



Integrated Pest Management

For the Backyard Fruit Grower

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[Disclaimer!]

- This presentation is apple oriented, but the principles apply to other fruits, nuts, vegetables, field crops, and even school pests!

[Agenda]

- About IPM
- Monitoring and Prediction
- Major Insect Pests of Apples
- Major Diseases of Apples
- Control Measures
- Resources

[What is IPM?]

- A **pest control strategy** based on the determination of an **economic threshold** that indicates when a pest population is approaching the **level at which control measures are necessary to prevent a decline in net returns.**
- In principle, IPM is an ecologically based strategy that **relies on natural mortality factors, such as natural enemies, weather, and crop management, and seeks control tactics that disrupt these factors as little as possible.**

About IPM

- What is different from traditional approaches
 - Control measures (e.g. spraying) are taken based on monitoring and prediction, not schedules
- What is different from organic approaches
 - IPM techniques are neither organic nor “traditional.”
 - Non-organic treatments may be used as warranted by pest/disease levels
 - Organic programs generally necessitate IPM techniques due to lower residual effects of most organic treatments

Benefits of Using IPM

- Improved pest and disease control
- Reduced expense through targeted pest control measures
- Reduced pesticide exposure to fruit and grower
- Reduced killing of beneficial/predatory components of the orchard
 - Ladybugs, bees, tachinid flies, trichogramma wasps
- Less of “one problem leading to another”
 - e.g. overspraying leading to outbreaks of European Red Mite
- A better understanding of your operation
 - Watching fruit grow and ripen
 - Special characteristics and situations within your orchard

[Approaches]

- The “traditional” way
 - Spray by season and by growth status (e.g. full pink)
 - Regardless of what pests are present and pest levels
 - Spray more if pest damage observed
 - Use the strongest, broad spectrum pesticide available
- The IPM way
 - Few sprays by season and growth status
 - Monitor for, and predict, pests and disease
 - Spray only when pests present in significant numbers
 - Spray only what is required to bring pest below significant threshold

Monitoring and Prediction

- Scouting
 - Sampling leaves
 - Checking fruit
- Insect Traps
 - Pheromone traps
 - Visual traps
- Prediction of pest emergence and disease
 - Growing Degree Days
 - Rainfall and leaf moisture

[Orchard Scouting]

- Know your enemies... and your friends
 - IPM is about maintaining beneficial populations while reducing pests to below a tolerable threshold
- Tools
 - Notebook
 - Loupe
 - 10x-20x
 - Weather monitoring equipment
 - Min-max thermometer
 - Rain gauge



Orchard Scouting - Planning

- Review problems from previous years
- Consider potential problems from surrounding areas
 - Woods, nearby orchards, abandoned orchards
- Decide on a regular schedule and time
 - Temperature readings
 - Trap monitoring
 - Leaf sampling
 - General observation
- Become familiar with identification of
 - Pests
 - Diseases
 - Beneficials

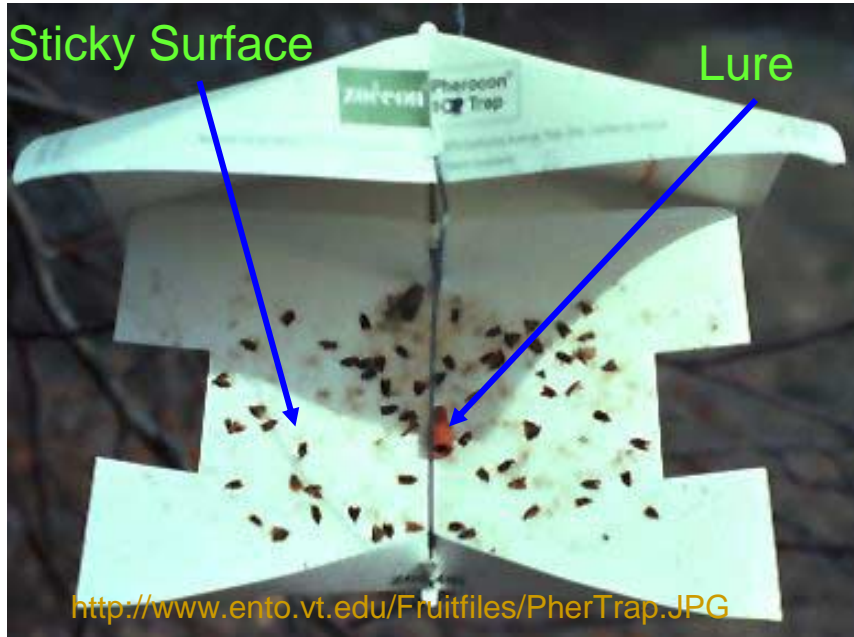
Orchard Scouting – Tree Examination

- During the early part of the season the orchard needs to be examined at least once a week
 - Always look for obvious problems as you move through the orchard
- Select a minimum of five trees per block
- Select trees that are representative of the different cultivars in the block
- Select five limbs on each tree to be examined as follows:
 - Equal distance around the tree
 - Three at chest level, one at head level, and one below your belt
 - On each limb, examine 20 leaves and 20 bud clusters, blooms or fruit whichever is present
 - Repeat for each of the five limbs
- This means you will have examined 100 leaves and 100 bud clusters, blooms or fruit for each tree
- Look for pests, disease, beneficials
 - Signs of activity, eggs, damage

[Insect Trapping]

- Trapping for monitoring
 - Pheromone traps
 - Moths
 - Visual traps
 - Plum curculio Tedders (pyramid) and Circle traps
 - Apple maggot red spheres
- Trapping for control
 - Generally not an effective measure
 - Some exceptions such as Circle trap for Plum Curculio
 - Is a fringe benefit of monitoring
- Monitoring traps is the first step in establishing insect activity that may need to be controlled
 - Use insect growth degree-day models

Insect Traps



“Wing-style” Pheromone Trap



Apple Maggot Fly Traps

- “Wing-style traps always use a pheromone lure
 - Used for all types of moths
 - One moth type (lure) per trap
- Many other sticky traps attract by color or shape
 - Some may still use lures, either pheromone or fruit scents

Insect Traps



<http://ufinsect.ifas.ufl.edu/weevil-trapping.htm>

Tedders or Pyramid Trap

- Plum Curculio traps
 - May or may not have lure
 - PC crawls up into trap at top
- Pyramid traps mimic tree trunks
- Circle traps attach to tree trunks



<http://ufinsect.ifas.ufl.edu/weevil-trapping.htm>

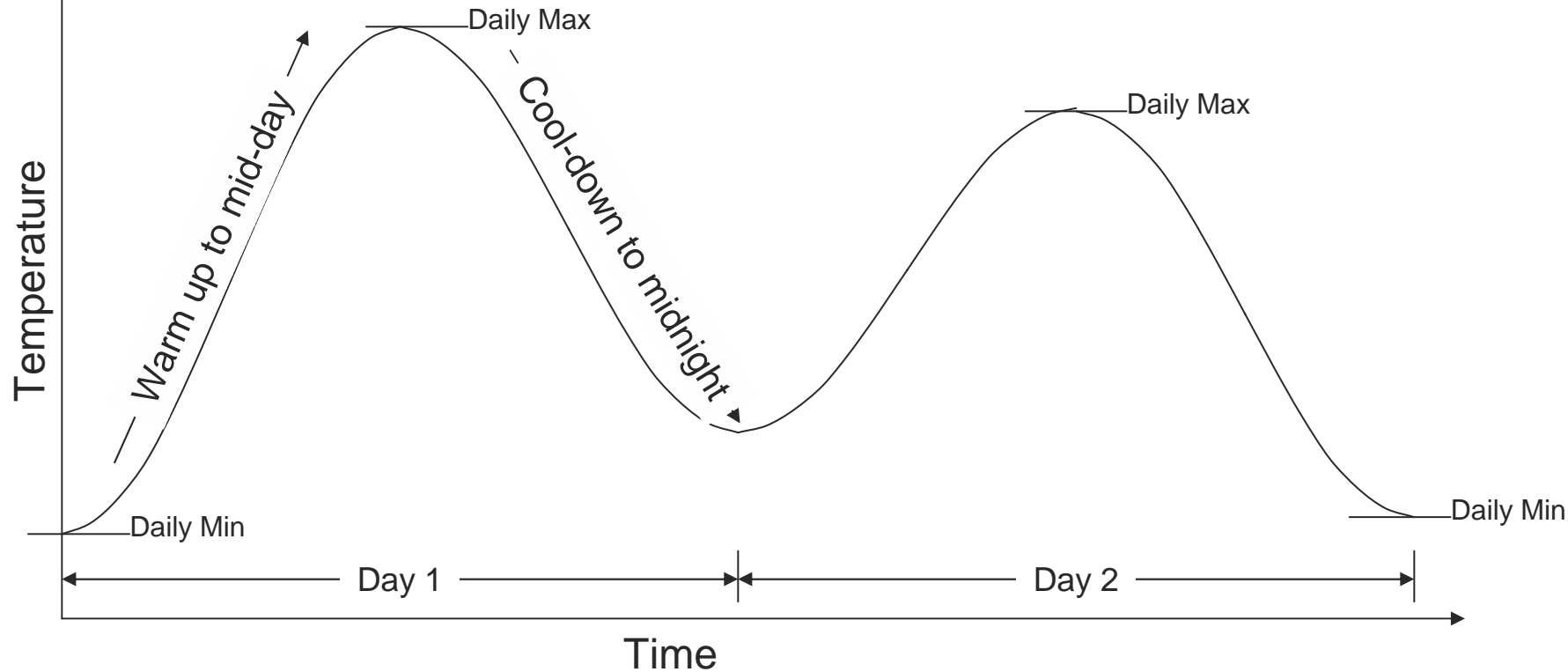
Circle Trap

Degree Days ($^{\circ}\text{D}$ or DD)

- What are Degree Days?
 - In practical terms for IPM, a measure of the growth energy available to an insect pest or disease
 - More strictly for IPM, degree-days are the accumulated product of time and temperature between two temperature thresholds for each day³
 - Degree days are also used in other applications such as building heating and cooling requirements
- How are Growing Degree Days measured?
 - The high and low temperatures for a given 24 hour period are applied to a model that represents the cycle of temperature over a 24 hour period
- How are Growing Degree Days used?
 - Degree days are applied to a model for insect or disease growth allowing for determination of when to apply control measures

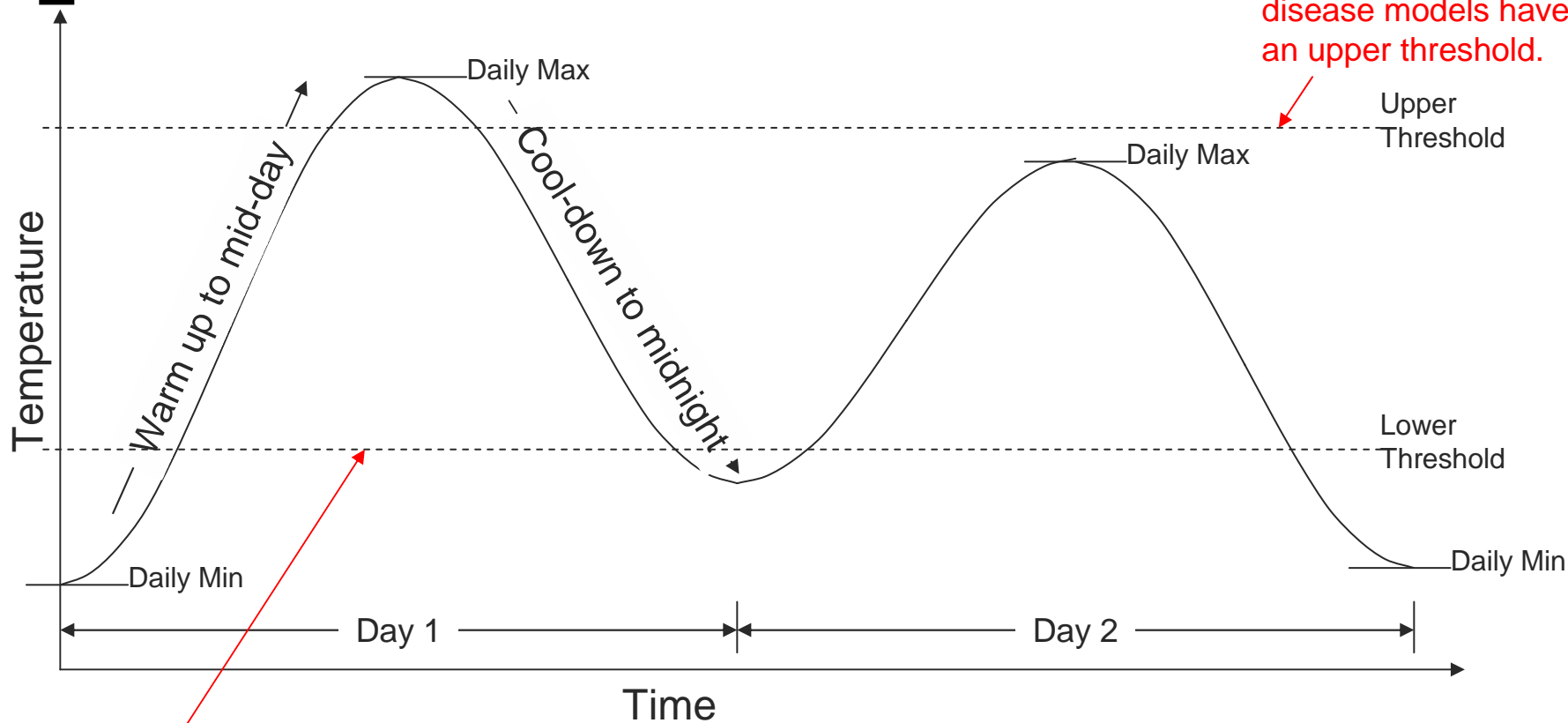
How Degree Days Work

Temperature changes are modeled for each day



How Degree Days Work

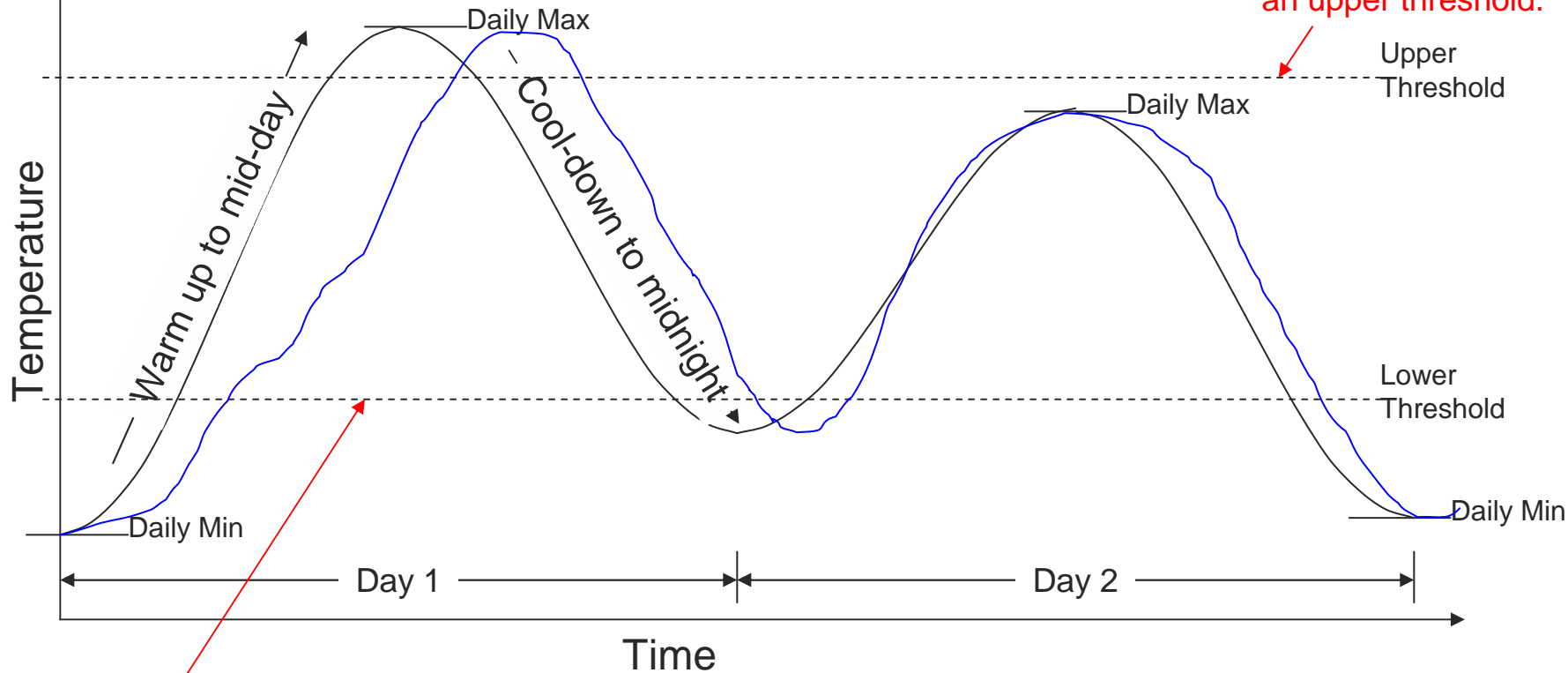
Temperature thresholds are added depending on pest or disease growth characteristics



The lower threshold is known as the "base." Example: If the lower threshold is 45° F, the degree day measurements are known as, "Base 45."

How Degree Days Work

Most Degree Day calculations are done using models - **real world temperatures** don't follow precise curves

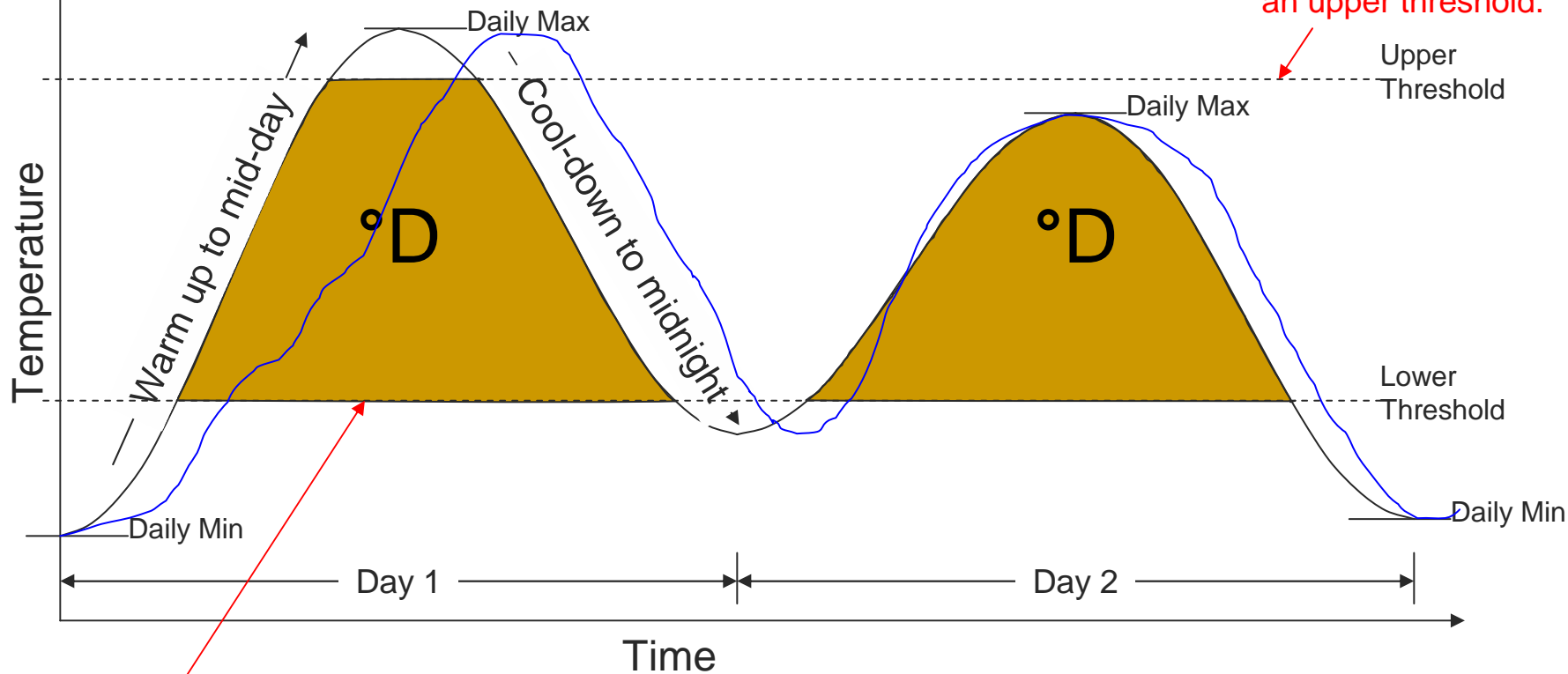


Not all pest or disease models have an upper threshold.

The lower threshold is known as the "base."
Example: If the lower threshold is 45° F, the degree day measurements are known as, "Base 45."

How Degree Days Work

Degree Days are the area under the temperature curve and between the thresholds

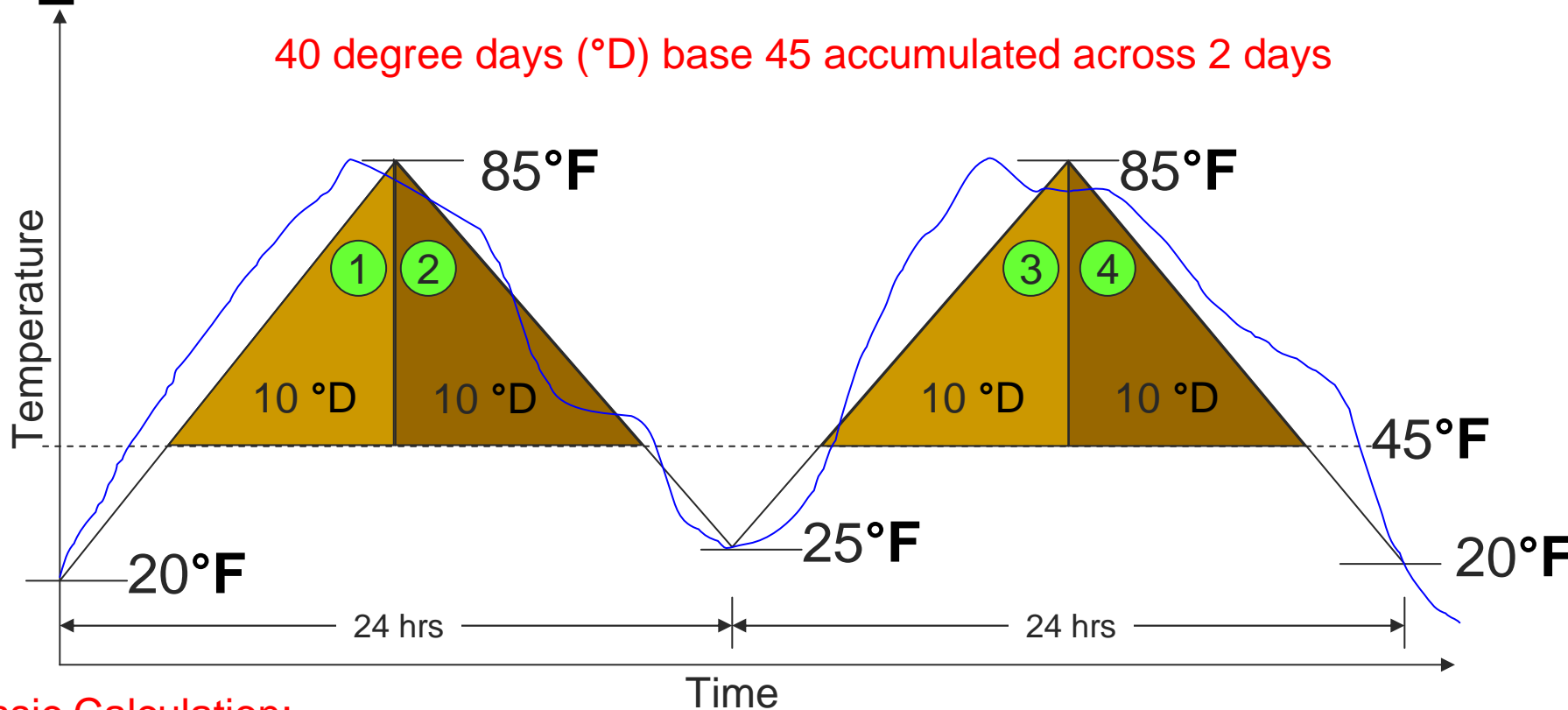


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Example: If the lower threshold is 45° F, the degree day measurements are known as, "Base 45."

Calculating Degree Days

Simplified (triangle, no upper threshold) Example



Basic Calculation:

- Area of triangle is $\frac{1}{2} \times \text{base} \times \text{height}$
- Base is 12 hours ($\frac{1}{2}$ day)
- Height is between temperatures
 - Depends on temps and thresholds

①: $\frac{1}{2} \times \frac{1}{2} \text{ day} \times (85-45 \text{ degrees}) = 10 \text{ °D}$

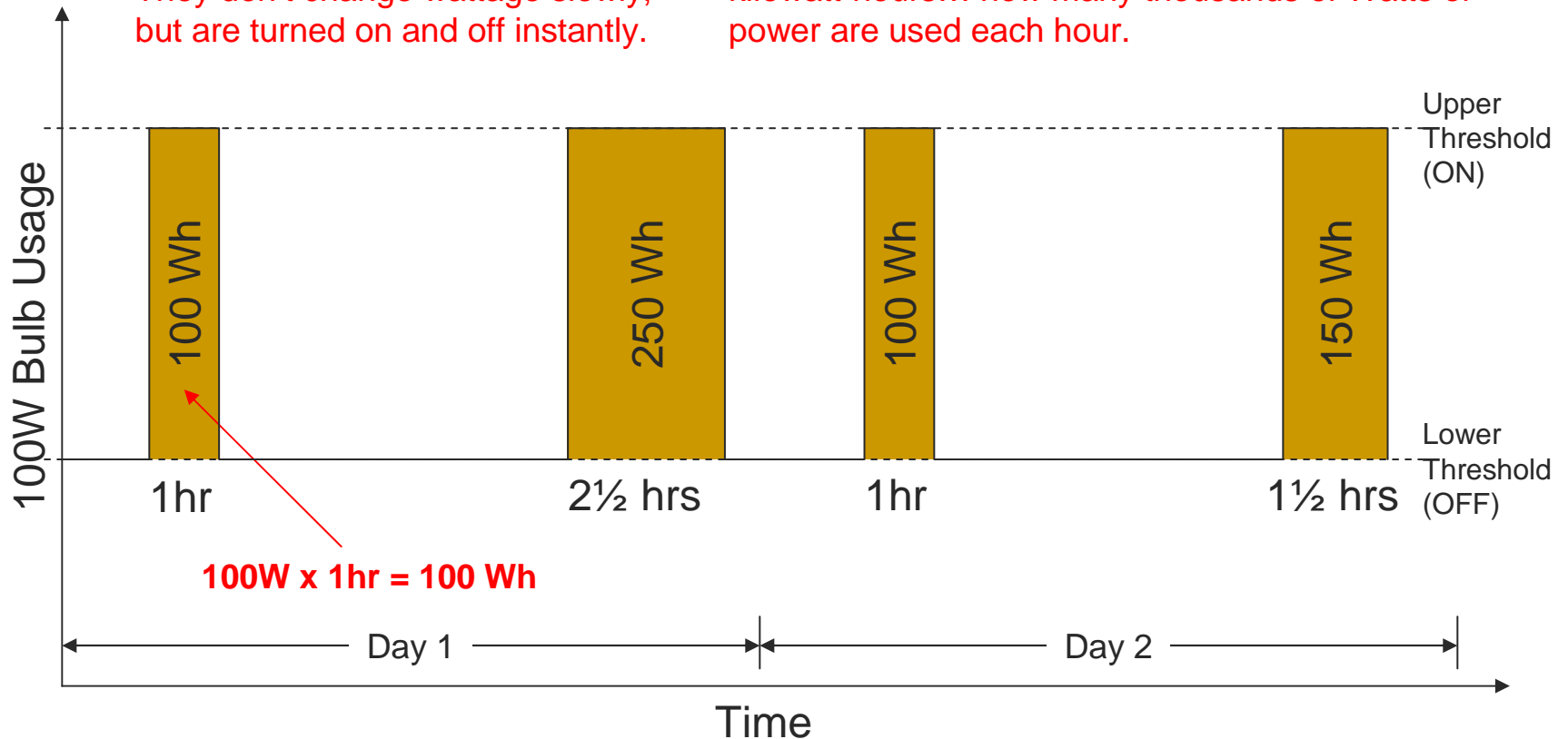
In this example, ② - ④ are also = 10 °D

Actual Temperature

How Degree Days Work

Not getting it? 100W light bulb Watt-hour (Wh) example

- Light bulbs are rated in Watts. They don't change wattage slowly, but are turned on and off instantly.
- The power company measures electric usage in kilowatt-hours... how many thousands of Watts of power are used each hour.



- Watt-hours are a measure of energy where the Watts are the power used over time
- Degree-Days are a measure of “growth energy” where the Degrees are the “power” used over time

[Biofix]

- A biofix is a point in time at which some significant indicator of pest activity occurs
 - Usually expressed as the date of the occurrence
- Typical biofixes
 - “x” many moths trapped for “y” many consecutive days
 - High temperature above “z” degrees for “n” consecutive days
 - A given date (e.g. March 1st)
- Biofix dates are used to begin the counting of Growing Degree Days for a pest model

Degree Day Look-up Tables

Lower Threshold: 45.0°F Upper Threshold: 90.0°F Method: Single Sine Cutoff: Horizontal

Max temps	Minimum temperatures																													
	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	
48	1	1	1	1	1	1	2	3																						
50	1	1	1	2	2	2	3	4	5																					
52	2	2	2	2	3	3	4	5	6	7																				
54	3	3	3	3	4	4	5	6	7	8	9																			
56	4	4	4	4	5	5	6	7	8	9	10	11																		
58	4	5	5	5	6	6	7	8	9	10	11	12	13																	
60	5	5	6	6	7	7	8	9	10	11	12	13	14	15																
62	6	6	7	7	8	8	9	10	11	12	13	14	15	16	17															
64	7	7	8	8	8	9	10	11	12	13	14	15	16	17	18	19														
66	8	8	9	9	9	10	11	12	13	14	15	16	17	18	19	20	21													
68	9	9	9	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23												
70	10	10	10	11	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25											
72	11	11	11	12	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27										
74	12	12	12	13	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29									
76	12	13	13	14	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31								
78	13	14	14	15	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33							
80	14	15	15	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35						
82	15	16	16	17	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37					
84	16	17	17	18	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39				
86	17	18	18	19	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41			
88	18	19	19	20	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43		
90	19	20	20	21	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	
92	20	20	21	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	45	
94	21	21	22	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	45		
96	21	22	22	23	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	45		
98	22	22	23	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	45			
100	22	23	23	24	24	25	26	27	28	29	30	31	32	33	34	35	36	37	37	38	39	40	41	42	43	44	45	45		
102	23	23	24	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	39	40	41	42	43	44	45	45			
104	23	24	24	25	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	41	42	43	44	45	45			
106	24	24	25	25	26	27	27	28	29	30	31	32	33	34	35	36	37	37	38	39	40	41	41	42	43	44	45	45		
108	24	24	25	26	26	27	28	29	30	31	31	32	33	34	35	36	37	38	38	39	40	41	42	42	43	44	45	45		
110	24	25	25	26	27	27	28	29	30	31	32	33	34	35	36	37	38	39	39	40	41	42	42	43	44	45	45			
112	25	25	26	26	27	28	28	29	30	31	32	33	34	35	36	37	38	39	40	40	41	42	43	43	44	45	45			
114	25	25	26	27	27	28	29	30	30	31	32	33	34	35	36	37	37	38	39	40	41	41	42	43	43	44	45	45		
116	25	26	26	27	27	28	29	30	31	32	33	33	34	35	36	37	38	38	39	40	41	41	42	43	43	44	45	45		
118	26	26	27	27	28	28	29	30	31	32	33	34	34	35	36	37	38	38	39	40	41	41	42	43	43	44	45	45		

http://www.ipm.ucdavis.edu/WATHER/DDTABLE/oriental_fruit_moth.html

- OFM example
 - Base 45°F
 - Upper threshold is 90°F
- Minimum temp across columns
- Maximum temp across rows
- Table value is degree days in whole numbers

Degree Day Calculator Spreadsheet

- Microsoft Excel spreadsheet for Growing Degree Day monitoring
- Daily temperatures entered on one sheet
- Biofix date marked on individual insect sheets
- Significant dates highlight in color
- Prediction available using historical weather data

Coding Moth							
Start 1st Gen. Egg Hatch (DD):		250	Post Biofix Degree Days - Pocket Guide for IPM Scouting in Michigan Apples, 4/2001				
End 1st Gen. Activity (DD):		1000					
Start 2nd Gen. Egg Hatch (DD):		1200					
End 2nd Gen. Activity (DD):		2100					
Larvae (DD):		529	UC Davis IPM pub. 3340				
Eggs (DD):		158	UC Davis IPM pub. 3340				
Thresholds:	Base (°F):	50	Pocket Guide for IPM Scouting in Michigan Apples, 4/2001				
	Upper (°F):	88	UC Davis IPM pub. 3340				
Only Other Input Required on this Sheet is to 'X' the Biofix Date							
B i o f i x	Date	High (°F)	Low (°F)	DD	Cumulative DD from Jan 1	Cumulative DD from Biofix	Count/Trap
	15-May-2004	86	60	23.0	428	0	
	x 16-May-2004	77	60	18.5	447	19	
	17-May-2004	77	56	16.5	463	35	
	18-May-2004	82	60	21.0	484	56	
	19-May-2004	71	57	14.0	498	70	
	20-May-2004	74	55	14.5	513	85	
	21-May-2004	81	65	23.0	536	108	
	22-May-2004	86	67	26.5	562	134	
	23-May-2004	90	67	28.2	590	162	
	24-May-2004	84	70	27.0	617	189	
	25-May-2004	90	57	23.3	641	213	
	26-May-2004	66	56	11.0	652	224	
	27-May-2004	86	61	23.5	675	247	
28-May-2004	86	62	24.0	699	271		
29-May-2004	73	46	10.2	709	281		

[Insect Pests and Diseases]

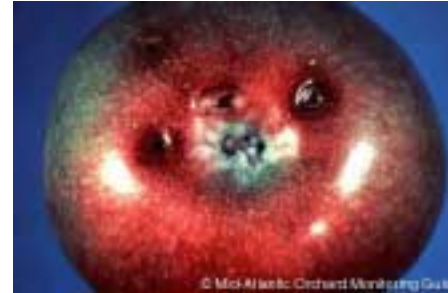
- New growers may not experience any pest pressure for some period of time
 - They will come!
 - Affected by proximity to other growers, abandoned operations, pest practices, orchard maturity
- IPM monitoring techniques support the detection of pests without treating for a problem that is absent or irrelevant

Major Apple Insect Pests

- Internal Fruit Feeders
 - *Plum Curculio*
 - *Codling Moth*
 - *Oriental Fruit Moth*
 - *Apple Maggot Fly*
- External Feeders
 - *Leaf Rollers*
 - *Tufted Apple Bud Moth*
 - *Aphids*
 - *European Red Mite*

Plum Curculio (*Conotrachelus nenuphar*)

- Adults 1/5-1/4 inch long
- Adults can be found in orchards for 5 to 7 weeks in spring
- Egg laying occurs as fruit begins to form. Eggs hatch in 7 days and larvae burrow into fruit.
- New adults may be active from July-September before seeking winter cover
- One generation in Mid-Atlantic region
- The critical period for controlling plum curculio is during the first few days of warm weather following petal fall, when maximum temperatures remain approximately 70°F
 - Adults not active in cool rainy weather below 70°F
- A spray residue should be maintained for 340 DD base 50 following petal fall¹
- The plum curculio is usually more abundant on fruit trees adjacent to woods, fencerows, and trashy fields where they overwinter
- Traps available for monitoring and limited control (see Control Measures)



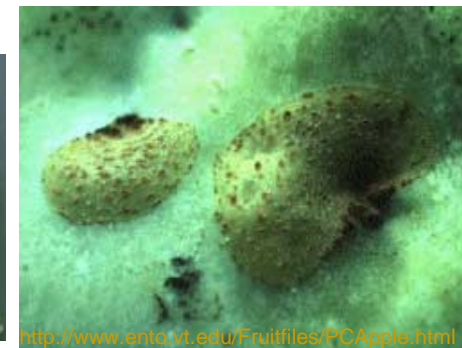
Feeding punctures, usually near calyx



Adult

Finished fruit "crescent" damage from egg laying

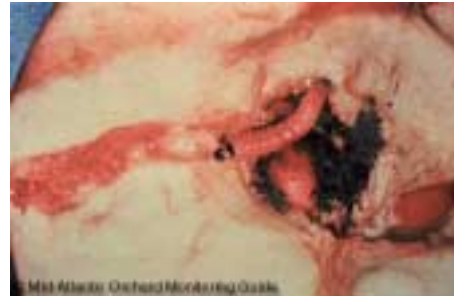
Oviposition cuts



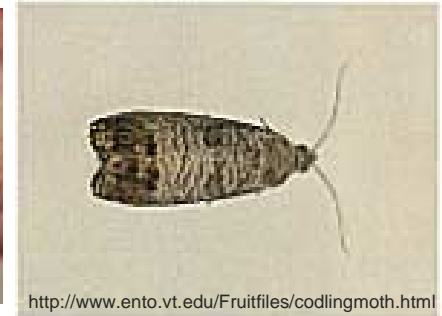
Codling Moth (CM)

(*Cydia pomonella*)

- Female adults 3/8 inch long, males slightly smaller
- Larvae 1/2-5/8 inch long at maturity
 - spots on the prothoracic shield,
 - no “comb” on the posterior end
- Overwinter as larvae under leaf litter, loose bark, etc.
- First flight about full bloom, peak flight 2 weeks later
- Newly hatched larvae bore through the fruit surface (generally calyx end) and feed near the surface for a time before boring to the core to feed on the seeds and surrounding flesh until full grown in 3-4 weeks.
- 2-3 generations in Mid-Atlantic region
- Later generations can inflict significant injury on fruit

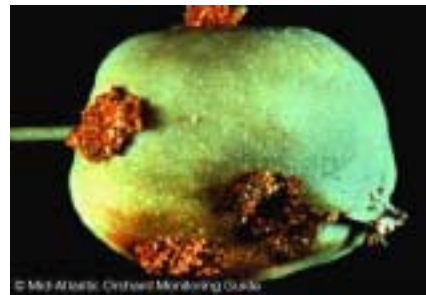


Larva feeding on seeds at core



Adult

Frass at entrances to feeding holes



Finished fruit damage from feeding



Oriental Fruit Moth (OFM) (*Grapholita molesta*)

- Adults 1/4 inch long
- Larvae 1/2 inch long at maturity
 - “Comb” on the posterior end
- Overwinter as larvae on tree or ground
- 4-5 generations in Mid-Atlantic region
- First flight from pink to early bloom, egg laying in May
- First-generation larva enters leaf axil near the tip of a shoot and bores down the central core for several inches, causing the terminal to wilt, or “flag.”
- Later-generation larvae may enter the fruit near the stem end and make feeding burrows that can extend to the pit or to the core
- Variability in hatch time due to weather necessitates DD measurement and monitoring

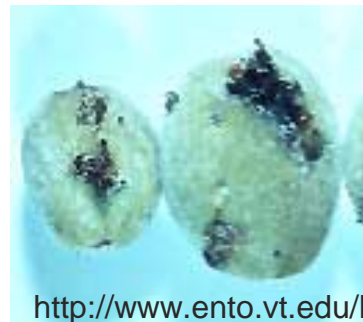


Larva feeding on apple



Adult

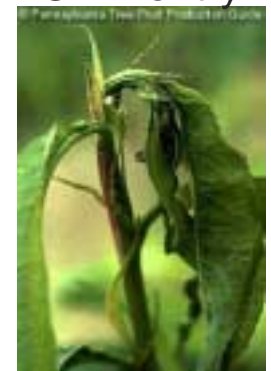
Frass at entrances to feeding holes



Posterior “comb” of larva



Terminal flagging due to OFM entry



Apple Maggot Fly (AM) (*Rhagoletis pomonella*)

- Size of a house fly (1/5 inch), with white and black wings and white spot on back
- Legless maggots are 1/4 inch at maturity
- Early-maturing, thin-skinned and sweet variety apples are often most severely infested
- One generation per year
 - Some new indication of 2 generations
 - Some adults emerge second year
- Pupae overwinter in the soil
- Adult emergence in July-August
- Fly makes a small hole in the apple skin and deposits a single egg hatching in 2-10 days. The young maggot feeds its way through the fruit for 20-30 days



Larvae



<http://www.ento.vt.edu/Fruitfiles/AppleMaggot.html>

Adult

Pitting and dimpling on apple surface due to AM



Maggot damage to apple



[Leafrollers]

- Often feed by tying together a number of leaves with silk or attaching a leaf to fruit
 - Pin-hole injury in late season
- Obliquebanded leafroller (OBLR)
 - *Choristoneura rosaceana*
 - Adults 3/4 to 1 inch long
 - Larvae 1 inch long at maturity
 - 2 generations
 - Feed on flower buds, developing fruit, late season terminal shoots
 - 1st generation causes most fruit injury
- Redbanded leafroller (RBLR)
 - *Argyrotaenia velutinana*
 - Adults have 1/2 inch wingspan
 - Larvae 5/8 inch long at maturity
 - 3 generations in Pennsylvania (2-4 elsewhere)
 - Skeletonize leaves from underside
 - 1st generation causes most fruit injury
- Variegated leafroller (VLR)
 - *Platynota flavedana*
 - Adults have 1/2 - 3/4 inch wingspan
 - Larvae 3/4 inch long at maturity
 - 2 generations
 - Injury cannot be distinguished from Tufted Apple Bud Moth

Larvae



Adult



Injury



<http://www.ento.vt.edu/Fruitfiles/apple-fruit-ipm.html>

Tufted Apple Bud Moth (TABM)

(*Platynota idaeusalis*)

- A type of leafroller, more significant in direct fruit damage than others
 - Feeds on fruit under leaf attached with silk
- Adult females 1/2 inch long, males slightly smaller
- Larvae start out 1/16 inch long with yellow/green body and black head
- Mature larvae are 3/4 inch long with brown head and dark brown stripe down back
- Eggs deposited on UPPER surface of leaf
 - Dime-sized green mass turning bronze then black
- Two generations per year
 - 2nd generation overwinters as larvae in leaf litter
- Adults emerge generally at beginning of May
- Peak egg hatch generally mid-June



Larva



Adults

Feeding on Apple Surface



Eggs

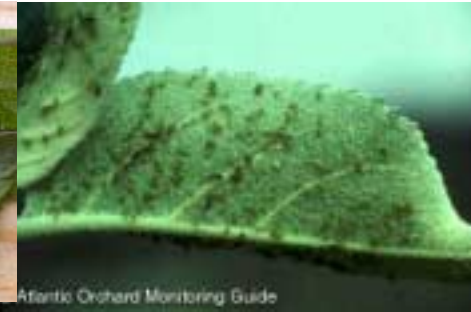


[Aphids]

- Major types
 - Rosy Apple Aphid (*Dysaphis plantaginea*)
 - Green Aphids (*Aphis spiraecola* & *Aphis pomi*)
 - Woolly Aphid (*Eriosoma lanigerum*)
- Aphids feed in colonies
 - Usually on the undersides of leaves
 - Leaves become deformed and curled
 - Woolly aphids feed on bark and roots and can prevent healing of tree wounds
- Aphids are difficult to control once leaf has curled around them
- Watch for ant activity on trees
 - Ants “harvesting” honeydew from aphids
 - Ants will protect aphids from natural predators
- Aphids cause secondary mold problems where honeydew drops on the tree or fruit
- Golden Delicious, Ida Red, Rome, Cortland, York, and Stayman apple varieties are especially susceptible to injury



Rosy Apple Aphids



Immature Green Aphids

Leaf curl due to aphid feeding



Woolly Apple Aphids



European Red Mite (*Panonychus ulmi*)

- Damages leaves
- Causes fruit russeting
- 1/64 inch long
- 6-8 generations per year
 - As little as 14 days per generation
- Overwinter as eggs on tree
- Leaves initially turn pale
 - With continued feeding the leaves turn bronze
 - Heavy mite feeding early in the season can reduce tree growth, yield, and also affect fruit bud formation for the following year
- Some apple cultivars, such as 'Red Delicious' and 'Braeburn', are more prone to mite buildup and injury
- Considered a secondary pest
 - Typically only builds to damaging levels after its natural enemies have been depleted by insecticide applications



<http://www.ento.vt.edu/Fruitfiles/erm.html>

Adults

Bronzing of leaves due to ERM



UC Statewide IPM Project
© 2000 Regents, University of California

Major/Common Apple Diseases

- ***Fireblight***
- ***Apple Scab***
- ***Powdery Mildew***
- ***Fly Speck and Sooty Blotch***

Fireblight (*Erwinia amylovora*)

- Bacterial infection
- Outbreaks occur during warm, wet periods
 - Particularly around bloom
 - When tree is wounded
 - Pruning
 - Hail/wind storm damage
 - Late frost < 28°F
- Can easily kill entire tree if not removed
 - Cut out diseased wood well below symptoms and burn
- Highly susceptible varieties include
 - Beacon, Fuji, Gala, Idared, Jonathan, Lodi, Paulared, Rome, Tydemans Red, Wealthy, Yellow Transparent and York, Liberty
- Resistant varieties include
 - Delicious, Golden Delicious, Stayman
- Resistant rootstocks are important for control of fireblight
- Prediction with MaryBlyt computer model
 - Available from Gemplers
- Prevention just prior to bloom with Bordeaux, Streptomycin or several newer alternatives
- Treatment with Streptomycin antibiotic

Ooze from Blossom Base

Typical “Shepherd’s Crook”



Canker in Trunk Wound



http://www.caf.wvu.edu/kearneysville/disease_descriptions/omblight.html

Apple Scab

(*Venturia inaequalis*)

- Fungal infection
- Occurs during humid, cool weather, generally in spring months
- Fruit losses occur directly from infection and indirectly from repeated defoliation of affected trees
- Occurs on leaves, petioles, blossoms, sepals, fruit, pedicels and young shoots
 - First lesions often on underside of leaf
- Infected fruit lesions become brown and corky as fruit enlarges
 - Followed by cracking and deformity
 - Early-season infection usually clustered around calyx
- Overwinters in leaves and fruit on orchard floor
- Mills Table predicts outbreaks
- Manage with resistant cultivars, orchard sanitation, fungicides
- Resistant cultivars include, Priscilla, Jonafree, Redfree, Liberty, Freedom, Goldrush, Pristine



Scab on Leaves

Scab on Apples



Powdery Mildew (*Podosphaera leucotricha*)

- Fungal disease
- Capable of infecting without wetting from rain or dew
- Infection causes stunted growth, blossom drop, poor fruit finish
- Overwinters in blossom and shoot buds
- Highly susceptible varieties include
 - Jonathan, Rome, Cortland, Baldwin, and Idared

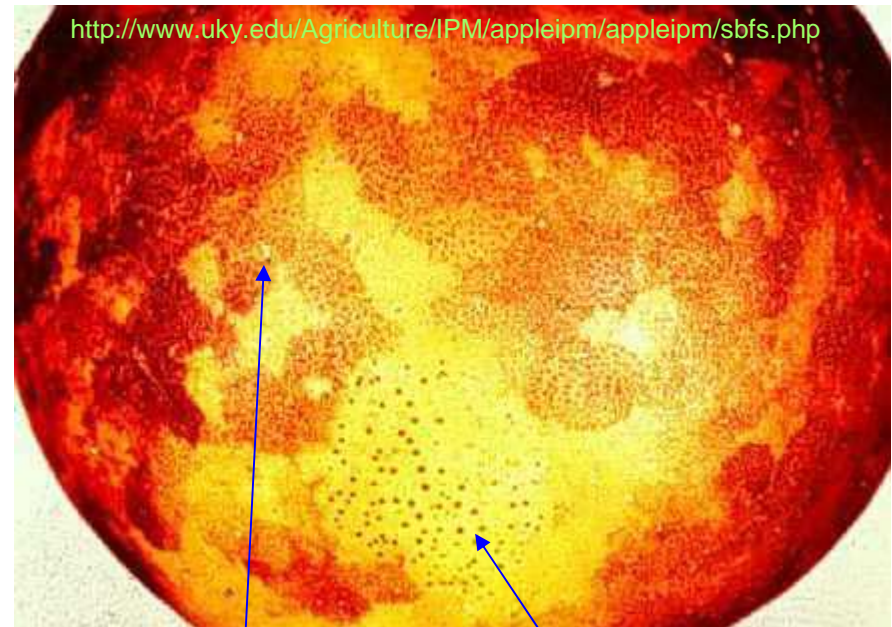


Powdery mildew on leaves and fruit
russetting effect

Sooty Blotch and Flyspeck

(*Glosodes pomigena* and *Schizothyrium pomi*)

- Fungal diseases, often found together
- Appear late summer and fall
- Do not cause fruit decay
 - Losses due to appearance
 - May cause some storage loss
- Manage with orchard sanitation and fungicides



Sooty blotch and flyspeck fungi

[Control Measures]

- For all disease and pests
 - Orchard grooming
 - Appropriate organic and man-made chemical applications
- Insect pests
 - Pheromone mating disruption
 - Traps
 - Puffers/spirals
 - Beneficials

[Orchard Sanitation]

- Removal of debris, prunings
 - Reduce spread and overwintering of pests and disease
- Mowing
 - Reduce hiding places for larger pests (voles!)
- Adjacent plots
 - Plum curculio generally overwinters in nearby wooded areas
 - Cedar apple rust vectors from cedar trees
 - Provide cover for beneficial predators/parasites

Orchard Spraying

- Spraying for pest and disease control is a given
 - Timing is key for efficacy and economy
- Any spray program should rotate application types to minimize disease and pest resistance
 - e.g. spraying only malathion will quickly result in malathion resistant pests.
 - Instead some rotation of multiple chemicals appropriate to the target should be made
- Specific chemicals and applications are not covered here due to
 - Varying approaches by different growers
 - Requirements for pesticide applicators license
 - Changing label certifications
 - Consult with your local Extension Agent

[Mating Disruption]

- Not practical for the small grower
 - Large blocks (5+ acres) are required for adequate effect
- Saturates the orchard with female mating pheromone
 - Confuses males keeping them from mates
 - Trapping required to ensure effect

Disruption "spiral"



[Beneficials]

- Two main groups
 - Predatory
 - Parasitic
- Predators
 - Ladybugs, Green lacewing, Syrphid fly
 - Feed directly on pests
- Parasites
 - Trichogramma wasps, Tachinid Flies
 - Lay eggs on host (pest), young feed on pest

[Beneficials]

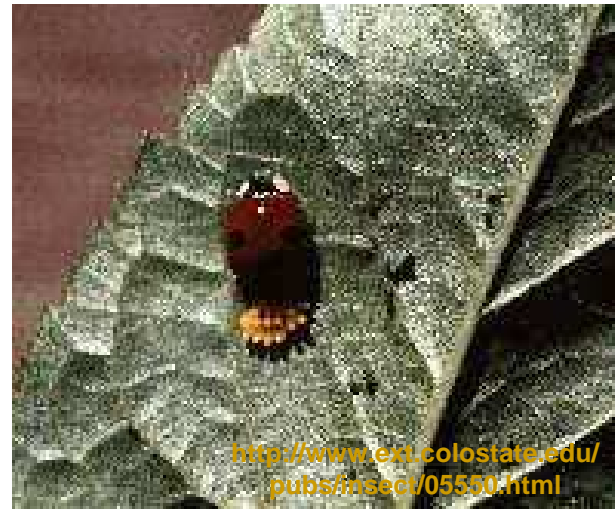
- Beneficials generally occur naturally, but may be introduced
- Beneficials require habitat
 - For adult populations
 - e.g. trichogramma wasp adults are nectar feeders
 - For overwintering
- Maintaining beneficial populations requires management of chemicals used
 - Improper chemicals or timing can eliminate beneficial populations, possibly leading to pest outbreaks

[Select Beneficials]

- Ladybugs
- Green Lacewing
- Trichogramma Wasps
- Tachinid Fly
- Syrphid Fly

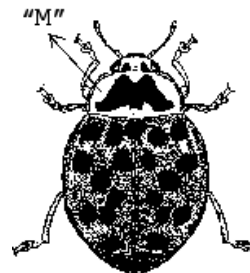
Ladybug/Ladybeetle/Ladybird beetle (order *Coleoptera*)

- Many varieties and colors
- Eggs are yellowish-orange and spindle-shaped
- Females lay from 300 to 1,500 eggs during their lifetime
 - depositing them in compact clusters on foliage or in ground litter
- Both adults and larvae feed
 - chiefly on aphids
 - also eat scale insects, mealybugs, spider mites and small egg masses of other insects.
 - A single beetle can consume more than 5,000 aphids in its life.
- Asian ladybeetle can become a pest
 - May feed on fruit in autumn
 - Invades building for overwintering
 - Characteristic black **M** behind head
 - Formed by spots that may or may not merge together



Adult laying eggs

Larva



Adult (19-spotted form)

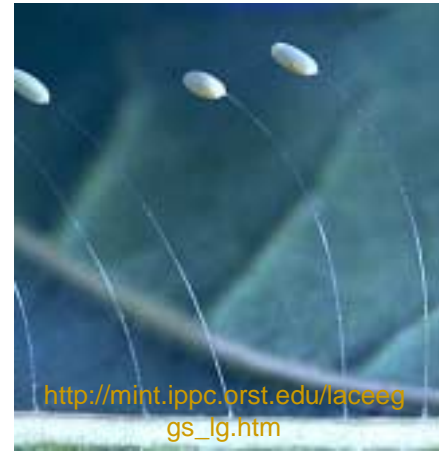
Asian



Green Lacewing (*Chrysoperla spp.*)

- Larva is predatory
 - grayish-brown
 - often called aphid lion
 - 3/8 inch long
 - sharp curved jaws that extend beyond its head
- feeds on aphids, scales, thrips mealybugs, mites, and insect eggs
- It can eat 100 or more insects a day.

Adult



Eggs

Larva attacking caterpillar

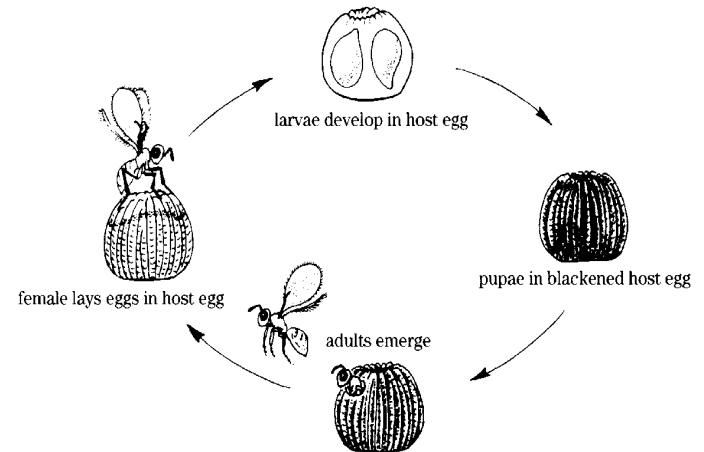


Trichogramma Wasp (*Trichogramma spp.*)

- Tiny, < 1mm
- Eggs are deposited in moth eggs
 - Wasp larvae eats moth egg from inside
 - Parasitized moth eggs turn black
- 8-10 day life cycle
- Harmless to people and animals
- Adult wasps are nectar feeders



Wasp ovipositing on moth egg



<http://www.entomology.wisc.edu/mbcn/kyf104.html>

Tachinid Fly

(*Erynnia tortricis*)

- Many species
 - *Erynnia* attacks CM, OFM, leafrollers
- Eggs laid on host body
 - Parasitic larvae do not kill the host until after the host pupates
- Adults 3-14mm (<1/2 in.)
- Resemble houseflies
 - Very bristly abdomen



Larva emerging from parasitized caterpillar



Adult



Eggs Laid on Caterpillar

[Syrphid Fly – “Hover” Fly (*Syrphus spp.*, *Allograptia spp.*)]

- 1000+ species in North America
- Larvae eats aphids and other small, soft-bodied insects
 - Adults eat nectar
- Not a commercially available insect to introduce



http://www.ipm.ucdavis.edu/PMG/NE/syrphid_flies.html

Disease and Insect Pest Models and Methods

- Temperature drives the developmental rate of many insects and diseases
- Models are empirical
 - Formulated through laboratory observation
 - Vary for different species and regions
 - Inexact because they model temperature based on sine curve or triangle
- All that said, coupled with observation they work very well!

Plum Curculio Monitoring and Control^{1,2}

■ Monitoring

- The critical period for controlling plum curculio is during the first few days of warm weather following petal fall, when maximum temperatures remain above approximately 70°F
- Adults not active in cool rainy weather below 70°F

■ Biofix

- Petal fall

■ Control

- A spray residue should be maintained for 340 DD base 50 following petal fall¹

Codling Moth Monitoring and Control^{1,2}

- Monitoring
 - Traps should be placed at the density of one trap per 5 acres by the pink stage and situated on the outside of the tree, 6–7 feet above the ground
 - For orchards over 5 acres in size a minimum of 5 pheromone traps is recommended, one on each of the four sides and one in the middle.
 - Traps should be checked daily until the first adult is caught and then weekly thereafter.
 - Fruits should be examined between mid-June and early July for evidence of larval entry. Examine 25-50 fruits per tree on 5 trees per block.
- Biofix
 - First adult capture in a pheromone trap is used as a biofix, and degree-days are accumulated thereafter.
- Control
 - Apply insecticide after 250 degree-days base 50°F for first generation
 - 150 DD if applying a Molt-Accelerating Compound (MAC)
 - For the second generation, initiate control at 1250-1300 DD after spring biofix
 - 1100 - 1200 DD if applying a MAC
 - For the rest of the season, if the action threshold of five moths per trap per week is exceeded an insecticide application should be made within 7–10 days
 - Repeat applications should only be made if the number of captured moths exceeds the five moths per trap per week threshold 14 days after the insecticide application.

Oriental Fruit Moth Monitoring and Control^{1,2}

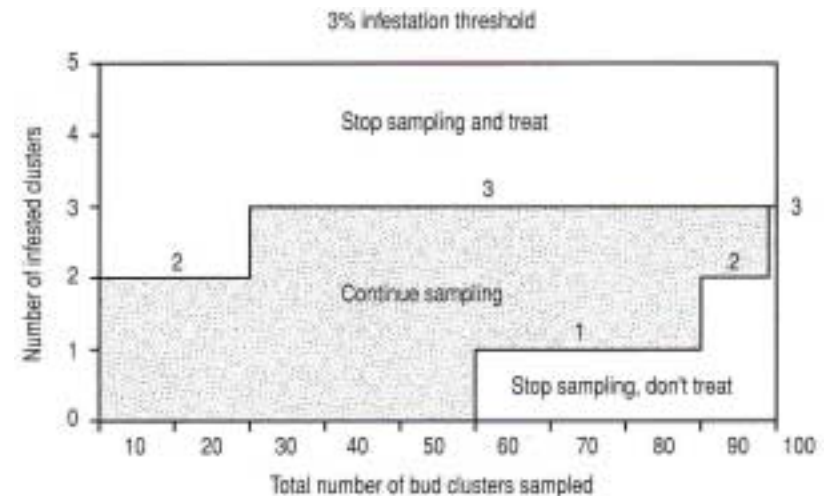
- Monitoring
 - Place sex pheromone traps in orchard in early April (pink to early bloom)
 - Check daily until biofix is established.
 - Monitor the traps weekly thereafter throughout the season
 - Because OFM targets peach and apple, possible adult movement between adjacent apple and peach orchards contribute to significant overlapping between generations late in the season
 - During mid- and late season, weekly examinations should be made of about 200 fruit in each block
 - As the season progresses, special attention should be paid to the stem ends of the
- Biofix
 - First sustained capture of two or more moths per trap
- Control
 - Degree days (DD) base 45°F
 - Following model is based on peaches because they are the primary target for OFM
 - First generation
 - Spray at 175 DD (75 DD if applying Intrepid)
 - Second application at 350 DD (10-18 days after first spray)
 - Second generation
 - At 1150-1200 DD (850-950 DD for methoxyfenozide) after biofix
 - At 1450-1500 DD
 - Third generation
 - At 2100-2200 (1800-1900 DD for Intrepid)
 - At 2400-2500 DD
 - Fourth and fifth generations (also optional for second and third generations)
 - Treatment threshold of 6 to 8 moths per trap per week
 - Applications should be assumed to last 10 days to 2 weeks, depending on weathering
 - Additional sprays should be applied if any flagging or fruit damage is seen

Apple Maggot Fly Monitoring and Control^{1,2}

- Monitoring
 - Adult apple maggot flies are monitored most effectively by sticky red spheres baited with apple volatile lures or less effectively with yellow sticky traps
 - Red traps are more sensitive under conditions on low apple maggot fly density
 - Both types of traps may be improved with the addition of ammonium acetate
 - The use of protein hydrolysate can greatly increase captures during the preoviposition period
 - Three traps are recommended per block, near the border, one to two rows in from the edge
 - Traps should be placed in the orchard mid to late June
 - Place about head height, positioned so they are surrounded by fruit and foliage but not touched by them or obstructed from view
 - Trees that are closest to woods or abandoned orchards should be chosen
 - Traps should be inspected and cleaned weekly until the end of August
- Biofix
 - Not applicable
- Control
 - Remove abandoned apple trees and alternate hosts from 100 yards around the orchard
 - Picking up and destroying dropped apples may reduce the problem the following year
 - but it will not be effective if infested, abandoned apple trees are nearby.
 - Effective control of apple maggots requires spray coverage when trap thresholds are exceeded. Insecticides are directed against adult flies before eggs are laid. In areas with a history of apple maggot problems, regular insecticide applications in July, August, and possibly early September, with thorough coverage of all foliage, should give adequate control of this important pest. Please refer to [Table 4-7](#) for recommended assortment of effective insecticides.
 - If an average accumulation of 5 AM flies per trap (using apple volatiles) are caught within a week, an application of an insecticide is recommended immediately (Cornell research)
 - If no apple volatiles are used, the threshold should be lowered to 1 fly/trap.
 - Capture of flies for 1-14 days following the insecticide spray can be discounted
 - Red sphere traps may be used for actual control in small orchards according to New York research
 - Traps should be placed in trees at the ratio of 1 trap per 100-150 fruit, with a maximum of 3-4/tree.

OBLR Monitoring and Control²

- Flight of male adults can be monitored with pheromone traps and used to predict when the various stages of OBLR may be present for timing sprays
 - However, males are capable of traveling long distances so pheromone traps cannot be used to predict population size
 - Traps should be hung by the end of May or early June depending on the locality
- Sequential sampling plan for monitoring larval populations and determining population size
 - Sequential sampling utilizes the results of the samples that are being evaluated to determine the total number of samples to be taken
 - The graph presents a sequential sampling chart for obliquebanded leafroller monitoring for the first summer generation
 - Sample at approximately 600 DD Base 43F after the first adult flight in your area
 - Examine 10 expanding leaf terminals per tree, selecting trees from as wide an area of the block as possible
 - If trees are >10 ft tall, an effort should be made to include some clusters from the mid- to upper canopy area, or from watersprouts, which are favored infestation sites
 - Try not to bias your sample by picking clusters that you suspect are infested
 - Record the number of clusters that are infested with live larvae, not the number of live larvae
 - Continue sampling until you reach one of the staircase lines in the Figure
 - If you reach the intersection of the two lines by the 100th cluster, this is equivalent to a Don't Treat decision
 - If you reach a Treat decision, an insecticide spray is recommended at that time
 - If you reach a Don't Treat decision, return in 3-5 days (100 more DD) and repeat the sample
 - 3% limit for Fresh Fruit production



VLR Monitoring and Control^{1,2}

■ Monitoring

- Traps should be hung at the peak of petal fall (beginning of May)
 - 6 feet high in the tree
- At peak flight, around the end of May, start searching for and marking the location of several egg masses
- Monitor the marked egg masses until they turn black

■ Biofix

- Sustained catch in traps (peak flight)

■ Control

- When eggs turn black then insecticides should be applied
- Provisional VLR DD timing
 - Base of 50 degrees F
 - Treat at 471 DD
 - Watch for refinements of this approach

TABM Monitoring and Control^{1,2}

- Monitoring
 - Traps should be placed at petal fall (by May 1), at least 200 yards apart and in trees located in the center of the block
 - They should be attached to a limb at a height of 5-6 ft in the outer third of the tree's canopy
 - Check traps every day until the first TABM adult is caught
 - After which the traps should be checked once a week
 - After the first sustained capture of TABM, maintain the above procedures for 3 weeks unless cool temperatures occur which affect male flight. If cool temperatures occur after first trap catch add one additional week of trap capture. At the end of the 3-week period average the number of moths caught in each trap to determine a average cumulative total per trap for the entire block
 - Refer to Penn State Tree Fruit Guide for how to use this average to estimate fruit injury thresholds
- Biofix
 - First sustained trap catch
- Control
 - Base 45 degrees F
 - For first generation applications
 - At about 10% egg hatch which occurs **530-585 DD**
 - Second application at **805-855 DD**
 - If using *Intrepid* and *SpinTor* apply at 585-640 DD
 - For second generation applications
 - sprays should be applied after an accumulation of 2280-2355 DD
 - or 530 DD from first trap capture of second brood moths
 - second application should be applied 300 DD after the first application
 - Additional insecticide applications may be needed for second brood control since the egg hatch period for second brood extends over a 650 DD period; whereas, the egg hatch period occurs over a 300 DD period
 - Using *Intrepid* or *SpinTor*, apply as two complete sprays at 2355-2435 and 2665-2740 DD

Fireblight Monitoring and Control¹

- Monitoring
 - To detect the first appearance of fire blight, inspect trees at 5- to 7- day intervals beginning at petal fall
 - Daily temperatures must average 65°F or above during pink through petal fall for bacterial populations to grow enough to cause severe disease
 - The disease also occurs later in the season when bacteria enter late-opening blossoms or growing tips of new shoots
 - The MaryBlyt computer program can be used to predict outbreaks
 - Measures combination of temperature and leaf wetness
 - Available from Gemplers
- Control (where disease was present previous year)
 - Prune out all cankers in limbs 1 inch or more in diameter
 - Cut apple limbs at least 8 inches below external evidence of the canker
 - Pruning tools do not need to be disinfected when temperatures are below 45°F.
 - Where the disease was severe the previous year, apply a dilute Bordeaux spray plus miscible superior oil at silver tip
 - This spray is not warranted if there were only occasional infections.
 - When daily temperatures average 65°F or higher during pink through petal fall, make at least two applications of a streptomycin formulation
 - Apply the first streptomycin spray anytime after first blossoms open when daily temperatures are above 65°F or are expected within 24 hours
 - Repeat sprays at 5- to 7-day intervals through late bloom. A minimum of two applications is necessary to provide control. (Streptomycin formulations are much more effective when applied during slow drying conditions, such as at night.)
 - When average daily temperatures fail to reach 65°F during pink through petal fall, delay the streptomycin application until the disease first appears
 - When the disease is seen, prune or break out all new infections
 - Remove shoots 8 to 12 inches below the last signs of browning
 - Disinfect pruning tools between cuts with a Chlorox solution or alcohol, as contaminated tools can spread the disease.
 - Cutting out blighted shoots after terminal growth has stopped is not recommended
 - When growth stops, the spread of fire blight should also stop
 - The most important thing to do to control fire blight during the summer is to control sucking insects like aphids and leafhoppers
 - Applying streptomycin sprays within 24 hours after hail to prevent new infections is a good practice

Apple Scab Monitoring and Control⁴

- Monitoring
 - Use of a Mill's table (leaf wetness/temperature relationship req'd for scab activity) provides an indicator of time required for lesion expression
 - Begin monitoring for first leaf symptoms on early-developing cultivars by examining the upper and lower leaf surfaces on a minimum of ten leaf clusters on each sample tree
 - walk around the perimeter of the tree and examine at least two leaf clusters at each of the four compass directions
 - For fresh market production, more than one infected leaf cluster per tree represents potentially damaging levels of apple scab
 - For processing apples, one to ten infected clusters represents a moderate risk, and more than ten infected clusters represents a high risk
 - During mid-season and the preharvest period, no monitoring is required for processing apples
 - For fresh market production, continue monitoring for lesions on leaves of vegetative terminal shoots
 - After harvest, for both fresh and processing apples, determine the percent of leaves infected and number of lesions per infected leaf on six terminal shoots from each sample tree after harvest and before natural defoliation begins
 - Greater than 0.5 percent leaves infected with an average of one lesion per leaf represents significant risk of early scab infection next season
- Control
 - Use scab resistant cultivars
 - Sanitation practices
 - Leaf pickup and destruction in late autumn
 - Flail mowing in late autumn to chop litter
 - Applications of 5% urea to foliage in autumn can hasten leaf decomposition
 - Applications should be made just prior to leaf fall to avoid stimulating tree growth and predisposing the trees to winter injury
 - Fungicides
 - Protectant fungicides are applied routinely at 7 to 10 day intervals or according to anticipated infection periods
 - Postinfection fungicides control the scab fungus inside leaves and fruit

University/Gov't Web Links

- Pennsylvania State University
 - [1http://tfpg.cas.psu.edu/](http://tfpg.cas.psu.edu/)
 - <http://frec.cas.psu.edu/>
 - <http://paipm.cas.psu.edu/>
- ⁴WVU Kearneysville
 - <http://www.caf.wvu.edu/kearneysville/>
- ²VA Tech Entomology/IPM
 - <http://www.ento.vt.edu/Fruitfiles/apple-fruit-ipm.html>
- ³UC Davis IPM
 - <http://www.ipm.ucdavis.edu/>
- Mid-Atlantic Fruit Loop
 - <http://www.caf.wvu.edu/kearneysville/fruitloop.html>
- Michigan State University IPM
 - <http://www.msue.msu.edu/fruit/fruitipm.htm>
- University of Kentucky
 - <http://www.uky.edu/Agriculture/IPM/appleipm/appleipm/>
 - <http://www.uky.edu/Agriculture/Entomology/>

[IPM Tool Links and Information]

- Great Lakes IPM
 - <http://www.greatlakesipm.com/>
- Advanced Pheromone Technologies (APT)
 - +1 (315) 299-2598, infoatapt@comcast.net
- Gemplers
 - <http://www.gemplers.com>
 - <http://www.ipmalmanac.com/>
- Peaceful Valley Farm Supply
 - <http://www.groworganic.com>

Other Resources

- Mid-Atlantic Orchard Monitoring Guide
 - \$48 from NRAES
 - <http://www.nraes.org/publications/nraes75.html>
- Pennsylvania Tree Fruit Production Guide
 - <http://tfpg.cas.psu.edu/>
 - Not small grower guide
- A Pocket Guide for IPM Scouting in Michigan apples
 - \$14 from Michigan State University (inventory #E2720)
 - <http://www.ipm.msu.edu/ApplePocket.htm>
- A Practical Guide for Scouting Apple Orchards
 - \$29.95 DVD from MSU (inventory #DVD-273)
 - <http://web2.msue.msu.edu/bulletins/viewitem.cfm?INVKEY=DVD273>