Sampling Insect Populations for Pest Management

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Why Sample?

Sampling and monitoring (scouting) are fundamental components of an IPM program

Increased awareness of insect activity in orchards and fields

Provides reliable indications of:

Presence Abundance Distribution	of pest and beneficial insects/ injury & damage caused by pests

Why Sample?

Make cost effective and environmentally sound insect management decisions

- When (if) to apply control measures
- Apply the right control
- Avoid pest outbreaks/ yield loss
- Avoid unnecessary treatments
- Resistance management
- Determine population trends
- Determine effect of treatments

Components of an insect sampling program

Knowledge of pest and beneficial insects

- Identification
- Life cycle and biology
- Injury caused

Action/ economic thresholds

Sampling/ monitoring plan or program

Sampling/ monitoring equipment supplies

Knowledge of pest and beneficial insects

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

AM

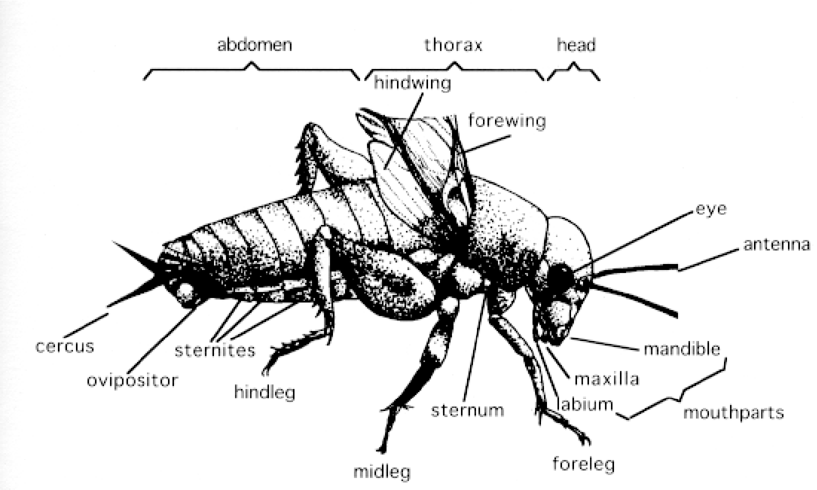
WHF

WCFF

Knowledge of pest and beneficial insects

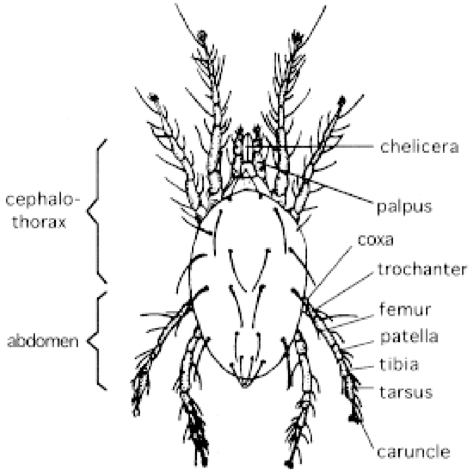
Some familiarity with basic insect and mite structure

Insects



- Small to tiny
- 3 body sections
- 6 legs

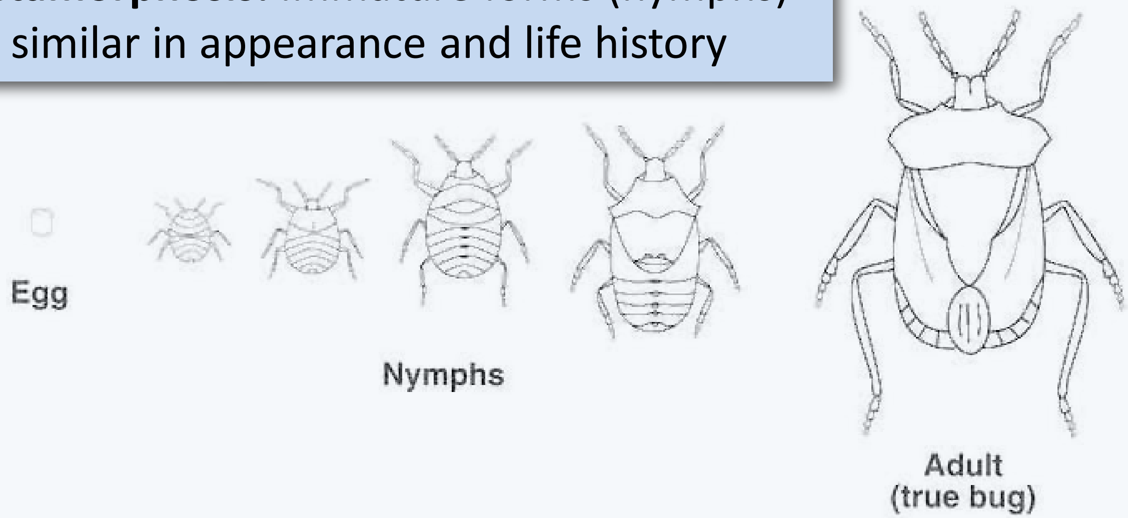
Mites



- Tiny to minute
- 2 body sections
- 4 to 8 legs

Knowledge of insect and mite biology: growth

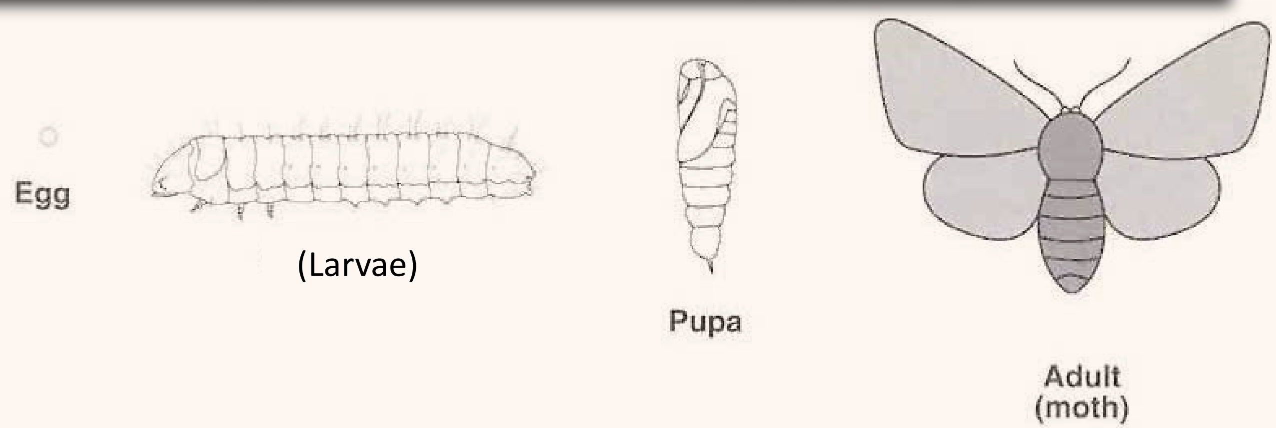
Simple Metamorphosis: Immature forms (nymphs) and adults similar in appearance and life history



True bugs
Grasshoppers
Leaf hoppers
Aphids
Scale insects

Mites

Complete metamorphosis: Immature forms (nymphs)s and adults differ in appearance and life history: pupa stage



Moths
Butterflies
Flies
Thrips
Beetles
Bees and wasps

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

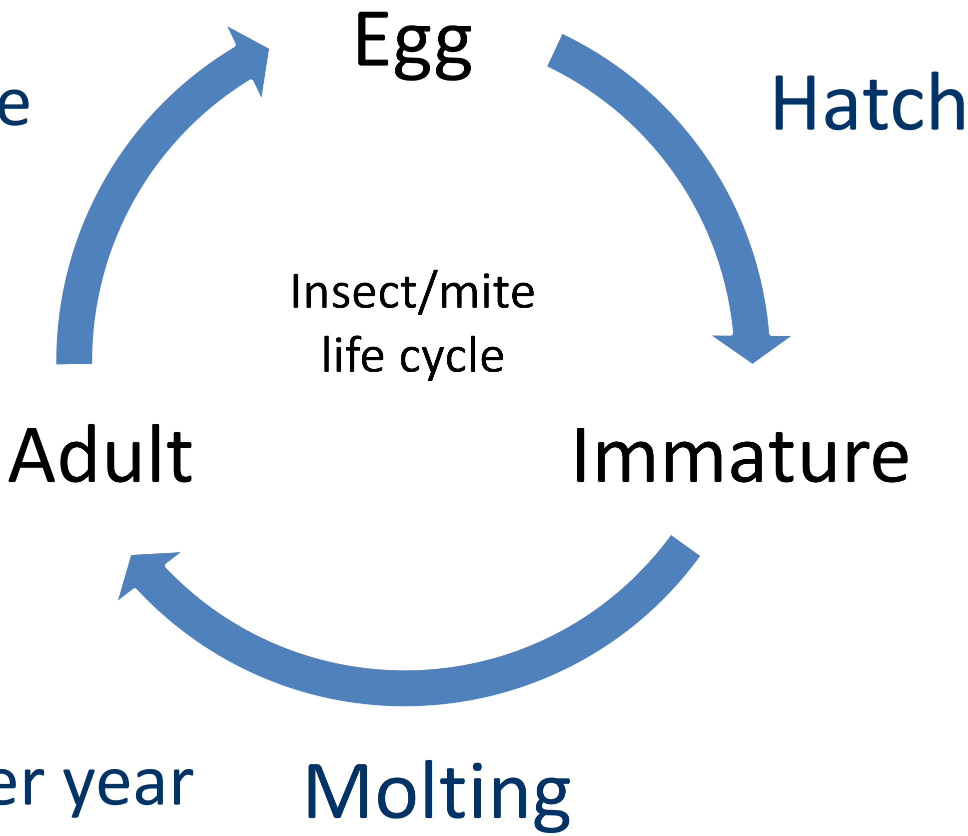
Knowledge of pest and beneficial insects

The life cycle and biology tells us when and where and how often to sample: narrows sampling effort

- Overwintering

  When, where, what stage

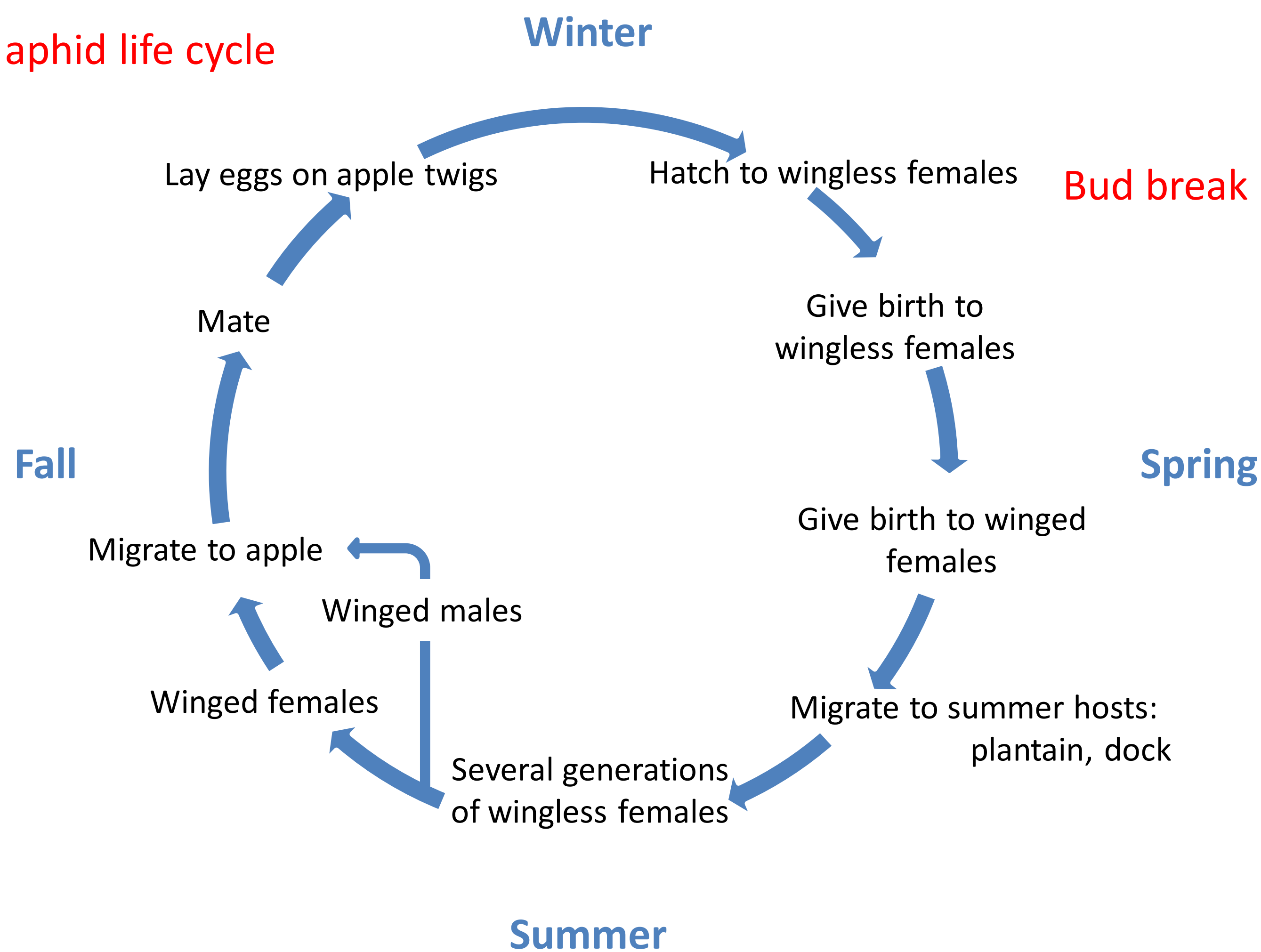
- Hosts: the plants attacked, used
- Plant parts attacked
- Damaging stage
- When it's present
- Number of generations per year
- Generation time



Knowledge of pest and beneficial insects

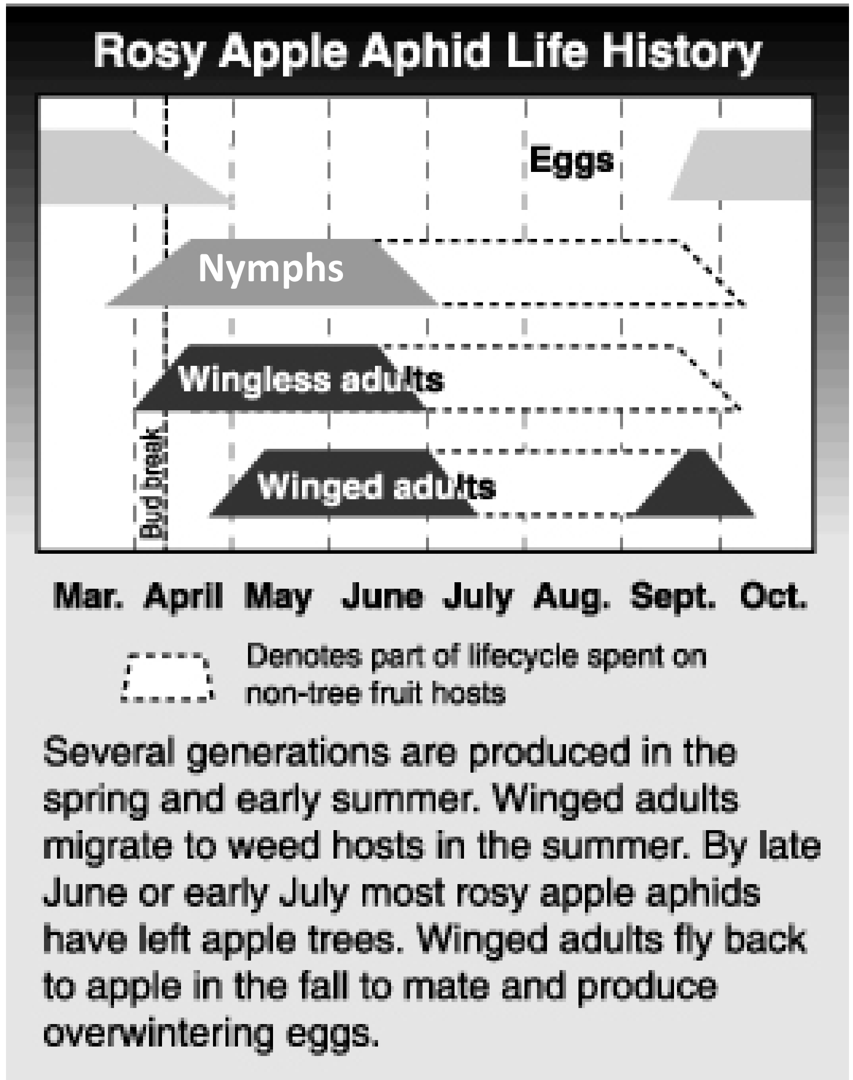
The life cycle and biology tells us when, where and how often to sample: narrows sampling effort in time and space

Rosy apple aphid life cycle



Knowledge of pest and beneficial insects

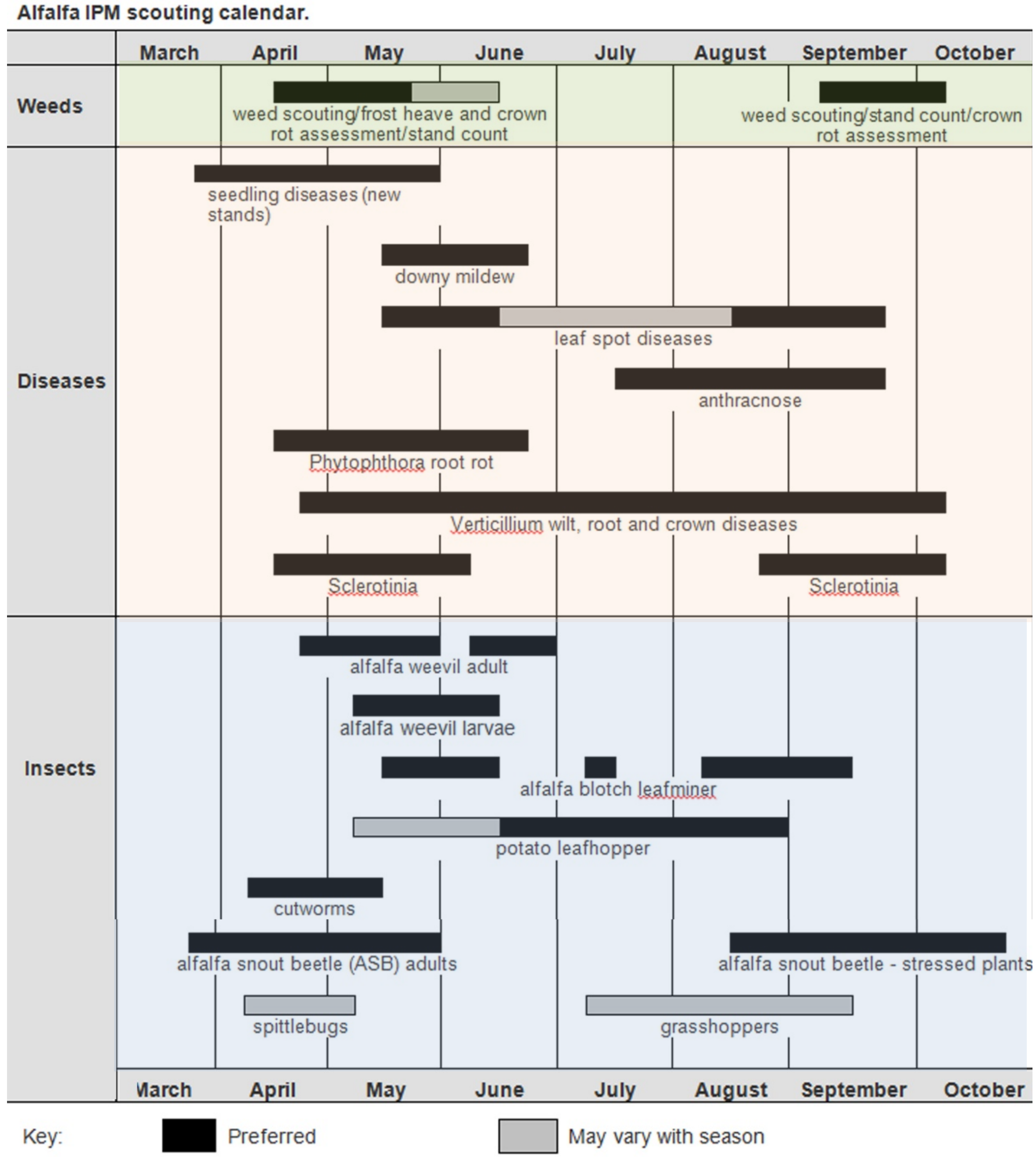
Life cycles can be displayed in life history tables



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

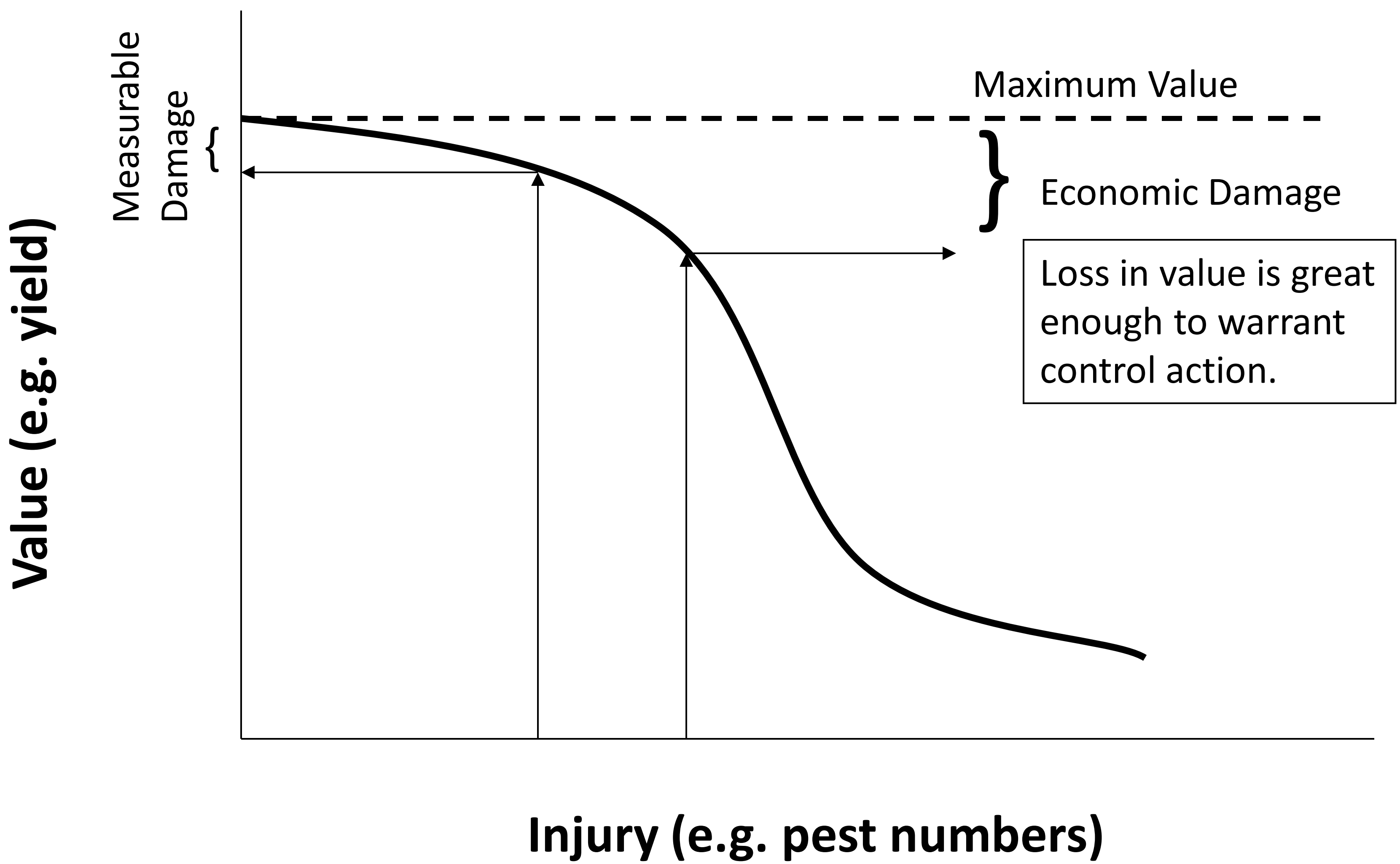
Knowledge of pest and beneficial insects

Life cycles for multiple pests can be combined in a season-long occurrence table or scouting calendar for a particular crop



From IPM for Apples and Pears. UC Statewide IPM project. Pub.3340

Pest Injury versus damage



Pest Injury versus damage

Injury – The effect that the pest has on the crop or commodity.

Damage – The effect that injury has on man's assessment of the crop's economic value.

For crops, "Injury" is biological and "Damage" is economic. For non-crops, "Injury" = "Damage".

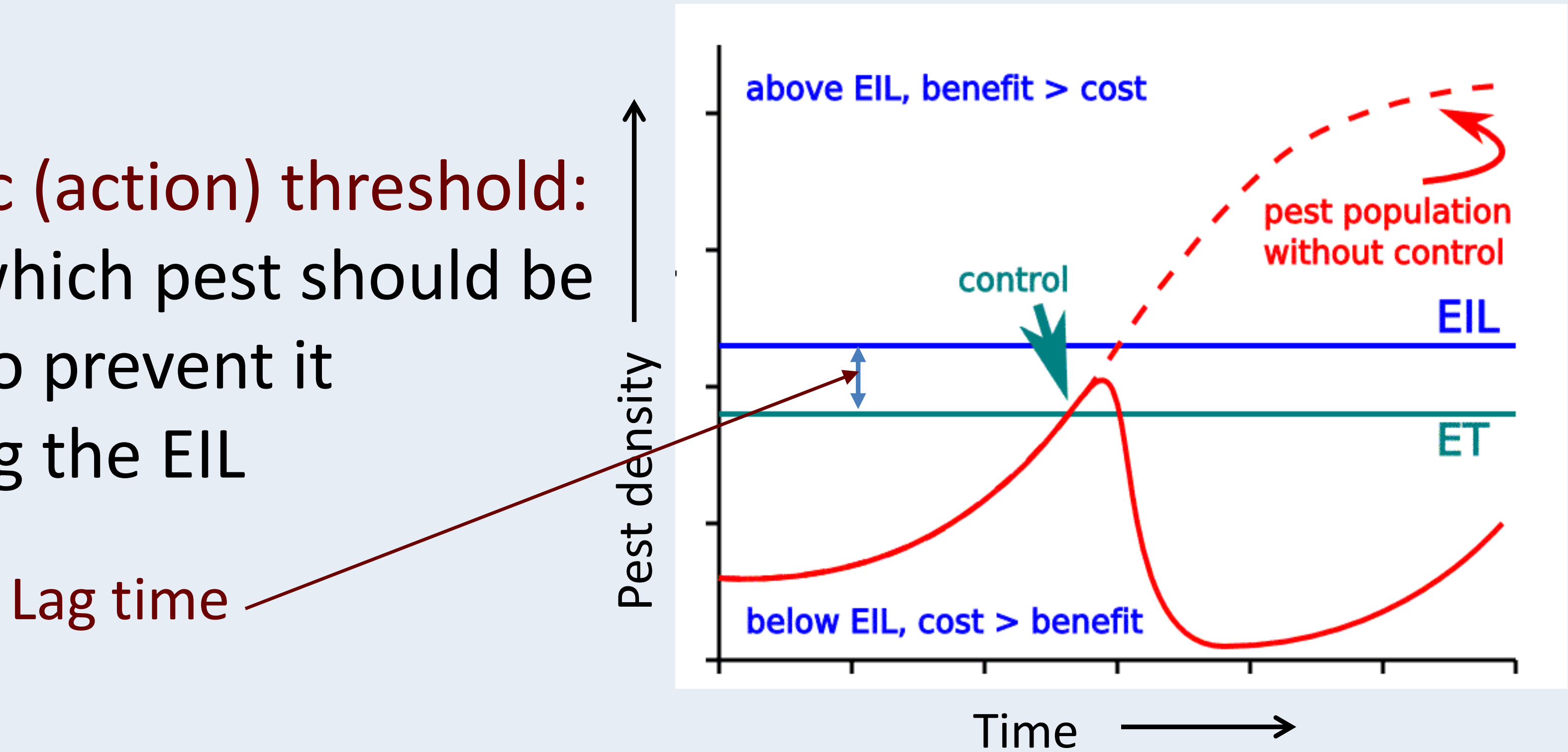
Economic injury levels and action thresholds

What do the sample numbers mean?

Economic injury level: pest density that causes economically significant crop loss, or when:

Cost of yield loss = cost of control efforts

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



Action thresholds

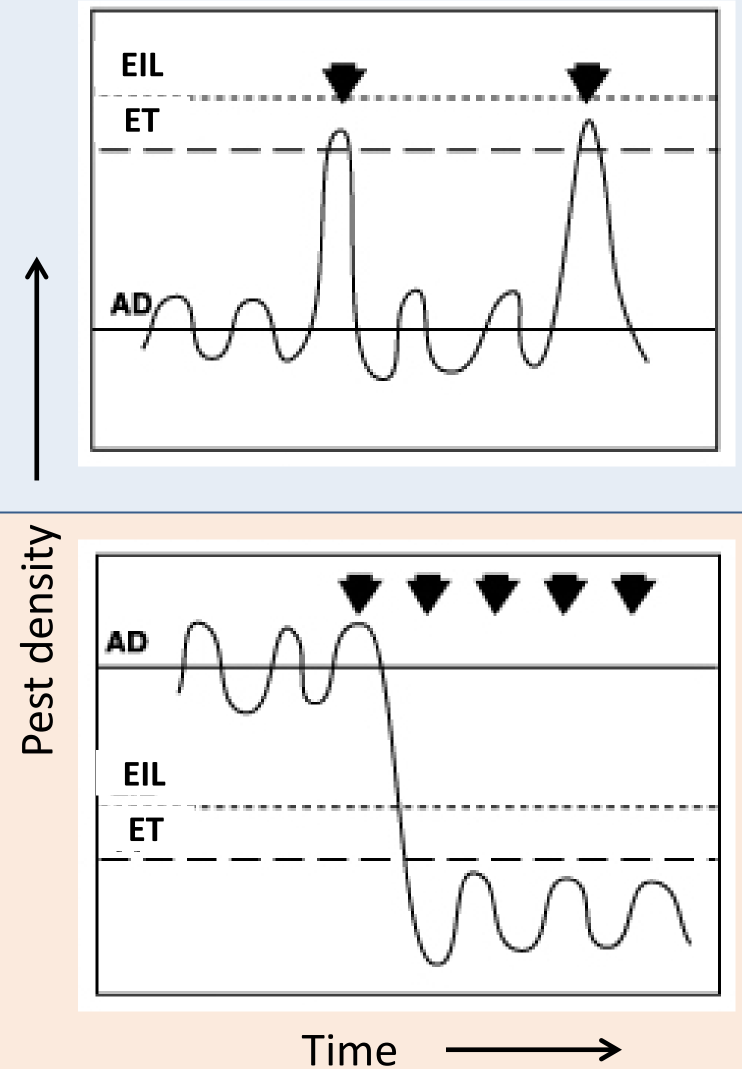
Indirect vs. direct pests

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



From Metcalf and Luckmann 1994

Action thresholds

Formal EIL and ET have not been developed for many pest/ crop combinations

Most ET's based on grower/ researcher experience

Sampling gives valuable information:

- Detect pest presence
- Detect damaging stage
- Presence of natural enemies
- Populations increasing or decreasing in density (from repeated samples)
- Effectiveness of control measures

How to sample

Walk through the field/ orchard and count pests and beneficial insects

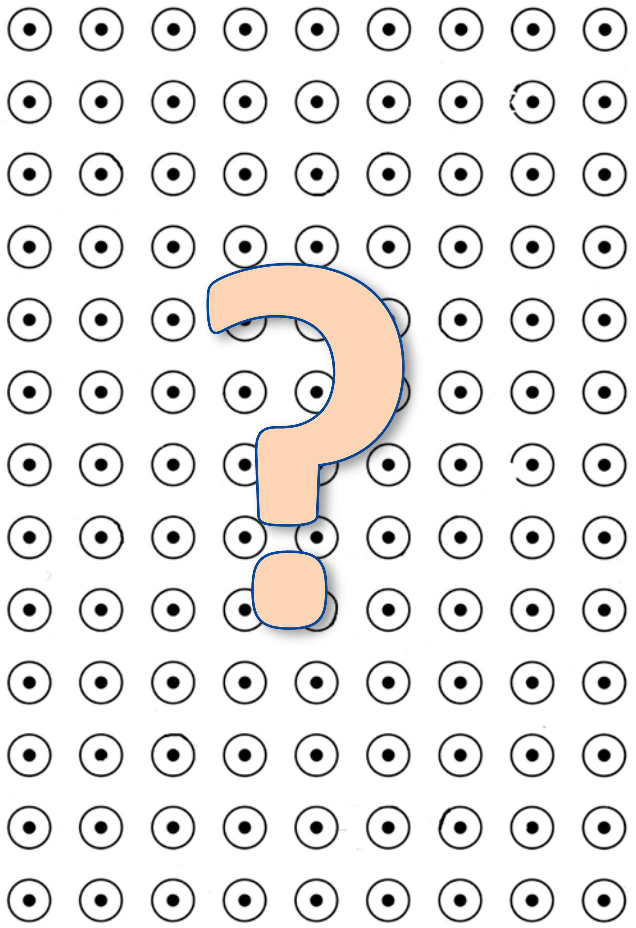
We need to reliably estimate the actual density (e.g. pests per leaf)

How do we find out?

Count them all?

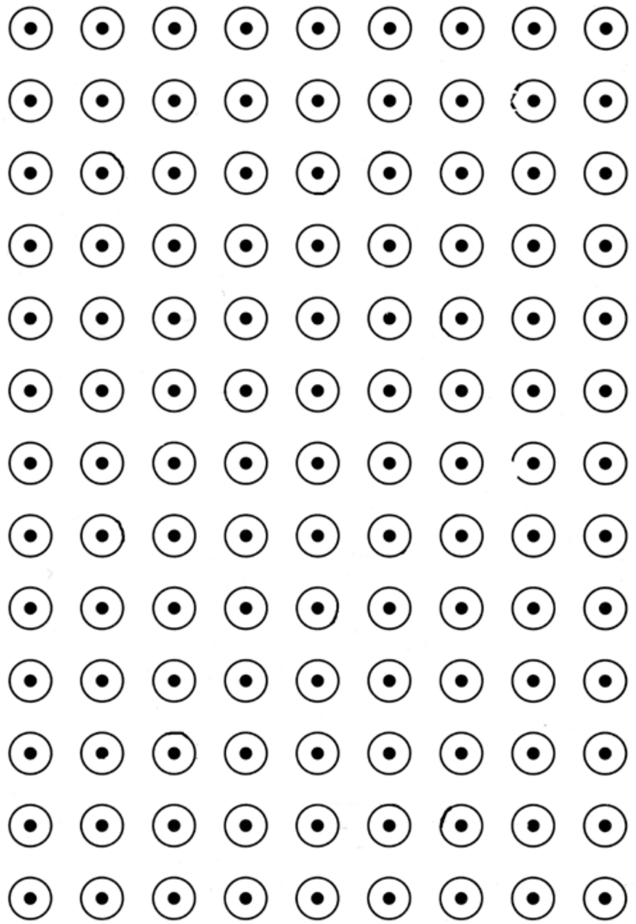
Estimate the density by sampling a only portion of the population

Almost always interested in estimating mean density per sample unit



Representative samples

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



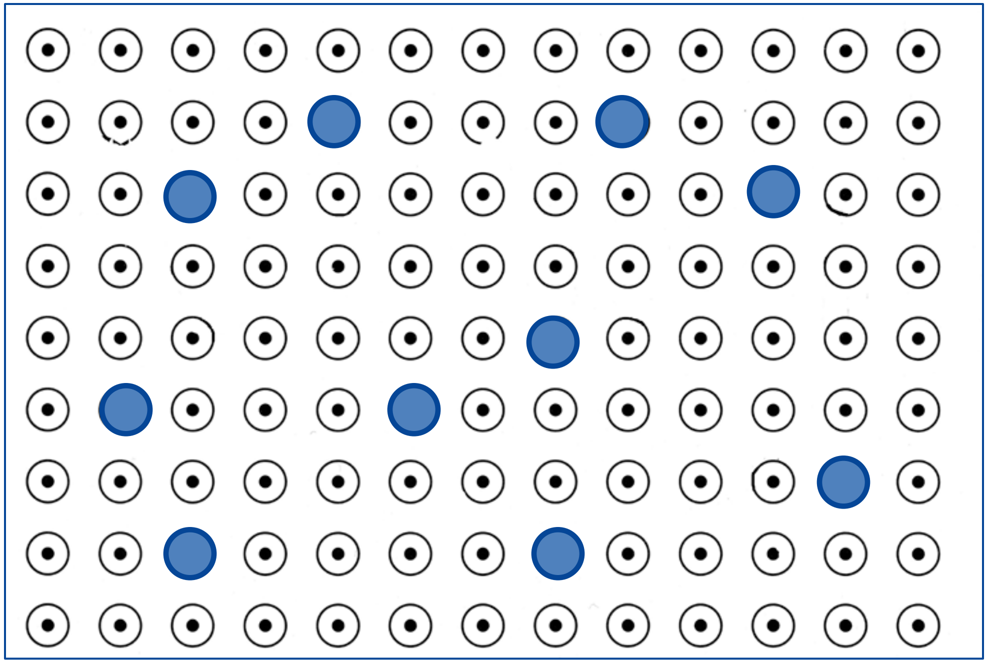
Samples should be unbiased

- 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

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
- Sweeps of an area
- Beat board/ cloth
- Trap



Sample: all of the sample units (subsamples) collected to estimate the population density 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

Sample size examples:

10 leaves per vine from each of 20 vines

Sample size =200

5 sweeps per site from each of 5 sites

Sample size =25

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

How to sample

Walk a predetermined route that covers the entire field

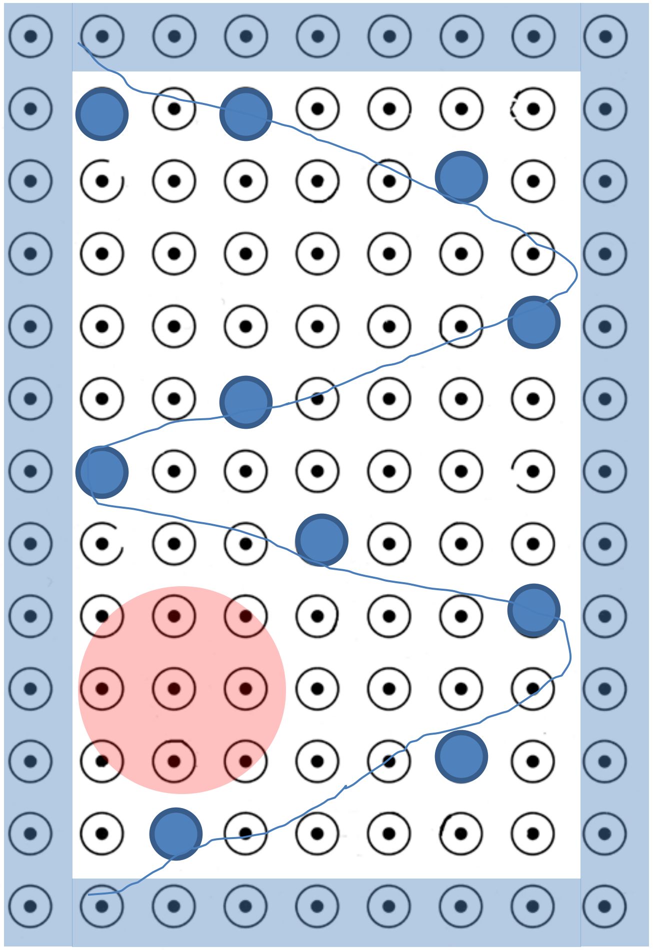
Zig-zag or “W” shaped routes are good

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

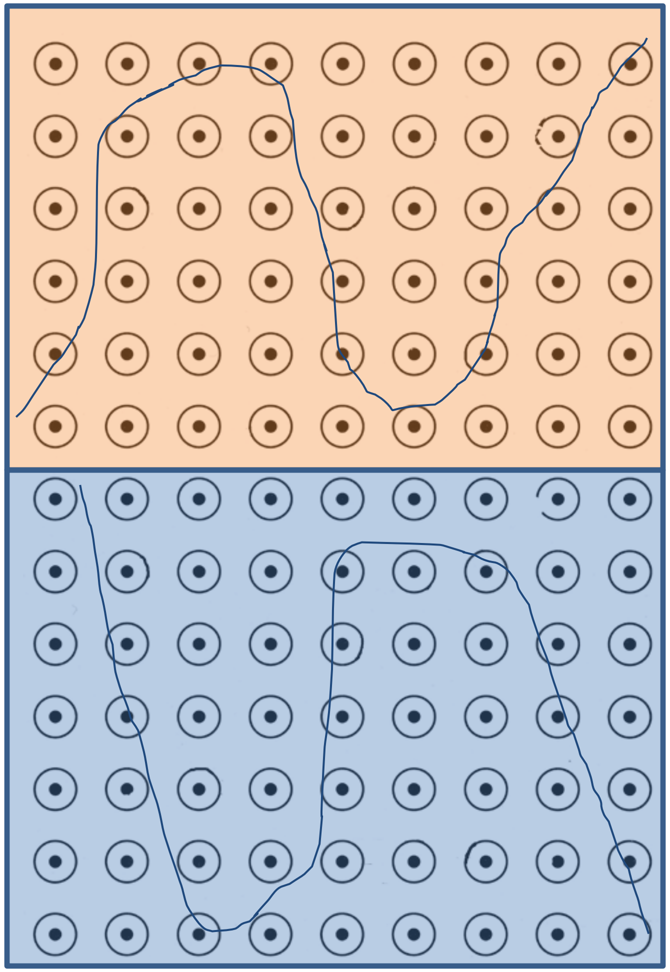
Consider separate samples from field edges and “hot spots”



How to sample

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

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

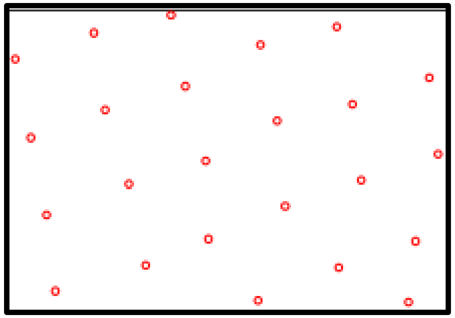


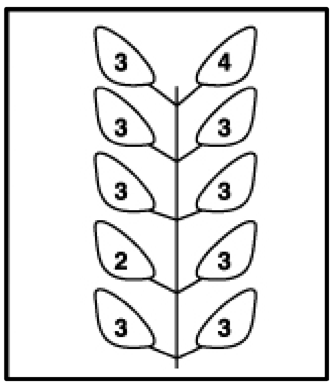
How many samples are required?
Depends on insect distribution

Possible Insect distributions in fields or on plants

Uniform

Mean>> variance





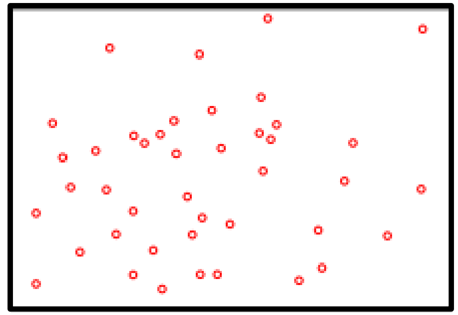
Mean=3

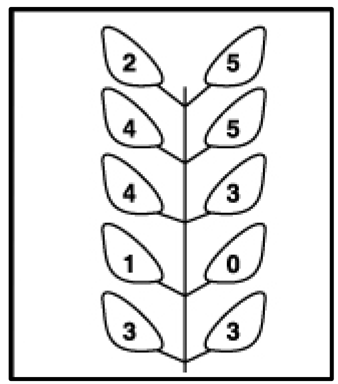
Variance=0.2

Few samples needed: rare

Random

Mean≈variance





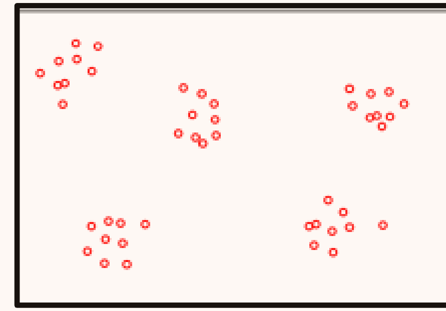
Mean=3

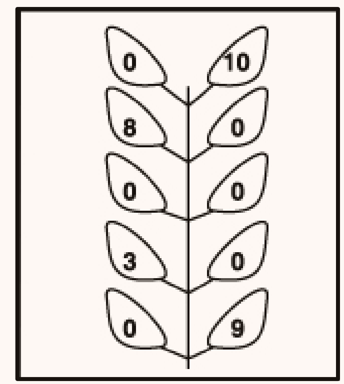
Variance=2.6

Many samples needed: uncommon

Clumped

Mean<< variance





Mean=3

Variance=18.2

Very many samples needed: 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

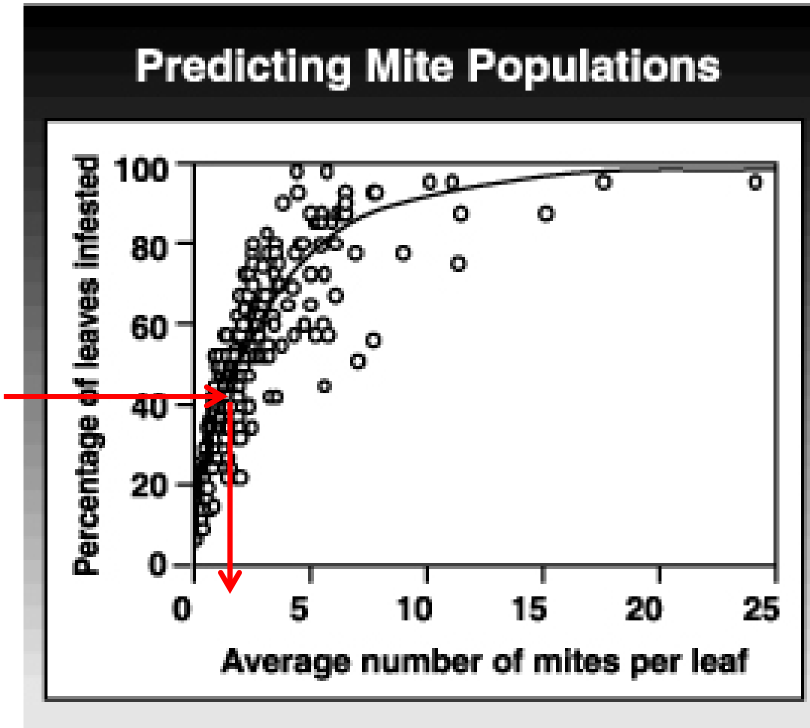
Most sampling plans use a fixed number of samples to provide a conservative estimate of the mean

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) 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

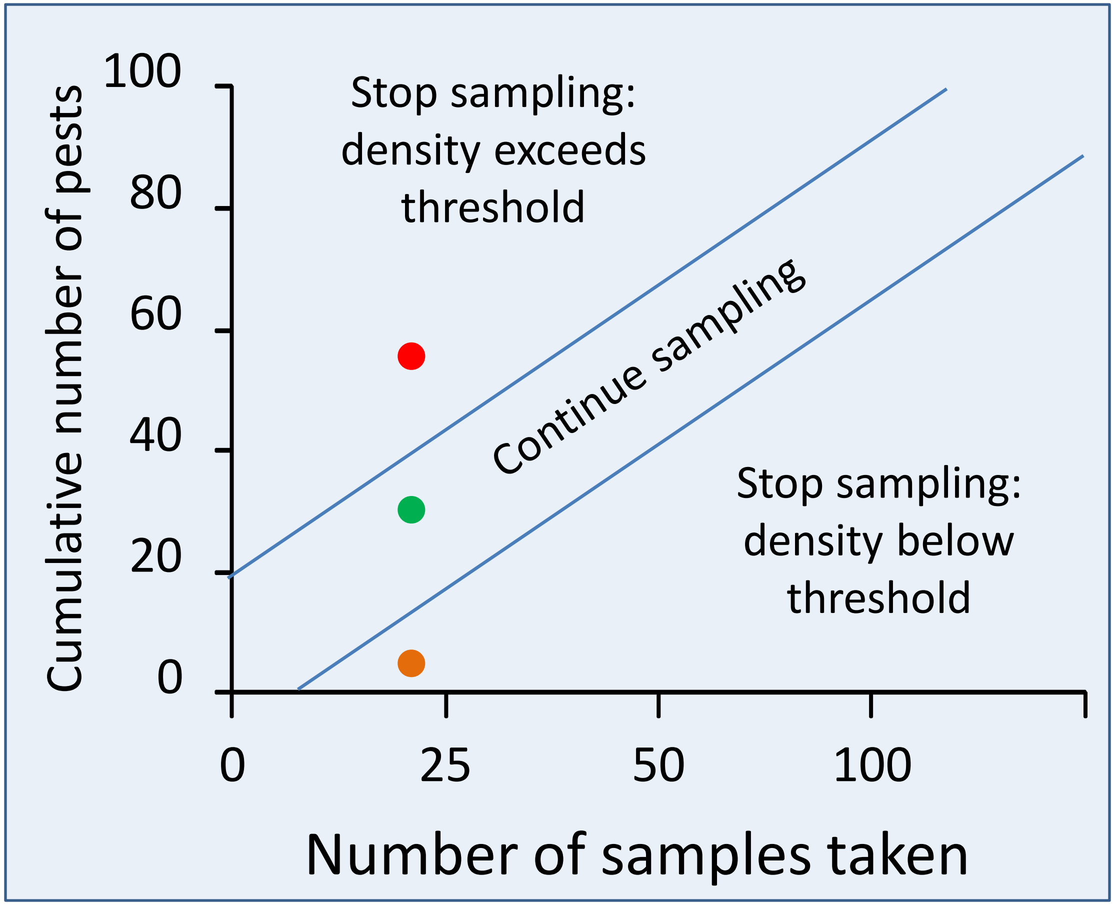
Sequential sampling

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

- Stop sampling: treat
- 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 samples per block
- Maximum sample: 50 samples per block
- Alternative fixed sample plan: 20 samples 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	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	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…

Aphids, scale insects mites, leafminers, small caterpillars, leaf hoppers, immature psylla…

Counts on site or in shop/lab

10x-20x hand lens useful

Sampling methods

Beat tray (tap) samples

Jar insects/mites onto a tray or cloth where they can be easily counted

Larger caterpillars, adult psylla, aphids

Counts on site or in Shop/lab

Hand lens/ aspirator useful

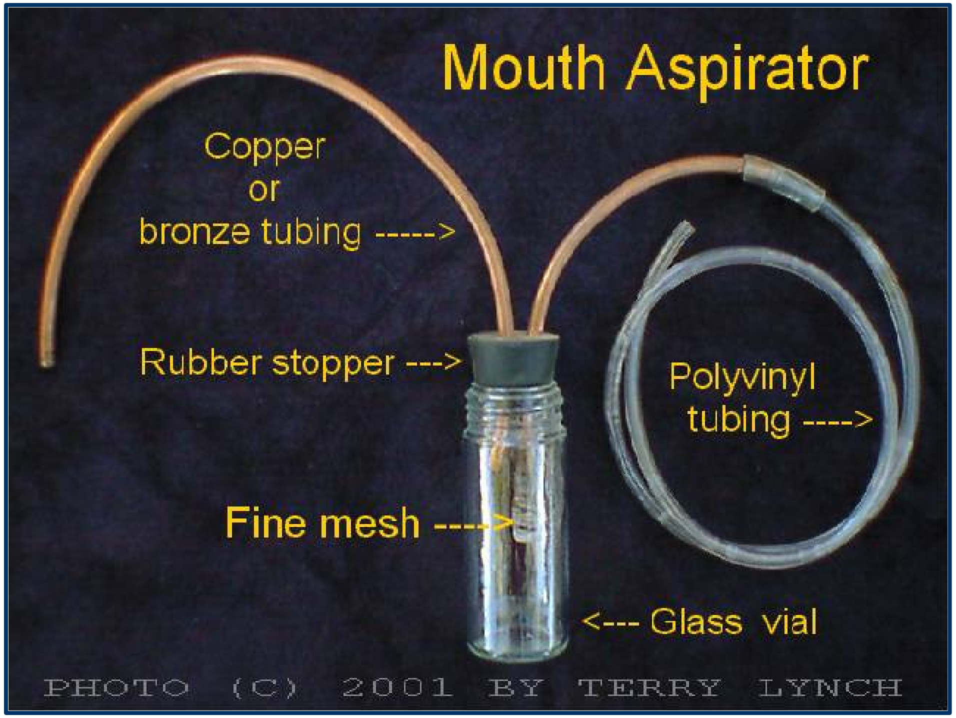
Sampling methods

Sweep net samples

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

Sampling methods

Insect aspirator



Sampling methods

Attractant traps

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

Yellow sticky cards:
aphids, cherry fruit flies,
thrips

Red spheres:
apple maggot

Sampling methods

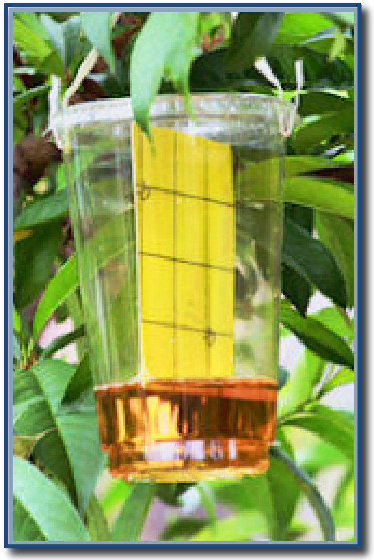
Attractant traps

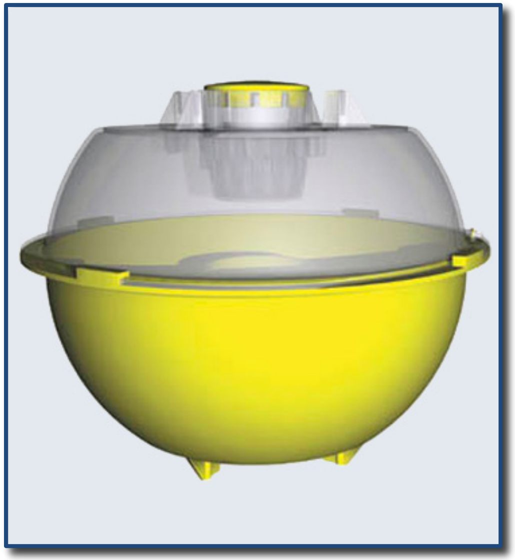
Food attractants: Food source scents

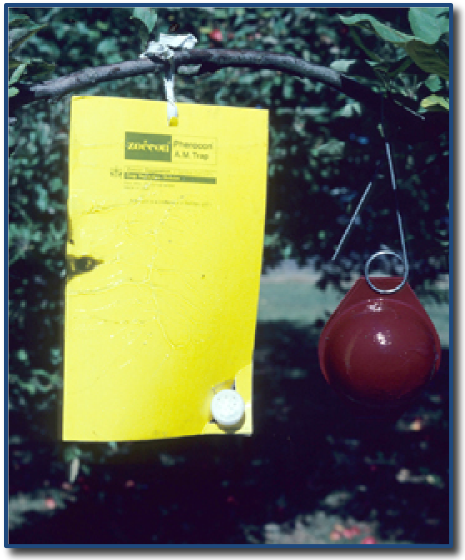
Often an ammonia source: ammonium acetate, or
ammonium carbonate

May have a protein source (casein)

Often combined with visual/sticky traps







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 pests

Codling moth
Cutworms (several)
Red-banded leafroller
Grape root borer
Peach twig borer
Mint root borer

Fruittree leafroller
Corn borer
Peachtree borer
Corn earworm
Spotted tentiform leafminer
California prionus

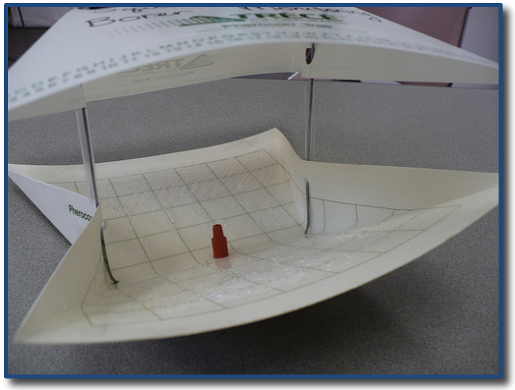
Sampling methods

Attractant traps

Pheromone traps

Consist of a lure or dispenser and a trap

+



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Many kinds of lures and traps available

Sampling methods

Attractant traps

Useful for monitoring pests and beneficial insects

- Monitor flight periods
- Synchronize DD models (setting biofix: peak flight)
- Monitor/ assess success of control programs
- Monitor exotic or invasive pests (BMSB)

Useful for controlling pests

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

Sampling methods

Monitoring degree days

- 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
- Between the lower and upper thresholds insect growth increases with temperature
- Predicts insect development by accumulating heat units (degree days)
- Determine best time to sample for or control

    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: $\left(\frac{T_{max} - T_{min}}{2} \right)$

Sampling methods

Accumlating 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

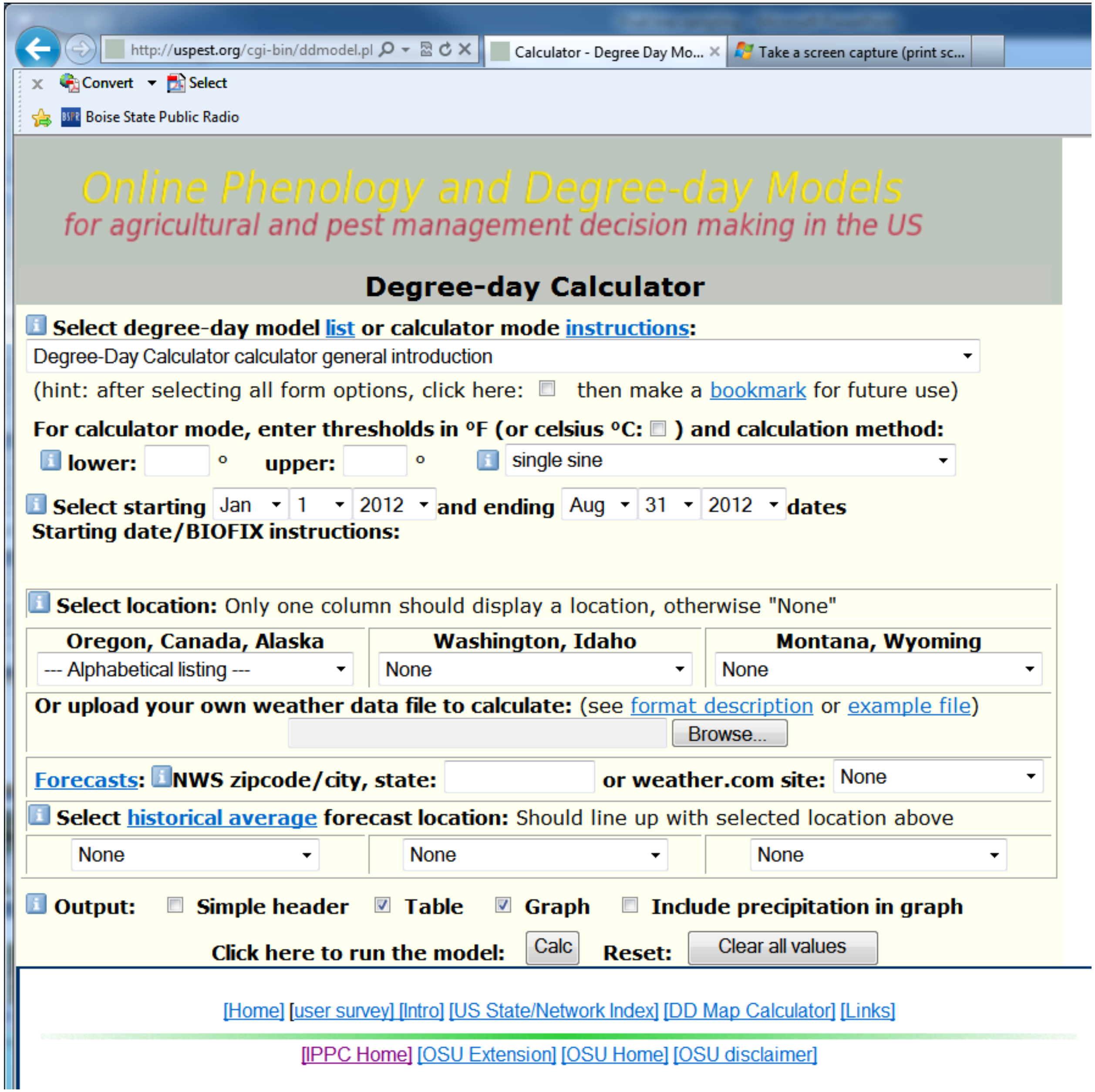
Mean daily temp. > Lower threshold: DD accumulation

Maximum daily temp never exceeds the upper development threshold

- 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)

Online models available for many pests

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



apple maggot 1st emerge [cherry & apple] Jones et al. 1989 JEE 82:788-792
apple maggot percent emergence [cherry & apple] Jones et al. 1989
apple scab infection season [apple] Gadoury et al. (1995)
pear scab infection season [pear] Hood River Exp. Sta./Bob Spotts
bertha armyworm [vegetables] Bailey 1976
black cutworm [vegetables] Luckmann et al. 1976
brown marmorated stink bug [multiple hosts] IPPC synthesis based on Nielsen et al. (2008)
Barley P. Miller, MSU
cabbage looper [vegetables] Toba et al. 1973
corn earworm [sweet corn] Hartstack et al. 1976
western cherry fruit fly v2 [cherry E. of Cascades] Jones et al. (1991)
western cherry fruit fly [cherry W. of Cascades] AliNiazee (1979)
chick Pea (Desi not Kabuli) intermediate requires stress to hasten maturity P. Miller, MSU
codling moth revised 06 [apple & pear] 2006 revision by A. L. Knight
codling moth WSU model 2008 [apple & pear] Jones, Doerr & Brunner 2008
cereal leaf beetle [grasses and grains] Fulton et al. 1975 EE 4:357, OSU1
codling moth [apple & pear] Brunner and Hoyt (1987)
cabbage maggot - Dreves 2005 newsletter (pdf)
canola (Argentine) indet. growth habit, will cont. to flower until stressed P. Miller, MSU
canola (Polish) indet. growth habit, will cont. to flower until stressed P. Miller, MSU
canary P. Miller, MSU
downy brome Dan Ball
Douglas-fir needle midge [fir trees] IPPC synthesis based on W. OR trapping data
emerald ash borer [ash trees] McCullough and Siegert (2006)
early blight (A. solani) [potato, tomato] Gent & Schwartz 2003
european grapevine moth [grapes] Univ. Calif. Cooperative Extension (2010-11)
european pine shoot moth [nursery crops] Regan et al. (1990)
cougarblight (fire blight risk calculator) [apple & pear] Smith (1998)
filbertworm [hazelnut] Aliniazee (1983)
flax stage flax early in morning before flower petals fall off P. Miller, MSU

Forecasts: **NWS zipcode/city, state:** **or weather.com site:** None

Select historical average forecast location: Should line up with selected location above

None | None | None

Output: Simple header, Table, Graph, Include precipitation in graph

Click here to run the model: Calc **Reset:** Clear all values

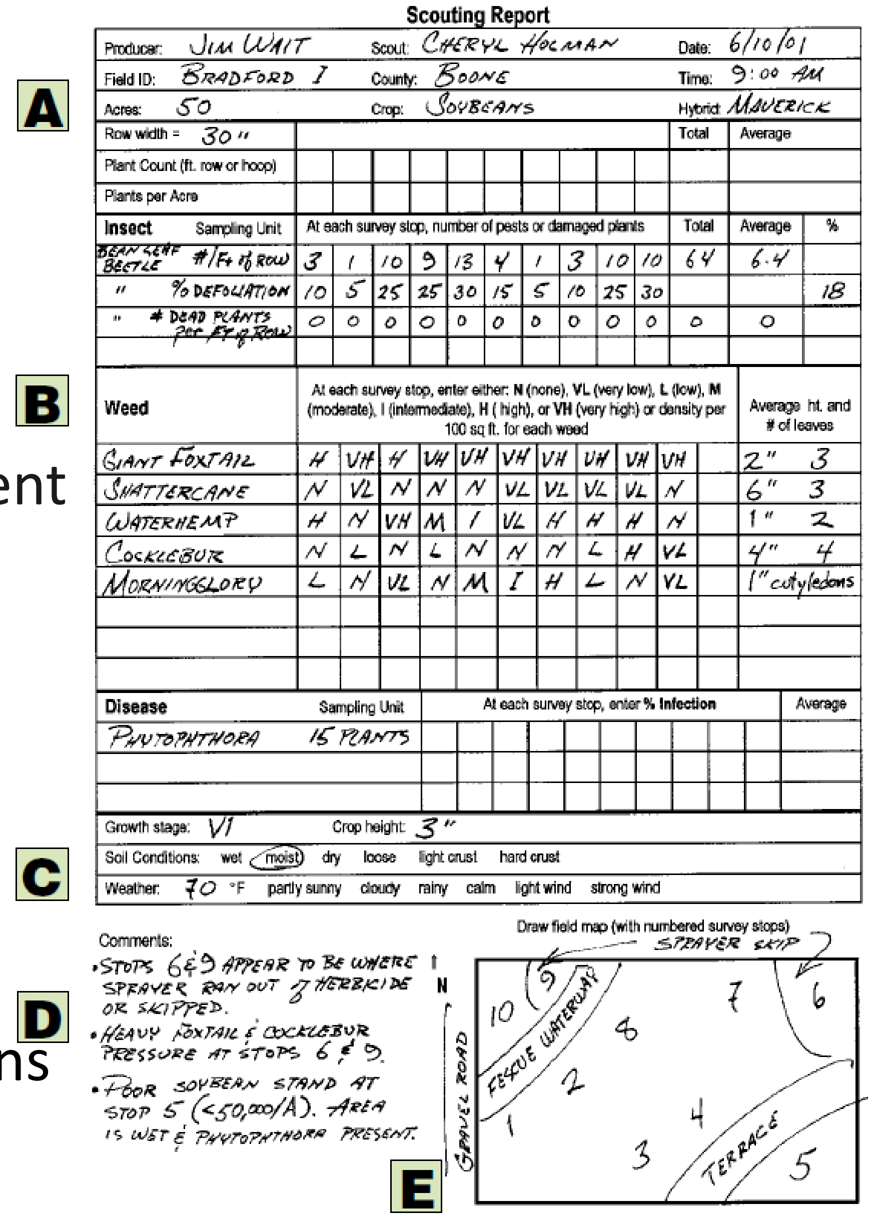
[Home] [user survey] [Intro] [US State/Network Index] [DD Map Calculator] [Links]

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

Record Keeping

Scouting forms –Record sampling/ monitoring data and observations

- 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
  - 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)

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 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