Integrated Pest Management & Understanding Pesticides

2018 Butte County Master Gardener Training

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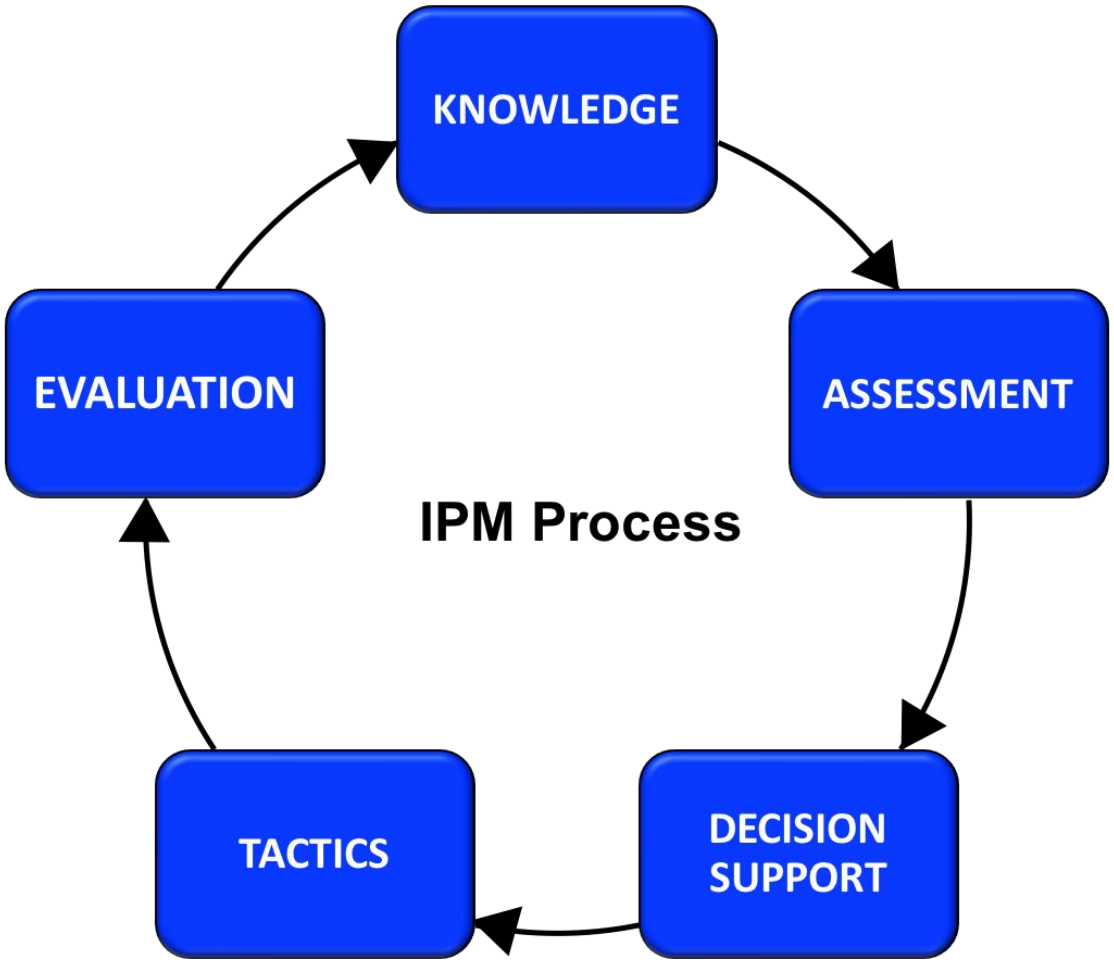
What is IPM?

IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques (=tactics) such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties.

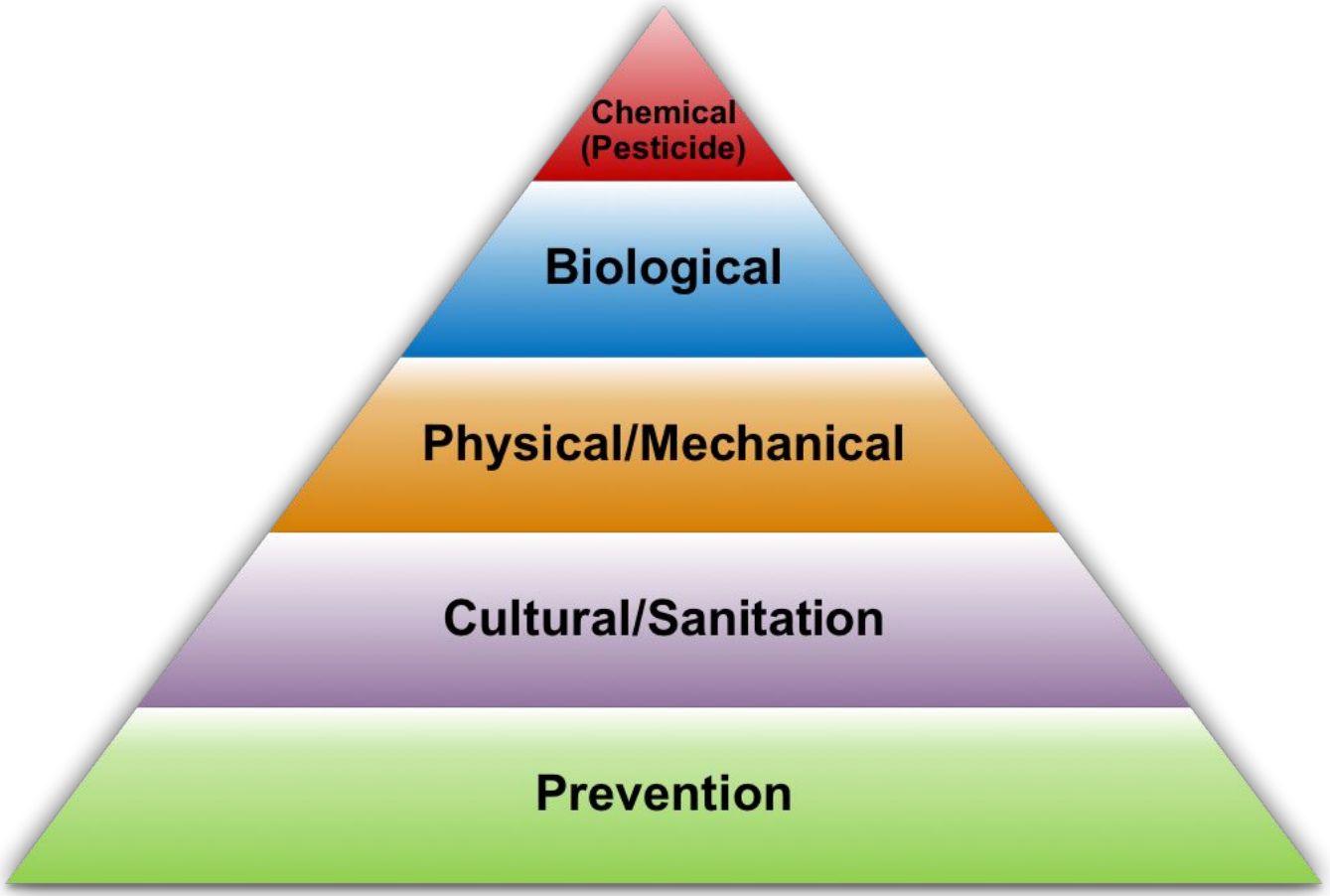
Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism.

Pest management tactics & materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.

IPM Process



IPM Management Tactics



IPM Management Tactics

Integration of ALL available tactics key to successful & sustainable pest management

IPM Management Tactics

Biological

Cultural

Physical/Mechanical

Genetic

Behavioral

Chemical

Defining a “Pest”

- Organisms detrimental, bothersome, annoying, or undesirable to humans
  - Reduce the availability, quality, or value of a human resource
- In theory, any organism has the potential to be considered a “pest”

Pest Impacts (Types of “Damage”)

- Plant/Agricultural
- Medical/Veterinary
- Urban/Structural

  - Economic
  - Aesthetic
  - Nuisance
  - Health

Pest Impacts (Types of “Damage”)

- **Understand “injury” vs. “damage”**

- **DISTINGUISHING BIOTIC & ABIOTIC**

  - **Biotic = caused by living organisms (pests)**

  - **Abiotic “disorders” = nutrient deficiencies, excesses, environmental damage (freeze, hail, sunburn, etc.) irrigation issues (too much, too little water), etc.**

Types of Pests

- Invertebrates
  - Arthropods (insects, mites, spiders, ticks, etc.)
  - Mollusks (slugs & snails)
  - Nematodes & other worms
- Pathogens
  - Bacteria, fungi, viruses
  - May or may not be transmitted/vectored by other organisms
- Plants ("weeds")
  - Annual vs. perennial
  - Grass vs. broadleaf
- Vertebrates
  - Birds, fish, reptiles, mammals (rodents, deer, swine, humans?)

Types of Pests

- **Native**
  - **Definition really depends on time frame**
- **Endemic**
  - **May be technically "non-native" but have existed in a particular ecosystem for some time**
- **Exotic**
  - **Not native to the local ecosystem**
  - **Also called "introduced"**
  - **Deliberate or accidental introduction**
- **Invasive**
  - **Likely to unintentionally spread with in the ecosystem and cause damage to the environment, human economy, or human health**

General Pest Characteristics

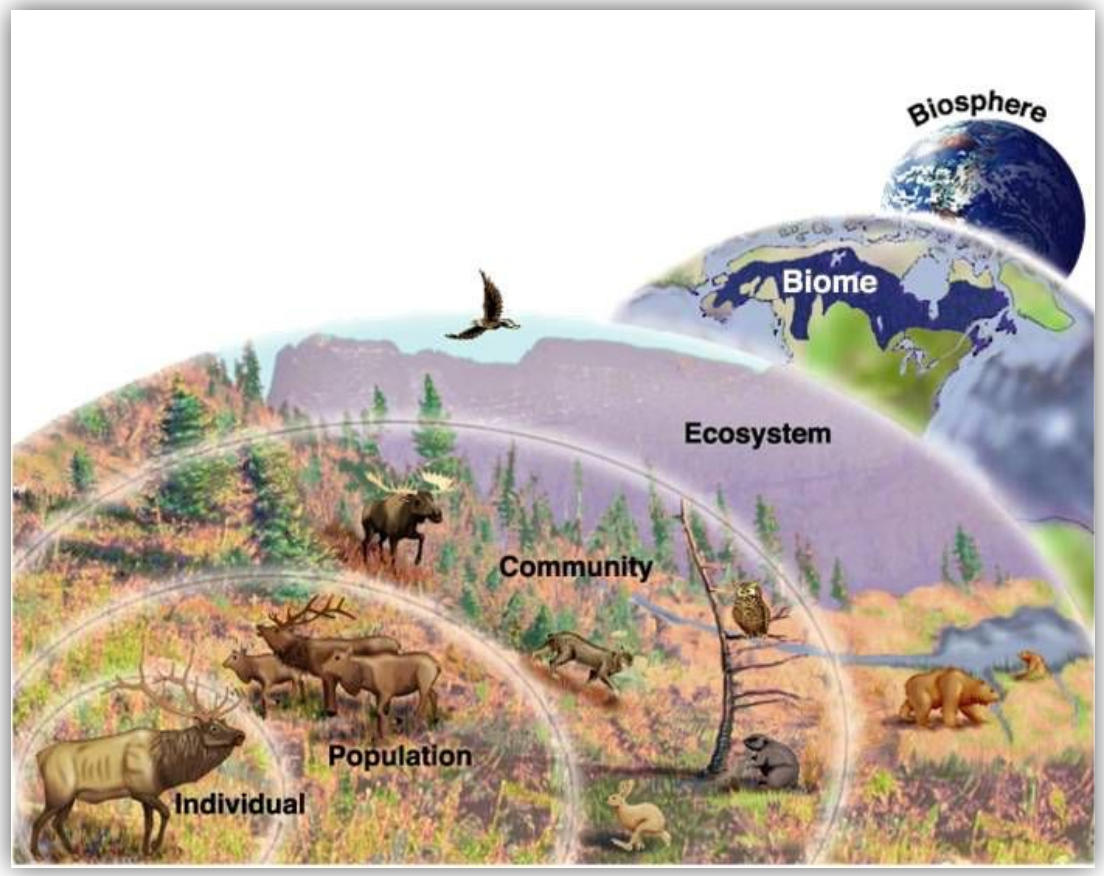
- Good competitors
- High reproductive rates
- Rapid reproduction
- High survival capability
- Highly adaptable
- Good dispersers
- Adept at finding/utilizing hosts, resources
- R vs. K selected species

Pest Management vs. Pest Control

- **Goal?**
  - **Reduce detrimental impacts of pests**
  - **Typically NOT complete eradication**
- **"If we prevent pests, we don't need to manage them…if we manage pests, we don't need to control them"**
- **Pest management**
  - **Focuses on reducing impacts of pest POPULATIONS while considering the COMMUNITY and ECOSYSTEM**
- **Pest control**
  - **Focuses on the INDIVIDUAL**

Basic Ecological Concepts

- **Individual → Population → Community → Ecosystem → Biosphere**



Basic Ecological Concepts

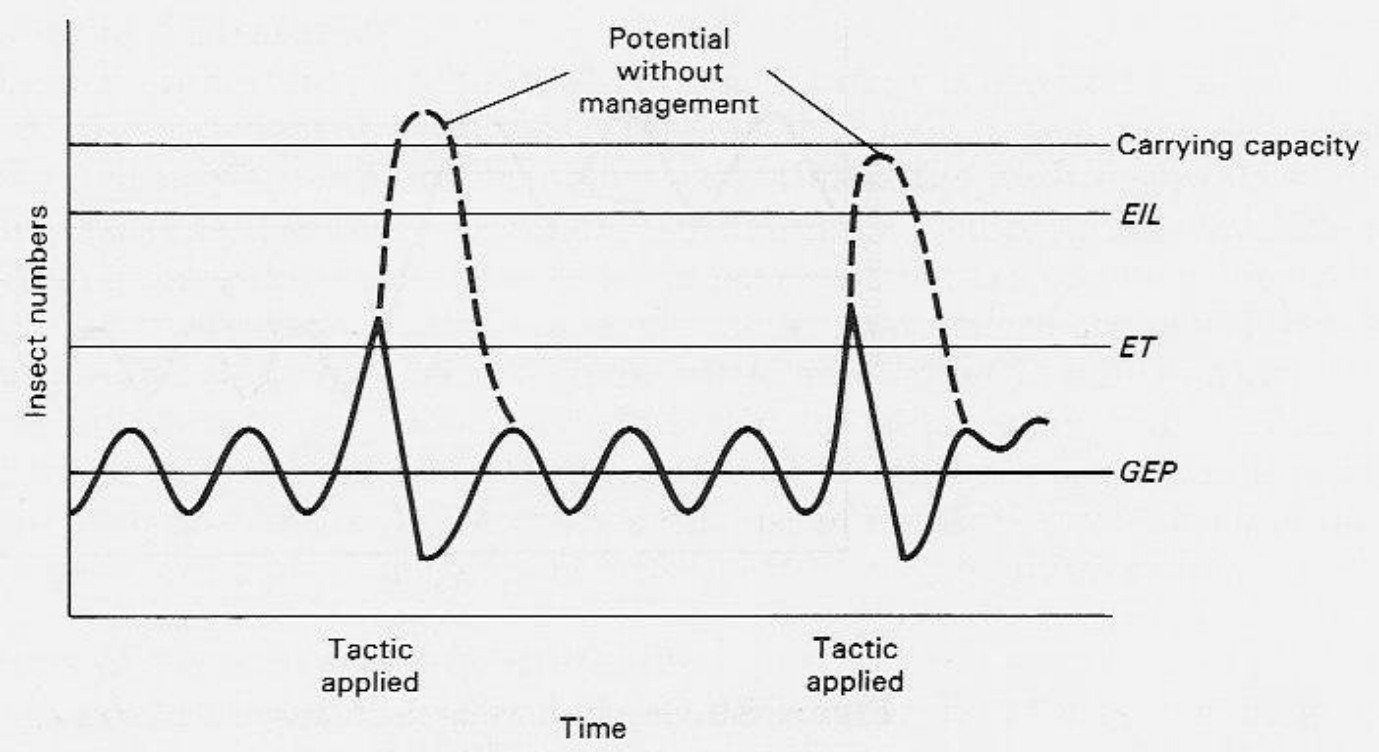
- General Equilibrium Position & Carrying Capacity
  - CC = maximum population size that the environment can sustain given the needs of the species
  - GEP = average long-term population density

- Factors regulating CC & GEP
  - Biotic & Abiotic Factors
    - Genetics
    - Biology
    - Environment
    - Natural selection

IPM Theory – Based on Thresholds

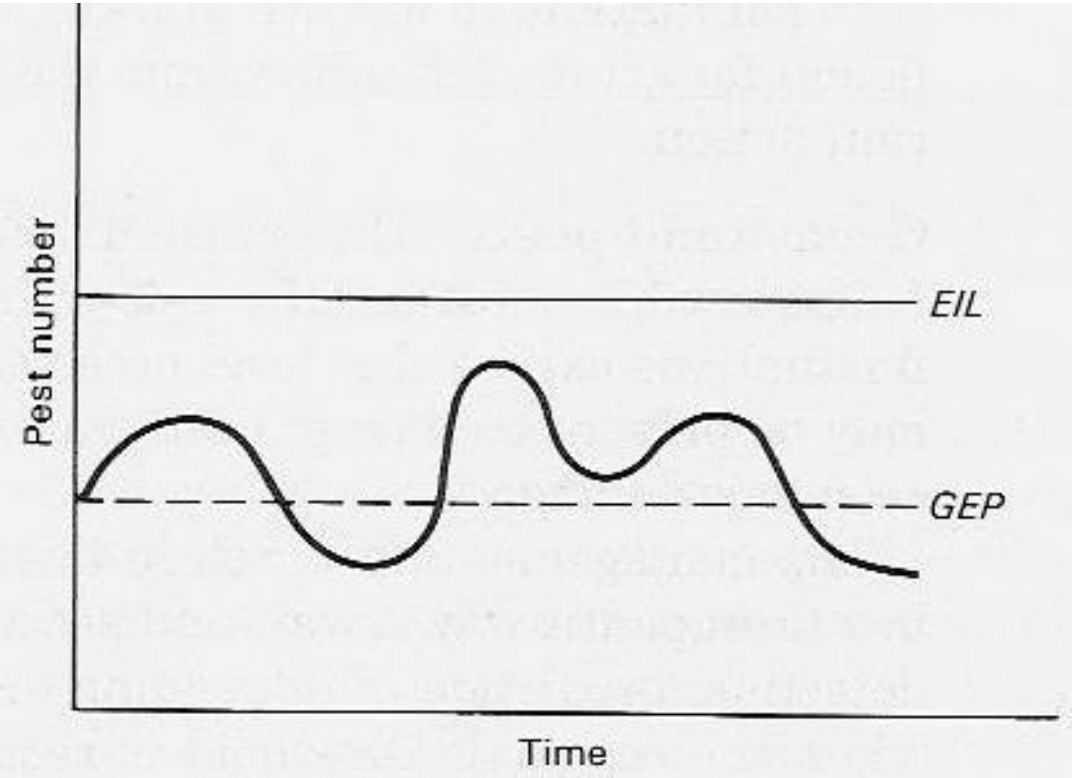
- **Economic Injury Level**
  - The lowest pest population that will cause economic damage
  - EIL = C/VIDK(E)
    - C = cost of management tactic
    - V = crop value
    - I = injury
    - D = damage
    - K = effectiveness of management tactic
    - E = environmental considerations
- **Economic (= Action) Threshold**
  - The pest population density that triggers management measures to prevent a pest population from reaching the economic injury level

Basic Ecological Concepts



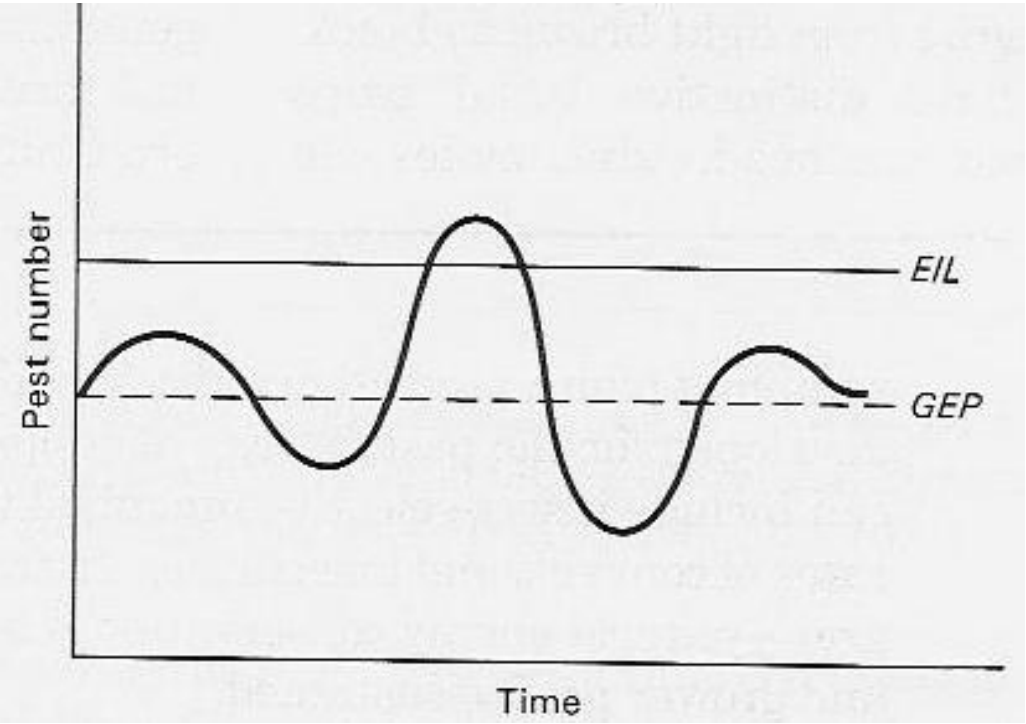
Pest Categories

- **Subeconomic Pests**
  - **GEP far below EIL**
  - **Rare economic damage**



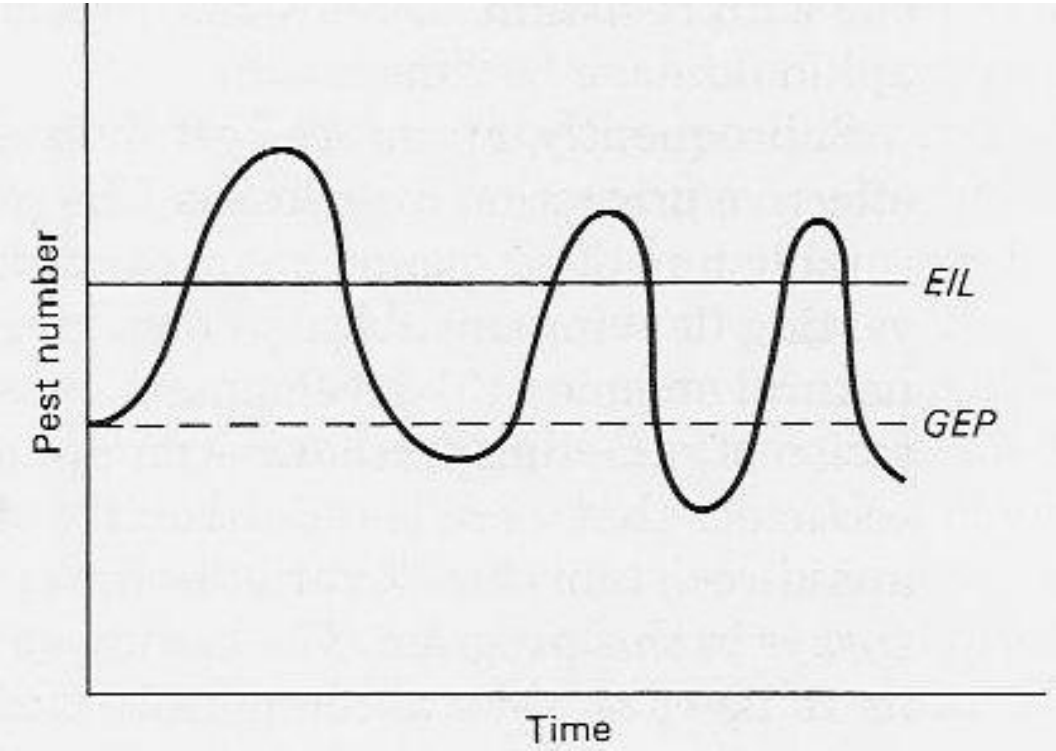
Pest Categories

- **Occasional Pests**
  - **GEP below EIL**
  - **Highest population peaks occasionally exceed EIL**
  - **Present on crop most years**
  - **Occasional economic damage**



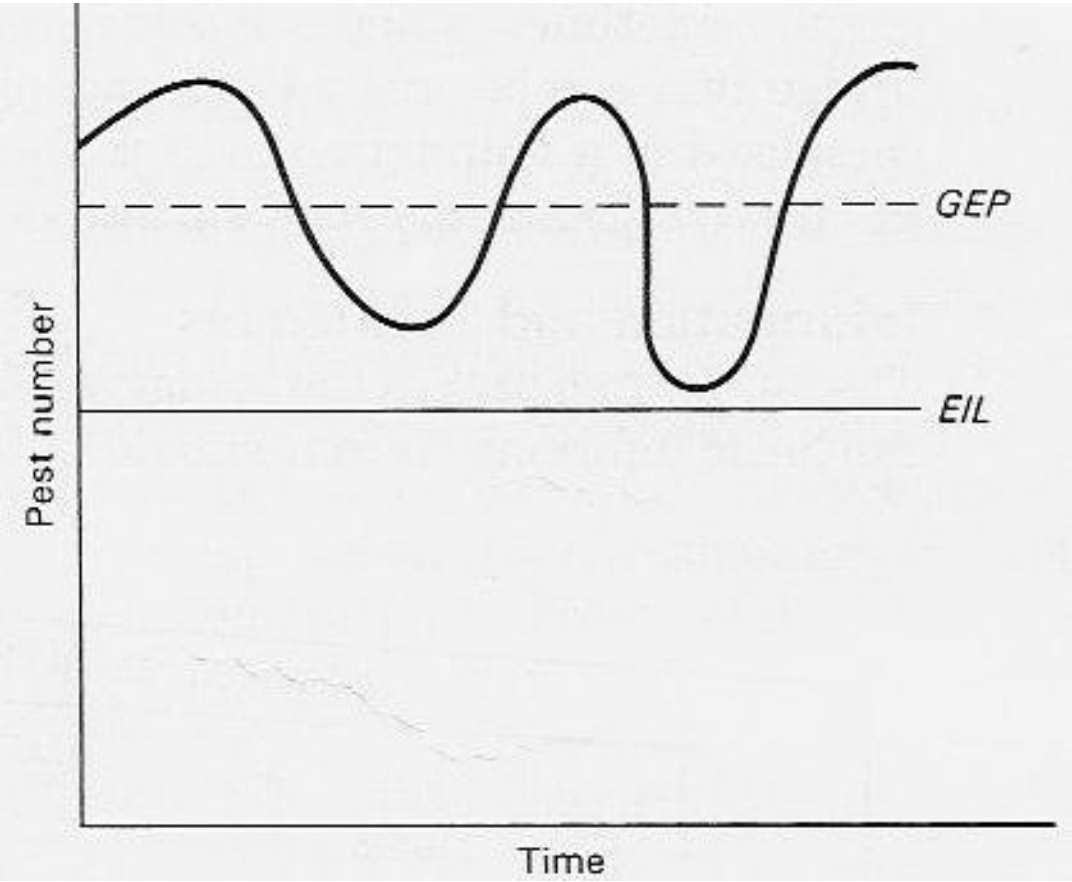
Pest Categories

- **Perennial Pests**
  - **GEP below, close to EIL**
  - **Population peaks frequently reach, exceed EIL**
  - **Economic damage occurs most years**



Pest Categories

- **Severe Pests**
  - **GEP above EIL**
  - **Constant problem**



Basic IPM Strategies

- **4 basic strategies**
  - **Based on economics & pest characteristics (category)**

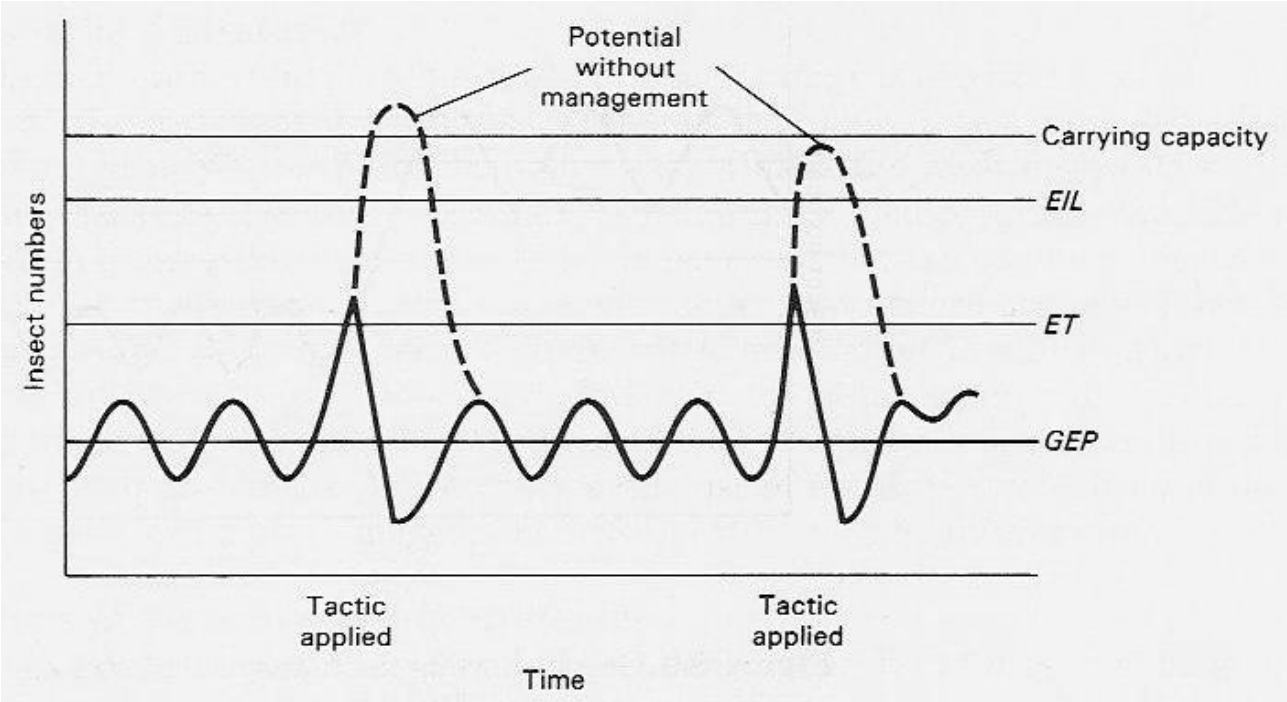
1. **Do nothing (wait & see)**
2. **Reduce pest population numbers**
3. **Reduce crop susceptibility to pest injury**
4. **Combination of 2 & 3**

Basic IPM Strategies

- Subeconomic Pests
  - Monitor pest activity over time
    - Changes in pest biology, crop biology, natural enemy populations, economics, environmental conditions
      - May alter pest status
    - Multiple subeconomic pest species populations may warrant action strategy
- Occasional Pests
  - Strategy
    - Wait & see
    - Dampen population peaks
    - No attempt to reduce GEP
    - Sampling important
      - Early detection
      - Prediction of outbreaks

Basic IPM Strategies

- **Subeconomic & Occasional Pests**

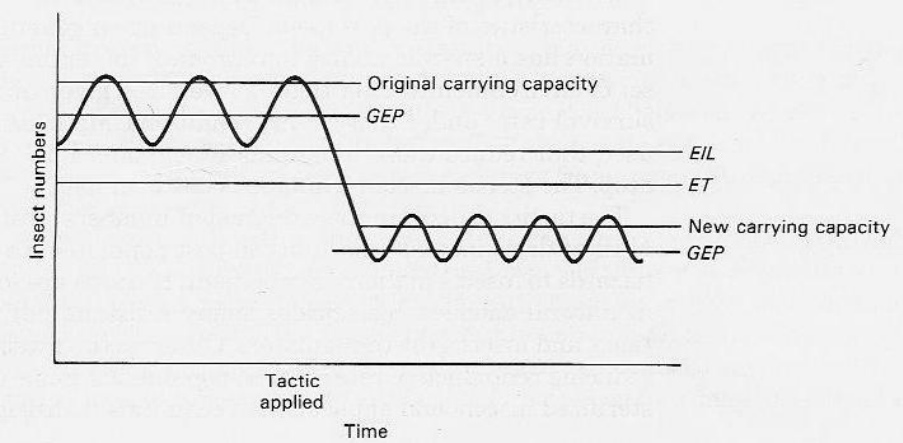


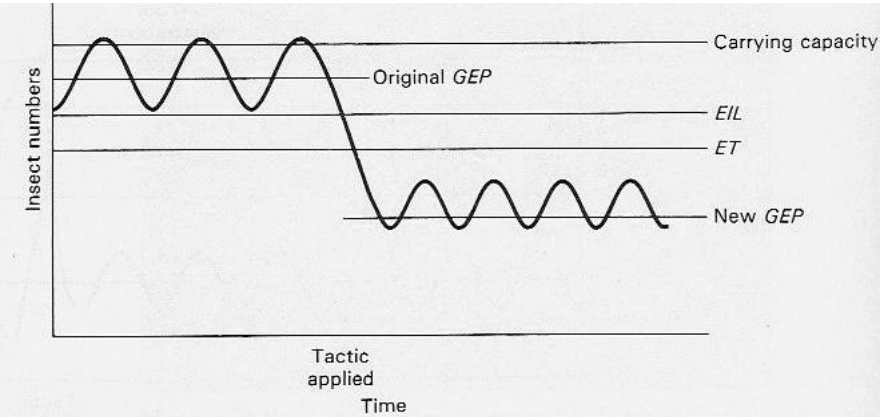
Basic IPM Strategies

- Perennial & Severe Pests
  - Combined strategies
    - Reduce pest #s
      - Reduce population GEP
      - Reduce environmental carrying capacity
    - Reduce crop susceptibility
- Multiple tactics
- Complex management programs

Basic IPM Strategies

- **Perennial & Severe Pests**





Levels of IPM – continuum

- No IPM
  - Treatments often based on calendar, plant phenology, or pest detection (not thresholds)

- Level I IPM (low level)
  - Focuses on monitoring and managing a single species or species complex
  - Involves monitoring program
  - Treatments based on thresholds
  - Treatments timed to minimize non-target impacts

Levels of IPM – continuum

- Level II IPM (medium level)
  - Considers how practices impact multiple pests, pest classes
  - Focuses on complementary, biologically-based management options

- Level III IPM (biointensive level)
  - Multicrop, multiseason, and multitactic considerations are well-integrated into the decision-making process

Levels of IPM

- IPM for single pest
- IPM for multiple pests in same class
- IPM for multiple pests across classes
- IPM across entire farm
- Area-wide IPM

Example: Managing codling moth in walnut orchard using multiple control tactics and considering how those tactics will impact non-target organisms

Levels of IPM

- IPM for single pest
- IPM for multiple pests in same class
- IPM for multiple pests across classes
- IPM across entire farm
- Area-wide IPM

Example: Managing codling moth and walnut husk fly in walnut orchard using multiple control tactics for each & considering how those tactics will impact both pests and non-target organisms

Levels of IPM

- IPM for single pest
- IPM for multiple pests in same class
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Example: Managing codling moth and walnut husk fly and walnut blight in walnut orchard using multiple control tactics for each & considering how those tactics will impact each pest and non-target organisms

Levels of IPM

- IPM for single pest
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- Area-wide IPM

Example: Managing all pests (arthropods, weeds, diseases, vertebrates) on entire farm using multiple control tactics and considering how each impacts all pests and non-target organisms

Levels of IPM

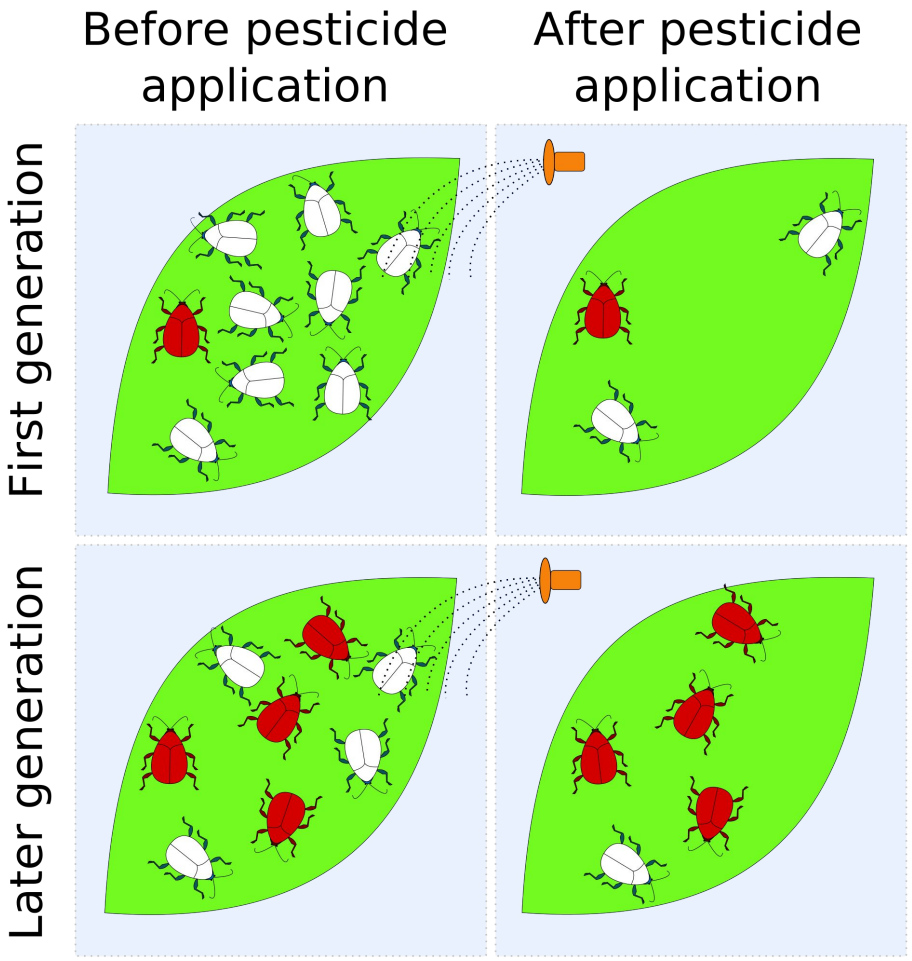
- IPM for single pest
- IPM for multiple pests in same class
- IPM for multiple pests across classes
- IPM across entire farm
- Area-wide IPM

Example: Managing all pests (arthropods, weeds, diseases, vertebrates) in a regional production area using multiple control tactics and considering how each impacts all pests and non-target organisms

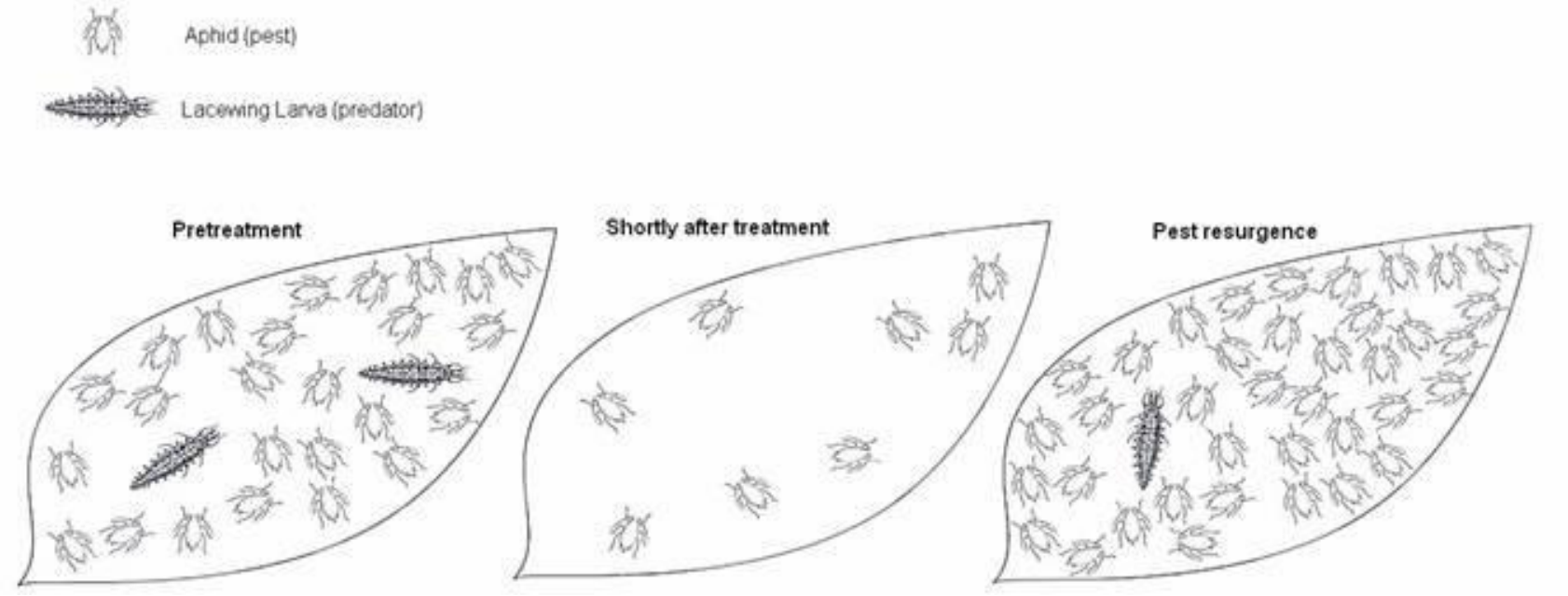
Why Practice IPM?

- Non-target impacts
  - Humans, wildlife, beneficial organisms (natural enemies and pollinators)
- Environment
  - Water, air, etc.
- Ecological system disruption
- Health
- Pesticide resistance, resurgence, secondary pest outbreaks (3 Rs)
- Economics
- Regulation – loss of materials
- Improved efficacy/control
- Personal philosophy
- Sustainability
- PR, public perception
- Others?

The 3 Rs – Resistance

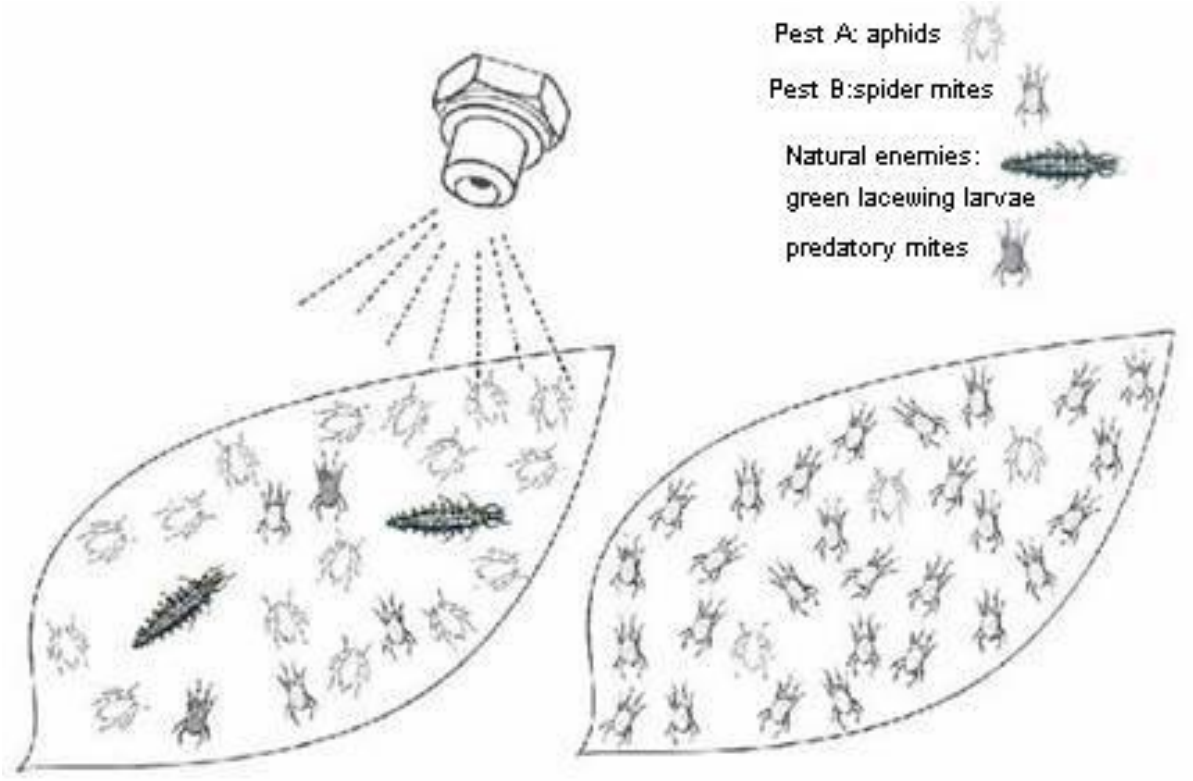


The 3 Rs – Resurgence



The 3 Rs – Replacement

= secondary pest outbreaks



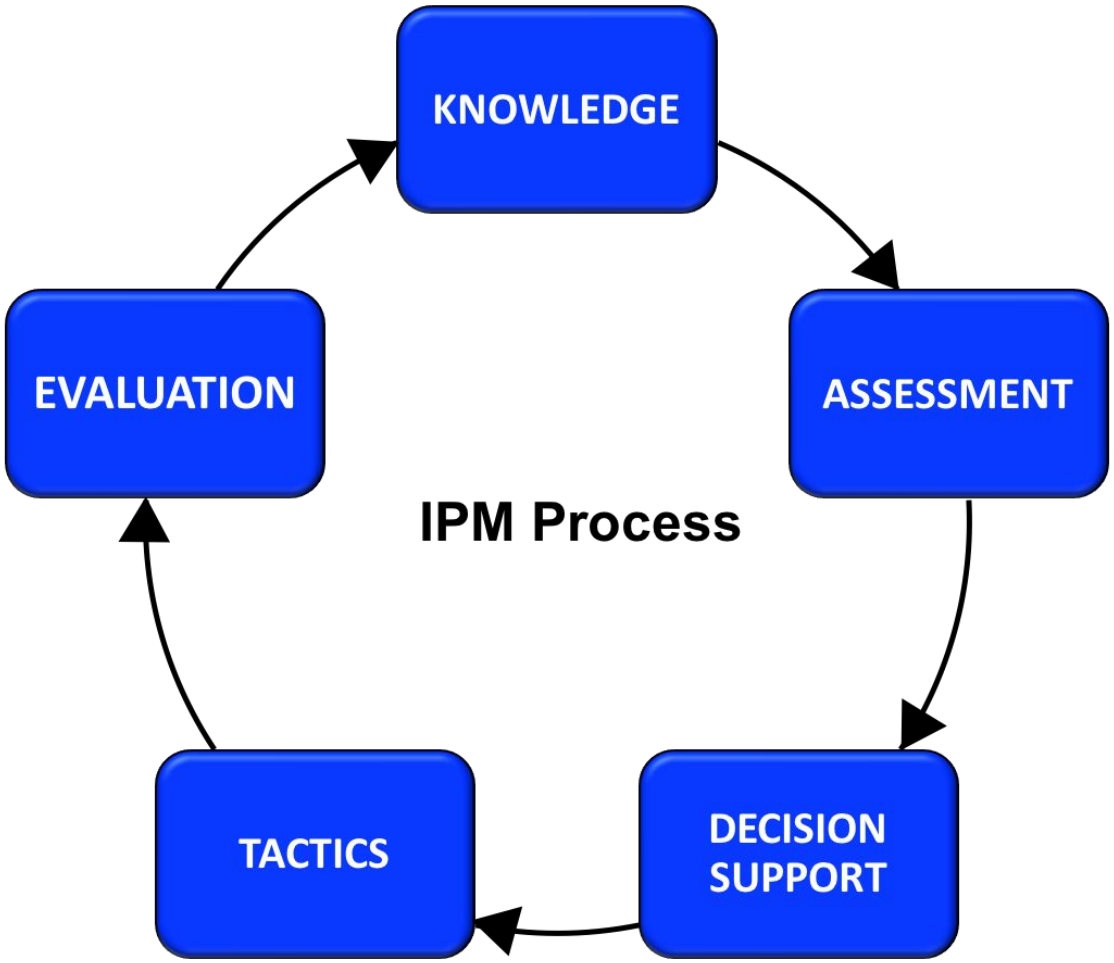
A pesticide applied to control pest A also kills natural enemies to pest B

Released from the control exerted by natural enemies, pest B builds up to economically damaging levels.

Barriers to Adopting IPM

- Time
- Economics
- Perception
- Efficacy
- Lack of knowledge
- “It’s too hard”
- Neighbor effect
- Aesthetics
- Personal philosophy?
- Others

IPM Process



Knowledge Base

- Pests, beneficials, non-target organisms
  - Identification, biology, phenology, interactions, abundance (population assessment), damage threat (decision-support)
- Crop
  - Biology, phenology, interactions (ecology)
  - Susceptibility to damage
- Other plants (hosts & non-hosts) in environment
  - Biology, phenology, interactions (ecology)

Knowledge Base

- Ecosystem considerations
  - The physical environment
    - Water, soil, light, heat, weather, etc.
  - Impacts of/on surrounding areas
    - Other crops, natural, urban
- Tactics
  - Effectiveness, other impacts
- Economics (damage, injury)
  - Dictate thresholds
- Choosing a Strategy
  - IMPORTANT – what are your goals?

Knowledge Base – Identification

- Know what you have – species
  - Life cycle, stages, growth requirements, habits, successful characteristics, dispersal & movement, etc.
- Know the type of damage
- Know the potential for damage
- Know typical pest status:
  - Key pest (severe, perennial), secondary pest, occasional pest

Knowledge Base – Identification

- Names – common & scientific – be careful
- Know the broader classification of pests
  - KPCOPGS
- Identifying based on damage or indirect evidence
- Be observant (& early!)
- Tools
  - Good eyes ☺, hand lens, microscope
  - Identification guides or keys
    - Many online & print resources
  - Photo ID through the internet
    - Many great websites (i.e., UCIPM, etc. – be careful!)
  - Identification experts
    - Public agencies, private labs
  - Identification non-experts ☺ - maybe your neighbor knows!

Population Assessment

- **Monitoring, sampling, predictive tools**

- **Why do we monitor?**
  - **Prerequisite for decision-making (thresholds)**
  - **Provides site-specific history**
  - **Maximize effectiveness of management tactics**
  - **Increase knowledge**
  - **Justification (& confidence in management decisions) – competitive edge**
  - **Info to improve or simplify future monitoring**
  - **Early warning of potential pest problems**
  - **Feedback**
  - **Predictions**

Population Assessment

- **Monitoring, sampling, predictive tools – what do we need? KNOWLEDGE**

- **What do we monitor?**
- **Pests**
  - **Presence**
  - **Which life stage?**
    - **Not always the one causing damage**
  - **Rate of population development**
  - **Rate of spread/dispersal**
  - **Population density**

Population Assessment

- **Monitoring, sampling, predictive tools – what do we need? KNOWLEDGE**

- **What do we monitor?**
- **Beneficials**
  - **Presence**
  - **Abundance (know impacts)**
- **Sometimes other non-targets**
- **Crop development**
  - **Susceptible stages**
- **Weather and other abiotic factors**
  - **Conditions that contribute to outbreaks**
- **Effectiveness of practices (evaluation)**

Population Assessment

- Monitoring, sampling, predictive tools

- Qualitative vs. quantitative
- Absolute vs. relative samples
- Direct vs. indirect
  - Ex – many pathogens are not “monitorable” – cannot visual detect in many stages – must monitor conditions that will contribute to outbreak
- Monitoring programs may or may not entail quantitative evaluation
  - Monitoring for population #s vs. monitoring for presence/absence
- Monitoring does not necessarily involve sampling (i.e., monitoring weather patterns, rainfall, etc.)

Population Assessment

- Developing a monitoring program (involving sampling & population assessment)
- Trade-off between economics, practicality, accuracy, precision, reliability
  - Sample size - how much to monitor, how big an area, how many traps, how many visual samples, how often?
- Knowledge of distribution patterns of populations to be sampled
- Many established guidelines available

Population Assessment

- Some efficient sampling methods
  - Presence-absence
  - Based on triggers (environmental or plant phenology)
  - Visual injury scales
  - Timed searches
  - Sequential sampling (vs. fixed sampling)
  - Monitoring multiple species at once

Population Assessment

- Sampling patterns
  - Random sampling
    - Most common
    - Use predetermined patterns (e.g., spring aphid monitoring)
  - Stratified sampling
    - Divide area into subunits based on some factor
    - Sample each subunit independently
  - Systematic sampling
    - Easy to implement
    - Randomly select starting point – sample from there (e.g., every 10^{th} plant or every 3 feet)
- Edge effects – neighbor effects – hot spots
- Want representative sample

Population Assessment

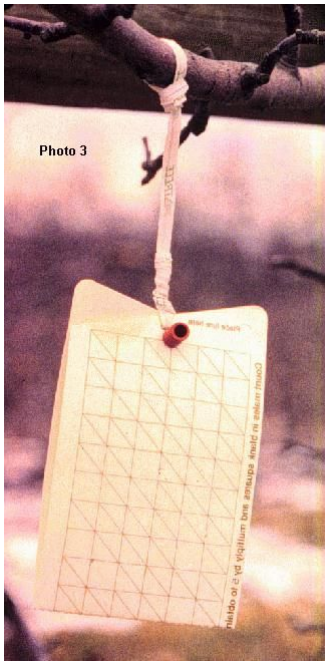
- Sampling techniques
  - Visual sampling
    - Pest or beneficial itself, damage, evidence of parasitism or predation
  - Traps
    - Color, baited (pheromones, other types of lures)
    - Light traps
    - Sticky traps
    - Pitfall traps
    - Shape, size, color, lure, location & arrangement in field (height, etc.) important for accuracy
    - Traps to detect different genders, stages of life cycle
      - Adult traps, egg traps, pheromone-baited traps
  - Knockdown (beat trays or cloths)
  - Suction (D-vacs)
  - Sweep nets
  - Damage estimates
  - Clues, signs

Population Assessment

Population Assessment

Figure 3. Water trap — *Piège à eau.*

Population Assessment



Population Assessment

- Sampling techniques
  - Laboratory tests
    - Pathogens, nematodes, weed seed bank, confirmation of species
  - Some test kits available for individual use
    - Plant pathogens
  - IMPORTANT – make sure you are properly collecting and preserving samples is sending away for analyses

Population Assessment

- Weather stations
- Data loggers
- Sources of temperature information available (county, UC)

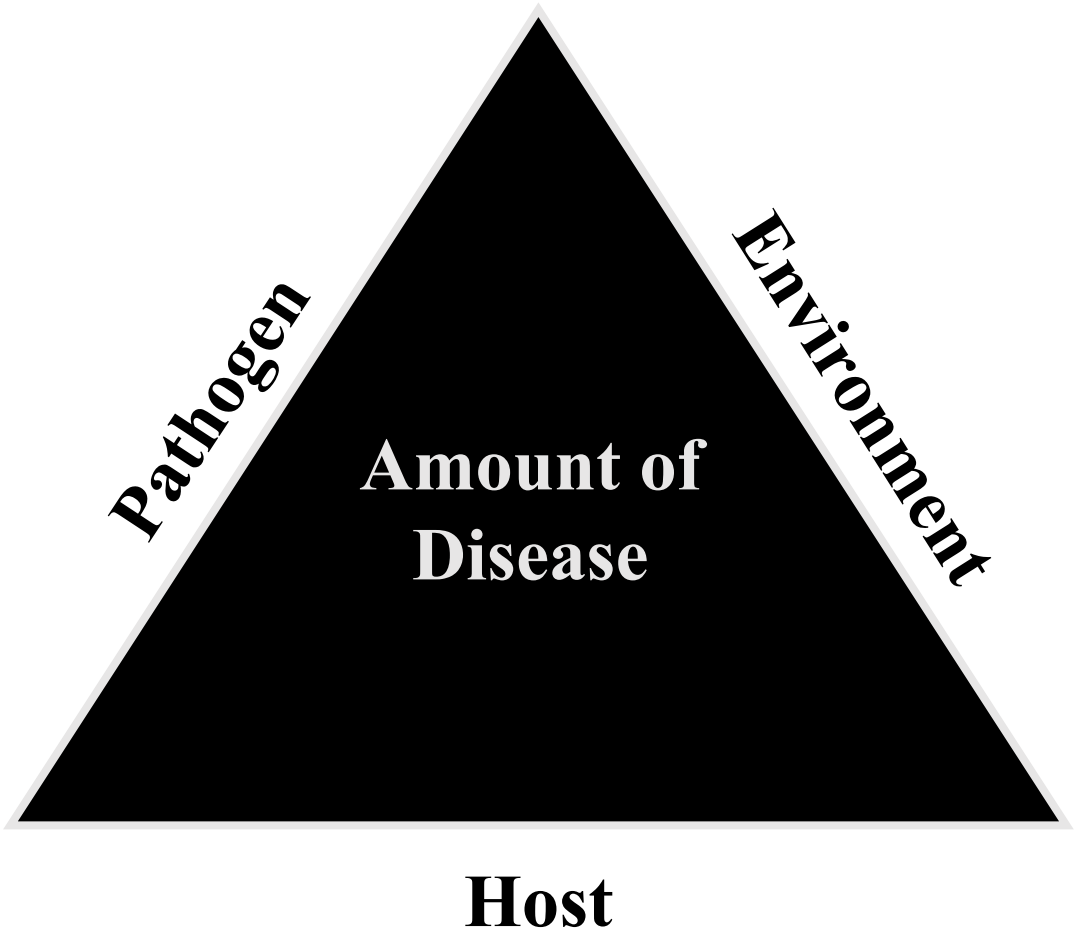
Population Assessment

- Predictive Tools
- Phenology models
  - Relationship between environmental conditions (temperature) and development of organism
- Degree days
  - Can be used to predict certain life stages
  - Used to determine treatment timing – target most susceptible stage
- Typically based on weather data, trap catches (or some other sampling), developmental thresholds, and a biofix
  - Biofix – date at which degree days begin being accumulated

Population Assessment

- Predictive Tools
- Disease forecasting
  - Based on rainfall, humidity, temperature, pathogen requirements for infection/spread
  - Can predict outbreaks – determine if preventative treatment warranted

Population Assessment



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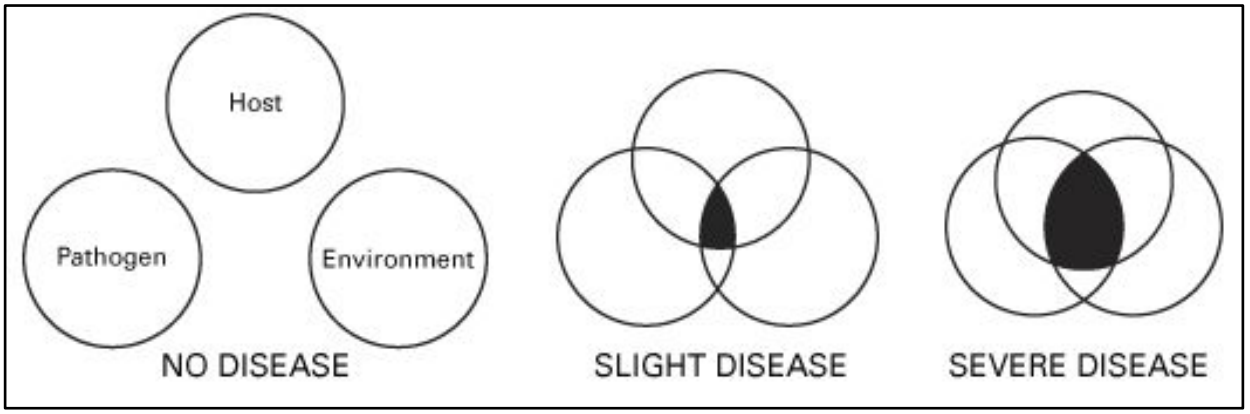
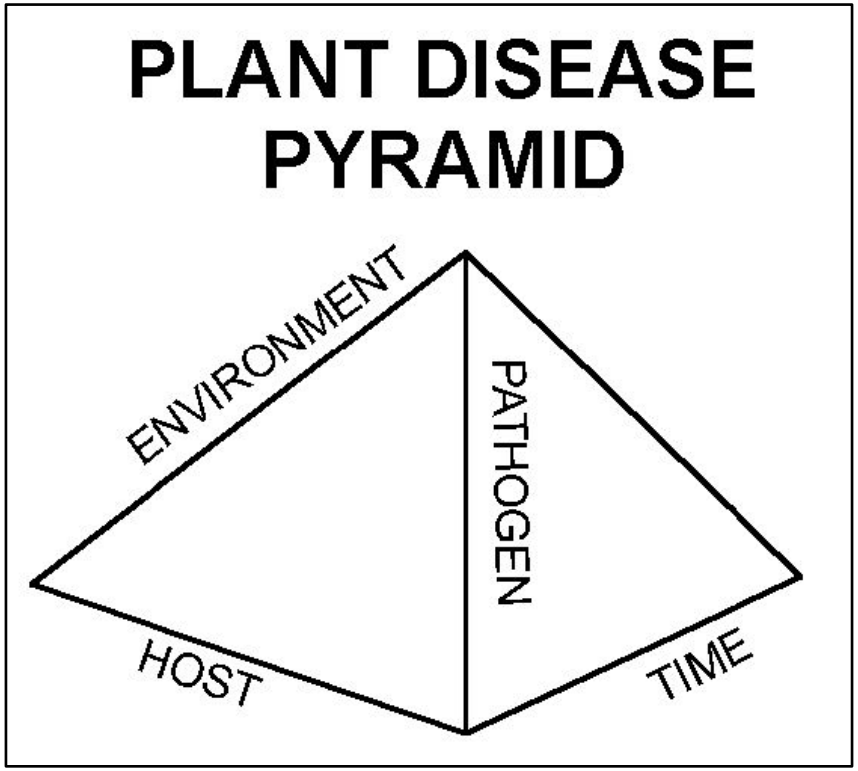




Decision Support (Thresholds)

- Key in decision-making
- Critical issue in IPM development is defining thresholds
- Know thresholds (if available)
  - Develop thresholds (if possible)
- Understand dynamic nature of thresholds
- Know the economics and your GOALS & STRATEGIES – these may dictate thresholds
- EIL, ET concepts

Pest Management Tactics

IPM Management Tactics

Biological

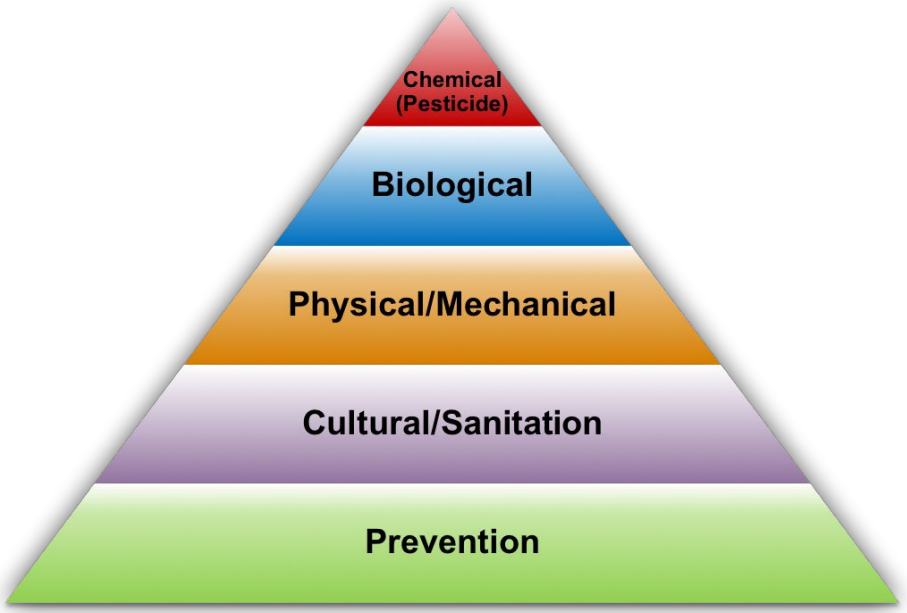
Cultural

Physical/Mechanical

Genetic

Behavioral

Chemical



Pest Management Tactics

- **Proper timing & implementation critical to effectiveness**
- **Use monitoring and sampling program along with thresholds**
- **Time to most susceptible stage**
- **Consider effect of management tactic on non-targets**
- **Consider effect of management tactic on environment**
- **Implementation – follow protocols!**

Evaluation – Record-Keeping

- Be organized ☺ - interpret properly – follow up of impacts of EVERYTHING!
- Use data sheets (if available) or devise your own
- Sampling records
- Permanent samples
- Graphs
- Data sheets & files
- Field maps
- Electronic databases
- Software

Tactics – Biological Control

- Broad definition
  - Any activity of one species that reduces the adverse effects of another
- Naturally-occurring
- Intentional management activities
  - Release of natural enemies, preservation of existing natural enemies or habitat

Tactics – Biological Control

- Biocontrol agents
  - Mammals, birds, amphibians, fish, snails, bacteria, plants, nematodes, arthropods
- Broad categories
  - Predators
  - Parasites and parasitoids
  - Pathogens
  - Herbivores (weed biocontrol)
  - Antibiosis
  - Competition

Tactics – Biological Control

- Approaches
  - Classical biocontrol
    - Importation and release for long-term establishment
  - Conservation & enhancement
    - Activities that improve survival, dispersal, synchrony, and reproduction of resident natural enemies
    - “Don’t starve them, don’t kill them”
  - Augmentation
    - Supplementing numbers of naturally-occurring biocontrol agents
    - Inoculative releases
      - Longer term – last several generations
    - Inundative releases
      - Immediate action through individuals released – no long-term establishment expected

Tactics – Biological Control

- Biocontrol of insects & mites
  - Predators
  - Parasitic insects
  - Entomopathogenic nematodes
  - Pathogens
    - Naturally-occuring
    - Available as “pesticide” – ex: Bt, *Beauveria* spp., *Metarhizium* spp.
  - http://www.ipm.ucanr.edu/PMG/NE/index.html
  - Some commercially available

Tactics – Biological Control

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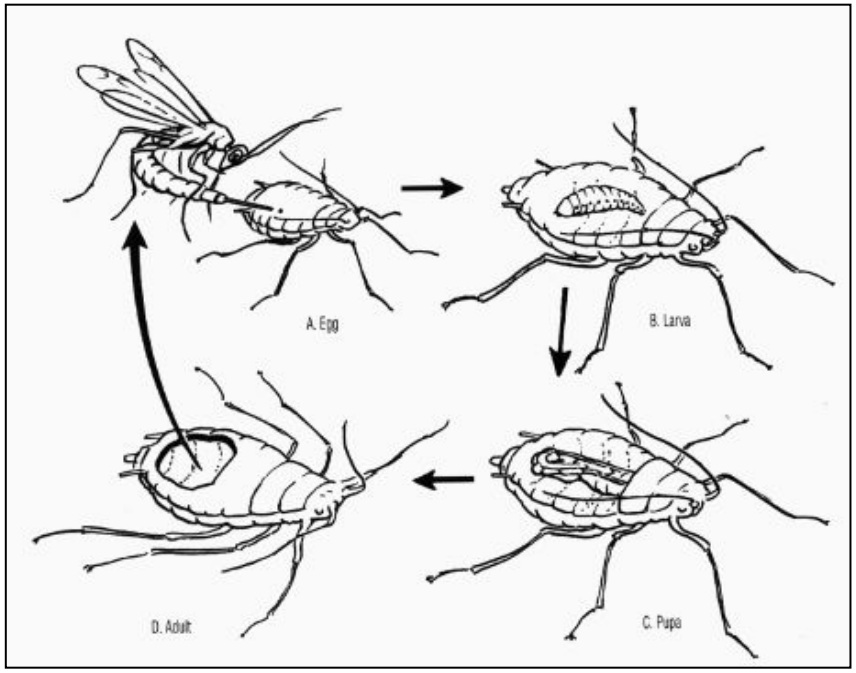


Tactics – Biological Control

- Biocontrol of weeds
  - Insects
  - Pathogens
  - Vertebrates
  - Other plants
    - Allelopathy – plant-released chemicals impair growth of other plant nearby
    - Competition
- Less successful examples than insects/arthropods
  - Very careful testing and selection of biocontrol agent required – do not want cross-over to an agronomic plant

Tactics – Biological Control

- Biocontrol of plant-parasitic nematodes & pathogens
- Not as well-developed for use
- Pathogens
  - Mycopesticides – beneficial organisms & their biproducts
  - Disease-suppressive composts, soils, and amendments
- Nematodes
  - Many naturally-occurring enemies
  - Very little knowledge limiting availability of nematode biocontrol agents for use

Tactics – Biological Control

- Encouraging beneficial organisms
- Conservation through good IPM program
  - Minimize toxic pesticides
    - Less toxic pesticides http://www.ipm.ucdavis.edu/QT/lesstoxicinsecticidescard.html
  - Time pesticide use to avoid destruction of natural enemies
  - Use selective materials
  - Impacts of pesticides on pollinators and natural enemies – by crop
    - Ex: http://www.ipm.ucdavis.edu/PMG/r3900311.html

Tactics – Biological Control

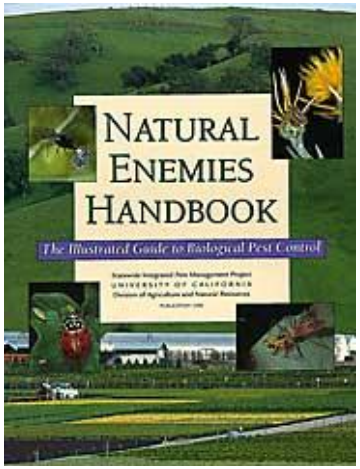
- Encouraging beneficial organisms
- Production practices to improve habitat – shelter, alternative food sources
  - Cover crops
  - Intercropping
  - Strip-cropping
  - Alternate harvest timings, techniques
  - Extrafloral nectaries
  - Flowers
  - Particular plant species
- Mitigate negative impacts of uncontrollable conditions (climate, weather)
  - Microclimates – cover crops, modify pruning techniques, border or strip harvest, hedge rows

Tactics – Biological Control

- Encouraging beneficial organisms
- Consider the needs of beneficials
  - Food (nectar, pollen), water, shelter, alternate food sources (hosts or prey)
- Augmentation of environment to synchronize life cycles of pests and natural enemies
- Again…knowledge of organisms present, their biologies, and life history strategies
- Will dictate plant species to utilize

Tactics – Biological Control

- Natural enemies Handbook



- Link to plants to encourage bees:
  - http://www.helpabee.org/uploads/1/9/0/5/19051461/ubg_master_list.pdf
- Great (long) scientific journal article
  - Manipulation of Natural Enemies in Agroecosystems: Habitat and Semiochemicals for Sustainable Insect Pest Control
    - Cesar Rodriguez-Saona, Brett R. Blaauw, and Rufus Isaacs
    - http://www.isaacslab.ent.msu.edu/Rofrigues-Saona,%20Blaauw,%20Isaacs%20Manipulation%20of%20Natural%20Enemies%20in%20Agroecosystems%20Habitat%20and%20Semiochemicals%20for%20Sustainable%20Insect%20Pest%20Control.pdf

Tactics – Cultural

- Site selection
  - Choose pest-free location or a crop, plant species, or variety that is well-suited to the location
- Sanitation
  - Remove breeding, refuge, overwintering sites
- Destruction of alternate hosts
  - Act as reservoirs for pests
- Habitat modification
  - Limit availability of pest requirements
    - Food, shelter, alternate hosts, proper environmental conditions

Tactics – Cultural

- Smother crops & cover crops
  - Suppress weeds, provide soil nutrients, harbor beneficials, improve soil quality, increase water infiltration, reduce run-off, reduce erosion
- Intercropping
  - 2 crops grown at the same time
- Crop rotation
  - Intentional planting in sequence
  - Good for pests that originate in the field & not likely to movein from adjacent areas
    - Soil-borne, less mobile
      - Nematodes, soil pathogens

Tactics – Cultural

- Planting and harvest dates
  - Favor crop development while discouraging pests
  - Weed management
    - Plant when conditions favor crop germination compared to weed germination
  - Insects & pathogens
    - Planting or harvesting early or late can minimize or avoid exposure, disrupt life cycle
    - Minimize exposure during susceptible plant development stages

Tactics – Cultural

- Irrigation & water management
  - Excess water – pathogen issues
  - Water-stressed plants – may be more susceptible to infection or infestation
- Fertilizers and soil amendments (nutrition management)
  - Healthy plants – higher yields, less susceptible to damage
  - But…overly-fertilization may attract or benefit pests

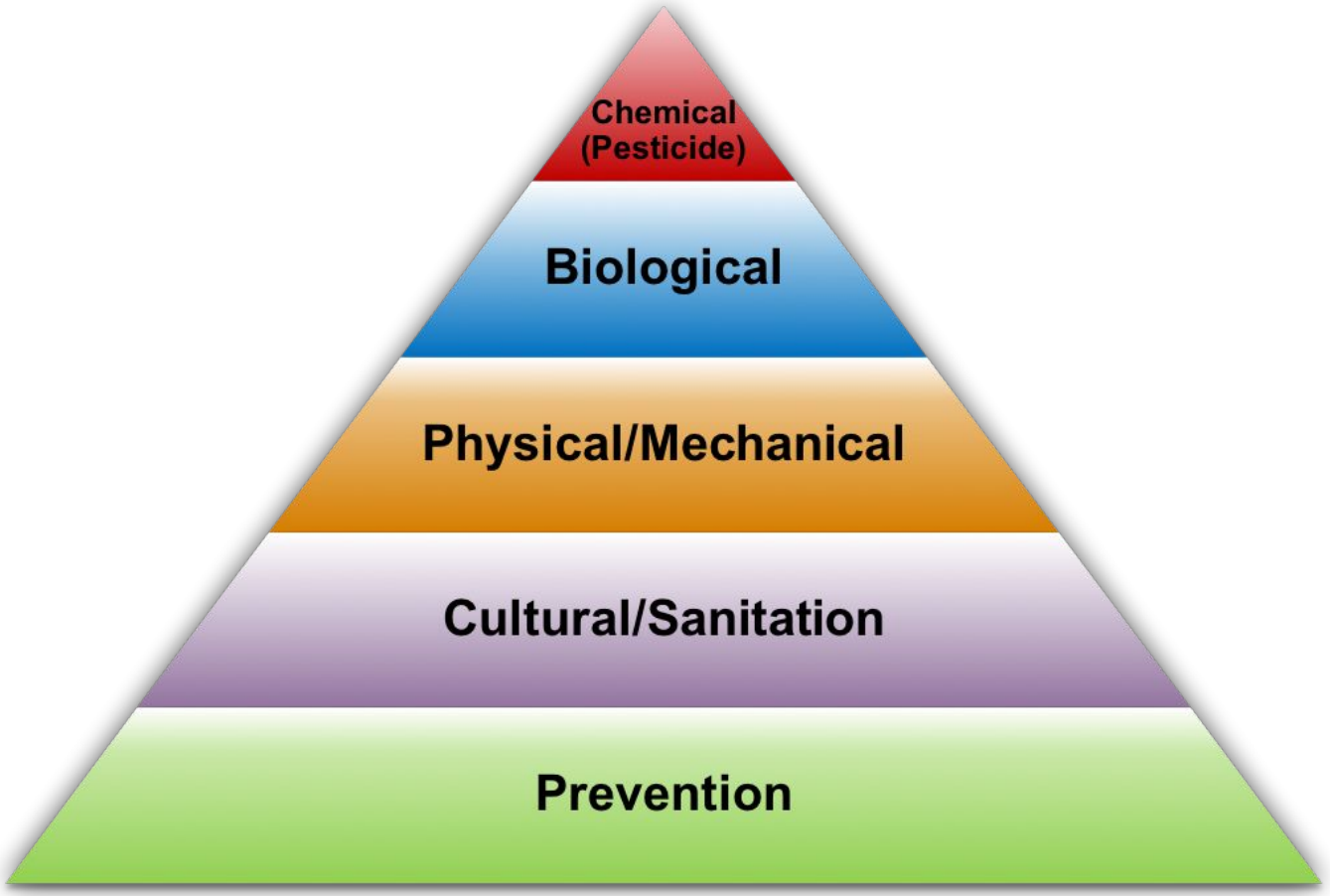
Tactics – Mechanical & Physical

- Land preparation
- Soil tillage
- Mowing
- Flaming
- Burning
- Mulches – reflective, weed management
- Soil solarization
- Temperature manipulation – greenhouse, nursery, stored products
- Traps – common for vertebrate pests
  - Placement is critical

Tactics – Host Plant Resistance & Tolerance

- Pest resistant or tolerant plants – can be most economical and effective (if available)
- True resistance vs. tolerance
- Rootstock and scion selection
  - Trees & vines
- Cultivar (variety) selection – seeds, transplants
- Biotechnology
- Use of non-host plants
- = Prevention!

Tactics – Chemical



Tactics – Chemical

- Pesticides
  - Herbicides, insecticides, acaricides, fungicides, bactericides, rodenticides, nematicides, etc.
- Organic vs. conventional vs. “other”
  - Microbials
  - Naturally occurring pesticides (copper, sulfur)
  - Horticultural oils
  - Botanicals
  - Bt
  - Semiochemicals (pheromones & kairomones) – mating disruption, mass trapping, attract & kill, pathogen dissemination, encourage beneficials?

Tactics – Chemical

- Issues – monitor for these situations
  - Efficacy of materials
  - 3 Rs – pest resistance (tolerance) pest resurgence, pest replacement (secondary pest outbreaks)
  - “Pesticide treadmill”
  - Impacts on beneficials and non-targets
  - Environmental impacts
    - Water, Air
  - Human health, other impacts

Tactics – Chemical

- Other factors impacting efficacy
  - Application technique
    - Coverage
  - Application rate
  - Application timing
  - Proper calibration of equipment
  - Follow label

What are Pesticides?

- **Substances that control, suppress, prevent or repel pests**

- **May be used against all types of pests**

Types of Pesticides

Nomenclature based on target organism

INSECTICIDES

ACARICIDES (MITICIDES)

Additional specifiers: Ovicide, larvicide, adulticide

Types of Pesticides

Nomenclature based on target organism

MOLLUSCICIDES

NEMATICIDES

Types of Pesticides

Nomenclature based on target organism

FUNGICIDES

BACTETIRICIDES (BIOCIDES)

Types of Pesticides

Nomenclature based on target organism

RODENTICIDES

Types of Pesticides

Nomenclature based on target organism

HERBICIDES

GRASSES

BROADLEAVES

General Modes of Action

How does it kill (or mitigate) the pest?

- **Selective vs. broad spectrum**
- **Contact vs. systemic**
- **Residual**
- **Fumigant**
- **Repellant**

General Modes of Action

How does it kill (or mitigate) the pest?

- **<u>Selective</u> vs. broad spectrum**

Selective pesticides kill only a few closely related organisms

- **Active ingredient: *Bacillus thuringiensis kurstaki***
- **Only kills caterpillars feeding on plant tissue**

General Modes of Action

How does it kill (or mitigate) the pest?

- **Selective vs. <u>broad spectrum</u>**

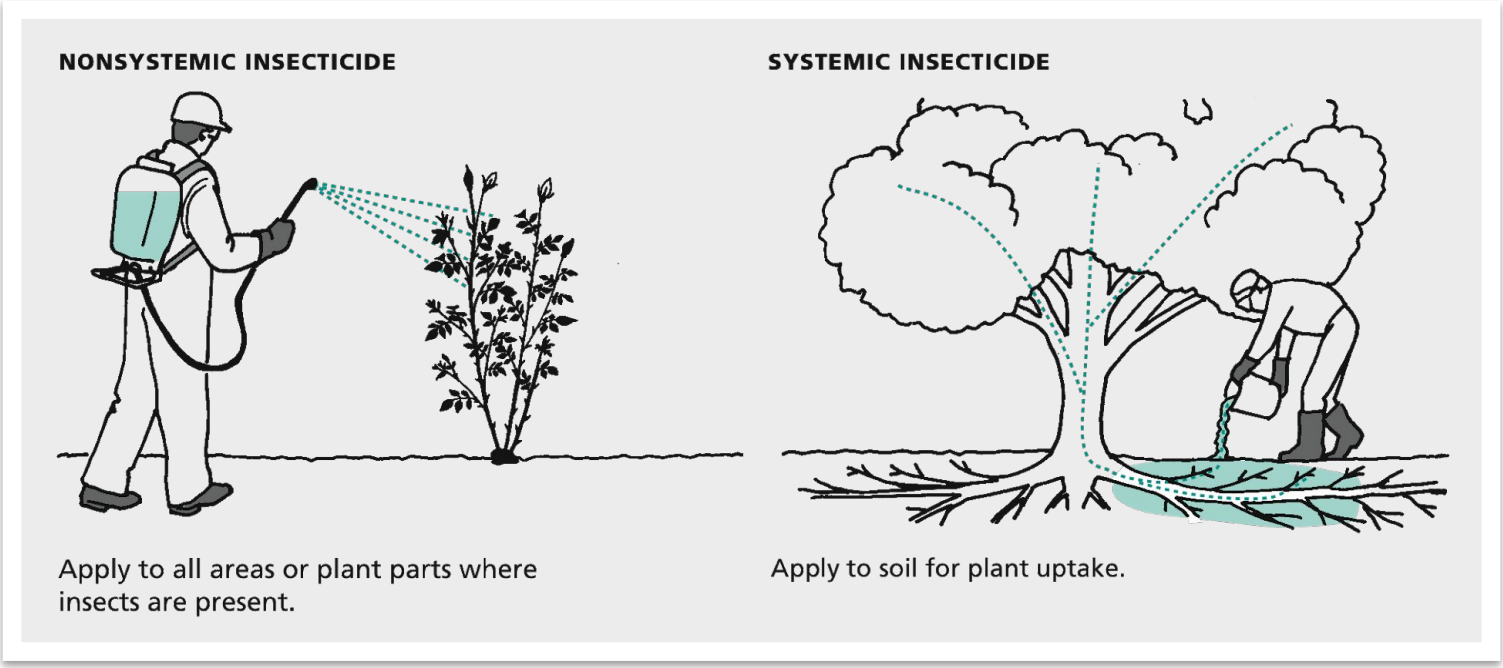
Broad-spectrum pesticides kill a range of pests and non-target organisms

- **Active ingredient: bifenthrin**
- **Label reads "Kills 235 listed insects" (!)**

General Modes of Action

How does it kill (or mitigate) the pest?

- **Contact vs. systemic**



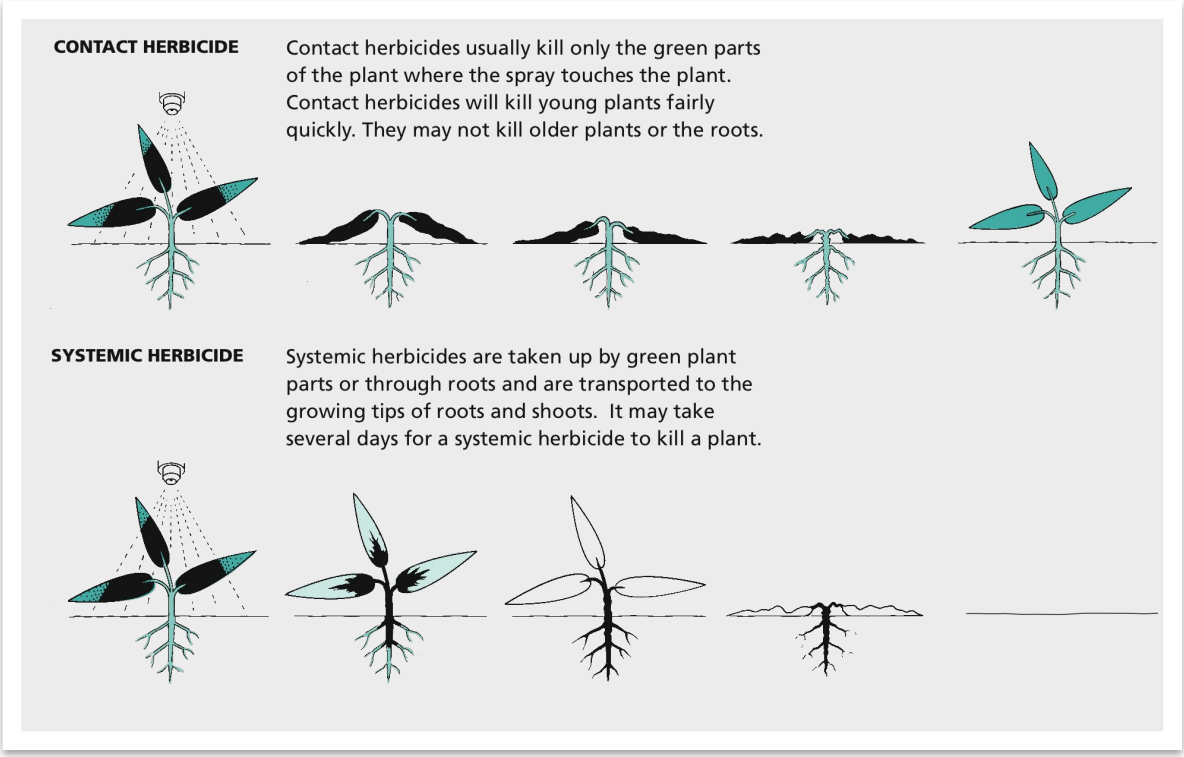
Many materials

Common example: imidacloprid

General Modes of Action

How does it kill (or mitigate) the pest?

- **Contact vs. systemic**



Ex: clove oil

Ex: glyphosate

General Modes of Action

How does it kill (or mitigate) the pest?

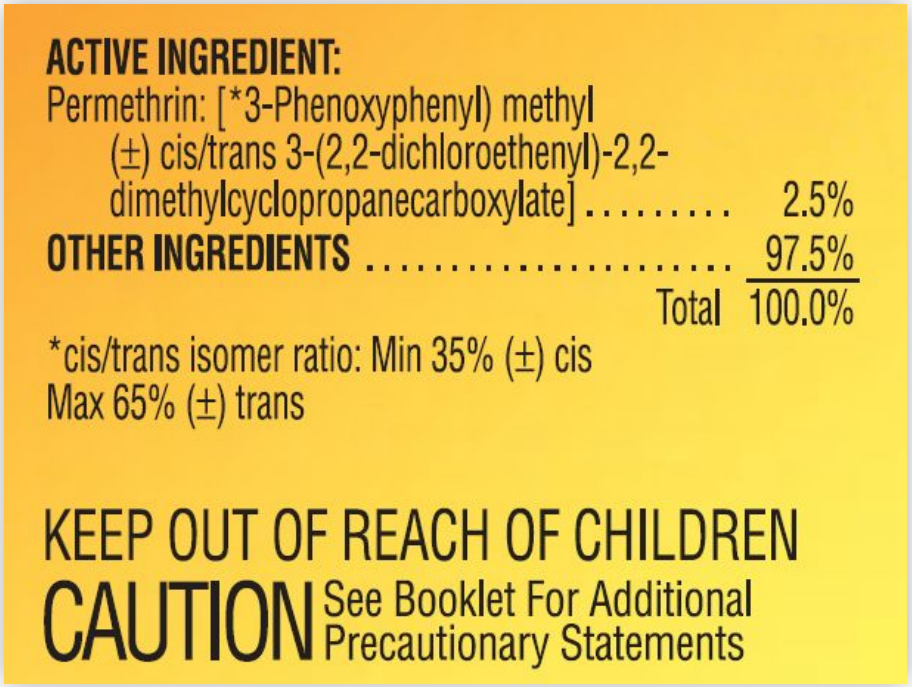
- **Residual** materials remain toxic long after application
- **Fumigants** kill target pests through inhalation of volatiles
- **Repellants** do not kill directly – effect behavior of pests (avoidance)
- **Protectant** vs **Eradicant** (fungicides)

Specific Modes of Action

- **IRAC**
  - http://www.irac-online.org/documents/moa-classification/
- **FRAC**
  - http://www.frac.info/docs/default-source/publications/frac-code-list/frac-code-list-2016.pdf?sfvrsn=2
- **WSSA/HRAC**
  - http://wssa.net/wp-content/uploads/WSSA-Mechanism-of-Action.pdf

Pesticide Formulations

- **Active ingredient(s) (A.I.)**
- **Inert ingredient(s)**



Pesticide Formulations

Common formulations:

- **Solution (S)**
- **Emulsifiable concentrate (E or EC)**
- **Aerosol (A)**
- **Bait (B)**
- **Soluble powder (SP)**
- **Wettable powder (W or WP)**
- **Granule (G)**
- **Dust (D)**

Pesticide Formulations

Solution (S)

- **Ready-to-use or concentrated liquid**

Emulsifiable concentrate (E or EC)

- **AI mixed with an oil base & diluted with water for application**
- **Requires constant agitation to remain in solution**

Pesticide Formulations

Aerosol (A)

- Low concentration solutions applied as a fine spray

Bait (B)

- AI mixed with attractive or edible substance

Pesticide Formulations

Soluble powder (SP)

- **Powders dissolved in water for application**

Wettable powder (W or WP)

- **AI combined with a fine powder and mixed with water for application**

Pesticide Formulations

Granule (G)

- AI mixed with coarse particles of inert materials that are applied directly

Dusts (D)

- AI added to a fine inert clay or talc that is applied directly

Pesticide Toxicity

How poisonous/dangerous is the material?

Anything has the potential to be toxic

- **Dose makes the poison**

LD_{50}

- **Commonly used measure of oral and dermal toxicity of pesticides**
- **Lethal dose required to kill 50% of the test population**
- **Typically expressed as mg/kg**

Pesticide Toxicity

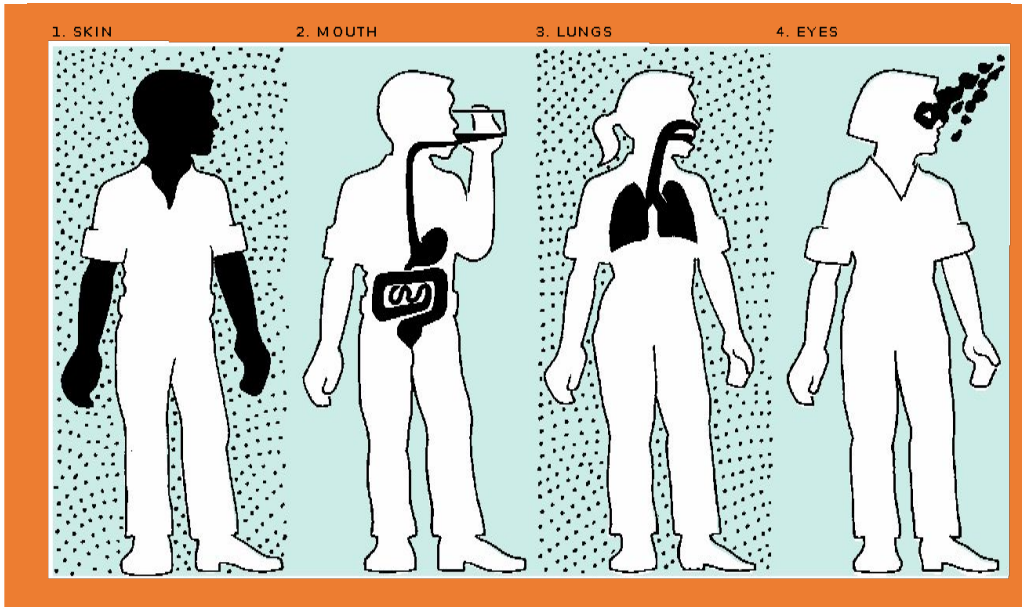
LOWER LD_{50} = MORE TOXIC

Category	Signal Word	Toxicity	Probable oral lethal dose*
 I	DANGER POISON	highly toxic	taste to 1 teaspoon
I	DANGER	highly hazardous	pesticide specific
II	WARNING	moderately toxic or hazardous	1 teaspoon to 1 ounce
III	CAUTION	low toxicity	1 ounce to 1 pint
IV	CAUTION	low toxicity	> 1 pint

*Based on 150-lb mammal

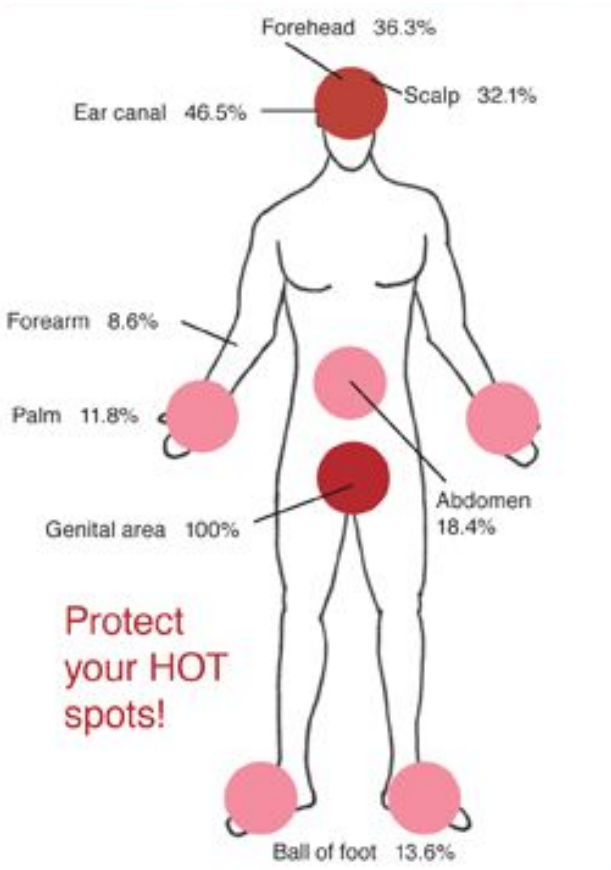
Routes of Exposure

- **Oral**
- **Dermal (most common, more dangerous)**
- **Inhalation (more dangerous)**
- **Potential skin & eye irritants**



Routes of Exposure

- **Dermal**
- **Protect your hotspots!**



Percents indicate relative amount of absorption of pesticide over a 24-hour period. (Feldman and Maibach. 1974. Percutaneous penetration of some pesticides and herbicides in man. *Toxicology and Applied Pharmacology* 28, pp. 399–404).

Pesticide Safety

- **Pesticide labels – READ THEM!!!**
- **Regulations & thus labels change frequently**
- **MSDS sheets**
- **Make the proper selection for your problem**
- **Principles of IPM**
- **PPE**
- **Watch mixes**
- **Proper storage & disposal**

Pesticide Labels

- Trade/brand name ®
- Active ingredient(s)
- Inert ingredient(s)
- EPA registration number*
- Allowable plants/sites
- Pests targeted
- Directions for use
  - Amount to apply
  - How & when to apply
- Required PPE
- Signal words
- Precautionary statements
  - Hazards to humans, other animals, environment
- Additional restrictions (PHI, REI, pollinator safety)
- Emergency & first aid measures if exposure occurs
- Proper storage & disposal

Pesticide Labels

Trade name

Signal word

Active & inert ingredients

Pesticide Labels

Concentrate

Residual period

Broad-spectrum

Insecticide, acaricide

Pesticide Labels

PRODUCT FACTS	Kills 235 listed insects!
KILLS INSECTS	Ants (including carpenter, red harvester, pavement, odorous, pyramid, pharaoh and Argentine), aphids, billbugs, caterpillars, centipedes, chinch bugs, cutworms, hornets, fleas, Japanese beetles (adults), millipedes, mites, mole crickets, mosquitoes, scorpions, stink bugs, spiders, ticks, wasps, whiteflies and other listed lawn and garden insects.
WHERE TO USE	• Roses and other ornamentals • Listed vegetables and fruit trees • Trees and shrubs • Lawns • Around house foundations, porches, patios and stored lumber
AMOUNT TO USE	• Roses, ornamentals, vegetable gardens, melons and fruit trees: Mix 3 Tbs (1.5 oz) per gallon of water. Spray plants until thoroughly covered. • Lawns: Mix 1.5 to 3 Tbs (0.75 to 1.5 oz) per gallon of water sprayed to cover 125 sq ft. • Around house foundations: Mix 3 Tbs (1.5 oz) per gallon of water sprayed to cover 65 sq ft.
PEOPLE & PETS	People and pets may enter treated areas after spray has dried.

Pesticide Labels

ROSES, FLOWERS, SHRUBS & SMALL TREES	
KILLS INSECTS	Aphids, Armyworms, Bagworms, Beetles (including Elm Leaf, Flea, Japanese (Adult), Pine Chaffer, Pine Shoot, Sap), Caterpillars (including Saltmarsh, Tent), Crickets, Eastern Sprucegall Adelgade, Grasshoppers, Hornets, Lace Bugs, Lygus Bug, Mealy Bugs, Mites (including Spruce, Two-Spotted Spider), Mosquitoes, Moths (including Gypsy, Zimmerman Pine), Periodical Cicadas, Plant Bugs (including Tarnished), Sawflies (including European Pine, Redheaded Pine), Spittlebugs, Stinkbug Spp. (including Brown Marmorated Stink Bug, Kudzu Bug), Thrips, Wasps, Webworms (including Fall, Mimosa, Oak), Weevils (including Northern Pine, Orchard, Pine Shoot), Whiteflies
AMOUNT TO USE	**When using a tank sprayer** • 1.5 fl oz per gallon of water. • Spray plants until thoroughly covered. **When using the Ortho® Dial 'N Spray® applicator** • Set dial to 1.5 fl oz. • Pour product into jar to full or one-half full. • DO NOT add water. • Attach hose to the sprayer. • Spray evenly on plants. • Unused product must be poured back into its original container.
HOW TO APPLY	• Spray to uniformly cover upper and lower leaf surfaces, stems, and branches. When treating potted plants also lightly spray the soil surface. • Spray when air is calm to avoid drift. Apply as necessary, waiting 7 to 14 days between each application. Hard to control insects may require 2 to 3 applications. • If temperature is expected to exceed 85° F, spray in early morning or late afternoon when it is cooler. • Mosquitoes coming to rest on treated areas will be killed for varying periods of time after application, depending on exposure of treated areas to weather conditions.

Pesticide Labels

VEGETABLES AND FRUITS	DAYS TO HARVEST	CALIFORNIA DAYS TO WAIT TO HARVEST
Corn (Sweet corn)	3	3
Tomatoes	1	1
Blackberries, Raspberries	3	3
Lima Beans	3	3
Peas (Green pea, Snow pea, Sugar Snap pea), Beans (Snap bean, Wax bean), Blackeyed pea	3	3
Chayote (fruit), Cucumber, Edible gourds, Cantaloupe, Casaba, Honeydew melon, Pumpkin, Summer squash (Zucchini), Winter squash (Butternut squash, Acorn squash, Spaghetti squash), Watermelon	3	3
Mustard Greens	7	DO NOT USE
Broccoli, Chinese broccoli, Cabbage, Cauliflower	7	7
Peppers (Bell and Non-bell), Eggplant	7	7
Head Lettuce	7	7
Pears	14	14
Pecans	21	21

Pesticide Labels

STORAGE & DISPOSAL

PESTICIDE STORAGE:	Keep from freezing. Keep pesticide in original container. Do not put into food or drink containers. Avoid contamination of feed and foodstuffs. Store in a cool, dry place, preferably in a locked storage area.
PESTICIDE AND CONTAINER DISPOSAL:	Nonrefillable container. Do not reuse or refill this container. **If empty:** Place in trash or offer for recycling if available. **If partly filled:** Call your local solid waste agency for disposal instructions. Never place unused product down any indoor or outdoor drain.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS & DOMESTIC ANIMALS

CAUTION: Harmful if swallowed. Causes moderate eye irritation. Avoid contact with eyes or clothing. Wear: Long-sleeved shirt and long pants, socks, shoes, and gloves. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

PPE

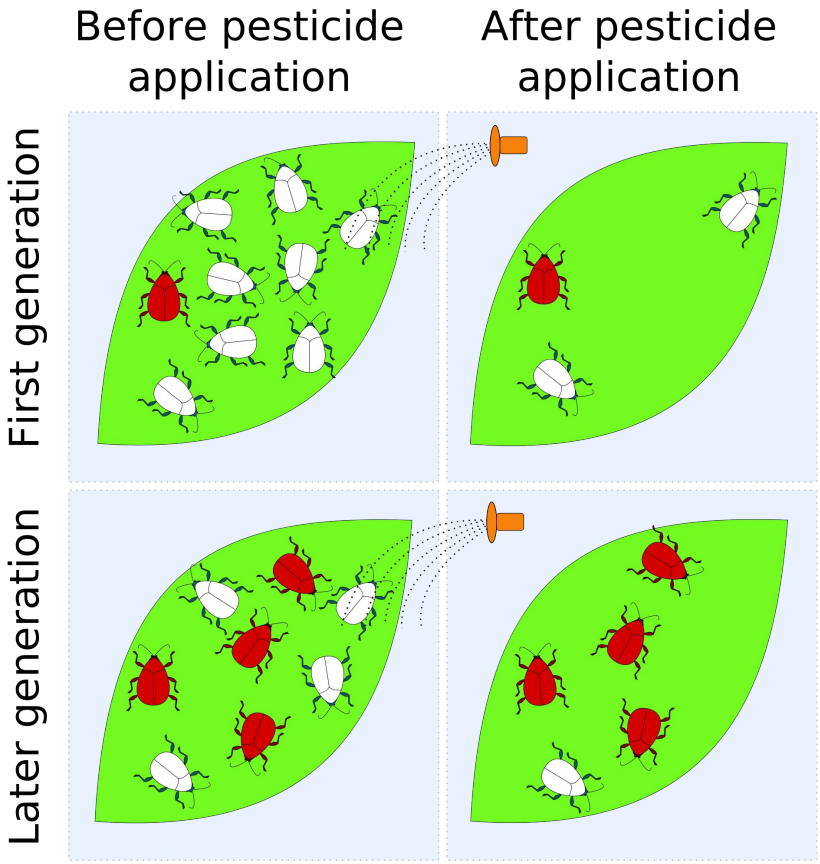
Pesticide Labels

imidacloprid, systemic

TREE NUTS
Beechnut, Brazil nut, Butternut, Cashew, Chestnut, Chinquapin, Filbert, Hickory nut, Macadamia nut, Pecan, Pistachio, Walnut [black and English]
PESTS CONTROLLED
Aphids, Leafhoppers/Sharpshooters, Mealybugs, Spittlebugs, Whiteflies
Restrictions Pre-harvest Interval: Do not harvest fruit until at least **7 days** after application. Do not make more than one application per year. Do not apply until after trees have flowered or when bees are actively foraging.

Pesticide Use & the 3 Rs

- **Resistance**
- **Resurgence**
- **Replacement (secondary pest outbreaks)**



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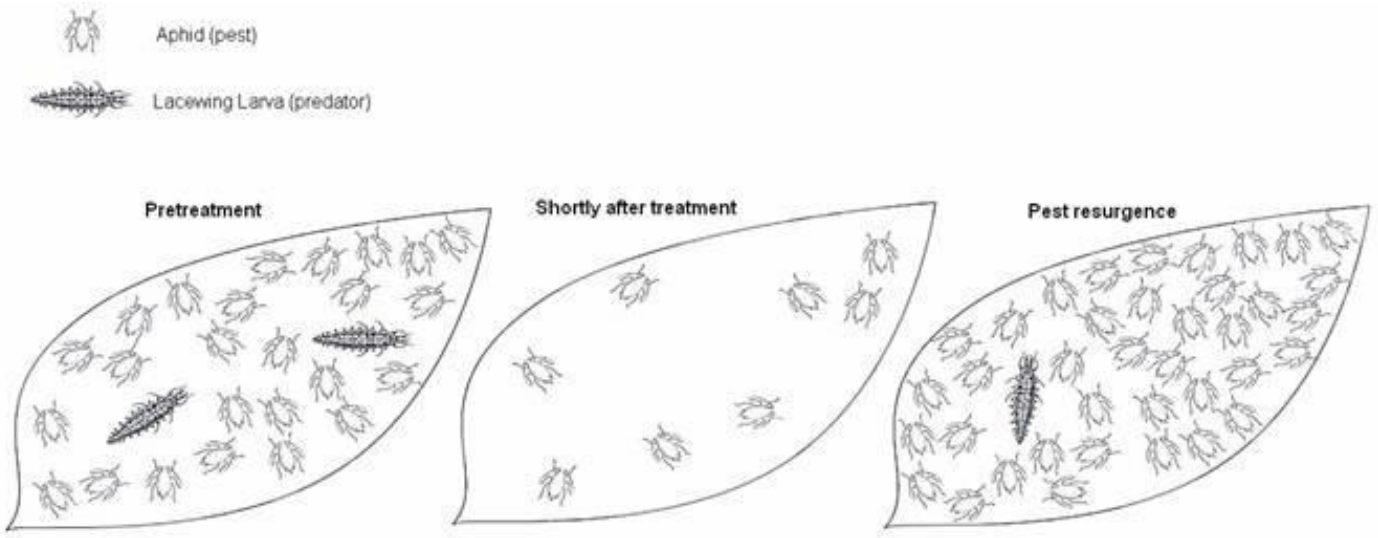

Pesticide Use & the 3 Rs

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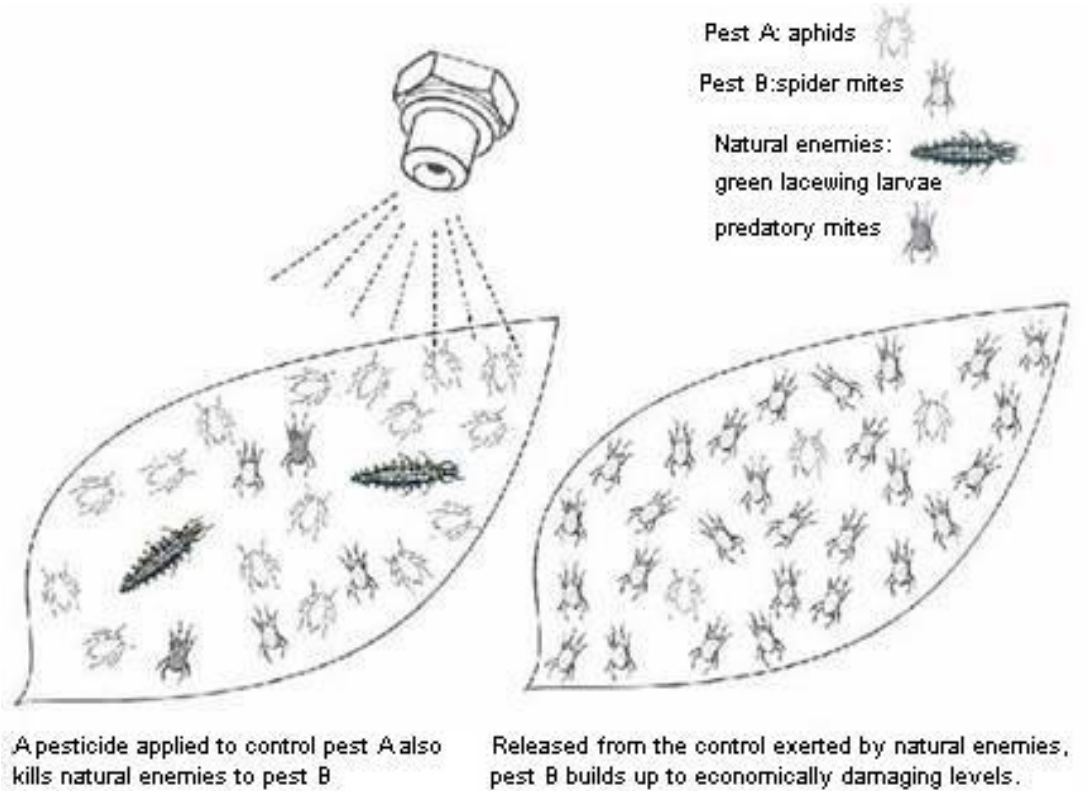


Pesticide Use & the 3 Rs

- **How to mitigate these?**

- **Use the principles of IPM**
  - **Proper ID of all organisms (knowledge)**
  - **Population assessment**
  - **Thresholds**
  - **Combination of tactics**
  - **Evaluation & follow-up**

- **Use selective pesticides that break down quickly**

Pesticide Use & the 3 Rs

- **How to mitigate these?**
- **Use selective pesticides that break down quickly**
- **Use non-chemical tactics when possible**
- **Rotate modes and/or sites of action**
- **Alternate between pesticide groups**
  - **Especially if there is >1 generation of the pest/year**

Reduced-Risk Tactics

- **Biological control**

  - **Natural enemies such as predators, parasitoids, microbials**
  - **UC IPM Natural Enemies Gallery online**

  - **Augmentation, conservation, enhancement**

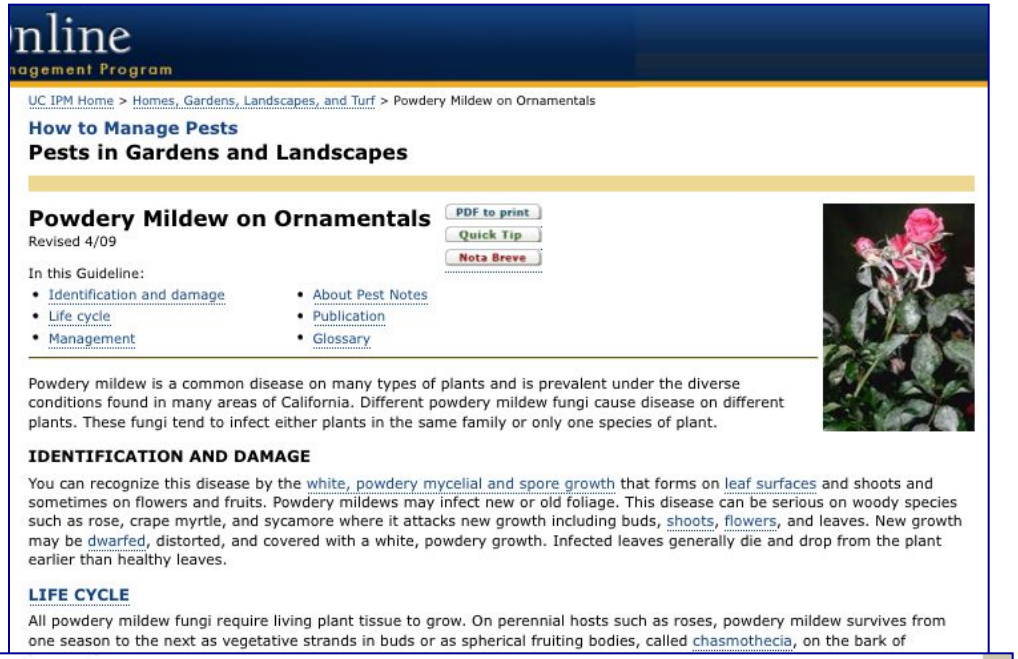
Reduced-Risk Tactics

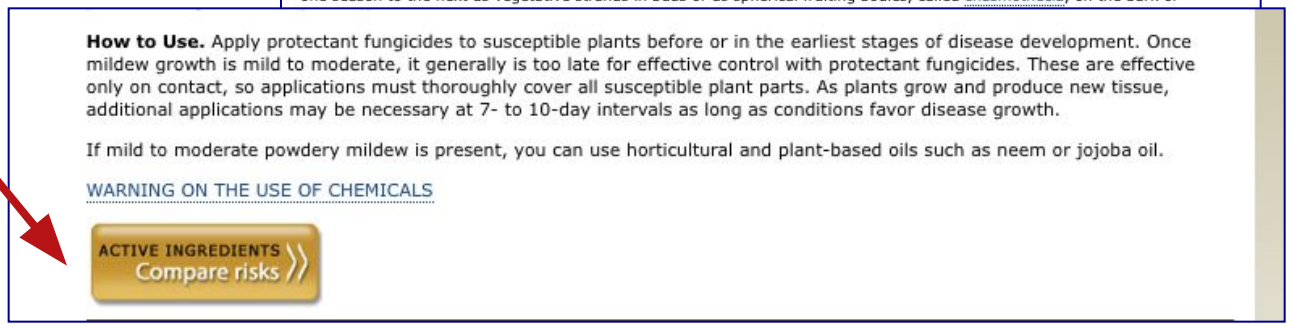
- **Low toxicity pesticides (a few examples)**

  - **DTE**
  - **Insecticidal, herbicidal soaps**
  - **Horticultural oils**
  - **Neem**
  - **Spinosad**
  - **Copper**
  - **Sulfur**
  - **Pyrethrum (pyrethrin)**
  - **Many repellants**
  - **Microbials**
  - **Essential oils**

Compare Risks

Find information on toxicity in the UC IPM Pest Notes





Compare Risks

How to Manage Pests

Pesticide Information

| About Pesticide Information |

Active ingredient: Horticultural oil

Pesticide type: fungicide, insecticide (oil)

Synonyms: fungicidal oil; horticultural oils; insecticidal oil; mineral oil; narrow range oil; oil; summer oil; supreme oil

See example products below.

Potential Hazard[1] to				
			People and Other Mammals	
Water quality[2] (aquatic wildlife)	Natural enemies (beneficials)	Honeybees[3]	Acute[4]	Long Term[5]
NKR	L	M	VL	Not listed

Acute Toxicity to People and other Mammals[4]

- Toxicity rating: **Not Acutely Toxic**

Long-Term Toxicity to People and other Mammals[5]

- **On US EPA list:** Not listed;
- **On CA Proposition 65 list:** Not listed

Water Quality Rating[2]

- Absorbed runoff toxicity risk to fish rating: **No Known Risk**
- Solution runoff toxicity risk to fish rating: **No Known Risk**
- Source: UC IPM WaterTox Database (originally NRCS Pesticide Properties Database)

Impact on Natural Enemies

- Overall toxicity rating: **Low**
- Specific impacts: predatory mites (**Low**), parasitoids (**Low**), general predators (**Low**)

Impact on Honeybees[3]

- Toxicity category: **III - Apply only during late evening, night, or early morning**

Pests for which it is mentioned in Pest Notes

Aphids • Apple and Pear Scab • Avocado Lace Bug • Biological Control and Natural Enemies • California Oakworm •

Sources of Pesticide Environmental and Health Impact Information on the Web

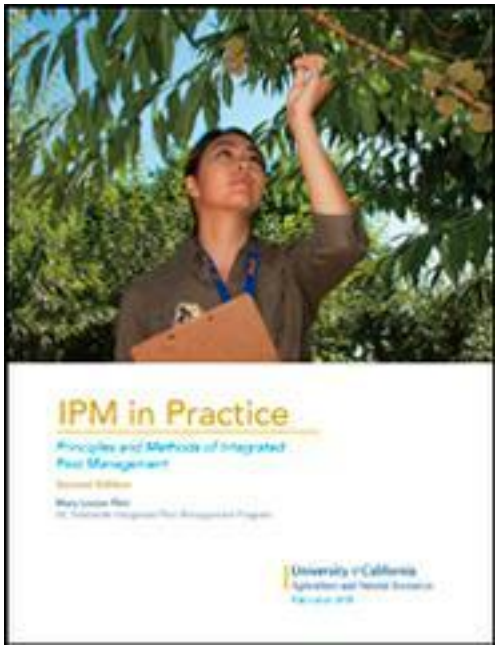
- National Pesticide Information Center:
  http://npic.orst.edu
- UC IPM Web site, pesticide active ingredients database
  http://www.ipm.ucanr.edu
- Pesticide Action Pesticide Database:
  http://www.pesticideinfo.org/

For information on how to manage specific home and garden pests, visit the UC IPM Web site: **www.ipm.ucanr.edu/homegarden**

Resources

- University of California Statewide IPM Program
  - http://www.ipm.ucanr.edu/
- UC Fruit & Nut Research & Information Center (FNRIC)
  - http://fruitsandnuts.ucdavis.edu/
- UC Vegetable Research & Information Center (VRIC)
  - http://vric.ucdavis.edu/
- UC Weed Research & Information Center (WRIC)
  - http://wric.ucdavis.edu/
- UC Small Farm Program
  - http://sfp.ucdavis.edu/
- UC Division of Agriculture & Natural Resources http://ucanr.edu/
  - Publications http://ucanr.edu/Publications_524/
  - Statewide programs http://ucanr.edu/ANR_Offices/Statewide_Programs_228/
  - County cooperative extension offices http://ucanr.edu/County_Offices/
  - Research & Extension Centers http://recs.ucanr.edu/

Utilizing Resources & The Web



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- UC Small Farm Program
  - http://sfp.ucdavis.edu/
- UC Division of Agriculture & Natural Resources http://ucanr.edu/
  - Publications http://ucanr.edu/Publications_524/
  - Statewide programs http://ucanr.edu/ANR_Offices/Statewide_Programs_228/
  - County cooperative extension offices http://ucanr.edu/County_Offices/
  - Research & Extension Centers http://recs.ucanr.edu/