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New York State Agricultural Experiment Station

Apple Insect Targets & IPM Practices

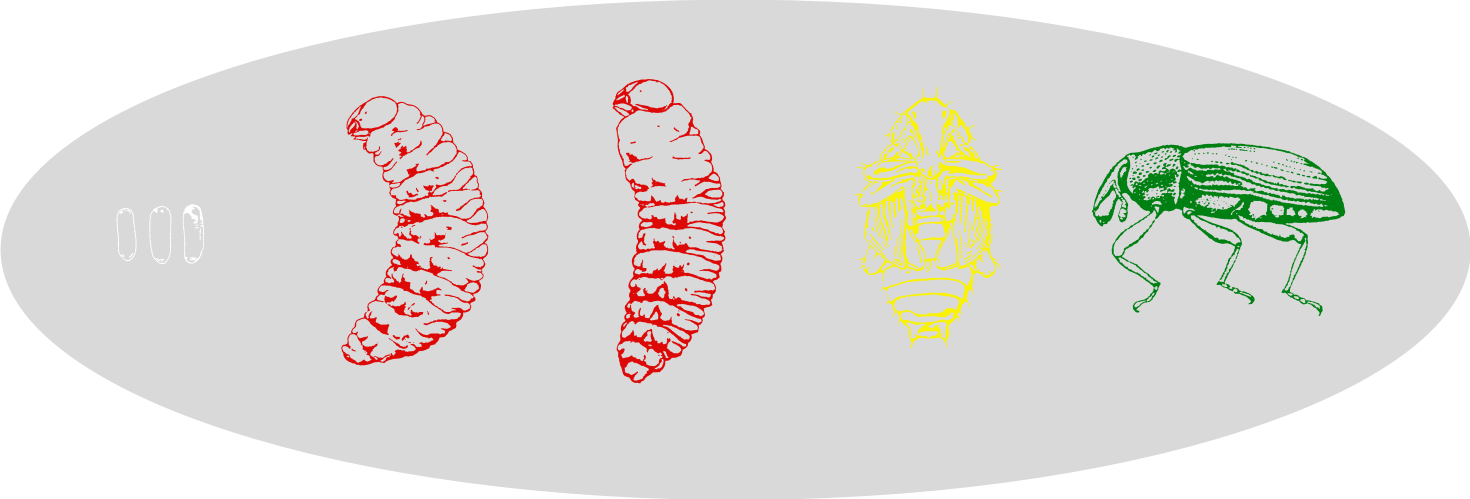
Arthropod Pest Development

Developmental Rates & Thresholds

Degree Day Calculation

Monitoring

Methods of Measuring and Predicting Arthropod Pest Development



Developmental Rates and Thresholds

- **Mammals are warm-blooded, develop at constant rate regardless of environmental temperature, because they can regulate their internal temperature (biochemical processes progress normally).**

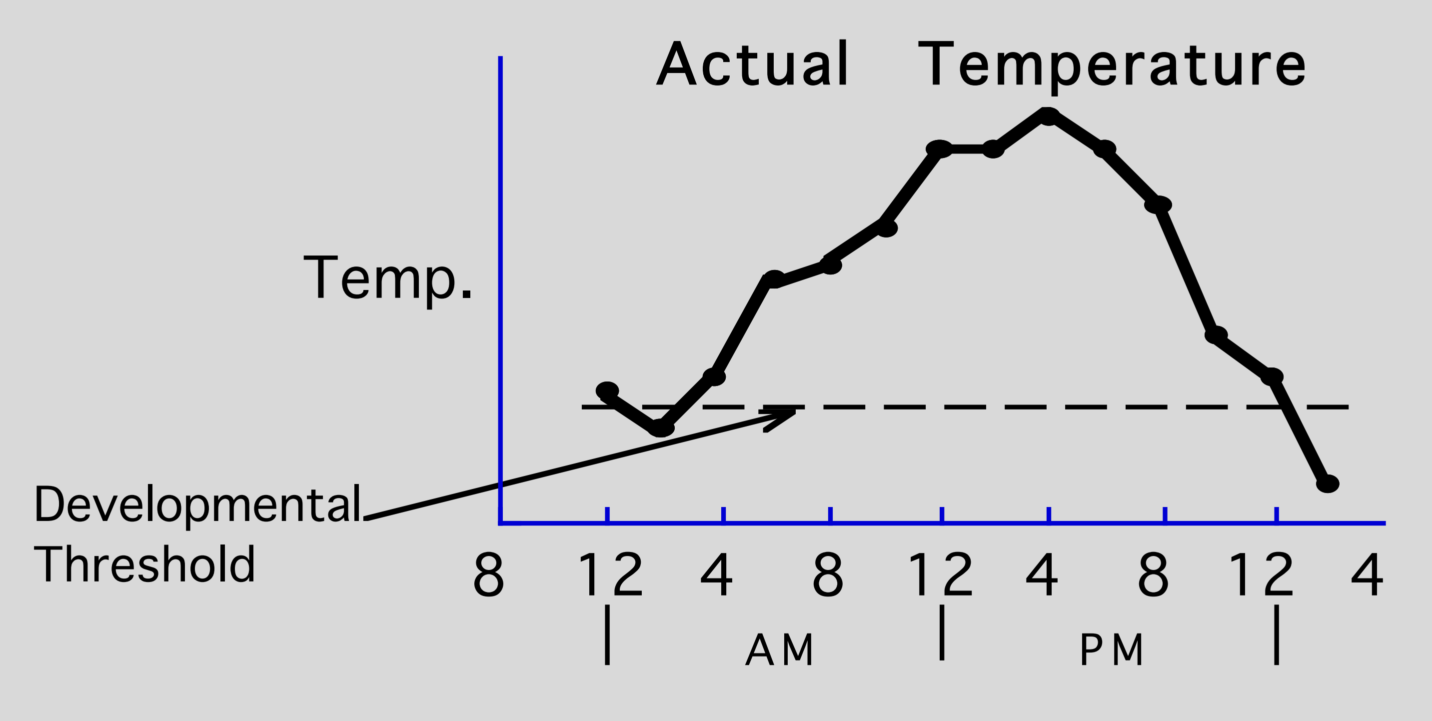
- **Insects are poikilothermic, do not generate body heat, therefore remain at same temperature as their environment, and depend on a favorable external temperature.**

- **Developmental Base or Threshold: The temperature below which an insect's biochemical reactions cannot proceed and development therefore stops.**

- **Charting ambient temperature makes it possible to track insect development, which is directly proportional to the amount of time accumulated above the Developmental Base. We divide this time arbitrarily into heat units or Degree Days.**

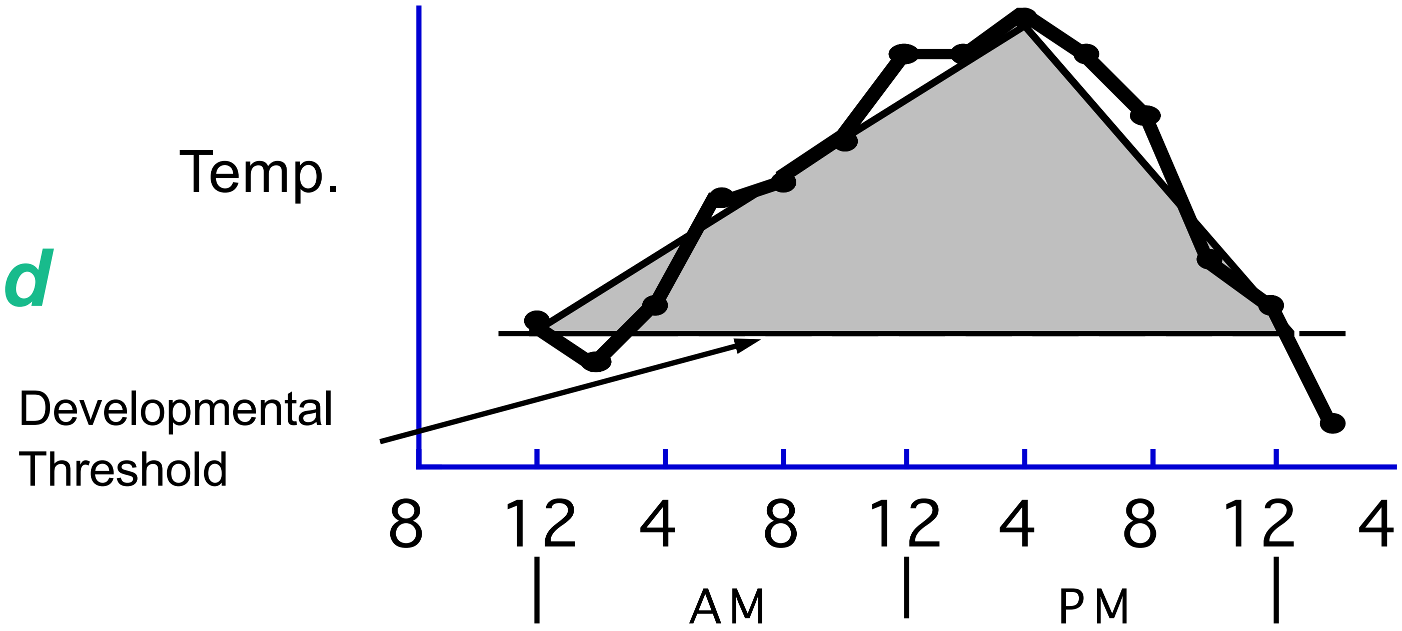
Degree Day Calculation Methods

- **There are different ways to determine the quantity of heat units accumulated; this is equivalent to the area under a temperature-vs.-time graph on a given day.**



Degree Day Calculation Methods

Average or Max/Min Method



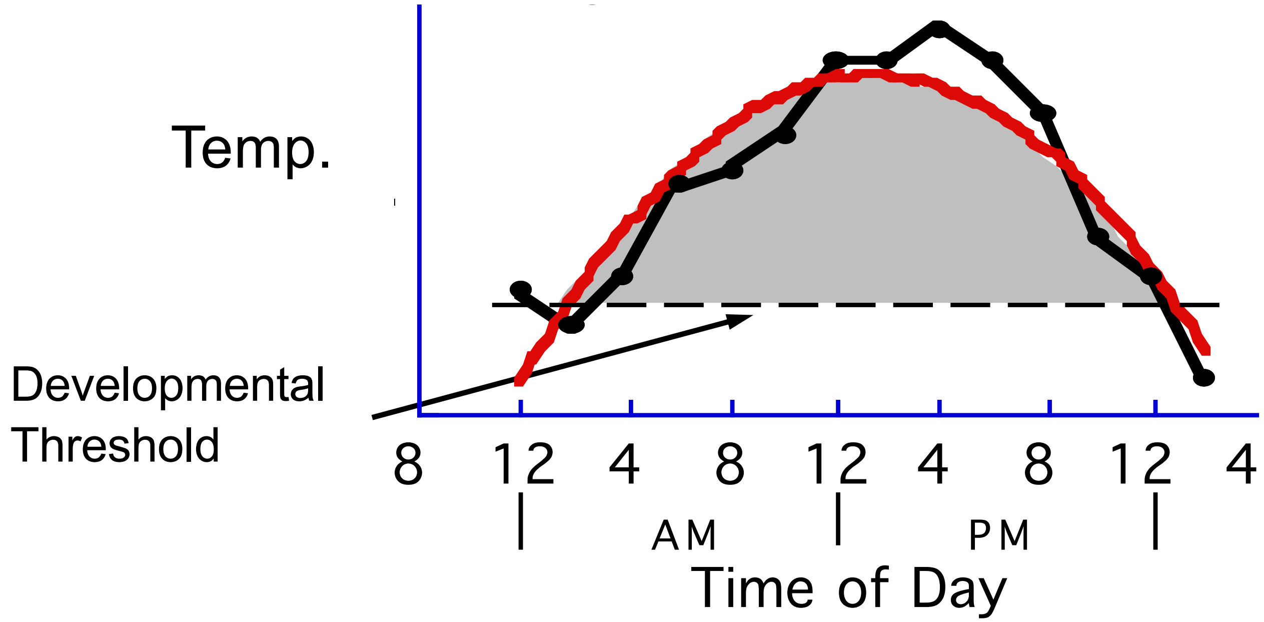
- **Simplest and least precise; assumes that the daily temperature graph is linear and the area beneath it is triangular:**

DD = (Max temp + Min temp*)/2 – Developmental Threshold

* or Developmental Threshold, whichever is higher

Degree Day Calculation Methods

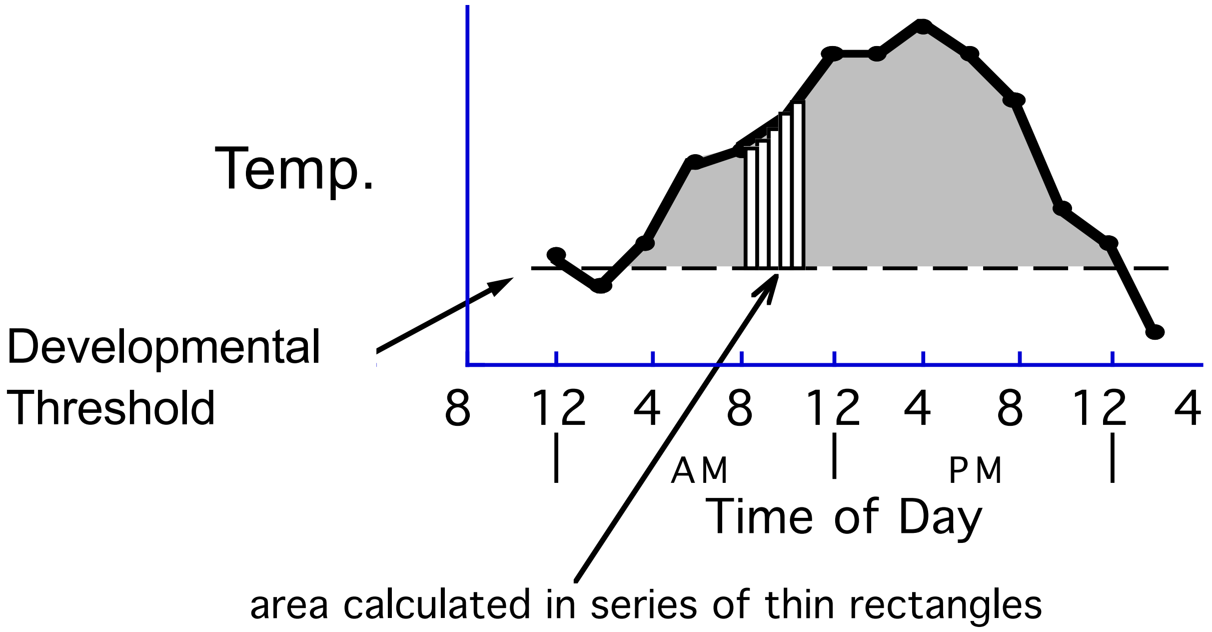
Sine Wave (Baskerville-Emin) Method



- **More precise; assumes the daily temp cycle takes the form of a sine wave. Area beneath the curve determined by integration (calculus). This method tends to accumulate more DDs than the Max/Min Method, particularly during the early part of the season.**

Degree Day Calculation Methods

Continuous Integration Method



- **Most precise method; requires multiple temperature readings hourly or more frequently throughout the day, to obtain a graph that is truly representative of the field situation. Area beneath the curve again calculated using integration; data collection most efficient if handled by a computer.**

Relating Degree Days to Life Cycle and Development

- Several methods attempt to correlate a pest event or activity with another event that can be measured more precisely. Events in an insect's life cycle often occur after the same number of heat units have accumulated each year, but many years' observations must be collected to measure them precisely. Degree days can be used to predict events where weather data are available.
  - *Temperature* - Monitor temp and pest activity simultaneously for many years; possible to build a database of events & their corresponding DD range.
  - *Phenology* - Some pest events occur at same time as easily observed biological field events; e.g., mite hatch from tight cluster to pink bud, sawflies lay eggs from bloom to petal fall.
  - *Biofix* - A distinct, easily monitored event in an insect's life history, used to fine-tune our predictions of its activity; e.g., 1st flight, 1st egg laid, 1st mine observed.

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Table 7.1.4. Degree-day accumulations (from Jan. 1) corresponding to selected fruit phenology and arthropod pest events.

Pest/Phenology Event	DD Base 43°F *mean*	DD Base 43°F *std dev*	DD Base 50°F *mean*	DD Base 50°F *std dev*	Approx. Date *mean*	Approx. Date *std dev*
STLM Traps set out			1-April			
Pear psylla – egg laying	84	44	33	21	4-Apr	11 days
Redbanded leafroller – 1st catch	145	32	62	20	16-Apr	9 days
Rosy apple aphid – 1st nymphs present	189	55	86	30	25-Apr	7 days
STLM – 1st adult catch	166	49	73	29	19-Apr	9 days
STLM – 1st egg observed	208	65	94	36	27-Apr	5 days
Tight cluster (McIntosh)	232	26	108	17	27-Apr	8 days
Tarnished plant bug – 1st observed	222	105	105	62	25-Apr	15 days
OBLR – 1st overwintered larvae observed	236	78	112	48	29-Apr	7 days
European red mite – egg hatch observed	284	53	134	34	6-May	4 days
STLM Egg Sample			Pink			
OFM Traps set out			Pink			
Pink (McIntosh)	291	25	140	18	3-May	7 days
Oriental fruit moth – 1st adult catch	273	51	129	33	2-May	8 days
STLM – 1st flight peak	338	70	168	45	7-May	8 days
OBLR Overwintered Gen. Sample			Bloom			
CM Traps set out			Bloom			
Full bloom (McIntosh)	380	36	194	25	10-May	6 days
Lesser appleworm – 1st catch	420	144	217	88	13-May	12 days
American plum borer – 1st catch	457	64	240	45	16-May	7 days
Oriental fruit moth – 1st flight peak	432	102	225	60	14-May	11 days
Codling moth – 1st adult catch	481	85	254	54	18-May	7 days
San Jose scale – 1st adult catch	526	88	279	60	21-May	8 days

- **Several methods** … **vent that can be measur** … **ur after the same number c** … **observations m** … **an be used to predict**
  - ***Temperature*** … **ears; possible to b**
  - ***Phenology*** **- S** … **logical field events;** … **eggs from bloom to peta**
  - ***Biofix*** **- A disti** … **to fine-tune our pred** … **observed.**

Use of Monitoring Techniques for Pest Management in Orchards

Monitoring Process

Physical Evidence
- Egg mass, pupal case, excrement

Plant/Fruit Damage
- Oviposition punctures, feeding damage, entrance

holes,

webbing

Traps
- Detection (presence)
- Establishment of biofix (e.g., 1st sustained flight)
- Determination of pest population level
- Chart developmental progress (e.g., peak flight)

Threshold Prediction
- Developmental model (start/end of egg laying;

progression

of hatch; development of specific stages)
- Estimation of timing (number of days until desired stage reached)

Types of Monitoring Traps

Pheromone Traps


Wing


Tent


Delta

Types of Monitoring Traps

Visual Attractant Traps

Yellow/White Panels

Sphere

Combination ("Ladd")

Types of Monitoring Traps

Odor Attractant Traps

plant volatiles

food extracts (bait)

Physical Traps

sticky tape

Components of an Integrated Crop and Pest Management System

Monitoring (Scouting)	• Detecting, identifying, and determining level of pest populations on a timely basis
Forecasting	• Use of weather data and crop phenological stage to predict when specific pest events will occur
Thresholds	• To determine when pest populations have reached a level that could cause economic damage
Management Tactics	• Cultural, biological, physical, as well as chemical control, when needed
Recordkeeping	• Annual records of pest occurrence are valuable tools for avoiding pests in future

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NEWA Apple Insect Models Website

- Developed to improve delivery of combined information resources to aid growers in timing and selection of pest control methods (including "reduced-risk" products).

- Crop and pest developmental stages are calculated from Degree Day accumulations at NYS IPM and National Weather Service stations throughout the state.
  - Apple maggot
  - Codling moth
  - Obliquebanded leafroller
  - Oriental fruit moth
  - Plum curculio
  - Spotted tentiform leafminer
  - San Jose scale

- DD models (supported by historical records) are used to estimate:
  - Tree Phenological Stage
  - Pest Status (activity)
  - Pest Developmental Stage
  - Pest Management Info

- When pesticide sprays are needed, a link is provided to NYS DEC label database.

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NEWA Apple Insect Models

Select a pest:

Plum Curculio

State:

New York

Weather station:

Crown Point

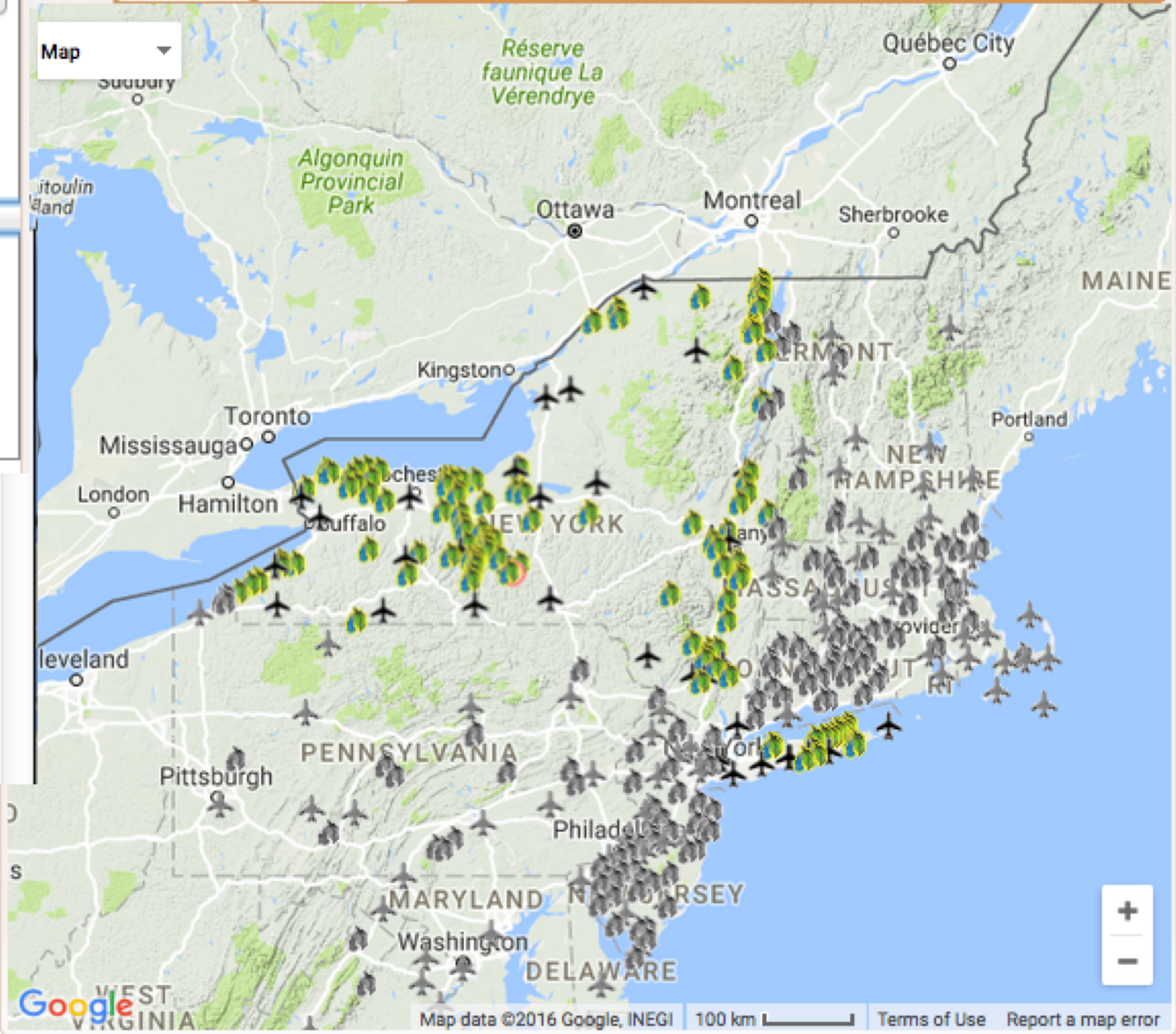
Accumulation End Date:

06/10/2015

Calculate

Eagle Bridge
East Moriches
Elba
Elmira
Fairville (The Apple Shed)
Farmingdale
Farmington
Fishkill
Fort Salonga
Freeville
Fulton

Map | Results | More info



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Apple insects

NEWA Apple Insect Models

Select a pest:

Plum Curculio

State:

New York

Weather station:

Crown Point

Accumulation End Date:

06/10/2015

Calculate

Map | Results | More info

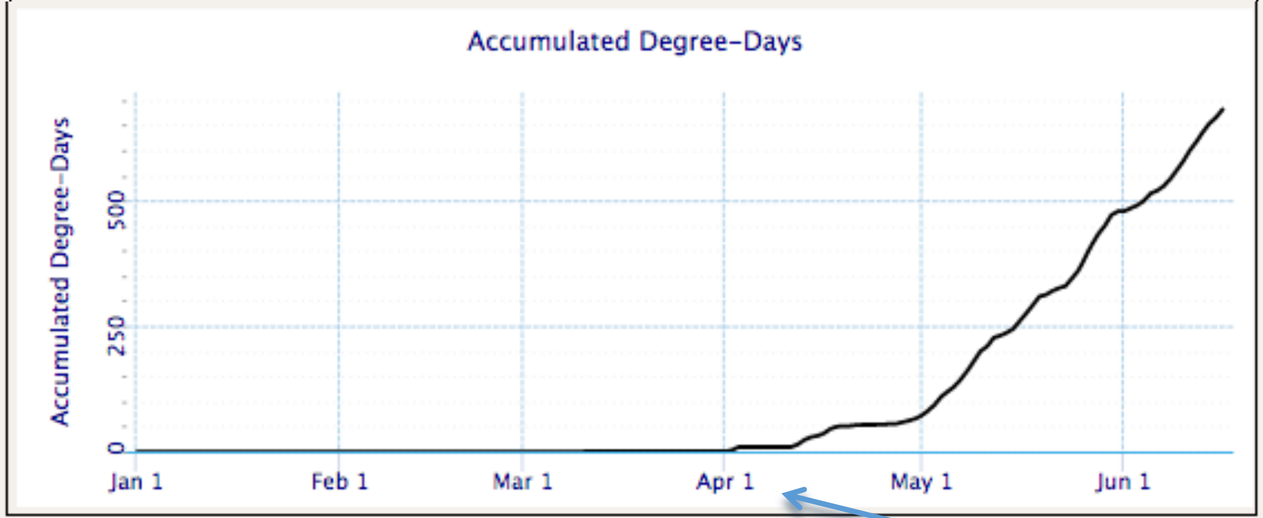
Plum Curculio Results for Crown Point

Petal Fall: 5/19/2015

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) petal fall through 6/10/2015: 287 (0 days missing)

	Past	Past	Current	Ensuing 5 Days				
Date	Jun 8	Jun 9	Jun 10	Jun 11	Jun 12	Jun 13	Jun 14	Jun 15
Daily Degree Days (Base 50BE)	14	18	18	21	17	19	17	12
Accumulation since January 1	543	560	578	600	617	636	654	665



<u>Plum curculio</u>

Pest stage

Pest status

Pest management

Pesticide information

Cornell Coop

ovides

opportunity.

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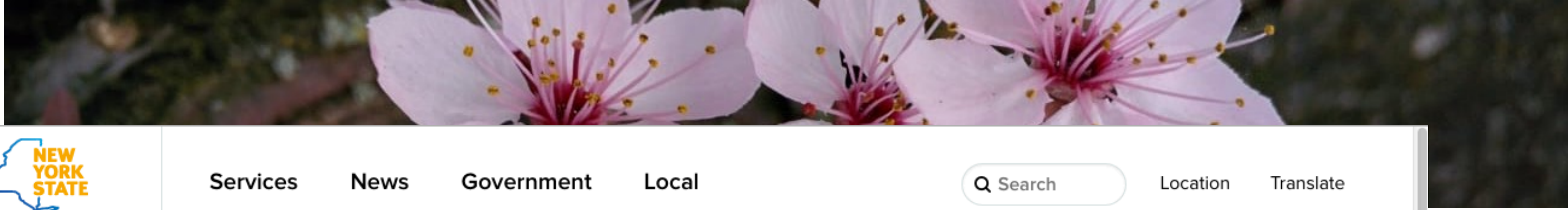
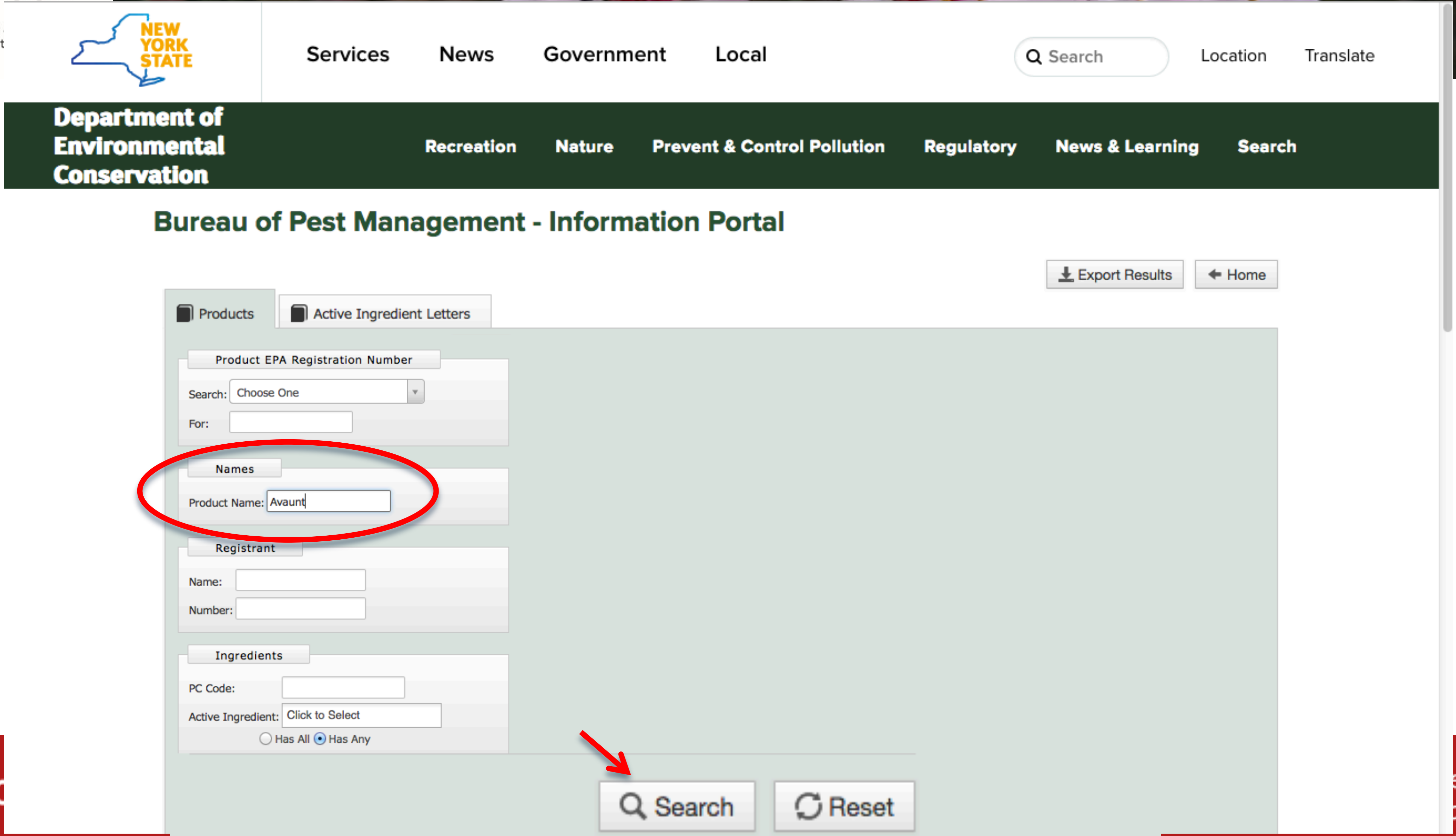
New York State Experiment Stat





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New York State Experiment Stat

DuPont™ Avaunt®
INSECTICIDE

GROUP 22 INSECTICIDE

Dispersible Granules

Active Ingredient	**By Weight**
Indoxacarb (S)-methyl 7-chloro-2,5-dihydro-2-[[(methoxy-carbonyl)[4(trifluoromethoxy)phenyl]amino]-carbonyl]indeno[1,2-e][1,3,4]oxadiazine-4a-(3H)-carboxylate	30%
Other Ingredients	70%
TOTAL	100%

EPA Reg. No. 352-597 EPA Est. No. 67545-AZ-001

KEEP OUT OF REACH OF CHILDREN
CAUTION

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

See back and side panels and attached booklet for First Aid, Precautionary Statements, and Storage and Disposal.

USER SAFETY RECOMMENDATIONS

USERS SHOULD: Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. Remove clothing and/or PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

ENVIRONMENTAL HAZARDS

This pesticide is toxic to mammals, birds, fish and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment rinsewater. Do not apply where/when conditions could favor runoff. Runoff from treated areas may be hazardous to aquatic organisms in neighboring areas. Cover, incorporate, or clean up granules that are spilled.

This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are foraging in the treatment area.

Refer to accompanying labeling for additional precautions and complete directions for use.

AGRICULTURAL USE REQUIREMENTS

Use this product in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. Refer to supplemental labeling under (Agricultural Use Requirements" in the Directions for Use section for information about this standard.

Notice to Buyer: Purchase of this material does not confer any rights under patents of countries outside of the United States.

A10001616 (SL-1970A 100516 09-24-15)

Net: 1 lb., 2 oz.
Nonrefillable Container

DuPont™ Avaunt®
INSECTICIDE

FIRST AID

IF SWALLOWED: Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Do not give anything by mouth to an unconscious person.
IF IN EYES: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
IF ON SKIN OR CLOTHING: Remove contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.
IF INHALED: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. Call a poison control center or doctor for treatment advice.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact **1-800-441-3637** for emergency medical treatment information.

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
CAUTION

Harmful if swallowed. Causes moderate eye irritation. Harmful if absorbed through skin. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling. Harmful if inhaled. Avoid breathing (dust, vapor or spray mist). Remove contaminated clothing and wash clothing before reuse.

PERSONAL PROTECTIVE EQUIPMENT

Some materials that are chemical resistant to this product are listed below. If you want more options, follow the instructions for Category A on the EPA chemical resistance category selection chart.
Applicators and other handlers must wear:
Long-sleeved shirt and long pants.
Chemical Resistant Gloves Category A (such as butyl rubber, natural rubber, neoprene rubber or nitrile rubber), all ≥14 mils.
Shoes plus socks.
Follow manufacturer's instructions for cleaning/maintaining personal protective equipment (PPE). If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry. When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides (40 CFR 170.240(d)(4-6), the handler PPE requirements may be reduced or modified as specified in the WPS. IMPORTANT: when reduced PPE is worn because a closed system is being used, handlers must be provided all PPE specified above for "applicator and other handlers" and have such PPE immediately available for use in an emergency, such as a spill or equipment breakdown.

Sold by: E.I. du Pont de Nemours and Company, Chestnut Run Plaza, 974 Centre Road, Wilmington, DE 19805 U.S.A. Made in U.S.A.

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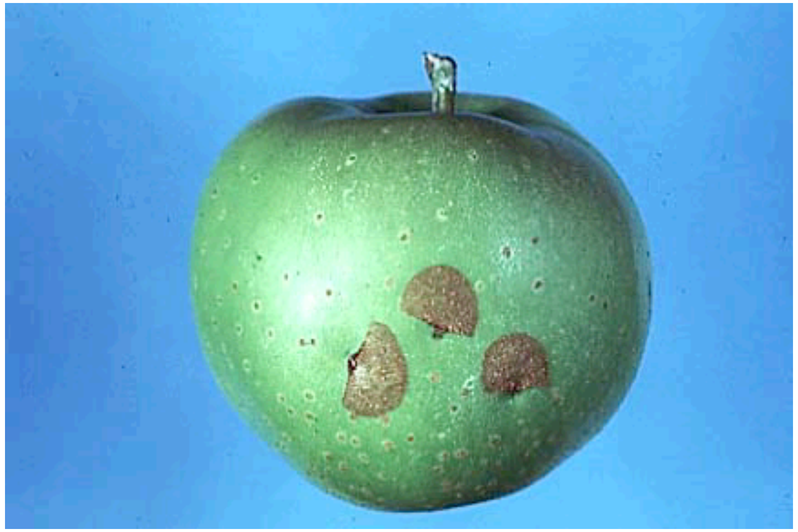
ortunity.

Plum Curculio Management Assumptions



- Commercial apple orchards in NY do not harbor indigenous infestations of PC adults.
- Adults overwinter in ground debris outside of orchard.
- PC adults begin to immigrate into the edges of orchards from outside sources in spring before petal fall (55-60°F).
- Usually in the trees during bloom.
- Annual length of oviposition period depends upon seasonal temperatures after petal fall.
- Effective control requires preventive insecticide sprays from petal fall until the end of oviposition period.

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PLUM CURCULIO OVIPOSITION MODEL

- After 1-2 warm (60°F) evenings following petal fall, egg laying will start
- Model experimentally derived from modeling cumulative Plum Curculio oviposition and DD accumulation (base temp 50°F) after petal fall of McIntosh.
- Model assumes that fruit requires protection from petal fall until about 40% of the cumulative oviposition is completed (308 DD) ➔ corresponds with the end of their immigration into orchard.

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EXAMPLE OF PLUM CURCULIO MODEL PREDICTIONS IN GENEVA FOR THE 2005 SEASON

0 DD

165 DD

308 DD, 40% oviposition; end of immigration

463 DD

PF spray
May 23

1C
June 6

June 11

June 20
End of Protection

2 Total sprays needed

EXAMPLE OF PLUM CURCULIO MODEL PREDICTIONS IN GENEVA FOR THE 2006 SEASON

0 DD	120 DD	291 DD	308 DD, 40% oviposition; end of immigration	
PF spray May 15	1C May 30	2C June 12	June 14	June 26 End of Protection

3 Total sprays needed

Most Important Internal Fruit Feeding Lepidoptera

Codling moth,
Cydia pomonella

Oriental fruit moth,
Grapholita molesta

Lesser appleworm,
Grapholita prunivora

Fruit Injuries by Various Internal Lepidoptera Larvae

CM

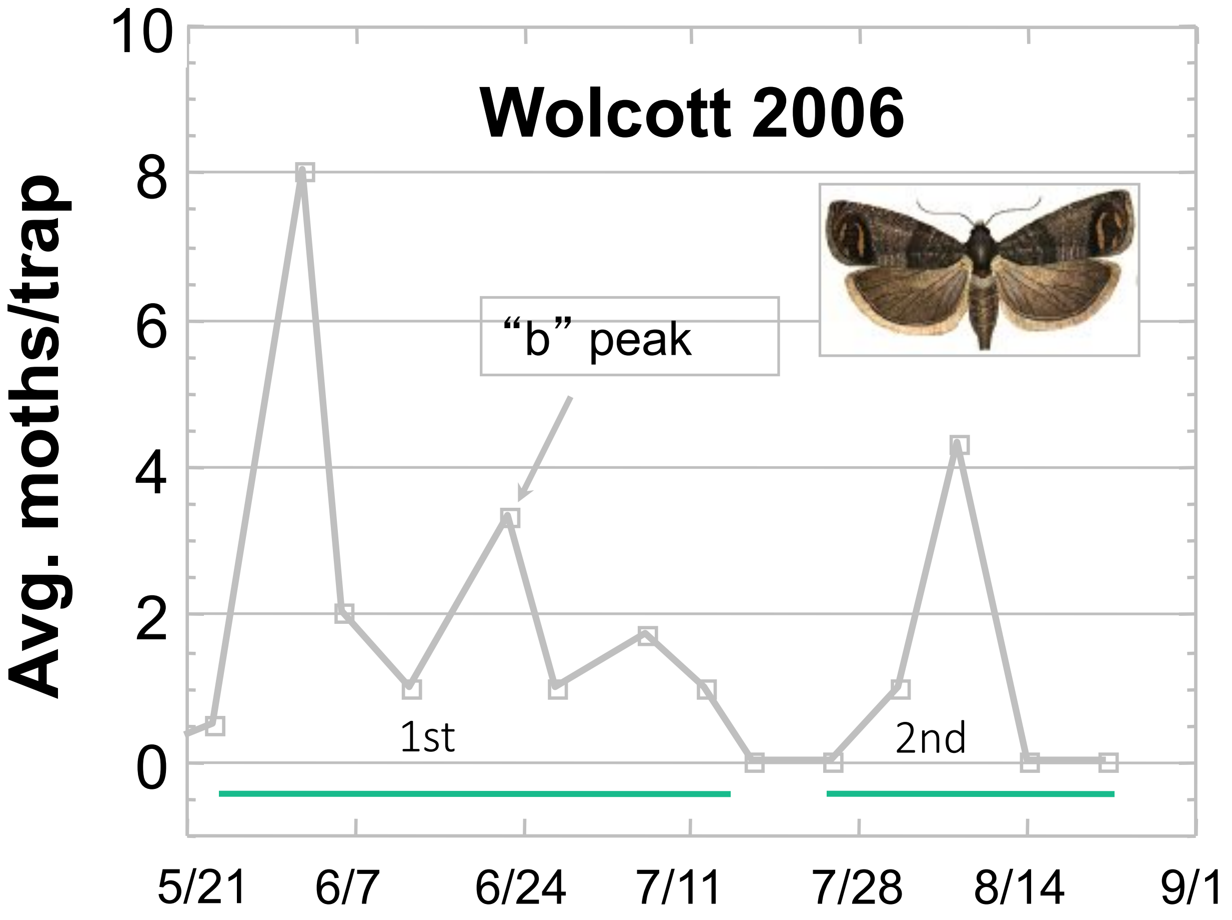
OFM

LAW

Codling Moth Biology...

- ✓ Native to Asia, in quince, apple and pear
- ✓ Brought to US by first colonists
- ✓ Hosts: apple, pear, quince; also hawthorn, crab apple; sporadic pest of apricot, peach, and plum (if planted adjacent to high population in apples)
- ✓ May be a different strain in walnut
- ✓ Larvae can overwinter in bin piles from infested crop

CM Flight Timing



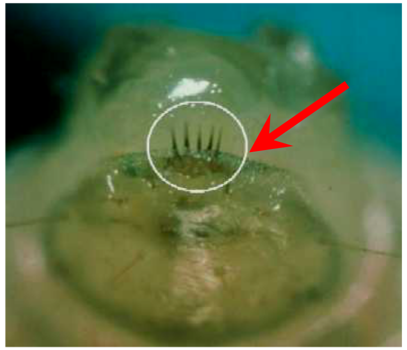
- Mean date of 1st catch in Geneva: May 18 ± 7 days
- 2019: May 29-June 3 in Wayne Co.
- Biofix generally corresponds with date of Red Delicious king bloom

CM Egg Stage

- ✓ Egg-laying starts ~100 $DD_{50°\ F}$ after biofix
- ✓ Single, flat, oval, 1/20 inch; mid "red ring" and later "black head" stages
- ✓ Laid mostly on upper (apple) or lower (pear) leaf surfaces, and on fruit
- ✓ About 100 eggs/female; 90% laid in first 5 days
- ✓ Hatch in 6-14 days (starting ~250 $DD_{50°\ F}$ after biofix)

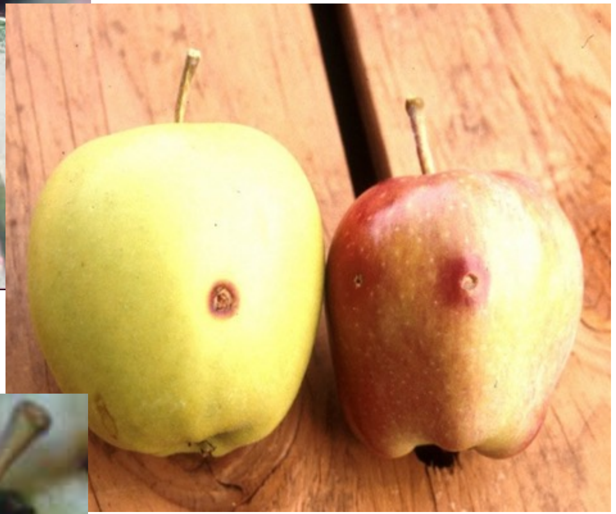
CM Larval Stage

- ✓ Newly hatched: 1/10 inch; mature: 5/8 inch
- ✓ Creamy white to pinkish
- ✓ Head capsule black (young) to brown (mature)
- ✓ No anal comb (differs from OFM)
- ✓ Feeds for 3-4 weeks in fruit



CM Larval Stage

- ✓ Injury (internal):
- ✓ “Stings”: shallow entries, larvae killed or exited from fruit
- ✓ “Deep entries”: to core, leads to fruit rot
- ✓ Commonly feed on seeds
- ✓ May find multiple larvae in single fruit


Codling Moth Problems in the 1990s to the Present

- In the early 1990s, outbreaks of codling moth occurred in commercial apple orchards throughout the world.
- First outbreaks of CM occurred in apple orchards in Washington & California apple growing regions
- Within the last 15 years, outbreaks of internal Lepidoptera have occurred in commercial apple orchards in all major production areas in the USA.
- Most of these outbreaks have been associated with the development of insecticide resistance, often to multiple classes of compounds.

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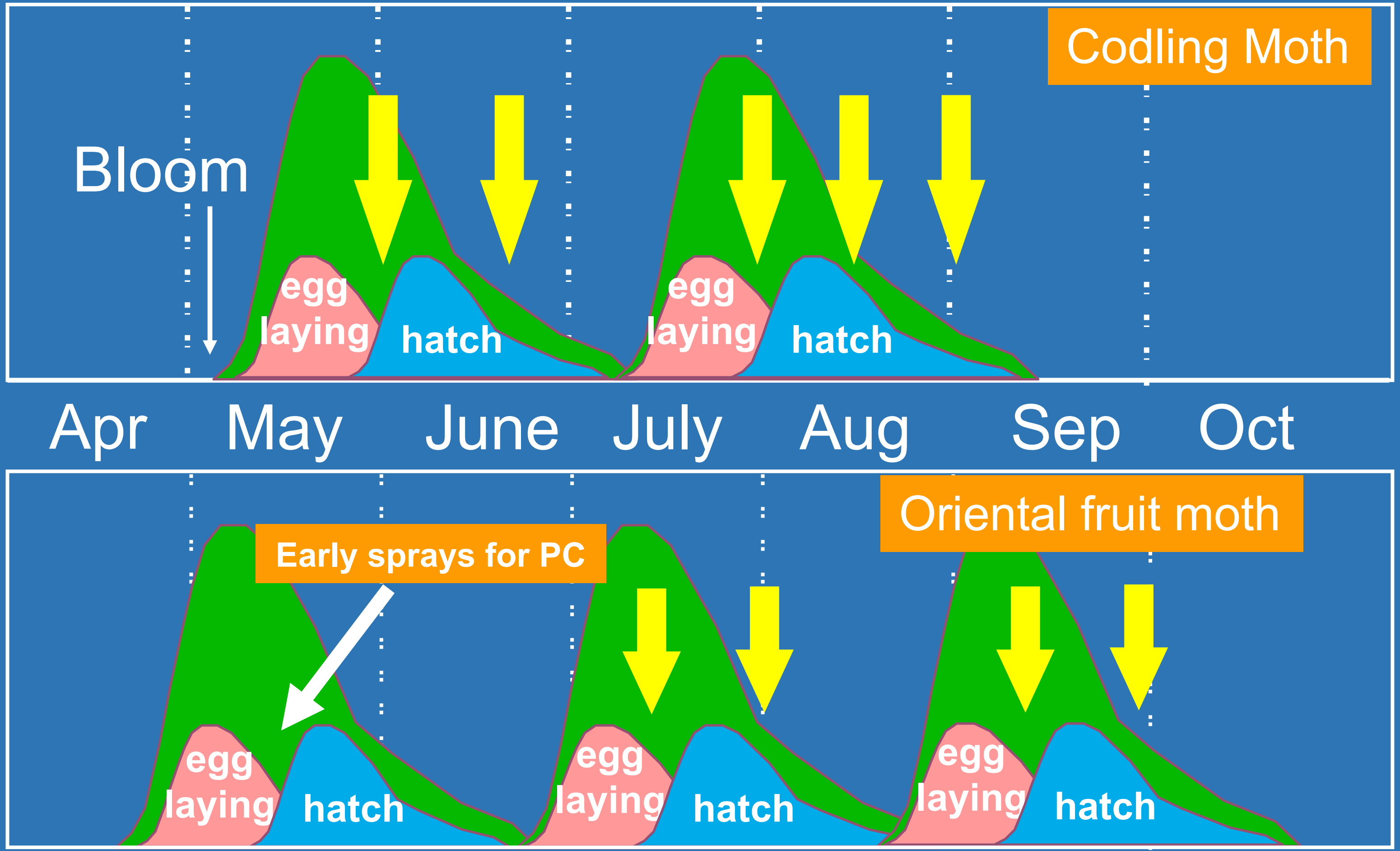
What causes lack of effective CM/OFM control?

- Resistance to standard insecticides
- Biological factors, such as overwintering survival or changes in generation timing or duration
- Less than adequate performance of new materials – changes in spray programs
- Poor timing or stretching of spray intervals ➔ gaps of opportunity
- Use of rates that are too low
- Inadequate spray coverage
- Rain events

Differences in Life Histories and Spray Timings

Critical protection windows for Internal Lepidoptera



Use of pheromone traps to assist in decision-making, to tell you:

- What? - Detection (presence)/species ID
- When? - Establishment of biofix
- How many? - Determination of pest level
- Significant points in life cycle - Chart developmental progress (e.g., 1st flight, peak flight, hatch period)

Density of traps - How many to use?

- 1 trap/5 acres (idealistic)
- 1 trap/10-20 acres (realistic)
- no traps (“asking for trouble”)

CM/OFM Adult Monitoring

What type of trap to use?
options:

- **Pherocon IIB**
- **Pherocon VI**
- **Pherocon 1C**
- **Multipher**

What type of lure to use?
- **Red septum - cheap, but short field life (3-6 weeks)**
- **Gray septum (L2) - more expensive, but longer life**
- **CM-DA - pheromone + pear essence (more useful in MD blocks)**

Use of CM & OFM Pheromone Trap Catches for Apple in New York

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Use pheromone traps to:

1. Establish biofix (1st trap capture) for Degree Day accumulations; need to calculate, or use NEWA (CM: base 50°F; OFM: base 45°F)

2. Determine need/timing for spraying
CM: If >5/week, 250 DD after start of each flight; 150 DD for ovicides; e.g., Rimon (1 application/season), Intrepid OFM: If >10/week, 170 DD after start of each flight
   a) 1st broods: PF-1C sprays
   b) if have both species => use either or both trap catch thresholds

1. What specific information is needed to use degree days to chart insect development?

A) biofix; calendar date; developmental baseline

B) biofix; developmental baseline; tree phenology

C) biofix, developmental baseline, daily maximum & minimum temperatures

D) calendar date; daily maximum & minimum temperatures; tree phenology

2. Pheromone monitoring traps can help indicate whether the insect population is over threshold for treatment

A) true

B) false

3. The plum curculio model is based on the need to protect the fruit until the oviposition period is completed

A) true

B) false

4. What is probably most responsible for the increase in CM and OFM damage in NY orchards over the past 20 years?

A) immigration of CM and OFM into orchards where they weren't previously present

B) development of insecticide resistance

C) climate change

D) development of newer apple varieties that are more susceptible to attack than the ones that used to be grown