 4	no	43	3	2	0
Apr 5	no	38	7	5	0
Apr 6	no	43	16	11	0.02
Apr 7	no	-	0	0	0
Apr 8	no	-	0	0	0

April 30, 2023

● Belchertown, MA



Ascospore Maturity Summary

Daily Discharge Thresholds: ≥ 10% > 20%

Date	Ascospore Maturity	Daily Ascospore Discharge	Cumulative Ascospore Discharge
Apr 28	61%	0%	35%
Apr 29	65%	8%	43%
Apr 30	69%	8%	50%
May 1	73%	7%	57%
May 2	76%	10%	67%
May 3	79%	4%	70%
May 4	82%	0%	70%
May 5	85%	0%	70%

Date of Interest

April 2023						
Su	Mo	Tu	We	Th	Fr	Sa
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	1	2	3	4	5	6

Where Rubber Meets the Road

● Belchertown, MA | v

Date of Interest

April 2023						
Su	Mo	Tu	We	Th	Fr	Sa
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	1	2	3	4	5	6

Infection Events Summary

Events: Dry Wet

Date (2023)	Infection Events	Average Temp (°F) for wet hours	Leaf Wetness (hours)	Hours > 90% RH	Rain Amount
Apr 28	no	41	9	9	0
Apr 29	combined	48	13	4	0.18
Apr 30	combined	49	19	21	0.42
May 1	combined	52	13	9	0.48
May 2	combined	47	22	17	0.41
May 3	yes	46	19	7	0.01
May 4	no	46	16	6	0
May 5	no	48	15	5	0

NEWA- Plum Curculio

- Biofix: petal fall, Gala 5/14/24



Belchertown, MA

Date of Interest

May 2023						
Su	Mo	Tu	We	Th	Fr	Sa
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

Petal Fall

At petal fall, fruit become susceptible to feeding and oviposition injury. Control measures are only needed until 308 degree days have accumulated since petal fall.

Petal Fall

05/14/2023 clear

Petal Fall date above is estimated based on degree day accumulations or user input. Enter the actual date for blocks of interest and the model will calculate the protection period after petal fall more accurately.

Accumulated degree days (base 50°F BE) petal fall through 5/15/2023: 14

Degree Day Accumulations

● Belchertown, MA

Date of Interest

May 2023						
Su	Mo	Tu	We	Th	Fr	Sa
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

Results Table

Forecast Details

DATE (2023)	Degree Days (base 50°F BE)		
	DAILY	FROM JAN 1	FROM MAY 14
May 13	19	293	N/A
May 14	6	300	6
May 15	8	308	14
May 16	16	324	30
May 17	3	327	33
May 18	4	331	37
May 19	7	338	44
May 20	6	344	50

Management

- “A petal fall spray should control PC for ~10-14 days.”
- “In high pressure orchards, additional perimeter sprays should be made until the model indicates

Belchertown, MA

Management Guide

Pest Stage: Adults ovipositing

Change the pest stage above and the model will recalculate recommendations.

Date of Interest						
May 2023						
Su	Mo	Tu	We	Th	Fr	Sa
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

PEST STATUS	PEST MANAGEMENT
<p>Plum curculio (PC) adults will continue to damage fruit and may be moving among trees. PC activity is highly dependent upon temperatures, particularly at night when adults are most active. PC usually do not feed or oviposit when nighttime temperatures are below 50°F. If the weather is extremely warm after petal fall, the oviposition cycle may be completed in 2 weeks. In cooler seasons, PC may continue to oviposit for 4-6 weeks.</p>	<p>A petal fall spray should control plum curculio (PC) for about 10-14 days. Incidence of observed PC damage is highly variable among different orchards. PC damage usually occurs primarily along the edges of commercial orchards, and noticeable damage occurs in the same locations in orchards year after year, regardless of treatment levels. Therefore, the potential for damage in any particular orchard can be predicted from past observations. Usually, a post-petal fall spray for control of PC is not necessary in low-pressure orchards in which no damage has been observed in the past. In high-pressure orchards, additional sprays along the perimeter of the orchards should be applied until the oviposition model predicts that control is no longer necessary, which is when at least 308 DD have accumulated after petal fall.</p>

Multi-cultivar Grafted Trees as Perennial Trap Crop

- Dr. Jaime Piñero



Stockbridge School of
Agriculture

- Steve Wood



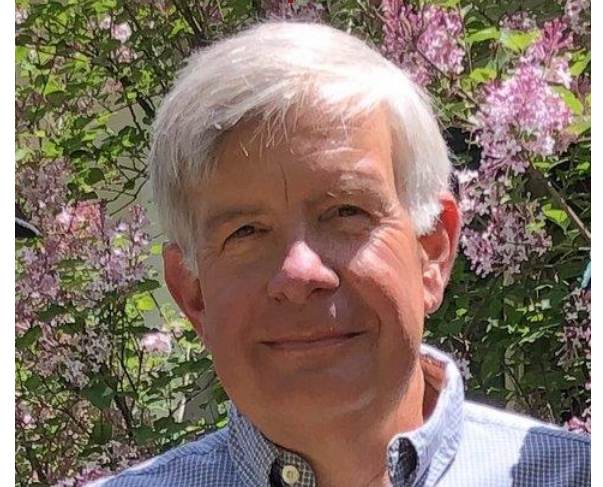
Poverty Lane,
Farnum Hill

- Jeremy Delisle



University of New
Hampshire, Extension

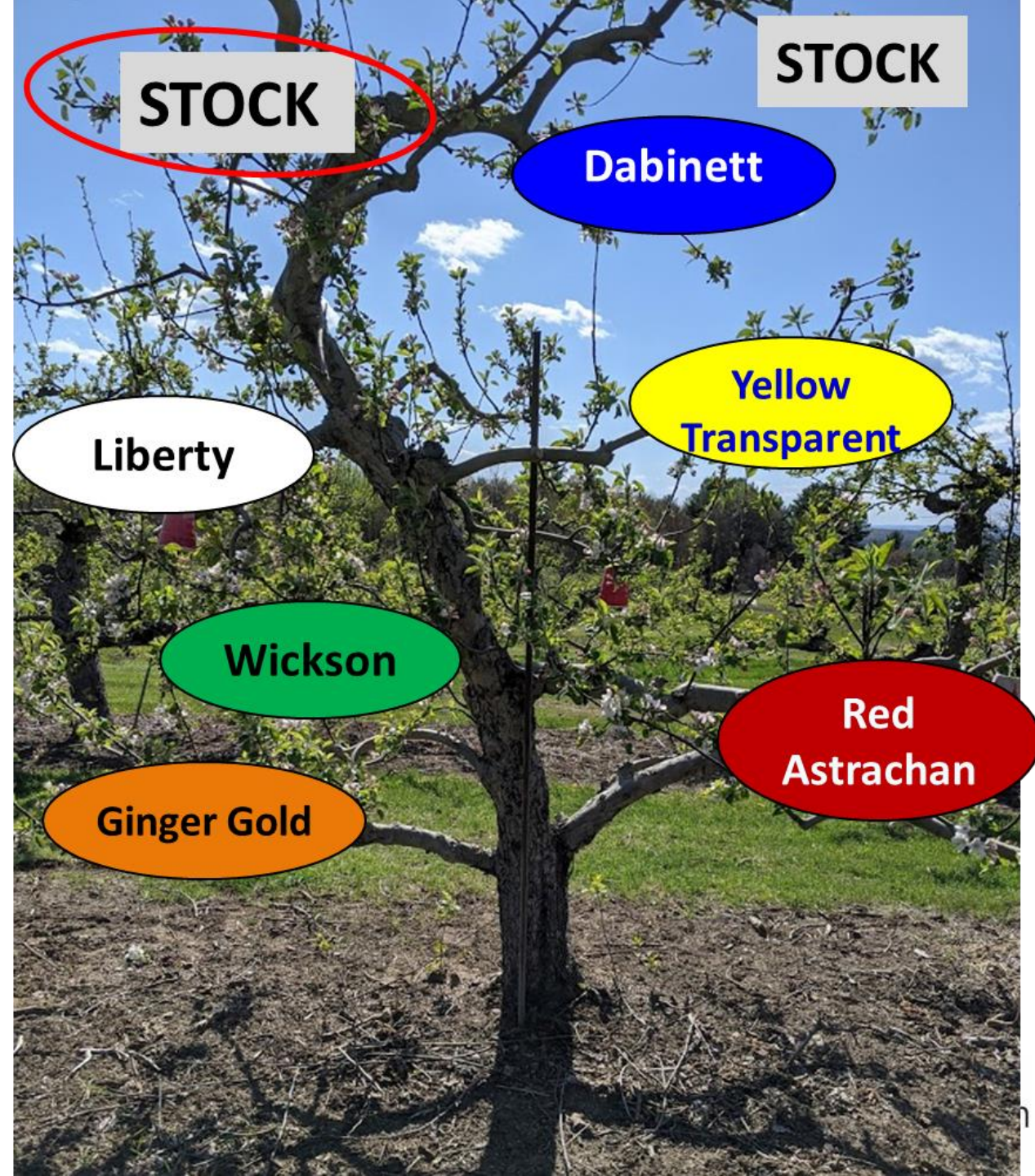
- Jim Krupa



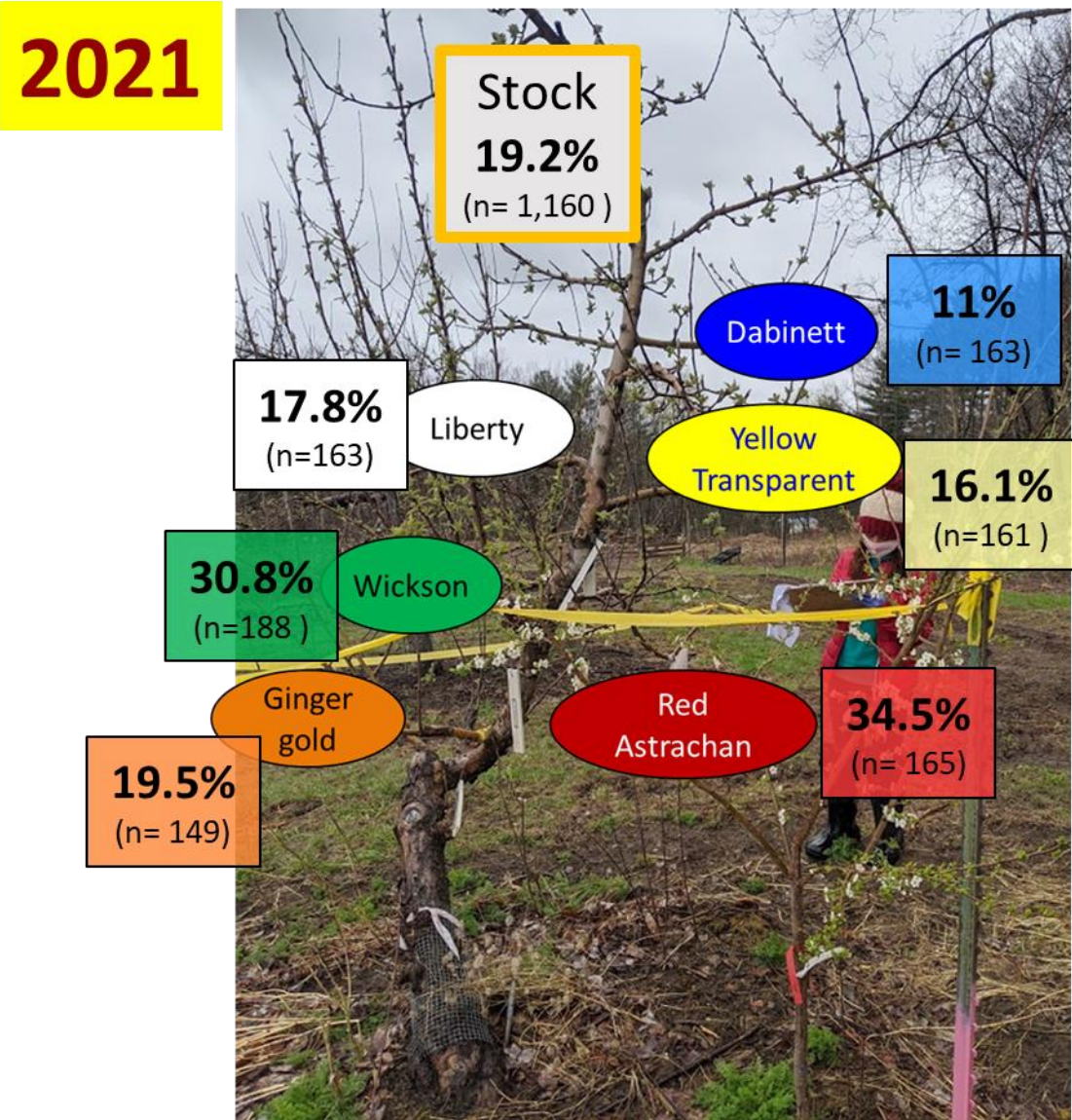
UMass Cold Spring
Orchard, retired

Multi-cultivar Grafted Trees as Perennial Trap Crop

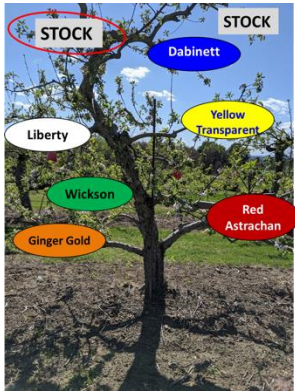
- Inexpensive lure option
 - PC lures \$\$\$
- Seven total CVs
 - "stock" tree
- Attract & kill
 - AMF & PC



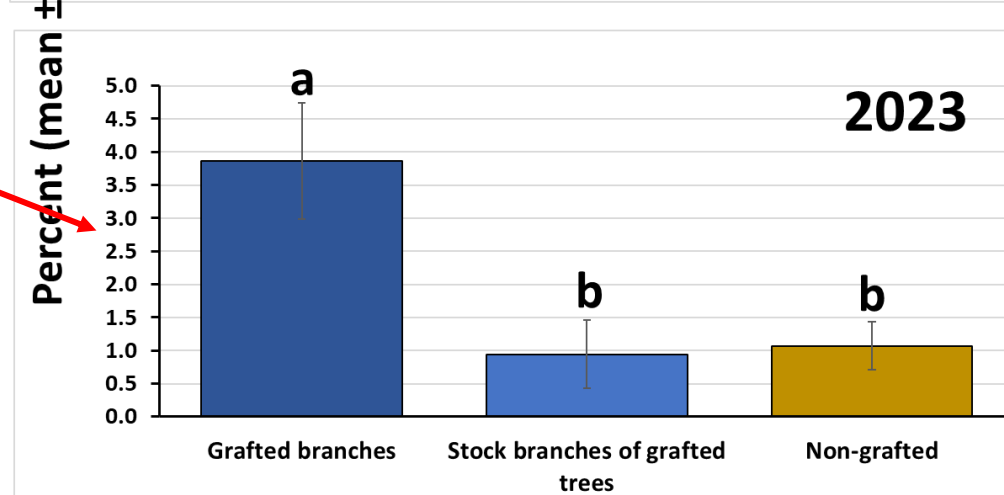
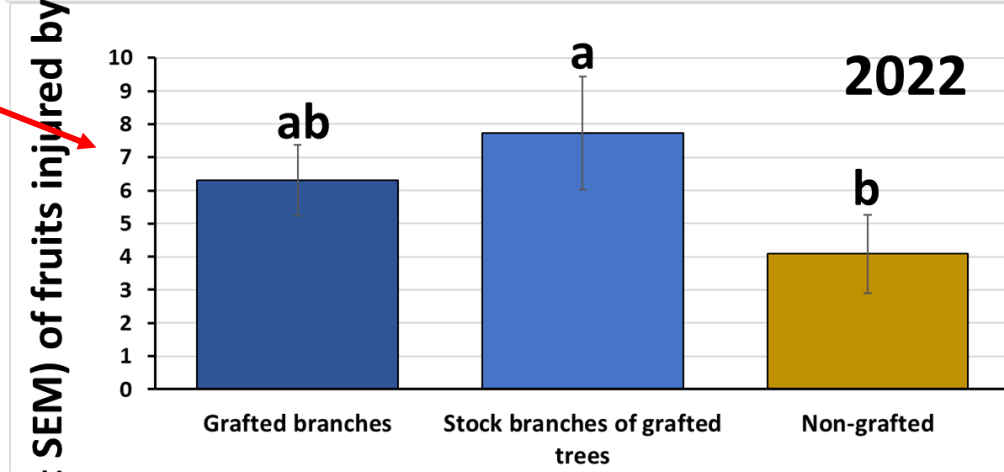
Relative Attractiveness to Plum Curculio



Plum Curculio Harvest Injury

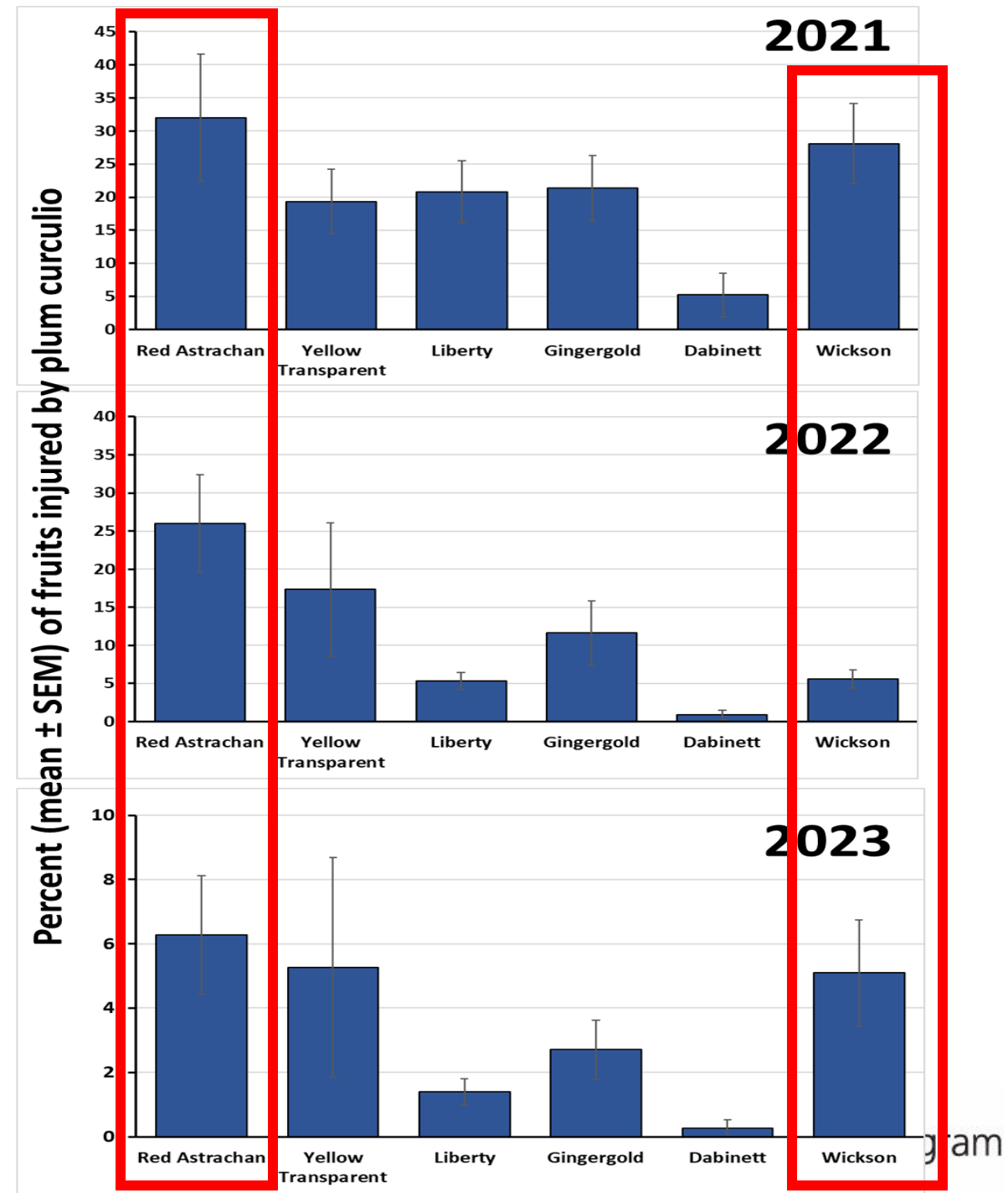


Distance between grafted trees: 30 meters



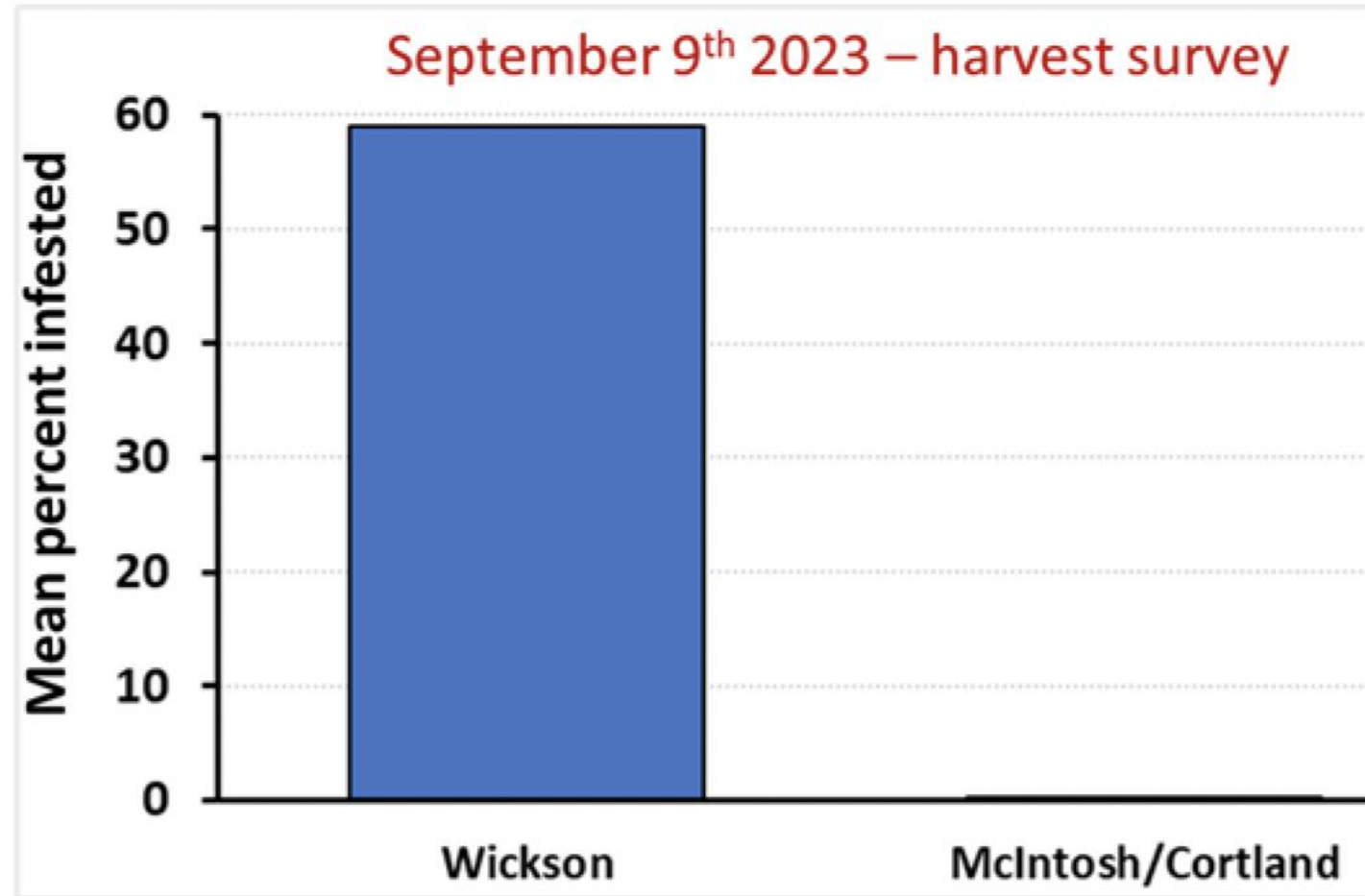
PC Injury by Cultivar

- 9 MA orchards
- Most attractive:
 - Red Astrachan
 - Wickson
 - Yellow transparent
 - Ginger gold
 - Liberty
- Dabinett... not so much



Harvest Survey- AMF Oviposition Scars

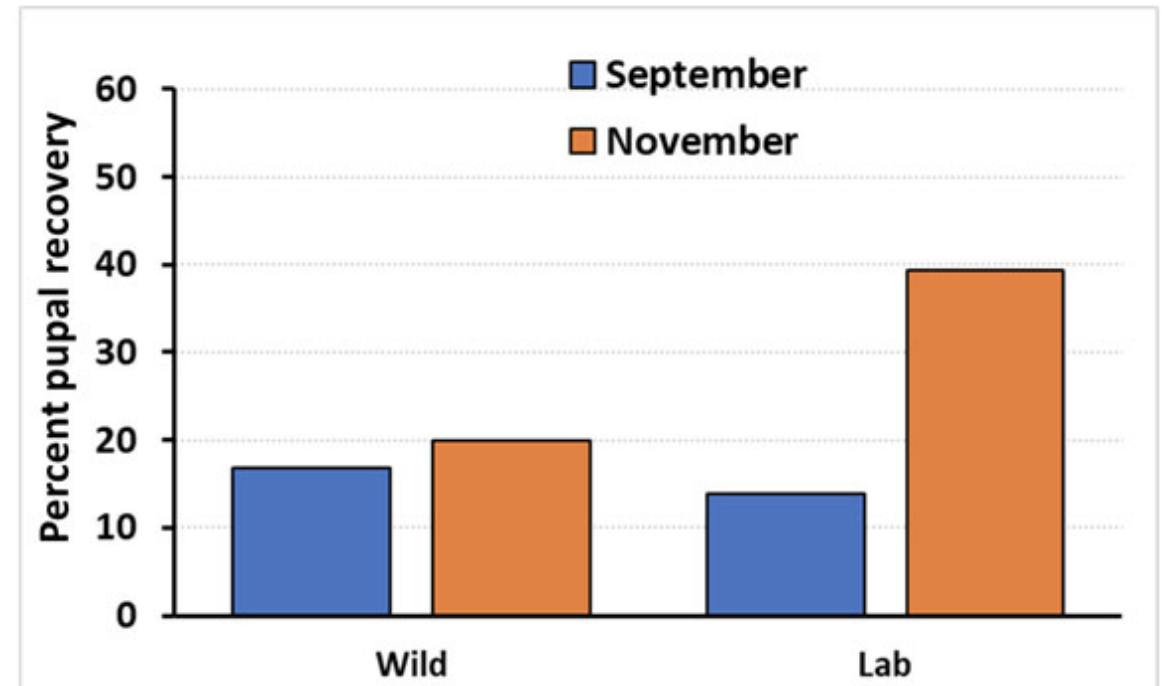
- Wickson ~60% injury
- Mac/Cortland 0.004%
- Highly attractive to AMF
- Excellent trap crop candidate



AMF Survival Rate

- Percent infestation (scars) VS pupae found
- Wild population VS lab reared

AMF pupal recovery, calculated as the number of pupae obtained after six weeks of incubation based on the total of egg-laying scars recorded on Wickson apples on each date.



Conclusion

- "In warfare there are no constant conditions. They who can modify their tactics in relation to their opponents and thereby succeed in winning may be called a Heaven born Captain." -Sun Tzu, Art of War
- IPM contributes to orchard sustainability by
 - First arming you with knowledge
 - Second giving you the tools necessary to apply that knowledge



Thank you! Questions?



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