Integrated (Insect) Pest 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

Integrated Pest Management (IPM) is a sustainable approach to managing pests that combines biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks.

The IPM Concept Recognizes

- An **integrated** approach using multiple methods to manage pests: 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: crop and pest and crop **management** is key
  - ➢ Some damage is unavoidable and acceptable
  - ➢ Low pest populations maintain natural enemy numbers
  - ➢ Manage rather than eliminate insect populations

Key IPM concepts:

- Knowledge of pest and crop biology and ecology
  - ➢ What does a normal crop look like?

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

- One or more management tactics:
  - ➢ Cultural
  - ➢ Chemical
  - ➢ Biological control

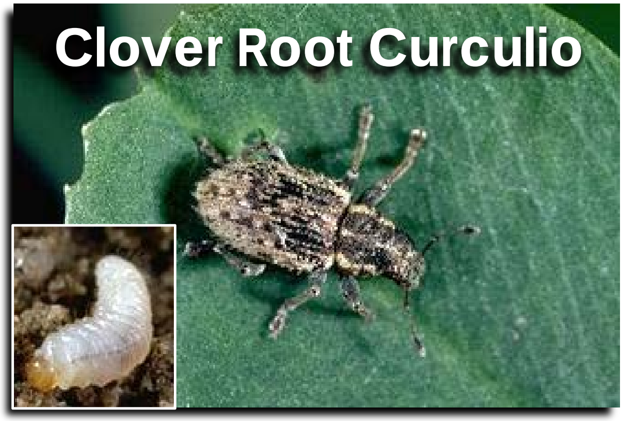
Decision making tools: Pest Identification

Ability to identify/ distinguish pest vs. 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

Weevils in alfalfa

Sitona spp: short snout, root feeding larvae

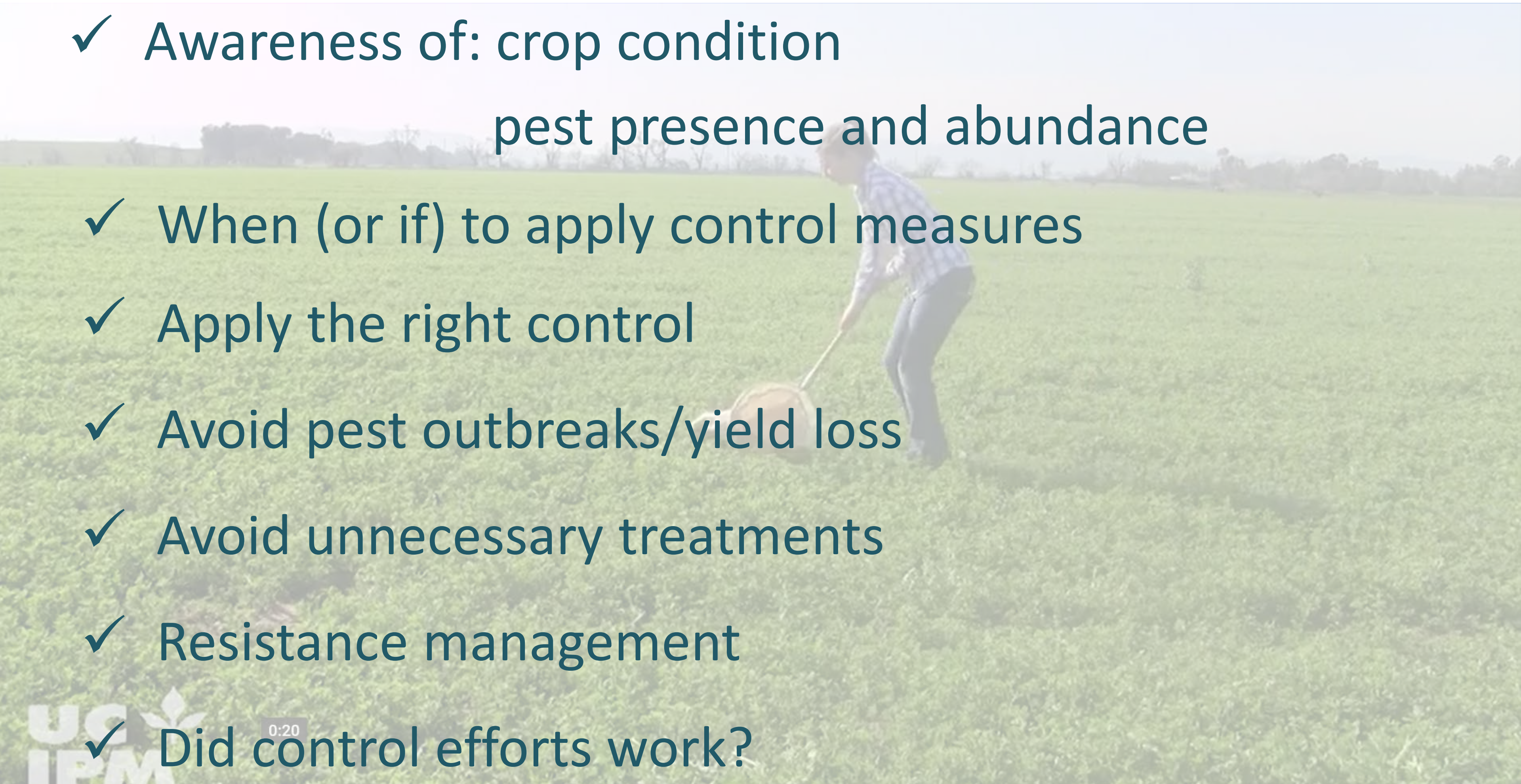


Sampling approaches and management options differ

Hypera spp: longer snout, leaf feeding larvae

Decision making tools: Sampling and monitoring (scouting)

Make cost effective and environmentally sound insect management decisions



- ✓ Awareness of: crop condition
  pest presence and abundance
- ✓ 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?

Sampling and monitoring

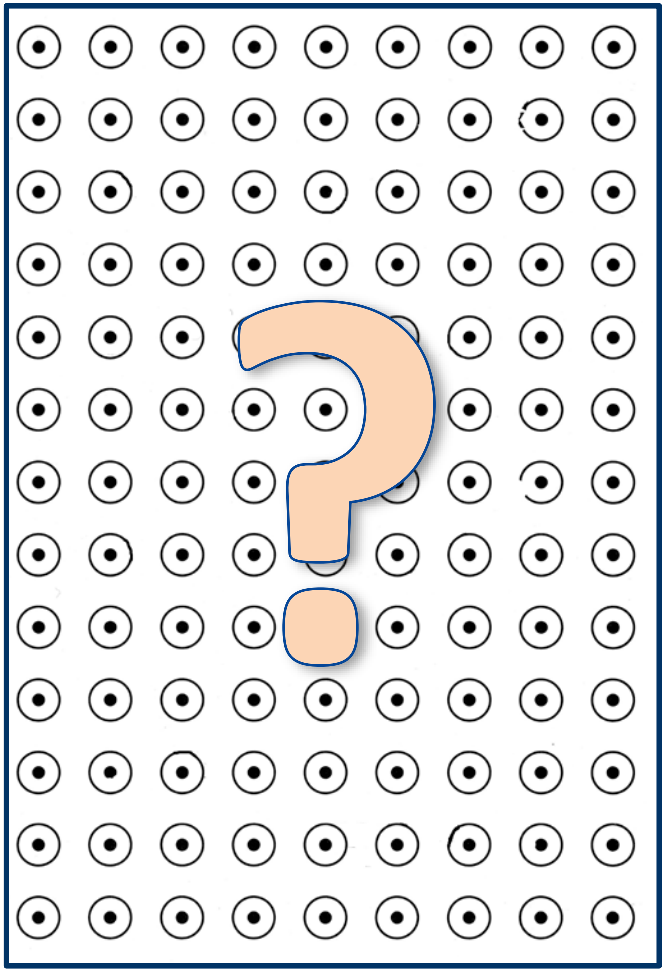
Generally we walk through the field and count pest and beneficial insects or pest damage

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

How?

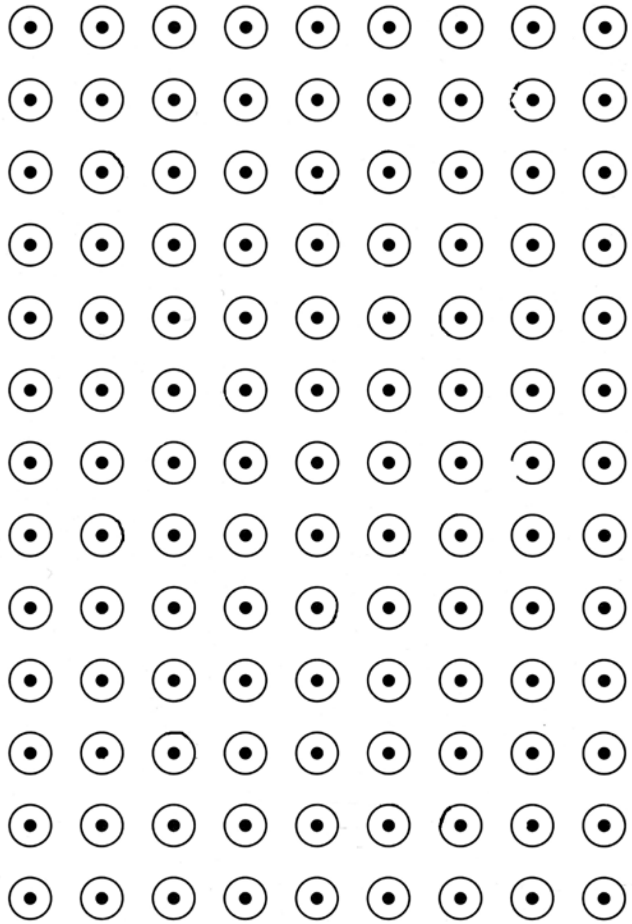
Count them all?

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



Sampling and monitoring

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



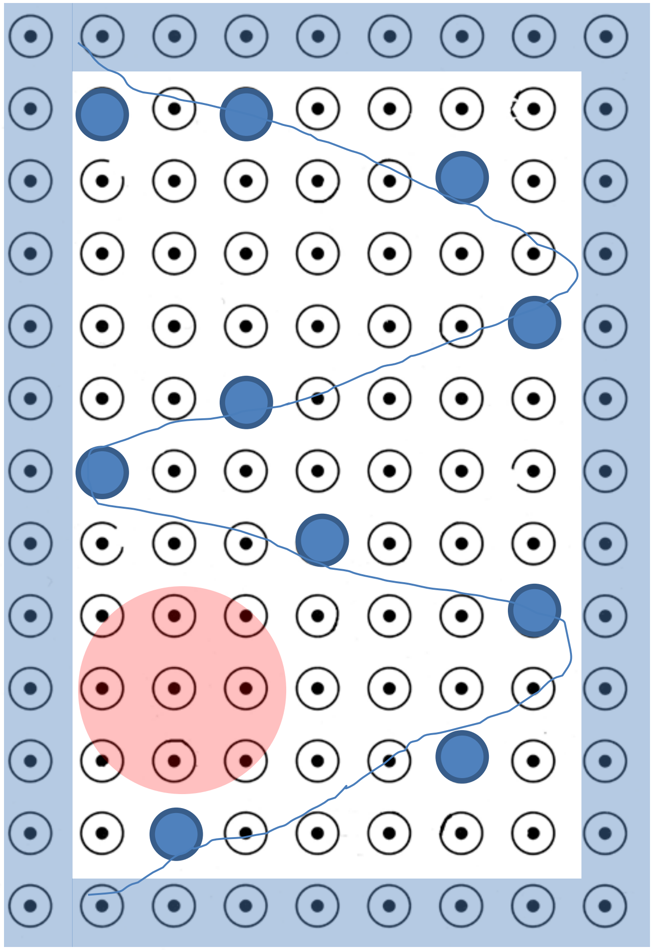
Samples should be unbiased

- 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

Sampling and monitoring

Walk a predetermined route that covers the entire field

- Zig-zag or "W" shaped routes are good
- Note 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"
- Always sample from more than one tree, vine, area per field or block using a standard method

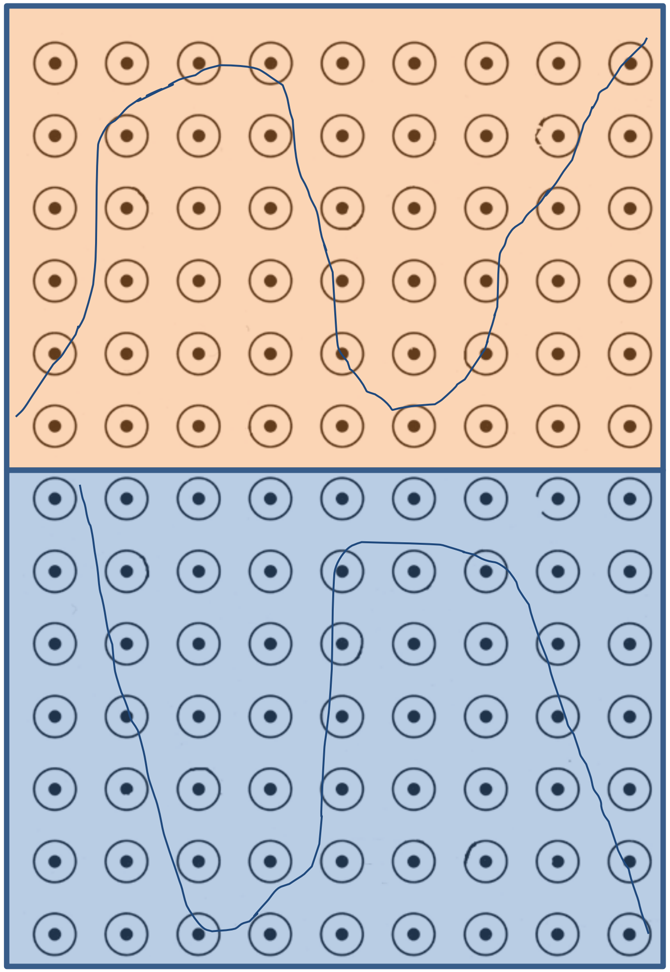


Sampling and monitoring

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

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

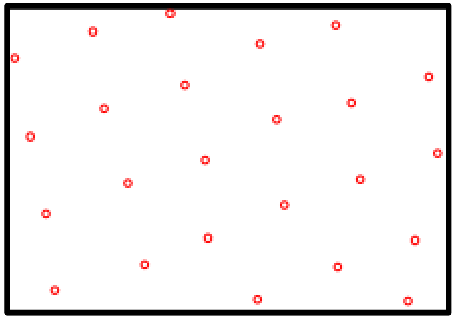
The number of samples required depends on insect distribution

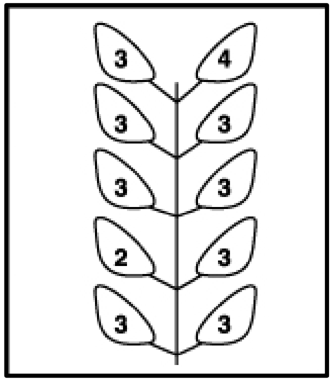


Possible Insect distributions in fields or on plants

Uniform

Mean >> variance





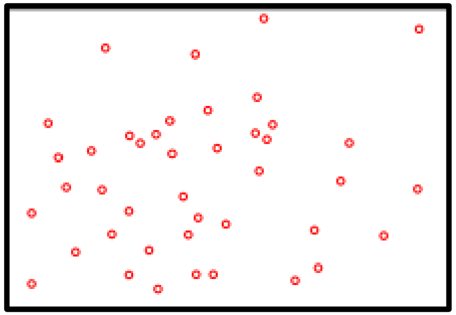
Mean=3

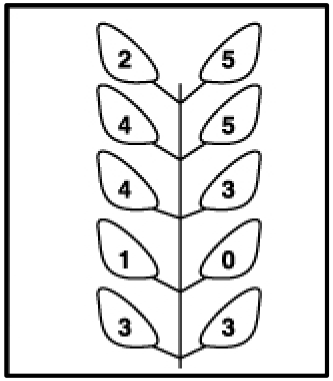
Variance=0.2

Few samples needed: rare

Random

Mean ≈ variance





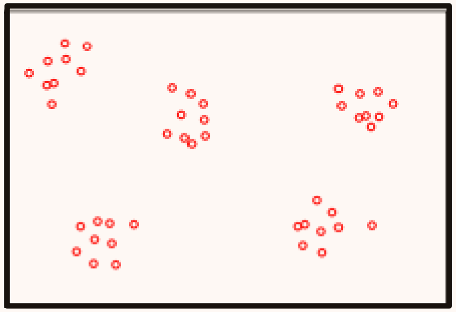
Mean=3

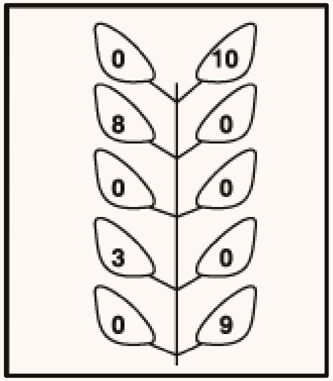
Variance=2.6

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 how many 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

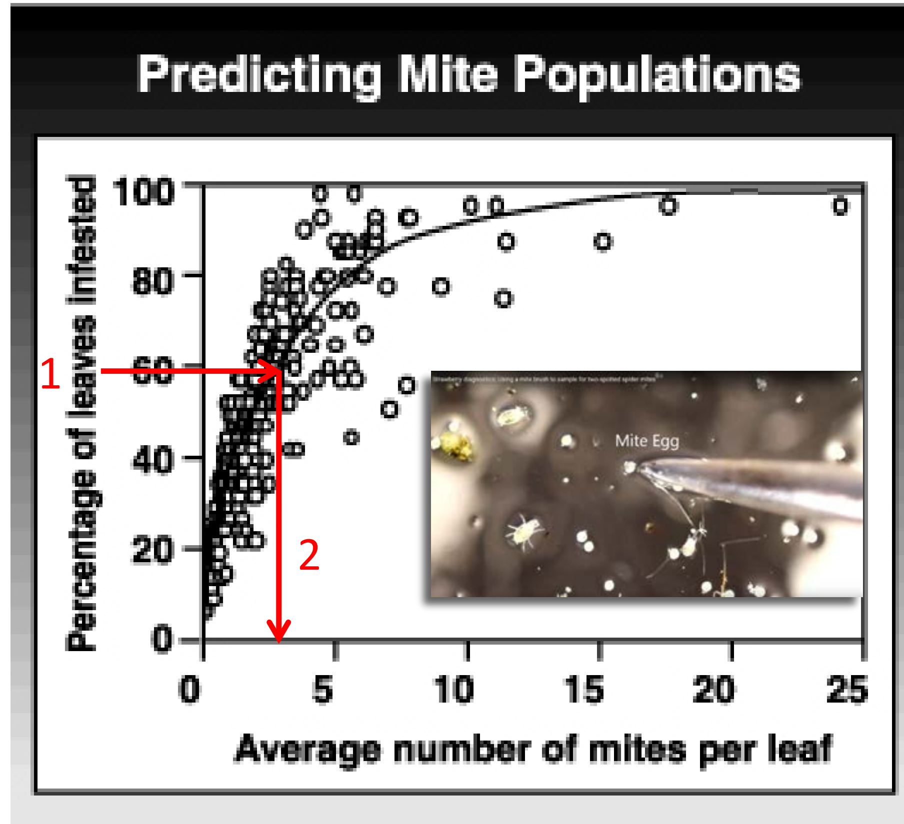
- Most sampling plans use a fixed number of samples to provide a conservative estimate of the mean no. of insects per sample

- 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 example from apple for European red mite

- Relationship between % of infested sampling units (e.g. leaves) and mean at different mite densities
- % infested leaves can provide an accurate estimate of the mean
- Tally number of leaves infested instead of counting pests



- Estimates unreliable when infestations are high (≥ 80%)

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: 1.3 mites per leaf

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

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

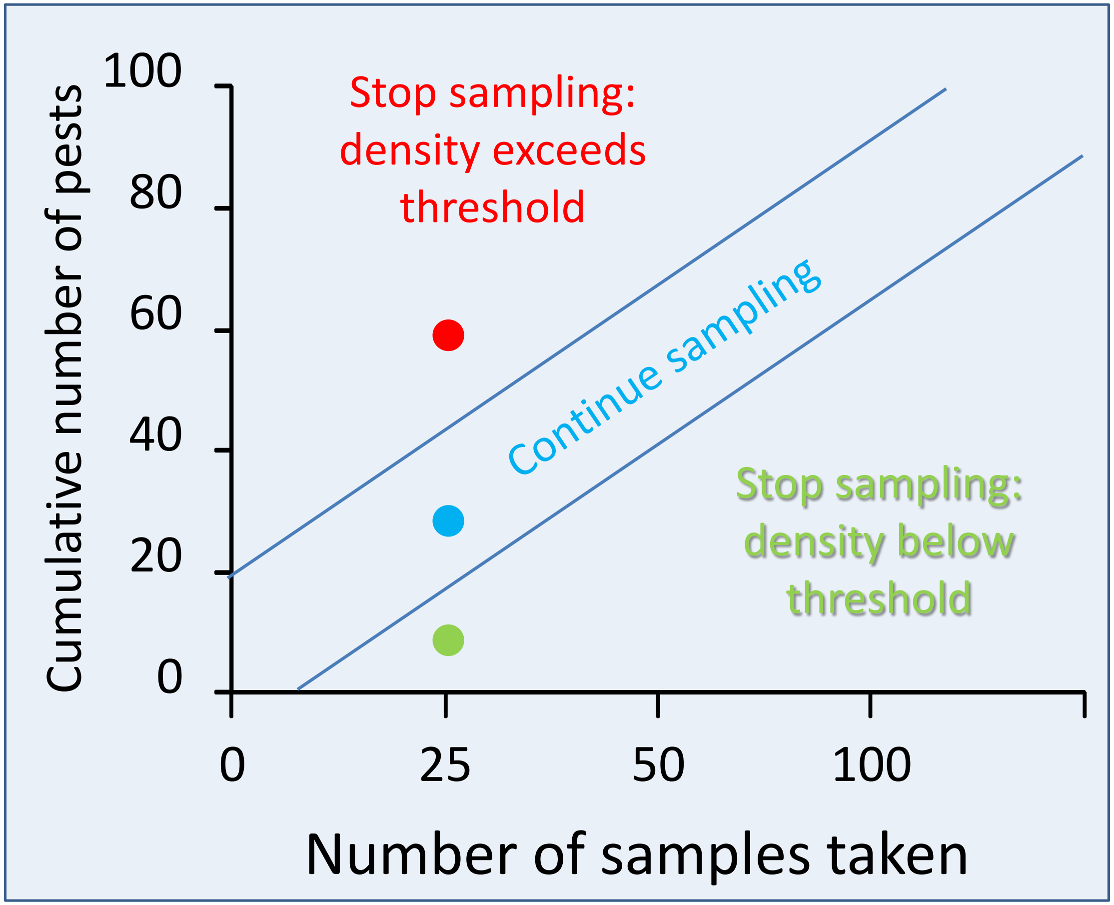
Sequential sampling

Take some minimum number of samples, accumulating numbers of pests per sample, then make a decision to stop or continue sampling

- Stop sampling: treat
- Stop sampling: 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

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

Sequential Sampling Plan for Campylomma

Red Delicious (threshold 4 per tap)

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

Golden Delicious (threshold 1 per tap)

Total taps	Cumulative no. of nymphs: Upper	Cumulative no. of nymphs: Lower
10	15	5
11	17	5
12	18	6
13	19	7
14	20	8
15	21	9
16	23	9
17	24	10
18	25	11
19	26	12
20	27	13
21	29	13
22	30	14
23	31	15
24	32	16
25	33	17
26	34	18
27	36	18
28	37	19
29	38	20
30	39	21
31	40	22
32	41	23
33	43	23
34	44	24
35	45	25
36	46	26
37	47	27
38	48	28
39	49	29
40	51	29
41	52	30
42	53	31
43	54	32
44	55	33
45	56	34
46	57	35
47	58	36
48	60	36
49	61	37
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…
- Good for: Aphids, scale insects, mites, leafminers, small caterpillars, leaf hoppers, immature psyllids…
- Counts on site or in shop/lab

10x-20x hand lens useful

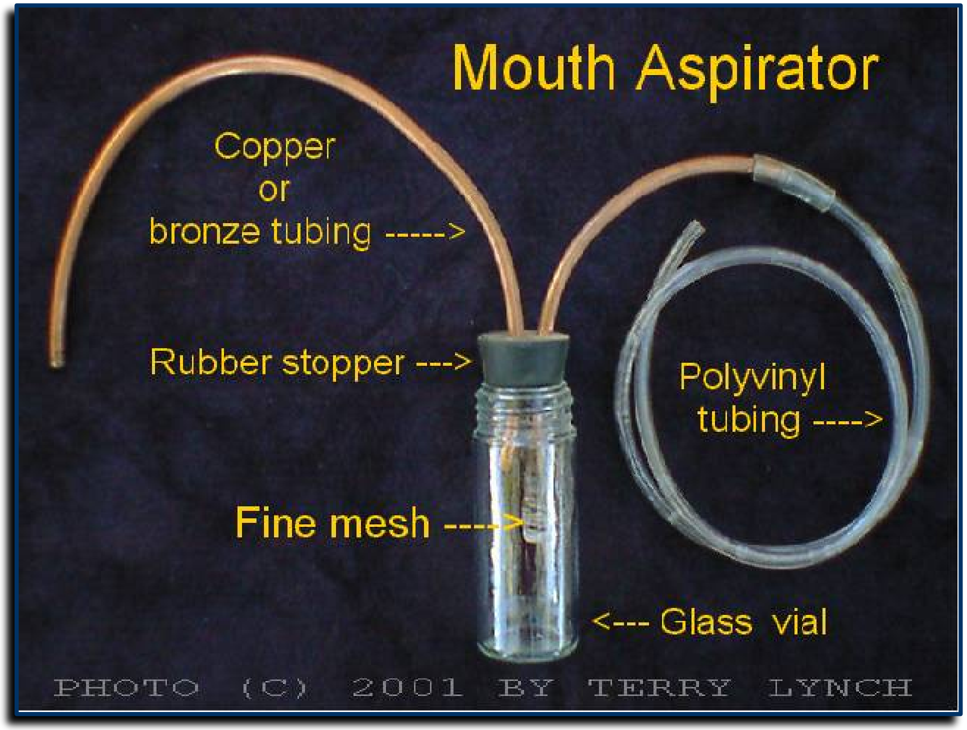
Sampling methods

Beat tray/cloth (tap) samples

- Jar insects/mites onto a tray or cloth where they can be more easily counted
- Good for: 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 very selective
- Not so 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

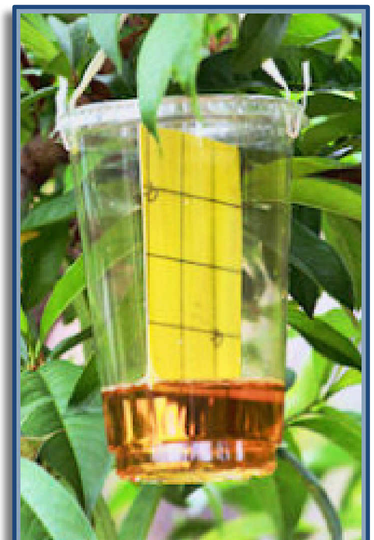
Can capture a lot of non-targets; difficult to handle and count

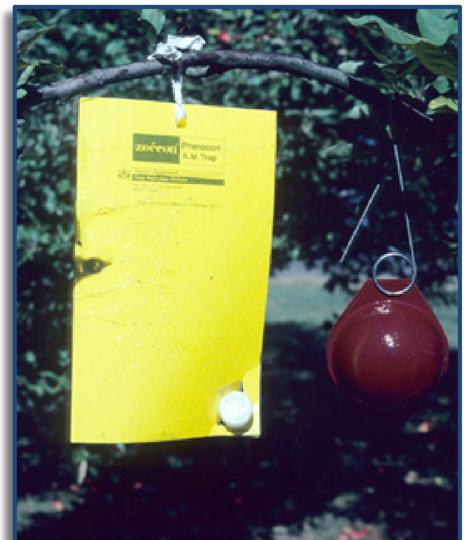
Sampling methods

Attractant traps

Food attractants: Food source scents

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




Increased selectivity, can capture large numbers!

Sampling methods

Attractant traps

Pheromone traps:

- Most commercial pheromones are synthetic versions of natural scents produced by insects to attract mates
- Usually 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

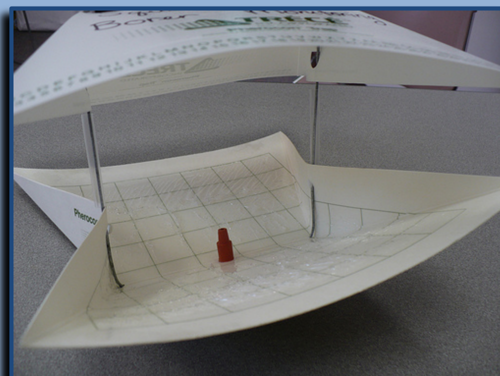
Corn earworm
California prionus
Mint root borer

Sampling methods

Attractant traps

Pheromone traps Consist of a pheromone lure and a trap

+



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Many available

Trap not needed for mating disruption dispensers

Sampling methods

Attractant traps

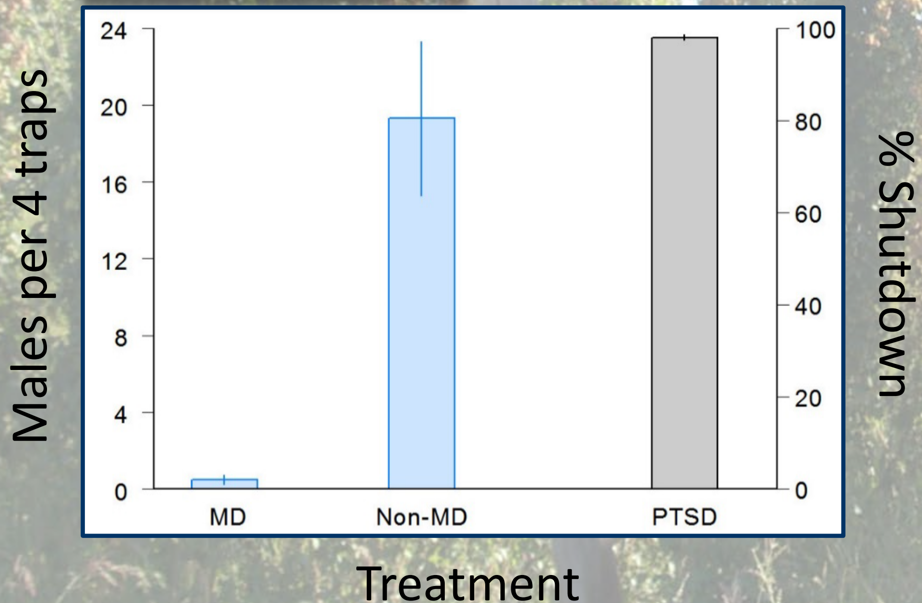
Useful for monitoring pests and beneficial insects

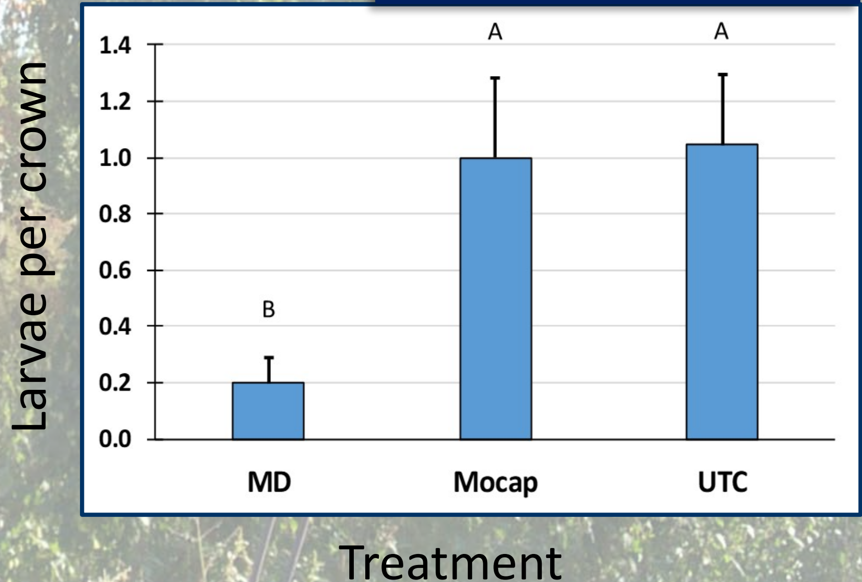
- Monitor flight periods (Mint root borer, CA prionus)
- Synchronize DD models (setting biofix: 1st, or peak flight)
- Monitor success of control programs
- Monitor exotic or invasive pests (apple maggot)

Useful for controlling pests

- Mating disruption (peach tree borer, CA prionus/ hops)
- Mass trapping (apple maggot: visual + food attractant sticky traps)

Large plot *P. californicus* mating disruption trials, 2014-2016





Sampling methods

Growing degree days (GDD, DD or phenological 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 (1st 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 1st trap catch to first egg laying for codling moth)

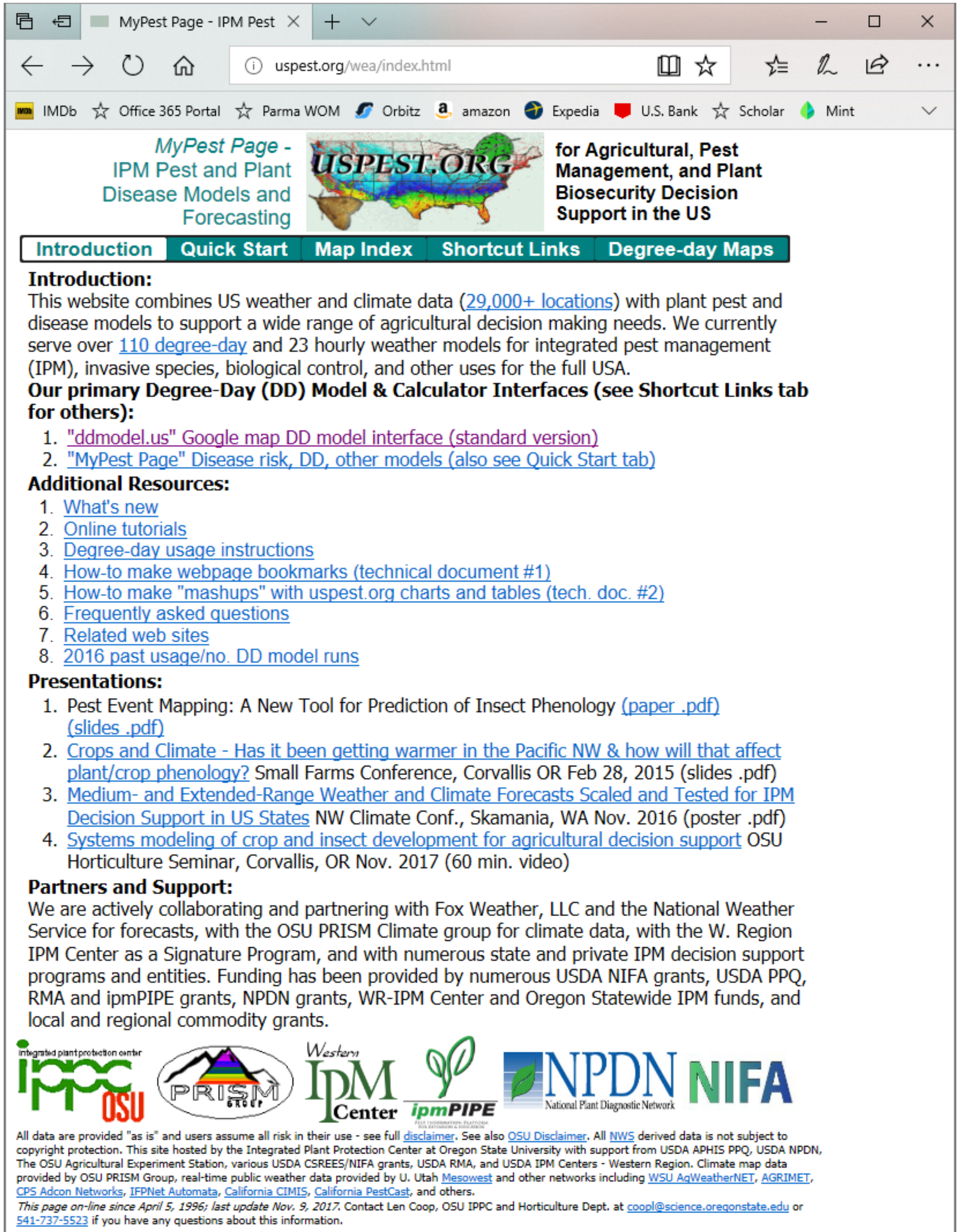
Sampling methods

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/wea/index.html



MyPest Page - IPM Pest and Plant Disease Models and Forecasting

USPEST.ORG

for Agricultural, Pest Management, and Plant Biosecurity Decision Support in the US

Introduction | Quick Start | Map Index | Shortcut Links | Degree-day Maps

Introduction:
This website combines US weather and climate data (29,000+ locations) with plant pest and disease models to support a wide range of agricultural decision making needs. We currently serve over 110 degree-day and 23 hourly weather models for integrated pest management (IPM), invasive species, biological control, and other uses for the full USA.

Our primary Degree-Day (DD) Model & Calculator Interfaces (see Shortcut Links tab for others):

1. "ddmodel.us" Google map DD model interface (standard version)
2. "MyPest Page" Disease risk, DD, other models (also see Quick Start tab)

Additional Resources:

1. What's new
2. Online tutorials
3. Degree-day usage instructions
4. How-to make webpage bookmarks (technical document #1)
5. How-to make "mashups" with uspest.org charts and tables (tech. doc. #2)
6. Frequently asked questions
7. Related web sites
8. 2016 past usage/no. DD model runs

Presentations:

1. Pest Event Mapping: A New Tool for Prediction of Insect Phenology (paper .pdf) (slides .pdf)
2. Crops and Climate - Has it been getting warmer in the Pacific NW & how will that affect plant/crop phenology? Small Farms Conference, Corvallis OR Feb 28, 2015 (slides .pdf)
3. Medium- and Extended-Range Weather and Climate Forecasts Scaled and Tested for IPM Decision Support in US States NW Climate Conf., Skamania, WA Nov. 2016 (poster .pdf)
4. Systems modeling of crop and insect development for agricultural decision support OSU Horticulture Seminar, Corvallis, OR Nov. 2017 (60 min. video)

Partners and Support:
We are actively collaborating and partnering with Fox Weather, LLC and the National Weather Service for forecasts, with the OSU PRISM Climate group for climate data, with the W. Region IPM Center as a Signature Program, and with numerous state and private IPM decision support programs and entities. Funding has been provided by numerous USDA NIFA grants, USDA PPQ, RMA and ipmPIPE grants, NPDN grants, WR-IPM Center and Oregon Statewide IPM funds, and local and regional commodity grants.

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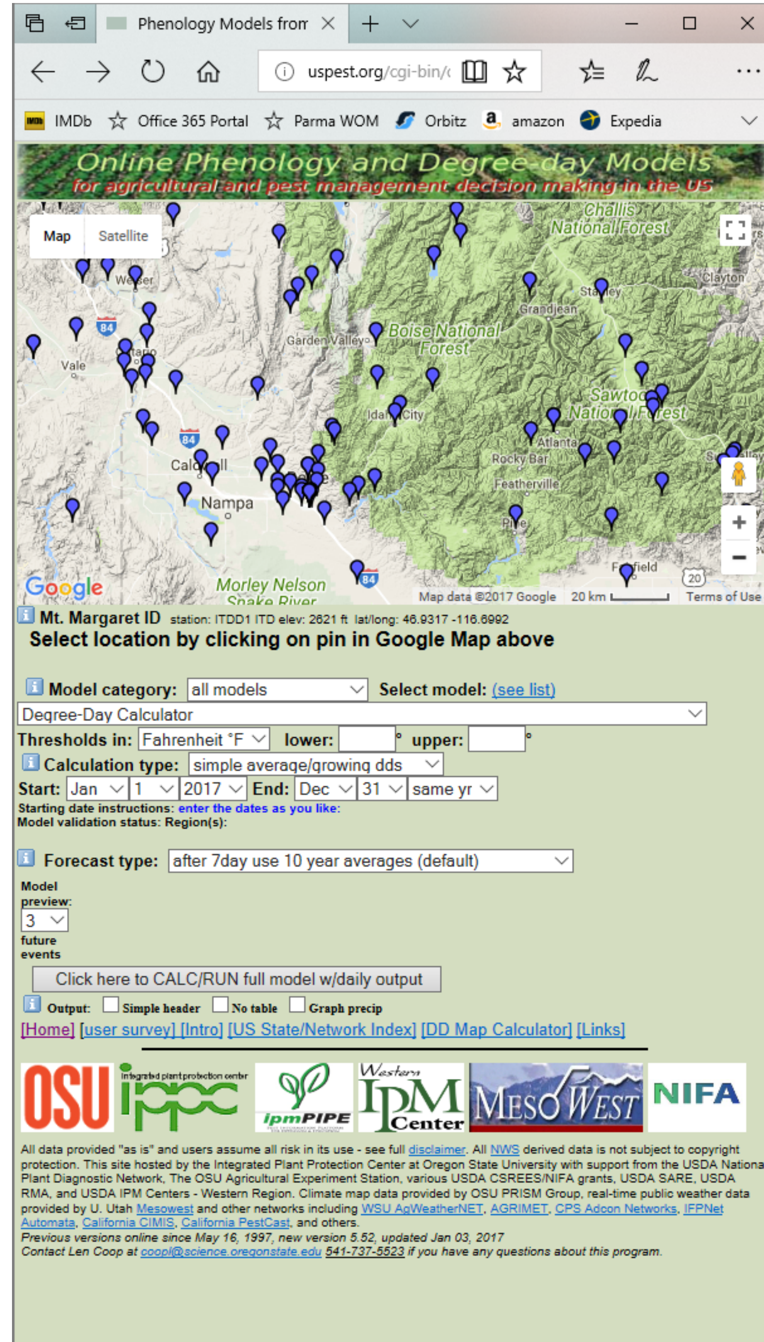
This page on-line since April 5, 1996; last update Nov. 9, 2017. Contact Len Coop, OSU IPPC and Horticulture Dept. at coopl@science.oregonstate.edu or 541-737-5523 if you have any questions about this information.

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



Online Phenology and Degree-day Models
for agricultural and pest management decision making in the US

Mt. Margaret ID station: ITDD1 ITD elev: 2621 ft lat/long: 46.9317 -116.6992
Select location by clicking on pin in Google Map above

Model category: all models **Select model:** (see list)
Degree-Day Calculator
Thresholds in: Fahrenheit °F **lower:** ° **upper:** °
Calculation type: simple average/growing dds
Start: Jan 1 2017 **End:** Dec 31 same yr
Starting date instructions: enter the dates as you like:
Model validation status: Region(s):

Forecast type: after 7day use 10 year averages (default)

Model preview: 3 future events

Click here to CALC/RUN full model w/daily output

Output: Simple header No table Graph precip

[Home] [user survey] [Intro] [US State/Network Index] [DD Map Calculator] [Links]

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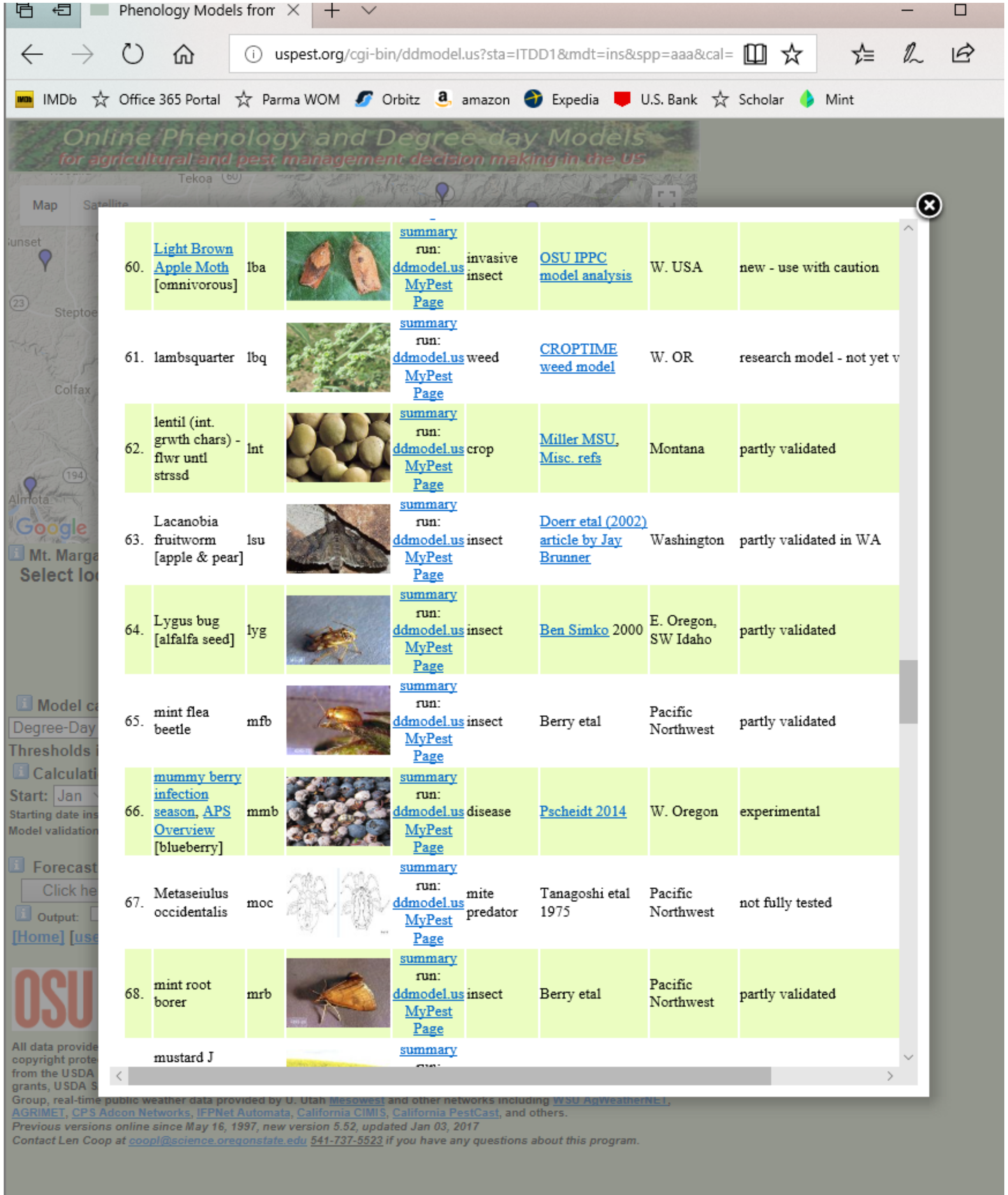
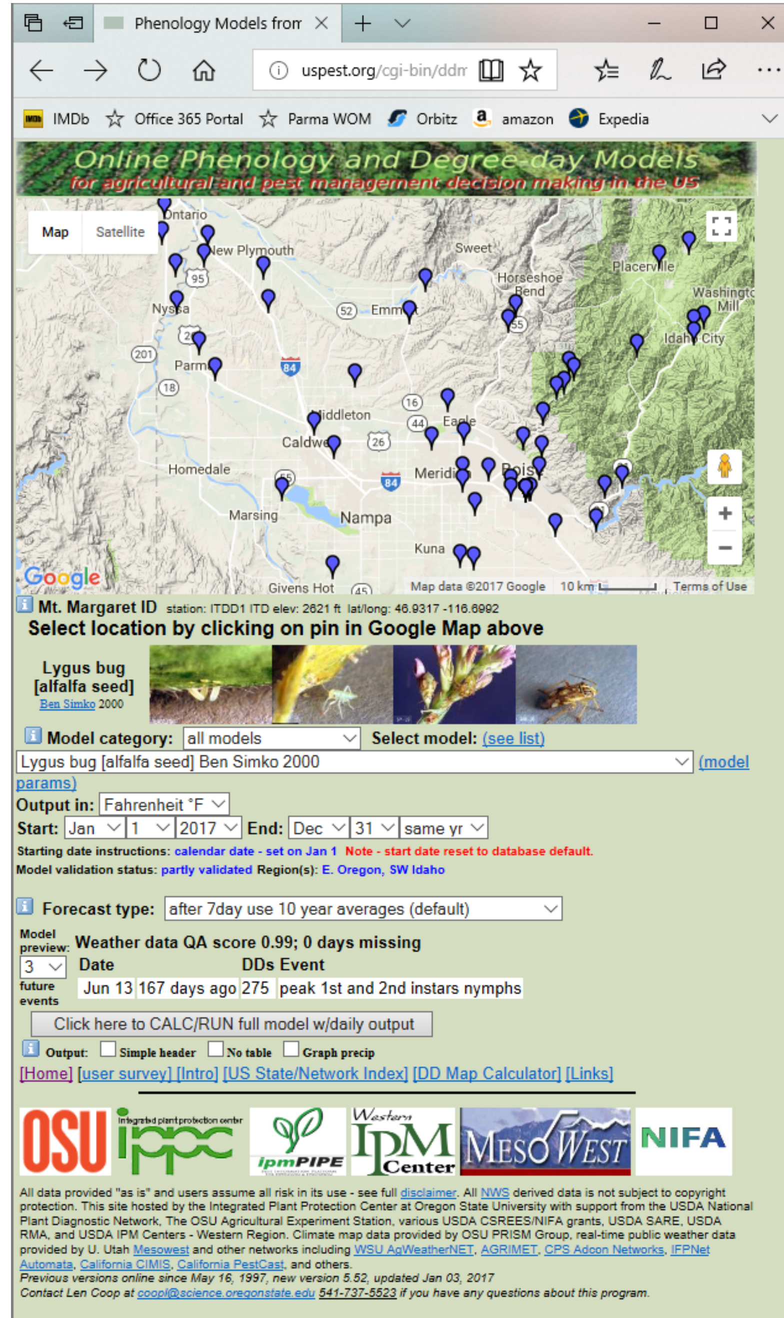
Previous versions online since May 16, 1997, new version 5.52, updated Jan 03, 2017
Contact Len Coop at coopl@science.oregonstate.edu 541-737-5523 if you have any questions about this program.

http://uspest.org/cgi-bin/ddmodel.us?spp=lyg&uco=1





Lygus bug [alfalfa seed]

uspest.org/cgi-bin/ddmodel2.pl?wfl=PMAI17.txt&hfl=p

IMDb | Office 365 Portal | Parma WOM | Orbitz | amazon | Expedia | U.S. Bank | Scholar

Online Phenology and Degree-day Models

for agricultural and pest management decision making in the US

Lygus bug [alfalfa seed]

insect model of Ben Simko 2000

```
Output from uspest.org/wea insect degree-day/phenology model program:
        Heat Units and predictions of key events from daily weather data

 ==============================MODEL INPUTS==============================
 Model species/general links:       Lygus bug [alfalfa seed]
 Type:                              insect
 Model source/other links:          Ben Simko 2000
 Calculation method:                single sine
 Lower threshold:                   52 degrees Fahrenheit
 Setting upper threshold to:        130 F (default)
 Directions for starting/BIOFIX:    calendar date
 No starting/BIOFIX date, set to:   default date  1 1
 No ending date, set to:            default date  12 31
 Model validation status:           partly validated
 Region of known use:               E. Oregon, SW Idaho
 ==============================EVENTS TABLE==============================
 1.  275 DD after biofix peak 1st and 2nd instars nymphs

==============================MODEL OUTPUT==============================

Weather station: 2017 PMAI Agrimet PARMA ID Lat43.8000 Long-116.9331 Elev:2306
 mn day  max   min  precip  DD52    CUMDD52  event
 -- ---  ----- ----- ------  ----    -------  -----
  1  1  17.40 12.30  0.03   0.00      0.0 * START *
  1  2  19.60  6.40  0.00   0.00      0.0
  1  3  22.40 16.60  0.08   0.00      0.0
  1  4  25.40 20.80  0.31   0.00      0.0
  1  5  20.70 -10.70  0.00   0.00      0.0
  1  6  -1.60 -19.20  0.00   0.00      0.0
  1  7  12.30 -19.90  0.24   0.00      0.0
  1  8  32.10 13.70  0.01   0.00      0.0
  1  9  42.10 23.20  0.79   0.00      0.0
  1 10  34.00 32.40  0.78   0.00      0.0
  1 11  41.30 23.80  0.07   0.00      0.0
  1 12  29.10 10.20  0.00   0.00      0.0
  1 13  13.40  0.20  0.00   0.00      0.0
  1 14  16.30  9.70  0.00   0.00      0.0
  1 15  11.80 -2.90  0.00   0.00      0.0
  1 16   7.60 -9.00  0.01   0.00      0.0
  1 17   8.50 -8.30  0.00   0.00      0.0
  1 18  32.70  4.20  0.55   0.00      0.0
  1 19  34.90 23.80  0.35   0.00      0.0
  1 20  37.50 25.90  0.02   0.00      0.0
  1 21  38.50 32.80  0.05   0.00      0.0
```

Lygus bug [alfalfa seed]

uspest.org/cgi-bin/ddmodel2.pl?wfl=PMAI17.txt&hfl=p

IMDb | Office 365 Portal | Parma WOM | Orbitz | amazon | Expedia | U.S. Ba

This year is about	versus	QA
DDs exceed full year	2016	ok
56 days behind	2015	ok
DDs exceed full year	30-yr normals	ok

```
Forecast using:  Fox - IPPC forecast for PMAI data
 11 27  50.30 42.20  0.00   0.00    3050.0  0.00_0.01%_precip.
 11 28  54.30 38.40  0.02   0.38    3050.4  0.018_0.58%_precip.
 11 29  48.20 37.40  0.00   0.00    3050.4  0.001_0.00%_precip.
 11 30  49.70 33.70  0.00   0.00    3050.4  0.00_0.00%_precip.
 12  1  54.10 34.20  0.07   0.29    3050.7  0.065_0.42%_precip.
Forecast using: 10 yr Hist Avg PMAI 2006-2015
 12  2  42.30 25.80  0.04   0.00    3050.7  *hist_fcst*
 12  3  44.90 25.00  0.05   0.00    3050.7  *hist_fcst*
 12  4  42.70 26.00  0.03   0.00    3050.7  *hist_fcst*
 12  5  43.10 23.90  0.03   0.00    3050.7  *hist_fcst*
 12  6  42.00 23.50  0.00   0.00    3050.7  *hist_fcst*
 12  7  41.60 23.40  0.06   0.00    3050.7  *hist_fcst*
 12  8  39.50 21.50  0.05   0.00    3050.7  *hist_fcst*
 12  9  38.50 20.00  0.00   0.00    3050.7  *hist_fcst*
 12 10  38.10 19.80  0.01   0.00    3050.7  *hist_fcst*
 12 11  39.30 20.10  0.02   0.00    3050.7  *hist_fcst*
 12 12  37.80 22.30  0.03   0.00    3050.7  *hist_fcst*
 12 13  39.60 25.70  0.07   0.00    3050.7  *hist_fcst*
 12 14  40.00 24.40  0.06   0.00    3050.7  *hist_fcst*
 12 15  40.70 25.20  0.04   0.00    3050.7  *hist_fcst*
 12 16  38.00 22.60  0.08   0.00    3050.7  *hist_fcst*
 12 17  36.80 21.10  0.01   0.00    3050.7  *hist_fcst*
 12 18  36.20 21.70  0.04   0.00    3050.7  *hist_fcst*
 12 19  37.80 22.70  0.04   0.00    3050.7  *hist_fcst*
 12 20  38.20 22.50  0.09   0.00    3050.7  *hist_fcst*
 12 21  37.90 23.20  0.07   0.00    3050.7  *hist_fcst*
 12 22  39.10 24.50  0.10   0.00    3050.7  *hist_fcst*
 12 23  38.50 22.10  0.03   0.00    3050.7  *hist_fcst*
 12 24  36.70 20.90  0.02   0.00    3050.7  *hist_fcst*
 12 25  36.60 18.80  0.07   0.00    3050.7  *hist_fcst*
 12 26  34.20 19.70  0.01   0.00    3050.7  *hist_fcst*
 12 27  33.60 19.00  0.04   0.00    3050.7  *hist_fcst*
 12 28  33.60 21.20  0.06   0.00    3050.7  *hist_fcst*
 12 29  35.90 22.60  0.09   0.00    3050.7  *hist_fcst*
 12 30  36.60 22.20  0.02   0.00    3050.7  *hist_fcst*
 12 31  34.20 18.20  0.01   0.00    3050.7  *hist_fcst*
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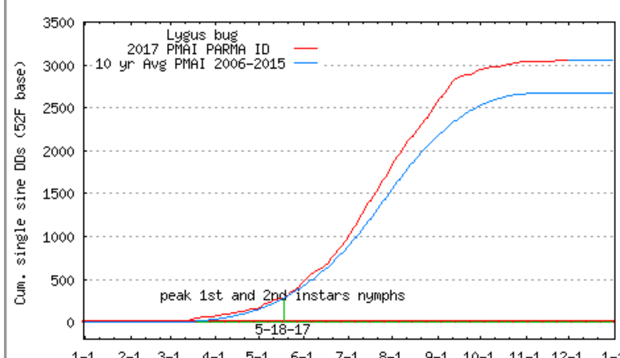
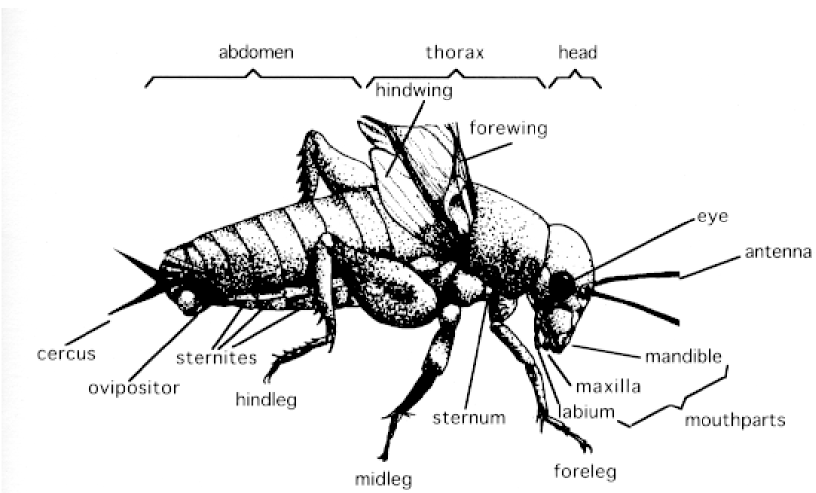


Knowledge of the pest and beneficial insects

Some familiarity with basic insect and mite structure

Insects



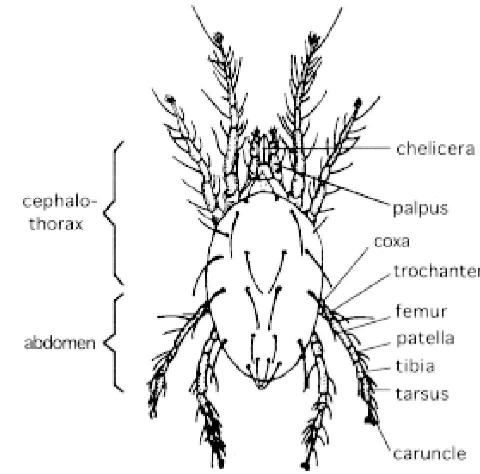
Small to tiny

3 body sections

6 legs

Adults usually winged

Mites



Tiny to minute

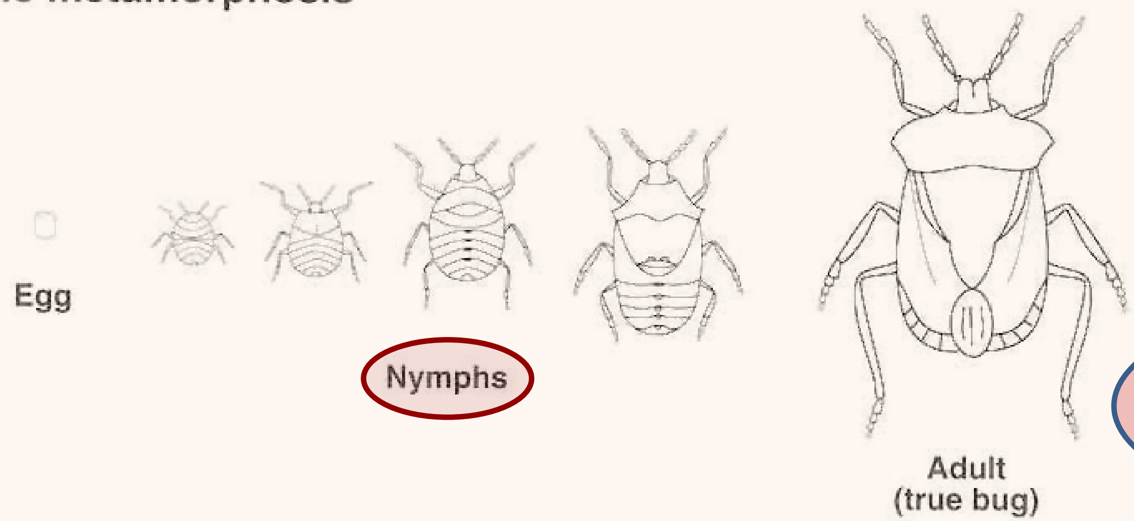
2 body sections

4 to 8 legs

No winged stages

Knowledge of insect and mite biology: growth

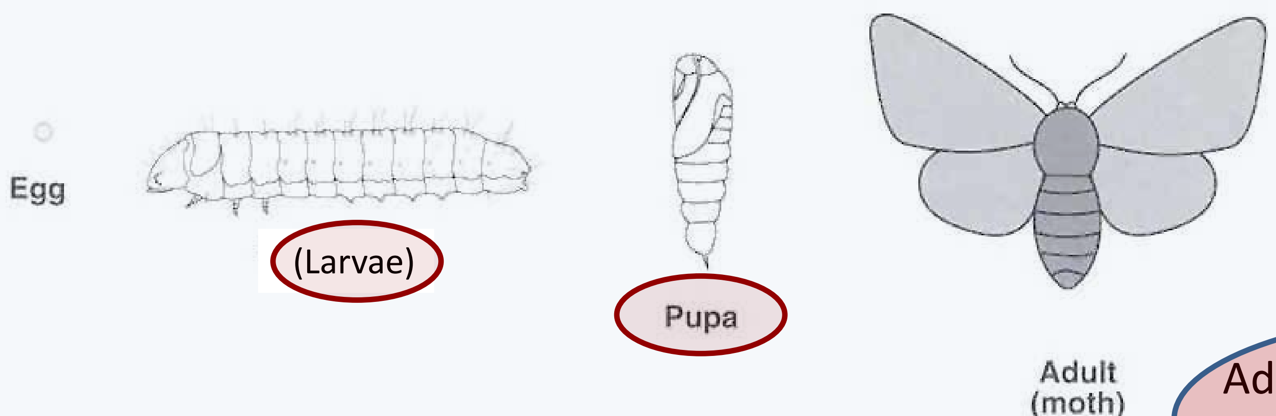
Simple metamorphosis



True bugs
Grasshoppers
Leaf hoppers
Aphids
Scale insects
Mites

Adults and immatures with similar appearance and habits

Complete metamorphosis



Moths
Butterflies
Flies
Thrips
Beetles
Bees and wasps

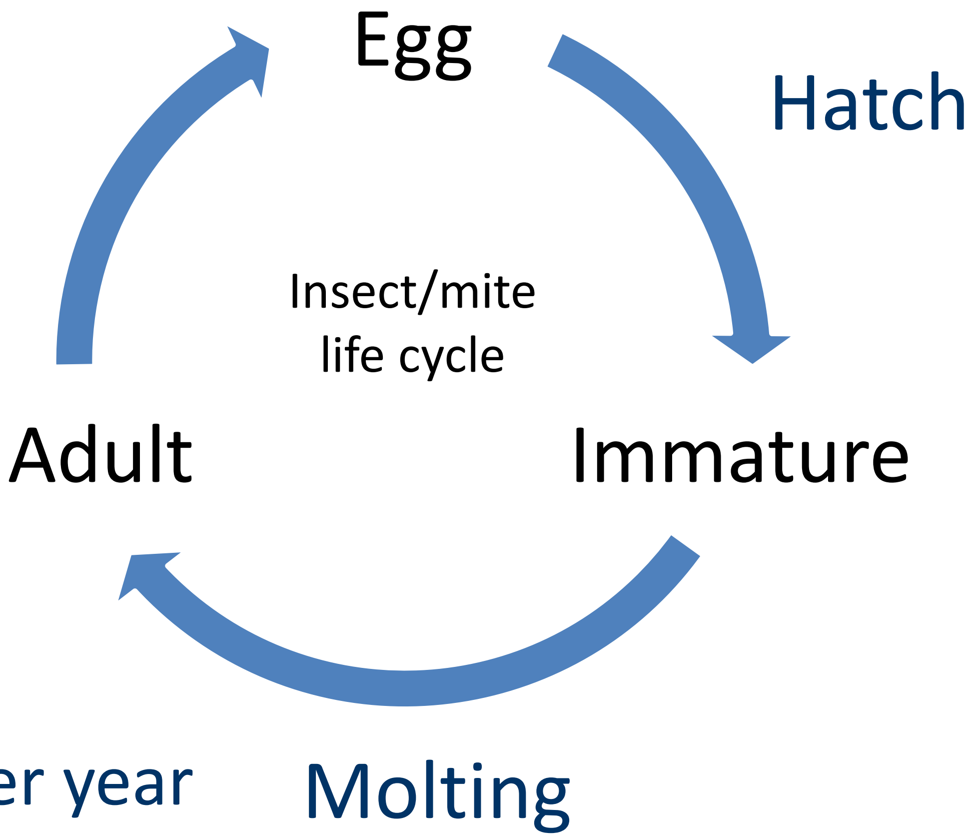
Adults and immatures with different appearance and habits

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

Winter

Bud break

Lay eggs on apple twigs

Hatch to wingless females

Mate

Give birth to wingless females

Fall

Spring

Migrate to apple

Give birth to winged females

Winged males

Winged females

Migrate to summer hosts: plantain, dock

Several generations of wingless females

Summer

In apple: don't treat

In apple: treat

Not in apple: don't treat

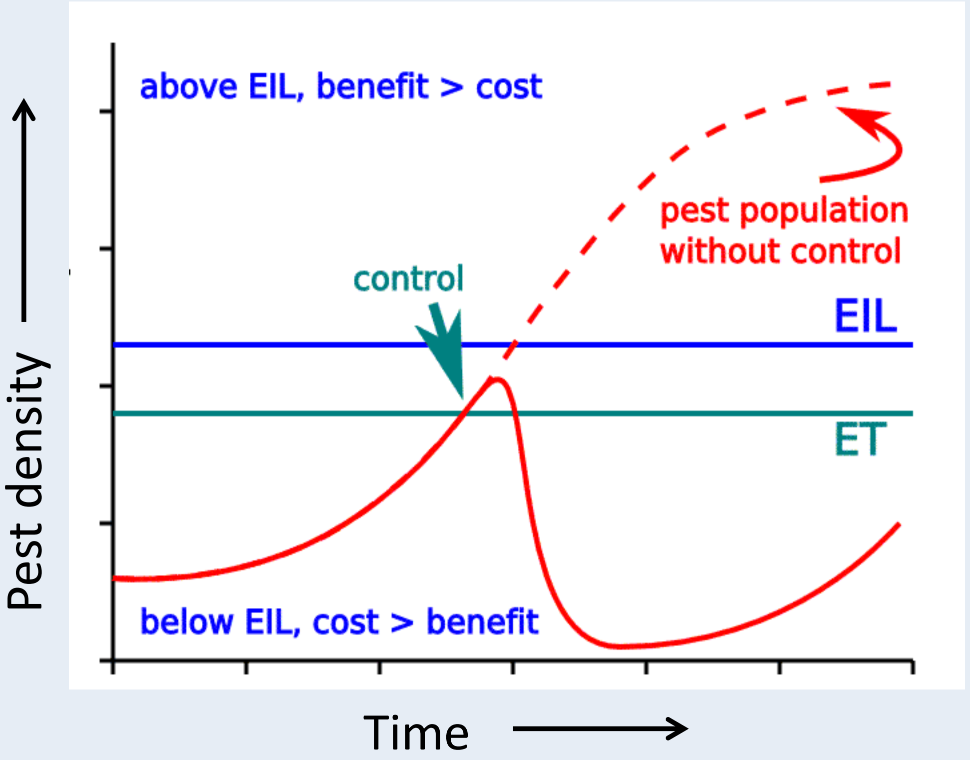
Economic injury levels and action thresholds

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

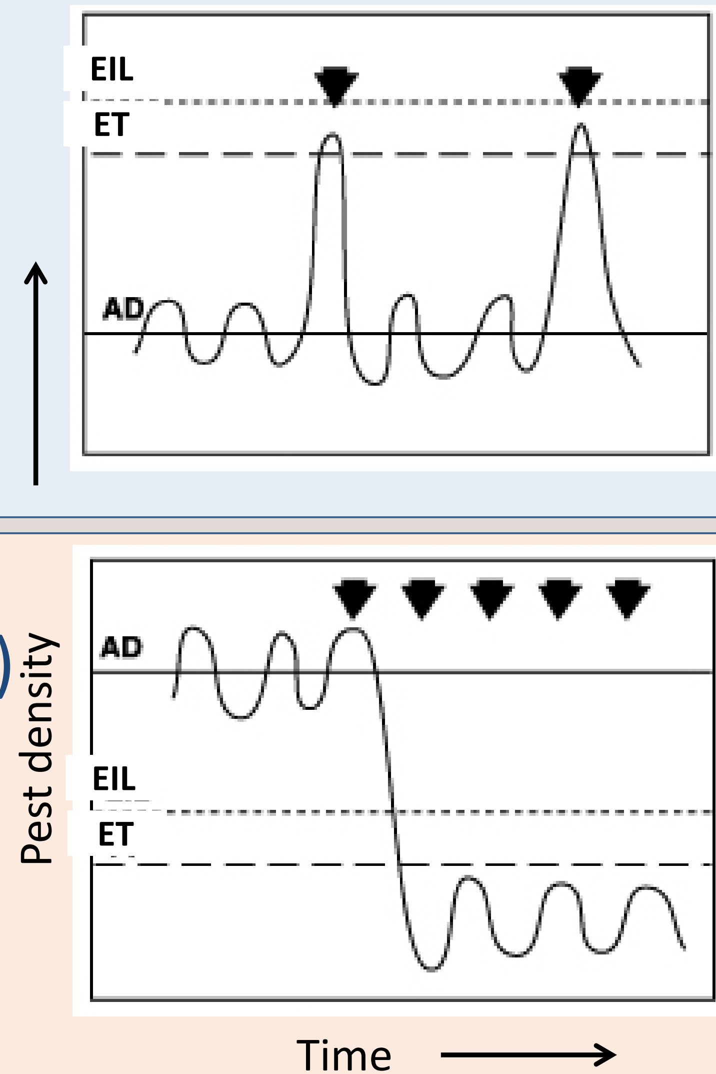
Indirect vs. direct pests

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

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

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

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



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

Action thresholds

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

Most ET's based on grower/researcher experience (empirical or nominal 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 and after 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 and can result 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 inheritied 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: insects may overcome resistance and tolerance, not available

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: routine rotation out of alfalfa/ legumes to reduce clover root curculio

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, or to produce economic yield in presence of pest damage

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

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

Bt:
flies, beetles

Viruses

NPH:
caterpillars

Fungi

B. bassiana:
Neozygites spp.
caterpillars,
mites

Nematodes

Heterorhabditids
and
Stienernematids:
caterpillars,
beetles

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

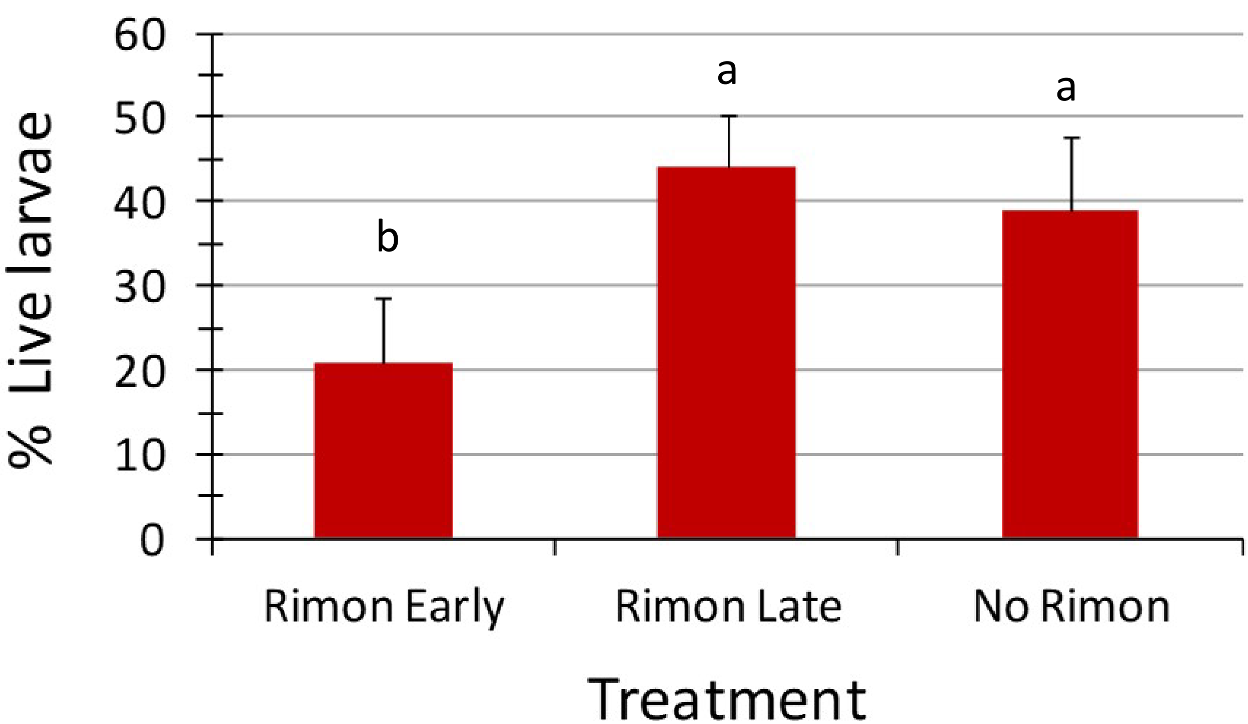
Chemical Control

- Despite concern over their use, pesticides are still a important component of most IPM programs.
- Problems arise when people rely too much on pesticides or mis-use them.
- IPM seeks a balanced approach 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 (bee management in alfalfa seed).

Novaluron (Rimon) is an IGR effective against lygus bugs-the major insect pest in alfalfa seed production.

It also is highly toxic to leafcutting bees needed to pollinate alfalfa for seed production

Percentage live leafcutting bee larvae from grower fields treated with Rimon early or late in the bloom period or not treated with Rimon.



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
- Generally easy to use

Chemical Control

Risks of pesticides

- Pest may develop resistance to the pesticide (lygus bugs, spider mites)
- 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 (phytosanitary certifications for import of hop plants to protect against *Verticillium* and powdery mildew)
- Inspections
- Compulsory crop or product destruction, and eradication of pests (cull management/ onion maggot; legal controls against the Mediterranean fruit fly have included insect eradication programs and quarantine and embargoes on affected fruit.

Record Keeping

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

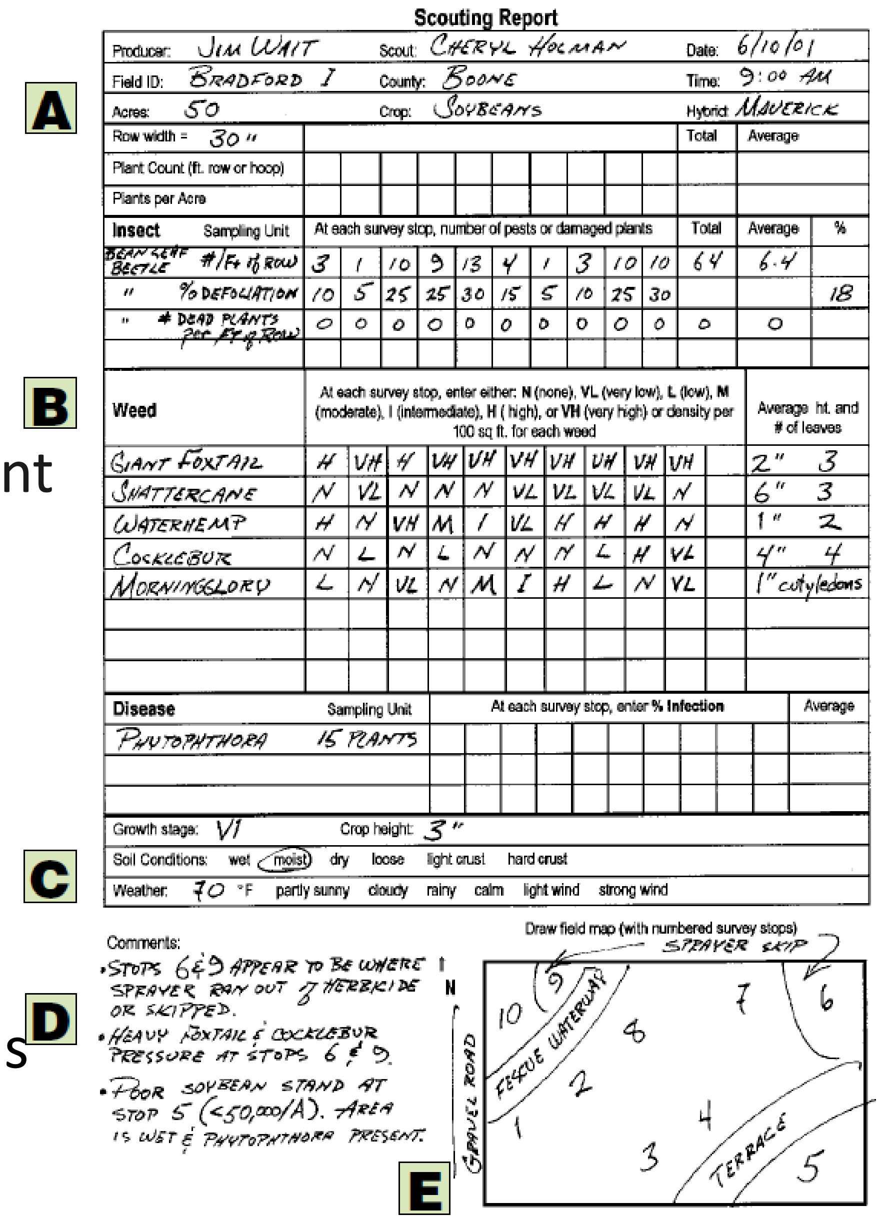
Provides permanent record

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



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												

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											

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

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.

Draw field map (with numbered survey stops)

Record Keeping assists evaluation of IPM programs

- 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?


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

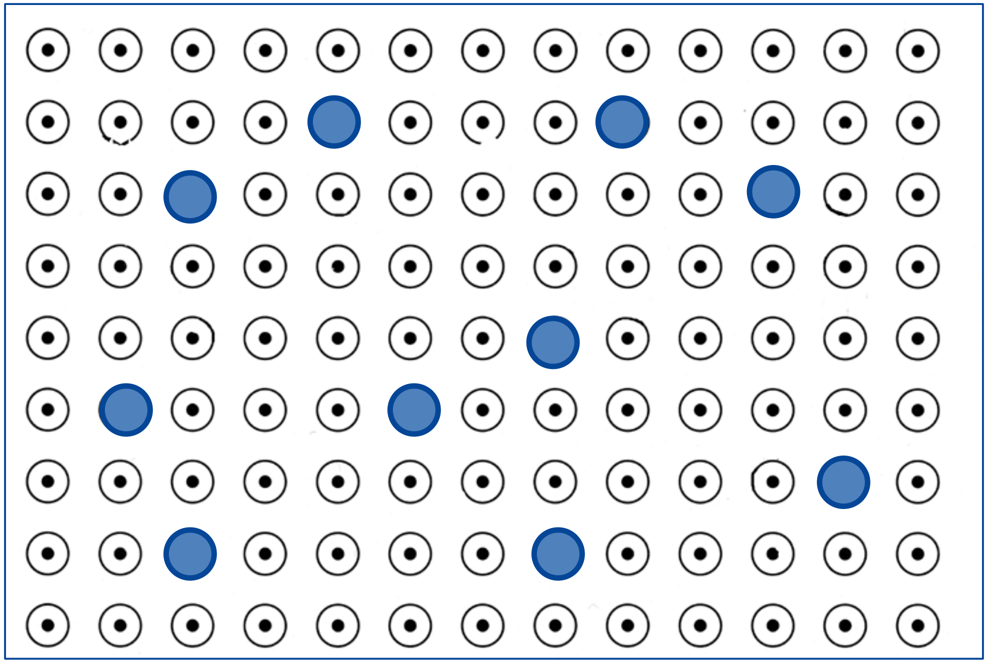
References –field guides, fact sheets, pictures of pests/damage

GPS unit –relocate sample sites accurately

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

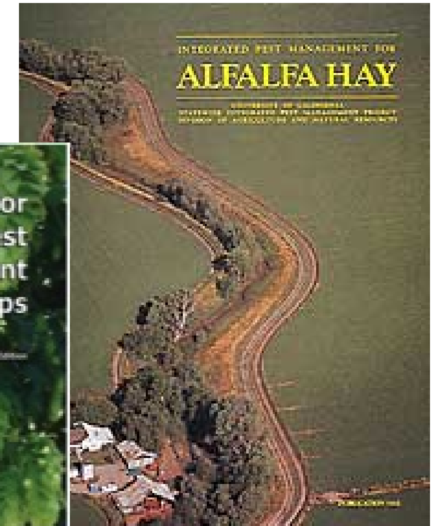
10 leaves (subsamples) per vine from each of 20 vines

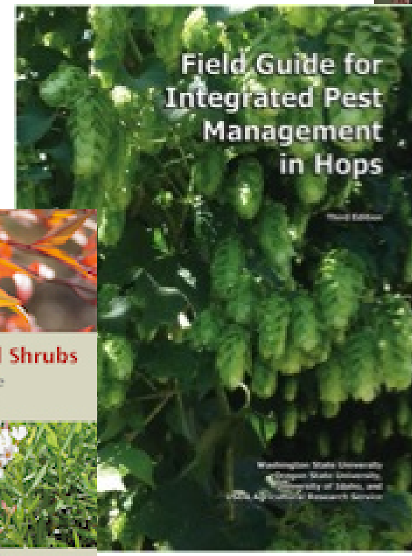
Sample size =200 leaves

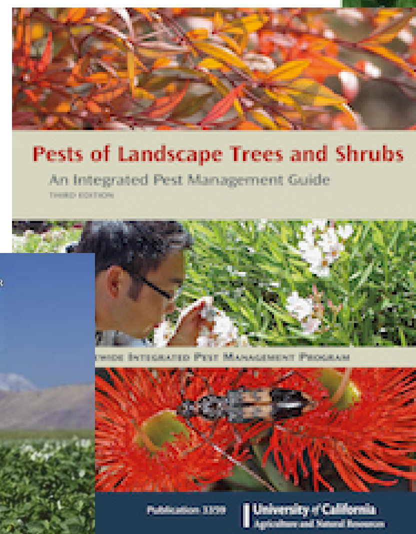
5 sweeps (subsamples) per site from each of 5 sites

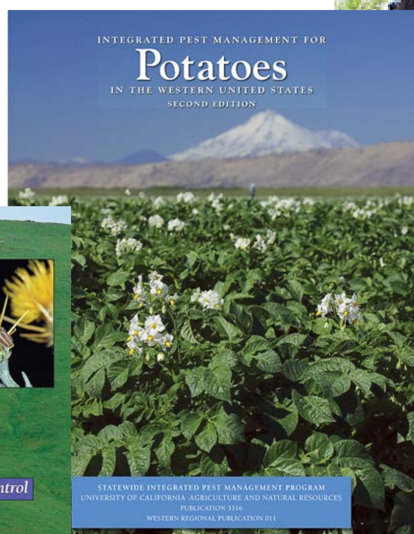
Sample size =25 sweeps

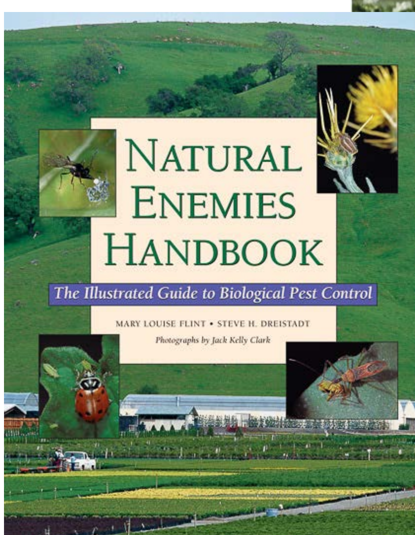
Always sample from more than one tree, vine, area per field or block using a standard method

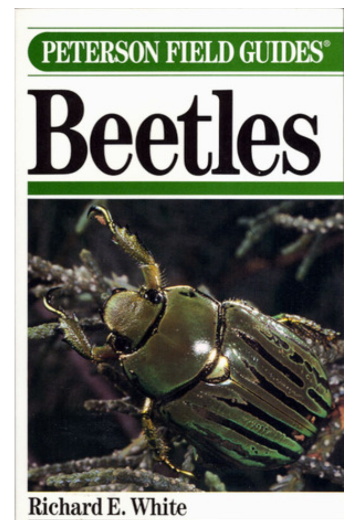




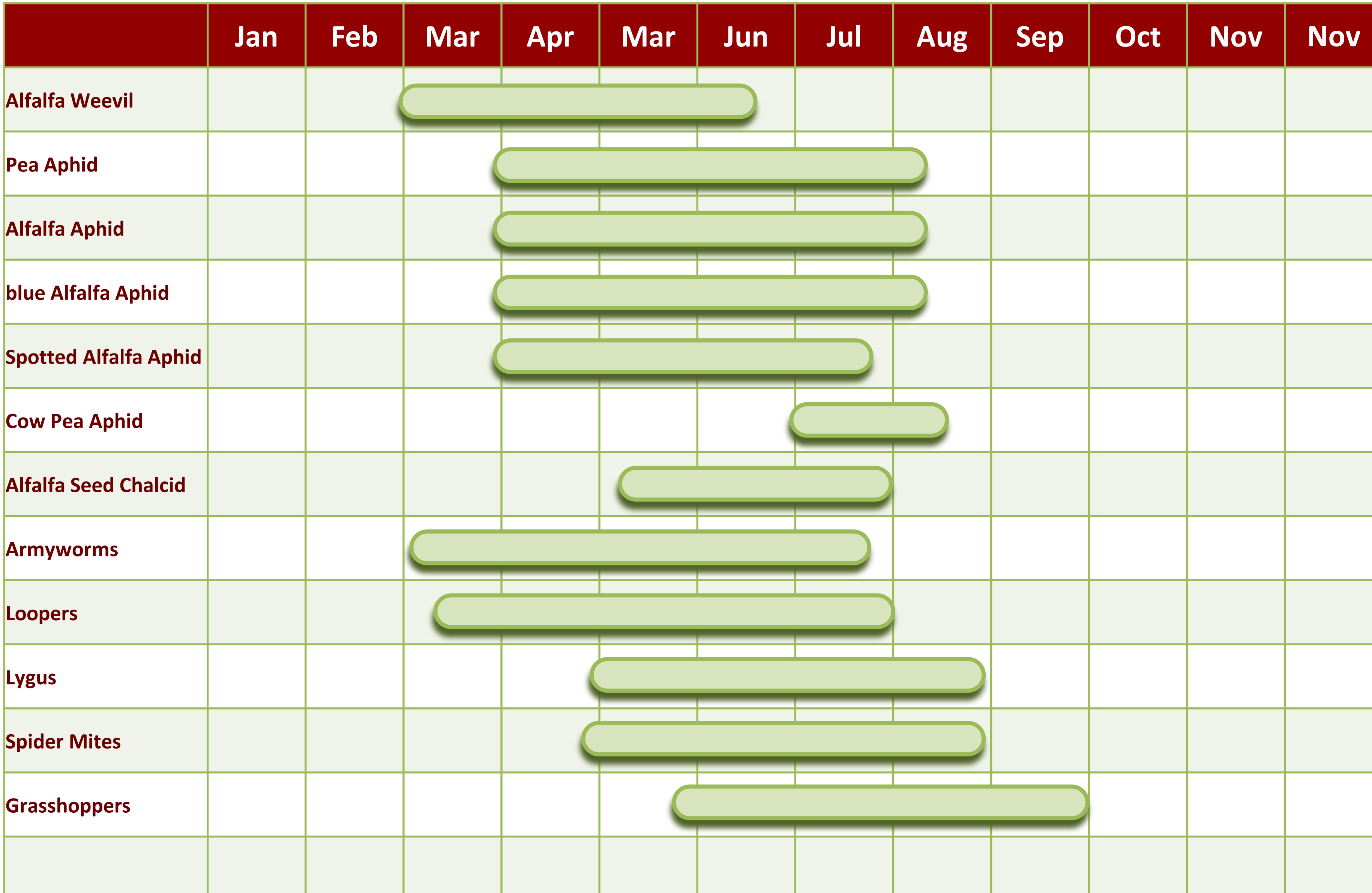








University of Idaho
Extension

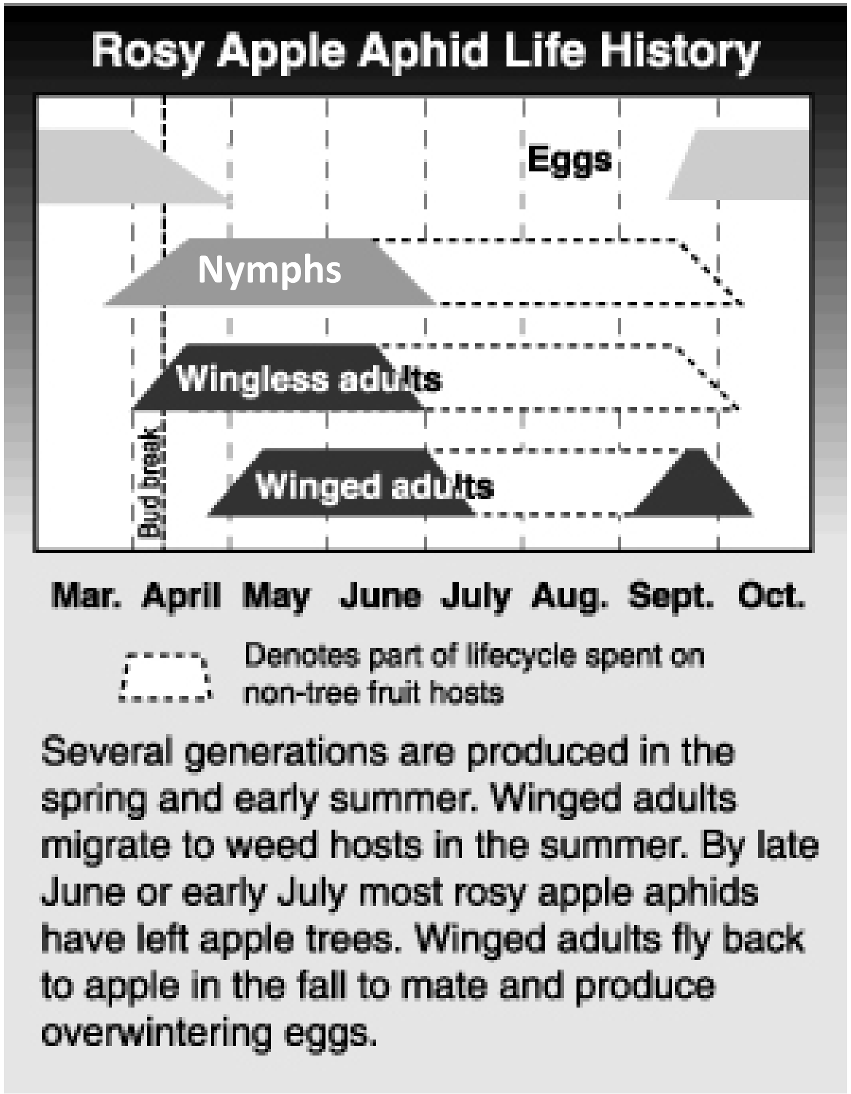

Jan
Feb
Mar
Apr
Mar
Jun
Jul
Aug
Sep
Oct
Nov
Nov
Alfalfa Weevil
Pea Aphid
Alfalfa Aphid
blue Alfalfa Aphid
Spotted Alfalfa Aphid
Cow Pea Aphid
Alfalfa Seed Chalcid
Armyworms
Loopers
Lygus
Spider Mites
Grasshoppers


Count mites down each "pie wedge"


Strawberry diagnostics: Using a mite brush to sample for two-spotted spider mites
Mite Egg

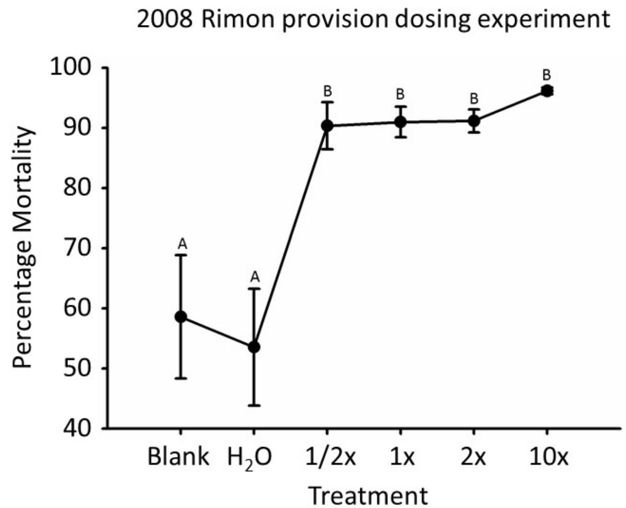
Knowledge of the pest and beneficial insects

Life cycles can be displayed in life history tables

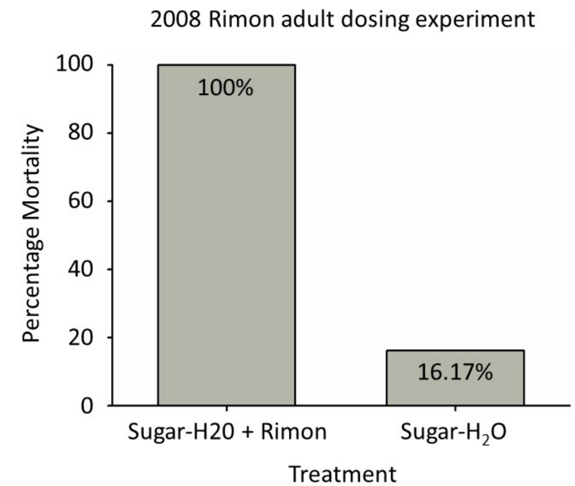


From Orchard Pest Management: A Resource Book for the Pacific Northwest

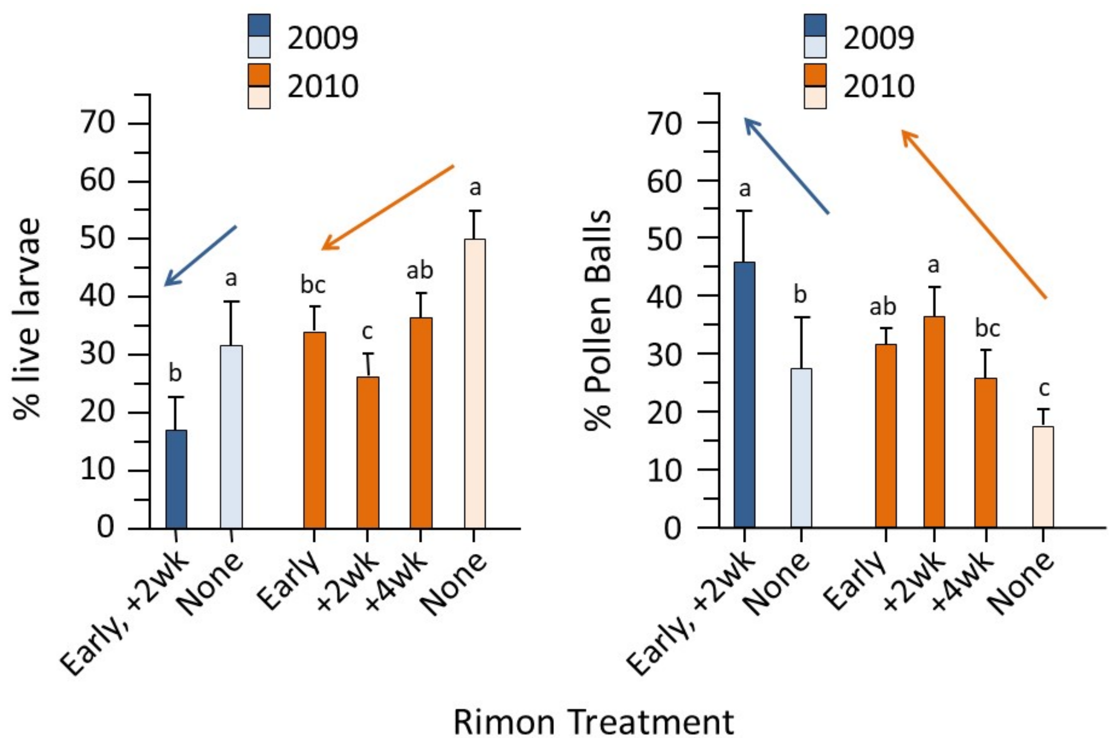
> 90 % mortality of ALCB eggs on Rimon-treated provisions



Adults fed Rimon dosed sucrose lay a high percentage of unviable eggs



Lower % live larvae and higher % pollen balls in Rimon-treated fields



Decision making tools: Sampling and monitoring (scouting)

✓ Increased awareness of:
- crop condition
- insect activity in fields and orchards

✓ Provides <u>reliable estimates</u> of:

Presence
Abundance
Distribution

of pest and beneficial insects