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Hop Pest Update

Erin Lizotte
Michigan State University Extension

Overview

- Scouting protocol
- Downy mildew
- Emerging Pests
- Beneficials
- Resources

Disclaimer—Check Labels (I'm from MI)

Information presented here does not supersede the label directions. To protect yourself, others, and the environment, always read the label before applying any pesticide. Although efforts have been made to check the accuracy of information presented, it is the responsibility of the person using this information to verify that it is correct by reading the corresponding pesticide label in its entirety before using the product. Labels can and do change. For current label and MSDS information, visit one of the following free online databases: greenbook.net, cdms.com, and agrian.com

The efficacies of products listed have not been evaluated on hop in Michigan. Reference to commercial products or trade names does not imply endorsement by Michigan State University Extension or bias against those not mentioned.

Scouting

- Scouting involves monitoring the crop and cropping area for problems
- Begin as soon as plants begin to grow or pests become active
- Continue until the crop is dormant or the risk of the pest has passed

Scouting

- A critical step in quantifying the potential pest damage
- Aids in determining if intervention to control the pest is warranted
- Helps determine the lifestage of the pest which is critical to optimize management
- Assists in determining management efficacy

Scouting

- Scouting for diseases includes monitoring the crop for signs and symptoms of disease and quantifying incidence and severity

Scouting

- Scouting for insects includes looking for all life stages and attempting to quantify the population
- May also include inspecting for crop damage and setting traps to collect them

Abiotic issues

- Unexplained by pests
  - Lack of water
  - Lack of nutrient
  - pH
  - Mechanical damage
  - Excessive water

Vertebrate damage

Scouting records

- Maps, a record of sampling, pest pressure, as well as the control measures utilized

Scouting protocol

- Section your farm off into manageable portions based on acreage, variety, and age
- Review the list of known pests and beneficials
- If biological information is available, use it to gauge when you might scout more intensively

Hop Pest Scouting Calendar

	Dormancy	Sprouting	Leaf expansion	Bine elongation and sidearm formation	Flowering	Cone develoment	Cone maturity	Senescence
Insects								
Two spotted spider mite	+	+	+	+	+	+	+	+
Potato leafhopper			+	+	+	+	+	+
Japanese beetle				+	+	+	+	
Rose chafer				+	+			
Damson hop aphid		+	+	+	+	+	+	
European corn borer				+	+	+	+	+

High risk, monitoring and control usually required
Less risk, monitoring or control may be required
+ Potential pest activity, monitoring should occur

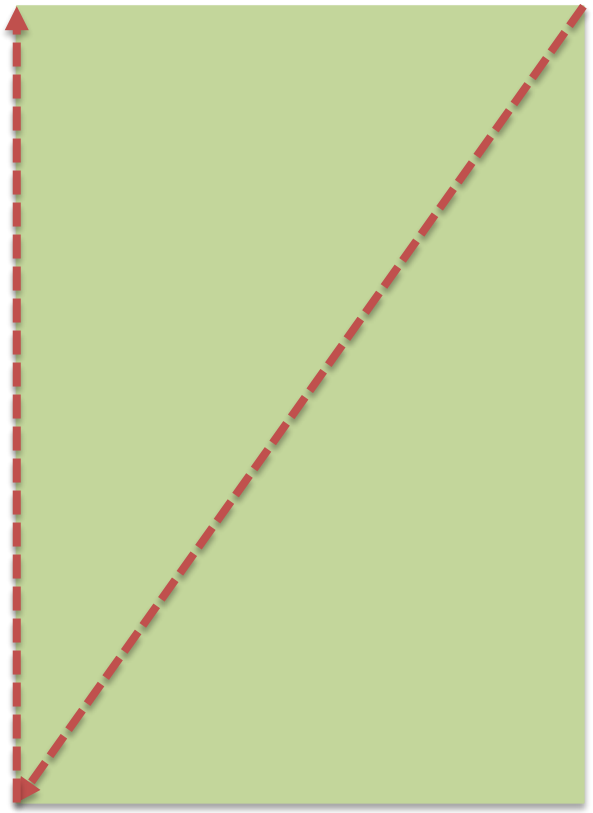
Hop Pest Scouting Calendar

	Dormancy	Sprouting	Leaf expansion	Bine elongation and sidearm formation	Flowering	Cone develoment	Cone maturity	Senescence
Diseases								
Downy mildew	+	+	+	+	+	+	+	+
Fusarium canker	+	+	+	+	+	+	+	+
Fusarium cone tip blight					+	+	+	+
Alternaria cone disorder					+	+	+	+
Gray mold					+	+	+	+
Verticillium wilt	+	+	+	+	+	+	+	+
Varios viruses	+	+	+	+	+	+	+	+
Powdery mildew	+	+	+	+	+	+	+	+

High risk, monitoring and control usually required
Less risk, monitoring or control may be required
+ Potential pest activity, monitoring should occur

General scouting protocol

- Walk a transect to ensure you view plants from both the edge and inner portion of the yard
- Change the path you walk each time you scout to inspect new areas
- Revisit problem areas
- Make up a scouting sheet and keep good records



Wait-- What am I looking for?

- One of the hardest things to learn about scouting is how to pick up on the visual cues that something is wrong with the plant
- Consider the following as a starting point:
  - Cupped, chlorotic, spotted or malformed foliage
  - Discolored, damaged, swollen or sunken areas of bark
  - A large number of insects—identify them!
  - Pockets of less vigorous or dying plants
  - **Anything out of the ordinary**

General Protocol

- Gently shake strings or ruffle foliage as you walk looking for a flush of activity
- Remove leaves as you move through the yard—turn them over and give a close inspection using a hand lens
- Check leaves from all reachable heights, but favor the lower, denser portion of the canopy
- The more you look, the more you see…..

Consider the weather

- One of the greatest allies a grower can utilize to be an effective scout and pest manager is historical and forecast weather data
- This information can inform you of when to intensify your scouting for certain pests and disease, when to apply a pesticide to optimize treatment, and when the ideal conditions might occur to apply a spray

Let's Get Specific

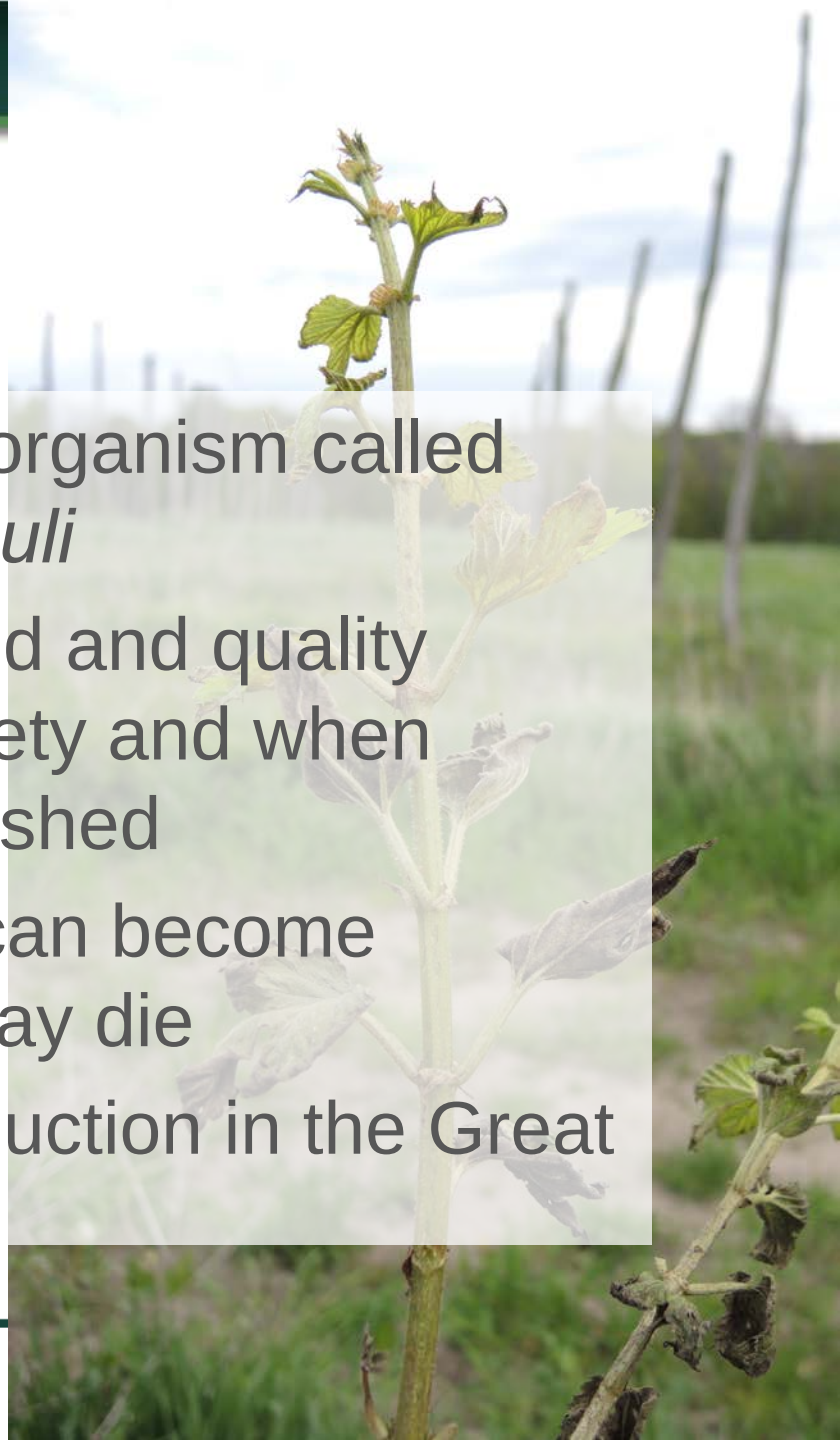
Downy Mildew

Emerging Insect Pests

- European Corn Borer
- Spotted Lantern Fly

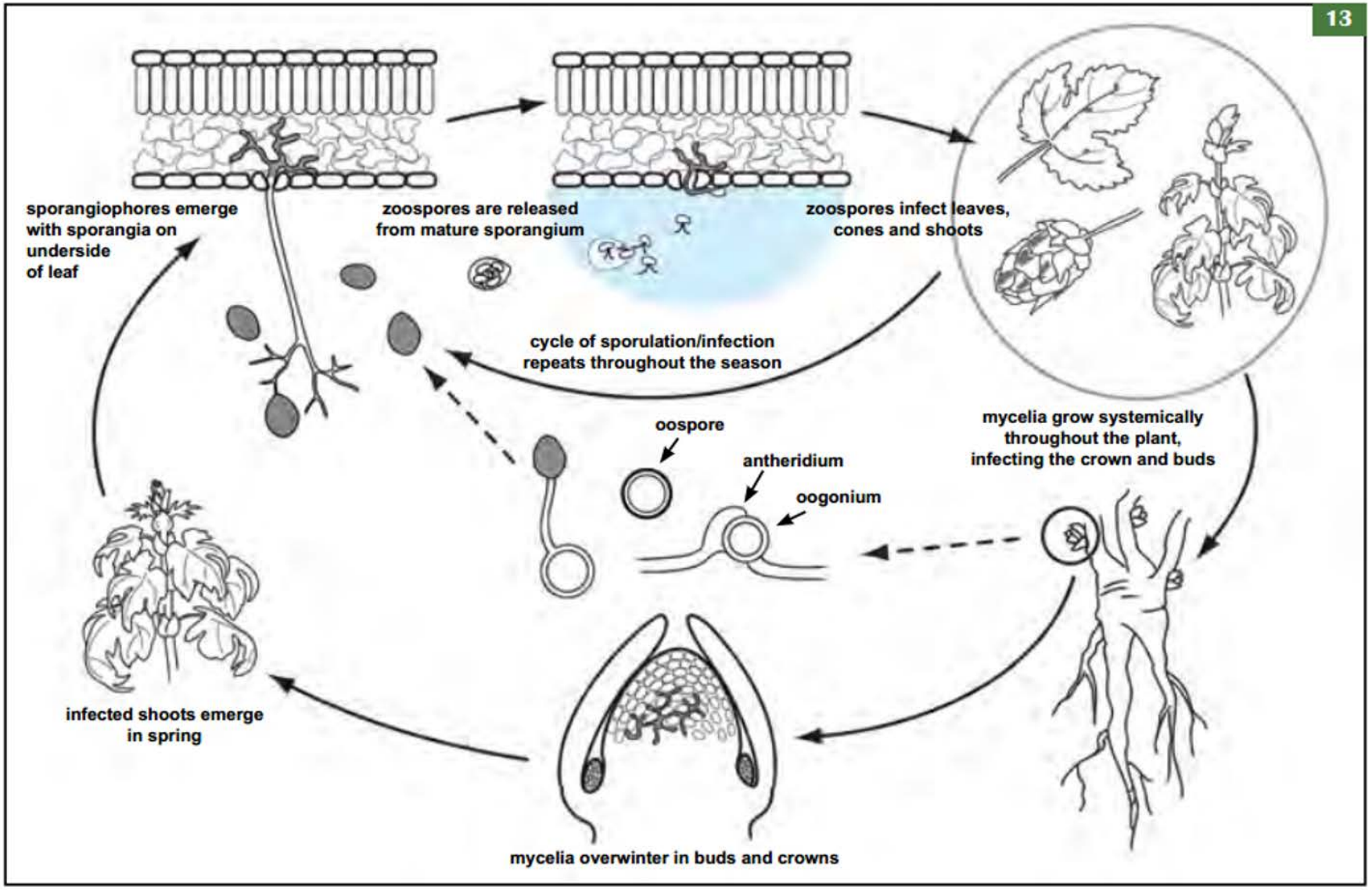
Downy Mildew

- Caused by a fungus-like organism called *Pseudoperonospora humuli*
- Can cause significant yield and quality losses depending on variety and when infection becomes established
- In extreme cases cones can become infected and the crown may die
- Biggest challenge to production in the Great Lakes Region



Downy mildew

- Infection is favored by mild to warm temperatures (60 to 70F) when free moisture is present for at least 1.5 hours
- Leaf infection can occur at temperatures as low as 41F when wetness persists for 24 hours or longer
- Initially, downy mildew appears early in the season on the emerging basal spikes
- Spikes then appear stunted, brittle and distorted



Disease cycle of *Pseudoperonospora humuli*, the causal agent of downy mildew in hop. (Cred. V. Brewster, Compendium of Hop Diseases and Pests)

Downy mildew

- Spore masses appear fuzzy and black on the underside of infected leaves
- As bines expand new tissue becomes infected and fails to climb the string
- Can retrain new shoots but often incur yield loss as a result
- Appearance may vary based on variety and timing

Downy mildew “spike”

Downy or glyphosate?

Downy mildew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Downy Mildew Management

Requires multiple tactics that **delay** onset of disease and reduce disease development

1. Source of planting material
2. Variety selection
3. Pruning and canopy management
4. Protectant fungicides season long
5. Harvest timing

Clean Plant Material

- State Department of Ag Inspection
- Clean Plant Network
- Overall plant health on delivery
- Talk to other growers
- Get plants tested

Variety Selection

S = Susceptible
MS = Moderately susceptible
MR = Moderately resistant
R = Resistant
U = Unknown

Table 3. Disease Susceptibility and Chemical Characteristics of the Primary Public Hop Varieties Grown in the U.S.

Variety	Usage	Disease Susceptibility*		
		Powdery Mildew	Downy Mildew	Verticillium Wilt
Brewer's Gold	Bittering	S	S	MR
Bullion	Bittering	S	S	R
Cascade	Aroma	R/MS	S	MR
Centennial	Bittering	MS	S	U
Chinook	Bittering	S	S	R
Columbia	Aroma	MS	MR	S
Comet	Bittering	R	S	R
Crystal	Aroma	R	S	R
East Kent Golding	Aroma	S	S	MR
Fuggle	Aroma	MR	MR	S
Galena	Bittering	S	S	R
Glacier	Aroma	S	S	U
Hall. Gold	Aroma	MS	R	S
Hall. Magnum	Bittering	S	R	MR
Hall. Mittelfrüh	Aroma	MS	S	S
Hall. Tradition	Aroma	MR	R	MR
Horizon	Bittering	MS	S	MR
Late Cluster	Aroma	S	S	R
Liberty	Aroma	MS	S	U
Mt. Hood	Aroma	MS/R	S	S
Newport	Bittering	MR/R	R	U
Northern Brewer	Bittering	S	S	R
Nugget	Bittering	S/MS/R	S	S
Olympic	Bittering	S	MS	R
Perle	Aroma	S	R	MR
Saazer	Aroma	S	MS	S
Saazer 36	Aroma	S	MS	S
Spalter	Aroma	S	R	MR
Sterling	Aroma	S	MR	U
Teamaker	Aroma	MR	MR	S
Tolhurst	Aroma	S	S	U
TriplePearl	Aroma	S/R	S	U
U.S. Tettnanger	Aroma	S	MR	S
Vanguard	Aroma	S	S	U
Willamette	Aroma	S	MR	S

Canopy Management, Pruning

- Early spring pruning (e.g. crowning, scratching) synchronizes growth
- Removes plant remnants from the previous season
- Can eliminate infected crown buds with powdery and downy mildew inoculum
- Do not do this to babies

Gent, USDA ARS

Chemical Downy Management

- Apply fungicide treatments on a protectant basis as soon as bines emerge in the spring (or reflush after pruning) regardless of symptoms
- Applications continue on a 7-10d reapplication interval until cone closure at which point disease pressure should be considered to determine treatment interval
- Several periods in the season are particularly critical for disease control:
  - Before and after training; lateral branch development; bloom; and cone development
  - Covering young, developing bracts before cones close up is critical to protecting against downy mildew on cones when conditions for disease are favorable

Hop Downy Mildew Fungicide Efficacy

Trade Names	Active ingredient (FRAC Code[1])	Efficacy[2]	REI/PHI[3]
Forum	dimethomorph (40)	E	12h/7d
MetaStar 2E, Metalaxyl 2E Ag	metalaxyl (4)	E	48h/135d (drench) 48h/45d (foliar)
Presidio[5]	fluopicolide	E	12h/24d
Ranman, Ranman 400 SC	cyazofamid (21)	E	12h/3d
Revus	mandipropamid (40)	E	4h/7d
Ridomil Gold SL, Ultra Flourish	mefenoxam (4)[4]	E	48h/135d (drench) 48h/45d (foliar)
Zampro	ametoctradin (45) + dimethomorph (40)	E	12h/7d
Curzate 60DF	cymoxanil (27)	G	12h/7d
Tanos	famoxadone (11) + cymoxanil (27)	G	12h/7d
Aliette WDG, Linebacker WDG	fosetyl-Al (33)	F	12h/24d
Agristar Basic Copper 53*, C-O-C-S WDG, Cuprofix-Ultra 40 Disperss, Cuproxat, Mastercop*	basic copper sulfate (M1)	P/F	See label
Cueva*	copper octanoate (M1)	P/F	4h/0d
COC DF	copper oxychloride (M1)	P/F	48h/See label
Champ DP Dry Prill, ChampION++, Champ Formula 2 Flowable, Champ WG*, Kentan DF, Kocide 2000, Kocide 3000, Nu-Cop 3L, Nu-Cop 50 DF*, Nu COP 50 WP*, Nu-Cop HB*, Nu-Cop XLR, Previsto	copper hydroxide (M1)	P/F	48h/14d
Badge SC, Badge X2*	copper oxychloride + copper hydroxide (M1)	P/F	48h/14d
Nordox 75 WG*	cuprous oxide (M1)	P/F	12h/-
Agri-Fos, Confine Extra, OxiPhos, Phiticide, Phostrol, Reliant	phosphorous acid, mono & di-potassium salts (33)	P/F	4h/0d
Fosphite, Fungi-Phite, Prophyt, Rampart	potassium phosphite (33)	P/F	4h/0d
Pristine	boscalid (7) + pyraclostrobin (11)	P	12h/14d
Luna Sensation	fluopyram (7) + trifloxystrobin (11)	P	12h/14d

1. FRAC - Fungicide Resistance Action Committee (FRAC) codes are used to distinguish the fungicide groups for resistance management purposes. Consecutive
2. 0= not effective, P = poor, F= fair, G = good, E = excellent, U = unknown. Ratings are based on published information and observations in Michigan, Oregon and
3. PHI-preharvest interval, REI-restricted entry interval expressed as h-hours or d-days.
4. Research in Michigan has shown that drench applications are more effective than foliar applications.
5. Requires a supplemental label for use in hops.

* OMRI approved for organic production.

Organic considerations

- Copper is the only organically available fungicide that has shown efficacy against downy
- Resistant cultivars
- Improved air flow through leaf stripping, weed control, etc.
- Removal of the first flush of growth on established plants

Organic growers can see complete crop loss under high disease pressure even when management is intensive

European Corn Borer

- *Ostrinia nubilalis* is a moth species native to Europe
- Has a relatively diverse host range, including hop
- 2019 outbreak in some Michigan hopyards, likely caused by delayed planting in corn

European Corn Borer Lifecycle

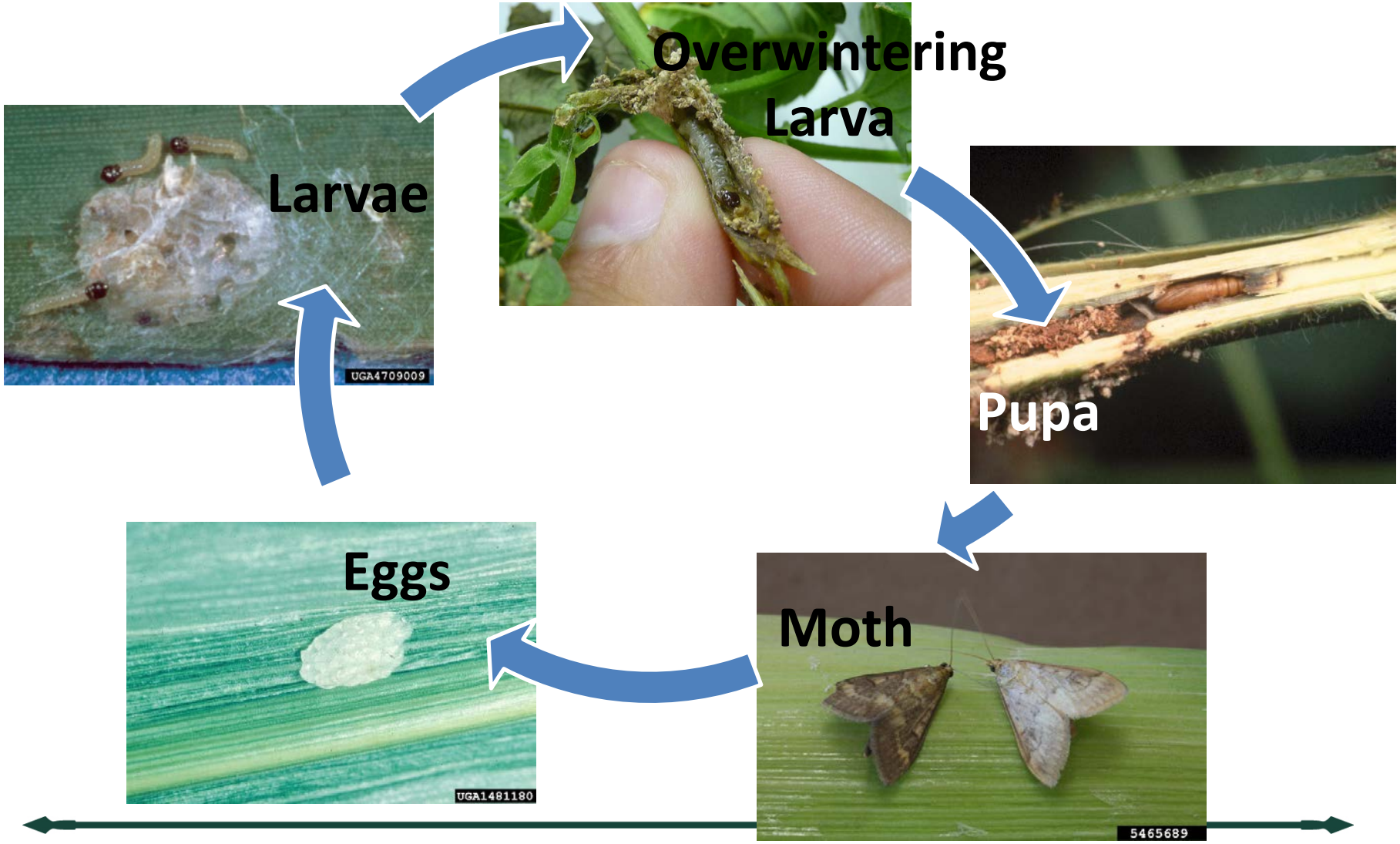


Photo credit: Bugwood and M.E. Rice

European Corn Borer

- Completes 2 generations in VT
- 1st gen flight is expected from 450-950DD50
- Females laying 200-500 eggs over a period of 2-3 weeks
- Eggs hatch in approximately 12 days, larvae feed externally on leaves for approximately 7 days before boring into stems
- Second generation flight occurs from 1450-1950 DD50

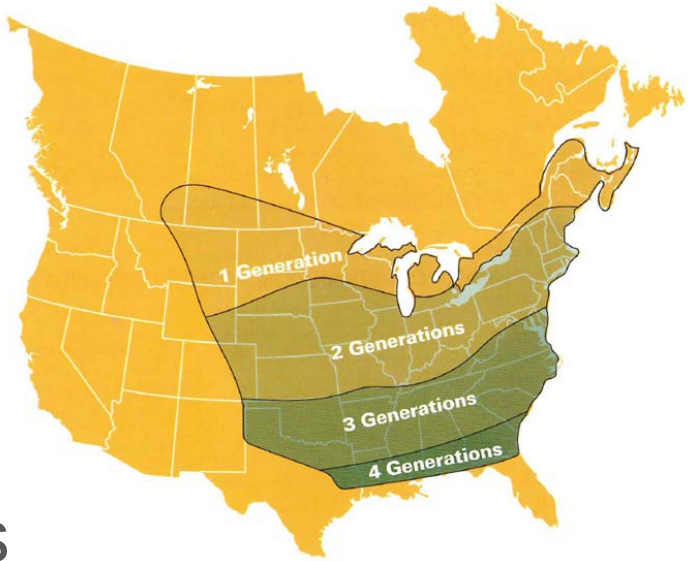


Figure 1. Approximate distribution of annual generations of European corn borer In the United States and Canada.

Iowa State University NCR 0372

European Corn Borer Damage in MI

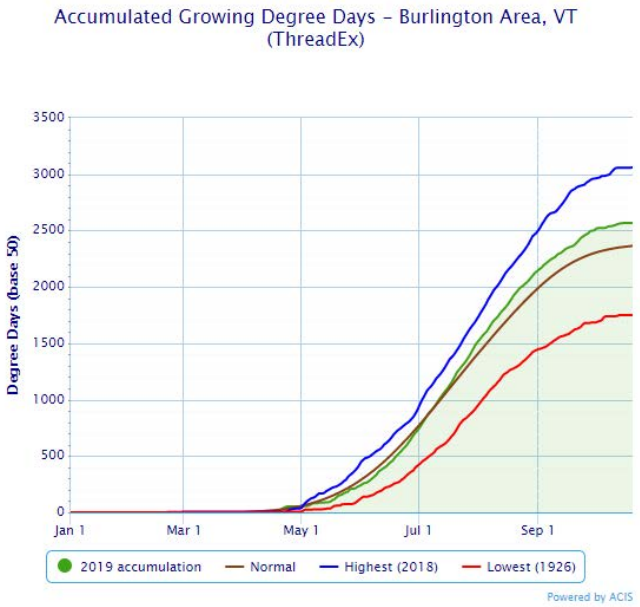
- ECB larvae damage vascular tissue, disrupting the flow of nutrients and water and impeding plant development
- Damage to vascular tissue in hop before bines reached the top wire and affected the critical sidearm and cone development stages, greatly reducing yield and likely qualit

ECB

- Symptoms of damage from ECB appear as generalized stunting and in some cases wilt
- Plants fail to thrive and may lose their ability to climb the coir
- Check for stem wounds along bines, particularly where sidearms originate or bines contact each other or the coir
- The larval frass appears a little like saw dust and is trapped in webbing
- You may also see holes or wounding
- Cut open bines where borer is suspected, you will see discolored tissue, frass and likely the larvae/pupae itself

Vermont Moth Flight Dates

- 1st gen flight 450-950DD50
  - June 13th-July 10th
- Second generation flight occurs from 1450-1950 DD50
  - August 3rd-August 30th



Scouting for ECB

- Growers can scout for **adults, eggs**, larvae, and pupae
- ECB eggs are smaller than the head of a pin but are laid in visible groupings
- Eggs are white when laid, but change to yellow and develop a black spot just before hatching
- Eggs are likely deposited on the underside of hop leaves in masses of 20-30 and covered with a waxy film

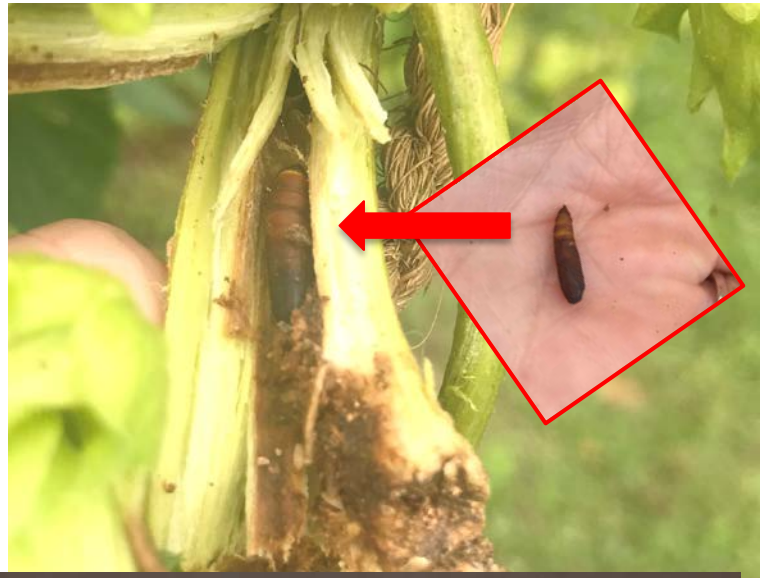
Ronald Smith, Auburn University, Bugwood.org.

ECB Scouting

- Larvae are light gray to faint pink caterpillars with a dark head
- Larvae have dark spots along the sides on each segment and a pale stripe along the back
- Grow to about one inch but start out very small at hatch

ECB Scouting

- Pupae are smooth, reddish-brown, cylindrical and found inside bines
- The moth is about 1” and light brown with wavy bands across the wings
- The tip of the body protrudes beyond the wings



Ronald Smith, Auburn University, Bugwood.org.

Monitoring

- Monitoring for adult flight and egg laying is critical to properly timing the start of pesticide application to control ECB
- Larvae are the intended target of pesticides but must be killed before moving inside the plant
- Unfortunately, simple wing or bucket traps used for other ‘field crop moths’ cannot be used to trap ECB
- Growers should begin scouting for adults/eggs before predicted flight begins at 450 DD50 and 1450DD50 respectively

Monitoring for ECB

- May use a sweep net at dusk/dawn to catch adults in grassy areas adjacent to fields
- Consider establishing a trapping and monitoring system with neighboring hop or corn growers to limit the workload on any one individual farm
- Growers can also work with neighboring corn growers (non Bt corn) to monitor their crop for egg masses as an indication of risk

ECB Management

- There are a number of effective insecticides for managing ECB and they should be applied to control larvae before they enter the protection of the bine
- Based on known pest biology, the windows of control in VT will likely occur
  - 1st gen: target larvae end of June through July
  - 2nd gen: target larvae mid-August through September
- Scouting must be performed to verify lifestage and pressure

ECB Management

Growers should scout to identify the current active lifestage before making management decisions

Larvacides

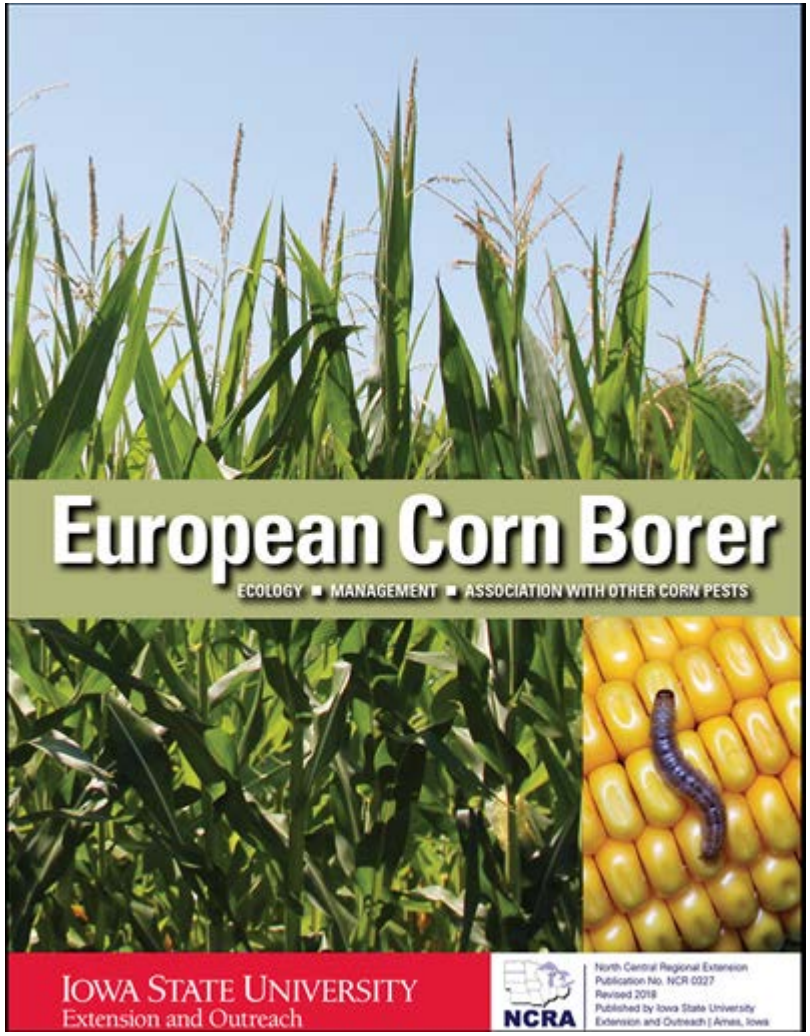
- Registered spinosad for hop growers include Entrust*, Entrust SC*, and SpinTor 2SC*
- Coragen (chlorantraniliprole)
- *Bacillus thuringiensis* (Biobit HP, Crymax Bioinsecticide, Deliver, Dipel DF*, Dipel ES, Javelin WG, Xentari*)

Larvacides and moth activity

- Product containing pyrethroids (too many to list) will also likely be effective though more disruptive to natural enemies

ECB Management

- Fields with substantial infestations should carefully dispose of crop waste
- Insecticide applications should be based on continued monitoring
- For more information on the European corn borer, refer to the Iowa State University publication, European Corn Borer – Ecology and Management and Association with other Corn Pests



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Preparing for spotted lanternfly

Prepared by Rufus Isaacs
Department of Entomology, Michigan State University
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Original slides developed by
Heather Leach, David Biddinger, Michela Centinari, Greg Krawczyk, Erica Smyers, and Julie Urban
Pennsylvania State University
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Spotted lanternfly

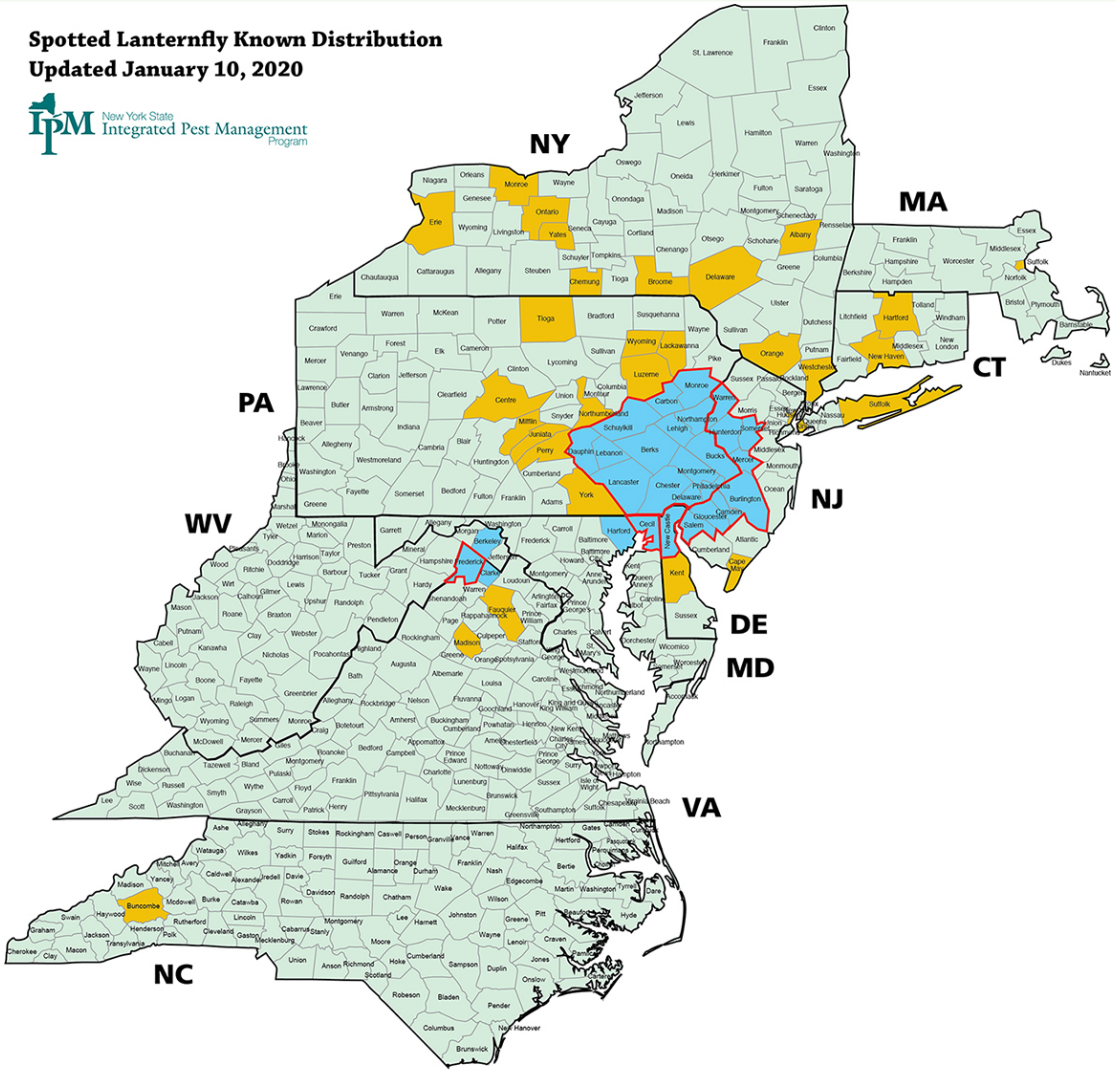
NEW INVASIVE PEST

Native to Asia, found in southeastern PA in 2014

Now **spread to** NY, MA, CT, DE, VA, NC

Spotted Lanternfly Known Distribution
Updated January 10, 2020

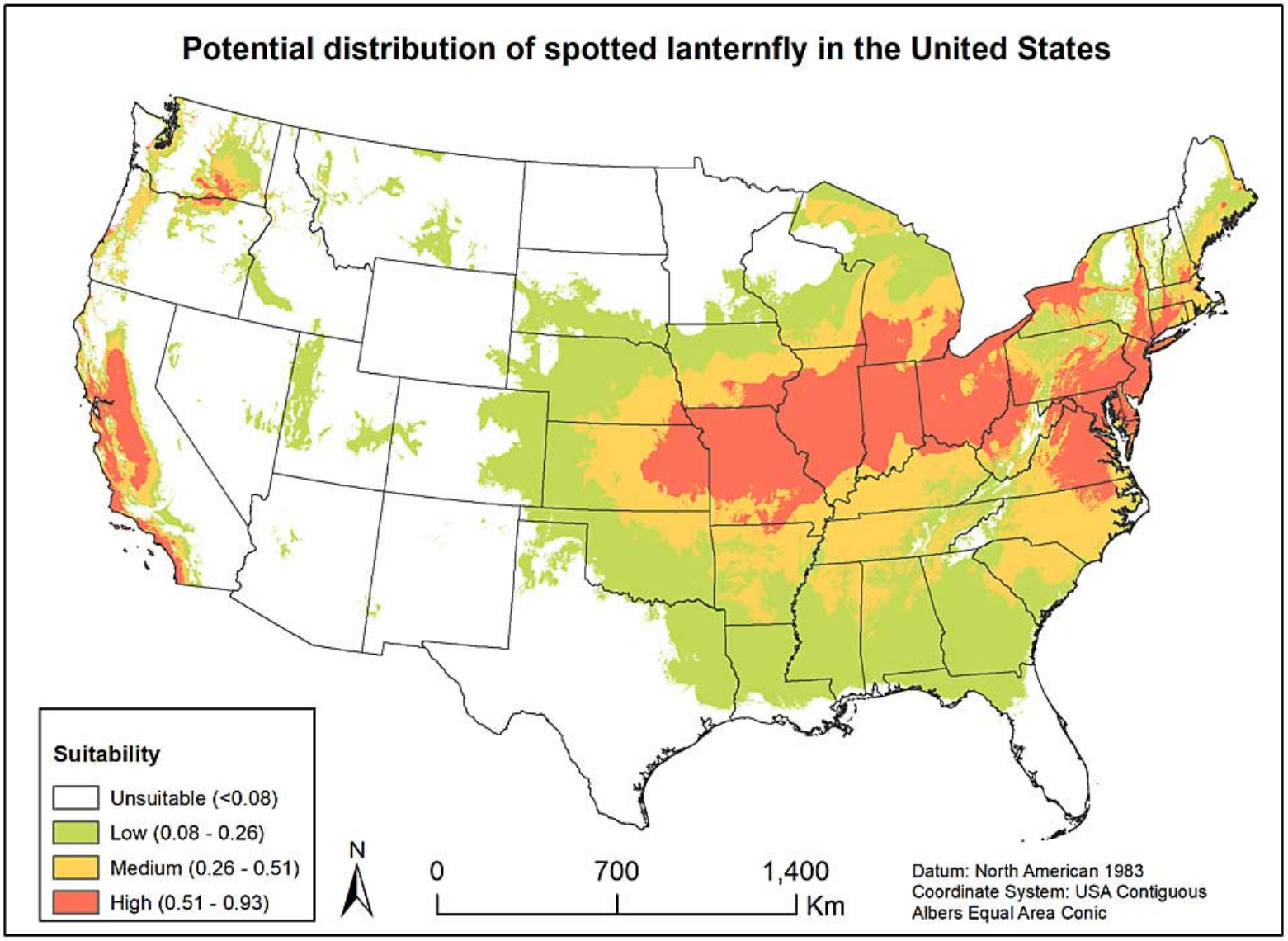
New York State Integrated Pest Management Program

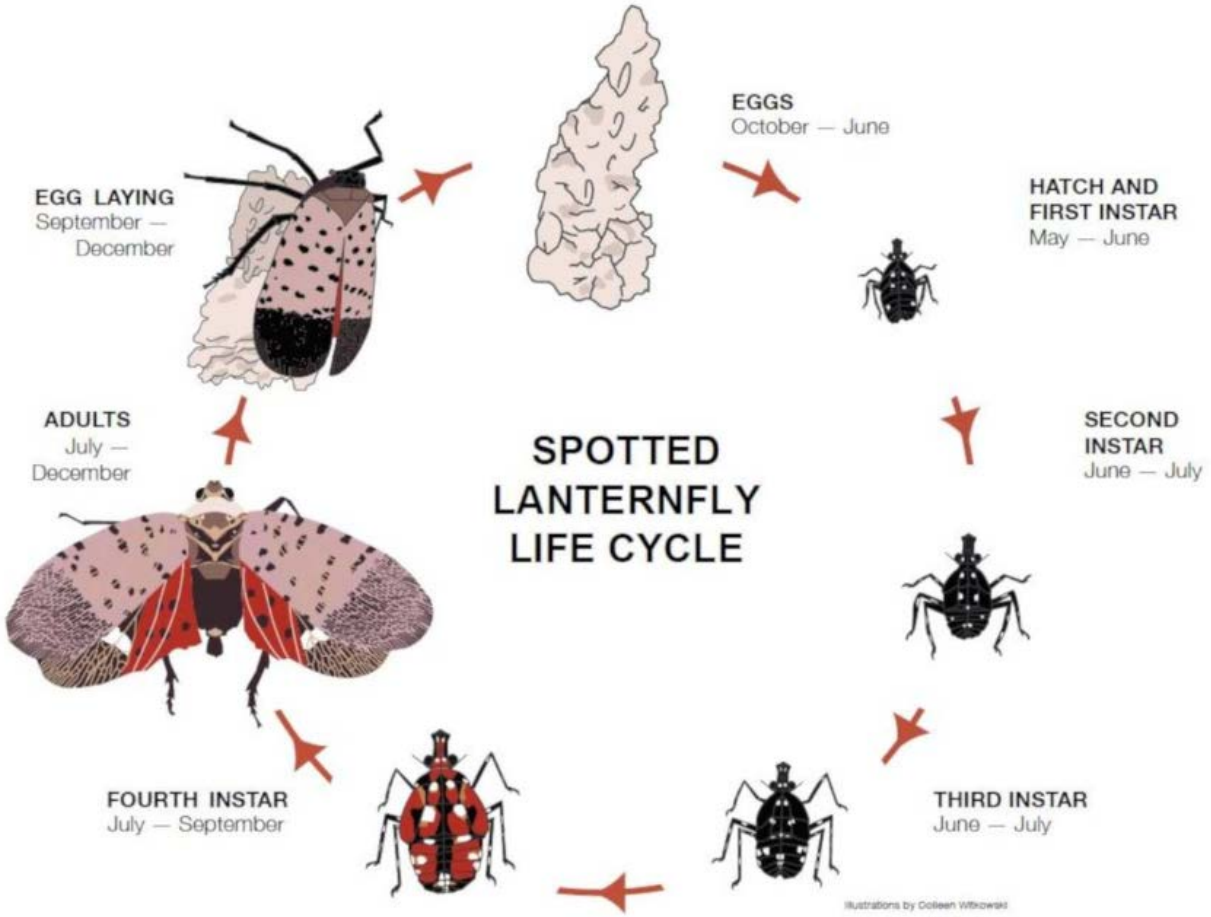


NY external quarantine areas. Spotted lanternfly infestation found.

Spotted lanternfly found, no infestation.

Internal state quarantine areas.


Potential distribution of spotted lanternfly in the United States
Suitability
Unsuitable (<0.08)
Low (0.08 - 0.26)
Medium (0.26 - 0.51)
High (0.51 - 0.93)
N
0
700
1,400
Km
Datum: North American 1983
Coordinate System: USA Contiguous
Albers Equal Area Conic


SPOTTED LANTERNFLY LIFE CYCLE
EGGS
October — June
HATCH AND FIRST INSTAR
May — June
SECOND INSTAR
June — July
THIRD INSTAR
June — July
FOURTH INSTAR
July — September
ADULTS
July — December
EGG LAYING
September — December
Illustrations by Colleen Witkowski

SLF life stages

E. Swackhamer

PA Department of Agriculture

PA Department of Agriculture

PA Department of Agriculture

PA Department of Agriculture

A. Egg masses

B. Early nymph

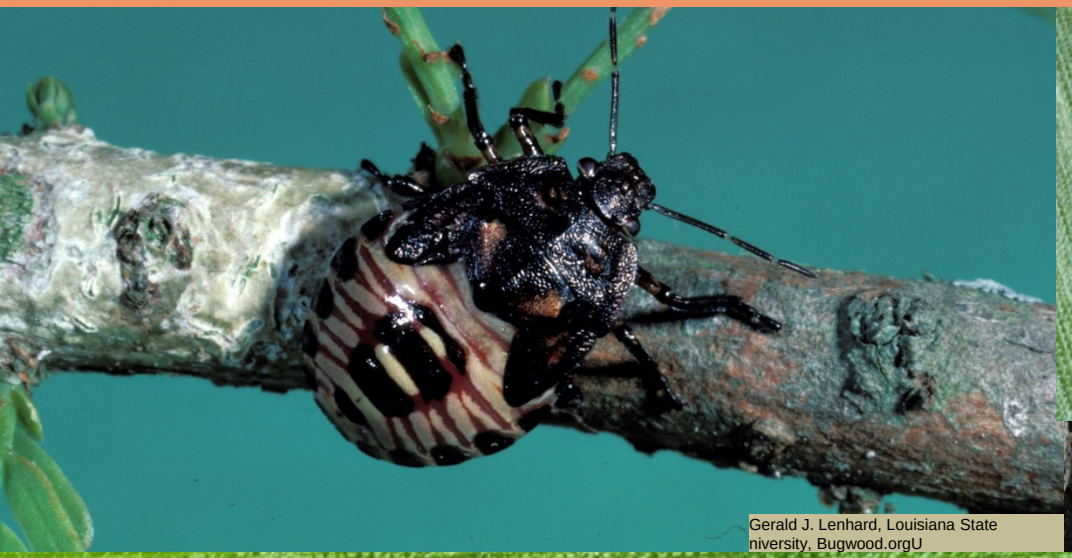
C. Late nymph

D. Adult, wings closed

E. Adult, wings open

PennState

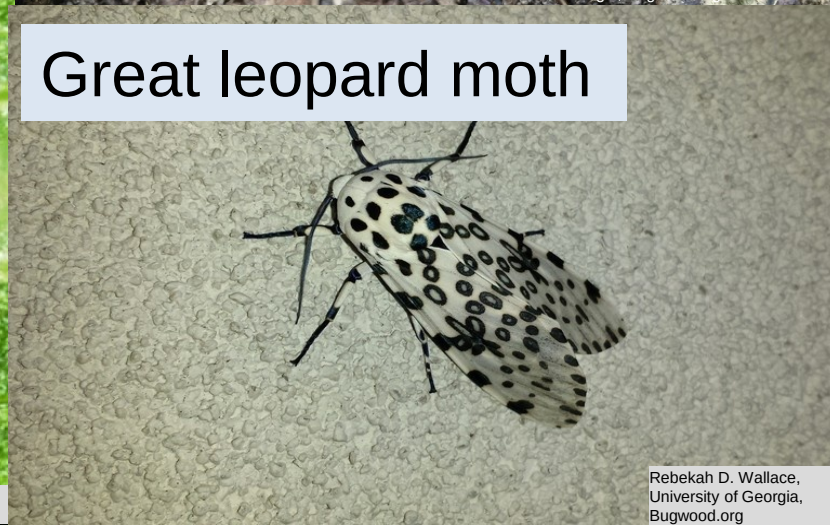
Insects that resemble SLF



Tiger moth

Green stink bug nymphs

Great leopard moth



SLF has a broad host range

HOSTS

tree-of-heaven
grape
apple
black walnut
silver/red maple
river birch
willow
& others

Substantial feeding not recorded on conifers

Tree-of-heaven identification

TREE of HEAVEN

Male and female trees

Reproduces by seed (samaras) or by **“clones”**

Bark has appearance of **cantaloupe** skin.

Leaf scars have a heart shape.

Few other animals are recorded on tree-of-heaven

Preparations

- SLF on the state watch list for invasive pests
- State and local organizations increasing awareness
- APHIS Task Force established
- Close connections with PSU research & extension
- Monitoring detections in other states
- MSU fact sheet available
- Report first any suspected sightings or samples to your state department of ag and your university

Natural enemies
Don't forget about the good guys!

- As research continues, our understanding of the importance of these partners continues to grow


D. Landis, MSU

Insect predators and parasites, known as natural enemies, can help control pest populations in agricultural crops and landscapes

Common Natural Enemies

Green Lacewing-Predator

- Adults of many species are not predaceous
- Predaceous larvae have long, curved mandibles that they use to pierce and suck the fluids out of their prey
- The larvae are about 1/8 inch long, look like tiny alligators, and prey on most small soft bodied insects, often pale with dark markings
- Eggs are laid on individual silken stalks

Common Natural Enemies

Lady Beetles-Predator

- Most adults and larvae feed on soft-bodied insects
- These may be important in aphid population control
- Adults are rounded, and range in size from tiny to medium-sized (about ¼ inch long), color ranges from black to brightly colored
- Larvae are active and elongate with long legs, and look like tiny alligators

Common Natural Enemies

Crab spiders-Predator

- Crab spiders stalk and capture insects resting on surfaces or walking, they do not spin webs
- The front two pairs of legs are enlarged and extend to the side of their body, giving them a crablike appearance
- Over 200 species in North America

Common Natural Enemies

Predatory mites

- Predatory mites are often translucent, larger than pest mites and move at a much faster speed across the leaf surface
- Play an important role in balancing the two-spotted spider mite populations and should be protected when possible

Supporting Natural Enemies

- Natural enemies are more likely to thrive in undisturbed areas that provide overwintering habitat, flowers to support their survival and reproduction, and refuge from pesticide applications in crops
- Natural enemies may be conserved with the same plantings that support pollinators

Continued from page 19- Signal Words and Relative Impact of Pesticides Registered for Use on Hop on Representative Non-target Beneficial Arthropods

Insecticides/Miticides		Beneficial arthropod	IOBC	rankings[1]
Active Ingredient	Signal word	Trade Name	Predatory mites	Lady beetles	Lacewing larvae
abamectin	Warning	Agri-Mek & other formulations	3	3	ND
B. thuringiensis subsp. aizawal	Caution	Xentari & other formulations	1	2	ND
B. thuringiensis subsp. kurstaki	Caution	Dipel & other formulations	1	2	ND
beta-cyfluthrin	Warning	Baythroid XL	4	4	4
bifenazate	Caution	Acramite-50WS	1	2	ND
bifenthrin	Warning	Brigade & other formulations	4	4	4
cyfluthrin	Danger	Baythroid 2E	4	4	4
dicofol	Caution	Dicofol	1	1	ND
etoxazole	Caution	Zeal	OK[2]	OK[2]	ND
fenpyroximate	Warning	Fujimite	1	3	ND
hexythiazox	Caution	Savey 50DF	1	1	ND
imidacloprid	Caution	Various formulations	1	3	3
malathion	Warning	Various formulations	2	4	3
naled	Danger	Dibrom	2	4	3
pymetrozine	Caution	Fulfill	1	1	1
pyrethrin	Caution	Pyganic & other formulations	2	2	2
spinosad	Caution	Success & other formulations	2	2	1
spirodiclofen	Caution	Envidor	2	2	1
spirotetramat	Caution	Movento	1	1	1
thiamethoxam	Caution	Platinum Insecticide	1	1	ND

[1]International Organization for Biological Control (IOBC) has categorized pesticides using a ranking of 1 to 4. Rankings represent relative toxicity based on data from studies conducted with tree fruit, hop, mint and grape. 1= less than 30% mortality following direct exposure to the pesticide; 2 = 30 to 79% mortality; 3 = 79 to 99% mortality; and 4 = greater than 99%. ND = not determined.

[2]IOBC rankings not available for this newly registered product. Tests in 2009/2010 determined these compounds safe on predatory mites and *Stethorus*.

Source: Pacific Northwest Hop Handbook 2010

Resources

- https://www.uvm.edu/extension/nwcrops/hops
- Hops.msu.edu
  - Michigan Hop Management Guide
  - Hop IPM Field Guide
  - Scouting flip guide
- Bine and Dine Webinar Series
- Great Lakes Hop Working Group Online Course
- Facebook: Michigan State University Hop News
- Sign up to receive scouting reports

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