Applied Entomology
Agricultural Concerns

Insects and People
Applied Entomology

A Short History of Humans

- Genus *Homo* perhaps 1.5-2 mybp
  - *Homo sapiens* perhaps 200,000 ybp
  - *H. s. sapiens* - (Cro-Magnon Man) perhaps 30-40,000 ybp
- A Hunter/Gatherer history

A Short History of Agriculture

- “The most important event in the cultural evolution of the human species”
- 12,000-18,000 ybp first implements and storage containers found
  - Middle East
  - Egypt
    - Wheat, lentils, chickpeas, dates

What allowed the development of an agricultural society?

- Development of cereals
  - Wheat, rye, barley
  - Corn (maize)
  - Rice
  - Sorghum
- Domestication of herbivorous animals

How did agriculture affect the development of human society?

- As hunter/gathers
  - Mobile
  - Low fertility
  - Active involvement
- An agricultural society
  - Sedentary
  - Increased fertility
  - Few individuals involved in food procurement

Advancements in Agriculture

- 12,000 ybp to 1700s - little change
  - Most of human population involved in “production agriculture”
- Recent changes
  - Improved mechanization
  - Improved crop plants
    - The “Green Revolution” - N. Borlaug, WSU
    - GMOs
  - Increased energy input

Where do the insects come in?

Insects are direct competitors with humans for “our” food and fiber!

Where do the Conflicts Exist?

- Plants and plant products
  - 30-40% of insects are herbivores
  - Vector plant diseases
- Stored products
- Structures
- Humans and domesticated animals
  - Arthropod vectored diseases
    - Arbodiseases
  - nuisances

Are Insects Inherently Pests?

- What is a Pest?
- Are all insects pests?
  - Subeconomic pests
  - Occasional pests
  - Key, perennial, or severe pests

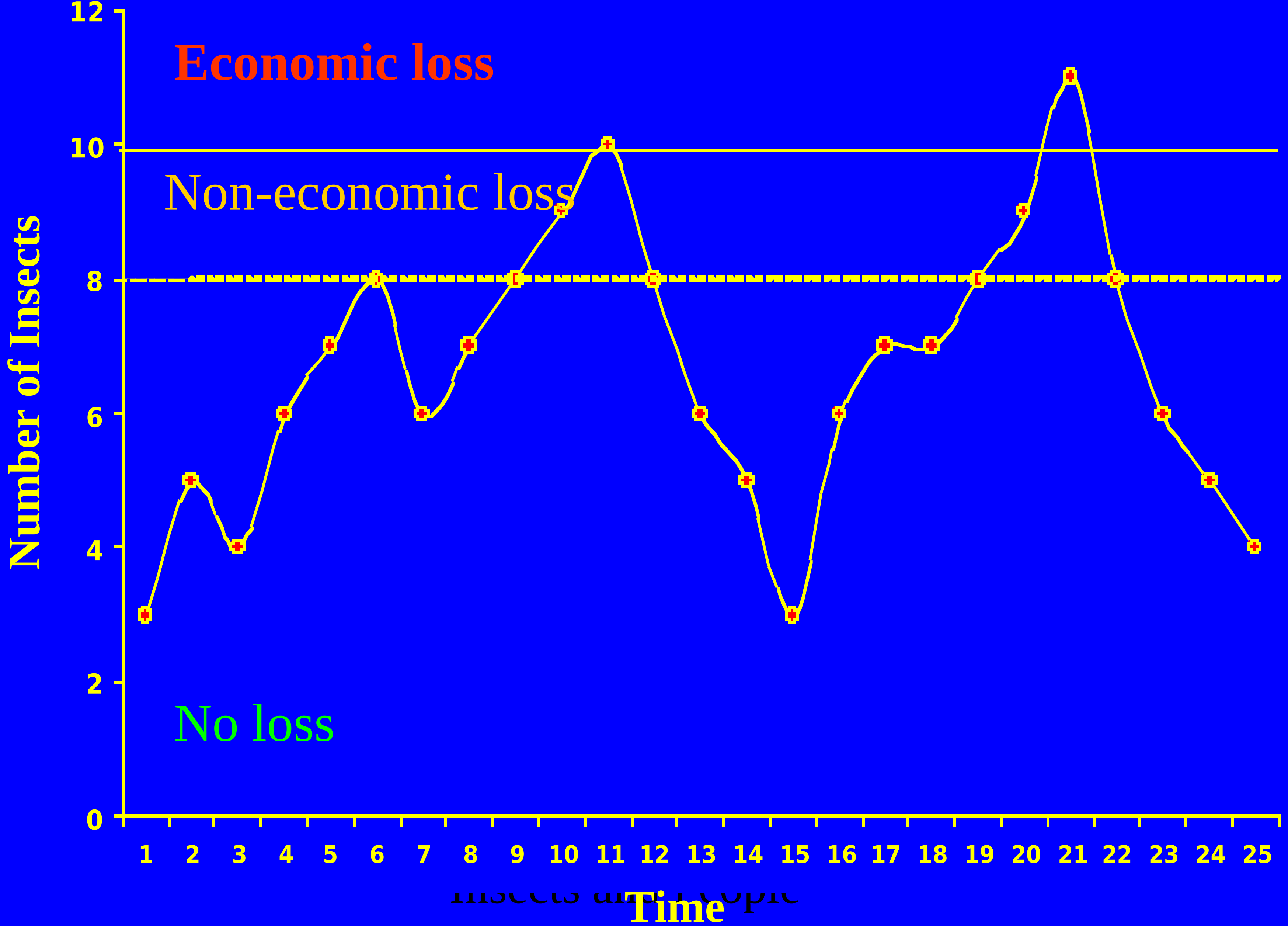
The Concept of an Economic Injury Level (EIL)

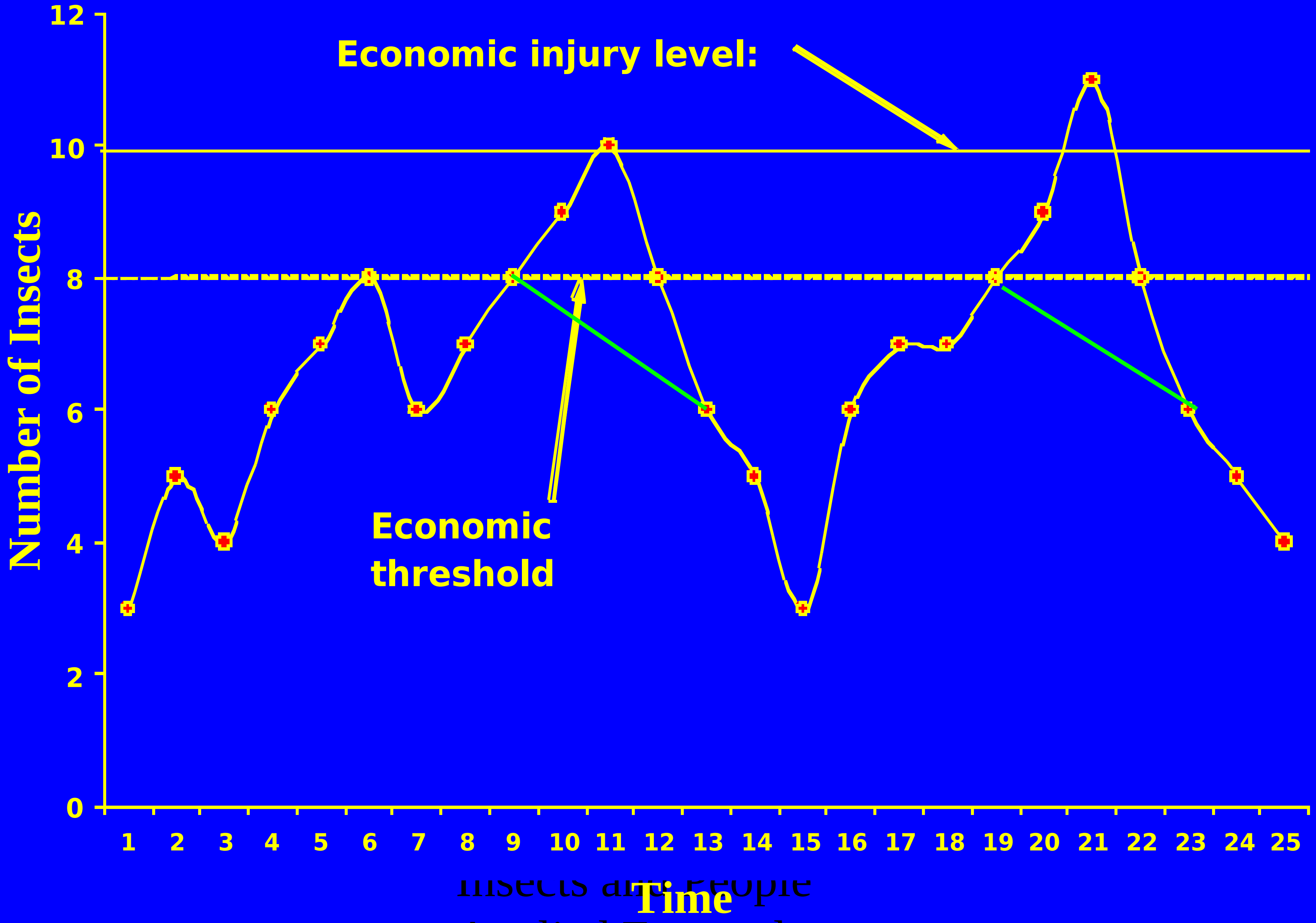
- The lowest number of insects that will cause an economic loss
- The point at which the loss due to damage is greater than the cost of control.
- Usually measured in number of insects/unit of measure

Economic threshold

- Also called *Action Threshold* – Insect density that would justify intervention

- May be a *fixed* economic threshold: e.g. if EIL is 6 insects per plant, intervene at 4 insects per plant;


Economic loss
Non-economic loss
No loss
Number of Insects
Time
0
2
4
6
8
10
12
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



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IPM Options:

- Biological control
- Physical control
- Cultural control
- Chemical control

Monitoring insect numbers is the cornerstone of IPM

Approaches to monitoring:

Various methods:

- Direct counts
- Traps
- Damage estimates
- Prediction: degree-days

Benefits of monitoring:

- Track numbers of pests and natural enemies;
- Able to target insecticide applications at the correct time;
- Enhances conservation of natural enemies;
- Indicate efficacy of treatments.

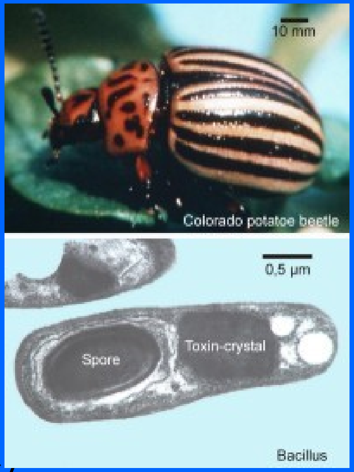
Biological control:

- Natural enemies of pests cause mortality;
- Can maintain pest population at below-threshold levels

Predators

Parasitoids

Pathogens



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Types of BC:

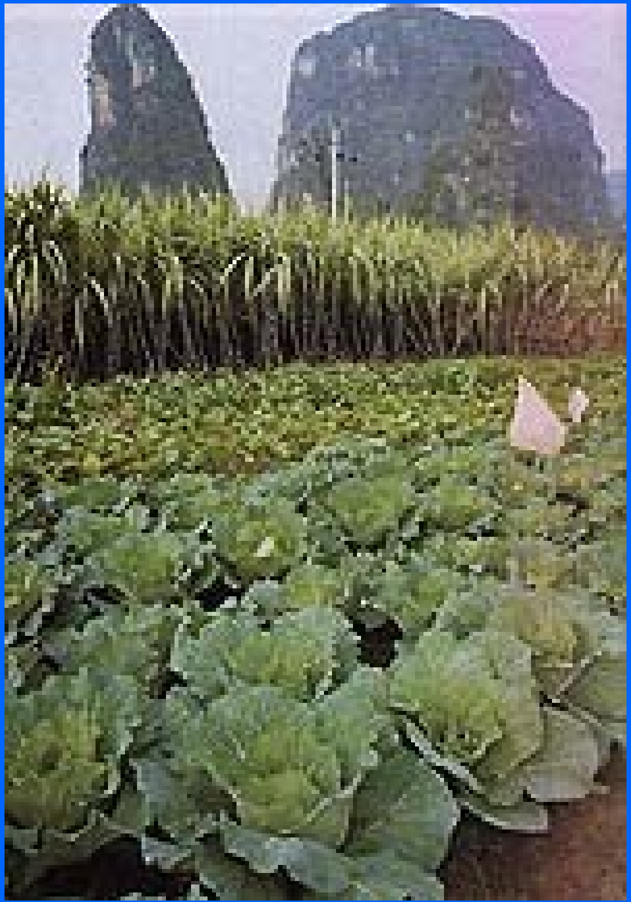
- Import natural enemies - establish in field - Classical BC;
- Augmentative releases: inundative or inoculative releases each season;
- “Conservation” BC: depend upon local natural enemies.
- All these approaches require *conservation* of natural enemies to be effective.

Conserving natural enemies

Reduce insecticide use;

Use softer chemicals;

Manipulate habitats,
e.g. intercropping.



Concerns: Biological Control

- Non-target effects?
- "*Necessary evils: murder, drugs and biological control*" (Lockwood 1999)
- Host specificity testing
- Risk assessment protocols?

Insecticides

- Insecticides as resources:

Huge financial investment for development;

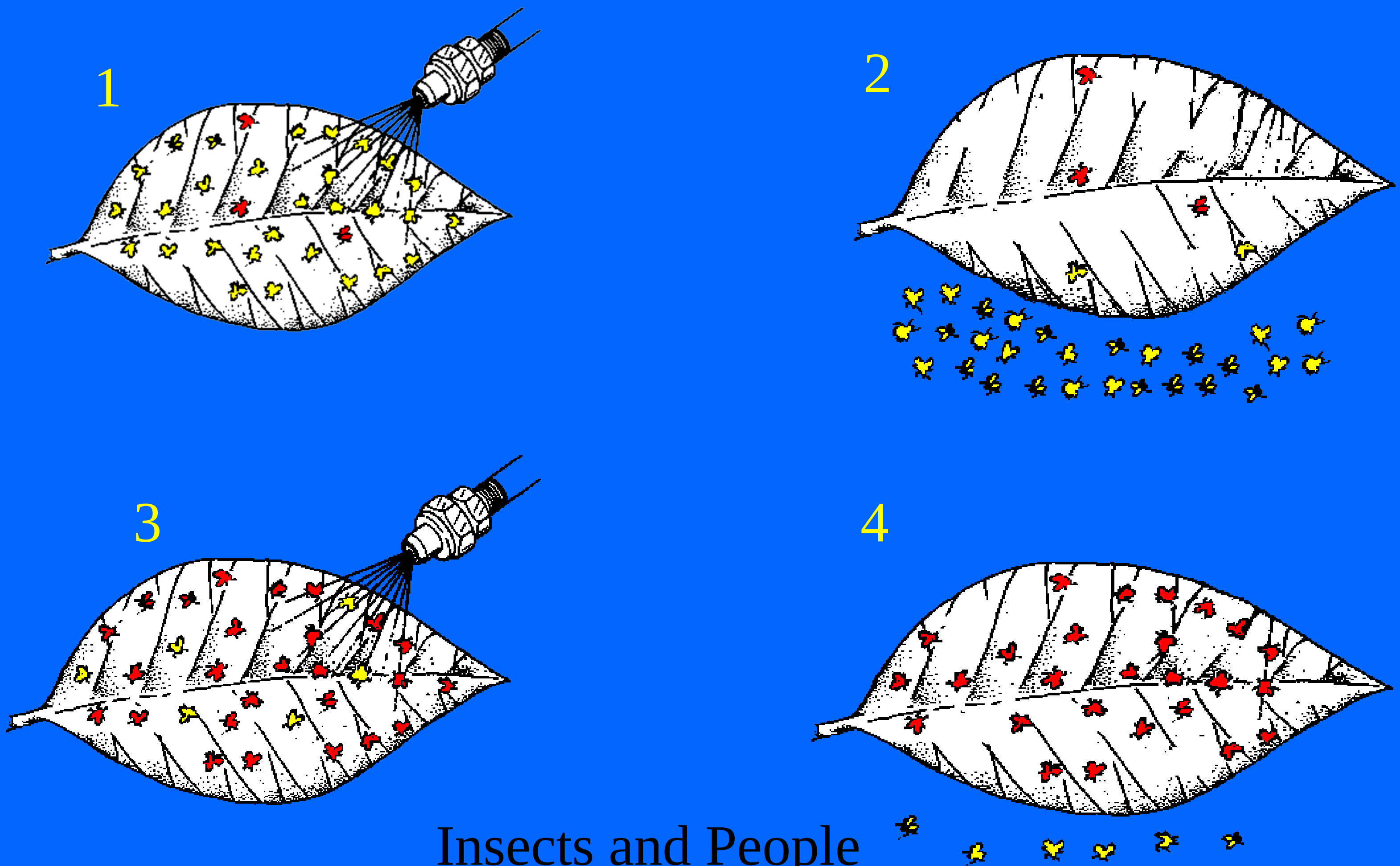
Potential for Use or Abuse of this resource;

Can play an important role in providing options for pest management.

Problems with insecticides:

- Kill or disrupt natural enemies
- Secondary pests
- Residues on produce
- Build-up of resistance – insecticide "treadmill"
- Environmental concerns

Build-up of resistance:



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Dealing with resistance

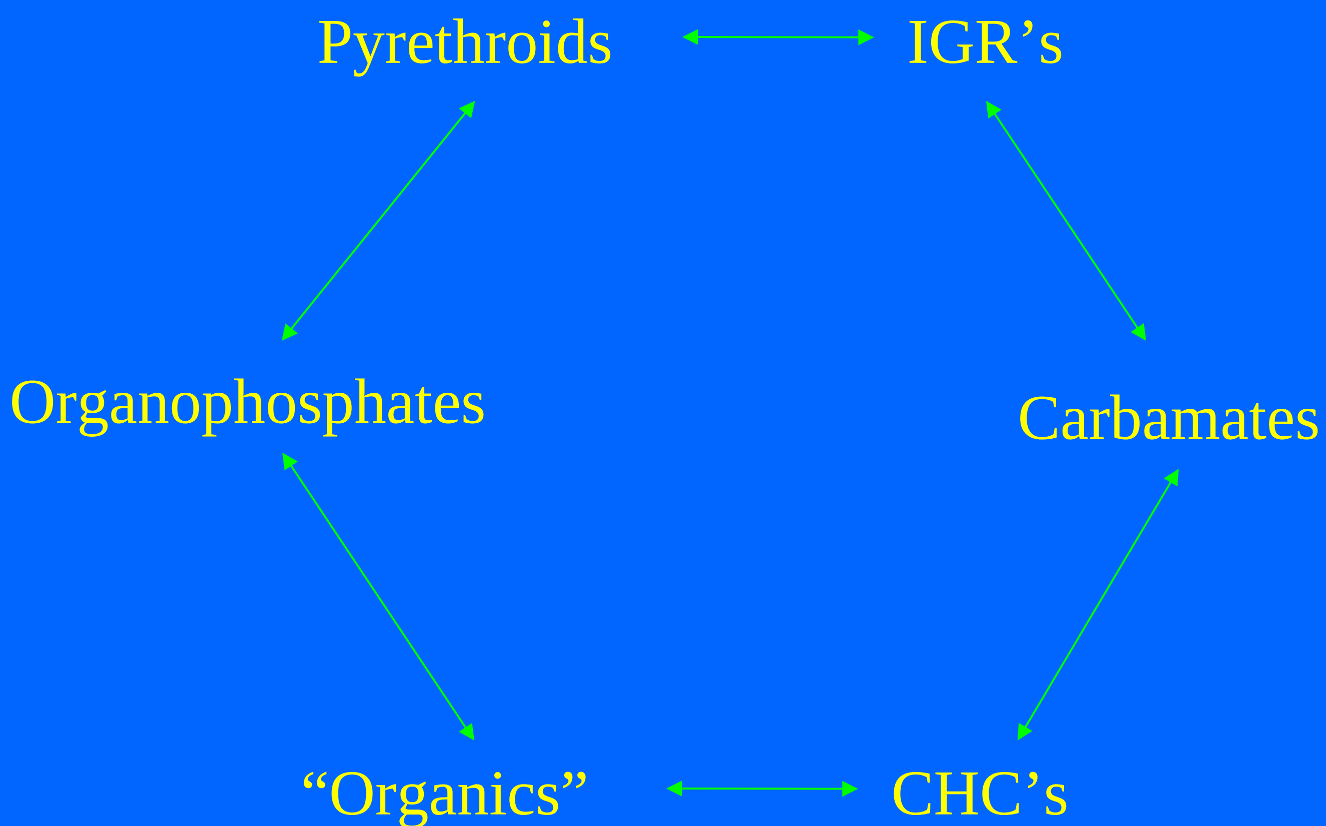
Wrong approach:

- Raised concentrations of active ingredients!
- Increased frequency of application!

Correct approach:

- Reduce reliance on chemicals.
- Alternation of chemical groups.
- Targeted insecticide applications.

Example of rotation program:



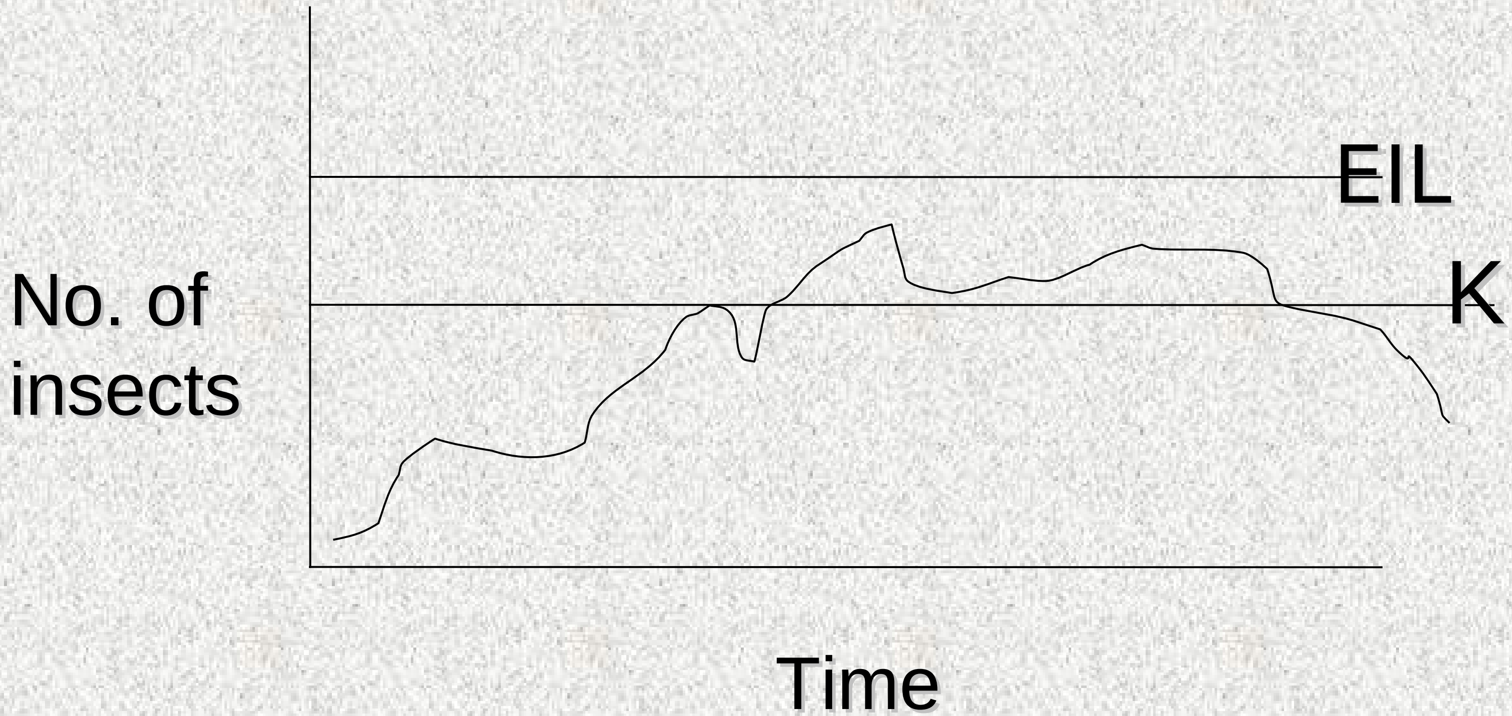
Benefits of insecticides:

- Can be effective if used correctly
- Can provide an immediate solution
- New formulations are safer
- Target-specific modes of action are being developed
- Effective chemicals should be conserved as a component of sustainable pest management programs.

Pest Levels
Subeconomic Pests

- Amount of damage done by “pest” is not sufficiently costly to manage
  - Costs more to manage a pest than the damage that it does is worth
- Rarely if ever managed

Pest Levels
Subeconomic Pests

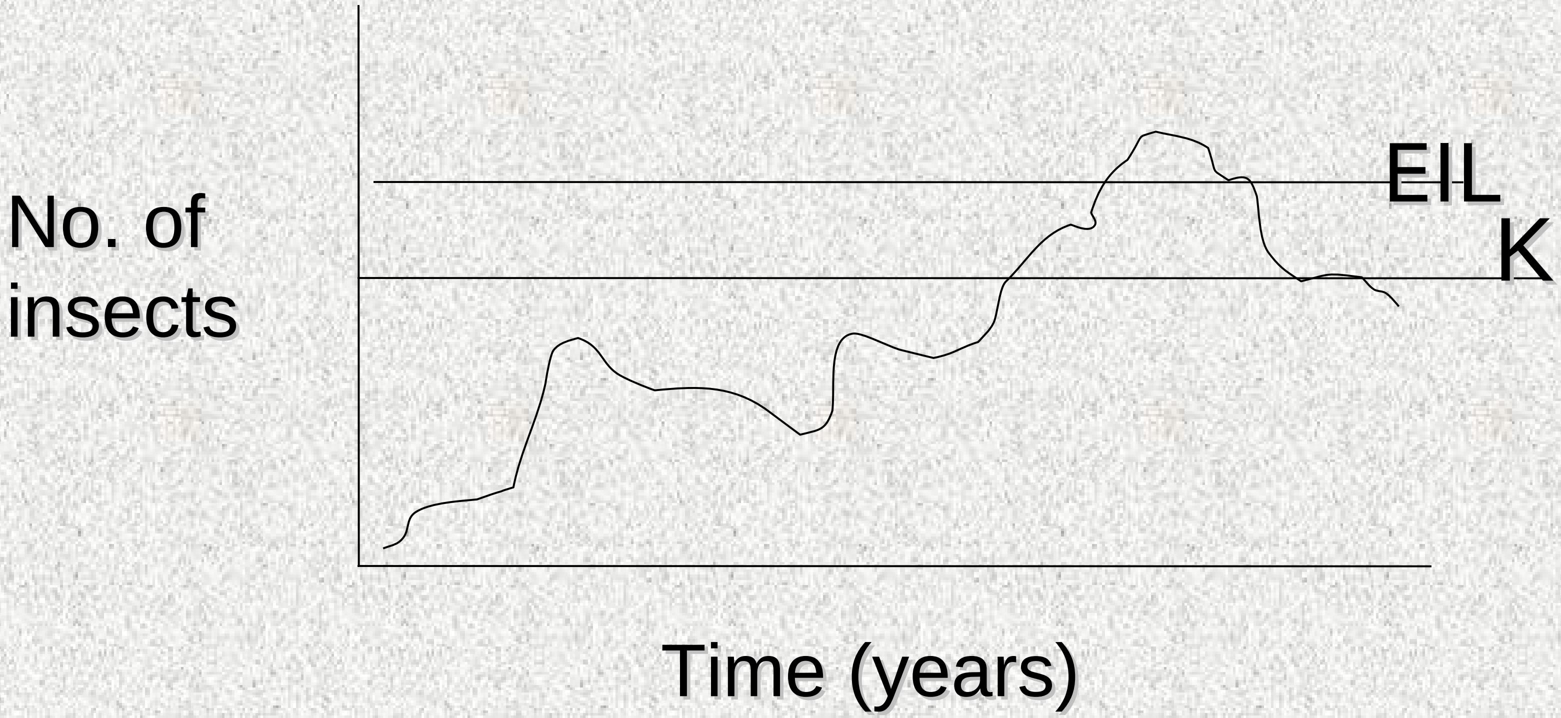


Subeconomic Pests

Pest Levels
Occasional Pests

- Do not usually do enough damage to justify management
- Favorable conditions may place the population above the EIL (may be cyclical over multi-year periods)

Pest Levels
Occasional Pests



Occasional Pests

Desert Locust

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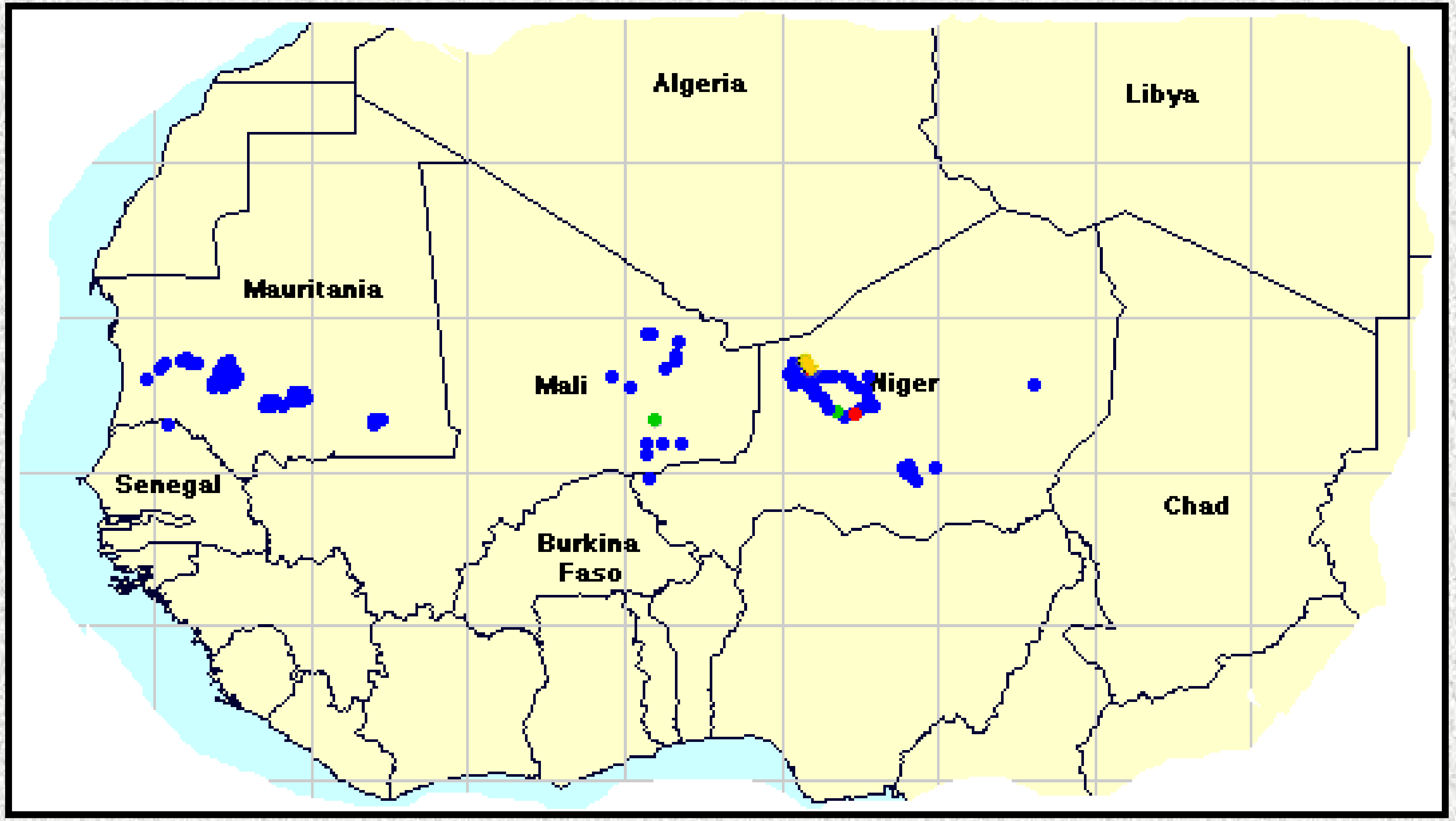
Desert Locust



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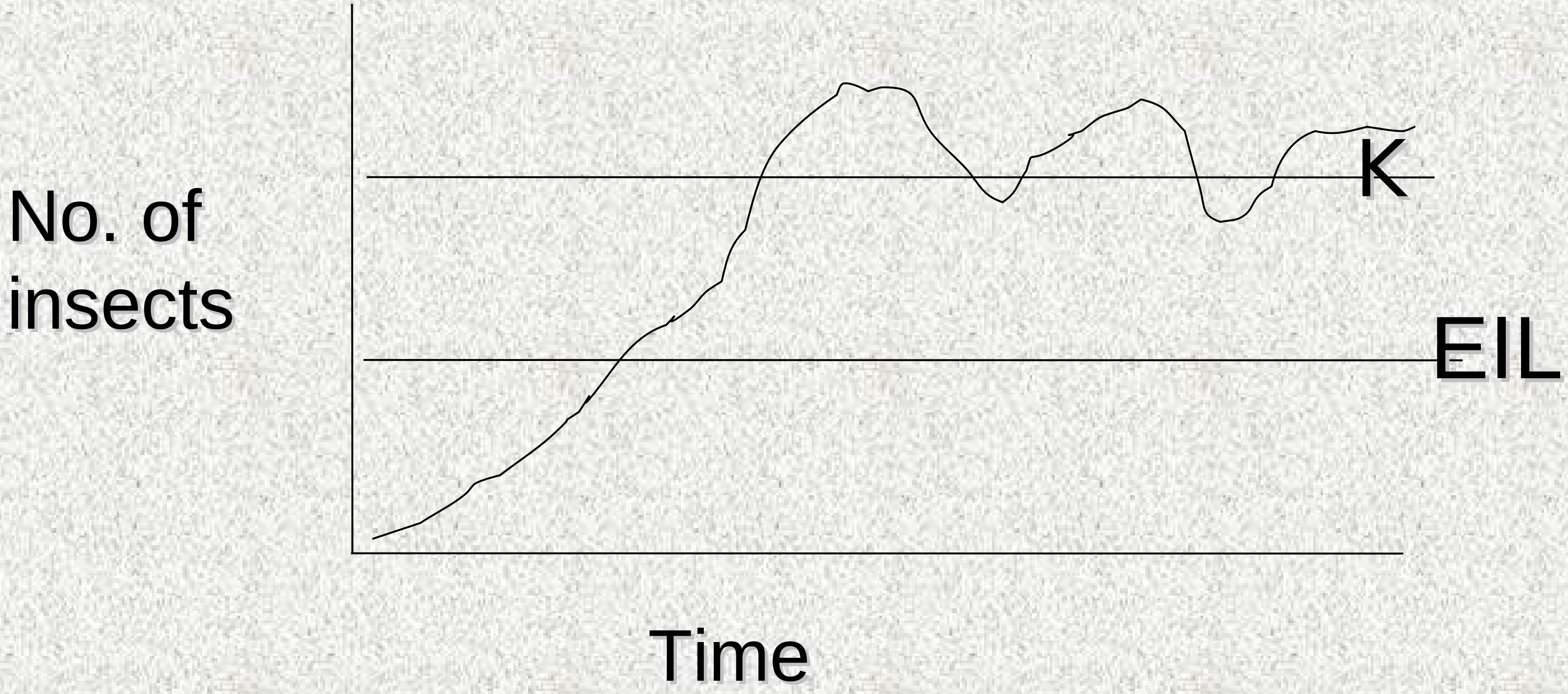
Pest Levels
Key, Perennial, Severe Pests

- Cause regular and serious damage
- High numbers or low numbers in high value crops
- Aesthetic damage
- Sometimes managed on a prophylactic basis
- Other management often revolves around this pest(s)
- Perhaps 200 species in United States, 2,000 in world

Pest Levels
Key, Perennial, Severe Pests



Key Pests

Codling Moth

Where Would You Place

- Head Lice
- Mosquitoes that vector malaria
- A beetle that sometimes is found in your box of corn flakes
- Gnats that fly around lights at night

Why do Certain Insects Become Pests?

- Insect population numbers and ecosystem modifications
  - Agricultural monocultures
  - r and K selection

r and K Selection

- Imagine a continuum
  - r---K
  - r-selected organisms
    - High reproductive capacity, little care of young
    - Often short-lived
    - Rebound quickly after change
    - Many insects
    - Most pests

r and K Selection

- Imagine a continuum
  - r--K
  - K-selected organisms
    - Low reproductive capacity, great care of young
    - Often long-lived
    - Have difficulty dealing with change
    - Humans, elephants, mammals, few insects

Why do Certain Insects Become Pests?

- Transportation
  - Moved in association with humans and products
  - Anthropogenic
  - Most key pests are “exotic”
    - Released from natural controls

Why do Certain Insects Become Pests?

- Human attitudes
  - Human standards
    - No lice on our children
    - No fleas on our pests
    - No fecal material on our corn
    - Blemish free fruit

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Managing Pest Populations

The reason I have a job!

How do we Manage Insects?

Appeal to a higher power

The Romans had a festival called Robigalia intended to appease Robigus the god of wheat rust (*Robigus* sp.)

https://en.wikipedia.org/wiki/Robigalia

How do we Manage Insects?

- Chemicals
  - Early pesticides (insecticides)
    - 1,000BC - “pest averting sulfur”
    - 200 BC - Bitumen - mineral pitch, asphalt
    - 40-90 AD - Arsenic
    - 1690 - Botanicals including nicotine
    - 1860s - inorganic materials

How do we Manage Insects?

- Chemicals
  - Mid-modern pesticides
    - Late 1800s to WWI and WWII
    - Synthetic materials including organics
      - Many natural products were not available
      - Studies of “nerve” poisons

DDT
dichloro**d**iphenyl**T**richloroethane

- Formulated in 1873 by Othmar Zeidler
- 1939, Paul Muller was looking for a moth-proofing agent, discovered insecticidal properties
- Broad spectrum, residual, low mammalian toxicity
- Saved many lives during WWII and post war
- The “Silver Bullet”

The Demise of DDT

- 1941-1976, 4.5 million tons produced
- “Bioaccumulation” in fat cells
- “Biomagnification” in food chain
- 1962, Rachel Carson wrote Silent Spring
- DDT banned in the late 1960s
- 1970, establishment of US Environmental Protection Agency (EPA)

Pesticide Terminology

- Pesticide - designed to kill
  - Active vs. inert ingredient
  - Broad-spectrum vs. narrow-spectrum
  - Residual vs. nonresidual
  - LD_{50} and LC_{50}
    - Lethal dose to kill 50% of a test population

Pesticide Terminology

- Mode of action
  - The way in which a pesticide “works”
    - Metabolic poison
    - Physical Poison
    - Nerve Poison

Pesticide Terminology

- Types of chemical pesticides
  - Inorganic
    - Do not contain carbon, not “organic”
    - Most with high mammalian toxicity
    - Mercury, tin, boron, arsenic, sulfur, zinc
    - Rarely used today
      - Old orchards in WA

Pesticide Terminology

- Types of chemical pesticides
  - Organic
    - Contain carbon as the “backbone” element
    - “Natural” organics - refined, naturally occurring
      - Oils, highly refined, can by phytotoxic, often applied at dormant state of plant
      - Botanicals
        - » Derived from plants
        - » Can be natural or synthetic
        - » Various mammalian toxicities
        - » Nicotine
        - » pyrethrum

Pesticide Terminology

- Types of chemical pesticides
  - Organic
    - Contain carbon as the “backbone” element
    - “Synthetic” organics - “man-made” materials
      - Most of the materials used today
      - Mammalian toxicity varies greatly
      - Can be very specific to certain pests (narrow-spectrum)
      - Thousands of products available

Advantages of Traditional Pesticides

- Can treat a problem while it is in progress
- Killing action is rapid
- Chemical pesticides are generally economical
- Chemical pesticides are generally easy to use

Disadvantages of Traditional Pesticides

- Development of resistance in the pest
- Pest resurgence and pest replacement
- Effects on non-target organisms
- Risks to the applicator

Are there other ways to manage pests?

Chemical Modifiers of Development and Behavior

- Based on knowledge of pest physiology
- Disrupt “normal” development
- Practical beginnings in 1960s
- Insect Growth Regulators (IGRs)
  - Juvenile hormone mimics (JH)
  - Molting hormone mimics

Chemicals that Modify Behavioral Patterns

- Pheromones
  - Sex pheromones
    - Can be synthesized
    - Sampling and monitoring
    - Mating disruption or confusion
- Allomones (benefit sender)
- Kairomones (benefit receiver)

Pheromones

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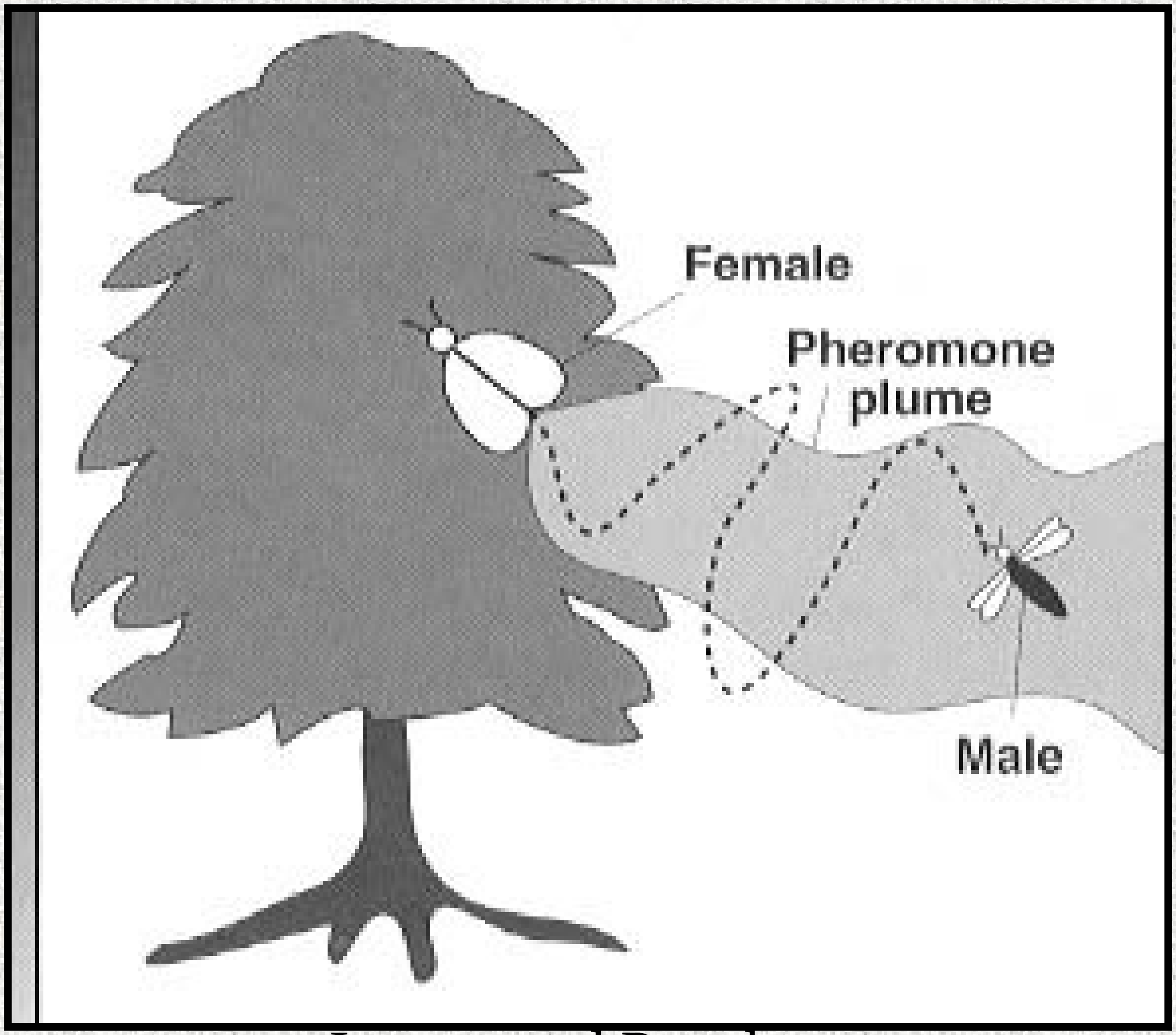
Mating Disruption



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Sterile Insect Technique (SIT)

- Developed in the 1930s
- Sterile individuals released into the environment in high numbers to mate with fertile individuals
- Geographically isolated pests
- Very costly
- Screwworm fly

Screwworm Fly

Screwworm Fly - Damage

Myiasis causing fly

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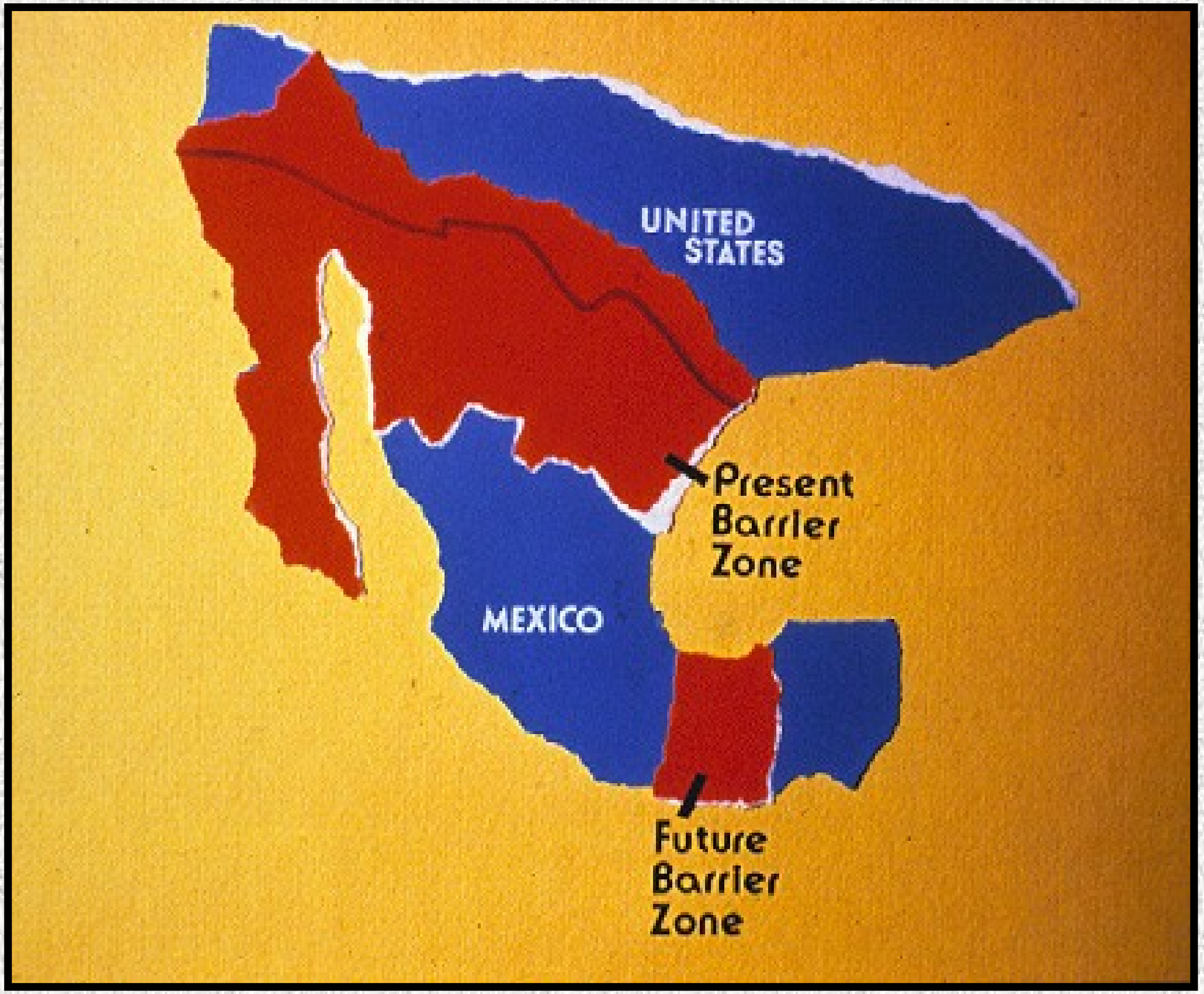
Screwworm Fly - Distribution



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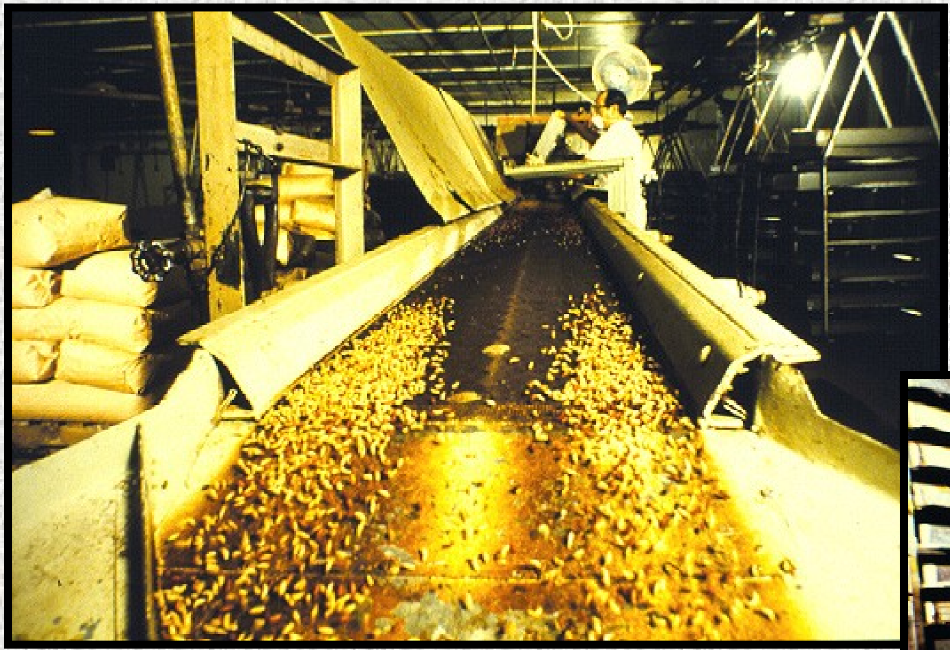
Screwworm Fly - SIT Facilities



Screwworm Fly - Human Myiasis

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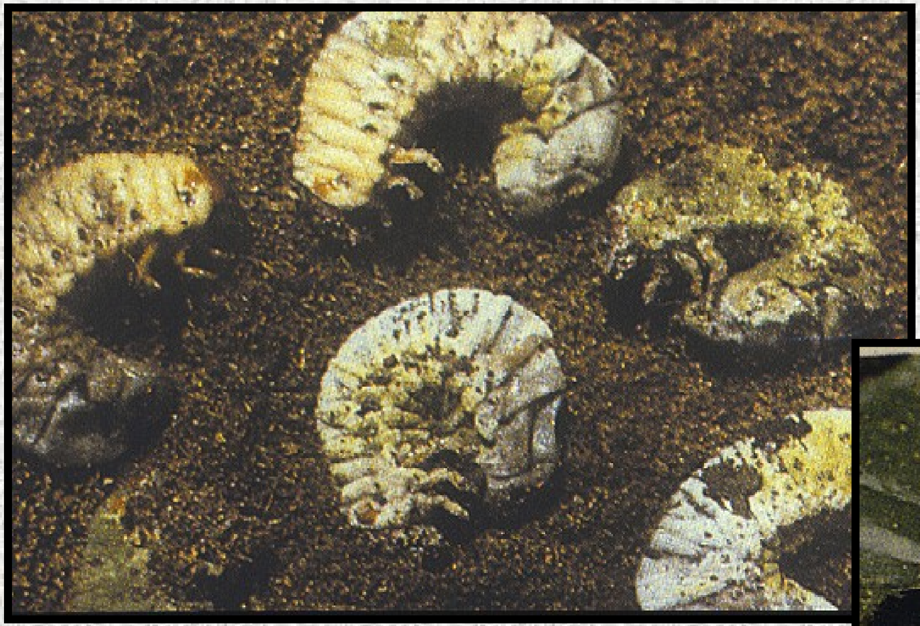
Microbial Control

- The use of “microbes (e.g, bacteria, viruses, fungi) to manage insects
- Little mammalian toxicity
- *Bacillus thuringiensis* (Bt)
  - Several varieties
  - Little mammalian toxicity
  - Often used in large-scale programs

Microbial Control



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Genetically Modified Organisms (GMOs)

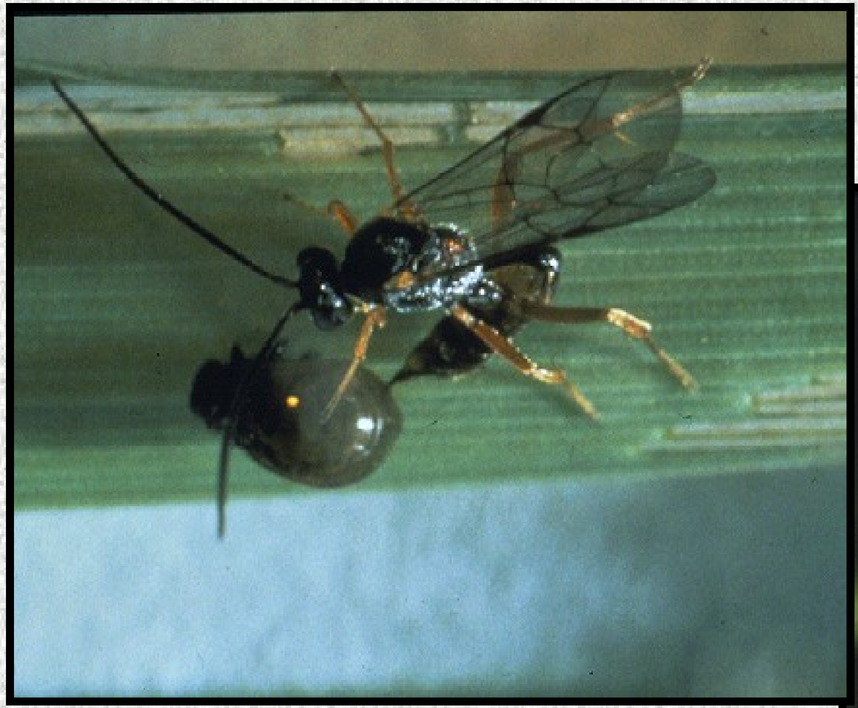
- Incorporate genetic material from one organisms into another (e.g., endotoxin from Bt)
- Transgenic plants
- Public acceptance has been a problem

Cultural and Physical Management Techniques

- Manipulation of the pest's environment
  - Sanitation
  - Tillage
  - Crop rotation
- Physical removal or containment
  - Screens
  - Fly swatter
  - Hopper dozer

Biological Control - Predators

Biological Control - Parasitoids



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