Integrated Pest Management: Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Areas


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Integrated Pest Management: Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Areas

Presenter

Allan S. Felsot, Ph.D.

- Professor of entomology and environmental toxicology
- Extension specialist, Washington State University
- Entomological Society of America's liaison to EPA's Office of Pesticide Programs
- Research interests: crop protection technologies, IPM, best management practices for reducing off-target pesticide movement, and pesticide risk assessment

WASHINGTON STATE UNIVERSITY EXTENSION

Integrated Pest Management: Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Areas

Allan S. Felsot

Washington State University

Department of Entomology

College of Agricultural, Human, and Natural Resource Sciences

AGRICULTURE | YOUTH & FAMILIES | HEALTH | ECONOMY | ENVIRONMENT | ENERGY | COMMUNITIES

Agenda

- Why IPM strategies are essential for “saving pollinators”
- IPM as a decision aid for protecting crop yield and making a profit
- The four basic elements of IPM-based crop protection strategies
- Preventative management by cultural practices that enhance habitat diversity will promote biocontrol services and conserve pollinators
- How pesticide management can be implemented to reduce off-target impacts

Bloviating Hyperbole, Hazard, or Risk??

The Atlantic

The World's Most Popular Insecticides Are Messing With Bees

They're turning them into incompetent pollinators, which is bad news for plants—and humans.

We don't know for sure that pesticides are killing the bees. But we know enough to worry.

The Washington Post

By Puneet Kollipara March 5, 2015

Harvard Study Proves Why The Bees Are All Disappearing

CS GLOBE The World Online

Jun 16, 2015 487149

The human race is really starting to feel the consequences of their actions.

C4 TRI-CITY HERALD | SUNDAY, APRIL 1, 2012

Pesticides causing problems for honeybees, bumblebees

ASSOCIATED PRESS

WASHINGTON — A common class of pesticide is causing problems for honeybees and bumblebees, important species already in trouble, two studies suggest.

But the findings don't explain all the reasons behind a long-running bee decline, and other experts found one of the studies less than convincing.

The new research suggests the chemicals used in the pesticide — designed to attack the central nervous system of insects — reduces the weight and number of queens in bumblebee hives. These pesticides also cause honeybees to become disoriented and fail to return to their hives, the researchers concluded.

The two studies were published online Thursday in the journal Science.

Just last week, activists filed a petition with more than a million signatures asking the government to ban the class of pesticides called neonicotinoids. The U.S. Environmental Protection Agency said it is re-evaluating the chemicals and is seeking scientific help.

For more than a decade, pollinators of all types have been in decline, mostly because of habitat loss and perhaps some pesticide use. In the past five years, a new mysterious honeybee problem, colony collapse disorder, has further attacked hives. But during the past couple of years, that problem has been observed a bit less, said Jeff Pettis, lead bee researcher at the U.S. Department of Agriculture's lab in Beltsville, Md.

Other studies also have found problems with the pesticide class singled out in the new research. These "strengthen the case for more thorough re-assessing," said University of Illinois entomology professor May Berenbaum, who wasn't involved in the new studies. "But this is not a slam-dunk indictment that could compel a ban. It's complicated."

Contemporary Headlines: Same as the Old Headlines?

Nearly two decades of data reinforce concerns that pesticides are really bad for bees

By **Chelsea Harvey** August 16 at 2:58 PM

The Washington Post

Wednesday, August 17, 2016 Edition: **U.S. & World** | Regional

A bumble bee collects nectar from the calyx of a marguerite in Berlin. (Wolfgang Kumm/AFP/Getty Images)

This story has been updated.

New research has provided some of the strongest evidence yet that pesticides can do serious, long-term damage to bee populations. And the findings may help fuel the ongoing debate about whether certain insecticides should be permitted for agricultural use at all.

Ancient History of Pesticide-Bee Relationships

- Late 1800s: Honey bees killed by arsenical insecticides applied to fruit trees in Illinois, Michigan, Ohio, and New York

- 1920s: Honey bees killed by calcium arsenate applied to cotton in SE U.S.

- 1921: First reported honey bee poisoning in WA State, involving copper acetoarsenite (Paris Green) applied to apples

  ✓ Management recommendation by Prof. Melander at Washington State College: Application during bloom should be prohibited

- 1940's - 1950's: Honey bees killed by parathion & dieldrin

Deja Vu?

- Carbaryl first became a severe problem in 1959 when it was used against certain orchard pests
  - ✓ During a peak problem year, 1967, it caused the destruction of an estimated 70,000 colonies of honey bees in California from use on cotton and an estimated 33,000 colonies in Washington from use on corn
  - ✓ The estimated national loss from all pesticide poisoning for the same year was 500,000 colonies
- During the 1970's, methyl parathion was formulated into a microencapsulated granule that was sprayable
  - ✓ The microcapsules could be taken back to the hive by foraging bees and thus the residue be transferred to the rest of the colony

Penncap-M (methyl parathion) Cancellation

Joanne Whalen, Extension IPM Specialist; jwhalen@udel.edu

Penncap-M (methyl parathion) – It should be noted that the notice to cancel all uses of this product was posted in the Federal Register on Feb 25, 2011. Any distribution, sale, or use of the products subject to this cancellation order is permitted only in accordance with the terms of this order, including any existing stocks provisions. For information on the details of this cancellation as well as existing stocks provision please refer to the Federal Register posting:

Johansen (1972) Ann Rev Entom 22:177-192

Deja Vu: Historical Perspective

DAMAGE TO HONEY BEE COLONIES (*APIS MELLIFERA*) BY INSECTICIDES IN GREAT BRITAIN, 1956–65

By P. H. NEEDHAM, S. R. B. SOLLY* and J. H. STEVENSON

Methods are described for detecting insecticides in dead bees. Bees received by the Chief Bee Advisory Officer of the Ministry of Agriculture, Fisheries & Food have been analysed by these methods and it is

Journal of Science of Food & Agriculture (1966) 17:133-137

Incidents of poisoning of honeybees (*Apis mellifera*) by agricultural pesticides in Great Britain 1981–1991

P. W. Greig-Smith[*,†], H. M. Thompson[‡], A. R. Hardy[†], M. H. Bew[§], E. Findlay[″] and J. H. Stevenson[¶]

Central Science Laboratory, Ministry of Agriculture, Fisheries and Food, [†]Tangley Place, Worplesdon, Surrey GU 3 3LQ, UK, [‡]London Road, Slough, Berkshire, SL3 7HJ, UK and [§]Luddington, Stratford-upon-Avon, Warwicks CV37 9SJ, UK; [″]Scottish Agricultural Science Agency, The Scottish Office Agriculture and Fisheries Department, East Craigs, Edinburgh EH12 8NJ, UK, and [¶]AFRC Institute of Arable Crops Research, Rothamsted Experimental Station, Harpenden, Hertfordshire AL5 2JQ, UK

Suspected cas … by the Ministry of Agriculture, … Agriculture and Fisheries Department (in Scotland). Studies include field visits to sites where bee mortality is recorded, examination of dead bees for disease, and analysis for the presence of pesticide residues. This paper

Crop Protection (1994) 13:567-581

We’ve Been Here Before

AGRICULTURE

Pollination Worries Rise As Honey Bees Decline

Substitute? The blue orchard bee is being developed as an almond pollinator.

When it comes to endangered species, most people think of creatures like the California condor or the giant panda—high-profile animals that are undoubtedly valuable members of their own ecosystems but don’t add much to human economies. Now, hard times have come to a species that may be less prominent, but is an economic linchpin: the honey bee, which pollinates approximately $10 billion worth of crops, including almonds, apples, and alfalfa

“The fe

practical purposes, gone,” says Roger Morse, an apiculturist at Cornell University. And while the number of beekeeper-maintained colonies has remained constant, hive quality has deteriorated and the populations of beekeepers themselves are dwindling in the United States. From a survey of beekeepers registered by the individual states, Kim Flottum, editor of the trade publication *Bee Culture*, estimates that their number has dropped by about 20% since 1990.

erica to a few Florida beekeepers apparently introduced the two parasites, known as tracheal and varroa mites. Although they came in from South America, neither mite species originated there. Tracheal mites were first identified on the Isle of Wight shortly after the turn of the century, while varroa mites are native to

tance to them. But the recently exposed honey bees of North America—actually European honey bees that were introduced by early European colonists—are another story.

“The varroa mites are virtually eliminating feral European bees that became widely established in the northern two thirds of North America,” says Taylor. The damage, which is being seen in maintained colonies as well, is done by the pinhead-sized, adult fe-

the mite probl
“Modern agricu
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Beekeepers
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Chinese honey
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only 42 cents p
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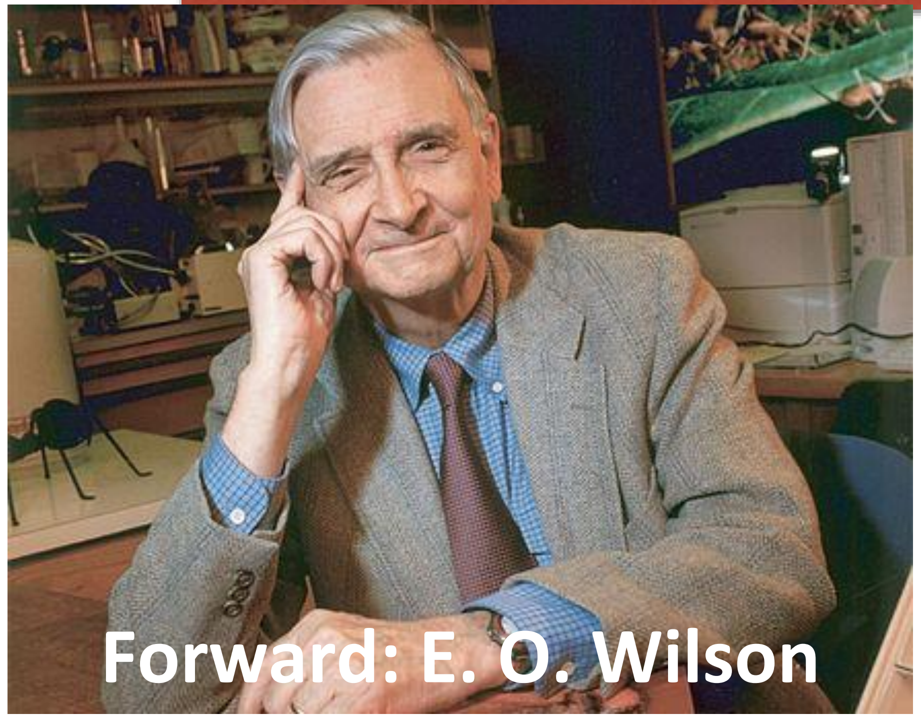
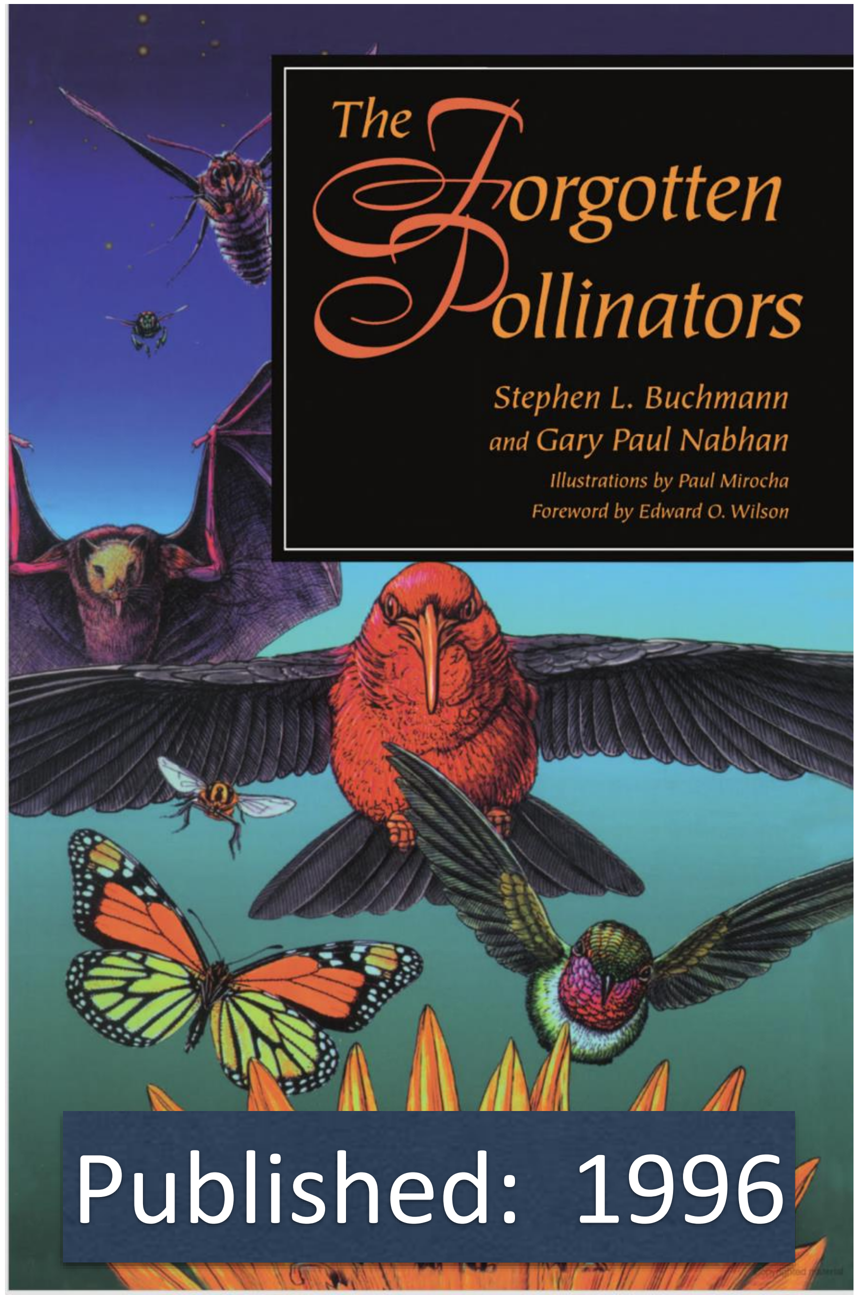
down to six, “m
the mites,” he

Published 1994 in Science (vol. 265, p. 1170)

Contemporary Perspectives On Pollinators

"The evidence is overwhelming that wild pollinators are declining around the world. Most have already experienced a shrinking or range. Some have already suffered or face the imminent risk of total extinction."





"It now appears that the majority of plants studied to date show evidence of natural pollinator limitation. That is to say, under natural condistion, 62 percent of some 258 kinds of plants studied in detail suffer limited fruit set from two few visits by effective pollinators."

“Meet the New Boss, Same as the Old Boss”

“Declines in bumble bee species in the past 60 years are well documented in Europe, where they are driven primarily by habitat loss and declines in floral abundance and diversity resulting from agricultural intensification.”

Goulson D. et al. (2008) *Annu. Rev. Entomol.* 2008. 53:191–208

“The reasons for these declines [in biodiversity] remain unclear and are the subject of ongoing debate, but it seems likely that the annually increasing use of neonics may be playing a role in driving these declines.”

Goulson, D. (2013) *Significance* (June 2013)

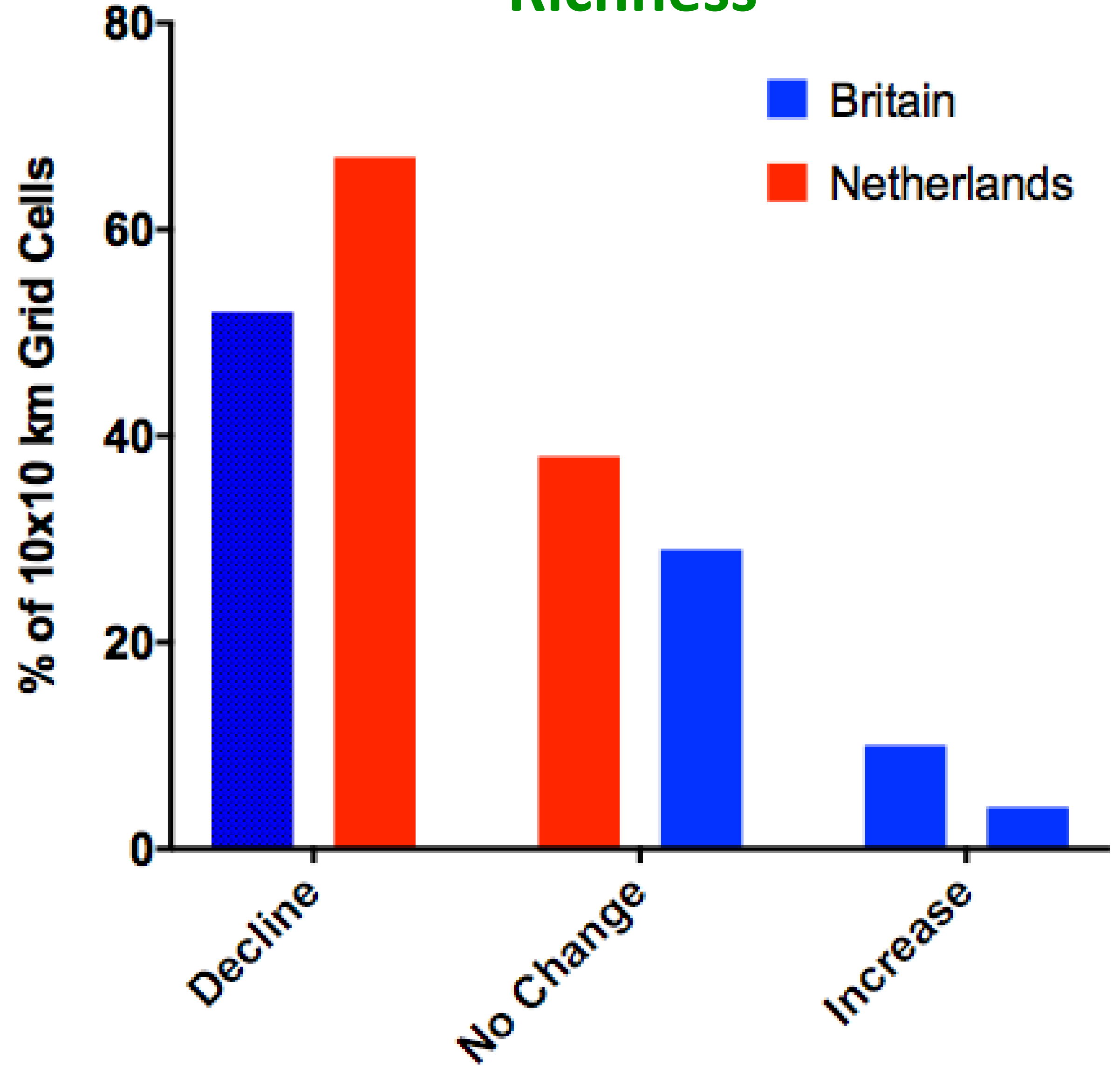
“Now clean cultivation and the chemical destruction of hedgerows and weeds are eliminating the last sanctuaries of these pollinating insects and breaking the threads that bind life to life”.

Carson, R. (1962) *Silent Spring*

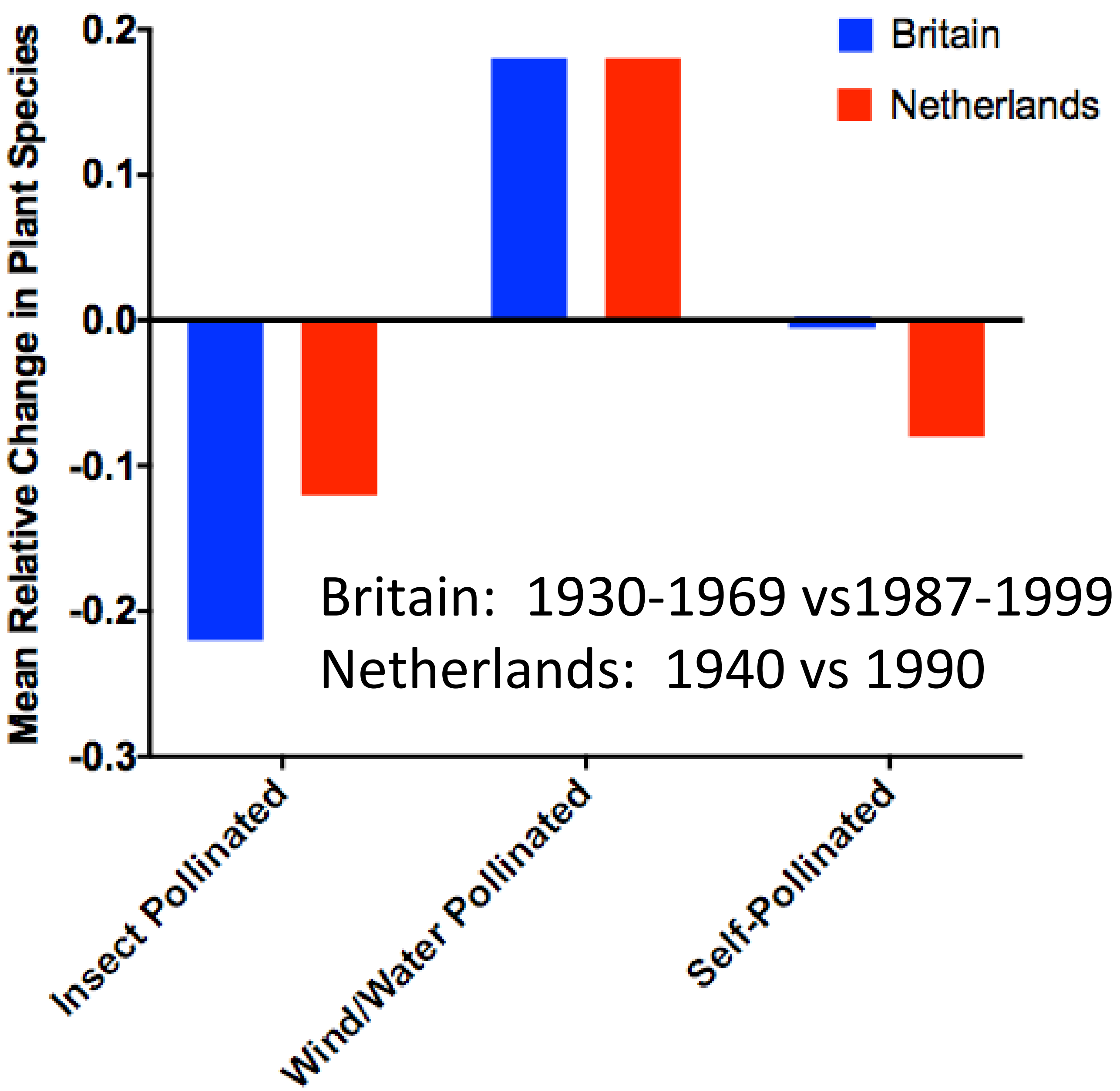
Trends in Bee Species Richness & Plant Species by Pollination Mechanism

Trends for Pre 1980 Sampling Periods vs Post 1980 Sampling Periods

Trends in Bee Species Richness

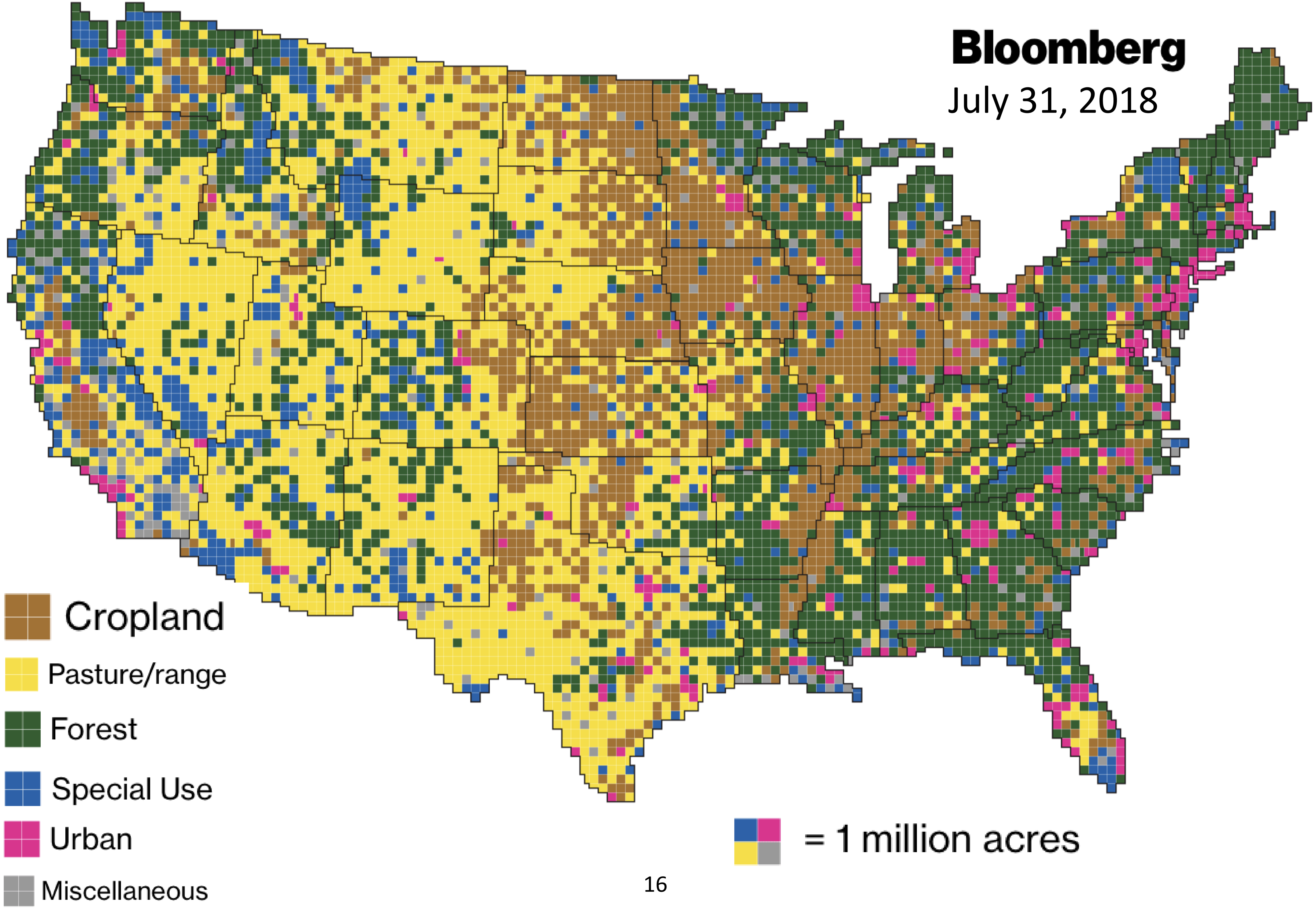


Trends in Plant Species by Pollination



Biesmeijer et al. (2006) Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands. Science 313:351

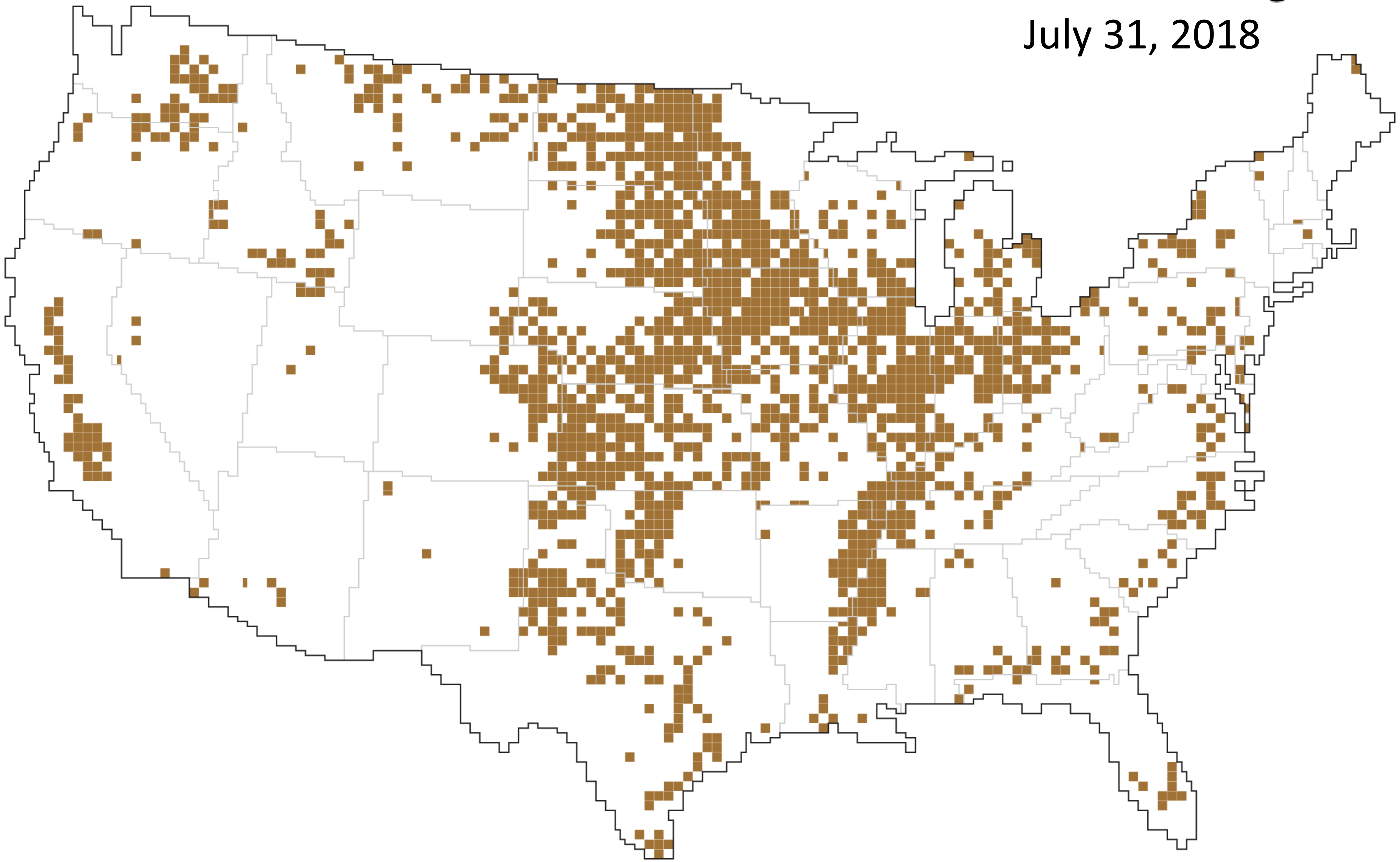
Distribution of Land Uses in the U.S. (2018)



Agricultural land takes up about a fifth of the country

Bloomberg

July 31, 2018



By & large we live on a peaceful planet, and nearly all organism are not only harmless, but beneficial to all life

Nearly All Organisms Are Beneficial & Play Important Roles in Stabilizing Our Ecosystems

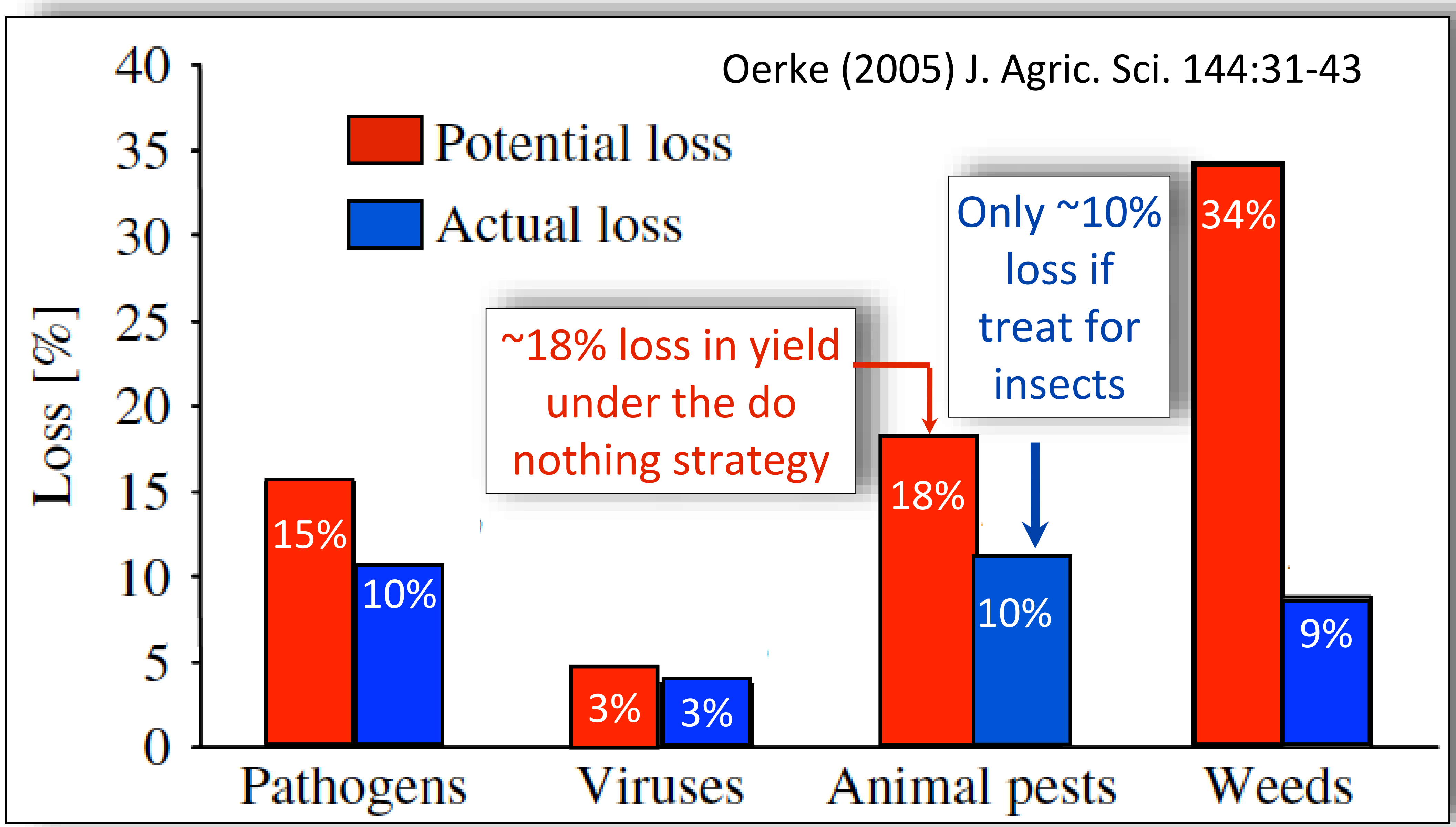
But...

Mother Nature Is Meaner Than You Think!!

Global Average Yield Losses from Pests Understood Through Estimations of Potential Losses and Actual Losses

- Average efficacy of pest control practices worldwide in reducing yield loss potential of pathogens, viruses, animals (mostly insects) and weeds is a surrogate for impact of pest damage on crop production

Reduction Rates Based on
barley
cottonseed maize
oilseed rape
potatoes
rice
soybean,
cotton
sugar beet
tomatoes
wheat



Value of Pesticide Use: A Strong Incentive to Use Them

- Transforming "saved" or "protected" yield to dollars, the ratio of costs to net returns for insecticide use in U.S. crop production has been estimated to be nearly 20:1

Value ($ Billions) of pesticides in US crop production

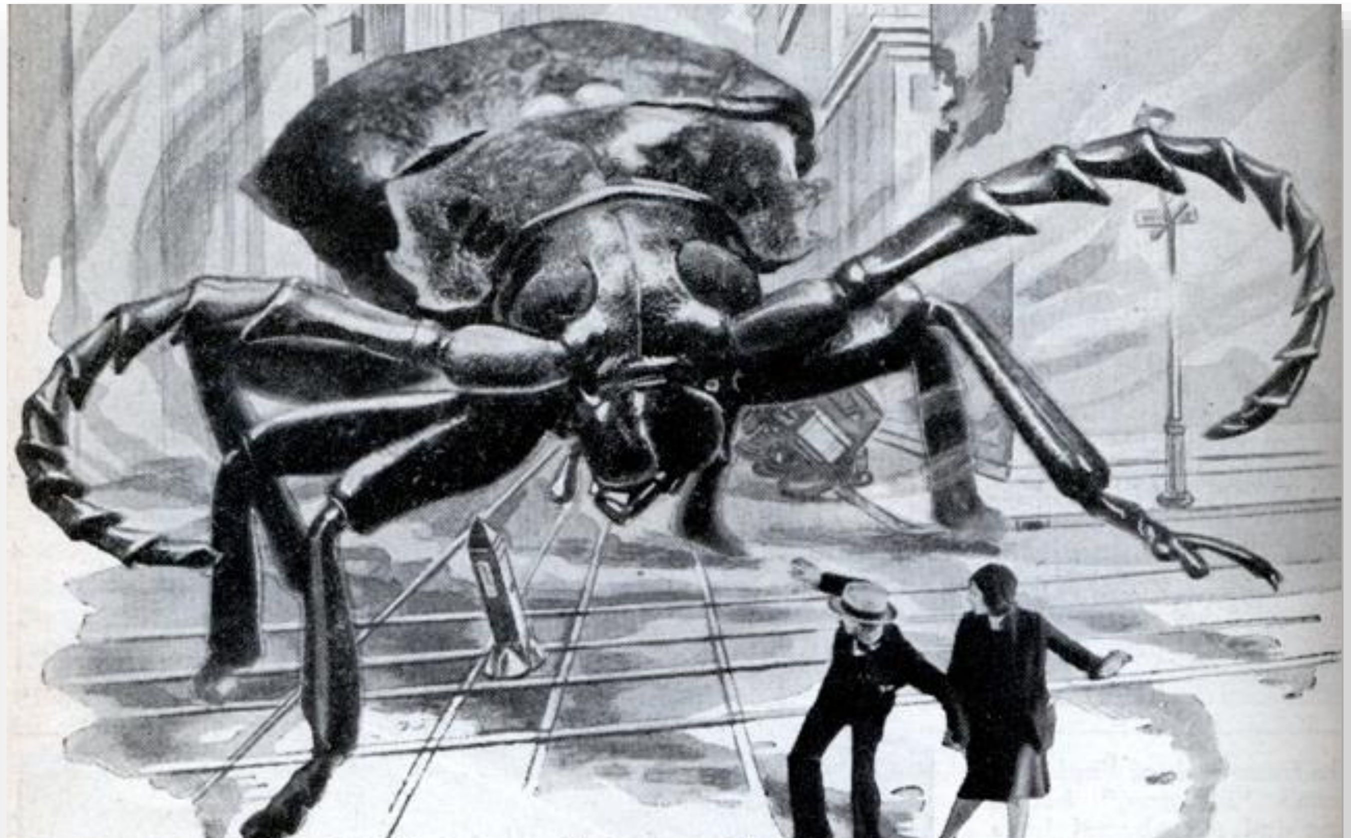
	Herbicides (2005)	**Insecticides (2008)**	Fungicides (2002)	Total All Pesticides (2002-2008)
Cost to growers	7.1	1.2	0.9	9.2
Non-use cost increase	9.7	--	--	9.7
Yield benefit	16.3	22.9	12.8	52
Net benefit	26	21.7	12	59.7
Return ratio: benefit/cost	3.7	18.1	13.3	6.5

Popp (2011) J. Verbr. Lebensm. 6:S105-S112

Why Do Organisms Become Pests?

- The nature of agricultural and human dominated ecosystems compared to natural ("wild") ecosystems
- Pest attributes
- Human attitudes

Exploring the factors contributing to pest status provide the clues for how to manage ecosystems compatibly with goals for sustaining environmental quality and health


Havoc that could be wrought by a monster longhorn beetle is graphically depicted in drawing.

Why Are Pests Pests?

- Humans with limited tolerance for damage
  - ✓ Implies that WE label insects (or other organisms) as pests; thus no real ecological relevance other than what we assign
- Invasive pest insects are often r-strategists (high fecundity, low survivorship) with multiple hosts
- Changes in conditions that enhance population abundance
  - ✓ Physical conditions more favorable
  - ✓ More food sources
  - ✓ Change in biotic mortality factors
    - ❖ Diseases
    - ❖ Predators & parasitoids

Natural vs. Agroecosystems

- **Natural Ecosystems**
  - ✓ Diversity rich
    - ❖ Plants of same species often occur in patches surrounded by other species
  - ✓ Infrequent perturbations
  - ✓ Dominated by native species
  - ✓ Good natural control
  - ✓ Plant nutrients stored & recycled

- **Agroecosystems**

  - ✓ Diversity poor
    - ❖ Monolithic distribution of one species
    - ❖ No patches with opportunity for harboring natural enemies
    - ❖ No patches to offer alternative food sources
  - ✓ Frequent perturbations
  - ✓ Invaded by exotic species
  - ✓ Poor natural control
  - ✓ Plant nutrients depleted

Agroecosystems as Islands Capable of Colonization

- Annual cropping is similar to creating a new island every year, wherein opportunist species with capability of rapid reproduction can invade and establish quickly

- They are successful because of limited plant diversity, a very abundant food resource, susceptible stages of plant growth, and a lag in colonization by biotic mortality factors (predators & parasitoids)

  ✓ Predators & parasitoids are not likely to be early colonizers because of a lack of food sources

Noted Problems with Pest Control's Over-reliance on DDT Post WWII Led to Disillusionment with Chemical Control

- Pest arthropods resistance to insecticides
- Secondary outbreaks of arthropod pests other than those against which control was originally directed
- Rapid resurgence of treated pest species necessitating repetitious pesticide applications
- Pesticide residues on food and forage crops
- Hazards to pesticide handlers and to persons, livestock, and wildlife subjected to contamination by drift
- Legal complications from suits and other actions pertaining to the above problems

Stern et al. (1959) Hilgardia

Why Did Problems in Pest Control Arise during the 1950's?

According to Stern et al. (1959)

- Limited knowledge of biological science
  - ✓ Population ecology; community ecology
- Narrow approach to insect control
  - ✓ DDT seen as "silver bullet"; rapidly adopted to exclusion of other tactics

- Few studies on effects of chemicals on other components of ecosystem besides pests
- Pressure to solve problems NOW
- Some skeptical that biotic factors are of any consequence in the control of pest populations

The Solution: Integration of Biological & Chemical Control

- **Biological control:** "The action of parasites, predators, or pathogens on a host or prey population which produces a lower average density than would prevail in the absence of these agents"
    - ✓ A.K.A. natural control mechanism in natural populations
    - ✓ May or may not be sufficient to lower pest population to economic insignificance
- **Chemical control:** Use of chemicals (synthetic or botanical) to reduce pest populations that rise to damaging levels
    - ✓ However, properties must be compatible with conservation of natural enemies

The Solution: Integration of Biological & Chemical Control

- "Biological control and chemical control are not necessarily alternative methods;"
  - ✓ "in many cases they may be complementary, and with adequate understanding, can be made to augment one another."

- "One reason for the apparent incompatibility of biological and chemical control is our failure to recognize that the control of arthropod populations is a complex ecological problem."
  - ✓ "This leads to the error of imposing insecticides on the ecosystem, rather than fitting them into it."

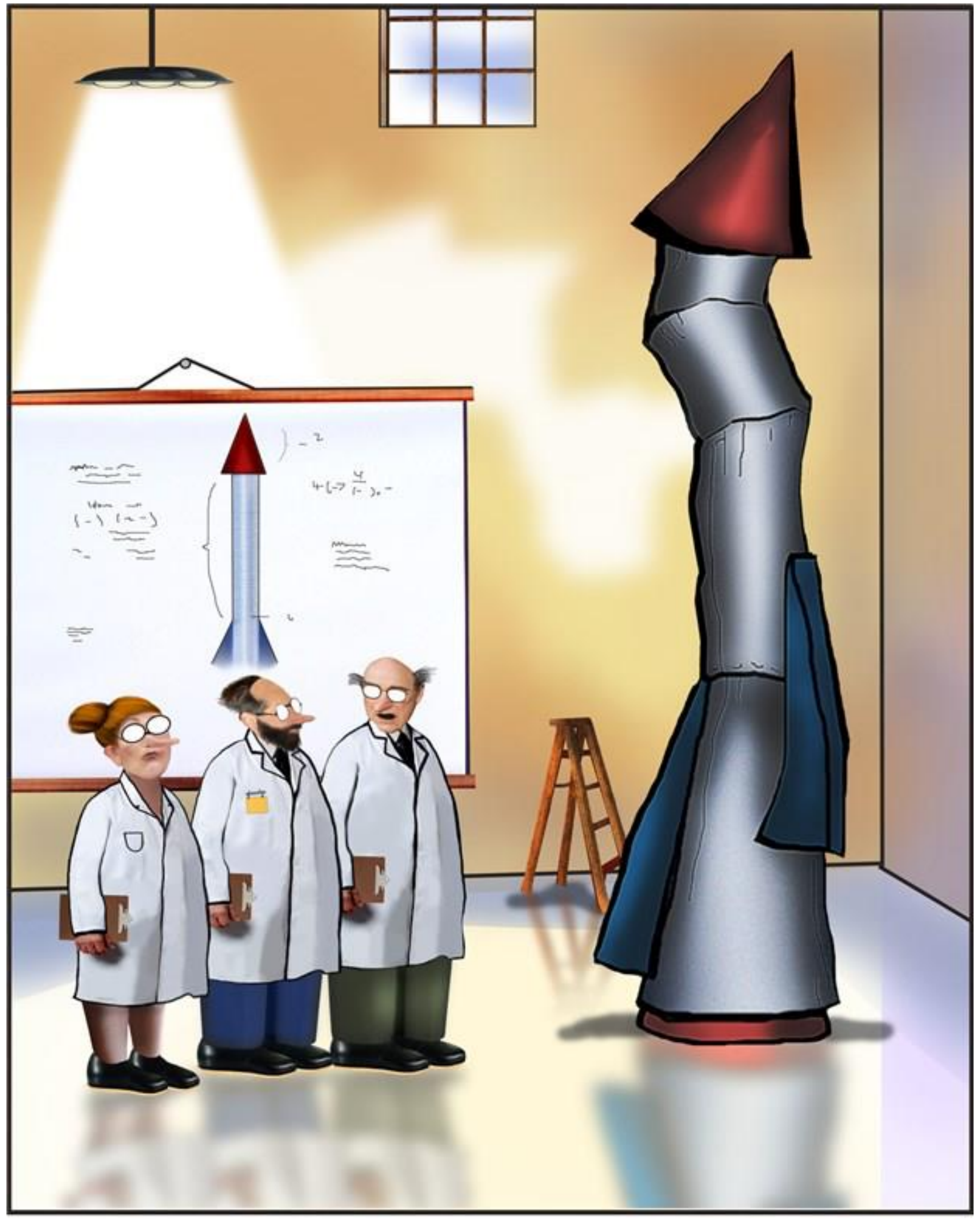
Stern et al. 1959

Integrated Control Concept

- Applied pest control which combines and integrates biological and chemical control
  - ✓ Recognition that a crop is an agroecosystem subject to ecological principles
  - ✓ Chemical control is used as necessary and in a manner which is least disruptive to biological control
  - ✓ Integrated control may make use of naturally occurring biological control as well as biological control effected by manipulated or introduced biotic agents

It Ain't Rocket Science

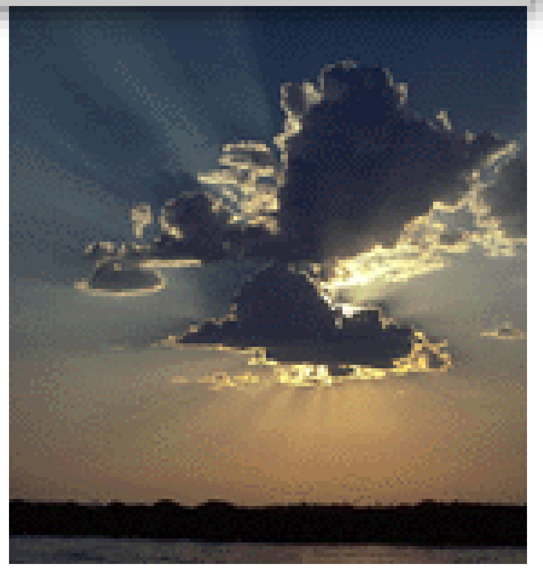
- Whatever you call your agronomic practice, crop protection is durable if you practice IPM
- IPM is not...
  - ✓ A method for reducing pesticide use (although such reduction is more likely than not)
  - ✓ A semantic argument to justify more research money (although that has worked well with funding agencies, esp. if you claim pesticide use will be reduced)
  - ✓ An acronym for integrated pesticide management (although that is more true than not, esp. with weed control)
  - ✓ Not a specific practice



"It's time we face reality, my friends… we're not exactly rocket scientists."

Silver Lining

System 'Out of Control'



Integrate biocontrol with chemical; chemicals with compatible properties (e.g., selectivity; low persistence)

Integrated Control Concept

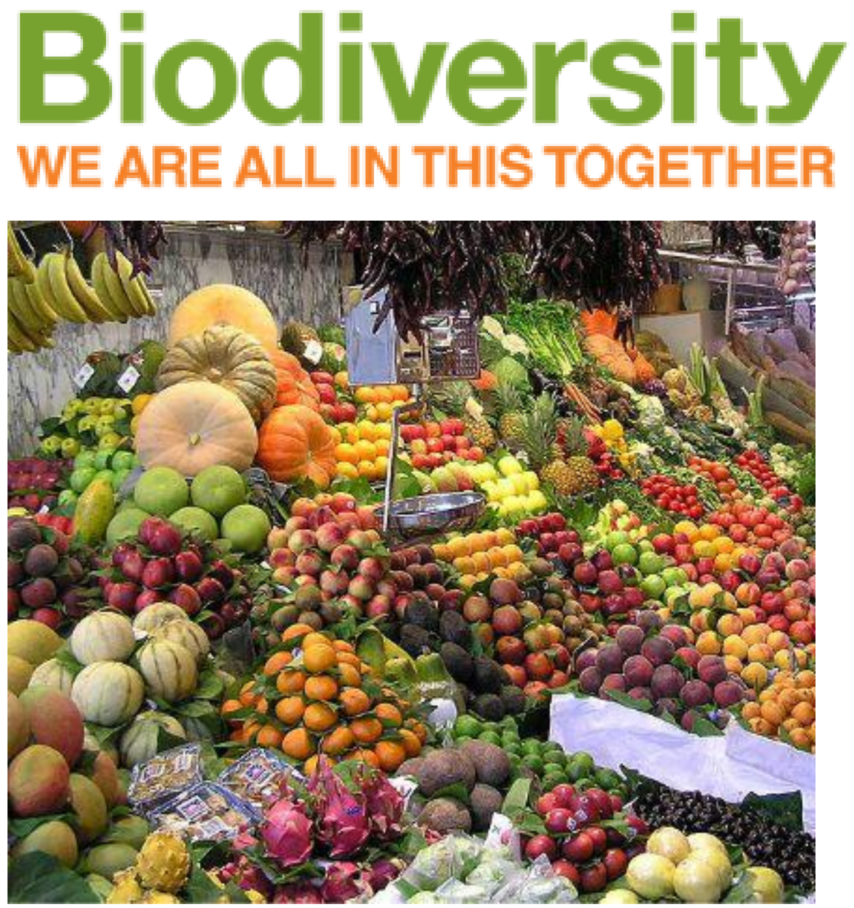
Integrate multiple suppressive tactics; e.g., host plant resistance; pheromones; cultural practices

Integrated Pest Management

What Should IPM Be?

- **A decision support system** to achieve the following objectives...
  - ✓ Maintain profitability, or economic soundness, when managing pests
    - ❖ i.e, pest management actions should be economically justified
  - ✓ Minimize selection pressure on pest populations from management tactics
    - ❖ i.e., manage to avoid development of pest resistance
    - ❖ i.e., avoid killing biocontrol organisms
  - ✓ Maintain environmental quality
    - ❖ i.e., minimize the impact of management tactics on the environment

Based on ideas of Funderburk & Higley (1994)

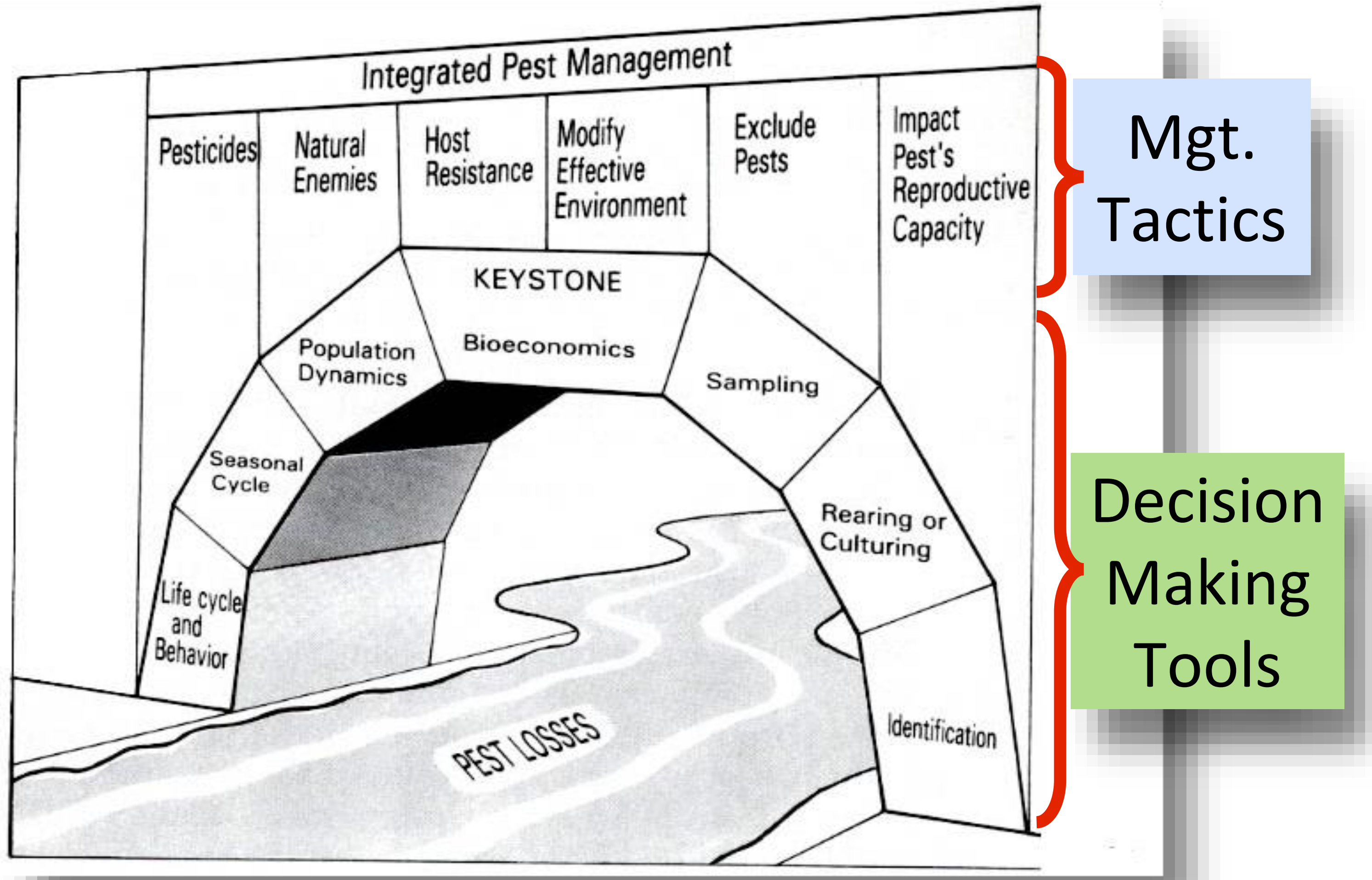


IPM is "A decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analysis that take into account the interests of and impacts on producers, society, and the environment."

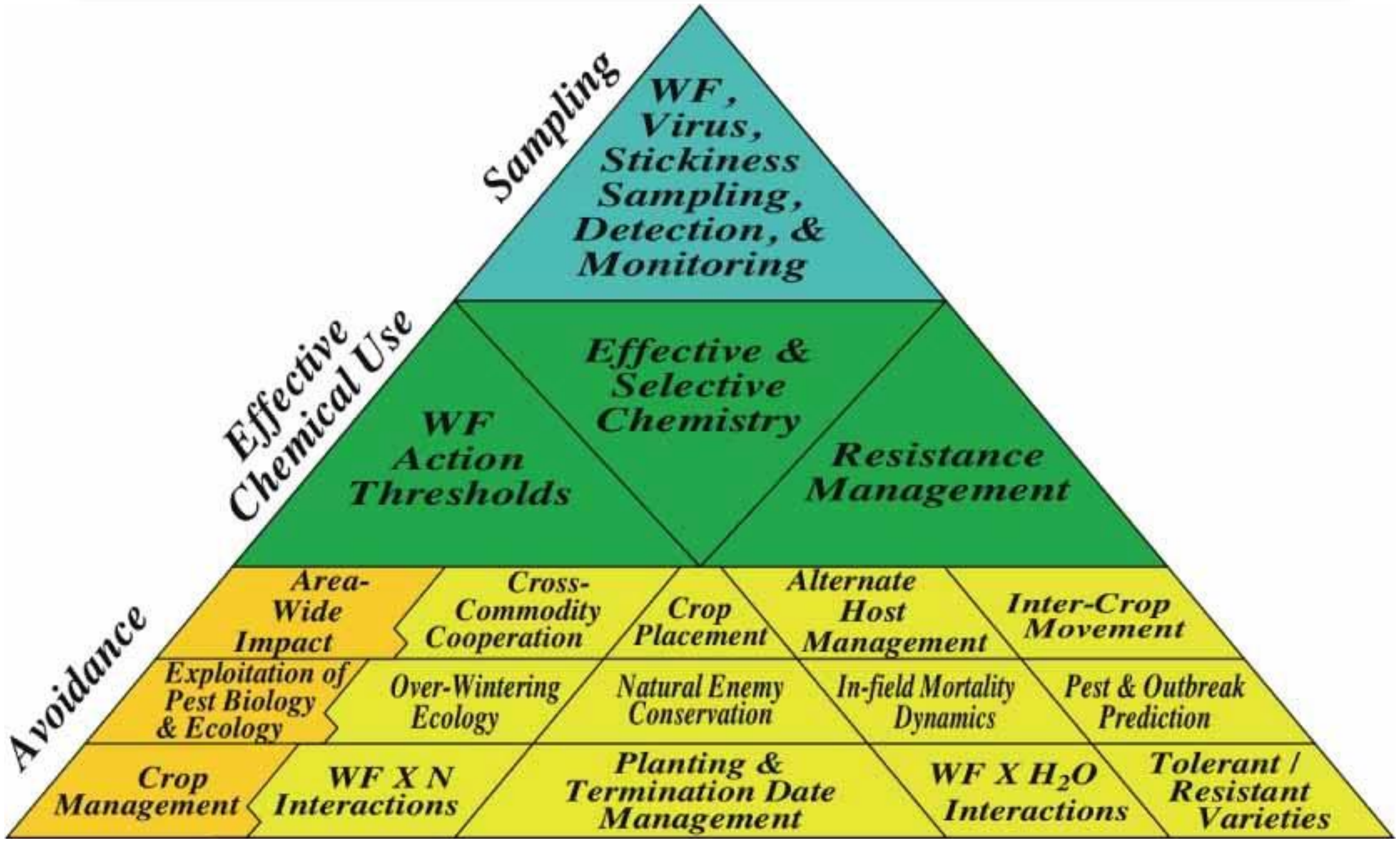
(Kogan 1998)

Principles of IPM

- **Bionomics**
  - ✓ Correct ID is the key that opens up our knowledge of the pests biology, especially population ecology
- **Bioeconomics**
  - ✓ Development of economic injury levels relies on integration of population dynamics with markets
- **Pest and crop population monitoring and surveillance**
- **Deployment of compatible and complementary practices**
  - ✓ Prevention (first line of defense)
  - ✓ Therapeutics (last resort as necessary)



An Alternative Perspective in More Detail: Focus on Tactics



Conceptual diagram of IPM showing the main interacting management tactics arranged in an inherently stable pyramid where elements build upon one another resulting in a sustainable management strategy

Naranjo & Ellsworth (2009) Pest Management Science 65: 1267–1286

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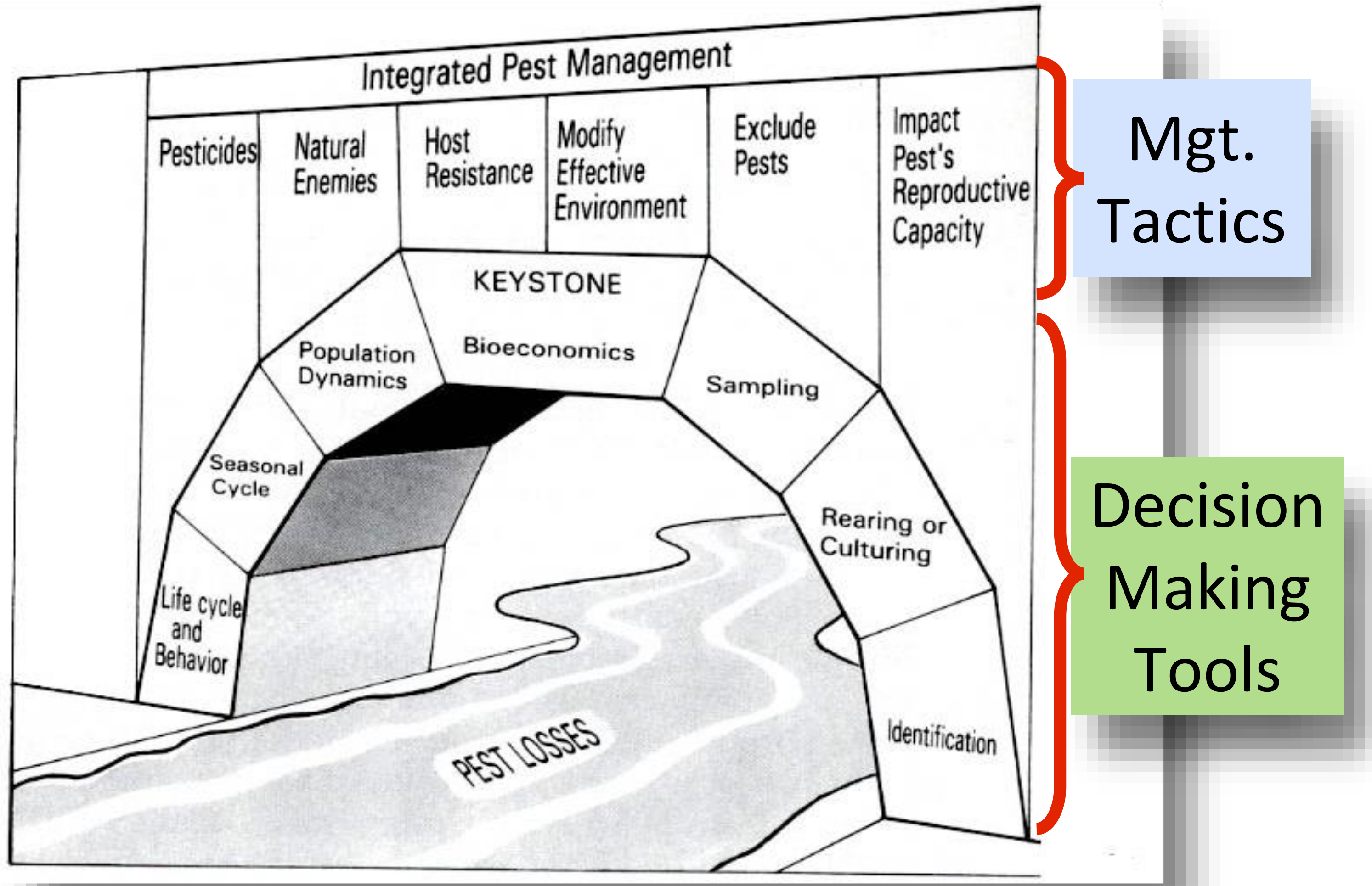


Insect Surveillance Can Be A Sticky Mess

Wing type pheromone trap with sticky surface on card

Trapped insects are stuck to adhesive, and don't appear as easily identifiable as freshly killed and mounted specimens

Consequences of Misidentification

- *Heliothis phloxiphaga* is not an economic pest of corn
- Misidentification of trapped moths as *Helicopvera zea* leads to wasted pesticide treatment

Males

Females

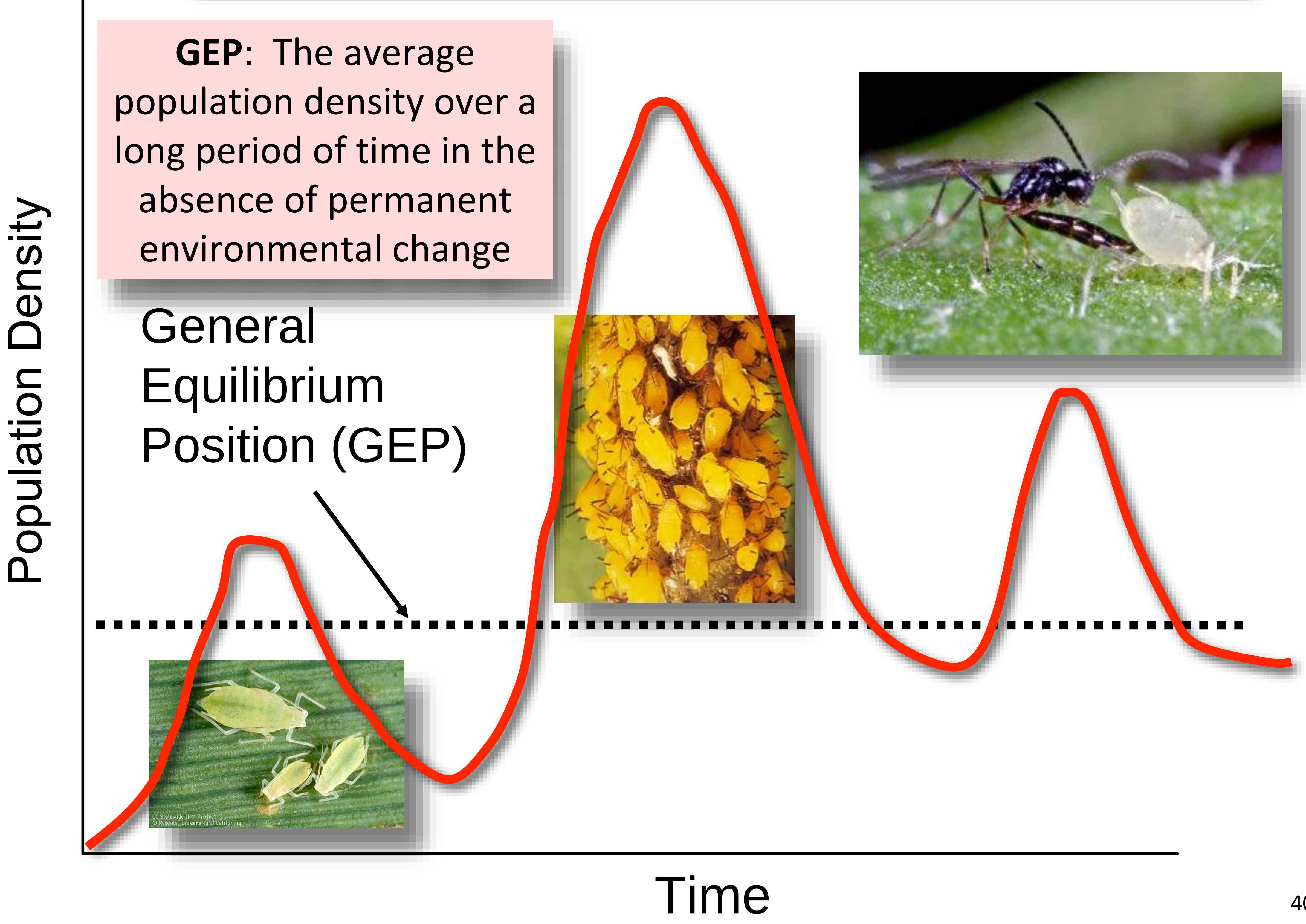
Bionomics

"The branch of biology concerned with the relations between organisms & their environment"

- Pest identification
- Life history characterization (natural history)
- Population ecology
  - ✓ Life systems approach
    - ❖ All extrinsic and intrinsic factors (within ecosystem) that determine the existence, abundance, and evolution of a population. Includes these components:
      - ➢ Properties of a pest population and its individual members (i.e., population attributes)
      - ➢ Resources available to the population
      - ➢ Inimical agents (abiotic & biotic mortality factors)
      - ➢ The abiotic environment (habitat, weather)

Population Dynamics: Insect Populations Fluctuate in Response to Biotic & Environmental Factors

GEP: The average population density over a long period of time in the absence of permanent environmental change



At What Population Density Do You Make a Decision to Take Action to Protect the Crop?

- Study of economic decision levels = **bioeconomics**
- Two economic decision levels relevant to integrated pest management
  - ✓ Economic Injury Levels
  - ✓ Economic Thresholds
- Economic decision levels are typically expressed as the number of insect per area, plant or animal unit or sampling procedure
  - ✓ Alternatively, economic decision levels are expressed as the degree of plant damage or as combinations of numbers and damage

- Economic Injury Level (EIL)

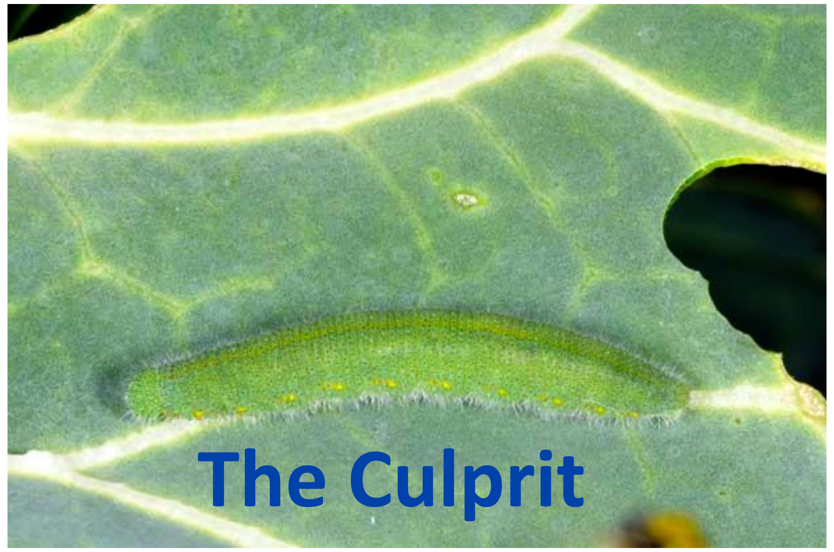
  ✓ The lowest population density that will cause economic damage

  ❖ Economic damage is the amount of injury that will justify the cost of a control measure

  ✓ Distinguish between damage and injury

  ❖ Injury is the deleterious effect of pest activities on host physiology (pest centric)

  ❖ Damage is a measurable loss of host utility, most often including losses of yield quantity, quality, or aesthetics (crop response centric)



Derivation of EIL

- C = V x I x P x D
  - ✓ C = Cost of management per area ($/acre);
  - ✓ V = Market value per unit of production ($/unit);
  - ✓ I = Injury units per insect per production unit (% defoliation/insect/acre);
  - ✓ P = Density or intensity of insect population (insects/acre)
  - ✓ D = Damage per unit injury (unit production lost/acre/% defoliation)

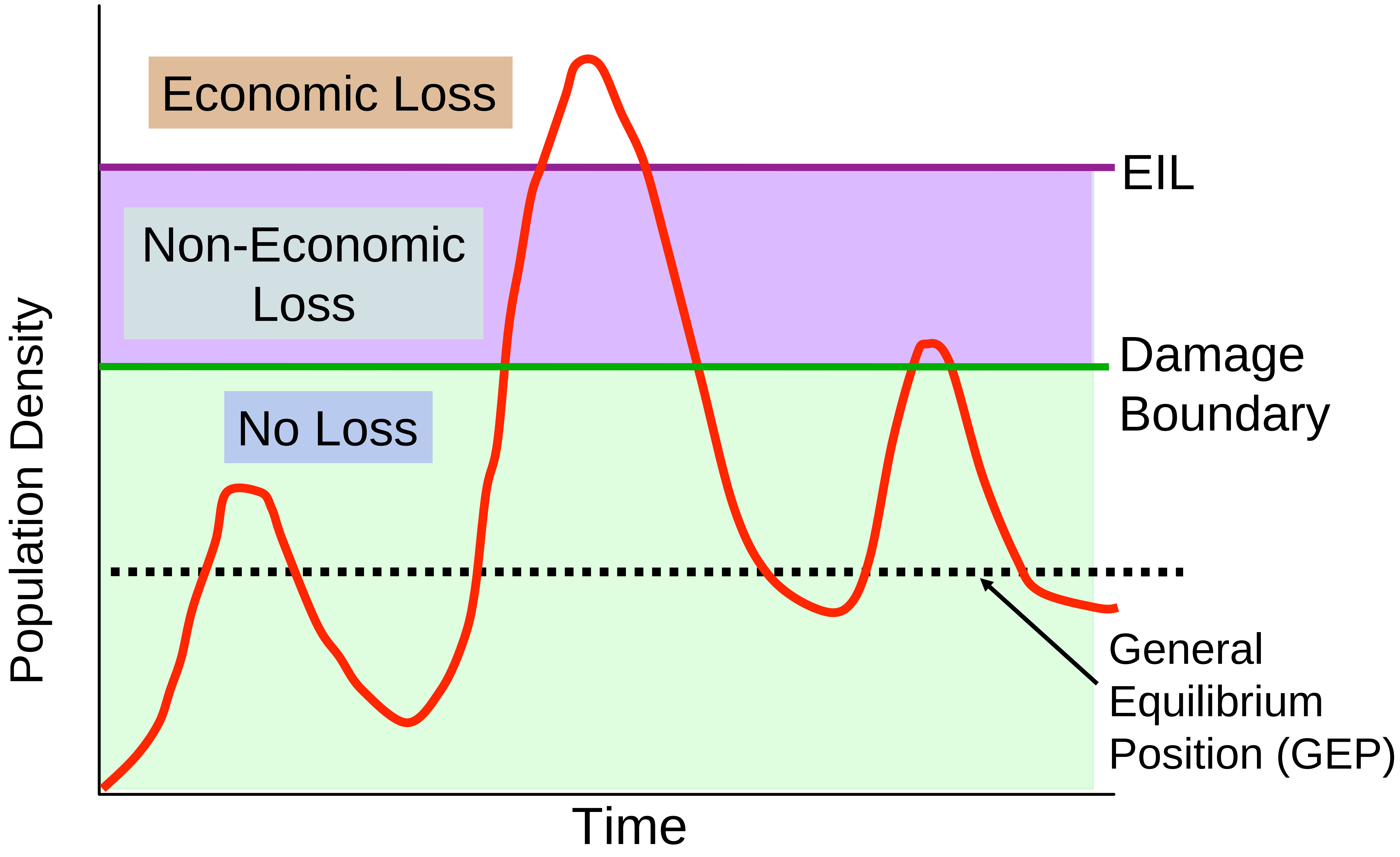
- Rearranging the equation yields

$$P = \frac{C}{V \times I \times D} = EIL$$

- ✓ Note that I x D = 'Yield Lost per Pest'
  - ❖ (% defoliation/insect/acre) x
  - ❖ (unit production lost/acre/% defoliation)
  - ❖ = unit production lost/insect

Caveat: You need lots of data for these calculations, and pertinently, the result is idiosyncratic to local conditions and dynamic

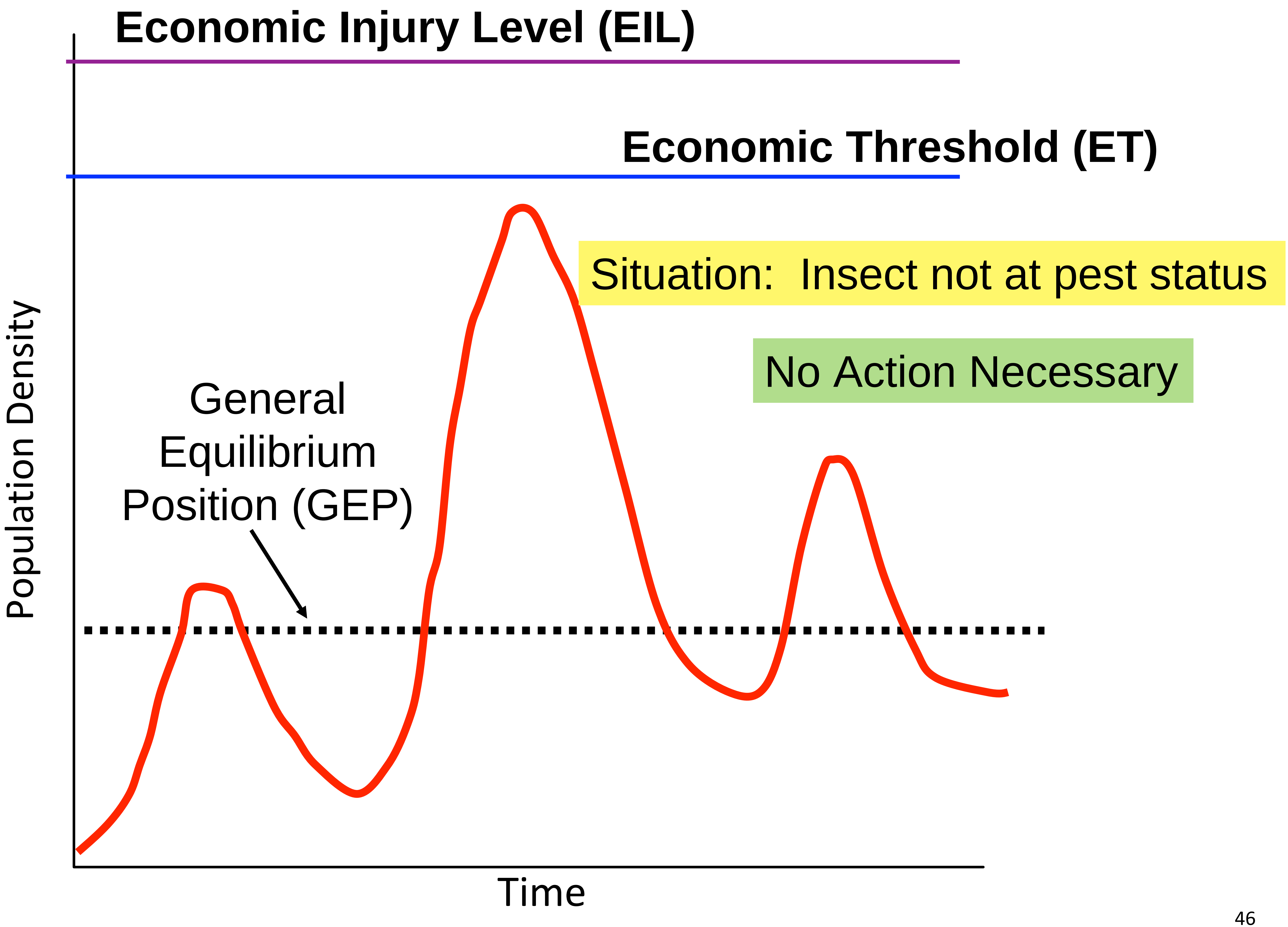
Relationship Between EIL & Damage Boundary



Economic Threshold (ET) = Action Level

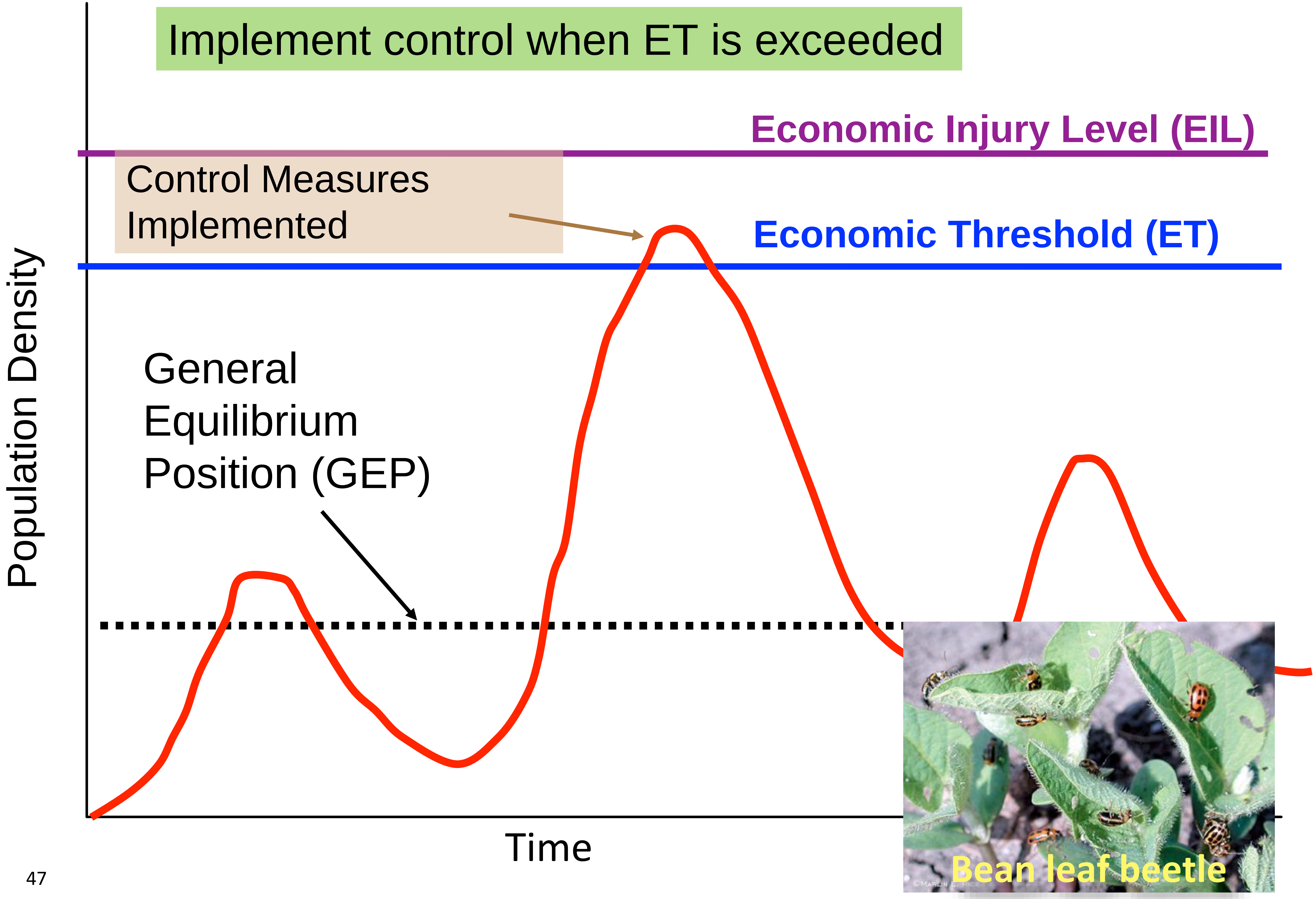
- The pest density at which control measures should be implemented to prevent an increasing pest population from reaching the economic injury level
  - ✓ Typically lower than the EIL (for example, can be set at a fixed percentage of the EIL)
  - ✓ Permits sufficient time for the initiation of control measures
  - ✓ Permits time for control measures to take effect before population reaches the EIL
- Function of crop economics + potential for injury + population dynamics
  - ✓ Population dynamics allows consideration of potential rate of population increase

ET Reduces Risk of Surpassing EIL


Economic Injury Level (EIL)
Economic Threshold (ET)
Situation: Insect not at pest status
No Action Necessary
General Equilibrium Position (GEP)
Population Density
Time

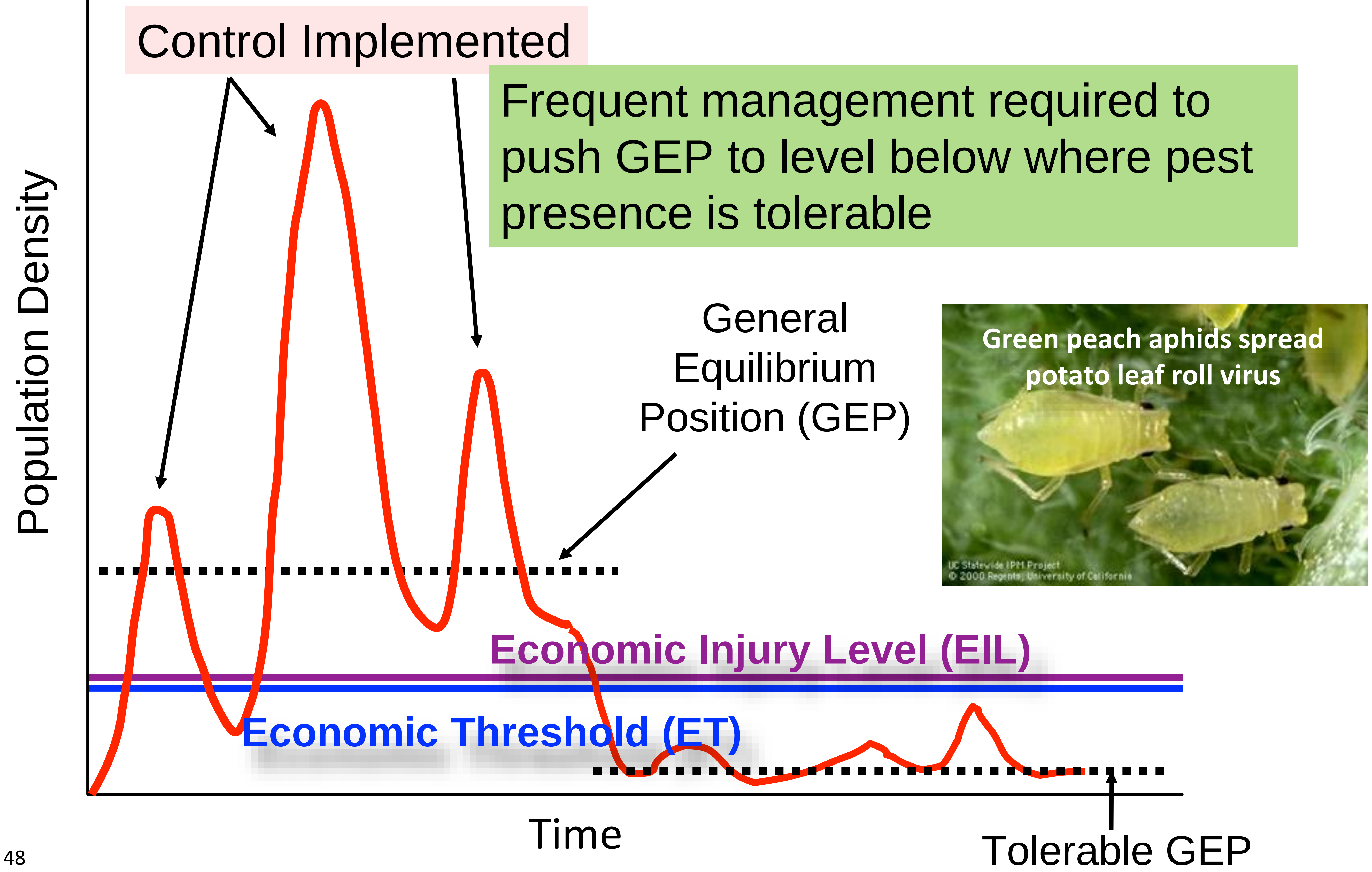
Situation: Insect occasionally at pest status

Implement control when ET is exceeded



Situation: Insect Frequently at Pest Status (e.g., insect vector of disease; annoyance)

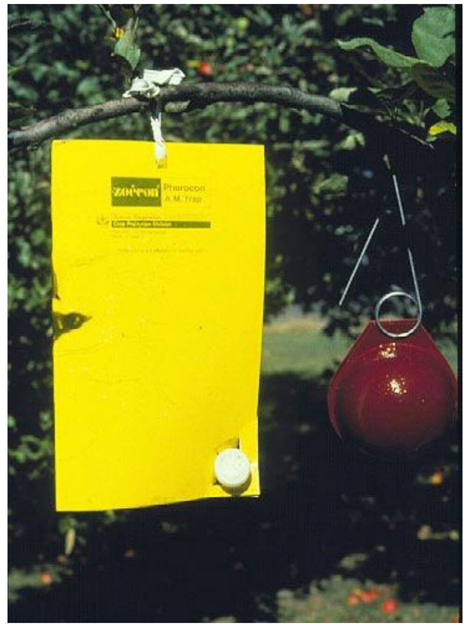
Frequent management required to push GEP to level below where pest presence is tolerable



Pest Surveillance

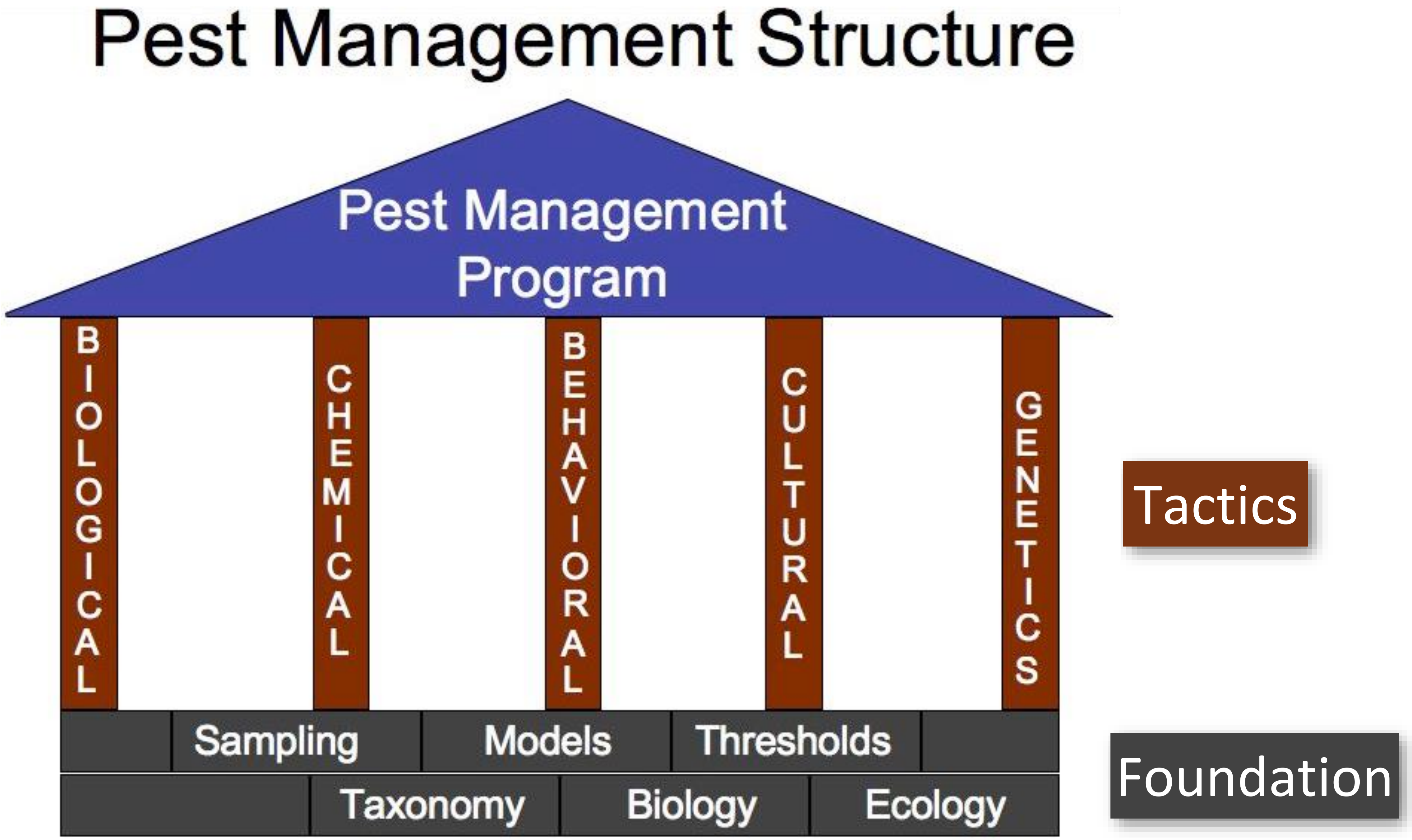
Monitoring a pest population for purposes of decision making

- Objectives
  - ✓ Detection of species presence
    - ❖ Necessity for correct identification of pest
  - ✓ Determination of population density
  - ✓ Determination of population dispersion
  - ✓ Determination of population dynamics



Population Management

Introduction to Tactics



Goals for Managing Pests

- Reduce pest status
- Conserve environmental quality
- Accept tolerable pest densities
- Improve net profits from production

All the principles of IPM theory and the various population management techniques work toward these goals

Strategies for Dealing With Insect Pests

- Do nothing
- Reduce pest numbers, i.e., lower pest density
- Reduce susceptibility of the host, i.e., raise economic damage boundary
- Use combinations of the latter two

Guiding Principles: Integrate Multiple Complementary & Compatible Population Management Tactics

- Think before acting:
  - ✓ How will the tactics be used?
  - ✓ What is the logical basis for selecting the tactics?
- Two categories of tactics
  - ✓ Preventive practices (first line of offense)
  - ✓ Therapeutic practices (when necessary)

Integrating Techniques Will Sustain the Management Program

- Because pest populations can adjust to a single tactic, limited technique programs are unlikely to be durable over the long term (although short term success in controlling the insect pest may occur)

- Pests have great difficulty adapting to the mortality and/or adverse reproductive effects induced by deploying multiple tactics

- Pesticides still form the core tactic for numerous IPM programs but shifting to the use of more tactics (i.e., integrating them together) should help reduce the amount of pesticide needed to achieve acceptable control

  ✓ Thus, less pesticide use will help achieve the goal of conserving environmental quality

Compatible Tactics for Prevention

Lowering Pest Density

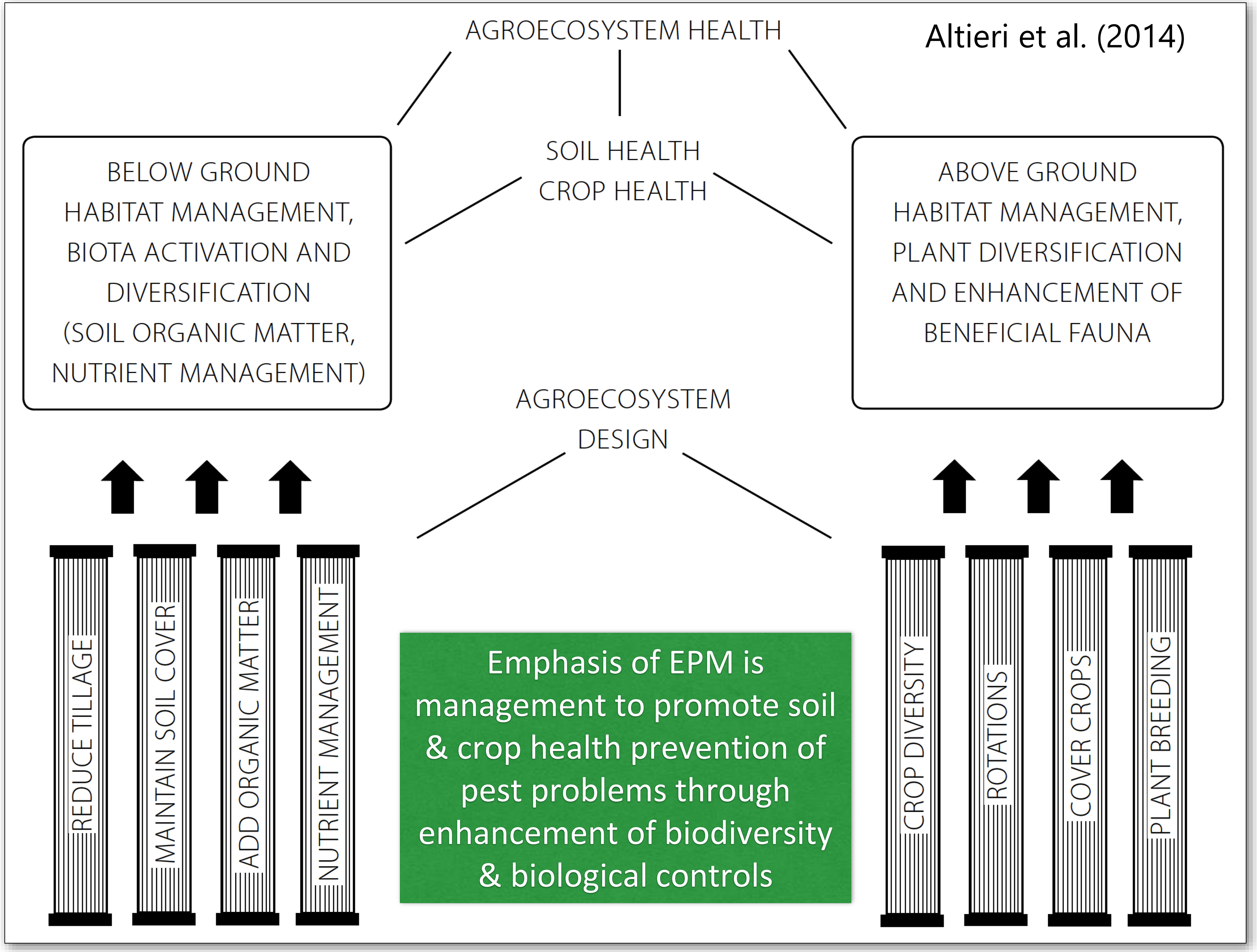
- Biological control
- Crop rotation
- Sanitation & tillage
- Altered planting dates
- Trap cropping
- Plant spatial arrangement
- Mating disruption
- Plant insect resistant cultivars

Raising Economic Damage Boundary

- Plant insect resistant cultivars
- Change agronomic practices to grow more vigorous plants
- Change planting dates to avoid peak pest population density
- Use barriers to prevent pest access to plant

Note that pesticides will achieve the same result but "older" compounds are often not compatible with other practices when building a durable, long term management program. Therefore, pesticides are best used as the practice of last resort.

Pillars of Ecological Pest Management

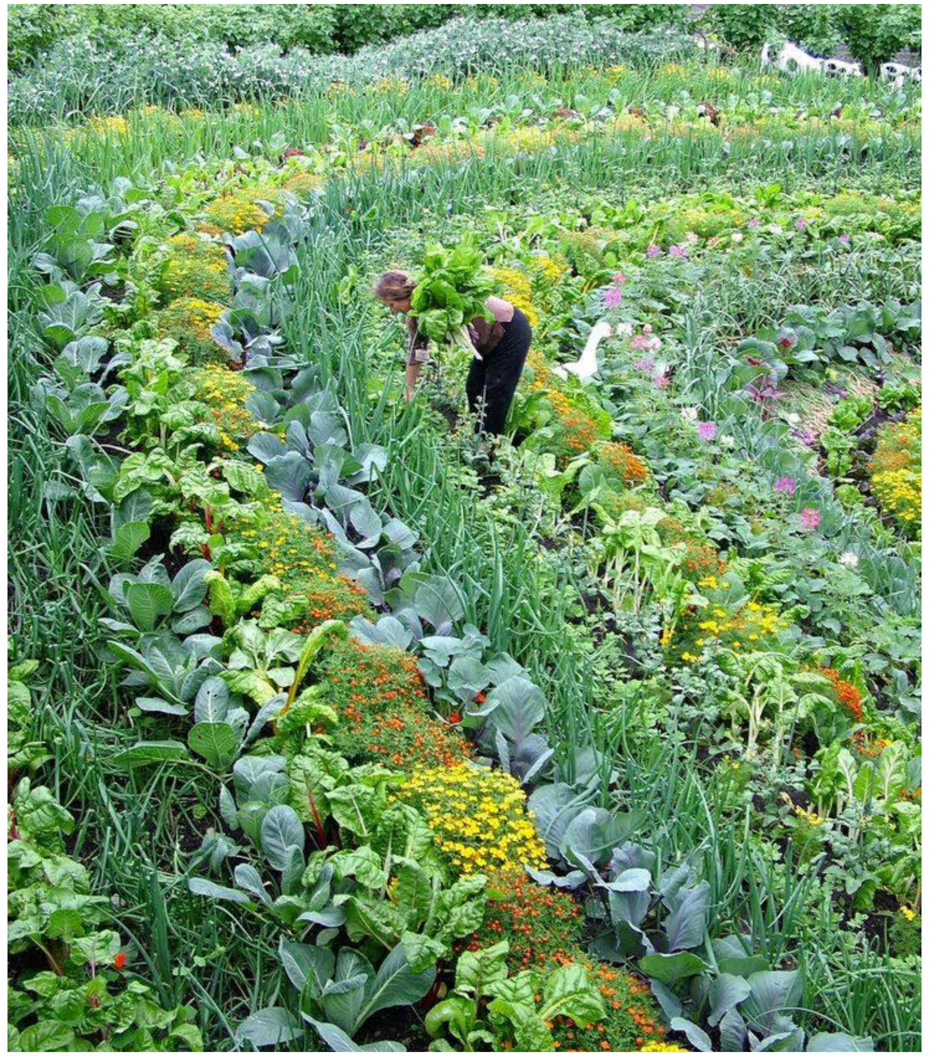


Preventive Tactics--
First Line of Defense

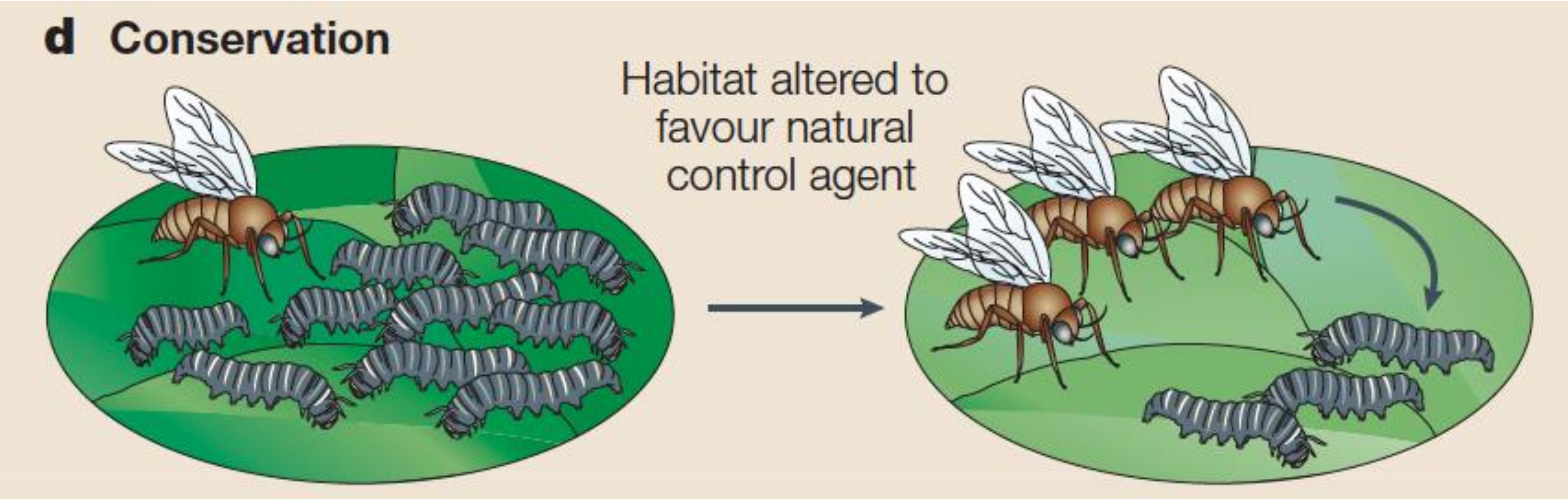
- "An ounce of prevention is worth a pound of cure"
- Taking action before insect injury occurs
  - ✓ Do not know if insect will become damaging (only that it has the potential if population is not managed)
- Can focus on the pest
  - ✓ Objective is to lower the average level of population fluctuations (i.e. lower the general equilibrium position, GEP)
- Can focus on plant
  - ✓ Objective is to raise the threshold of economic damage

Cultural and Biological Control

- Cultural management is effective for raising the economic damage boundary
- Cultural management (e.g., avoiding monocultures, plant diversity, proper fertilization and irrigation, sanitation, etc.) enhances biological control
- Biological control is effective in lowering the pest density
  - ✓ Augmentation of biological control depends on proper cultural management with respect to providing plant diversity, refuges, and nutritional resources for natural enemies (predators and parasitoids)
- Cultural management will contribute to pollinator conservation and reduce the need for insecticides, especially when semi native habitat is increased at the landscape scale
  - ✓ Thus, both in field diversity and regional diversity are essential to pest management



Conservation within Habitats: Not a Passive Process

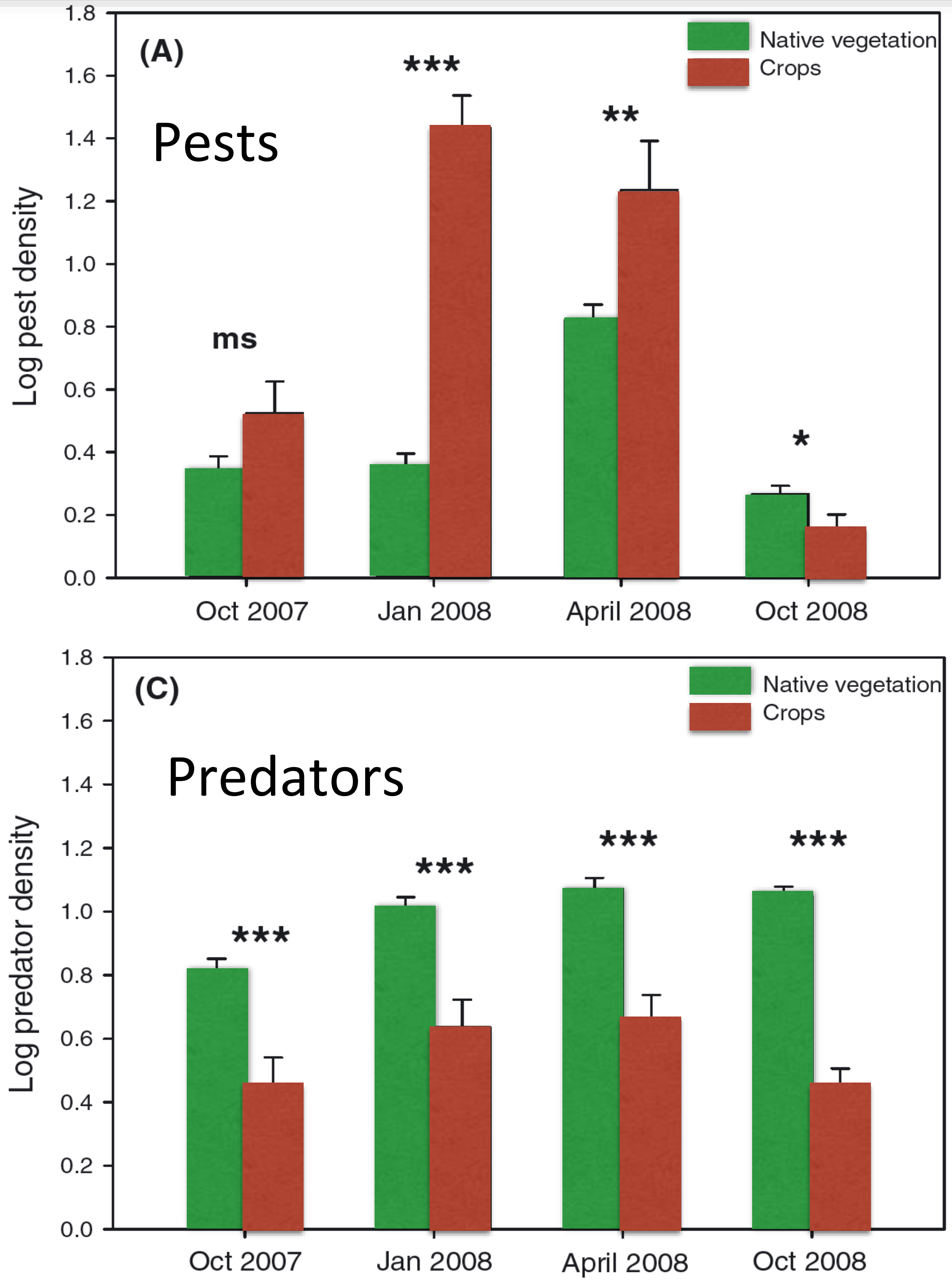


Pests Insects More Abundant on Crops than on Native Plants

- Arthropod assemblages on six crops and on seven abundant native plant species in two landscapes were studied over one yr in Australia

- Native plants had higher predator densities than crops, where as crops support higher pest densities

- Reproduction of pests seemed to be occurring in the crops disproportionately than in native plants



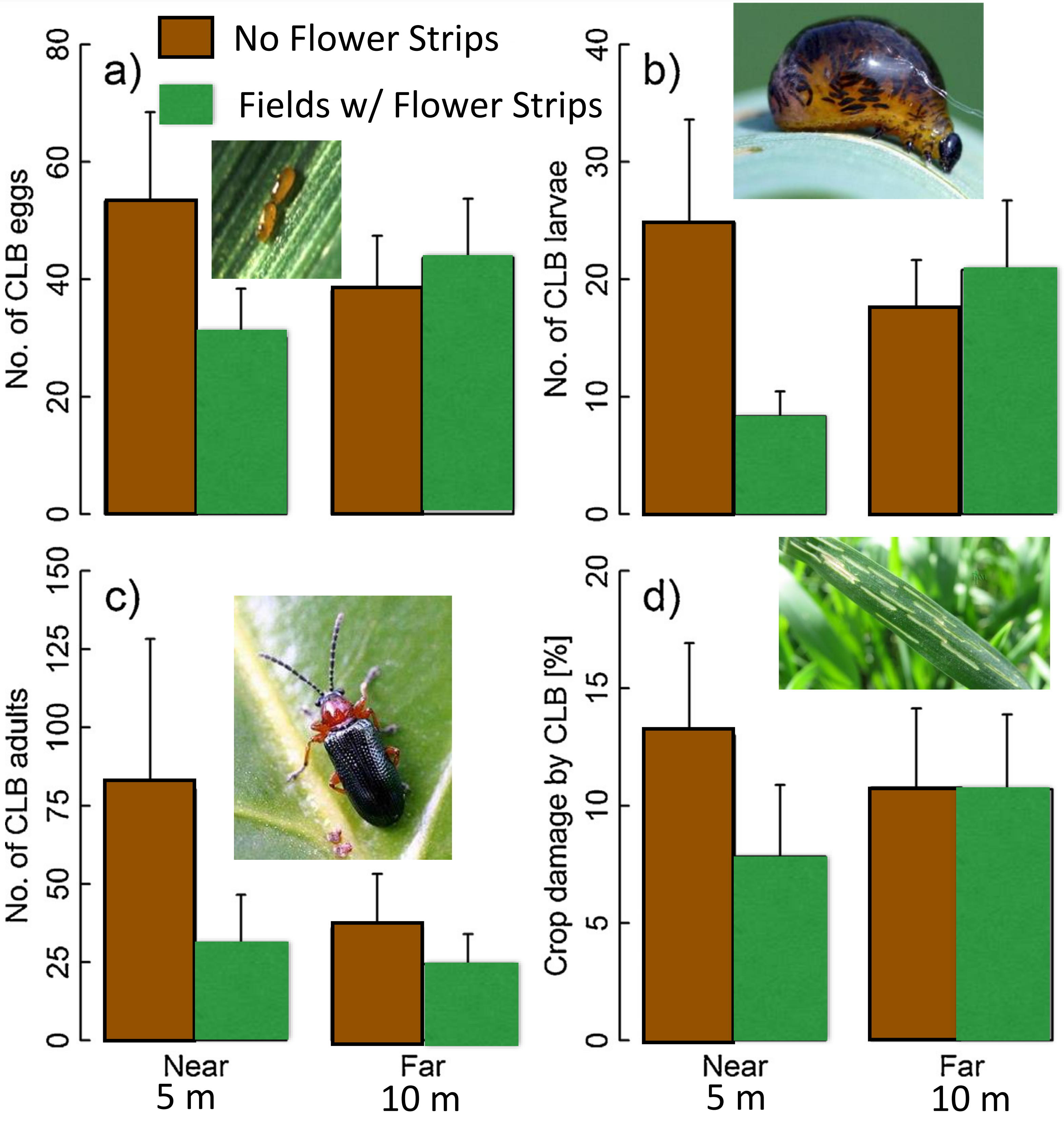
Bianchi et al. (2013) Habitat functionality for the ecosystem service of pest control…Agric Forest Entomol. 15:12-23

Wildflower Field Strips Enhance Pest Control & Crop Yield

- Sown, species-rich, perennial wildflower strips were studied for their effect on pest control services and yield of nearby winter wheat

- Strong reductions in cereal leaf beetle *Oulema* sp. (CLB) density (eggs: 44%, larvae: 66%) and crop damage (40%) in winter wheat besides wildflower strips compared with control fields without steps (N = 10)

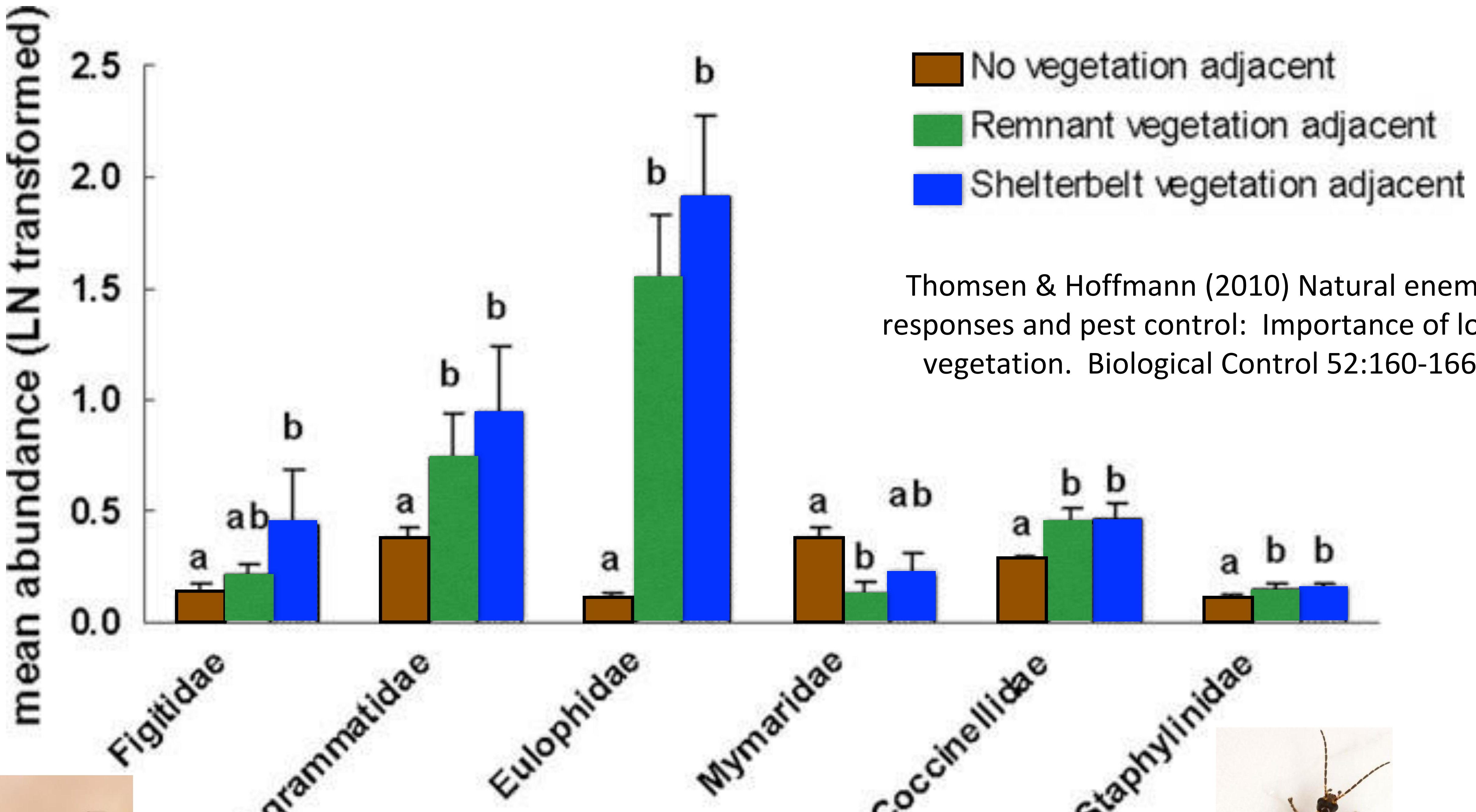
- Average crop yield was increased by 10% in winter wheat next to wildflower strips



Tschumi et al. (2016) Perennial, species-rich wildflower strips enhance pest control and crop yield. Agriculture, Ecosystems and Environment 220:97–103

Adjacent Vegetation Enhances Natural Enemy Populations

Natural enemies were sampled at 61 vineyards with and without vegetation on one margin of the vineyard to assess the influence of woody vegetation at the local scale. The potential impact of adjacent vegetation on light brown apple moth egg predation and parasitism was also examined.

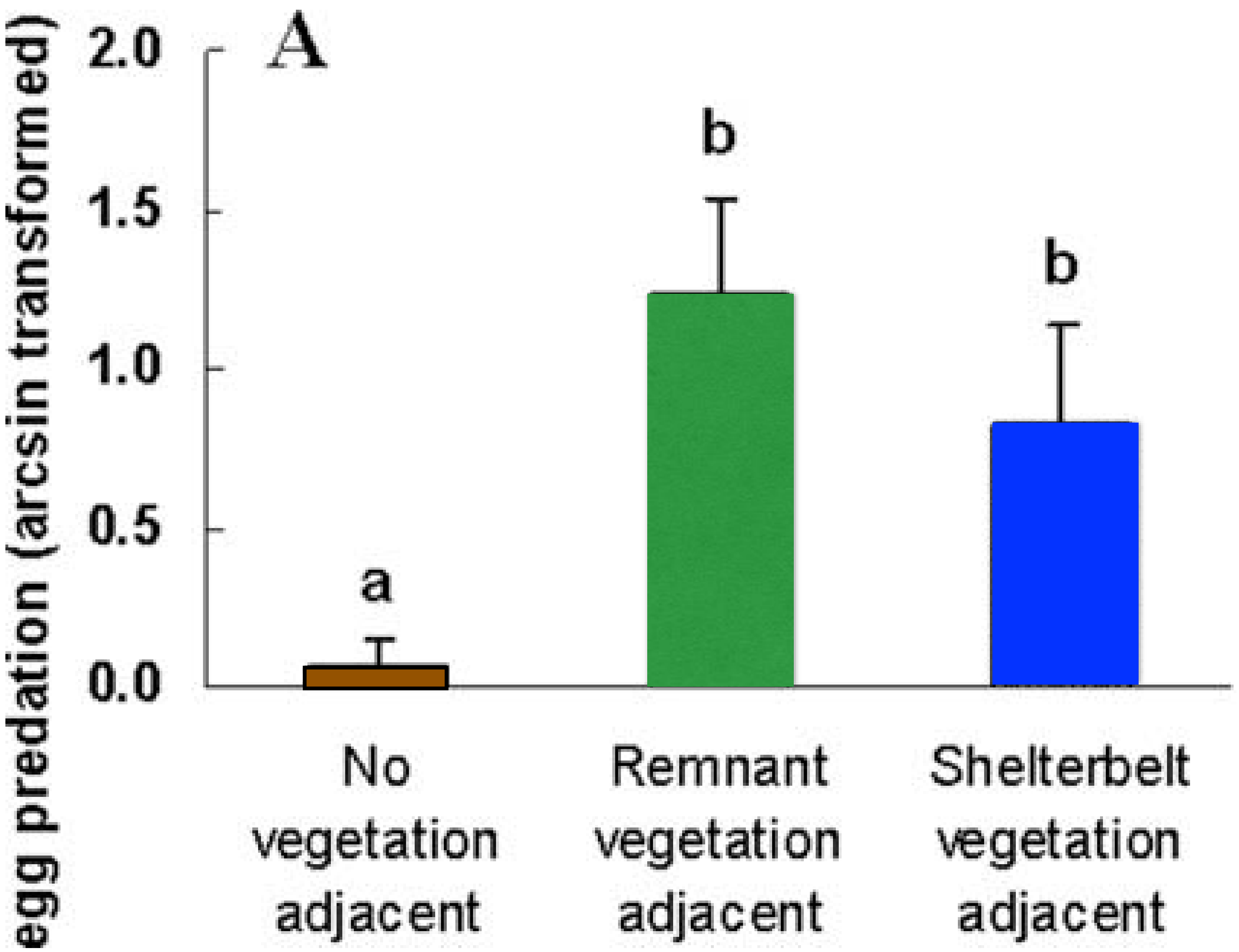


Thomsen & Hoffmann (2010) Natural enemy responses and pest control: Importance of local vegetation. Biological Control 52:160-166






Observed Light Brown Apple Moth Egg Predation Was Greatest When Vineyards were Adjacent to Native Vegetation

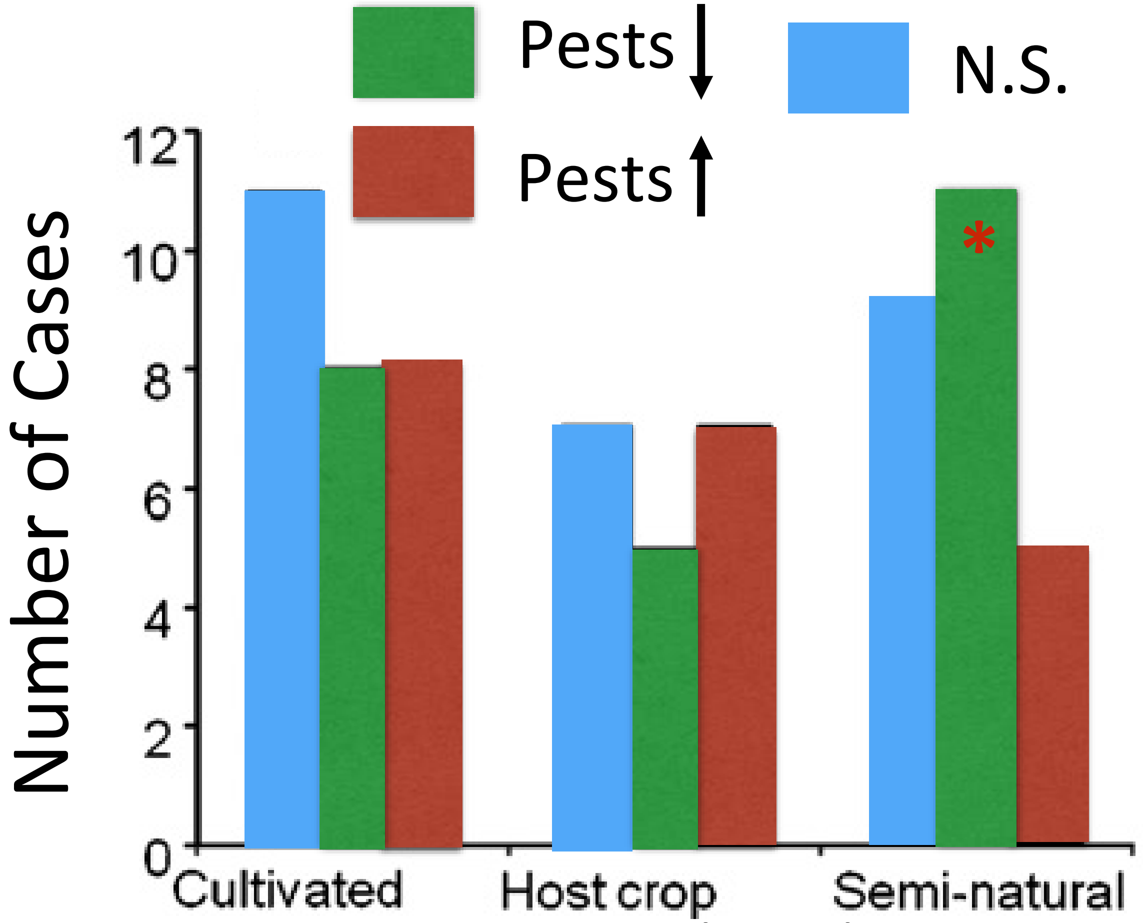


Thomsen & Hoffmann (2010) Natural enemy responses and pest control: Importance of local vegetation. Biological Control 52:160-166

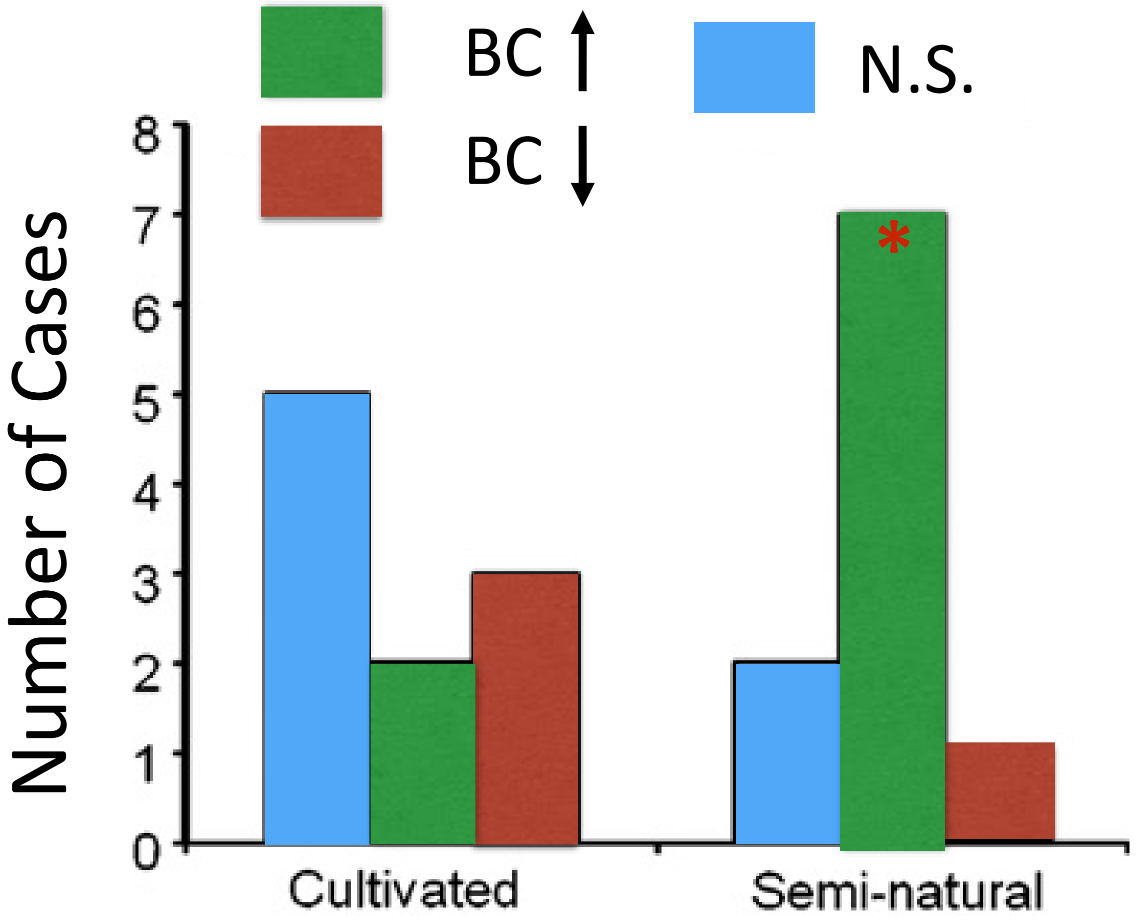
Pest Abundance & Biocontrol Services Are Influenced by Area of Cultivated Land & Semi-Natural Areas

Veres et al. (2013) analyzed 24 studies in the scientific literature to assess how the proportion of different land covers at the landscape level is related to the abundance of pests or to their control by natural enemies.

Pest abundance relative to area of cultivated land, host crop area, and semi-natural areas in the landscape



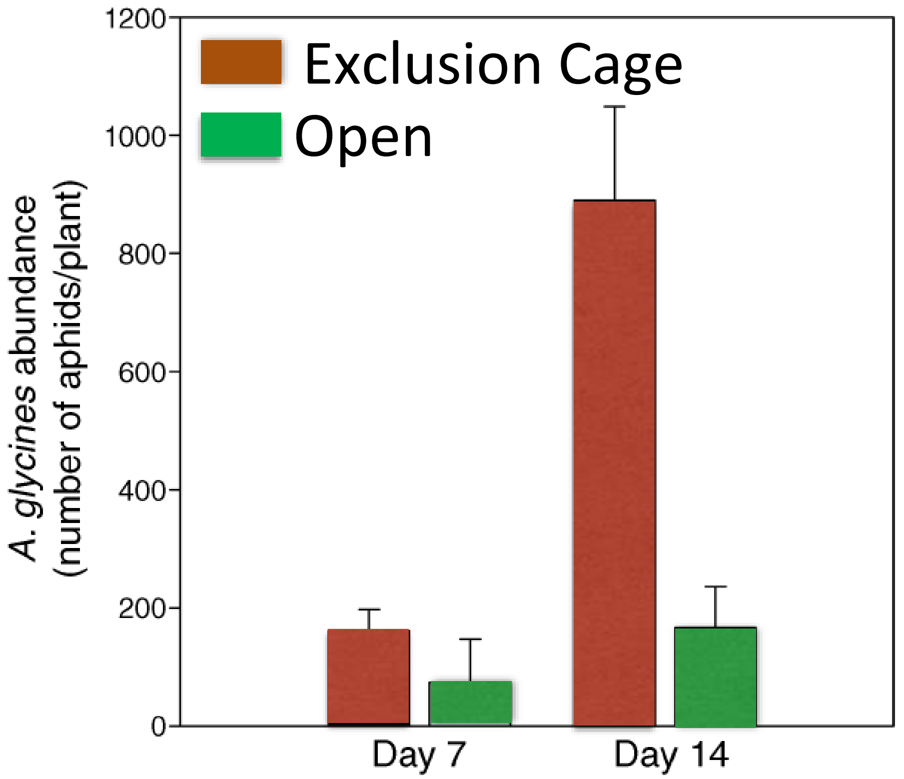
Biological control (BC) relative to area of cultivated land and semi-natural areas in the landscape



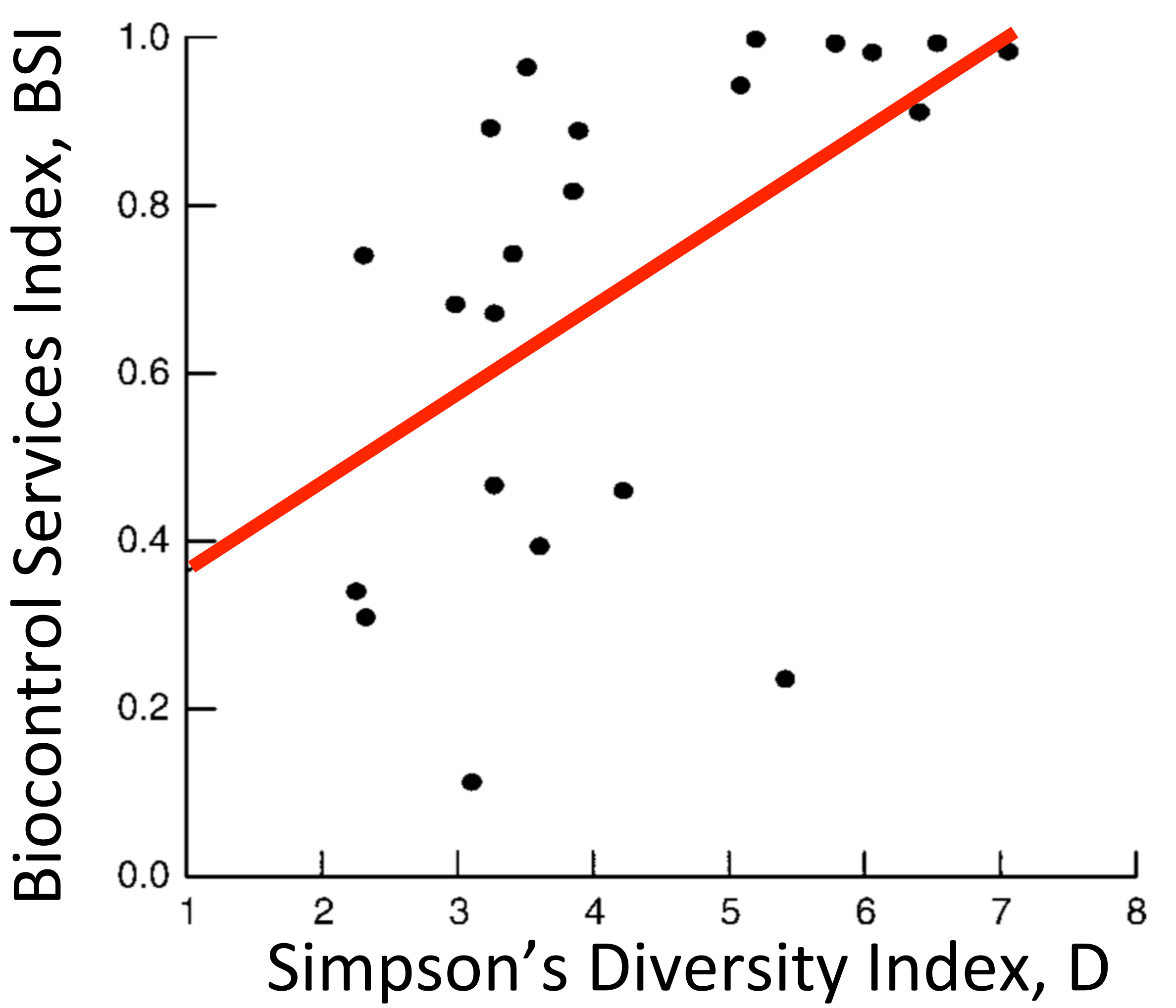
Veres et al. (2013) Agriculture, Ecosystems & Environment 166:110– 117

Landscape Diversity Increases Biocontrol Potential for Management of Soybean Aphid

- 26 Soybean fields outfitted with exclusion cages to eliminate natural enemies; open field as control
- Landscape diversity measured up to 3.5 km distant
- Exclusion cages resulted in greater aphid numbers
- Landscape diversity resulted in greater greater reduction of aphid #s

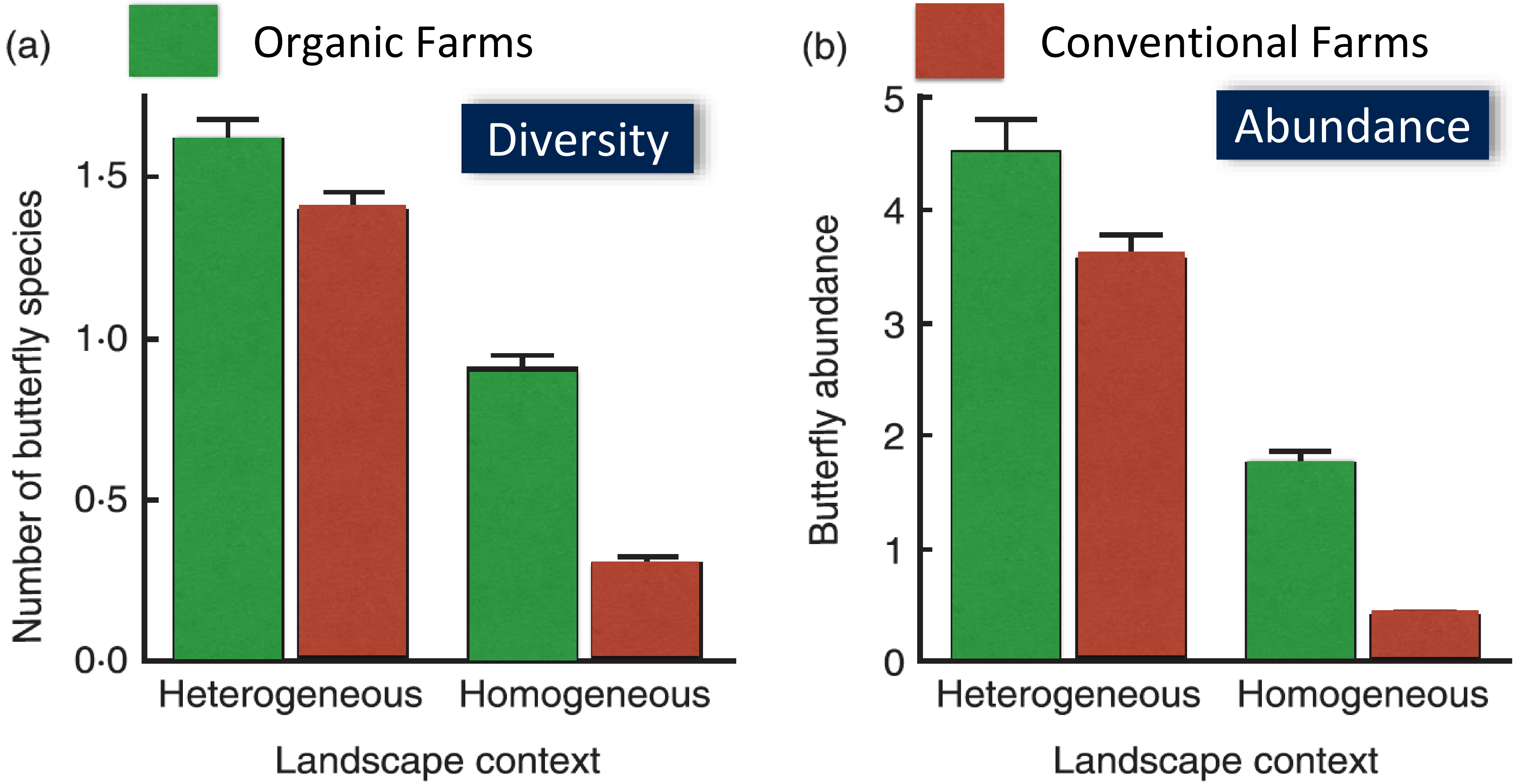


Gardiner et al. (2009) Landscape diversity enhances biological control of an introduced crop pest in the north-central USA. Ecol. Applications 19:143-154



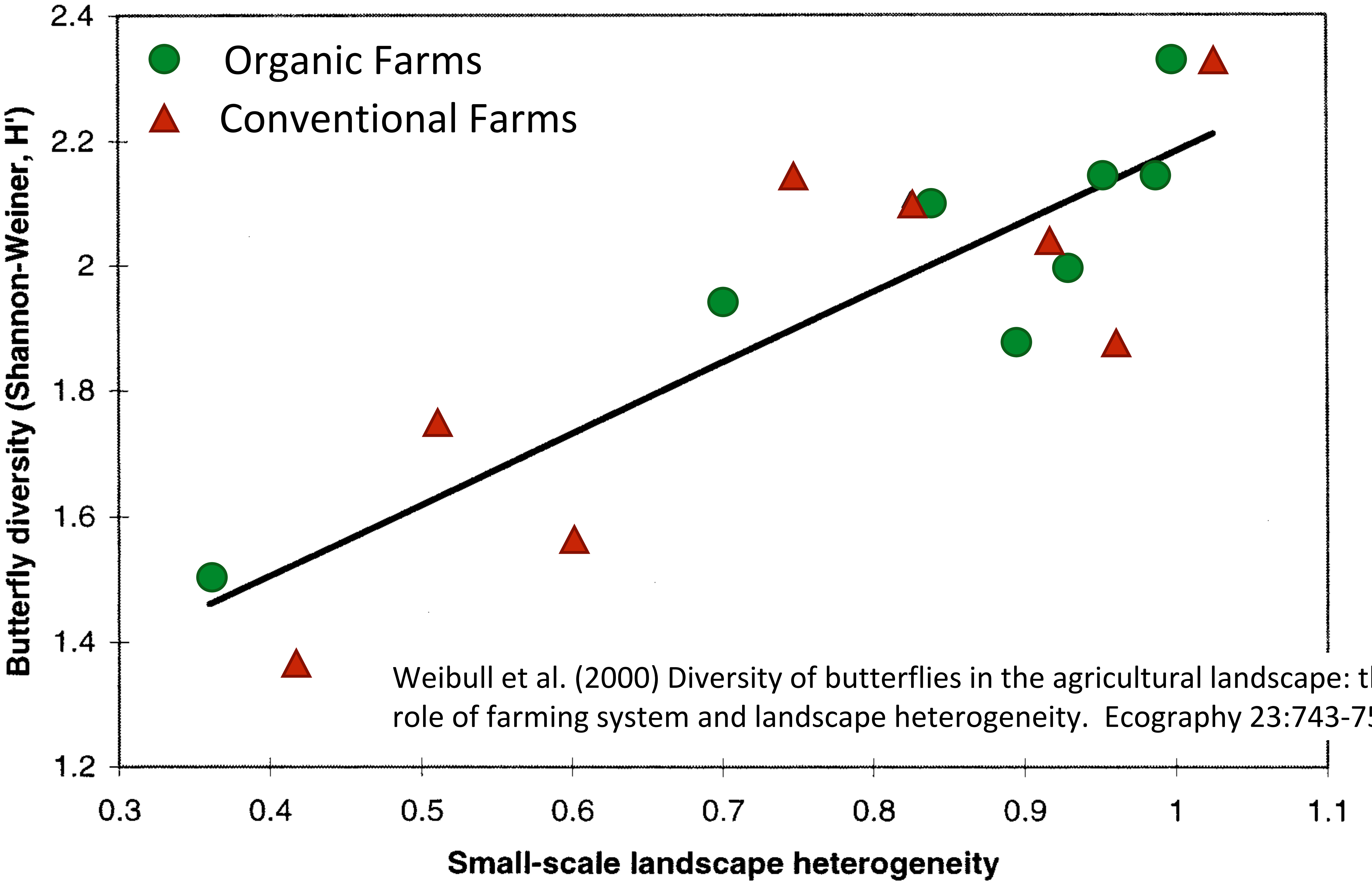
Conventional Farming Can Favor Butterfly Diversity & Abundance When Landscapes Are Heterogeneous

The effect of farming practice on butterfly species richness and abundance along cereal field headlands and margins was investigated on 12 matched pairs of organic and conventional farms in contrasting landscapes



Rundloff & Smith (2006) The effect of organic farming on butterfly diversity depends on landscape context. J. Appl. Ecol. 43:1121-1127

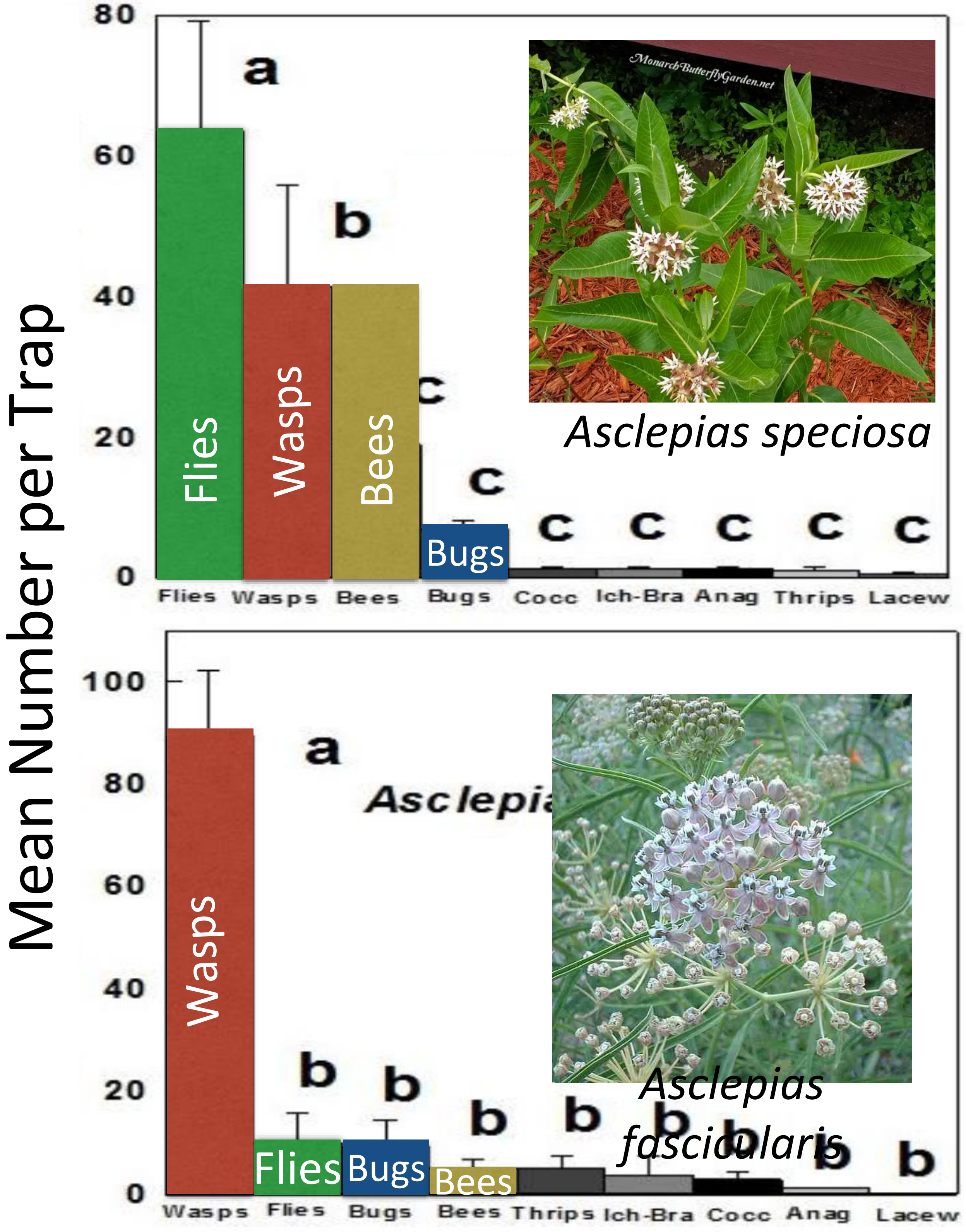
Butterfly Diversity Correlated with Landscape Diversity, Not Farming System

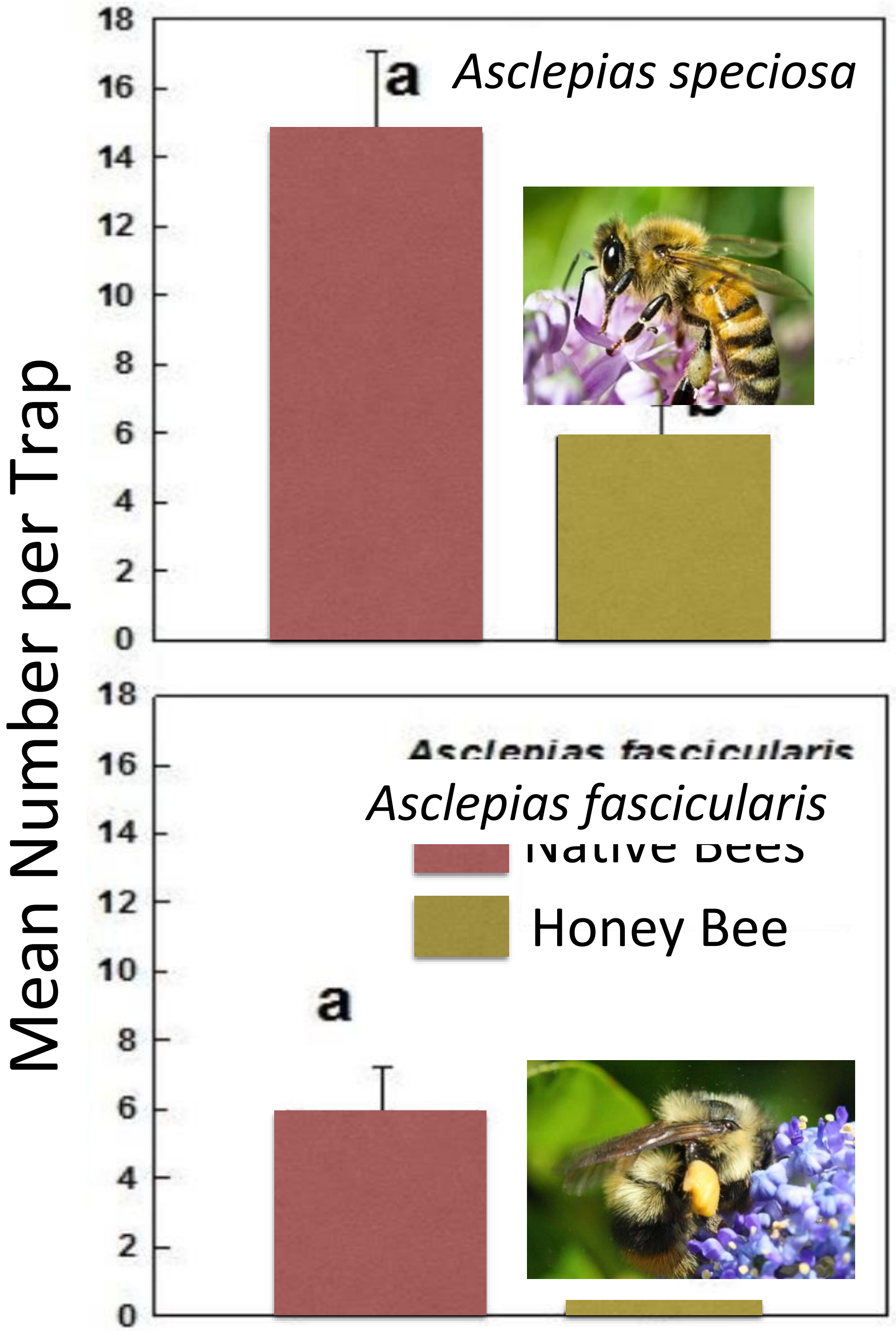


Weibull et al. (2000) Diversity of butterflies in the agricultural landscape: the role of farming system and landscape heterogeneity. Ecography 23:743-750

Milkweed Is Attractive to Natural Enemies & Native Bees

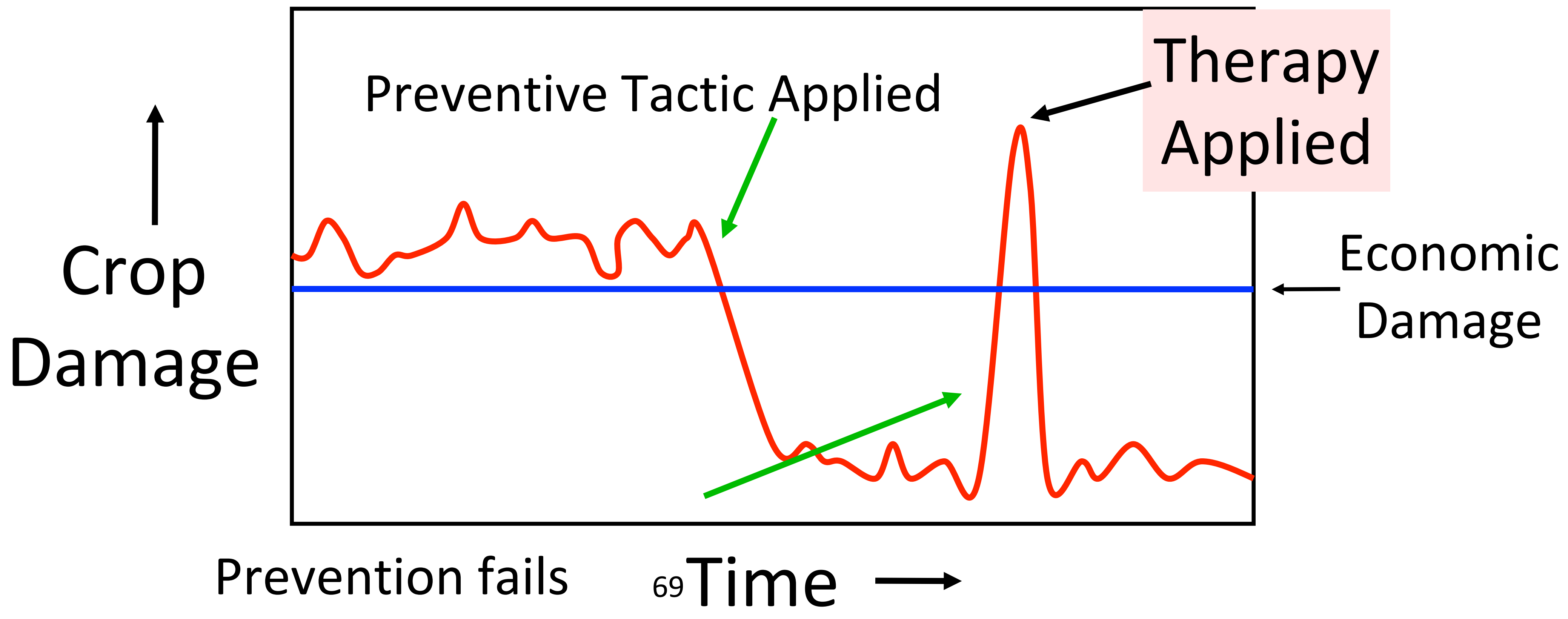
James et al. (2016) Beneficial insect attraction to milkweeds… *Insects* 7:30





Therapeutic Tactics--
2nd Line of Defense

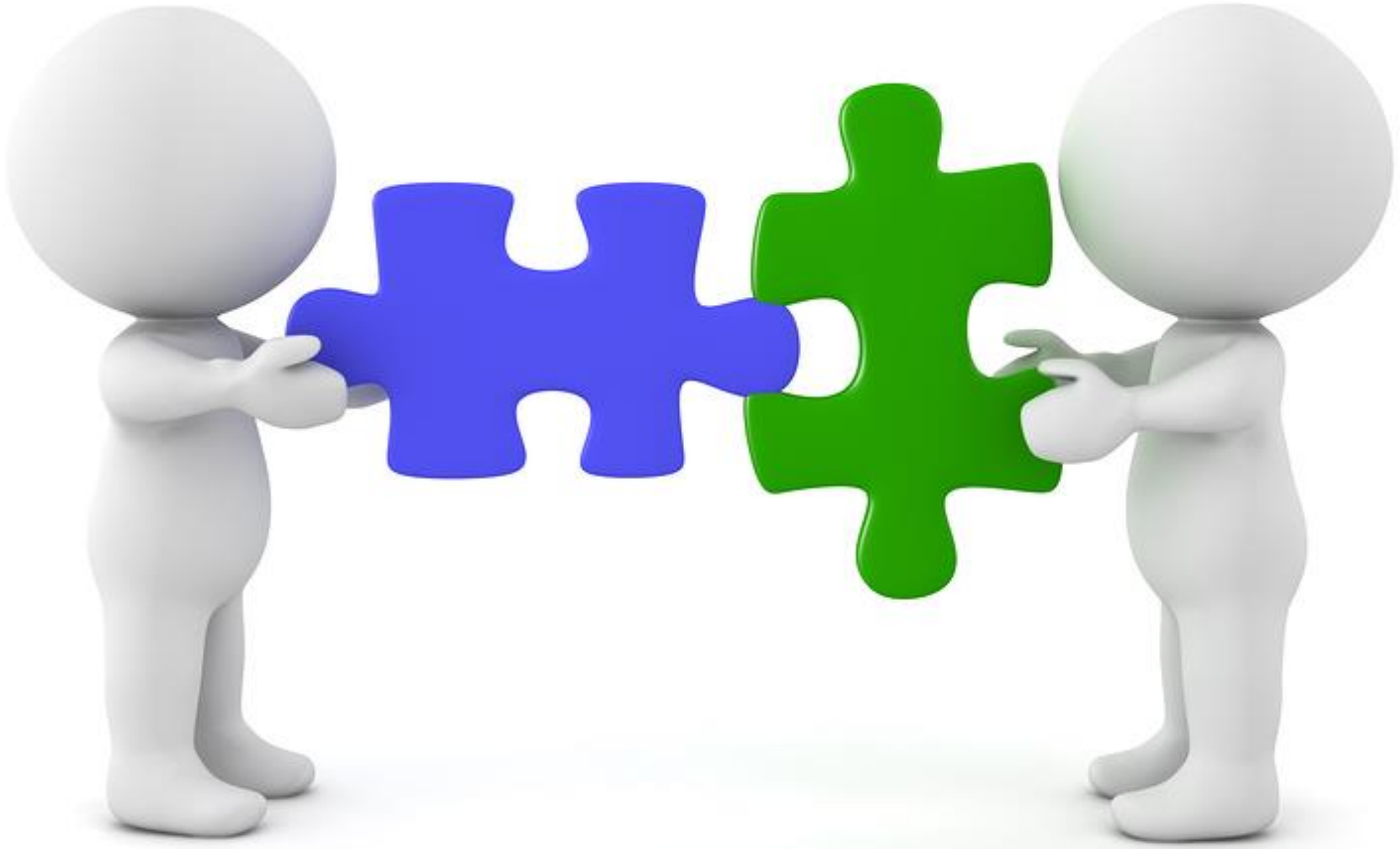
- Deployed after pest injury is already occurring
  - ✓ It follows sampling and determination of pest status relative to economic damage
- However, the primary goal is <u>prevention</u> of future economic losses
- Best deployed with occasional pests
  - ✓ Insect populations that only flare up once in a while are under sufficient natural control to be below the EIL



Therapeutic Tactics

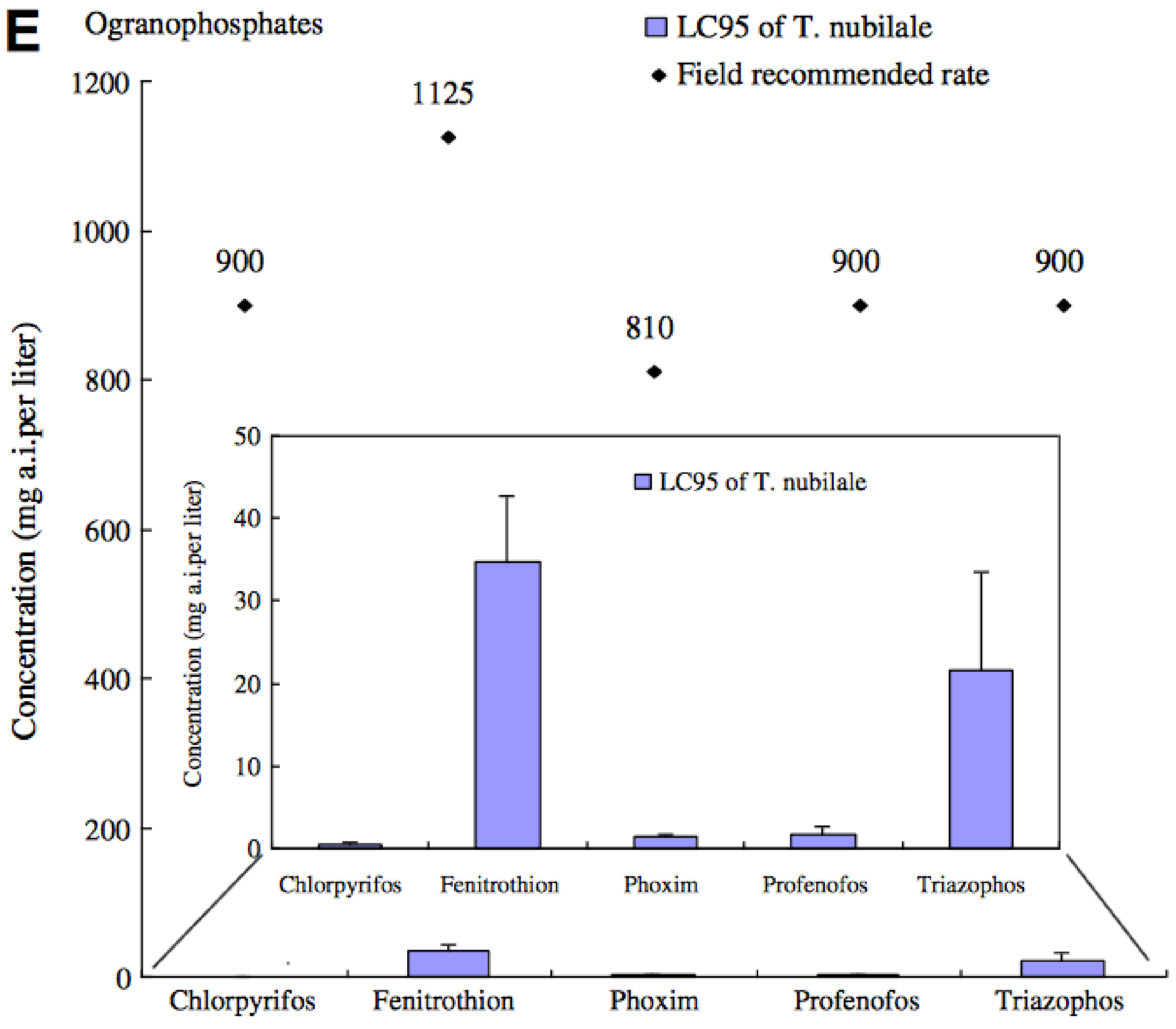
- Selective pesticides
- Fast acting, non-persistent microbial pesticides
- Early harvest
- Mechanical removal of pests

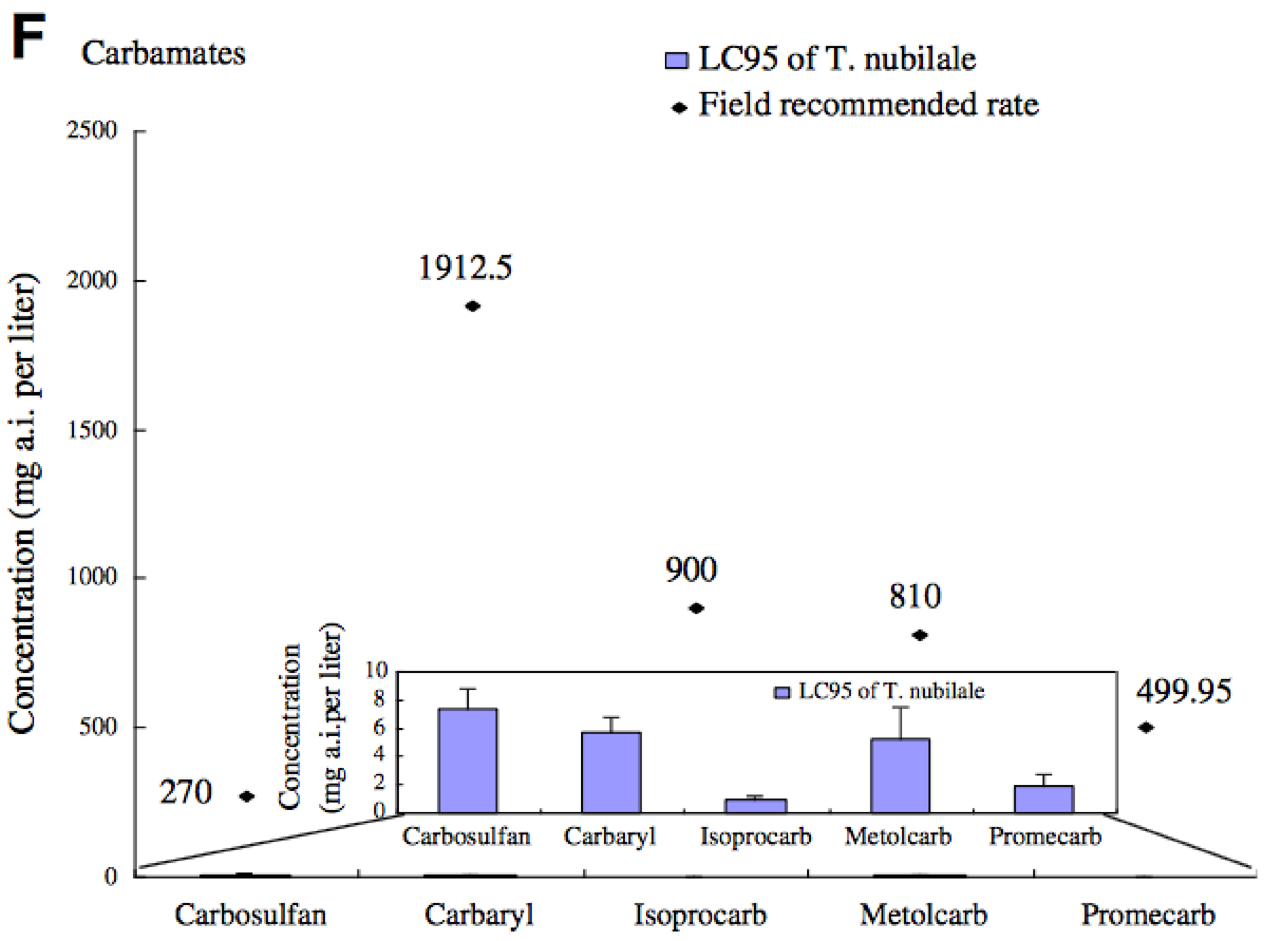
Can Insecticides Be Compatible with Biological Control?



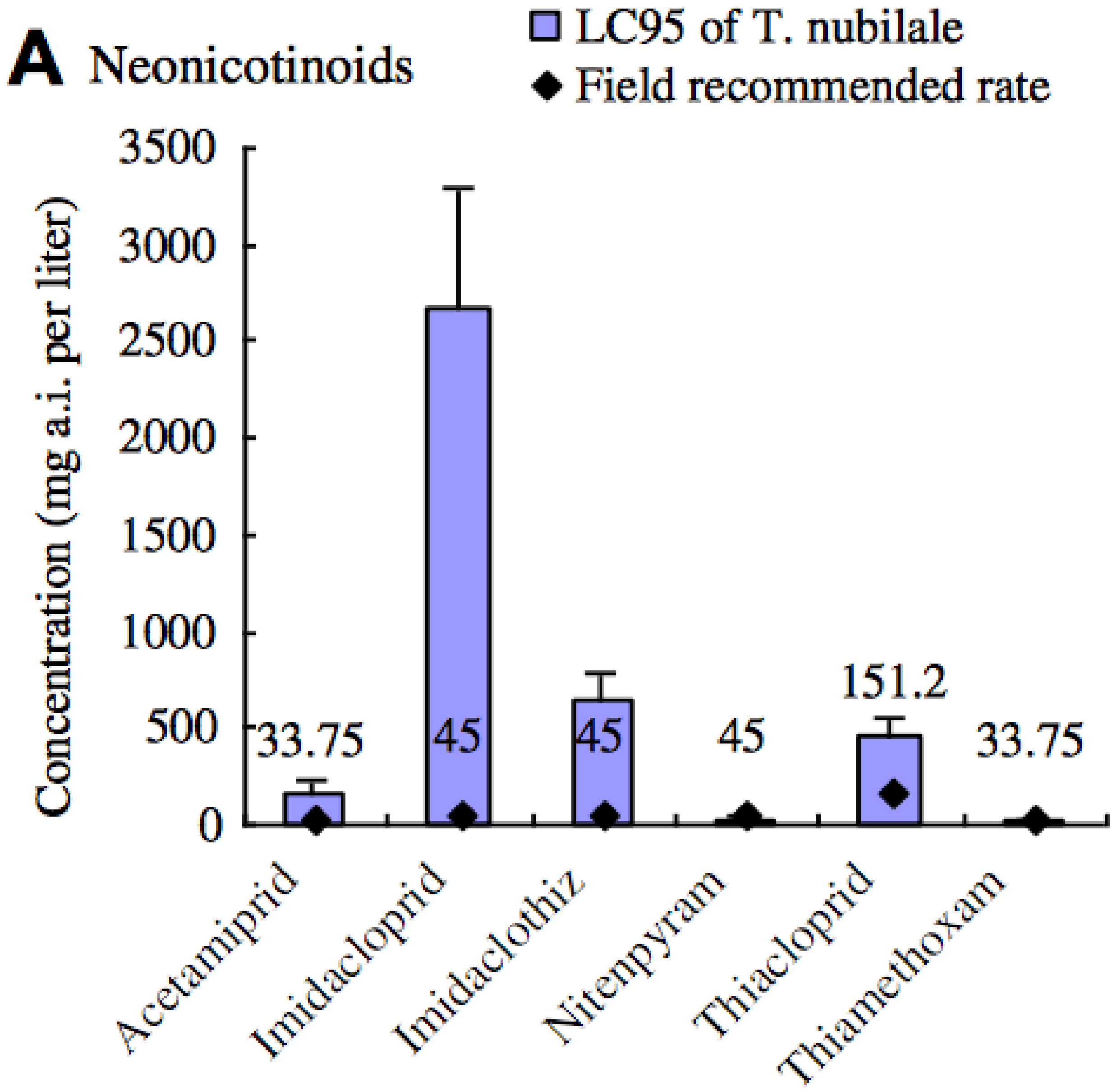
Comparison of LC_{95} Values for *Trichogramma* to Field Application Rates

Wang et al. (2012) *Crop Protection 34:* 76-82.

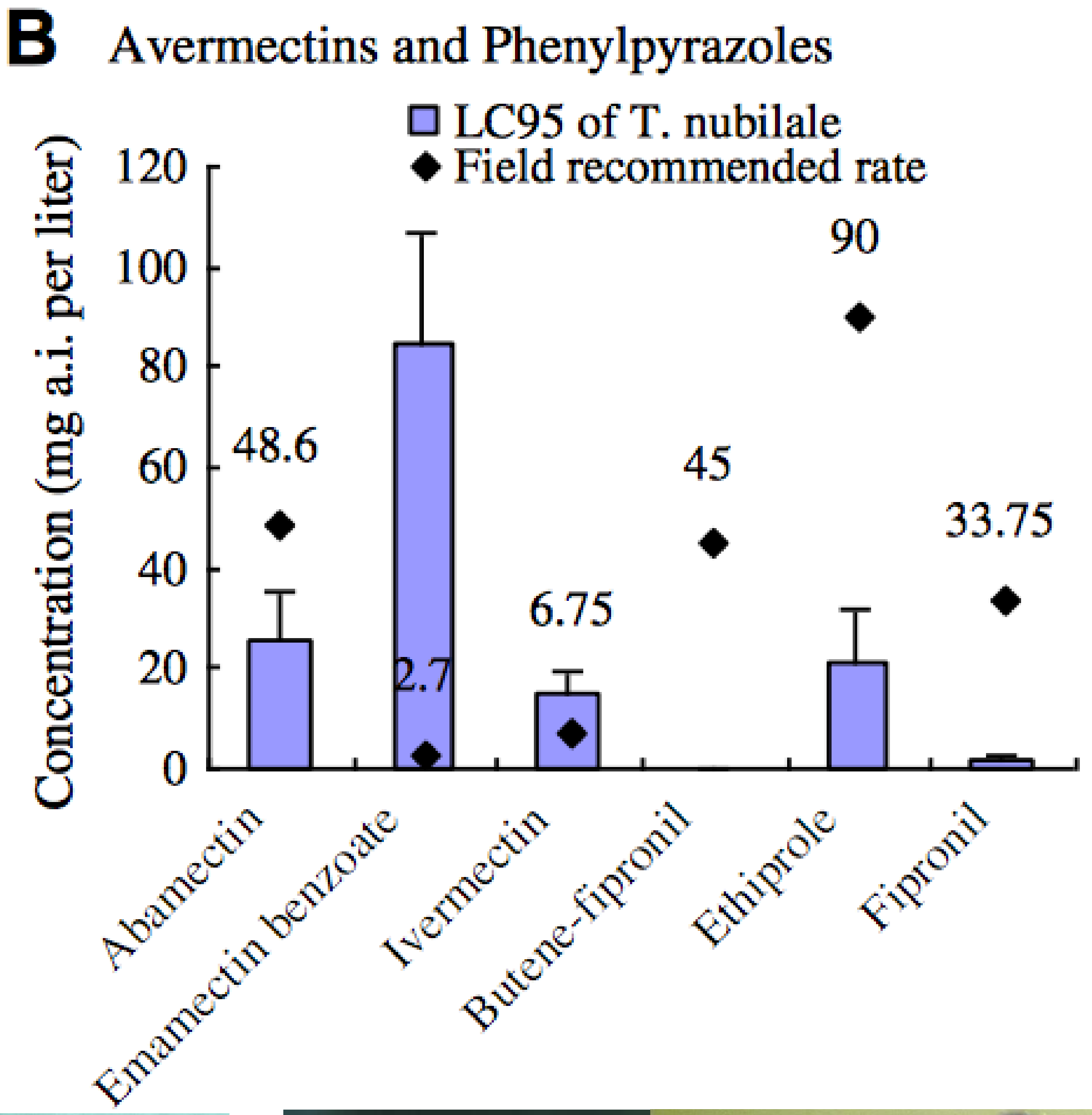


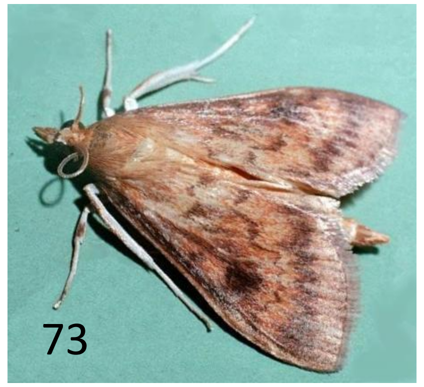


Comparison of Insecticide LC_{95} Values for *Trichogramma* to Field Application Rates



Wang et al. (2012) *Crop Protection 34:* 76-82.





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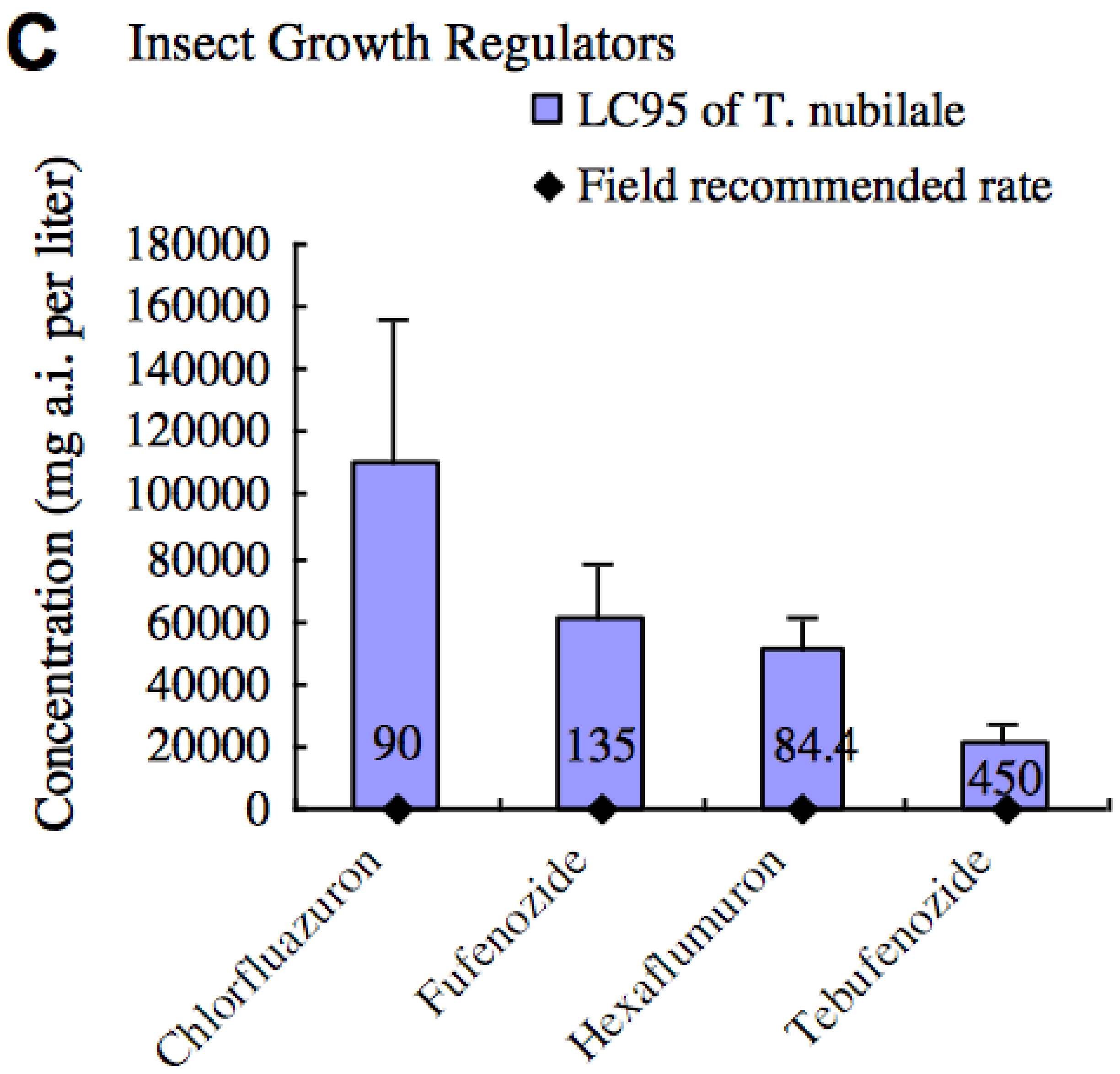
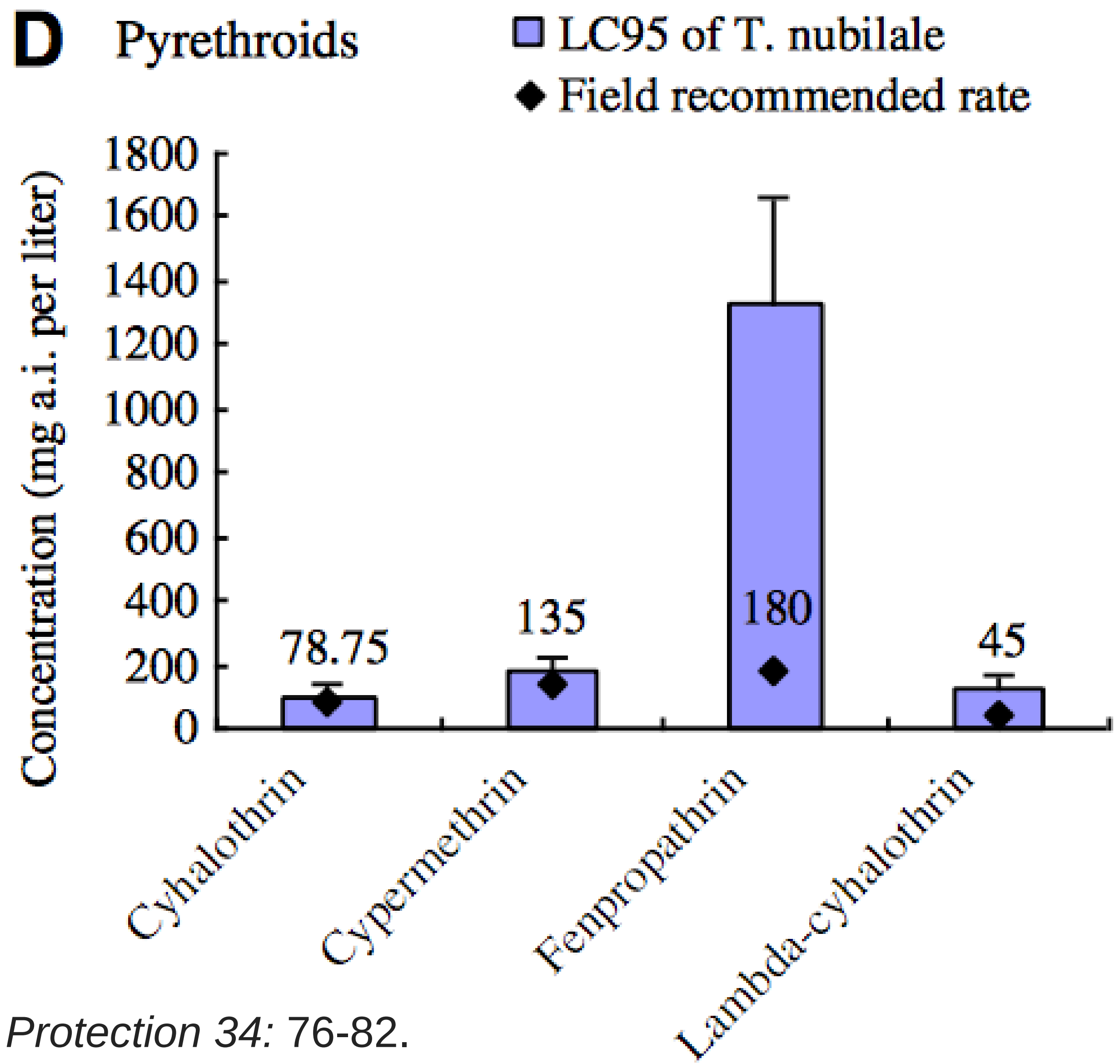




Wang et al. (2012) *Crop Protection 34:* 76-82.





An Early Attempt to Integrate Toxicity & Application Rate

$$\text{Hazard Index} = \frac{\text{Application Rate}}{\text{LD50} \times 100}$$

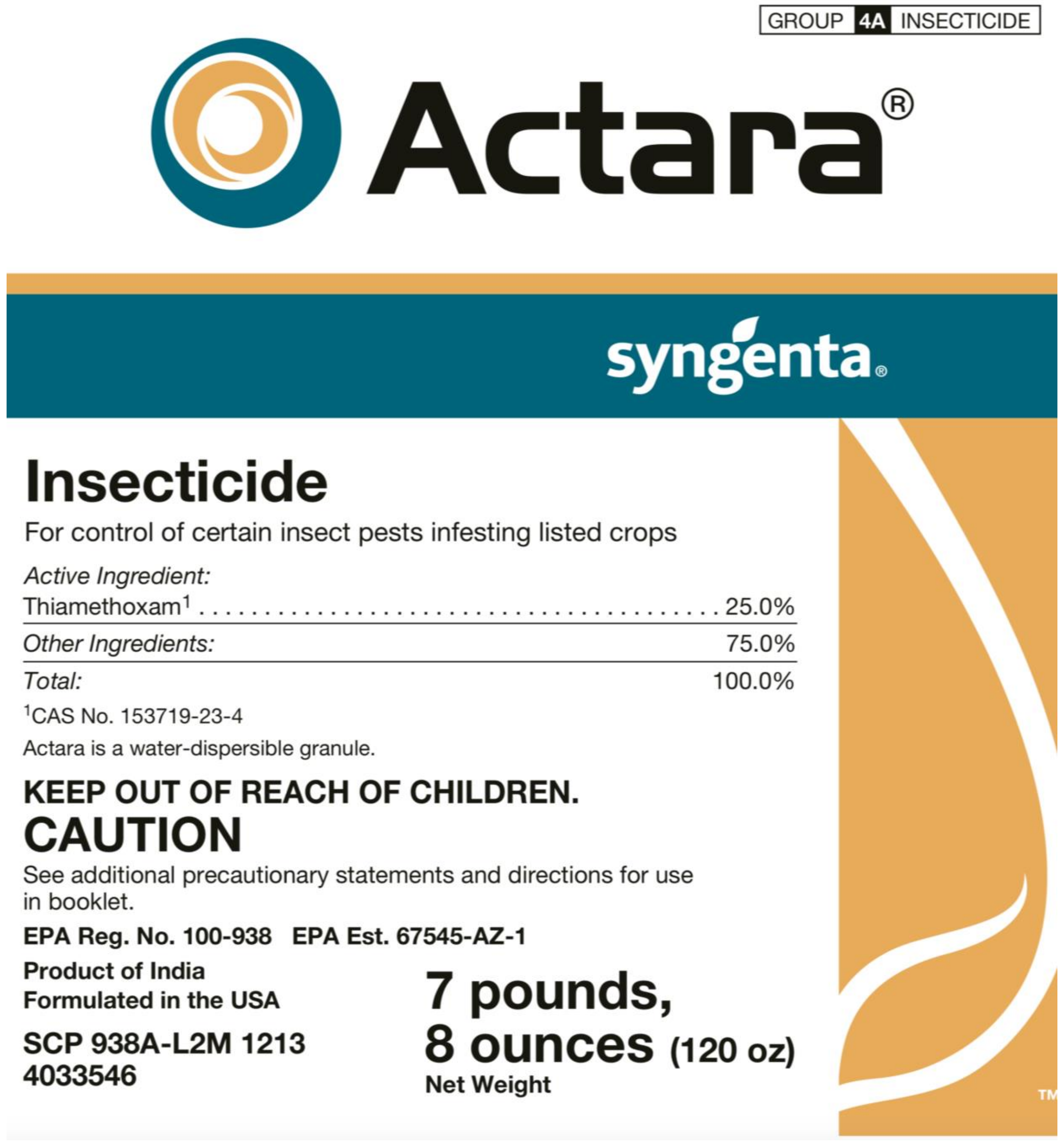
Modified from Davis & Williams (1990)

Pesticide	LD50 (µg/bee)	Application Rate (g/ha)	Hazard Index
Imidacloprid	0.0179	224	125.1
chlorpyrifos	0.06	480	81.4
malathion	0.27	1260	46.7
carbaryl	1.3	850	6.5
permethrin	0.08	40	5.3
deltamethrin	0.04	7.5	2.1
Acetamiprid	7.07	168	0.24
2,4-D	>100	908	0.091
diuron	145	908	0.063
glyphosate	3.548×10^{32}	8757	2.4×10^{-33}

Are Product Labels Useful for Protecting Pollinators?

Imidacloprid

Thiamethoxam



Do Not Break the Law

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

See individual crops for specific pollinator protection application restrictions. If none exist under the specific crop, for foliar applications, follow these application directions for crops that are contracted to have pollinator services or for food/feed & commercially grown ornamentals that are attractive to pollinators:

APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE TO PROTECT POLLINATORS.

Look for the bee hazard icon  in the Directions for Use for each application site for specific use restrictions and instructions to protect bees and other insect pollinators.

This product can kill bees and other insect pollinators.

Admire (Imidacloprid) Label Directions-Sweet Cherries

Stone Fruit – Foliar Application Restrictions – Apricot, Nectarine, Peach:
Pre-Harvest Interval (PHI): **0 day**
Minimum interval between applications: **7 days**
Maximum ADMIRE PRO SYSTEMIC PROTECTANT allowed per year: **8.4 fluid ounces/Acre** (0.3 lb AI/A)
Minimum application volume (water): 50 GPA – ground application; 25 GPA – aerial application.
Do not apply pre-bloom or during bloom or when bees are foraging.

Stone Fruit – Foliar Application Restrictions – Cherries, Plums, Plumcot, Prune:
Pre-Harvest Interval (PHI): **7 days**
Minimum interval between applications: **10 days**
Maximum ADMIRE PRO SYSTEMIC PROTECTANT allowed per year: **14.0 fluid ounces/Acre** (0.5 lb AI/A)
Minimum application volume (water): 50 GPA – ground application; 25 GPA – aerial application
Do not apply pre-bloom or during bloom or when bees are foraging.

Actara (Thiamethoxam) Label Directions-Fruit

CROP USE DIRECTIONS

Pollinator Precautions

- Actara is highly toxic to bees exposed to direct treatment on blooming crops/plants or weeds.
  - For **apples,** do not apply Actara after pre-bloom (early pink growth stage) or before post bloom (petal fall growth stage).
  - For **citrus,** do not apply during pre-bloom or during bloom when bees are actively foraging.
  - For **pears,** do not apply Actara after pre-bloom (green cluster stage) or before post bloom (petal fall growth stage).
  - For **stone fruit,** do not apply Actara between the pre-bloom (swollen bud) and post bloom (petal fall) growth stages.
- Do not apply Actara or allow it to drift to blooming crops/plants or weeds if bees are **foraging in/or adjacent to the treatment area.** This is especially critical if there are adjacent orchards that are blooming. (Refer to **Spray Drift Precautions** for additional information).
- **After an Actara application, wait at least 5 days before placing beehives in the treated field.**
- If bees are foraging in the ground cover and it contains any blooming plants or weeds, always remove flowers before making an application. This may be accomplished by mowing, disking, mulching, flailing, or applying a labeled herbicide.

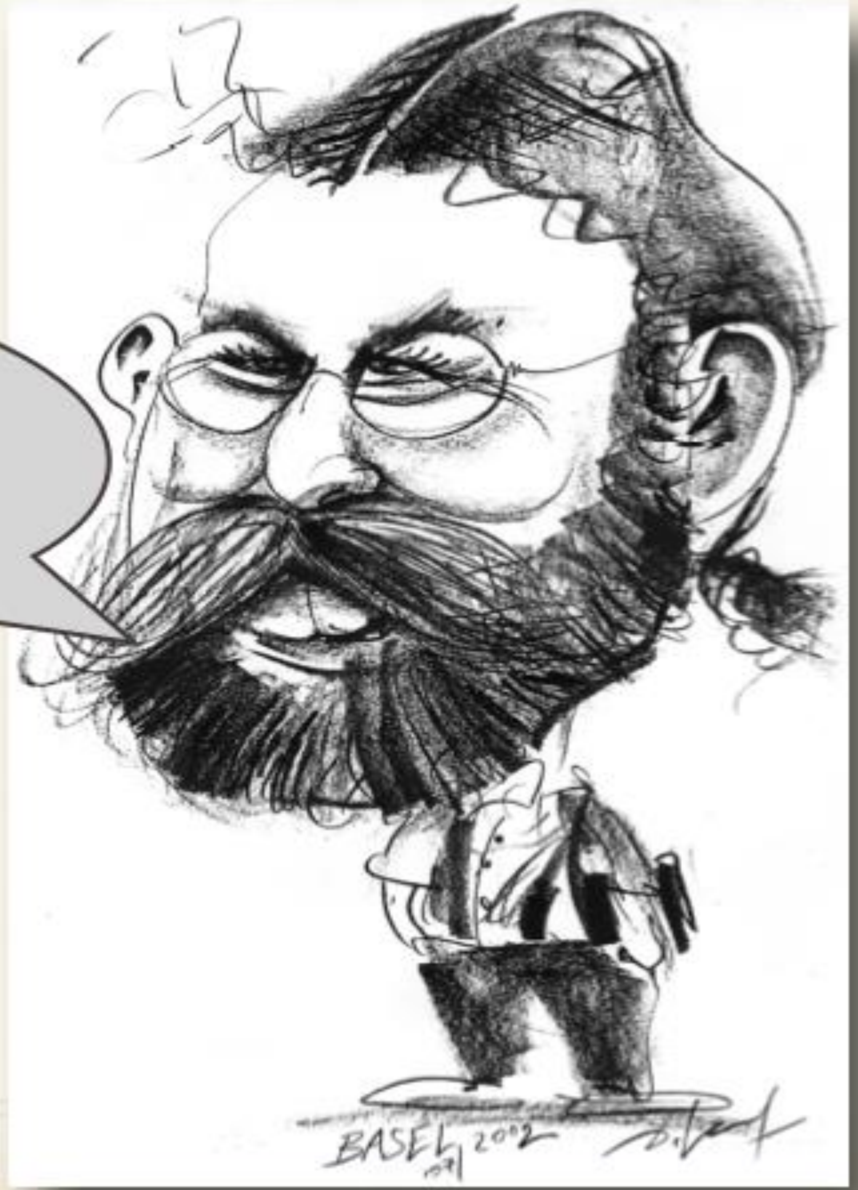
Conclusions

- IPM is a systematic strategy for making decisions that ideally are conservationist (protect environmental quality and health) while making a profit from farming
- Implementation of an IPM strategy is based on principles of ecology and economics
- IPM does not favor more or less pesticide use, but does favor tactics for preventing pest economic damage and when necessary implementing therapeutic techniques, like pesticides
- Cultural practices that enhance plant and animal diversity within a field and at landscape levels can lead to lower pest density and higher tolerance for pest injury while enhancing pollinator habitat
- When pesticides are used, choices should be made to use the most selective products…those least hazardous to natural enemies and pollinators
- AND ALWAYS, follow label directions—it's Federal Law

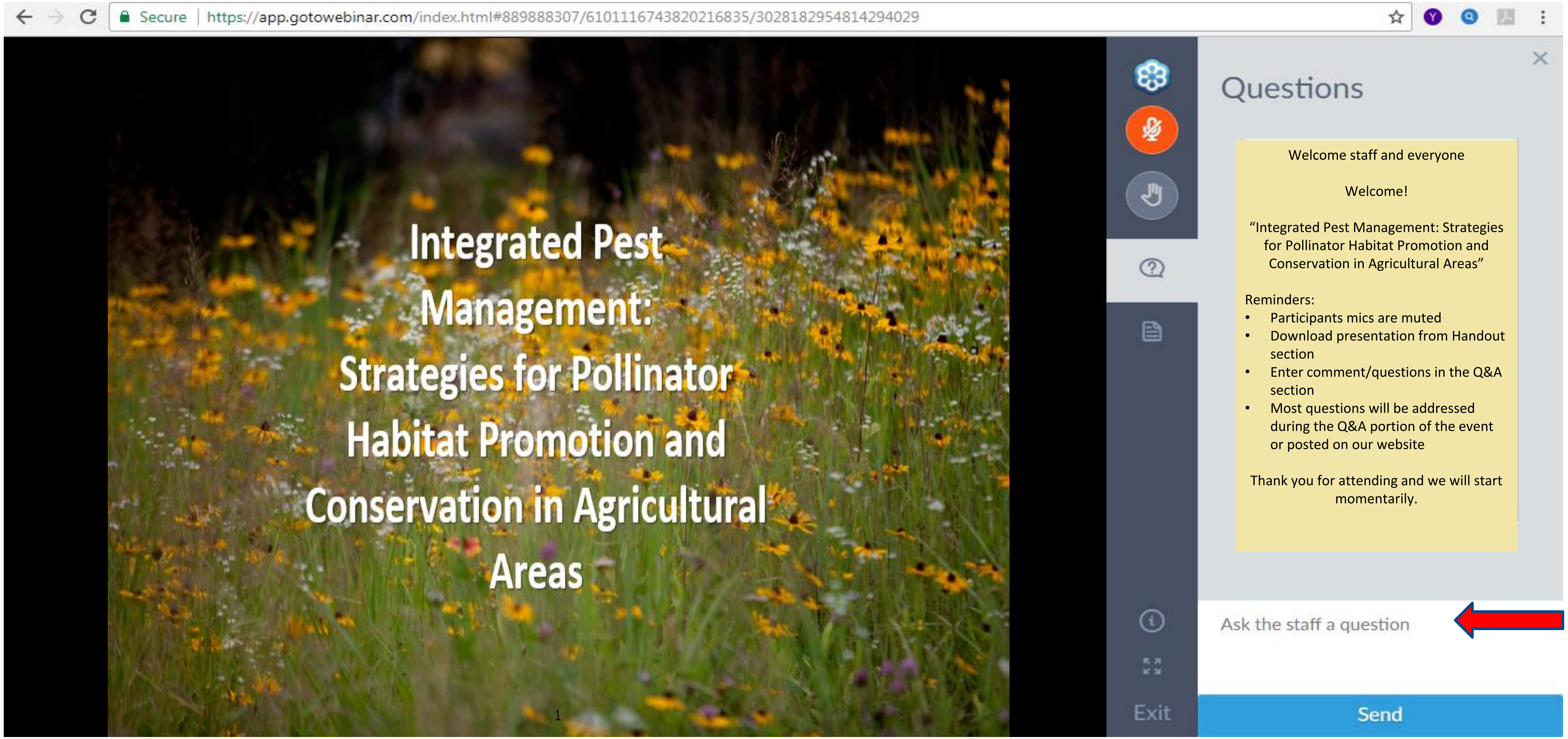
WASHINGTON STATE UNIVERSITY

afelsot@wsu.edu

Questions??



Submit Your Questions



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Related Topics: Pesticides and Consumers | Pesticide Environmental Stewardship Program (PESP)

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Integrated Pest Management (IPM) Principles

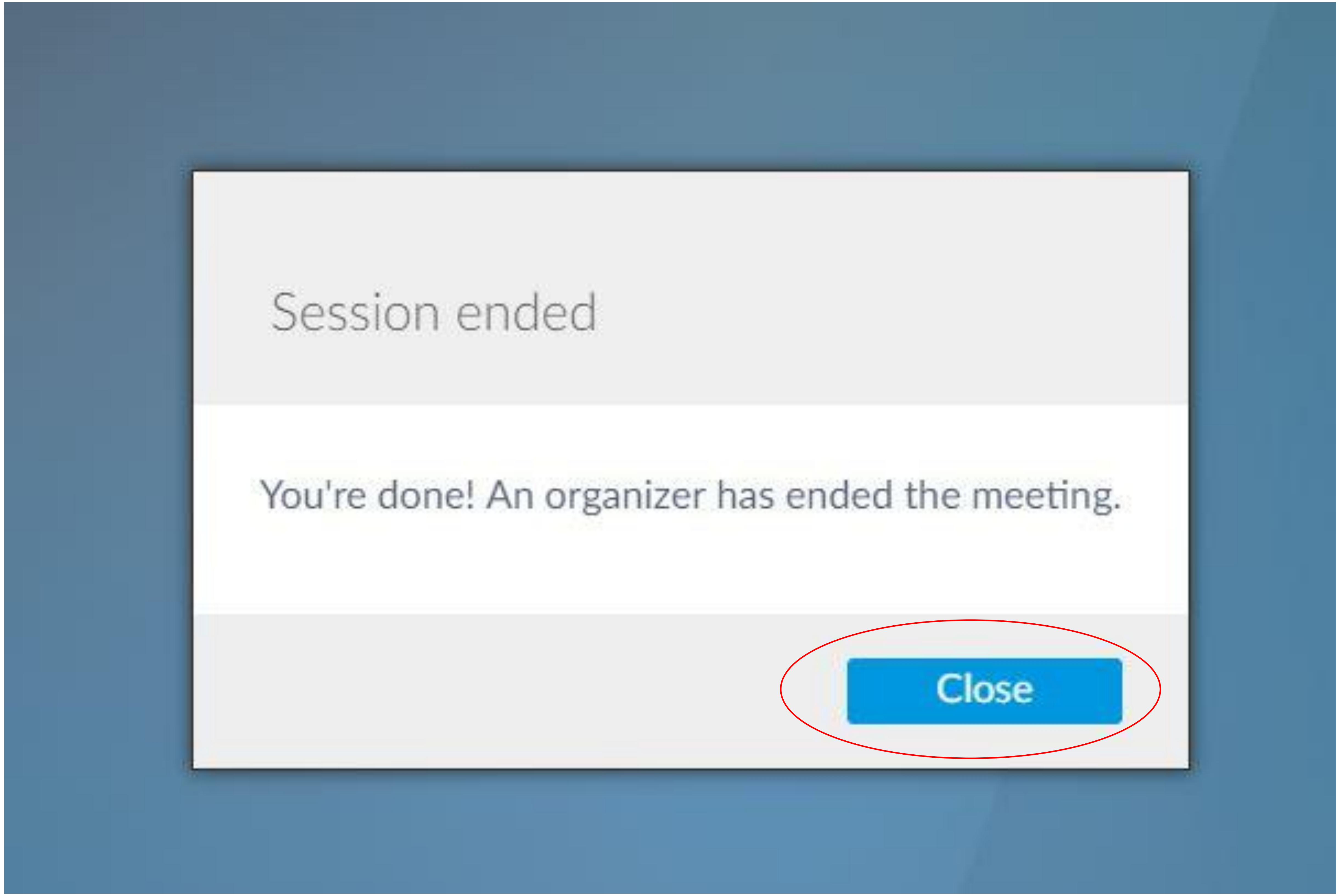
On this page:

- What is IPM?
- How do IPM programs work?
- Do most growers use IPM?
- How do you know if the food you buy is grown using IPM?
- If I grow my own fruits and vegetables, can I practice IPM in my garden?
- For more information

What is IPM?

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles


Session ended
You're done! An organizer has ended the meeting.
Close

Integrated Pest Management: Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Area

1. After viewing this webinar, I would share this training with other growers/applicators/land managers to educate them about this topic if it were accessible on YouTube.

- Yes
- No

2. After viewing this webinar, I will use the information I've learned to manage agricultural land and/or promote or conserve pollinator habitat.

- Yes
- No

3. Which IPM recommendations were most helpful?

4. Which IPM recommendations were least helpful?

5. In your opinion, what are the biggest obstacles for implementing IPM strategies in agricultural areas?

6. What modifications would you like to see in future webinars to improve your learning experience?

7. How many other people are in the room with you for this webinar (including yourself)?

Submit

Thank you for attending the webinar, "Integrated Pest Management: Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Areas". We hope you gained valuable insights on strategies to implement Integrated Pest Management for pollinator habitat conservation and promotion.

Please click the following link to receive your certificate of completion:
https://epawebconferencing.acms.com/pollinator_ipm/

Thank you again for your participation in the webinar and for providing valuable feedback. You will receive an email when the recording for this webinar is available online.

Questions? Contact us at school.ipm@epa.gov or visit our website @ https://www.epa.gov/managing-pests-schools/webinars-about-integrated-pest-management-schools.

Please send your questions, comments and feedback to: school.ipm@epa.gov.

CERTIFICATE *Of* PARTICIPATION

This is to certify the above participant attended the 90-minute webinar entitled

IPM: Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Areas

PRESENTED BY: **EPA's Office of Pesticide Programs (OPP)**

ON THIS DAY: **August 28, 2018**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