An Update on Colony Collapse Disorder: What's Happening to the Honey Bees?

(AP Photo/Haraz N. Ghanbari, File)

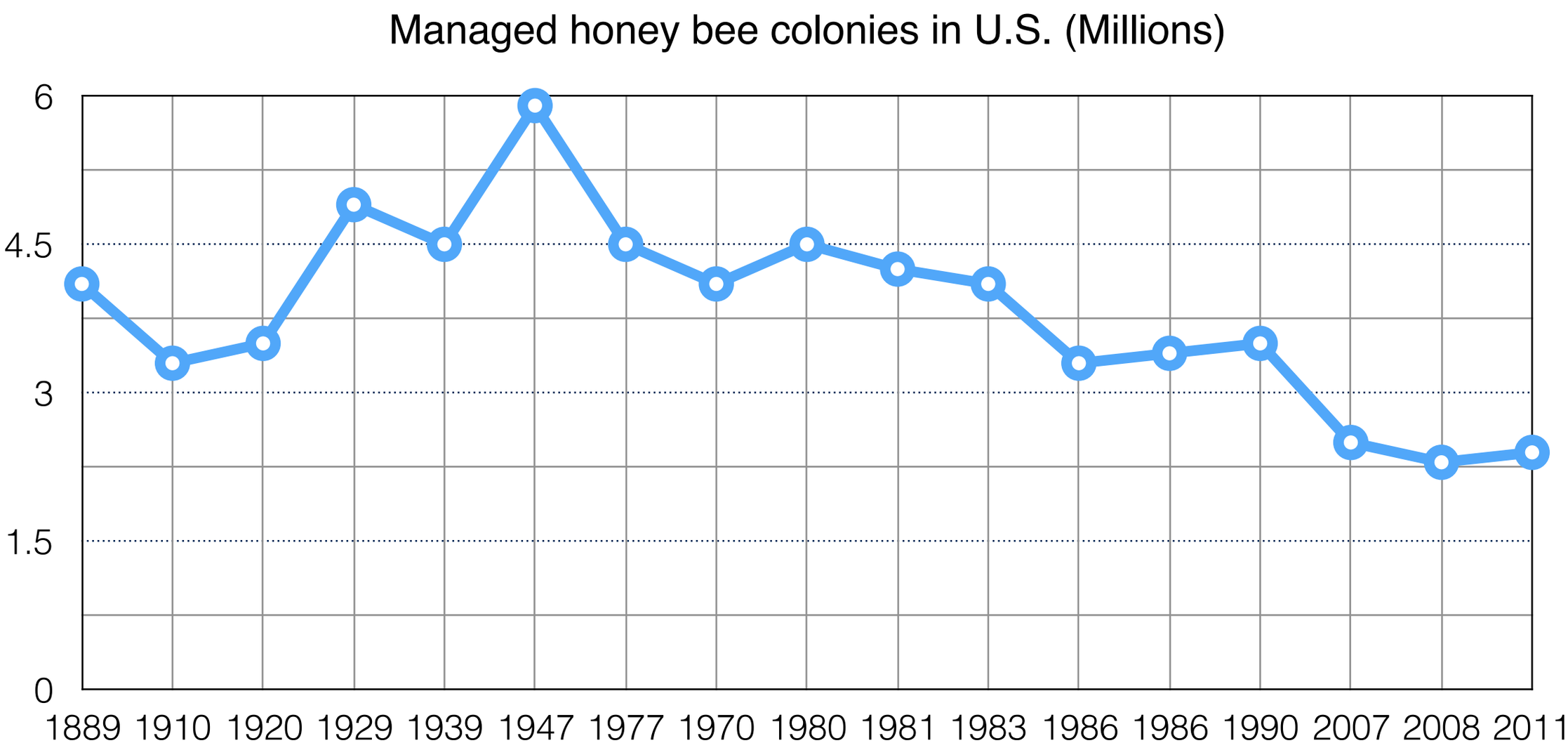
Jeff Pettis

Honey bee colonies have been dying at a rate of about 30 percent a year over the past few winters which leave virtually no cushion of bees for pollination.

Surveys of beekeepers throughout the United States have documented this 30 percent or greater loss for five consecutive years while for … 2011-2012, the losses were only 22 percent.

—(Dr. Jeff Pettis, USDA ARS, Beltsville, Maryland; Dr. Dennis vanEngelsdorp, University of Maryland, College Park, Maryland)

Declining numbers of managed colonies in the U.S.



(Source: Daberkow et al, USDA)

Why the honey bee is such a valuable pollinator:

- Perennial colony
- Nectar and pollen diet
- Plumose (branched) body hairs
- Flower-consistent behavior
- Manageable populations

Clay Stauffer photo

Photograph: Johanna James-Heinz

Bumble bees are in decline across North America. The rusty-patched bumble bee (*Bombus affinis*)—shown here foraging on wild bergamot (*Monarda fistulosa*)—is in particular peril.

- Alfalfa
- Almonds
- Apples
- Asparagus
- Avocado
- Blackberries
- Blueberries
- Broccoli
- Cantaloupe
- Cherries
- Clover
- Vegetable seeds
- Citrus fruits
- Cranberries
- Cucumber
- Celery
- Onions
- Peach, nectarine
- Pears
- Pumpkin
- Raspberries
- Squash
- Sunflowers
- Watermelon

Almond industry alone requires
1.5 million colonies each spring.

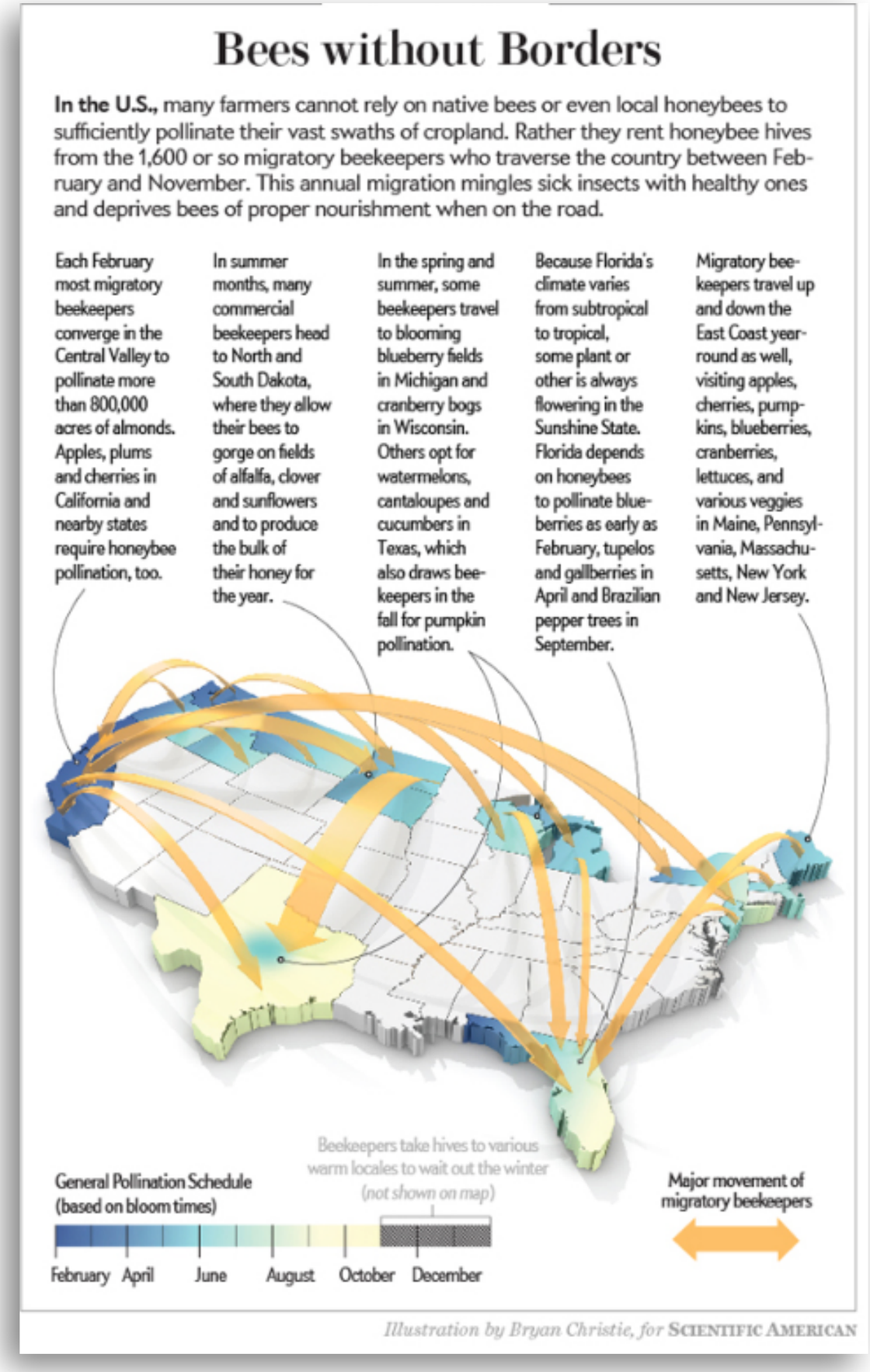
A few important crops requiring insect pollination

Bee colonies are transported cross-country on tractor-trailer rigs.

Pollination

- Honey bees alone pollinated $12.4 billion in dependent crops in 2010, and $6.8 billion in indirectly dependent crops in 2010.

- Crops pollinated by honeybees and other insects contributed $29 billion to farm income in 2010.



Improving Agriculture

Improving Agriculture

Why Does Agriculture Need to Be Improved?

What Is Monsanto Doing to Help?

Producing More

Conserving More

Improving Lives

Monsanto and Water

Features

How We're Making a Difference

Partnerships & Projects

- Conservation International Partnership to Preserve Biodiversity
- Field to Market
- Haiti Seed Donation
- Project SHARE
- Sustainability Consortium
- Monsanto's Beachell-Borlaug International Scholar Program
  - About the Program

Honey Bee Health

The Challenge

Bees play a vital role in agriculture as natural pollinators. Pollination is a necessary part of some plants' fertilization processes, because it allows for the development of fruits and seeds.

One-third of the food you eat depends upon pollination, including almonds, apples, berries, cucumbers and melons. Honey bees have an important role in contributing a service that helps provide us with variety and more nutritious food.

Farmers are facing the challenge of providing more food for a growing population. And, the honey bee population has been facing its own problems. Colony Collapse Disorder (CCD) - is a phenomenon in which bees are disappearing abruptly from an otherwise healthy colony. The USDA report confirms that there are many causes that compromise bee health, including pathogens or diseases, poor nutrition and pesticides.

What Monsanto is Doing to Help

Related Resources

Learn more about the Clinton Global Initiative (CGI) Commitment to Action on honey bee health.

The Bayer Bee Care Tour

Continuing Our Commitment to Promoting Bee Health for Over 25 Years

Tour Stops:
Orlando, FL
Columbus, OH
Indianapolis, IN
Urbana-Champaign, IL
Ames, IA
Lincoln, NE
Minneapolis, MN

Follow us
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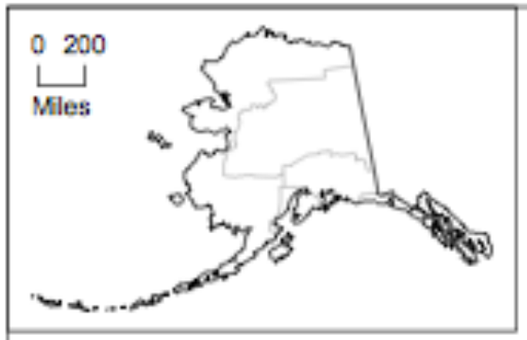
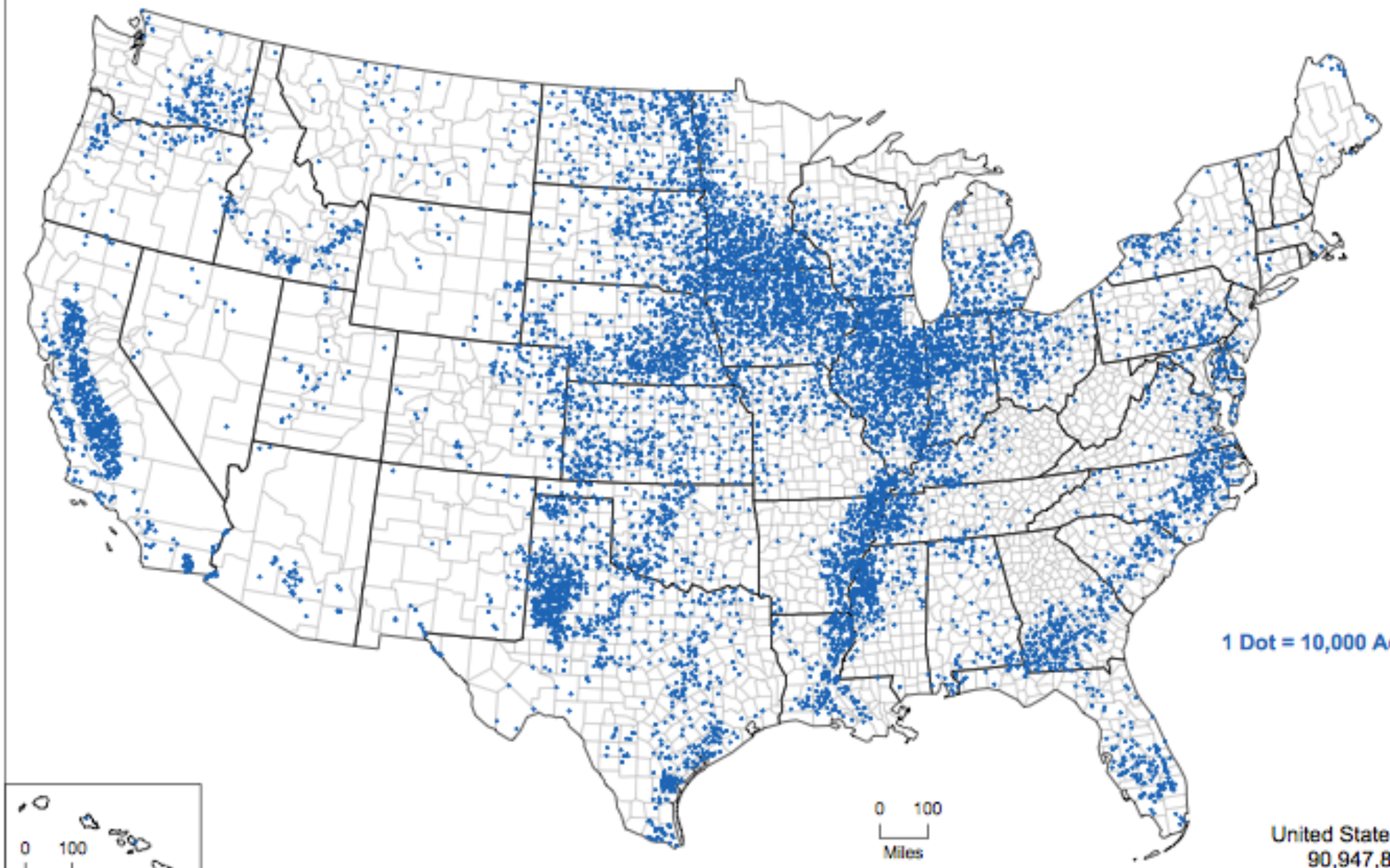
bee care

Visit the Bayer Bee Care Experience at Commodity Classic, Booth #141

Bayer CropScience

Acres Treated with Chemicals to Control Insects: 2007



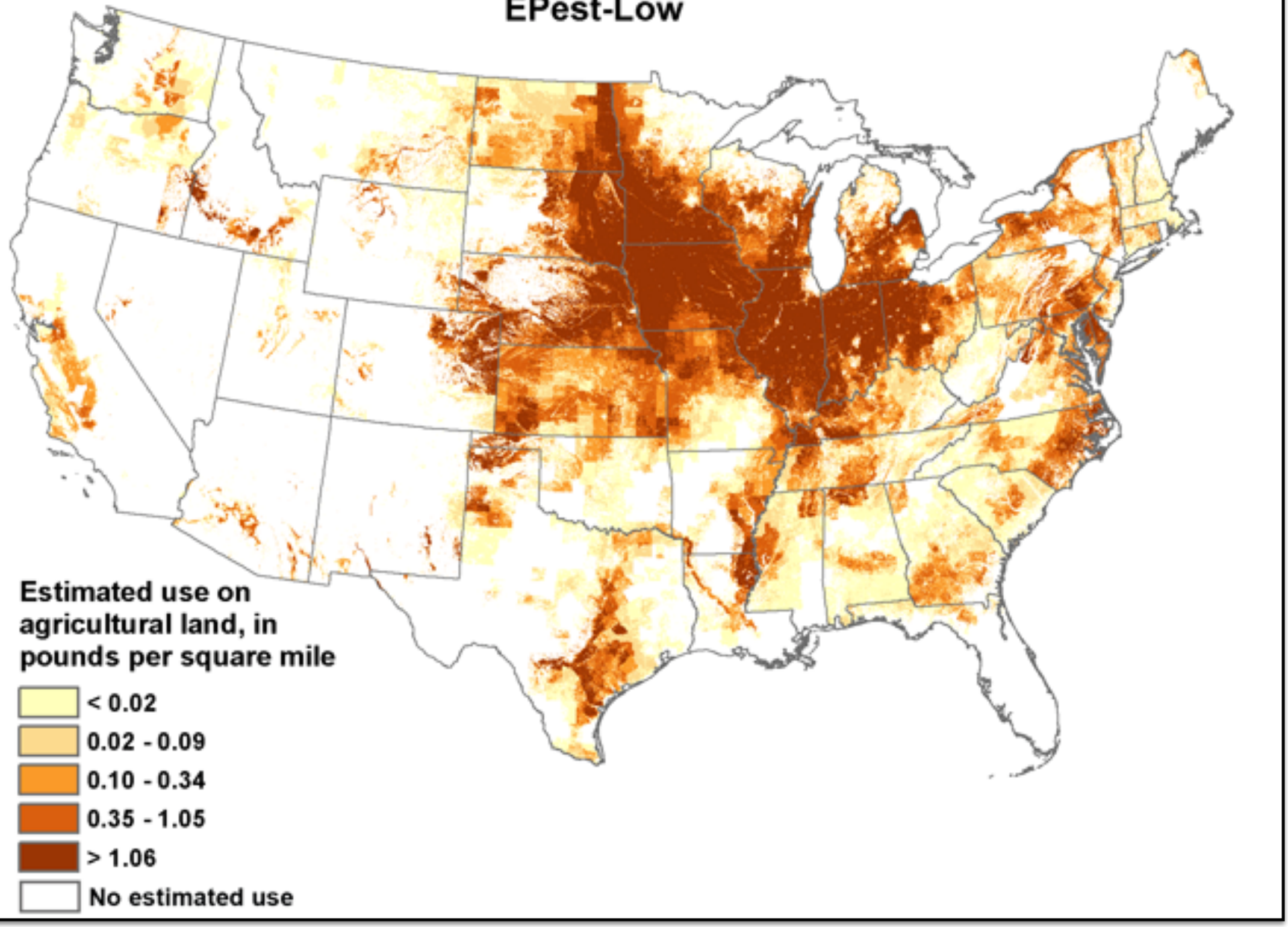


07-M106
U.S. Department of Agriculture, National Agricultural Statistics Service

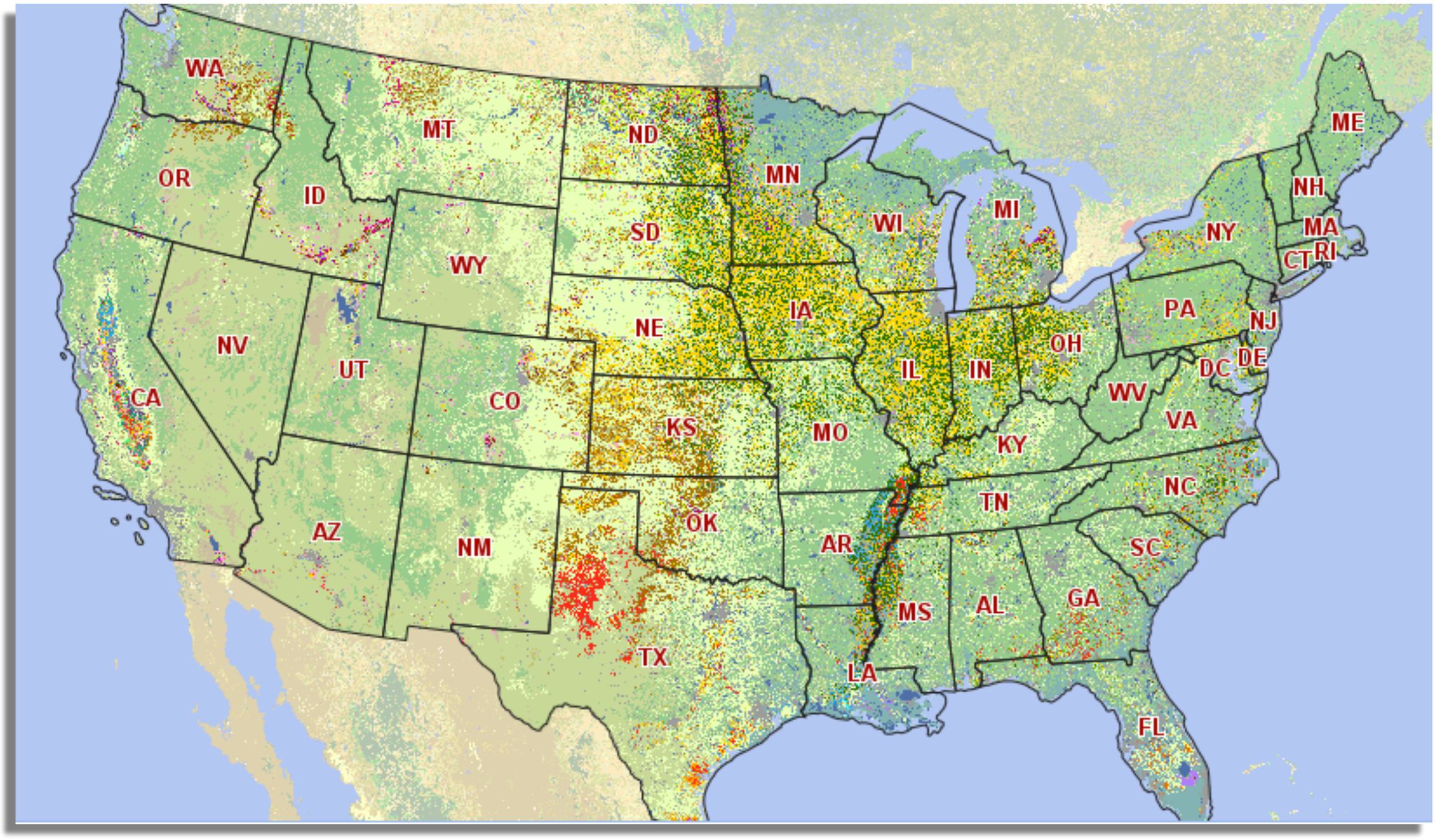
2007 Census of Agriculture

Estimated Agricultural Use for Clothianidin , 2010

EPest-Low



U.S. Crop distribution 2012



USDA CropScape Yellow=Corn Green=Soybeans Red=Cotton

Advanced social behaviors

- Longevity of female parent (queen) coexisting with her offspring
- Reproductive castes (two female castes)
- Siblings help with brood care
- Progressive brood feeding
- Age-determined division of labor
- Nest construction, thermoregulation
- Food storage
- Swarming as colony reproductive process
- Perennial colony
- **Communication among members**

Clay Stauffer photo

Waggle dance

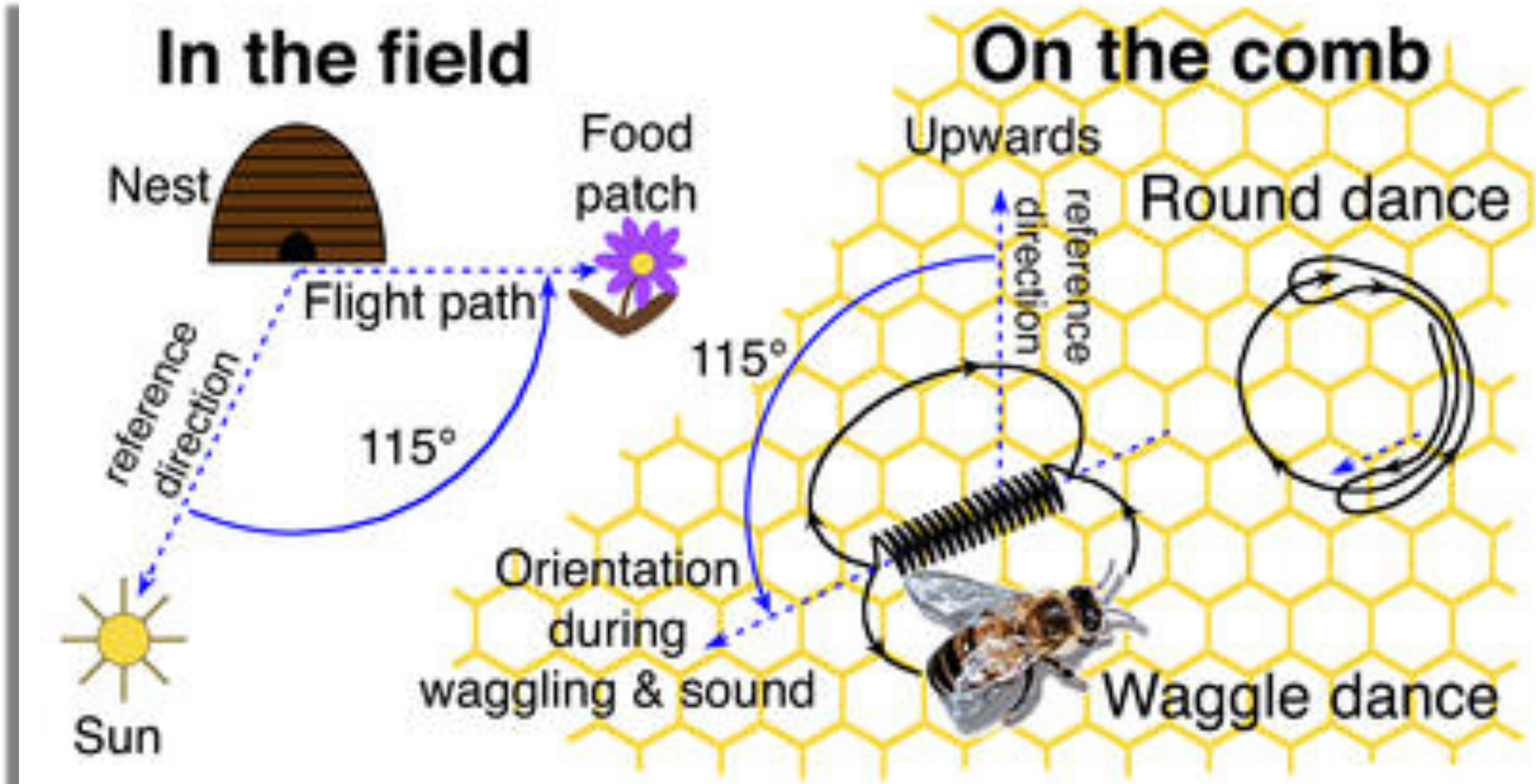


Diagram of the honeybee dance. (Credit: P. Kirk Visscher.)

Honey bee genome

- Compared with other insects' genomes, the honey bee genome encodes fewer proteins implicated in pathways, suggesting that "honeybees use novel immune pathways, are poorly defended against pathogens at the individual level, and/or have immune systems that are narrowly focused on a relatively small group of co-evolved pathogens" (HGSC, 2006).

- "Honey bees are unusually sensitive to certain pesticides, have fewer detoxifying genes than other insects. Sub-lethal effects of pesticides affect honey bee initial learning and odor responses, traits directly linked to foraging" (HGSC, 2006).

Table 3 | Gene family size differences with possible effects on honeybee lifestyle

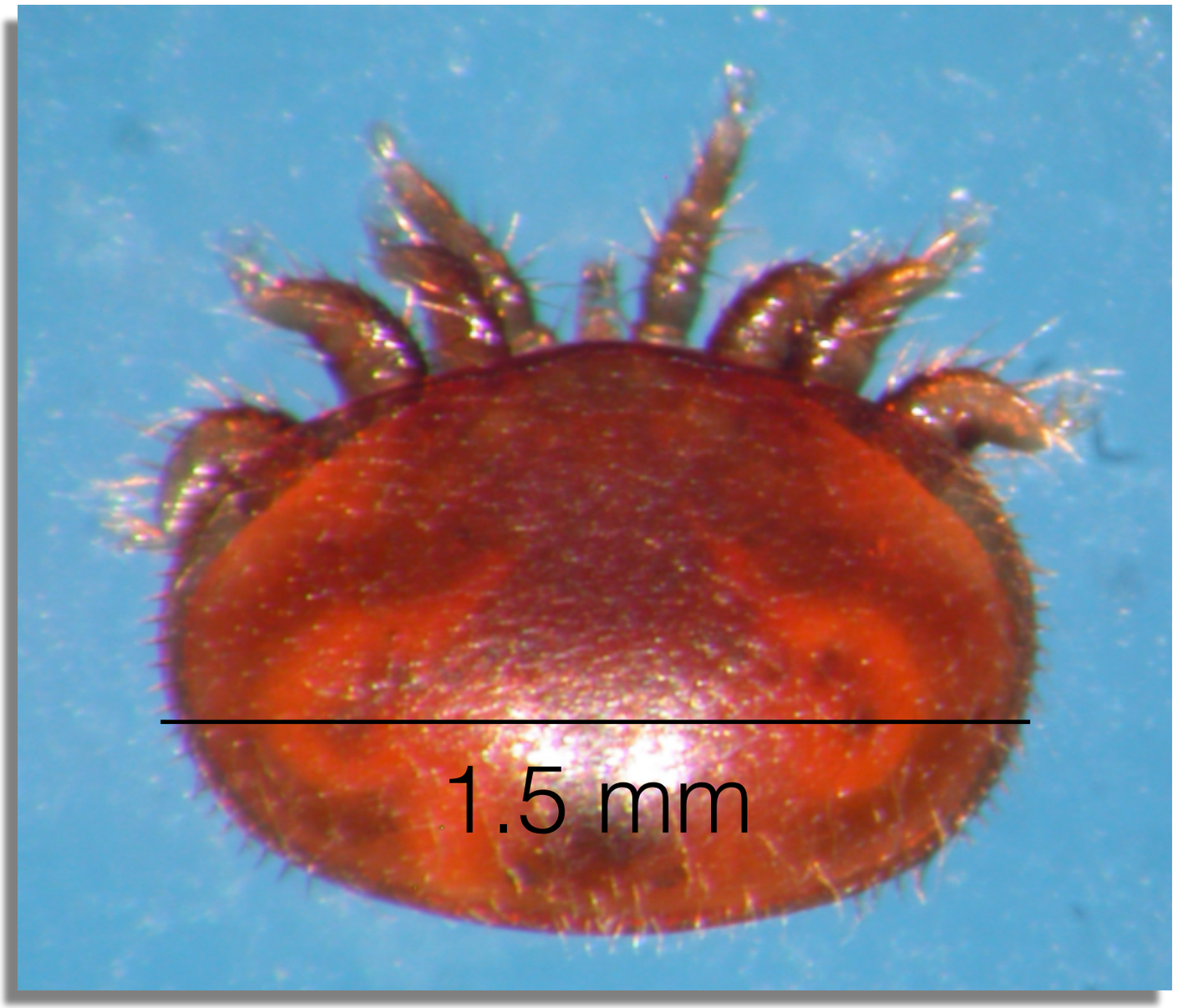
Family	Function	Family compared with *Drosophila*	Possible lifestyle effects
Major royal jelly	Brood feeding	Larger	Brood care; caste development[92]
Insulin/insulin-like growth factors	Ageing, fertility, many others	Variable for different subfamilies	Unique reversal of typical lifespan/fertility trade off
Cuticular proteins	Cuticle stability	Smaller	Protected hive environment allows simpler cuticle
Odorant receptors	Olfaction	Larger	Enhanced pheromone communication; odour-based kin recognition; generalist flower feeder
Gustatory receptors	Gustation	Smaller	Brood feeding; mutualistic flower feeder reduces threat of toxic food
Immunity	Infectious disease protection	Smaller	Paradox: high pathogen load due to sociality
Detoxification genes	Defence against xenobiotics	Smaller	Managed environment; specialized lifestyle

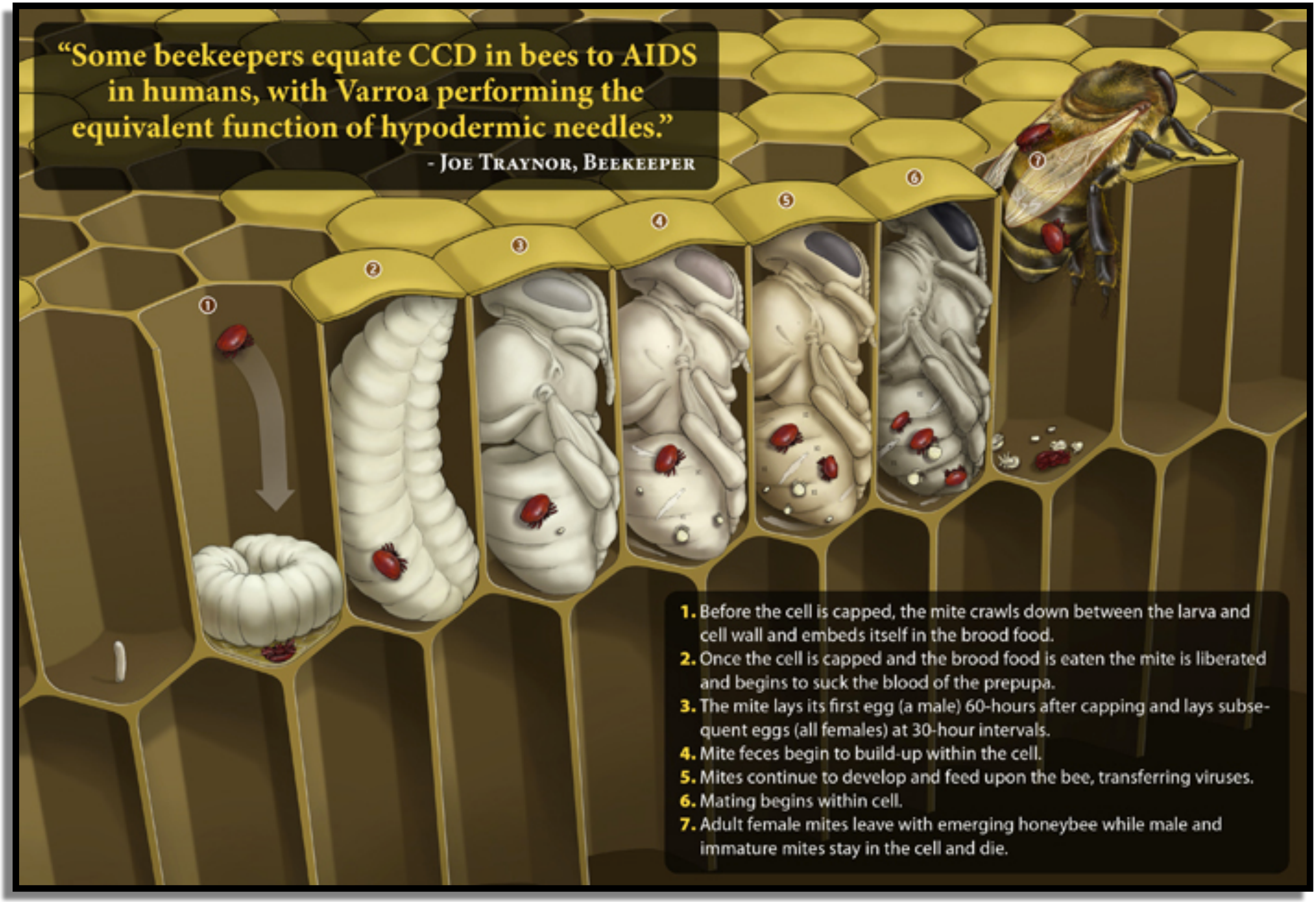
“What’s happening to the bees?”

- **Parasites:** especially Varroa destructor
- **Pathogens**
- **Pesticides**
- **Poor nutrition** because of habitat loss, prevalence of “monocultures”
- Loss of genetic diversity

Parasites

Varroa destructor:
the honey bee's biggest challenge




"Some beekeepers equate CCD in bees to AIDS in humans, with Varroa performing the equivalent function of hypodermic needles."
- Joe Traynor, Beekeeper
1. Before the cell is capped, the mite crawls down between the larva and cell wall and embeds itself in the brood food.
2. Once the cell is capped and the brood food is eaten the mite is liberated and begins to suck the blood of the prepupa.
3. The mite lays its first egg (a male) 60-hours after capping and lays subsequent eggs (all females) at 30-hour intervals.
4. Mite feces begin to build-up within the cell.
5. Mites continue to develop and feed upon the bee, transferring viruses.
6. Mating begins within cell.
7. Adult female mites leave with emerging honeybee while male and immature mites stay in the cell and die.

Tony Linka

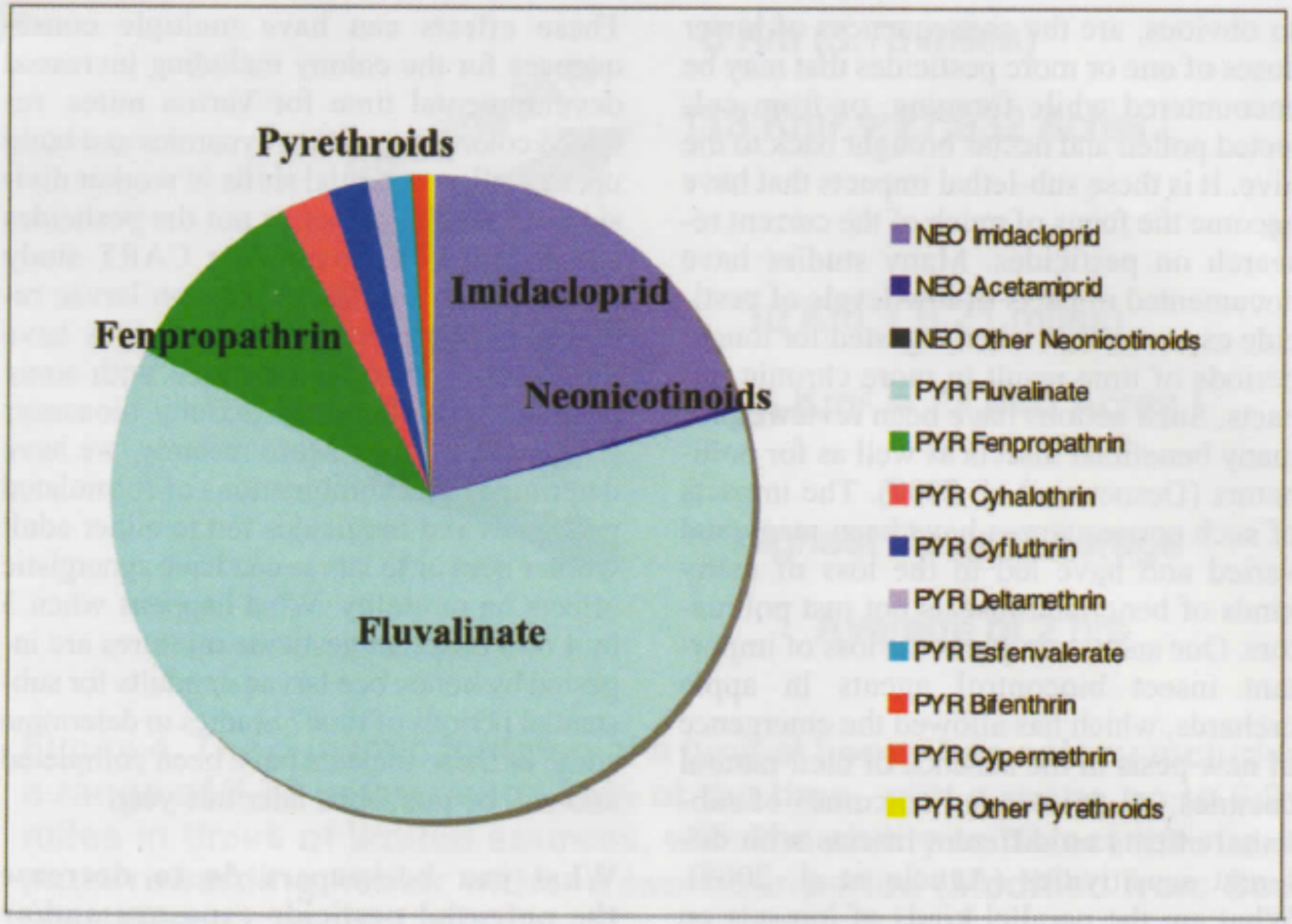


Figure 2. Relative hazard to honey bees of pyrethroids and neonicotinoids detected in 503 pollen samples estimated by (mean detection X frequency)/LD50.

Breeding better bees

Varroa sensitive hygiene or VSH: Some strains of honey bees do better than others at combating varroa mite. Bee breeders are actively developing these genetic lines of bees.

Pathogens

European foul brood

American foul brood

Nosema

Sacbrood virus

Israeli acute paralysis virus

Acute paralysis virus

Kashmir bee virus

Chronic bee paralysis virus

Deformed wing virus

Hairless black syndrome

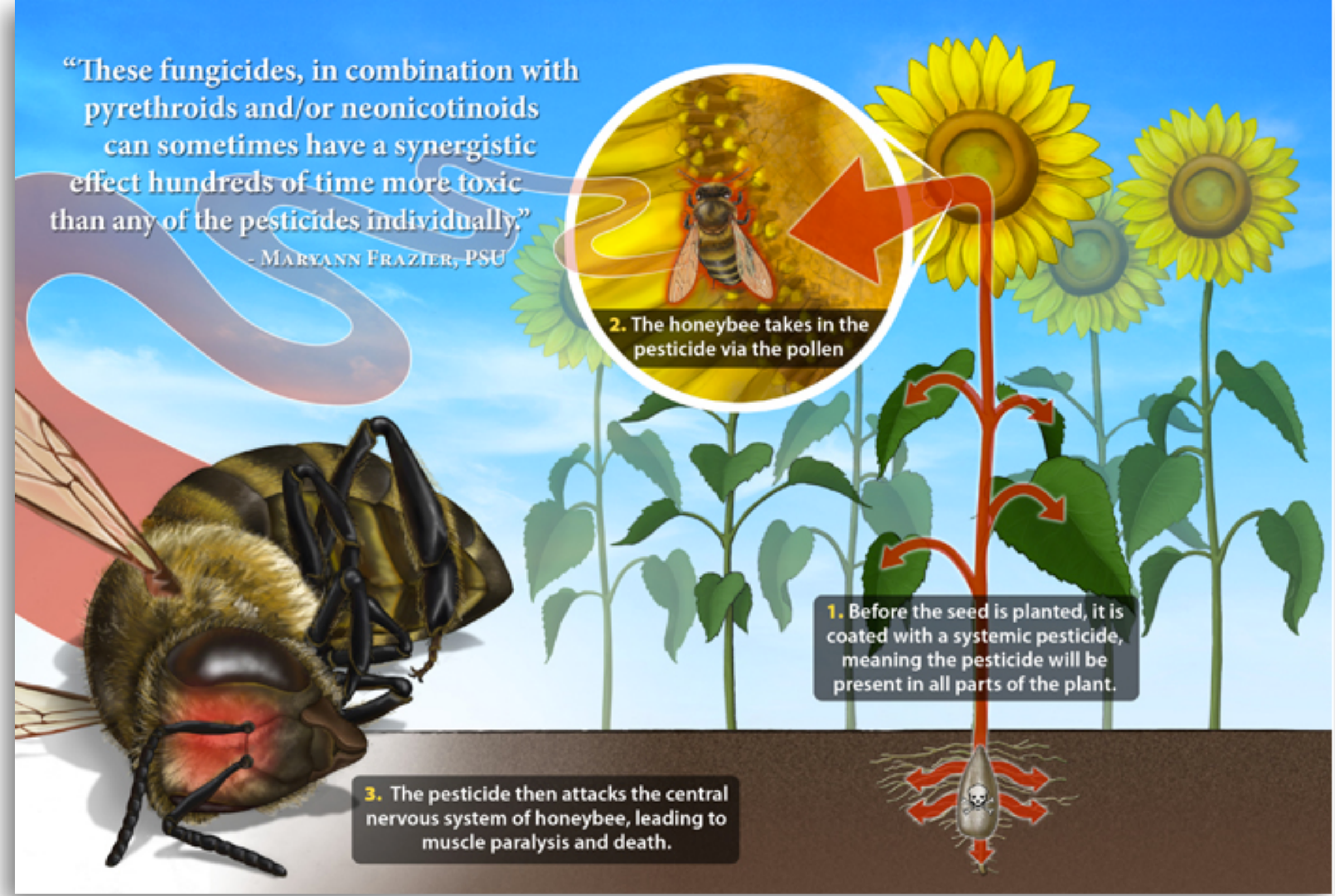
Pesticides

- Modern U.S. agriculture dependent on pesticides, herbicides, fungicides. More than 1,200 registered active ingredients in some 18,000 products: A complex chemical landscape.

- In France, fewer than 500. In Britain, fewer than 300.

- New classes of insecticides, such as systemic neonicotinoids, while in some ways safer for bees, may pose serious problems at sub-lethal doses, since entire plant (including pollen) is toxic.

- “The 98 pesticides and metabolites detected in mixtures up to 214 ppm in bee pollen alone represents a remarkably high level for toxicants in the brood and adult food of this primary pollinator. This represents over half of the maximum individual pesticide incidences ever reported for apiaries. While exposure to many of these neurotoxicants elicits acute and sublethal reductions in honey bee fitness, the effects of these materials in combinations and their direct association with CCD or declining bee health remains to be determined.” (Mullin, 2010)


"These fungicides, in combination with pyrethroids and/or neonicotinoids can sometimes have a synergistic effect hundreds of time more toxic than any of the pesticides individually."
- Maryann Frazier, PSU
2. The honeybee takes in the pesticide via the pollen
1. Before the seed is planted, it is coated with a systemic pesticide, meaning the pesticide will be present in all parts of the plant.
3. The pesticide then attacks the central nervous system of honeybee, leading to muscle paralysis and death.

Tony Linka

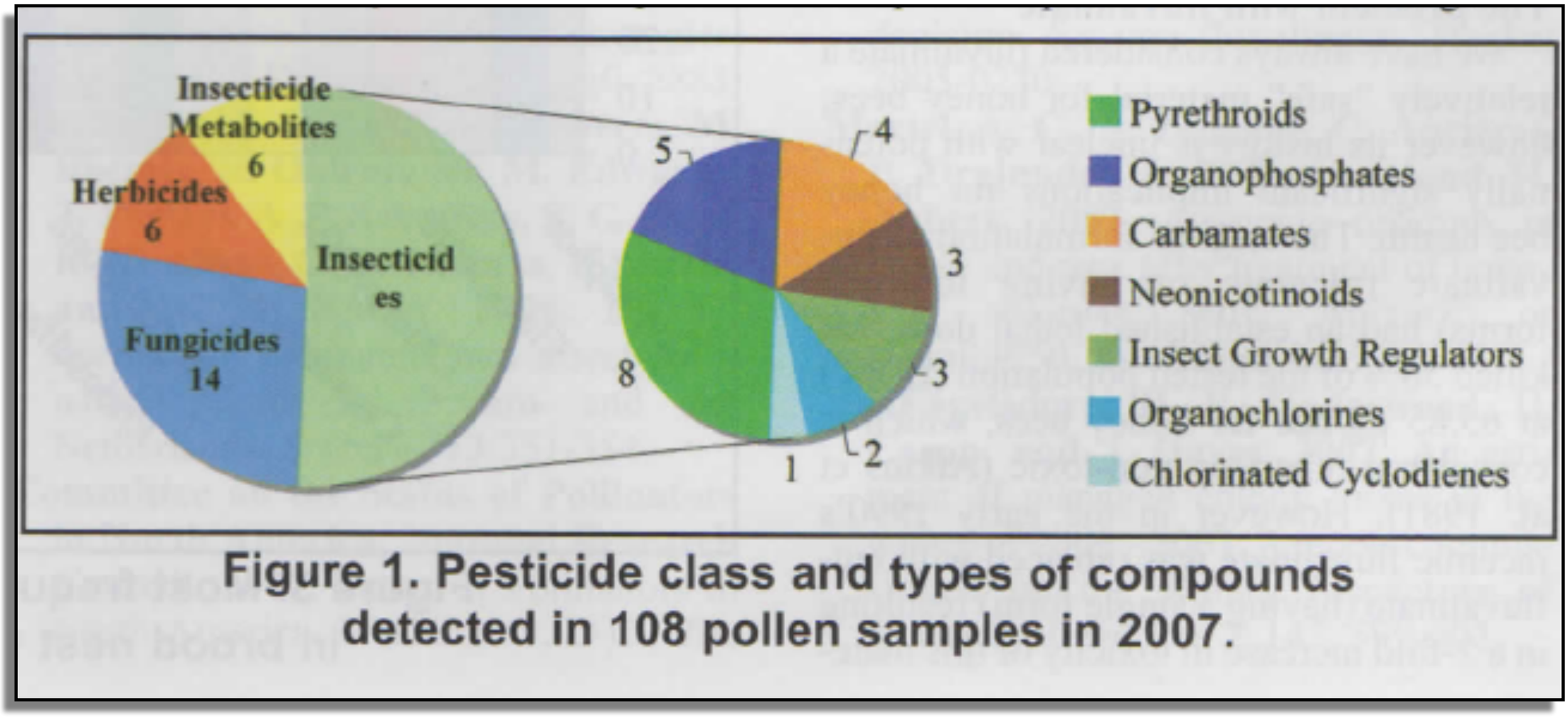


Figure 1. Pesticide class and types of compounds detected in 108 pollen samples in 2007.

Frazier, Mullin et al, 2008

“Laboratory tests on individual honey bees have shown that field-relevant, sublethal doses of some pesticides have effects on bee behavior and susceptibility to disease.”

—(Dr. Reed Johnson, Ohio State University, Columbus, Ohio; Dr. James Frazier, Pennsylvania State University, University Park, Pennsylvania)

“The use of neonicitinoid seed treatments over hundreds of millions of acres annually, coupled with their extremely high toxicity to honey bees, and their persistence in plants (including nectar and pollen that bees eat) combine to create and environment where it is very difficult for bees to avoid exposure to these highly toxic chemicals.”

—Greg Hunt, professor, Behavioral Genetics, Purdue University

—Christian Krupke, associate professor, Dept. of Entomology, Purdue University

THE NEW EPA BEE ADVISORY BOX

On EPA's new and strengthened pesticide label to protect pollinators

PROTECTION OF 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.

Bees and other insect pollinators will forage on plants when they flower, shed pollen, or produce nectar.

Bees and other insect pollinators can be exposed to this pesticide from:

- Direct contact during foliar applications, or contact with residues on plant surfaces after foliar applications
- Ingestion of residues in nectar and pollen when the pesticide is applied as a seed treatment, soil, tree injection, as well as foliar applications.

When Using This Product Take Steps To:

- Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants around the application site.
- Minimize drift of this product on to beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives can result in bee kills.

Information on protecting bees and other insect pollinators may be found at the Pesticide Environmental Stewardship website at:

http://pesticidestewardship.org/pollinatorprotection/Pages/default.aspx

Pesticide incidents (for example, bee kills) should immediately be reported to the state/tribal lead agency. For contact information for your state/tribe, go to www.aapco.org. Pesticide incidents can also be reported to the National Pesticide Information Center at www.npic.orst.edu or directly to EPA at beekill@epa.gov

Alerts users to separate restrictions on the label. These prohibit certain pesticide use when bees are present.

The new bee icon helps signal the pesticide's potential hazard to bees.

Makes clear that pesticide products can kill bees and pollinators.

Bees are often present and foraging when plants and trees flower. EPA's new label makes it clear that pesticides cannot be applied until all petals have fallen.

Warns users that direct contact and ingestion could harm pollinators. EPA is working with beekeepers, growers, pesticide companies, and others to advance pesticide management practices.

Highlights the importance of avoiding drift. Sometimes, wind can cause pesticides to drift to new areas and can cause bee kills.

The science says that there are many causes for a decline in pollinator health, including pesticide exposure. EPA's new label will help protect pollinators.

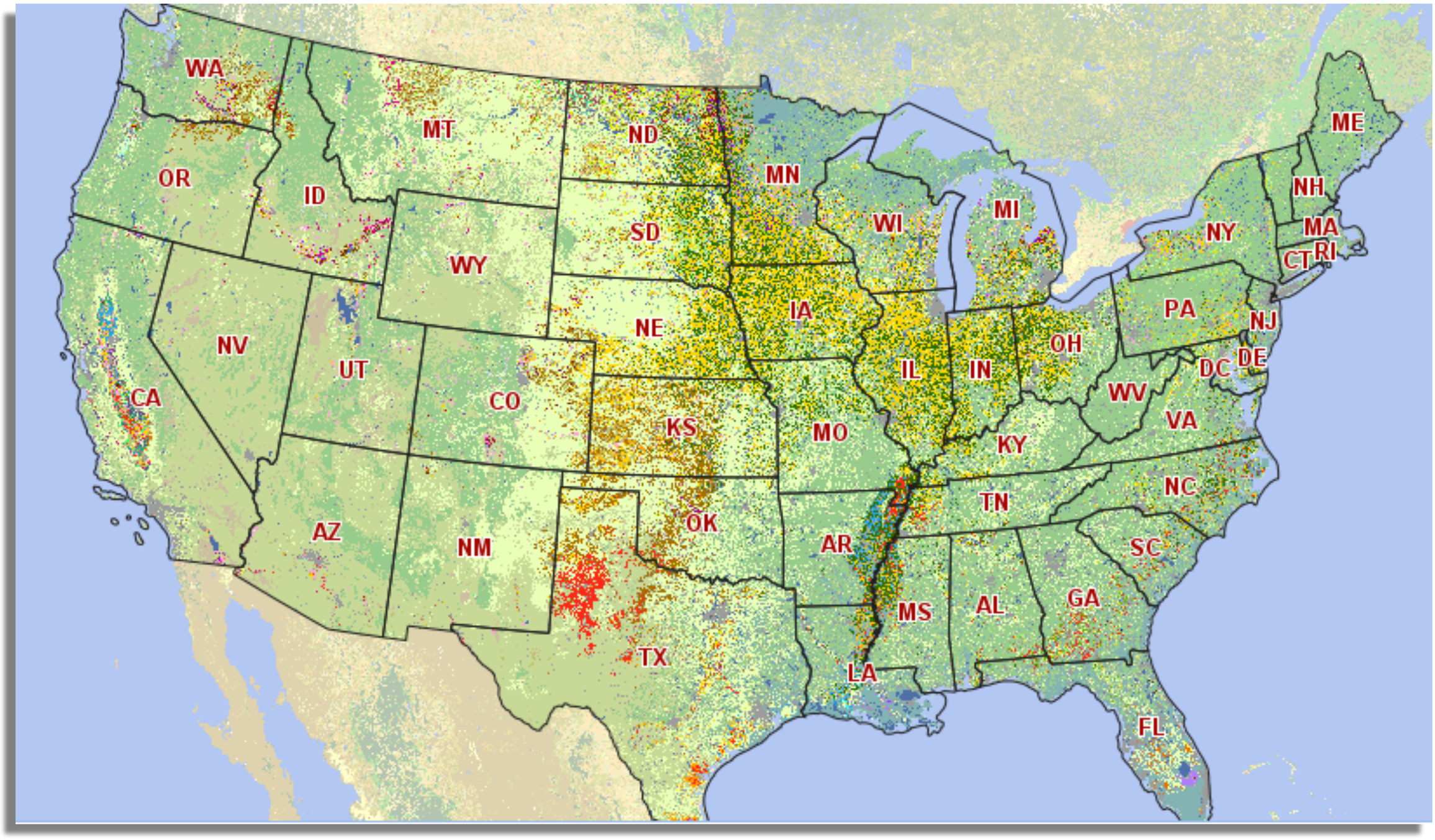
EPA

Read EPA's new and strengthened label requirements: http://go.usa.gov/jHH4

Habitat loss

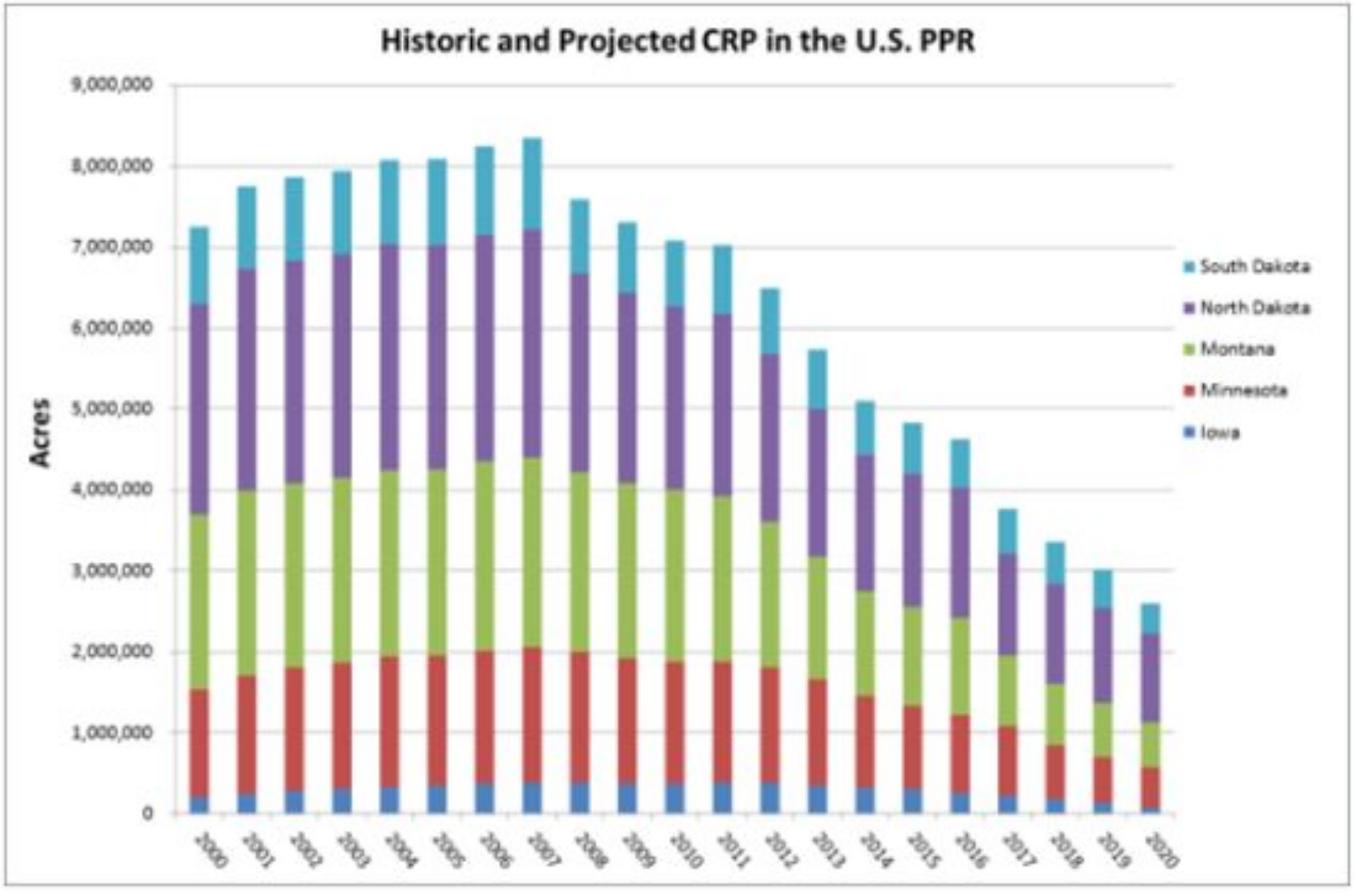
Bees need diverse flowering plants to provide adequate nectar and pollen. Intensive, chemically dependent cultivation of soybeans and corn, which dominates the Midwest farm belt, forms agricultural deserts .

U.S. Crop distribution 2012



USDA CropScape Yellow=Corn Green=Soybeans Red=Cotton

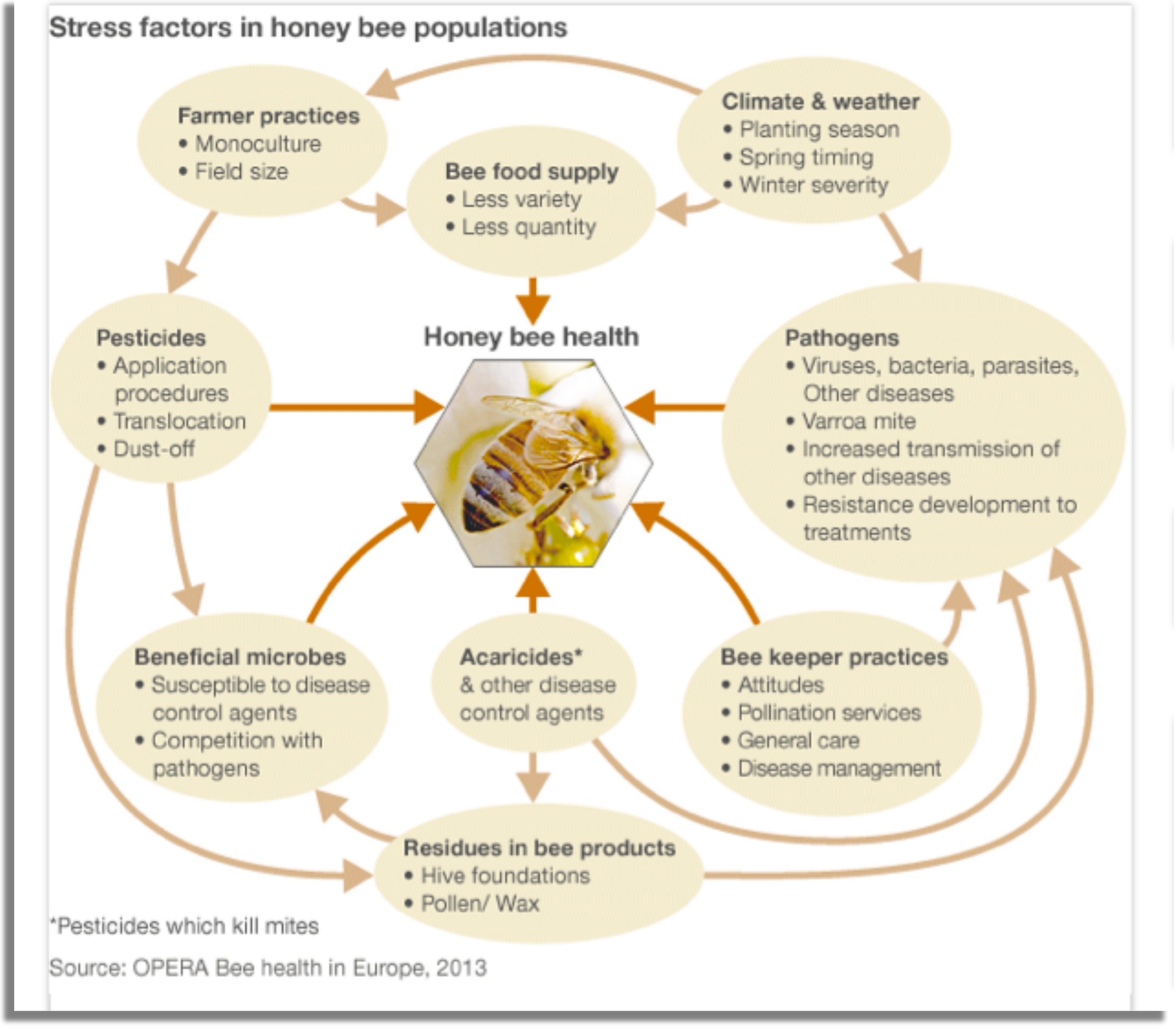
Unfortunately, during the past 5 years, more than 30 percent of the CRP lands (peak of 8.3 million acres enrolled in 2007 compared to 5.7 million acres in 2013) have expired across the U.S. Prairie Pothole Region and these downward trends are expected to continue for the next several years.




Alberta
Saskatchewan
Manitoba
Montana
North Dakota
Minnesota
South Dakota
Iowa
The Prairie Pothole Region

“CCD”: A complex of factors rather than a single cause

“The interactions between pesticides, mite stresses and diseases including the newly identified Israeli acute paralysis virus … are likely contributing factors, and support an emerging hypothesis that no one factor alone is responsible for the dramatic losses of honey bees in general or for CCD specifically.” (Mullin, 2010)


Stress factors in honey bee populations
Farmer practices
• Monoculture
• Field size
Climate & weather
• Planting season
• Spring timing
• Winter severity
Bee food supply
• Less variety
• Less quantity
Honey bee health
Pesticides
• Application procedures
• Translocation
• Dust-off
Pathogens
• Viruses, bacteria, parasites, Other diseases
• Varroa mite
• Increased transmission of other diseases
• Resistance development to treatments
Beneficial microbes
• Susceptible to disease control agents
• Competition with pathogens
Acaricides*
& other disease control agents
Bee keeper practices
• Attitudes
• Pollination services
• General care
• Disease management
Residues in bee products
• Hive foundations
• Pollen/ Wax
*Pesticides which kill mites
Source: OPERA Bee health in Europe, 2013

Findings from 2012 Report on the National Stakeholders Conference on Honey Bee Health

- Consensus is building that a complex set of stressors and pathogens is associated with CCD.
- The parasitic mite Varroa destructor remains the single worst pest of honey bees, and is closely associated with overwintering colony losses.
- Multiple virus species have been associated with CCD.
- Varroa is a vector and amplifier of bee viruses.
- Nutrition has a major impact on individual bee and colony longevity.

- Acute and sublethal effects of pesticides on honey bees have been increasingly documented, and are a primary concern.
- The most pressing pesticide research questions lie in determining the actual field-relevant pesticide exposure bees receive and the effects of pervasive exposure to multiple pesticides on bee health and productivity of whole honey bee colonies.
- Genetic variation improves bee thermoregulation, disease resistance and worker productivity.
- Genomic insights from sequencing the honey bee genome are now widely used to understand and address major questions of breeding, parasite interactions, novel controls (*e.g.*, RNA*i*), and management to make bees less stressed and more productive.

Clay Stauffer photos

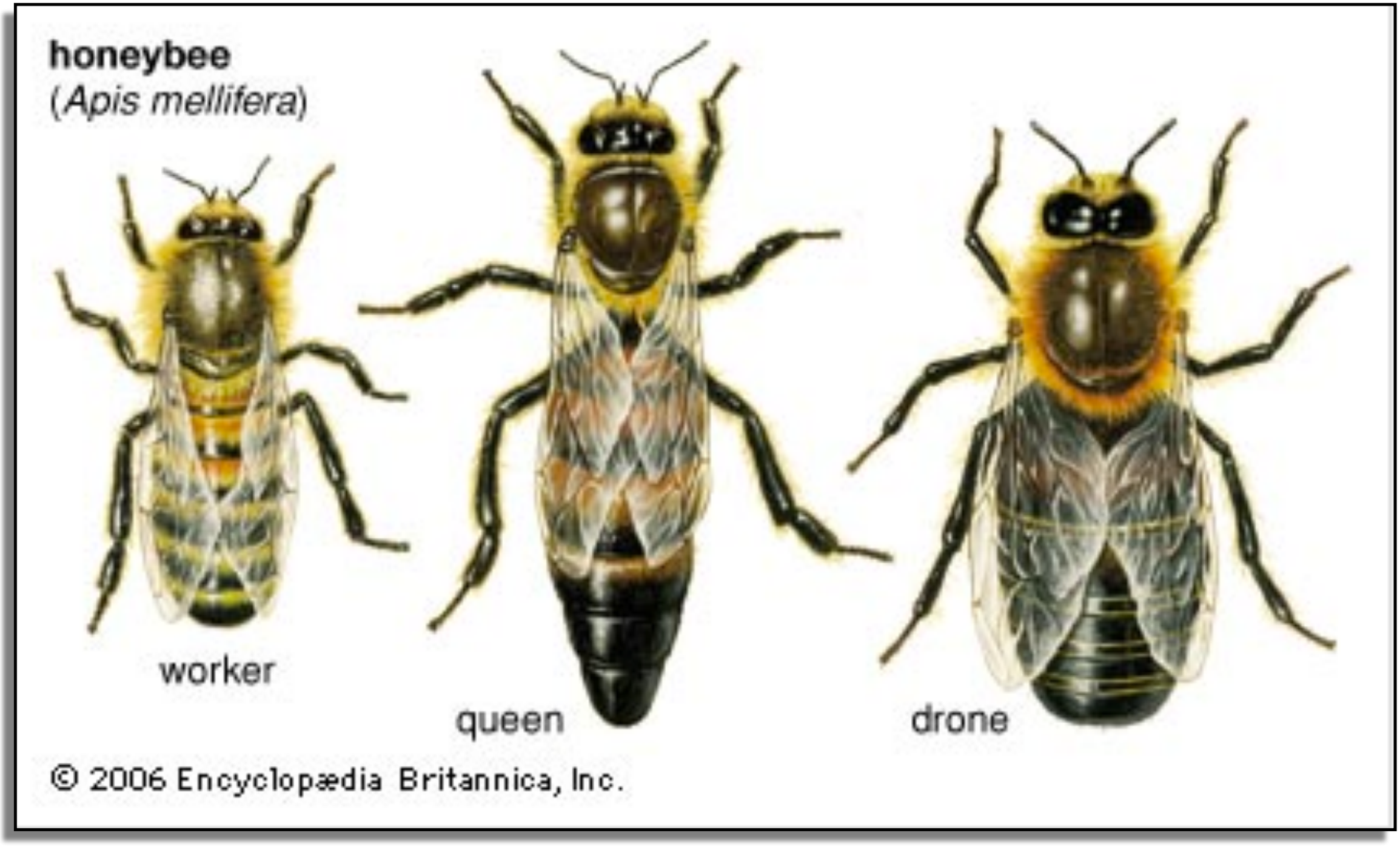
Queen

Clay Stauffer photo

Drone

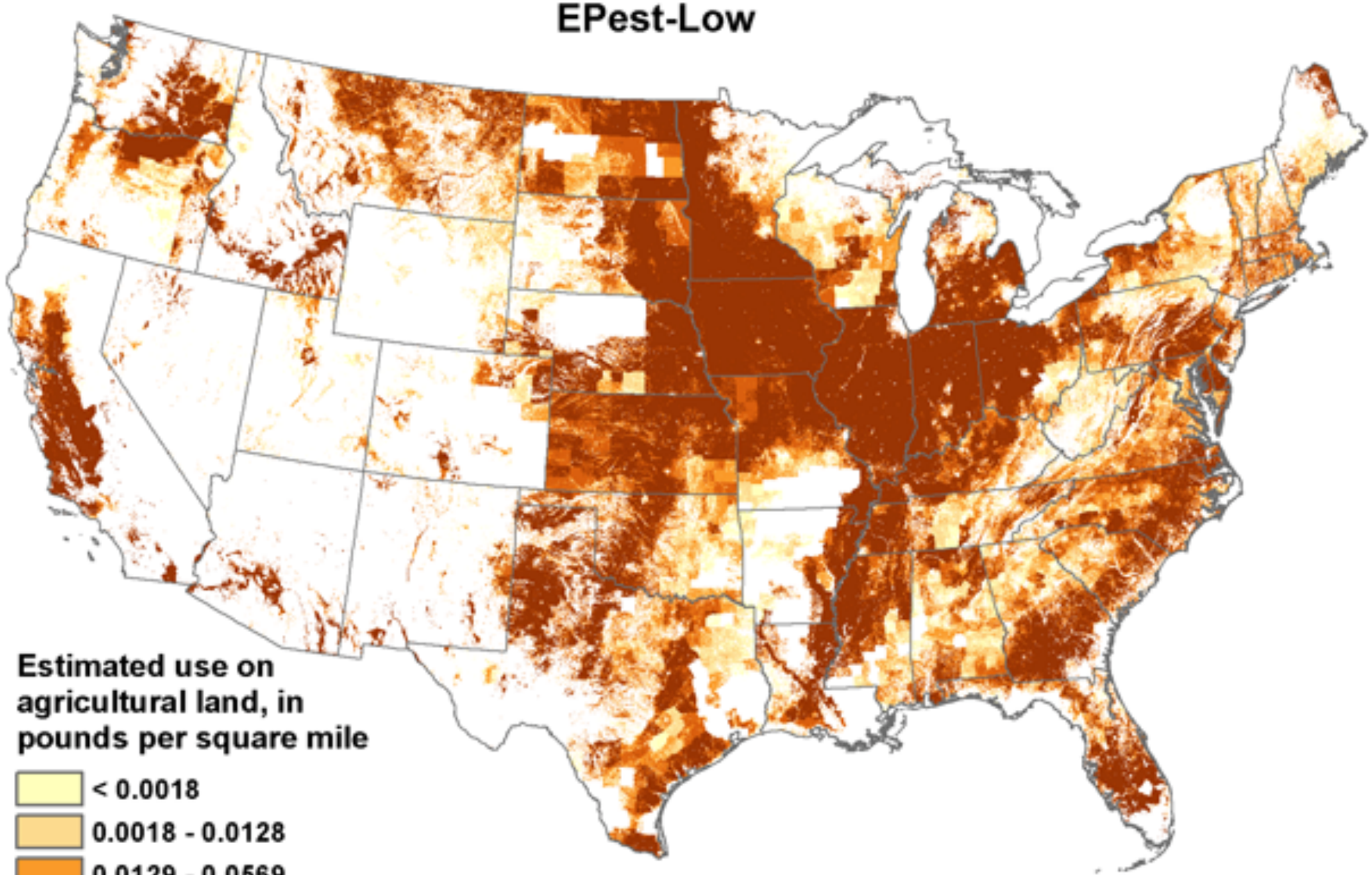
Clay Stauffer photo

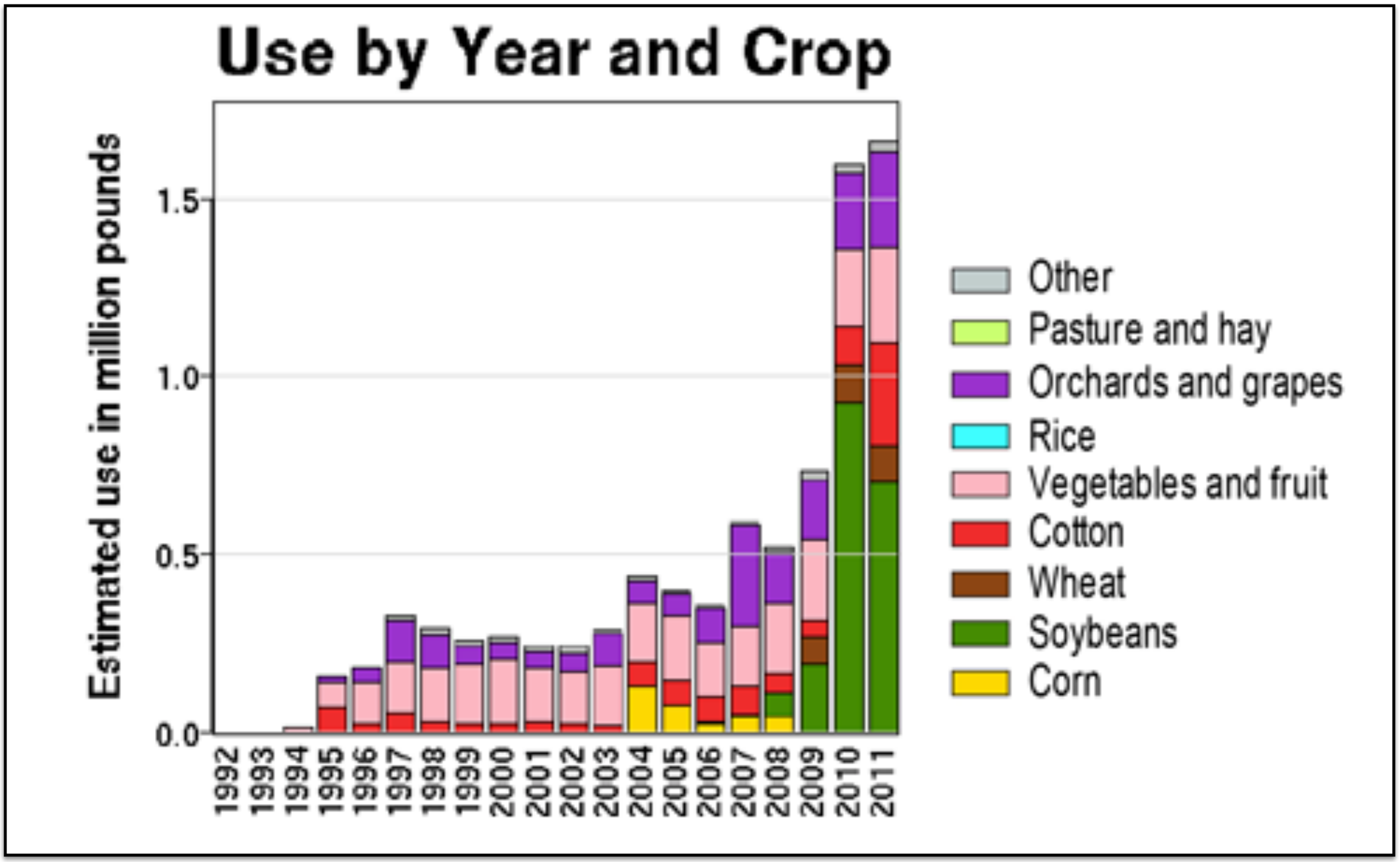
3 castes: worker, queen, drone



Estimated Agricultural Use for Imidacloprid , 2011

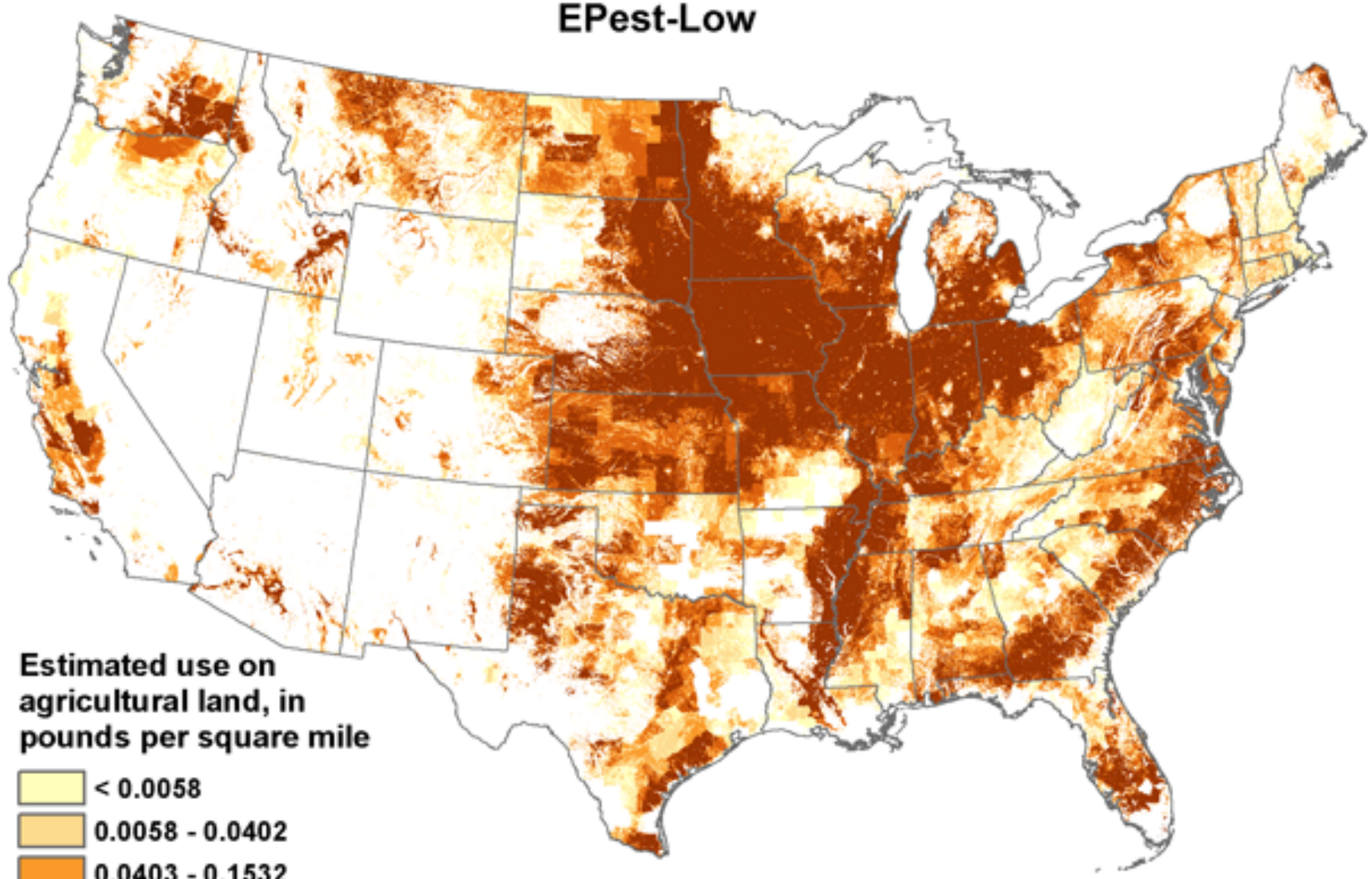
EPest-Low

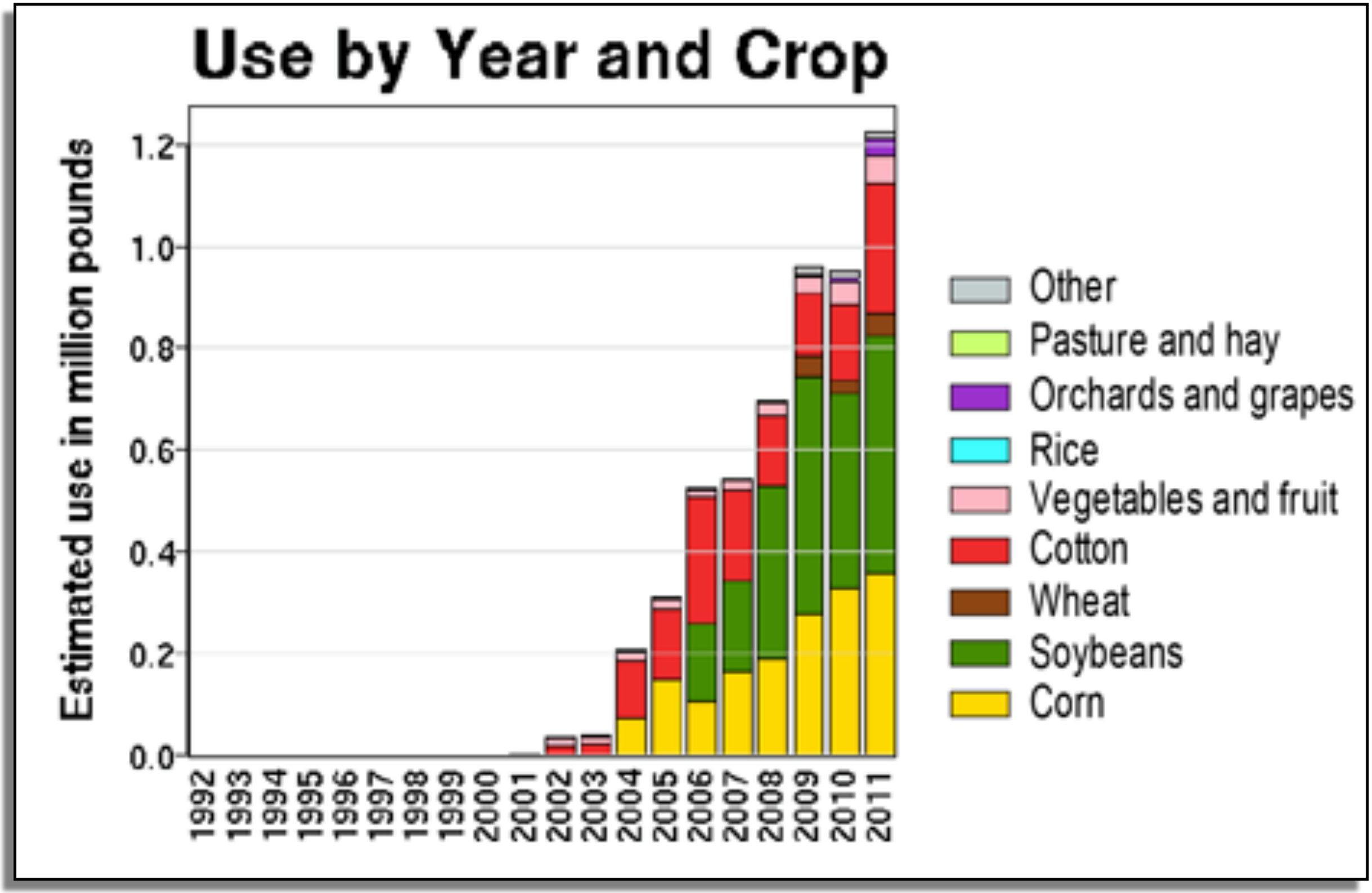



Use by Year and Crop
Estimated use in million pounds
1.5
1.0
0.5
0.0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Other
Pasture and hay
Orchards and grapes
Rice
Vegetables and fruit
Cotton
Wheat
Soybeans
Corn

Estimated Agricultural Use for Thiamethoxam , 2011

EPest-Low



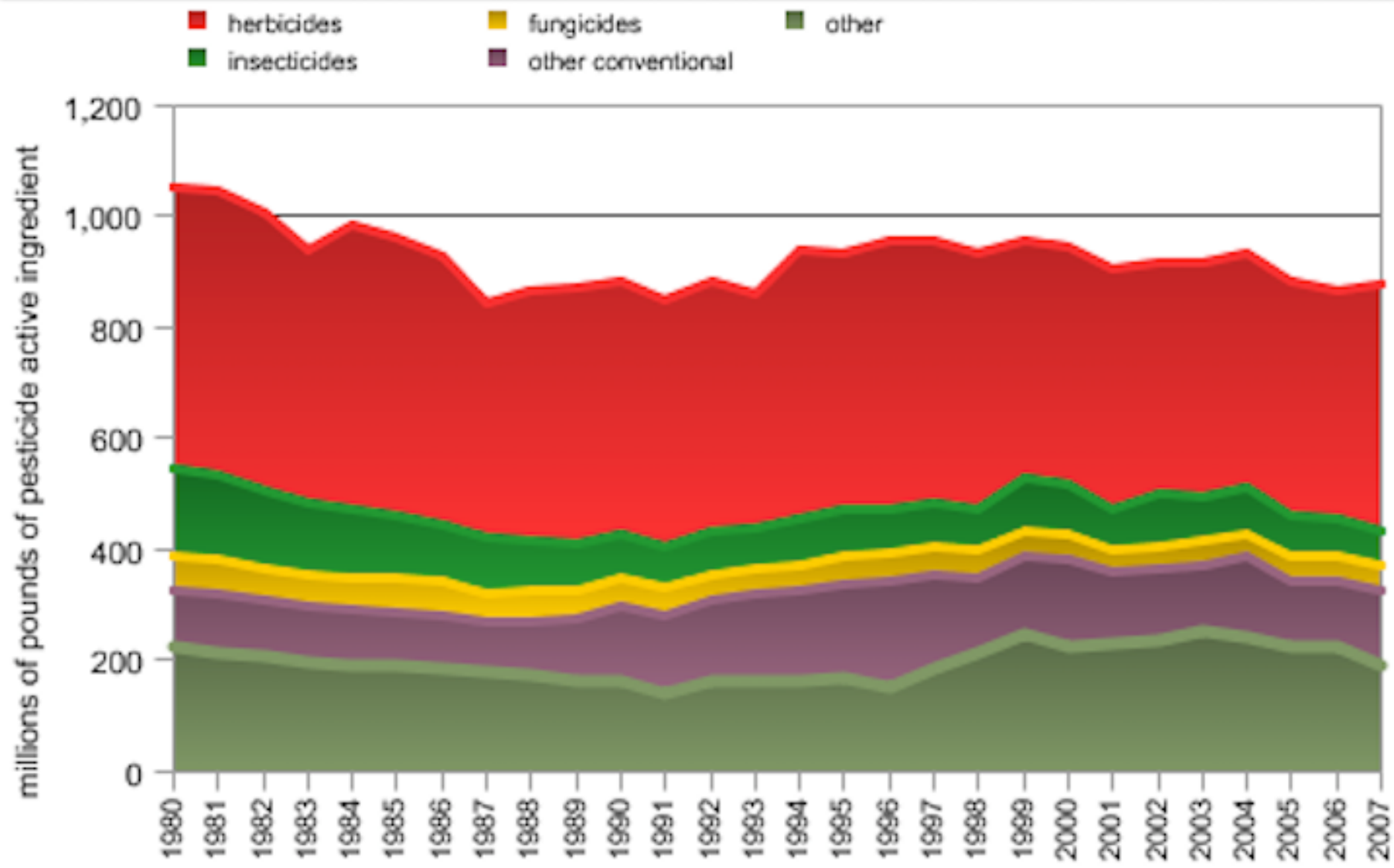

Use by Year and Crop
Estimated use in million pounds
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Other
Pasture and hay
Orchards and grapes
Rice
Vegetables and fruit
Cotton
Wheat
Soybeans
Corn

Genetic diversity is critical to honey bees colonies

- Historical pattern of honey bee introductions to the New World primarily occurred between 1622 and 1922. Eight Old World subspecies were introduced, including several from Africa, the Middle East and Europe. Only three European strains found favor with U.S. beekeepers: Italian, Carniolan, and Caucasian.
- At the intra-colony level: genetic variation improves thermoregulation, disease resistance, worker productivity, i.e., related to colony health
- At the population level: U.S. honey bees show effects of multiple “bottlenecks”
- Initial introductions of limited numbers of queens, queen production methods (One million queens produced from less than 600 “mother” queens), highly restricted importation of new breeding germplasm since 1922.
    - (Dr. Marla Spivak, University of Minnesota, St. Paul, Minnesota; and Dr. W. Steve Sheppard, Washington State University, Pullman, Washington).

Foraging worker bee with a load of pollen.

Pesticide active ingredients applied by U.S. agricultural producers, 1980-2007



Source: Estimates for 1980-1987 are from Donaldson et al., and the estimates for 1988-2007 are from Grube et al.

ERS