IPM

Integrated Pest Management

(Insect/Mite Management)

A pest population management system that anticipates and prevents pests from reaching damaging levels by using economically, environmentally, and socially suitable methods to maintain pest populations below levels that are economically harmful

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The IPM Concept Recognizes

- No silver bullet
  - Dependence on any one management method likely will have undesirable effects
    - ✓ Pesticide resistance
    - ✓ Secondary pest outbreaks
    - ✓ Pest resurgence
    - ✓ Unacceptable/ unnecessary economic/ environmental costs

- Determine and correct the cause of the pest problem
  - Understanding pest biology and ecology is essential
  - Manipulate the environment to the crop's advantage and to the detriment of the pest

- Pest eradication is generally not possible and usually not desirable
  - Some damage is unavoidable and acceptable
  - Low pest populations maintain natural enemy numbers
  - Manage rather than eliminate insect populations

Key IPM concepts:

- Decision making tools:
  - Pest/benefiicial identification
  - Sampling/monitoring
  - Economic/action threshold

- Knowledge of pest and crop biology and ecology
- One or more management tactics:
  - Cultural
  - Chemical
  - Biological control

Decision making tools: Pest Identification

Ability to identify pest and beneficial insects: know what to count.



Pest or Beneficial?

Which pest is it?

What stage is it?

Generally need to determine to the species level




Which weevil is most evil?

Sitona spp: short snout, root feeding larvae

Sampling approaches and management options differ

Hypera spp: longer snout, leaf feeding larvae

Decision making tools: Sampling and monitoring (scouting)

- ✓ Increased awareness of insect activity in fields, orchards and fields
- ✓ Provides reliable estimates of:

Presence
Abundance
Distribution

} of pest and beneficial insects

Decision making tools: Sampling and monitoring (scouting)

Make cost effective and environmentally sound insect management decisions

- ✓ When (or if) to apply control measures
- ✓ Apply the right control
- ✓ Avoid pest outbreaks/yield loss
- ✓ Avoid unnecessary treatments
- ✓ Resistance management
- ✓ Did control efforts work?

How to sample

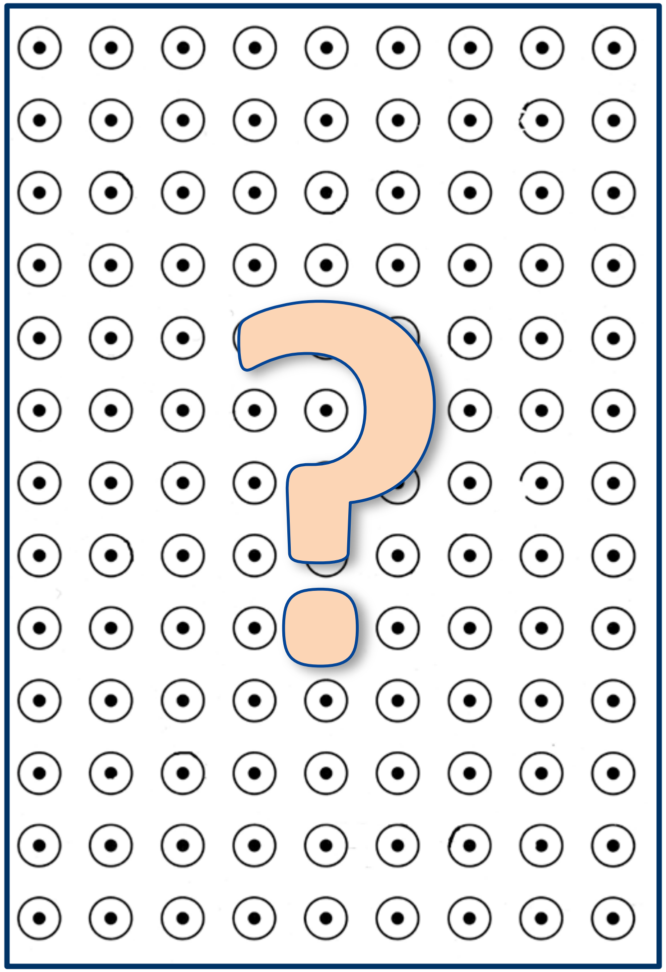
Generally we walk through the field/orchard and count pest and beneficial insects or pest damage

- Our goal is to reliably estimate the actual density (e.g. insects per leaf or sweep)

How do we find out?

Count them all?

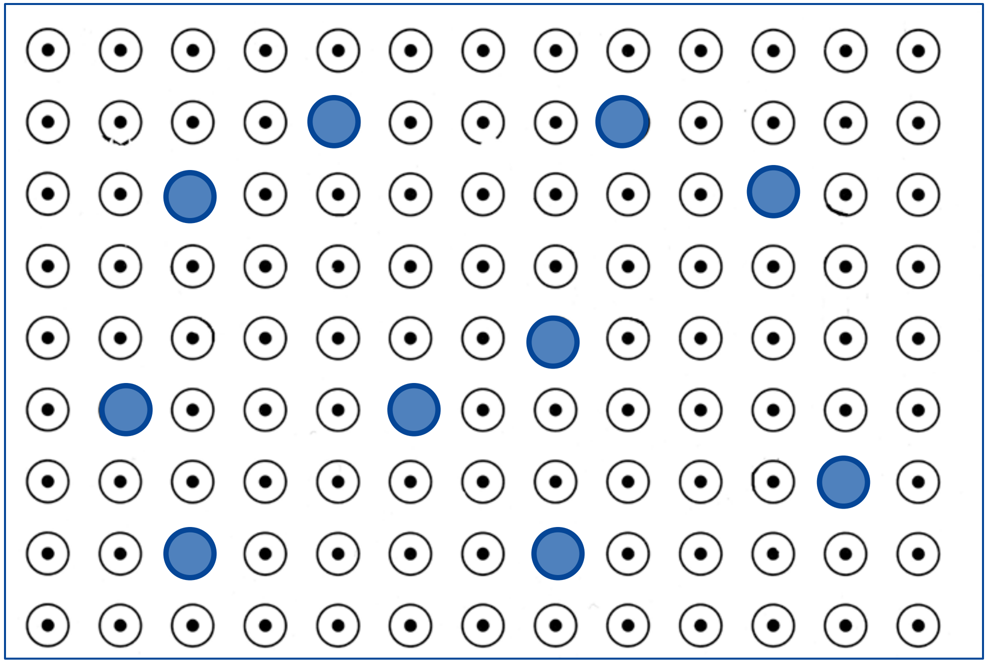
- Estimate the density by sampling a only portion of the population
- Almost always interested in estimating mean density per sample unit (leaf, sweep, etc.)



Sample vs. subsample

Sample unit (subsample): the individual unit from which insects are counted: the counts from one or more inspections at a scouting stop

- Single leaf
- Stem, shoot or branch
- Fruit
- Sweep of an area
- Trap counts



Sample: all of the sample units (subsamples) collected to estimate the population density of pest or beneficial insects or mites in a field or portion of a field

Sample size: the number of sample units (subsamples) per sample

Sample vs. sample unit

10 leaves (subsamples) per vine from each of 20 vines

Sample size =200

5 sweeps (subsamples) per site from each of 5 sites

Sample size =25

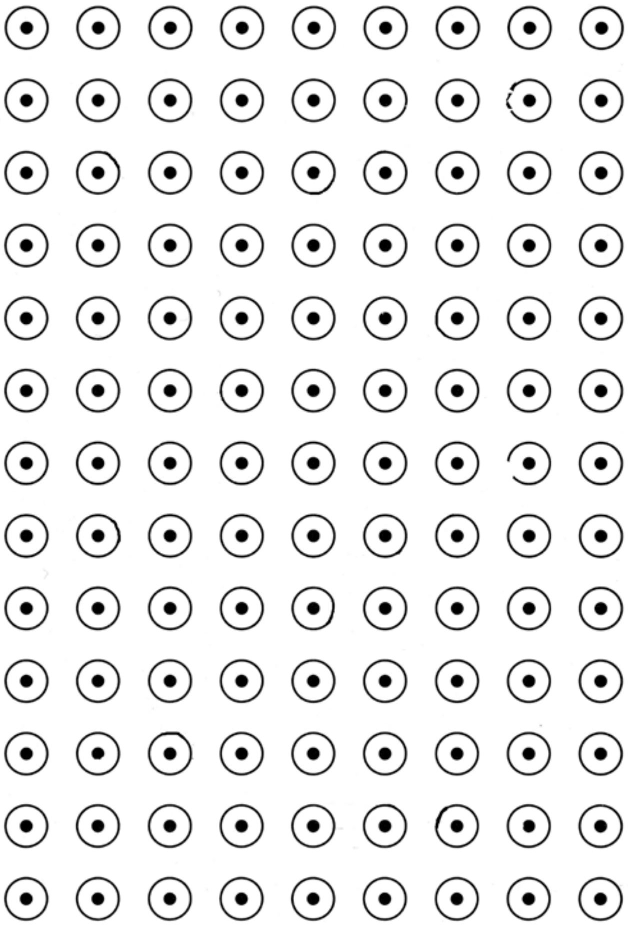
Always sample from more than one tree, vine, area per field or block

Representative samples

We need to reliably estimate the actual mean density (e.g. pests per leaf or sweep)

Samples should be unbiased

- Representative of the area (field/block) being sampled
  - Sampling only from areas showing damage gives estimates higher than actual mean
  - Sampling only from undamaged areas gives estimates lower than actual mean
- Each sample unit should have an equal chance of being selected



How to sample

Walk a predetermined route that covers the entire field

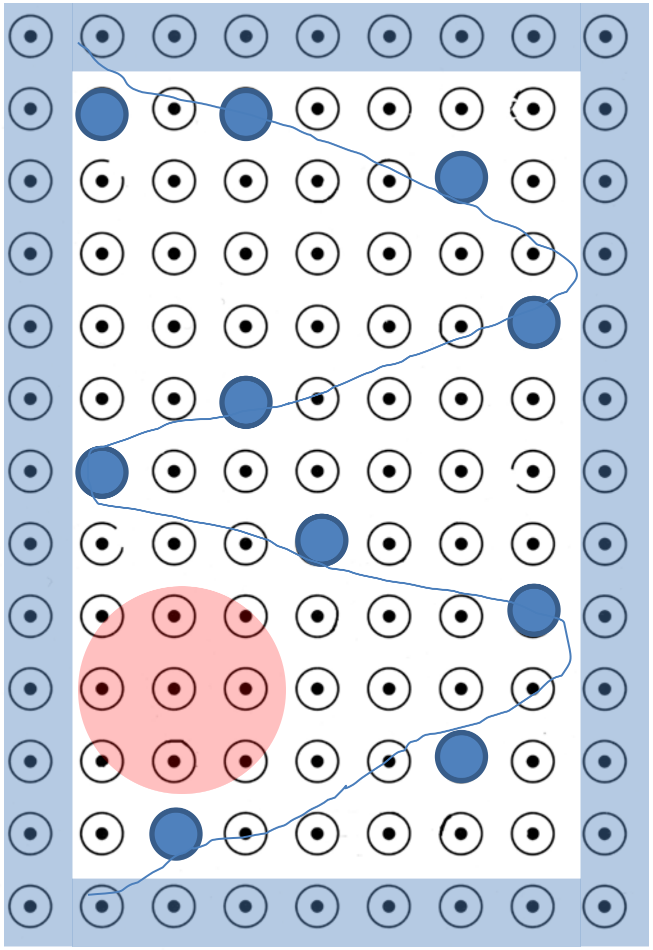
Zig-zag or "W" shaped routes are good

Make observations about field conditions while scouting

Don't sample from plants that are obviously more or less healthy than the field generally

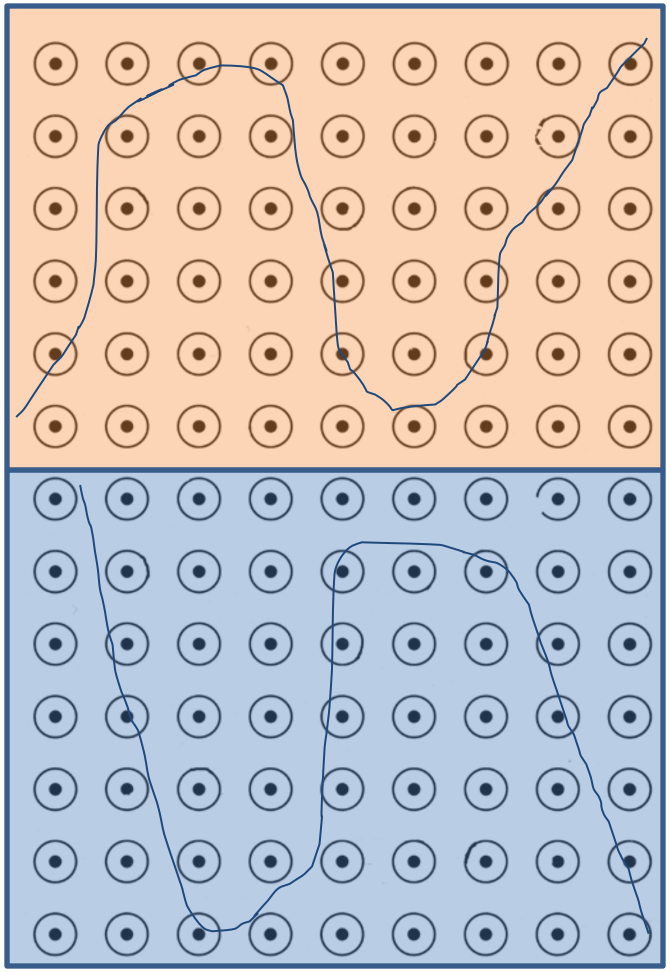
Don't consistently sample from leaves/areas within easy reach

Consider separate samples from field edges and "hot spots"



How to sample

Take separate samples for units (fields/blocks) managed differently



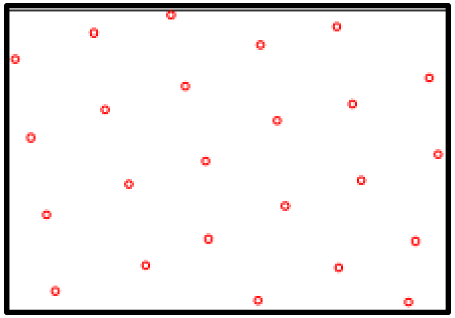
- Different varieties
- Different fertilization
- Different irrigation
- Different ages
- Different previous crop

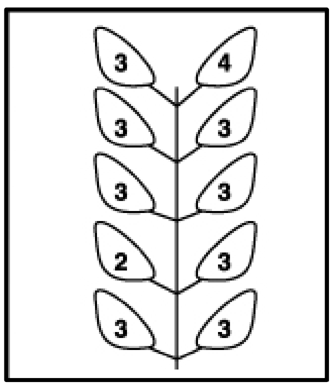
How many samples are required?
Depends on insect distribution

Possible Insect distributions in fields or on plants

Uniform

Mean>> variance





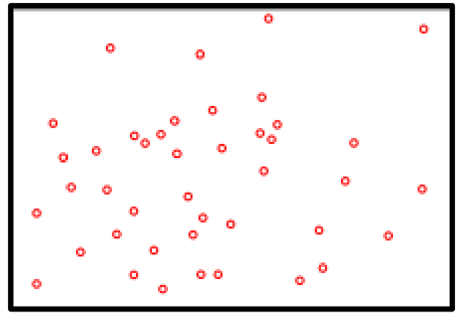
Mean=3

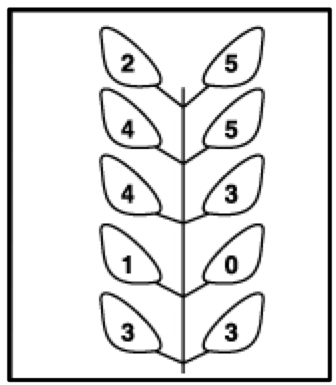
Variance=0.2

Few samples needed: rare

Random

Mean≈variance





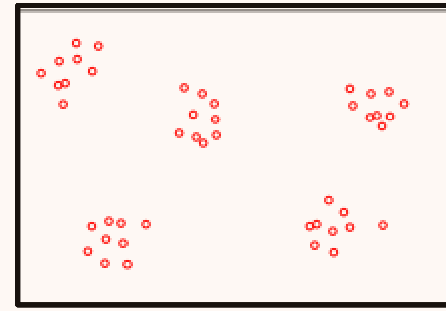
Mean=3

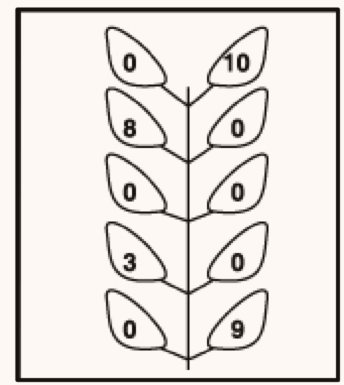
Variance=2.6

More samples needed: uncommon

Clumped

Mean<< variance





Mean=3

Variance=18.2

Many samples needed: most common

From Orchard Pest Management: A Resource Book for the Pacific Northwest

Knowing the number of samples to take requires detailed information about the mean to variance relationship

- Changes with each pest and crop combination
- Changes as density increases for each pest
- Changes for different stages of same pest

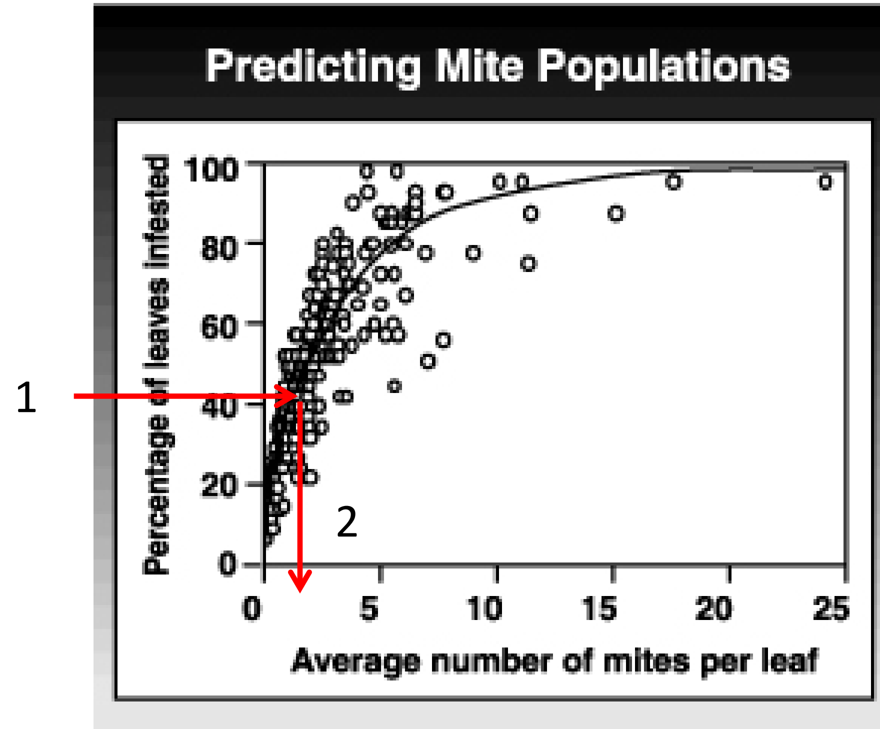
Most sampling plans use a fixed number of samples to provide a conservative estimate of the mean

Mean to variance relationship can also be used to develop sampling plans that don't rely directly on the sample mean

- Presence absence (binomial) sampling plans
- Sequential sampling plans

Presence absence (binomial) sampling

- Relationship between % of infested sampling units (e.g. leaves) and mean at different pest densities
- Tally number of leaves infested instead of counting pests
- Estimates unreliable when infestations are high (≥ 80%)



% infested leaves can provide an accurate estimate of the mean

From Orchard Pest Management: A Resource Book for the Pacific Northwest

Presence absence (binomial) sampling example

European red mite in apple

- Examine 5 leaves from each of 10 trees per block
- Sum the number of infested and uninfested leaves from each tree
- Calculate the % infested leaves in the entire sample (27/50)*100 = 54%
- Read estimated density from table

From Orchard Pest Management: A Resource Book for the Pacific Northwest

Binomial (Presence-Absence) Sampling Scheme for European Red Mite

% of mite-infested leaves	Estimated density (mites/leaf)	95% confidence interval lower	95% confidence interval upper
40	0.7	0.25	1.20
45	0.9	0.35	1.45
50	1.1	0.45	1.75
55	1.3	0.60	2.13
60	1.6	0.80	2.65
65	2.0	1.05	3.25
70	2.6	1.35	4.10
75	3.4	1.85	5.35
80	4.7	2.55	7.25
85	6.8	3.85	10.55
90	11.4	6.50	17.55
95	26.4	15.30	40.30

Choose 5 to 10 leaves from 5 to 10 trees scattered throughout a block. Scan the leaves with a hand lens to determine whether or not mites are present. Keep track of the total number of leaves scanned, and the total number of leaves infested by one or more mites. Divide the number infested by the total number scanned and multiply by 100 to calculate the percentage of infested leaves. Use the nearest value from the first column of the table above and read across to obtain the estimated number of mites per leaf for the orchard block.

EXAMPLE

Tree	Infested leaves	Uninfested leaves
1	//	///
2	/	////
3	///	//
4	//	///
5	////	/
6	///	//
7	/	////
8	~~////~~	0
9	~~////~~	0
10	/	////
Total	27	+ 23 = 50

Keep a tally sheet of infested and non-infested leaves, similar to the one above, as you go through the orchard. For example, you find 27 infested leaves and 23 uninfested leaves, for a total of 50 leaves. Divide 27 (the number of infested leaves) by 50, which is 0.54. Then multiply by 100 to obtain the percentage of infested leaves, which is 54 percent. According to the table, 54 percent infested leaves is equivalent to 1.3 mites per leaf.

From the *Tree Fruit Production Guide 1992-1993*, Penn State College of Agricultural Sciences

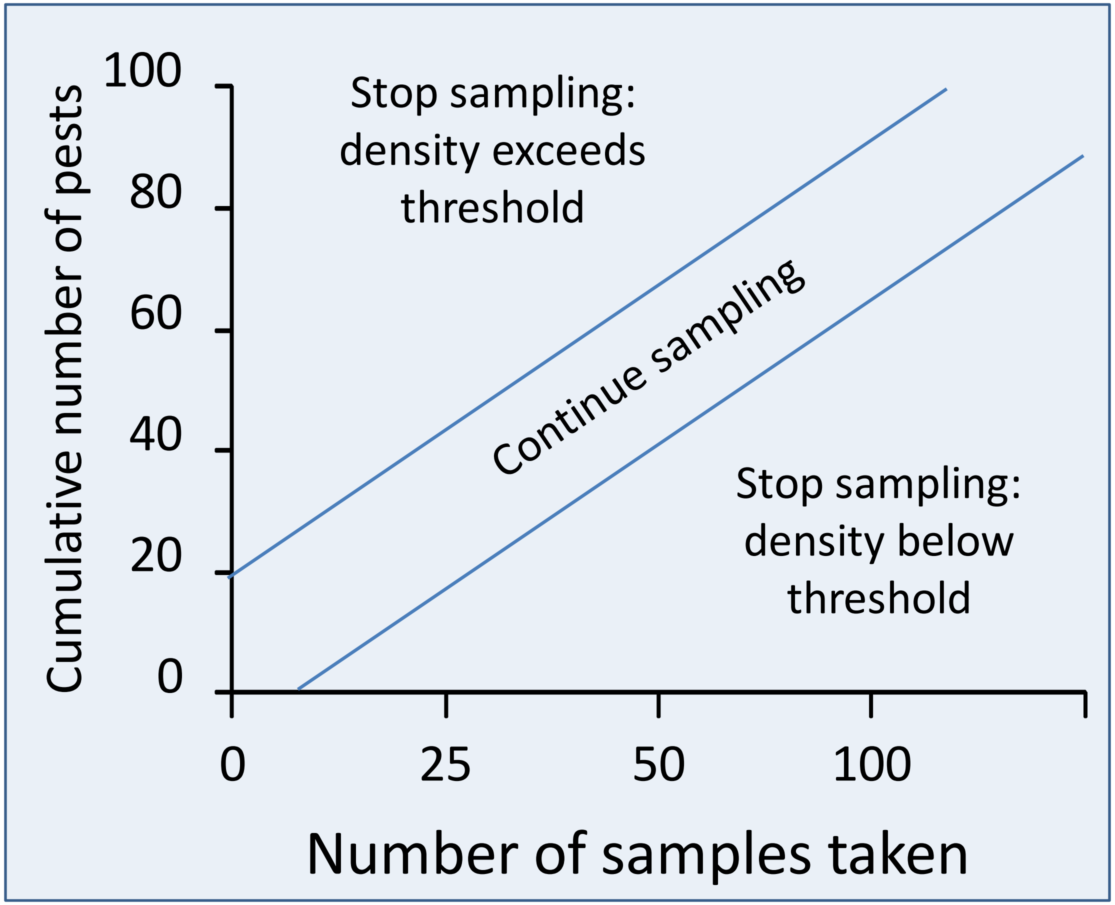
Sequential sampling

Take some minimum number of samples, then make a decision to stop or continue sampling

- Stop sampling: treat or don't treat

You've taken enough samples to make a decision

- Continue sampling: need more samples to make a decision



Usually some maximum sample number

Sequential sampling example: *Campylomma* plant bugs in apple

- Minimum sample: 10 taps per block
- Maximum sample: 50 taps per block
- Alternative fixed sample plan: 20 taps per block

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Sequential Sampling Plan for Campylomma

Red Delicious (threshold 4 per tap)			Golden Delicious (threshold 1 per tap)		
Total taps	Cumulative no. of nymphs: Upper	Lower	Total taps	Cumulative no. of nymphs: Upper	Lower
10	53	27	10	15	5
11	58	30	11	17	5
12	62	34	12	18	6
13	67	37	13	19	7
14	71	41	14	20	8
15	76	44	15	21	9
16	80	48	16	23	9
17	85	51	17	24	10
18	89	55	18	25	11
19	94	58	19	26	12
20	98	62	20	27	13
21	103	65	21	29	13
22	107	69	22	30	14
23	112	72	23	31	15
24	116	76	24	32	16
25	121	79	25	33	17
26	125	83	26	34	18
27	129	87	27	36	18
28	134	90	28	37	19
29	138	94	29	38	20
30	143	97	30	39	21
31	147	101	31	40	22
32	151	105	32	41	23
33	156	108	33	43	23
34	160	112	34	44	24
35	164	116	35	45	25
36	169	119	36	46	26
37	173	123	37	47	27
38	177	127	38	48	28
39	182	130	39	49	29
40	186	134	40	51	29
41	190	138	41	52	30
42	195	141	42	53	31
43	199	145	43	54	32
44	203	149	44	55	33
45	208	152	45	56	34
46	212	156	46	57	35
47	216	160	47	58	36
48	221	163	48	60	36
49	225	167	49	61	37
50	229	171	50	62	38

To use the chart, take a minimum of 10 taps. If the total number of nymphs is above the upper limit, control is warranted. If the number is below the lower limit, no control is needed and sampling may be discontinued. If the number lies between the two limits, continue sampling. If 50 taps are taken and no decision is reached, sample again in 5 to 7 days.

Plan developed for 90% confidence interval, 1st generation nymphs, in a 1.2 acre block of a conventionally managed commercial orchard (H.M.A. Thistlewood. 1989. Environmental Entomology 18(3):398).

Sampling methods

Visual samples

- Counts of insect/mites or damage directly on leaves, stems, fruit, roots…
- Aphids, scale insects mites, leafminers, small caterpillars, leaf hoppers, immature psyllids…
- Counts on site or in shop/lab

10x-20x hand lens useful

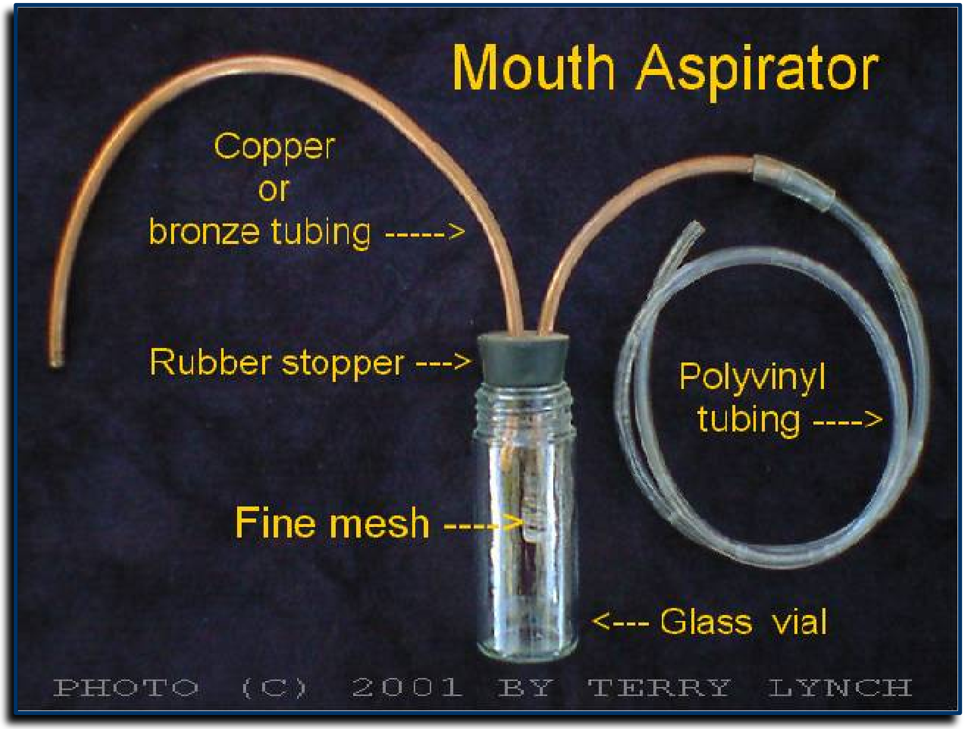
Sampling methods

Beat tray/cloth (tap) samples

- Jar insects/mites onto a tray where they can be easily counted
- Larger caterpillars, adult psyllids, aphids
- Counts on site or in shop/lab
- Hand lens/ aspirator useful

Sampling methods

Insect aspirator



Sampling methods

Sweep net samples

- Collects many insects quickly
  - Not selective
- Not as useful for tree and small fruits
- Useful for sampling ground cover and field edges
- Counts on site or in shop/lab
- Hand lens/ aspirator useful

Sampling methods

Attractant traps

Visual traps: colors and/or shapes used to attract insects

Yellow sticky cards:
aphids, fruit flies, thrips

Red spheres:
apple maggot

Can capture a lot of non-targets

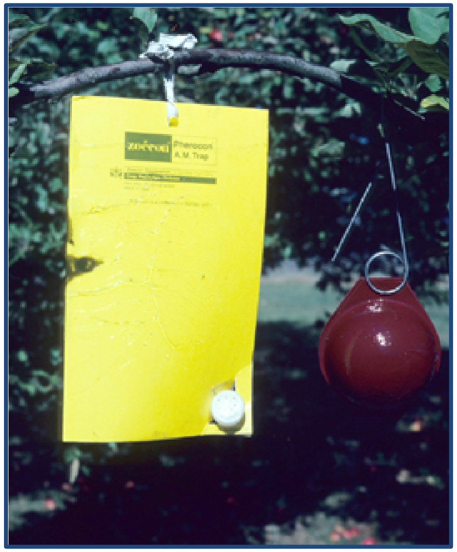
Sampling methods

Attractant traps

Food attractants: Food source scents

- Often an ammonia source: ammonium acetate, or ammonium carbonate
- May have a protein source (casein)
- Usually combined with visual/sticky traps





Increased selectivity

Sampling methods

Attractant traps

Pheromone traps:

- Most commercial pheromones are synthetic versions of natural scents produced by insects to attract mates
- Most are female-produced scents that attract males
- Usually species specific
- Synthetic pheromones available for many orchard and some field crop pests

Codling moth
San Jose scale
Red-banded leafroller
Oblique-banded leafroller
Peach twig borer

Fruit tree leafroller
Oriental fruit moth
Peachtree borer
American plum borer
Spotted tentiform leafminer

Corn earworm
California prionus
Mint root borer

Sampling methods

Attractant traps

Pheromone traps Consist of a lure or dispenser and a trap

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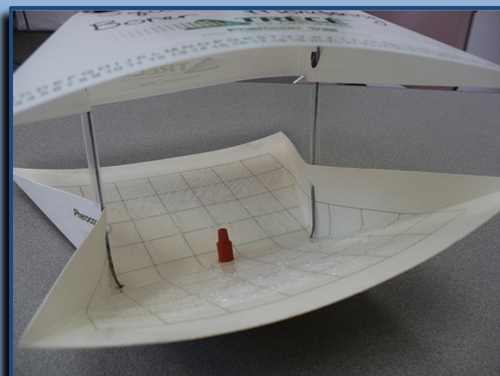

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Many available

Trap not needed for Mating disruption dispensers

Sampling methods

Attractant traps

Useful for monitoring pests and beneficial insects

- Monitor flight periods (Mint root borer)
- Synchronize DD models (setting biofix: peak flight)
- Monitor success of control programs
- Monitor exotic or invasive pests (apple maggot)

Useful for controlling pests

- Mating disruption (codling moth, peach tree borer)
- Mass trapping (apple maggot: visual + food attractant sticky traps)

Sampling methods

Growing degree days (GDD or DD models)

- Insects don’t grow or grow very slowly below some lower temperature threshold
- Insects don’t grow or grow very slowly above some upper temperature threshold
- Insect growth rate between the lower and upper thresholds increases with temperature
- Predicts insect development by accumulating heat units (degree days)
- Determine best time to sample or treat
    - ✓ Insects/ mites
    - ✓ Particular insect/ mite growth stage

Sampling methods

Monitoring degree days

- Biofix: When to begin accumulating degree days

  Calendar date or biological event (1^{st} or peak flight)

- Threshold temperatures
  - Lower threshold: no development below this
  - Upper threshold: no development above this
- Mean daily temperature: $\left(\frac{T_{max}-T_{min}}{2} \right)$
- Thermal constant: no. of DD required to reach a development stage (e.g. 50-60 DD from 1^{st} trap catch to first egg laying for codling moth)

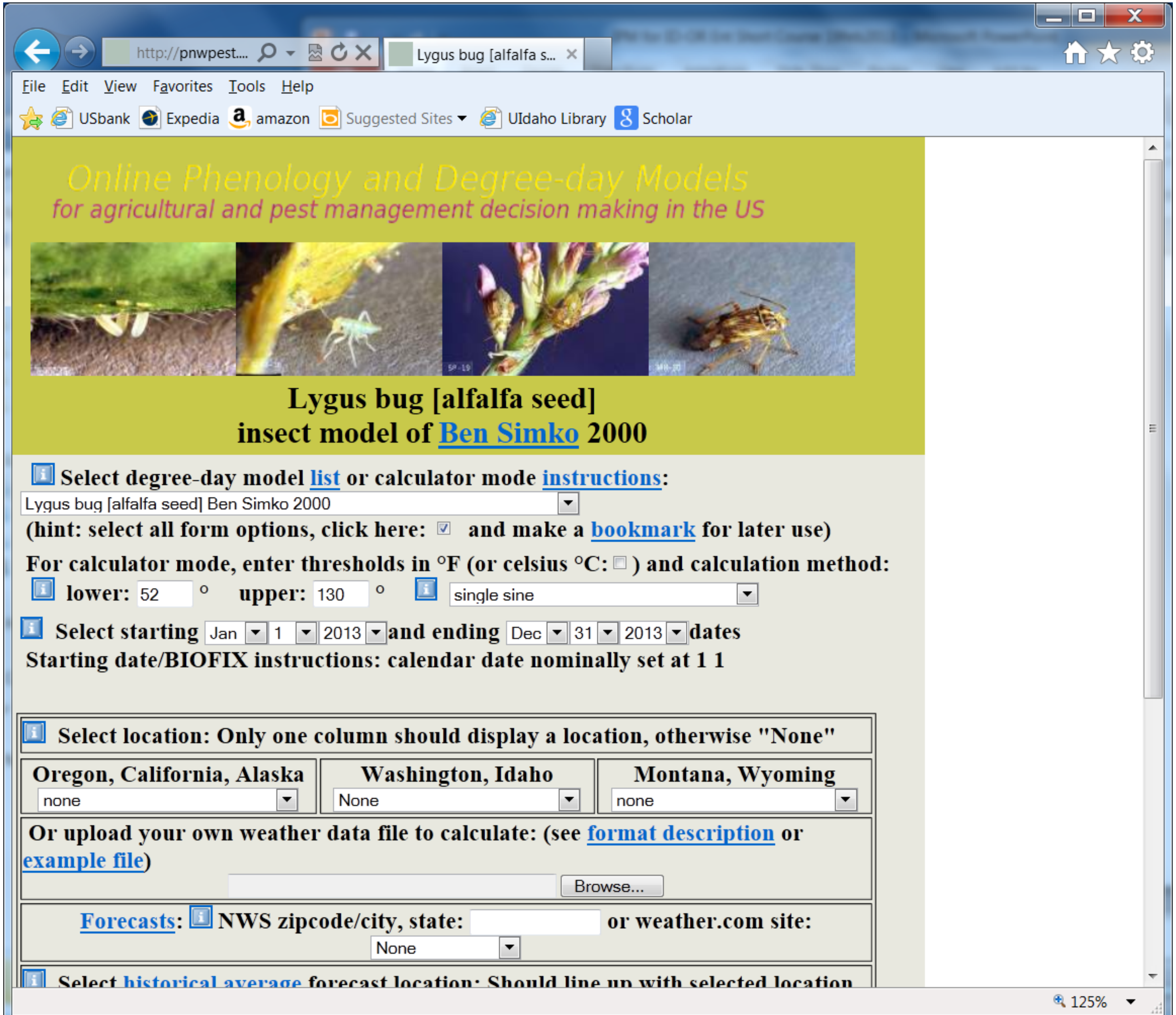
Sampling methods

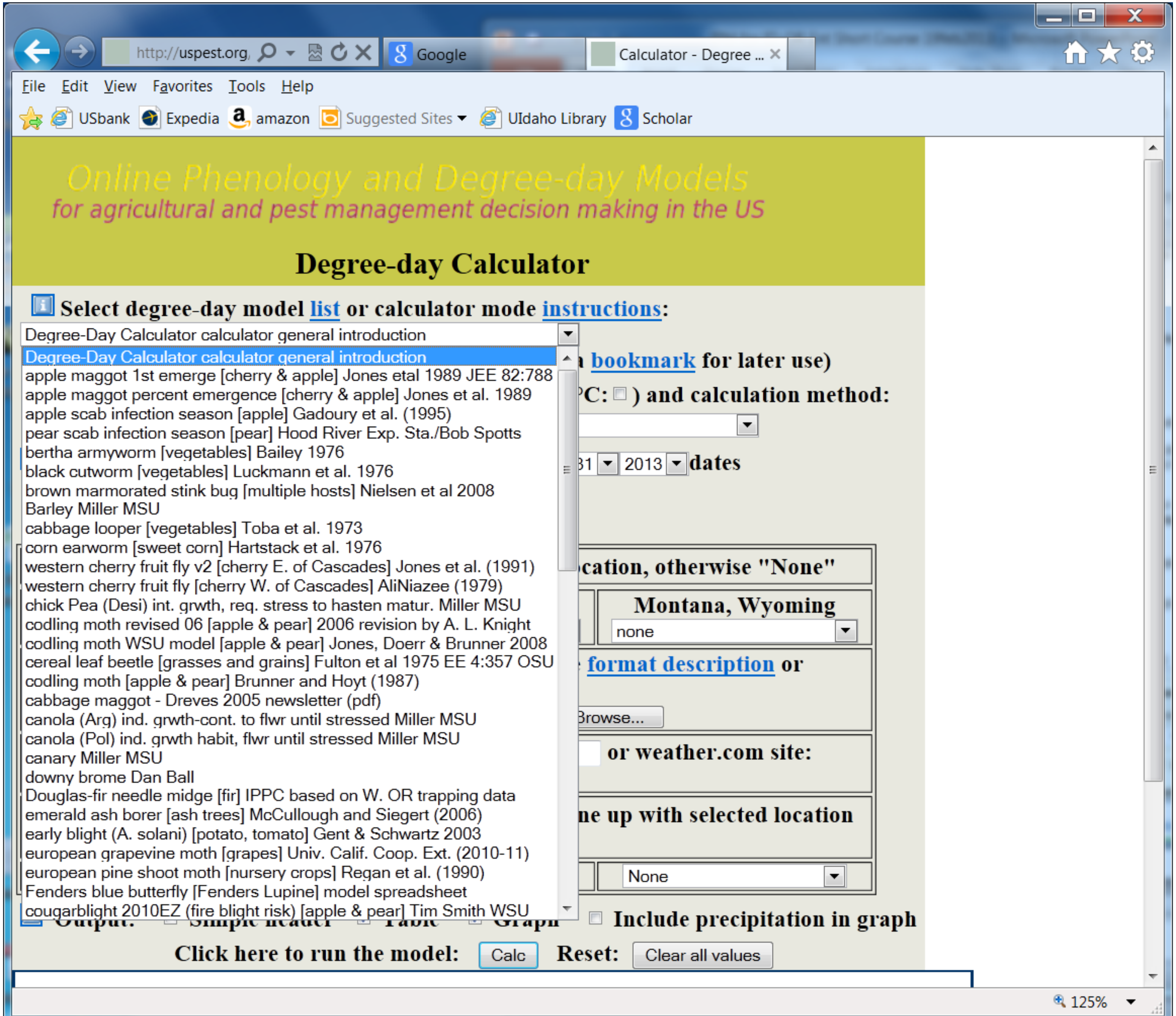
Accumulating degree days: for each day

$$\text{Degree days} = \left(\frac{T_{max}-T_{min}}{2}\right) - T_{low}$$

- ✓ Mean daily temp. ≤ Lower threshold: No DD accumulation
- ✓ Mean daily temp. > Lower threshold: DD accumulation
- ✓ Maximum daily temp never exceeds the upper development threshold

- Online models available for many pests http://uspest.org/cgi-bin/ddmodel.pl



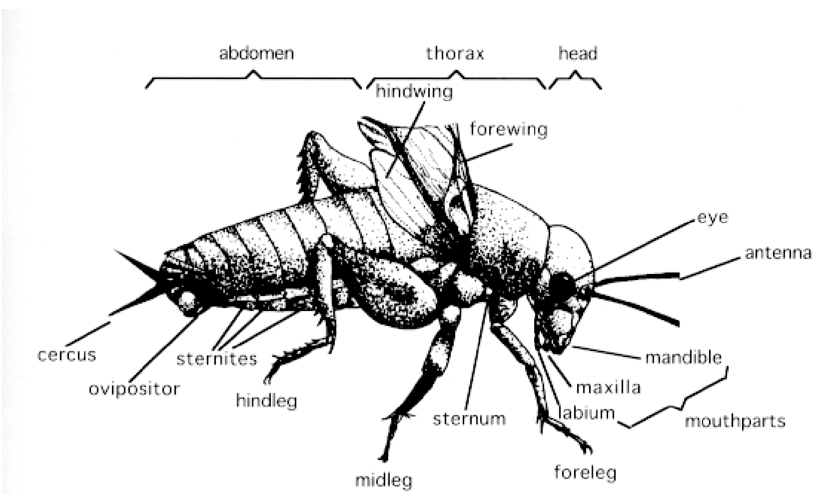


http://uspest.org/cgi-bin/ddmodel.pl

Knowledge of the pest and beneficial insects

Some familiarity with basic insect and mite structure

Insects



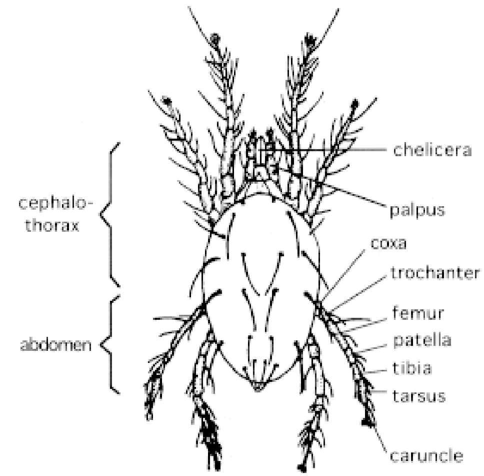
Small to tiny

3 body sections

6 legs

Adults usually winged

Mites



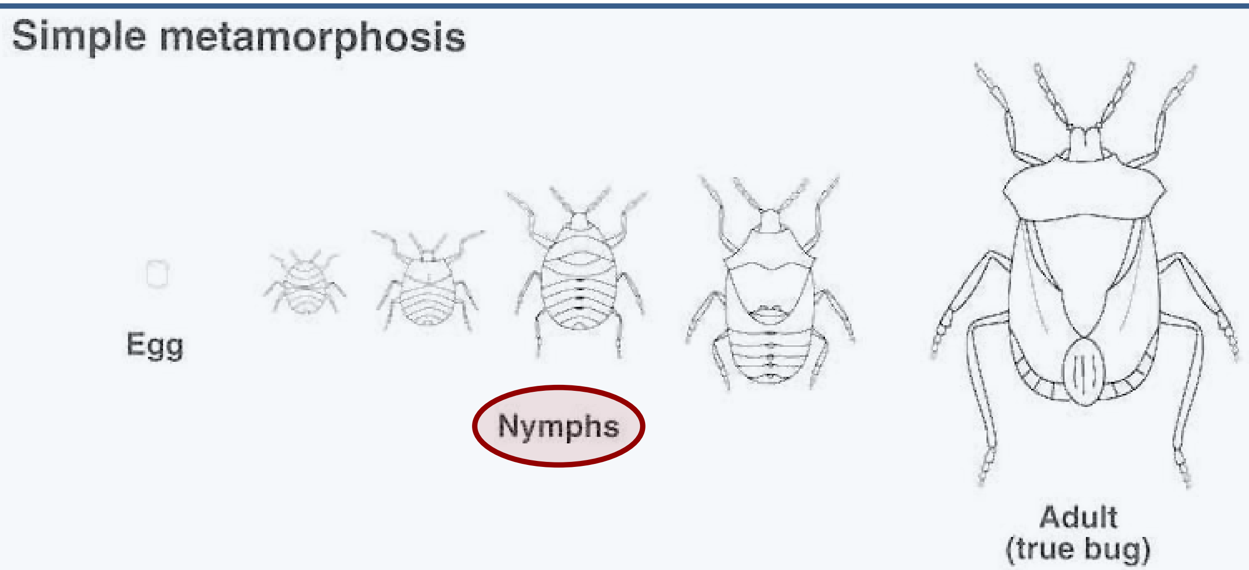
Tiny to minute

2 body sections

4 to 8 legs

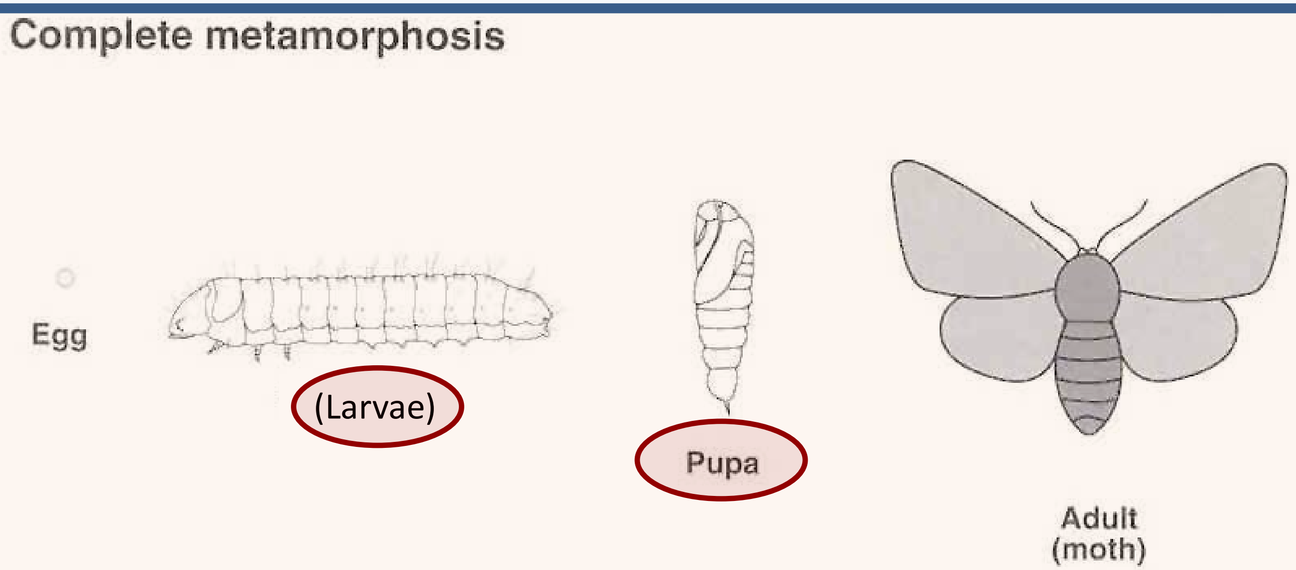
No winged stages

Knowledge of insect and mite biology: growth



True bugs
Grasshoppers
Leaf hoppers
Aphids
Scale insects

Mites



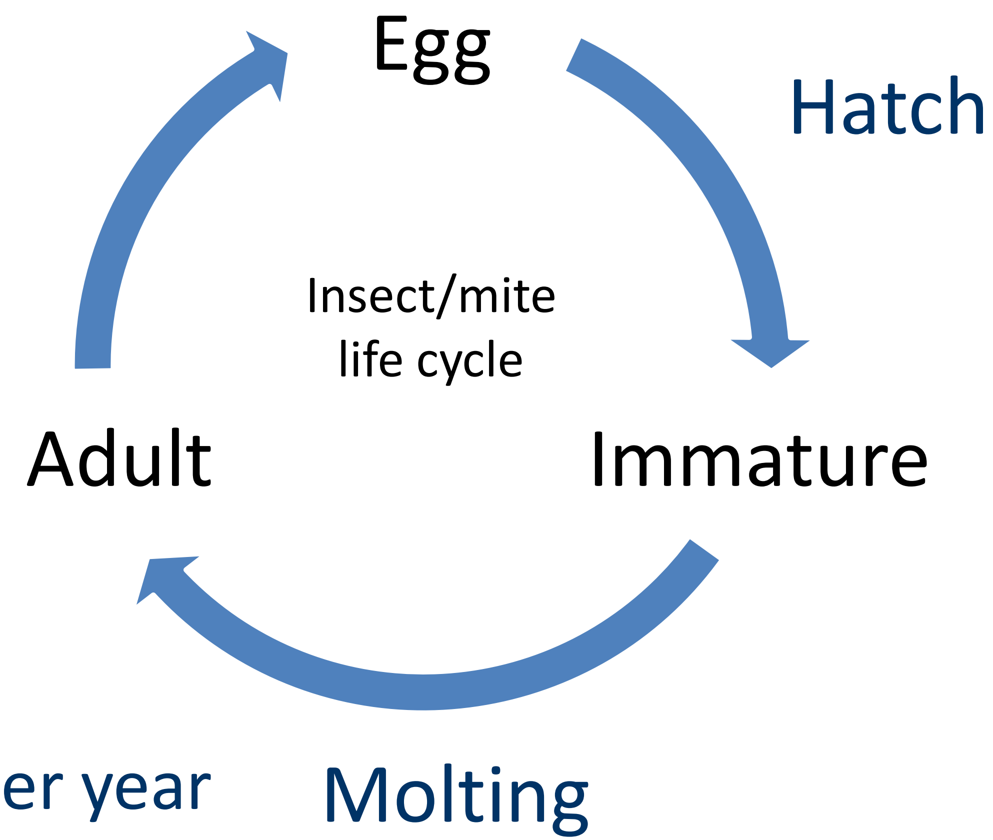
Moths
Butterflies
Flies
Thrips
Beetles
Bees and wasps

From Orchard Pest Management: A Resource Book for the Pacific Northwest

Knowledge of the pest and beneficial insects

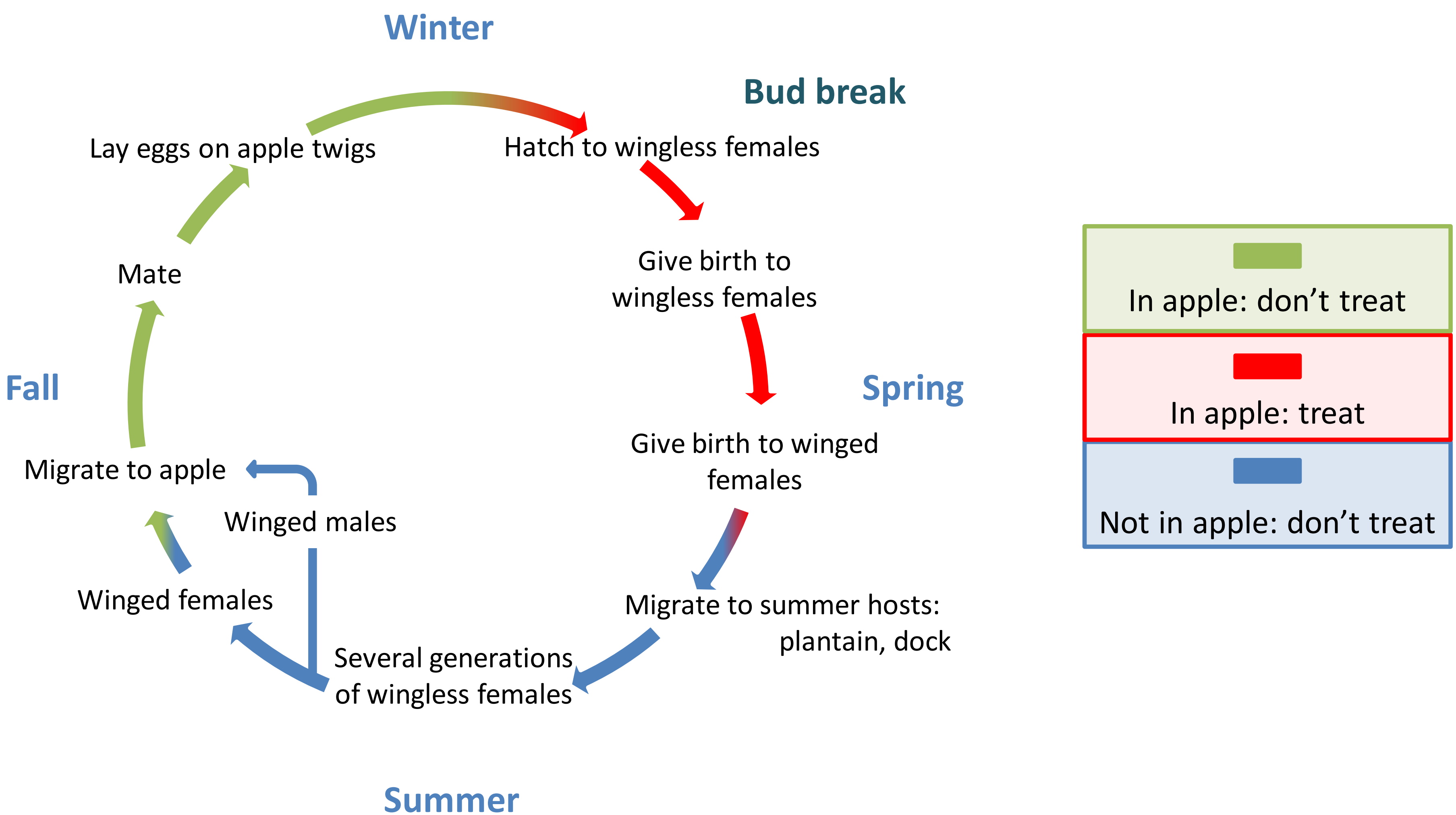
The life cycle and biology tells us when and where and how often to sample and treat: focuses sampling and control efforts

- Overwintering: where, when, what stage
- Hosts: the plants attacked
- Plant parts attacked
- Damaging stage
- When it’s present
- Number of generations per year
- Generation time



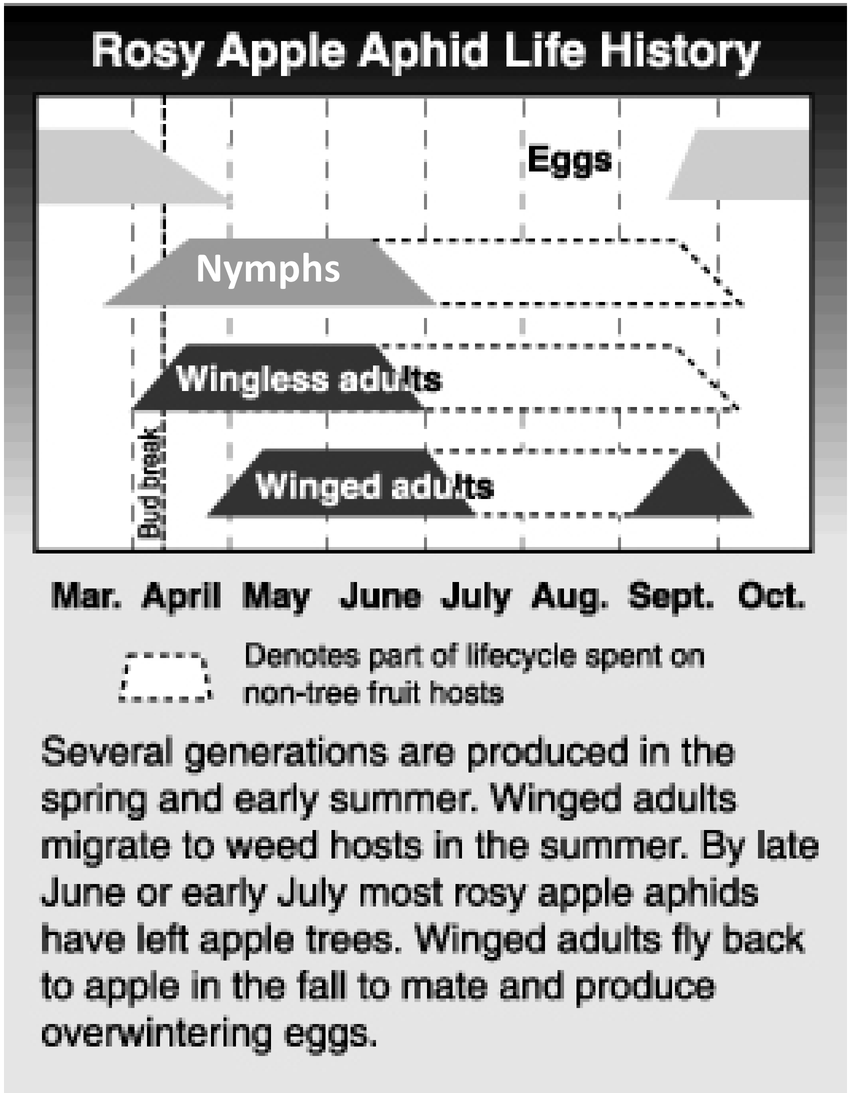
Knowledge of the pest and beneficial insects

Rosy apple aphid life cycle



Knowledge of the pest and beneficial insects

Life cycles can be displayed in life history tables



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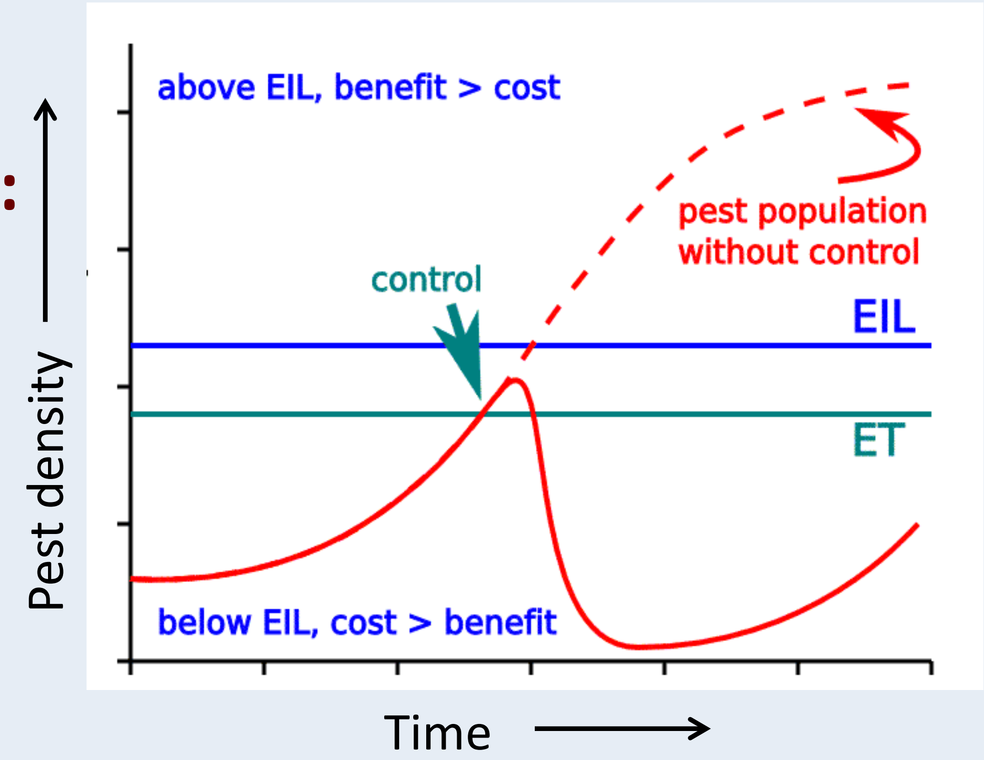
Economic injury levels and action thresholds

What do the sample numbers mean?

Economic injury level: pest level that causes significant crop loss defined as the pest population resulting in:

Yield loss = cost of control efforts

Economic (action) threshold: level at which a pest should be treated to prevent it exceeding the EIL

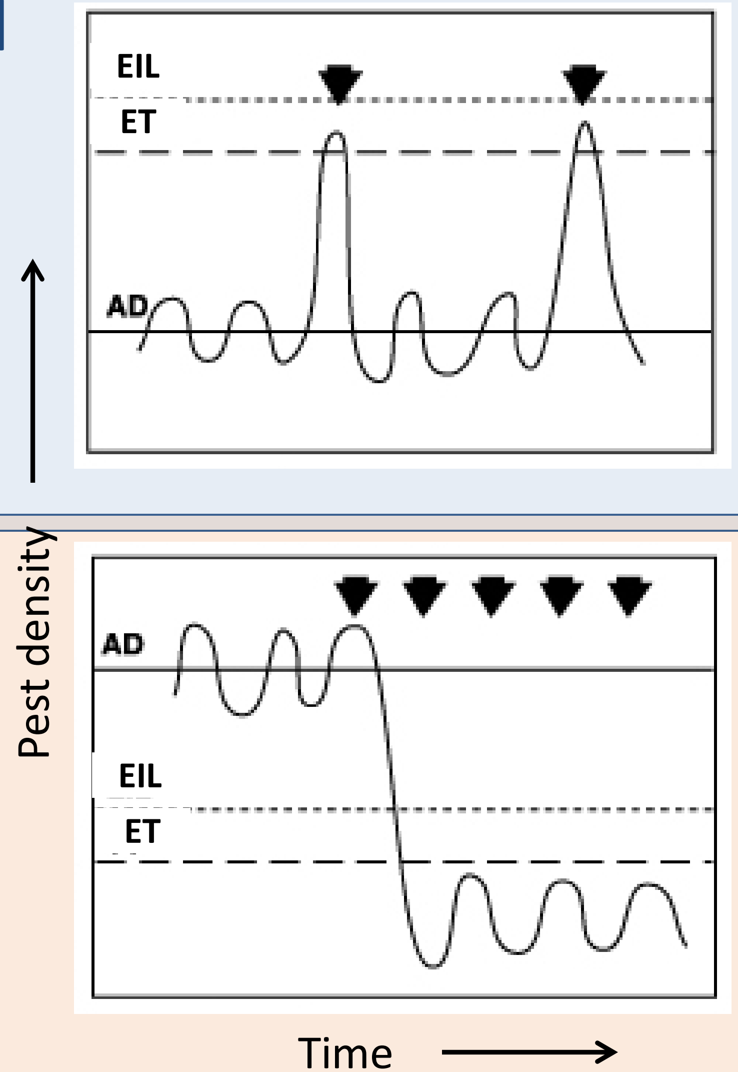


Action thresholds

Indirect vs. direct pests

Indirect pests: attack non-harvested plant parts (roots , shoots, leaves…)

- Higher tolerance level
- Density often below ET
- More response time



Direct pests: attack harvestable commodity (fruit, fruit buds…)

- Lower tolerance level
- Density often above ET
- Less response time

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Action thresholds

Formal EILs and ETs aren't available for many pest/crop combinations

Most ET's based on grower/researcher experience (empirical ET)

Sampling still a good idea:

- Detect pest presence
- Detect damaging stage
- Determine if effective natural enemies are present
- Determine if populations increasing or decreasing in density (from repeated samples)
- Determine effectiveness of control measures
    - Always sample before a treatment

Management options

All suitable pest management tactics should be considered

- Cultural
- Physical & Mechanical
- Natural or biological
- Chemical

Some tactics might fall Into several categories.

CULTURAL CONTROLS

Agronomic practices that are designed to:

- ✓Optimize growing conditions for the crop
- ✓Create unfavorable conditions for the pest

Any practice that increases a crop’s competitive edge will increase tolerance to pests often resulting in reduced pesticide use

CULTURAL CONTROLS

Tillage buries crop residues containing insects, diseases, and weed seeds, and disrupts root systems of perennial weeds
Drawback: stimulates weed seed germination; can cause soil erosion

Mulching with plastics or straw controls weeds , increase natural enemy nos.
high cost of equipment and labor, may increase pest nos. (e.g. slugs)

Burning crop residues reduces diseases.
Drawback: increase soil erosion, air pollution

Resistant/tolerant varieties have characteristics that protect them from diseases or insects. Example: a chemical produced in young corn plants gives them resistance to the European corn borer
Drawback: diseases or insects may overcome resistance tolerance

Crop rotation growing different crops in sequence can provide better weed and insect control, reduce levels of disease (especially those that survive on crop residue), and improve fertility. Example: rotating corn with soybeans to control corn rootworm

CULTURAL CONTROLS

Altering planting or harvest dates can reduce the impact of pests.

Example: cutting alfalfa early during alfalfa weevil infestations; planting wheat after the fall Russian wheat aphid flight.

Drawback: possible yields and quality reductions

Controlling alternative hosts means controlling weeds and crops that harbor pests. Example: weedy grasses in corn may attract armyworms, stalk borers

Drawback: many of these alternative hosts also support natural enemies of the pests

Sound agronomic practices promote vigorous crop growth and reduce risk of injury and increase the crop's ability to withstand pests

Physical and Mechanical Control

Devices and machines used to control pests or to alter their environment, including:

- Traps for insects, rodents, gophers, and birds
- Light to attract or repel pests; bug zappers
- Sound to kill, attract, or repel pests
- Barriers such as screens in homes and livestock shelters, metal or plastic barriers to prevent black vine weevil movement
- Radiation to sterilize or kill pests
- Cold or heat to kill pests, e.g. cooling grain bins over the winter to stop activity of grain-infesting insects and molds

Biological and Natural Control

Uses natural enemies or natural products to reduce pest populations.

Conservation biocontrol Create an environment that preserves already existing natural enemies. Examples: strip harvesting alfalfa to allow natural enemies to stabilize; avoiding pesticides, if possible, to preserve insect predators and parasitoids; planting cover crops, flower borders to provide natural enemy habitat

Inundative biocontrol Release reared natural enemies usually in very large numbers into the environment. Like applying a selective insecticide. Examples: the bacteria *Bacillus thuringiensis,* available locally, is very effective against the European corn borer; the parasitic wasp *Trichogramma* attacks European corn borer eggs and can be applied by air on certain high-value crops like peppers and sweet corn.

There are four types of natural enemies

Biological and Natural Control

Predators: each attacks and feeds on a few to many prey insects. May be specialists (*Stethorus* beetles on mites) or generalists (big-eyed bugs on aphids and insect eggs and small larvae.

Lady Beetles
(Coleptera)

Minute Pirate bugs
(Hemiptera)

Syrphid flies
(Diptera)

Biological and Natural Control

Parasitoids: each lives in or on a larger host which is killed as the parasitoid(s) develops. *Bathyplectes* wasps lay their eggs in alfalfa weevil larvae

Trichogramma spp.

Braconid and Ichneumonid wasps

Aphidius and Aphytis, wasps

Biological and Natural Control

Diseases (pathogens) attack insects and occur in natural or induced epidemics, killing large numbers of insect pests. The fungus *Beauveria bassiana* can cause decreases in population many caterpillar pests

Bacteria

Viruses

Fungi

Nematodes

Biological and Natural Control

Herbivores are insects that feed on plants. Some are crop pests, but some are important for control of noxious weeds: the weevil *Rhyncocyllus* has been introduced to feed on musk thistle seeds.

Galerucella leaf beetle on purple loostrife

Eustenopis seed head weevil on star thistle

Chemical Control

- Despite concern over their use, pesticides are still a important component of most IPM programs.
- Problems arise when people rely too much on pesticides.
- IPM seeks to restore balance so that pesticides are used only when they are really needed.
- Be aware of the possible *benefits* and *risks* of using pesticides.
- Wisely select when, where, and how to use pesticides to your best advantage in an IPM program.

Chemical Control

Benefits of pesticides

- Effective and reliable against a wide variety of pests
- Quick acting—when a problem reaches economically damaging proportions, pesticides can provide a rapid cure
- Economical when used properly
- Easily tested and incorporated compared to biologicals
- Widely available able compared to pest resistant varieties in most crops
- Easy to use

Chemical Control

Risks of pesticides

- Pest may develop resistance to the pesticide
- Injury to applicator and others
- Impacts on non-target organisms, including natural enemies of pests, pollinators, wildlife, and plants.
- Environmental contamination, such as residues in food and water
- Safety hazards in production, transportation, and storage

Legal Control

Actions taken under federal, state, or local laws to slow or stop the spread of plant pests, especially those that are brought in from other areas.

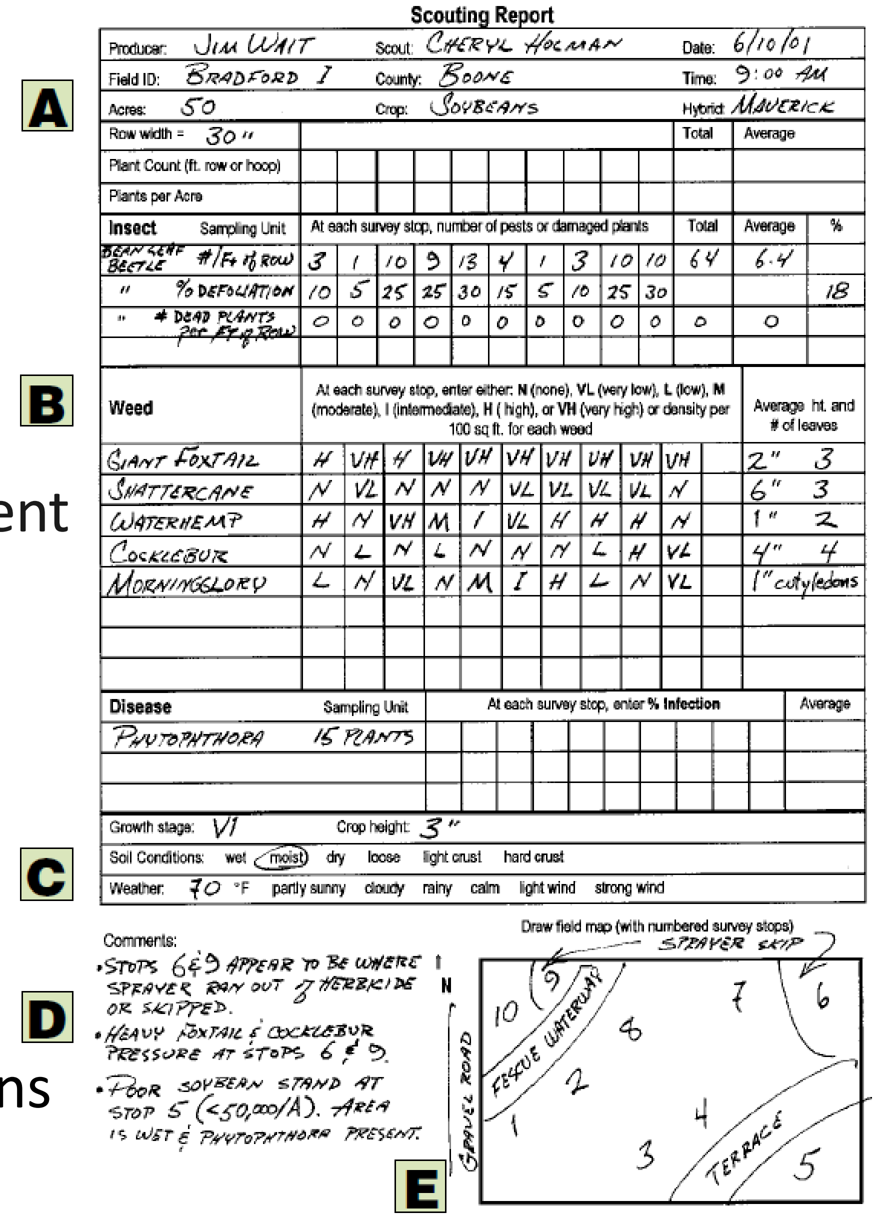
- Quarantine
- Inspections
- Compulsory crop or product destruction, and eradication of pests.

Example: legal controls against the Mediterranean fruit fly have included insect eradication programs and quarantine and embargoes on affected fruit, phytosanitary certifications for import of hop plants.

Record Keeping

Scouting forms –Record sampling/ monitoring, treatment data and observations and outcomes

- Provides permanent record
- Develops field history
  - Time line of pest/ crop development
  - Improved management for entire field and hot spots
- Minimum data
  - A: field description/location
  - B: Pest observations/results
  - C: Crop/field/weather observations
  - D: Comments/treatment results
  - E: Field map and sampling route



A

Scouting Report

Producer: JIM WAIT Scout: CHERYL HOLMAN Date: 6/10/01

Field ID: BRADFORD I County: BOONE Time: 9:00 AM

Acres: 50 Crop: SOYBEANS Hybrid: MAVERICK

Row width = 30"											Total	Average
Plant Count (ft. row or hoop)												
Plants per Acre												

B

Insect	Sampling Unit	At each survey stop, number of pests or damaged plants										Total	Average	%
BEAN LEAF BEETLE	#/Ft of ROW	3	1	10	9	13	4	1	3	10	10	64	6.4	
"	% DEFOLIATION	10	5	25	25	30	15	5	10	25	30			18
"	# DEAD PLANTS PER FT of ROW	0	0	0	0	0	0	0	0	0	0	0	0	

Weed	At each survey stop, enter either: **N** (none), **VL** (very low), **L** (low), **M** (moderate), **I** (intermediate), **H** (high), or **VH** (very high) or density per 100 sq ft. for each weed										Average ht. and # of leaves
GIANT FOXTAIL	H	VH	H	VH	VH	VH	VH	VH	VH	VH	2" 3
SHATTERCANE	N	VL	N	N	N	VL	VL	VL	VL	N	6" 3
WATERHEMP	H	N	VH	M	I	VL	H	H	H	N	1" 2
COCKLEBUR	N	L	N	L	N	N	N	L	H	VL	4" 4
MORNINGGLORY	L	N	VL	N	M	I	H	L	N	VL	1" cotyledons

Disease	Sampling Unit	At each survey stop, enter **% Infection**	Average
PHYTOPHTHORA	15 PLANTS		

C

Growth stage: V1 Crop height: 3"

Soil Conditions: wet (moist) dry loose light crust hard crust

Weather: 70 °F partly sunny cloudy rainy calm light wind strong wind

D

Comments:

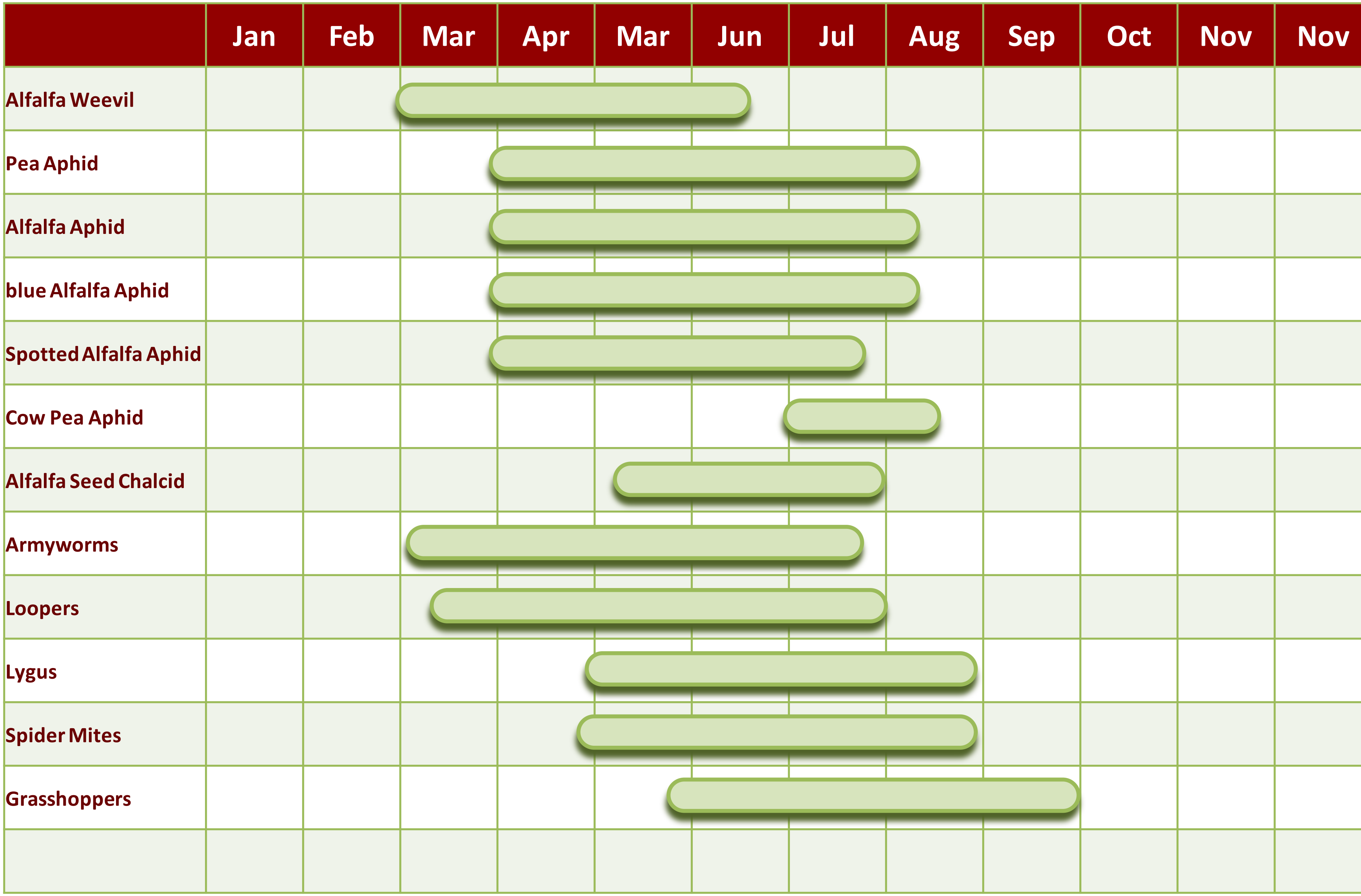
- STOPS 6 & 9 APPEAR TO BE WHERE SPRAYER RAN OUT of HERBICIDE OR SKIPPED.
- HEAVY FOXTAIL & COCKLEBUR PRESSURE AT STOPS 6 & 9.
- POOR SOYBEAN STAND AT STOP 5 (<50,000/A). AREA IS WET & PHYTOPHTHORA PRESENT.

E

Draw field map (with numbered survey stops)

EVALUATION

- Is the management program working?
  - What works?
  - What doesn't work?
- How much chemical is being used?
  - Are chemicals being reduced?
  - Are costs being reduced?
- How should program be adjusted



Jan
Feb
Mar
Apr
Mar
Jun
Jul
Aug
Sep
Oct
Nov
Nov
Alfalfa Weevil
Pea Aphid
Alfalfa Aphid
blue Alfalfa Aphid
Spotted Alfalfa Aphid
Cow Pea Aphid
Alfalfa Seed Chalcid
Armyworms
Loopers
Lygus
Spider Mites
Grasshoppers

Sampling/monitoring tools

Clipboard –Keep all the scouting forms and field maps in one place.

Pencils –Carry a spare

Field maps –Jot notes, location pest problems and record observations

Scouting forms –Record sampling monitoring data, field history.

Hand lens –See and correctly identify pests, 10-20x

Pocket knife –Cutting shoots, scraping at trunks skinning berries.

Shovel /sturdy trowel –digging soil

Traps/ trap parts (lures) –There's always a broken/missing trap

Collection bags and vials –Send pest /damage samples to others

Camera –Send pest /damage photo to others for ID

References –field guides, fact sheets, pictures of pests/damage

GPS unit –relocate sample sites accurately