# What to do when over-zealous pesticide use exacerbates pest management problems

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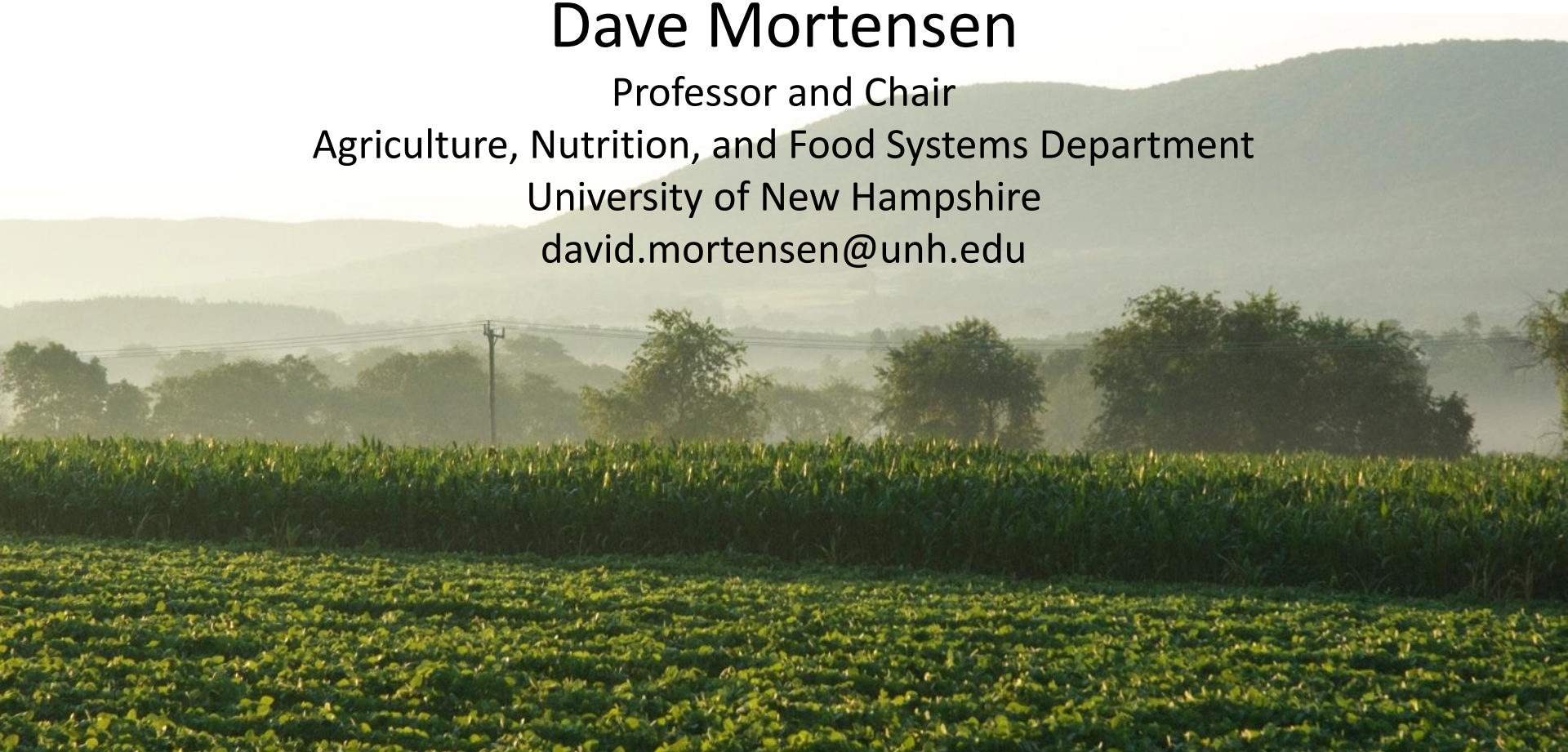


# Outline

- Intensification justified by doubling yield by 2050
- Lock-in on intensification syndrome of production
- Research, outreach and policy that takes a more sustainable path forward

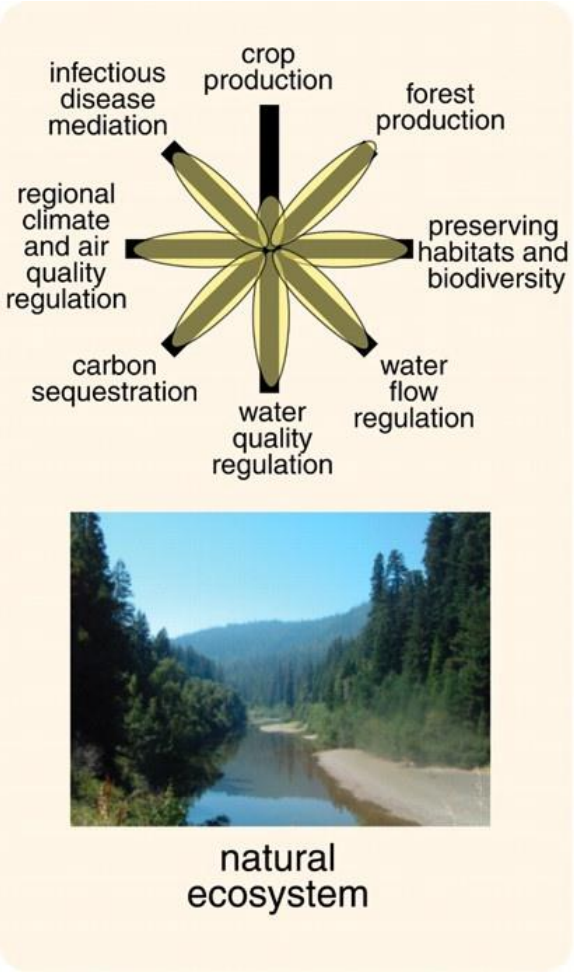
# Agriculture in 2050: Recalibrating Targets for Sustainable Intensification

MITCHELL C. HUNTER, RICHARD G. SMITH, MEAGAN E. SCHIPANSKI, LESLEY W. ATWOOD, AND DAVID A. MORTENSEN

*The prevailing discourse on the future of agriculture is dominated by an imbalanced narrative that calls for food production to increase dramatically—potentially doubling by 2050—without specifying commensurate environmental goals. We aim to rebalance this narrative by laying out quantitative and compelling midcentury targets for both production and the environment. Our analysis shows that an increase of approximately 25%–70% above current production levels may be sufficient to meet 2050 crop demand. At the same time, nutrient losses and greenhouse gas emissions from agriculture must drop dramatically to restore and maintain ecosystem functioning. Specifying quantitative targets will clarify the scope of the challenges that agriculture must face in the coming decades, focus research and policy on achieving specific outcomes, and ensure that sustainable intensification efforts lead to measurable environmental improvements. We propose new directions for research and policy to help meet both sustainability and production goals.*

BioScience, 2017

# We need more from our cropping systems




Foley et al. 2005

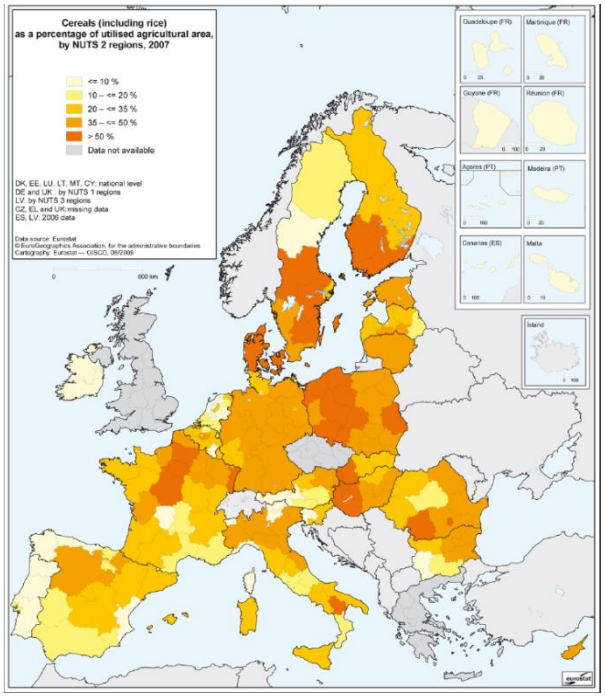
# Intensification syndrome

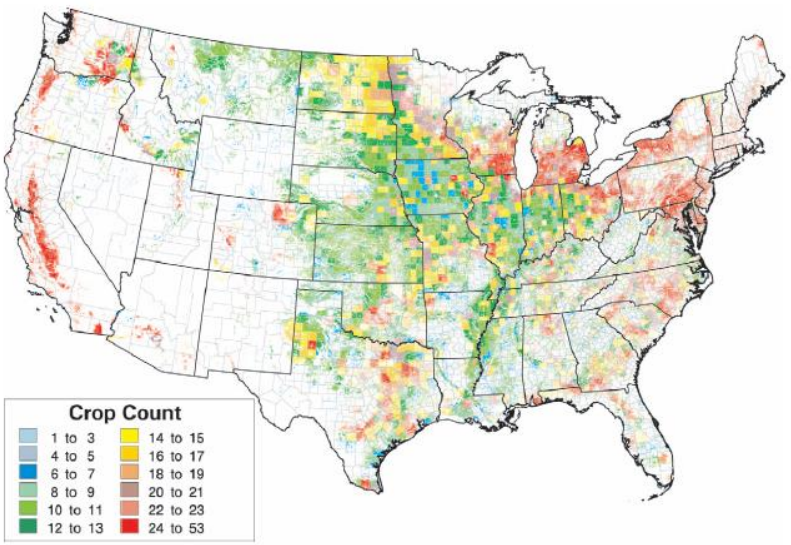
A syndrome of production

# Intensification syndrome

- Larger fields
- Reduced or no crop diversity
- Larger farms
- Increased reliance on pesticides and synthetic fertilizers
- Increased reliance on genetically modified crops
- Fewer people
- Depopulation of rural communities

# Snapshot of European and U.S. Agriculture

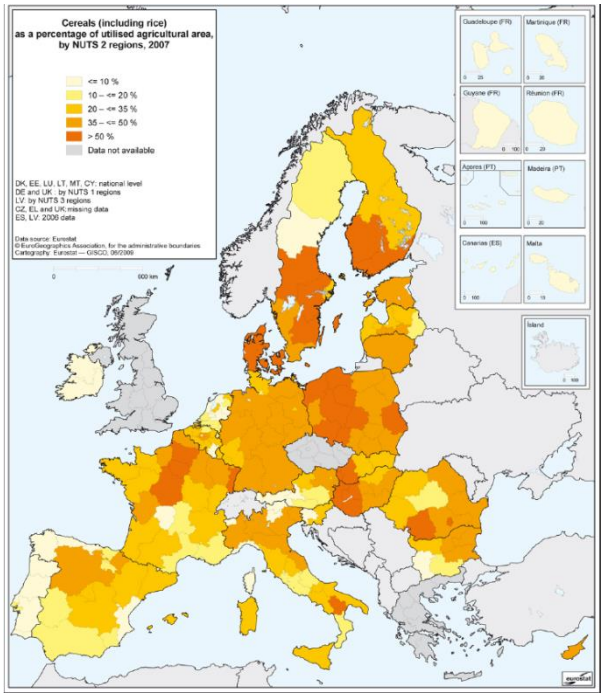


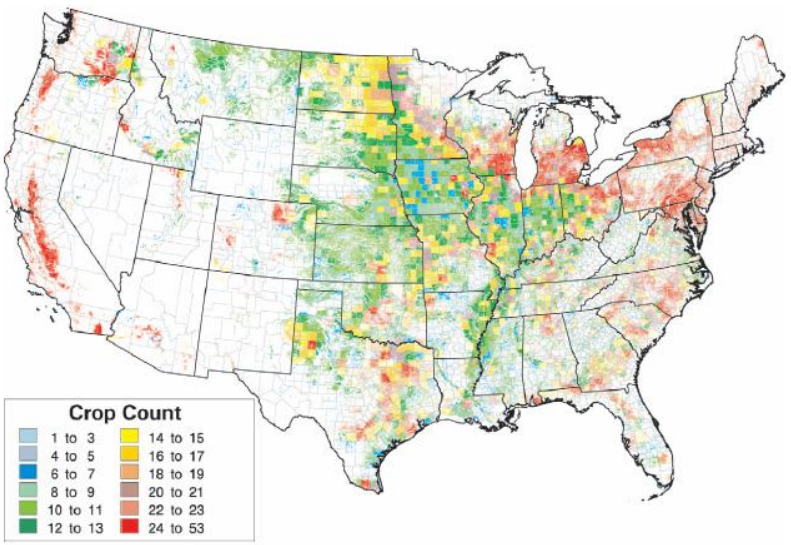




| | E.U. 27 | U.S. |
|---|---|---|
| Area in Agriculture (ha) | 184 mil | 373 mil |
| Gross Value of Ag products (€) | 143 bil | 240 bil |
| Employment (people) | 10.5 mil | 1.3 mil |
| Average farm size (ha) | 19.3 | 418 |
| Area planted to GMO (ha) | .09 mi | 66.8 mil |

Source: European Commission 2010; NASS 2010

# Snapshot of European and U.S. Agriculture

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Replace more-toxic herbicides
Reduce total amount of herbicide use
Simplify and improve weed management
Unlikely weeds would develop resistance

Moving forward

In 1996, glyphosate-resistant soybean and canola were released

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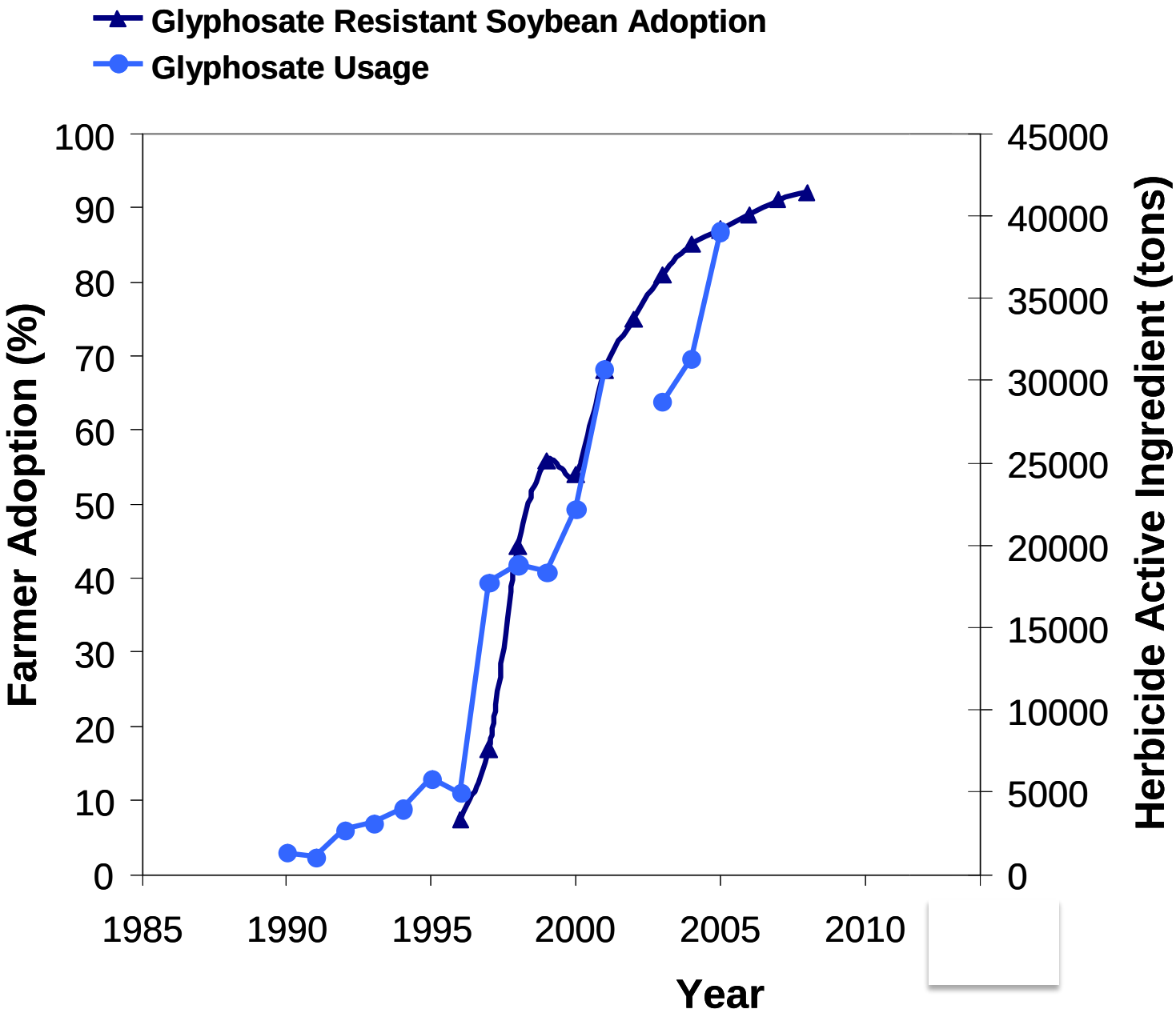
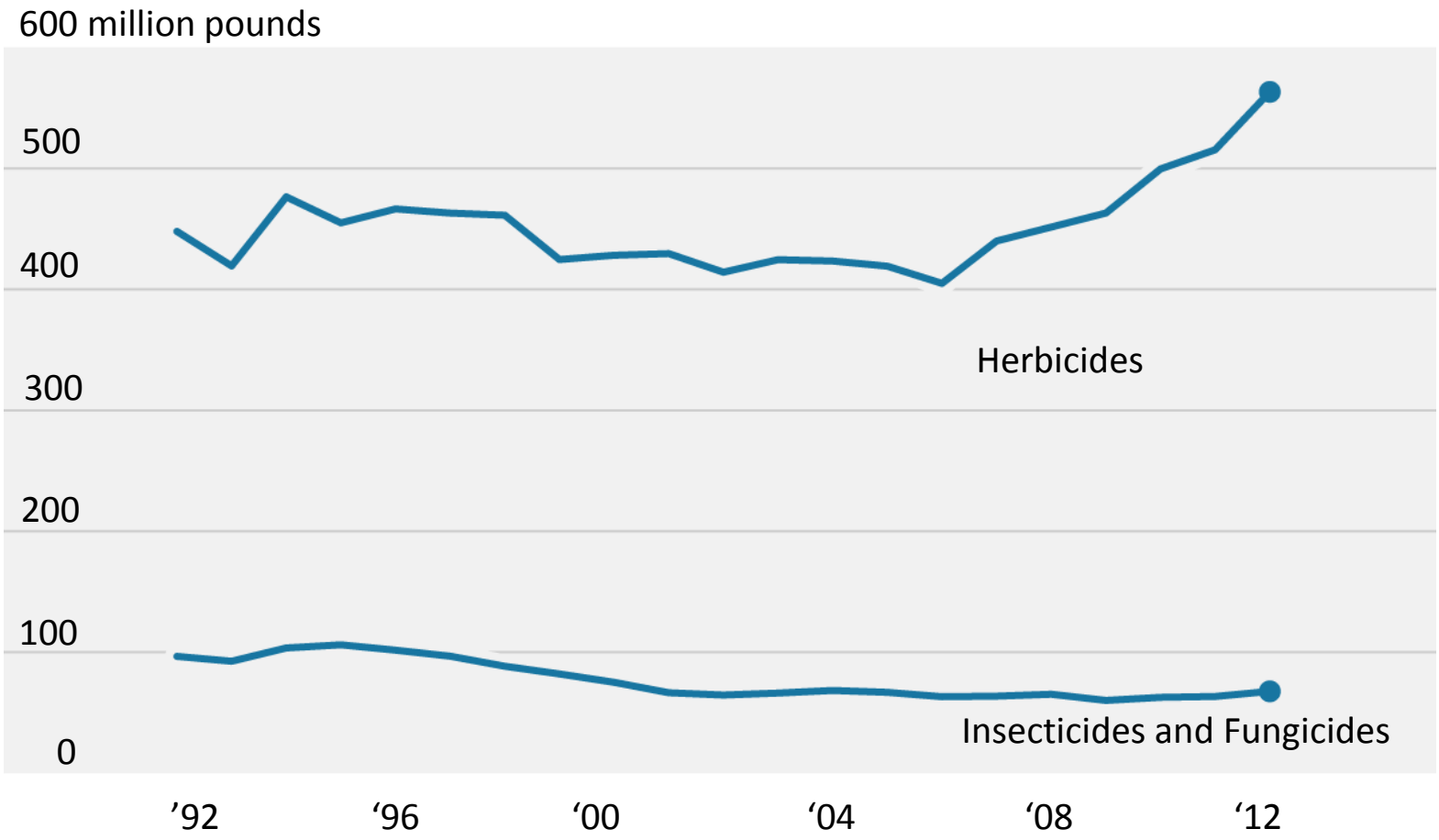
Moving forward

Herbicide use increases
and resistance is widespread

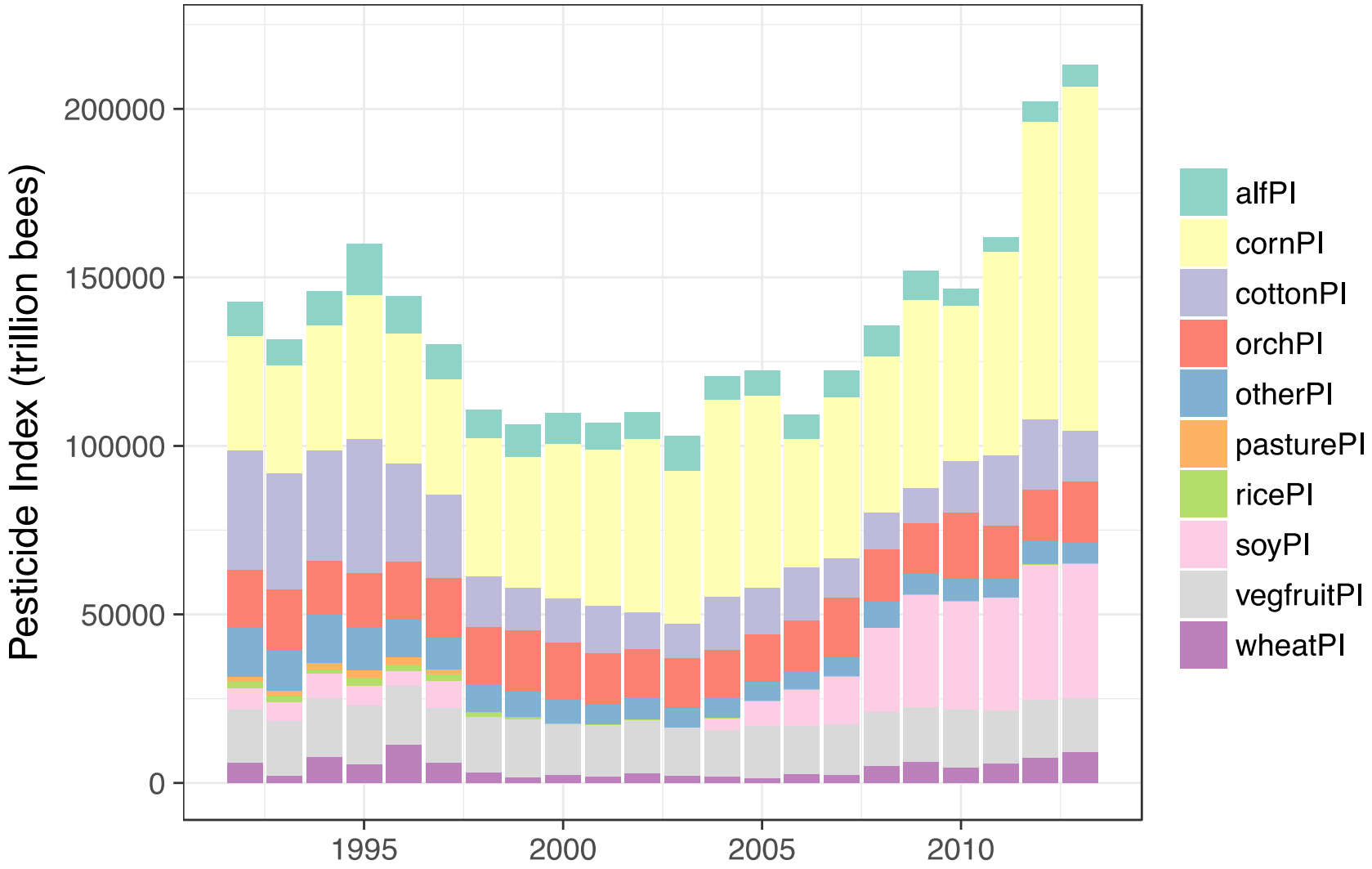
28 weed species now infest 24 million ha of arable cropland in the US

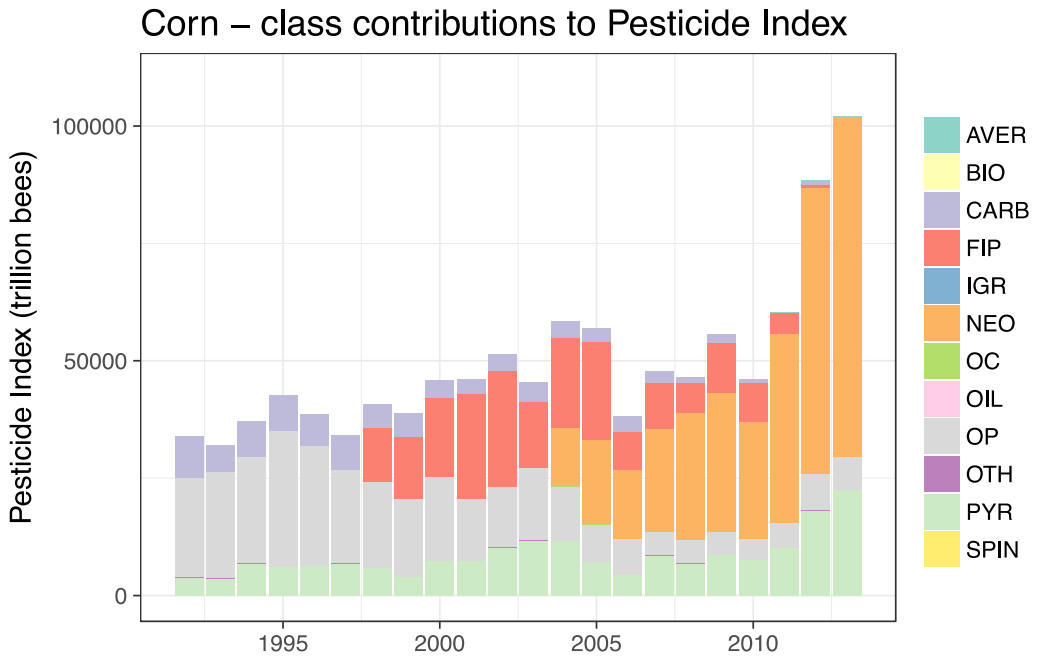

Glyphosate Resistant Soybean Adoption
Glyphosate Usage
Farmer Adoption (%)
Herbicide Active Ingredient (tons)
Year
0
10
20
30
40
50
60
70
80
90
100
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
1985
1990
1995
2000
2005
2010

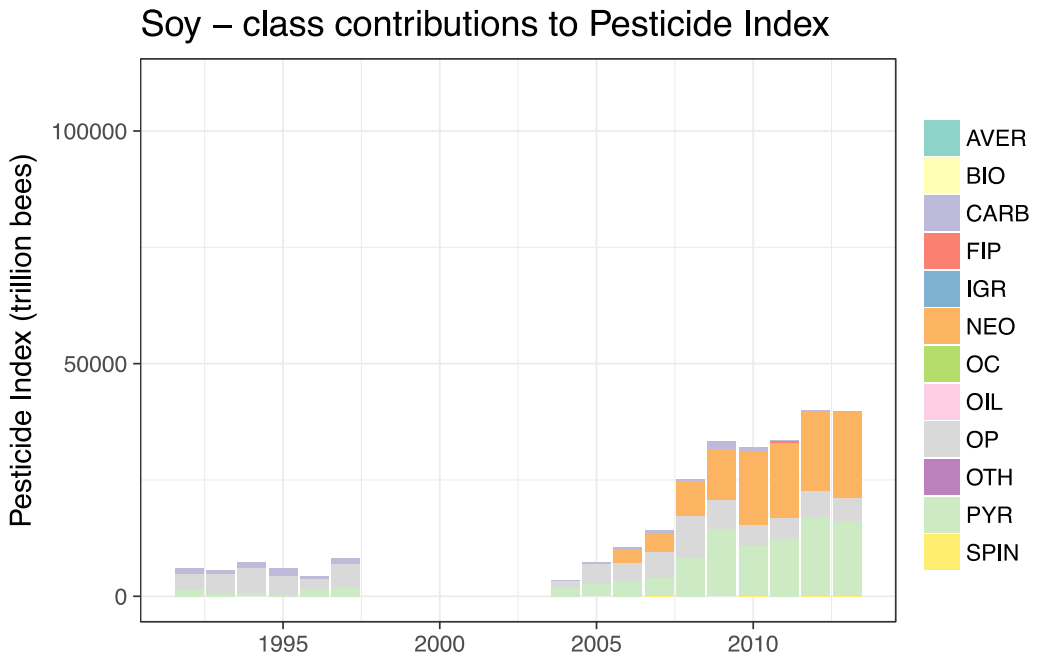

600 million pounds
500
400
300
200
100
0
Herbicides
Insecticides and Fungicides
’92
‘96
‘00
‘04
‘08
‘12

# Trends in insecticide use – $LD_{50}$ equivalents

## USGS high estimate



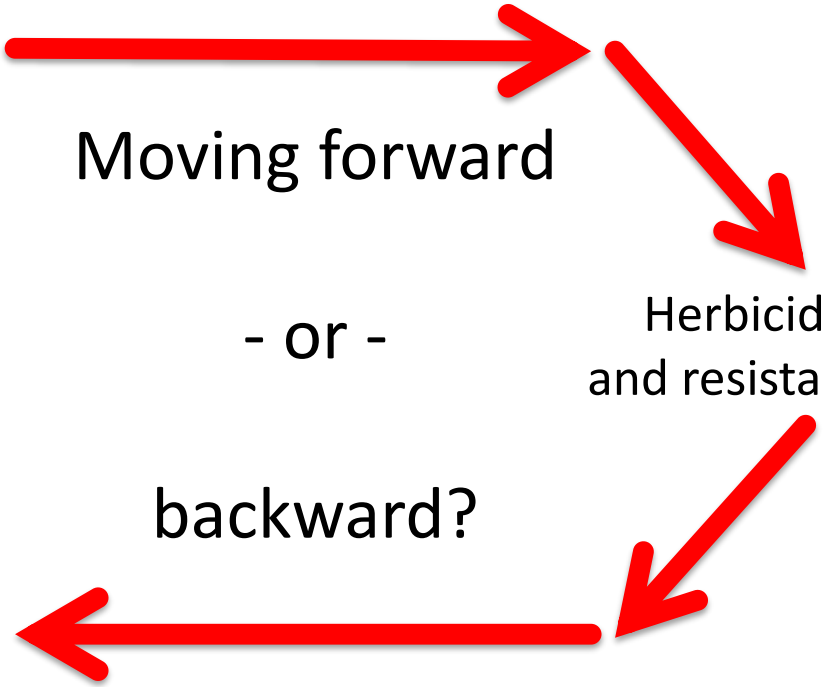


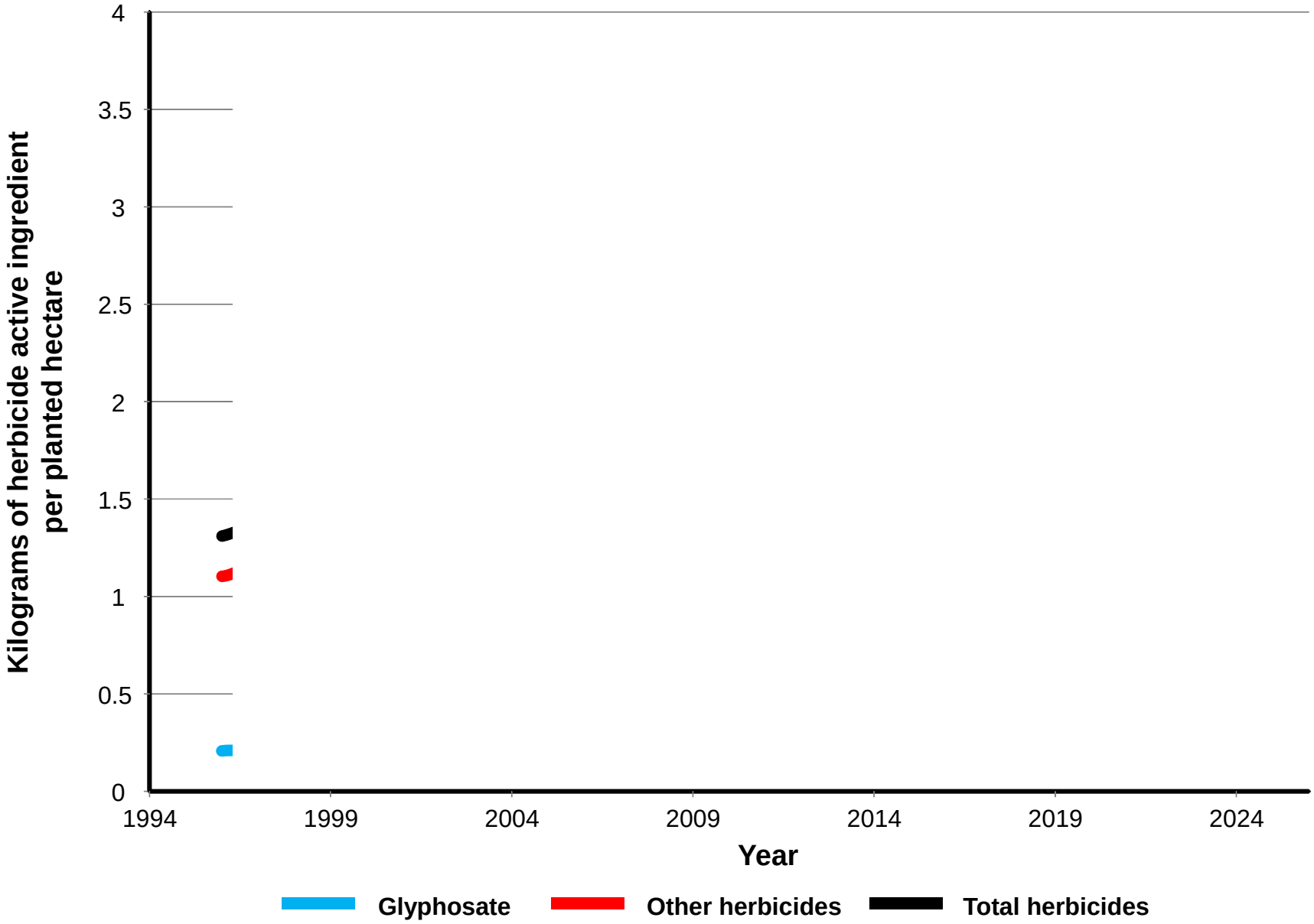

Neonics and pyrethroids have driven most of the increase in corn & soy

Keep in mind virtually all of the neonics are seed treatments

Replace more-toxic herbicides
Reduce total amount of herbicide use
Simplify and improve weed management
Unlikely weeds would develop resistance




Return to older, more problematic herbicides
Stacked traits and new recommendations will increase total herbicide use
Facilitates resistance by increasing selection pressure




Mortensen, Egan, Maxwell, Smith, Ryan, *in BioScience 2012*

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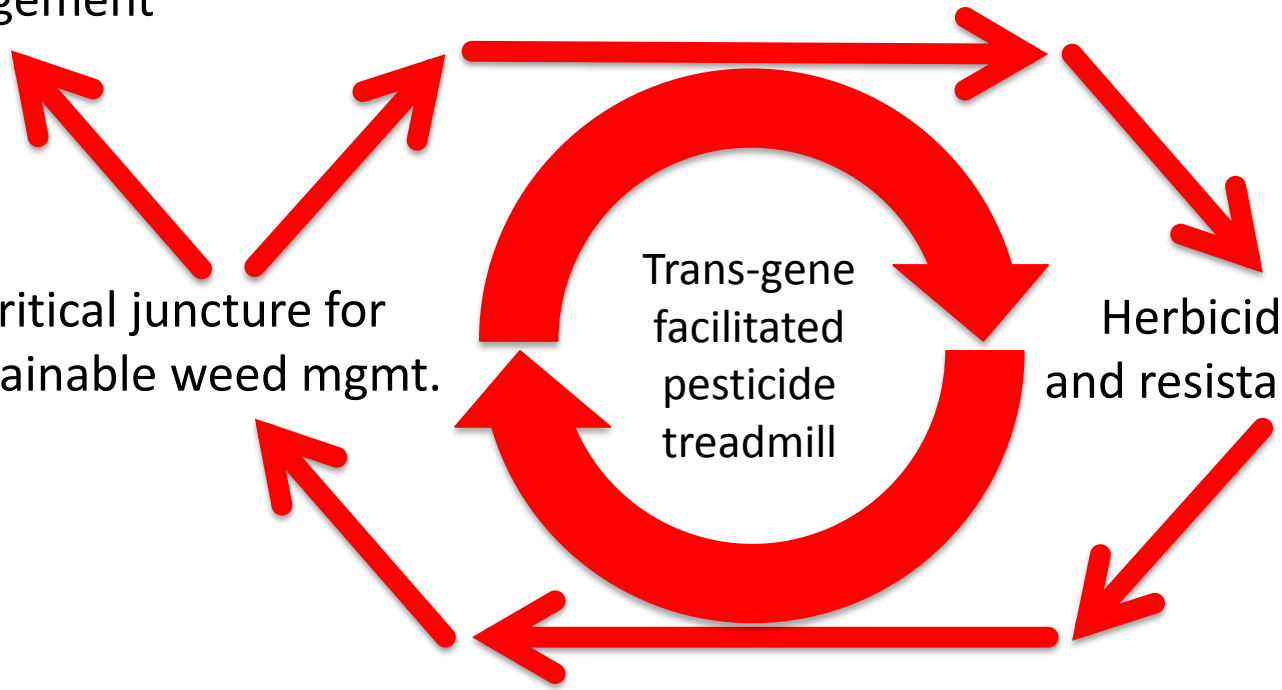
Integrated weed management




Critical juncture for sustainable weed mgmt.

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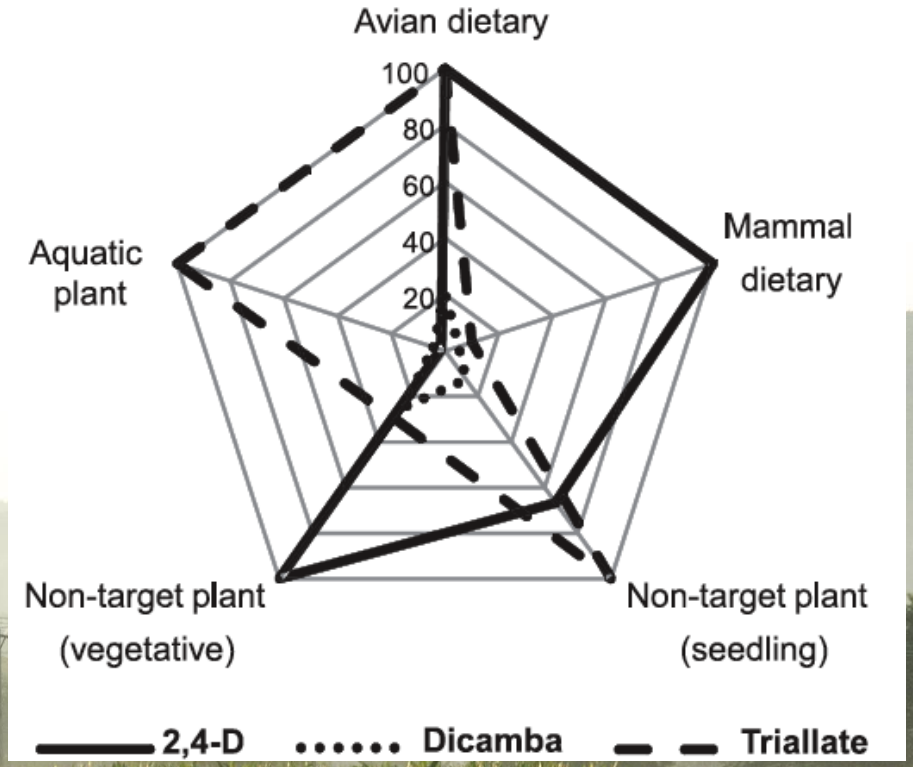
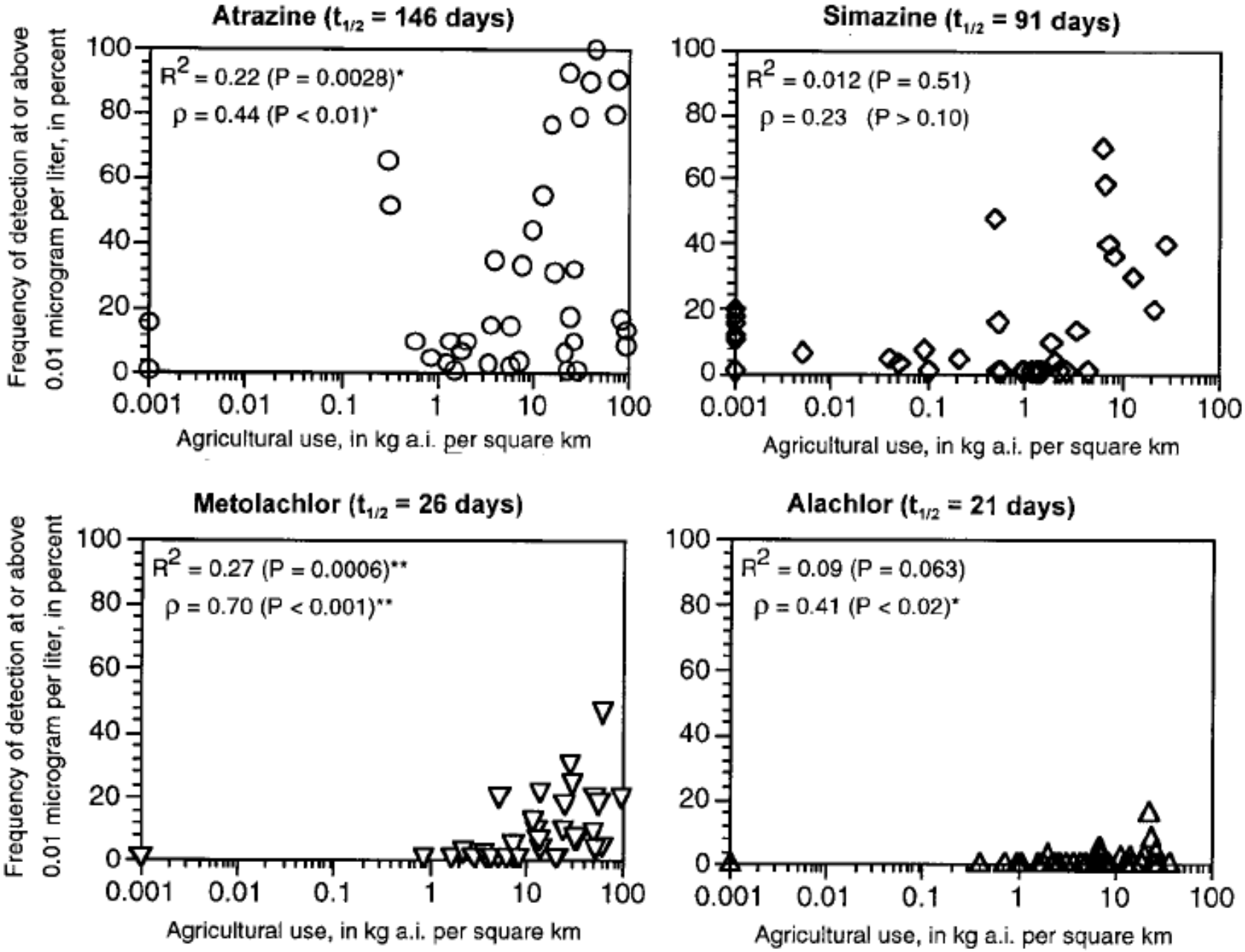
# Why Ecologists should care

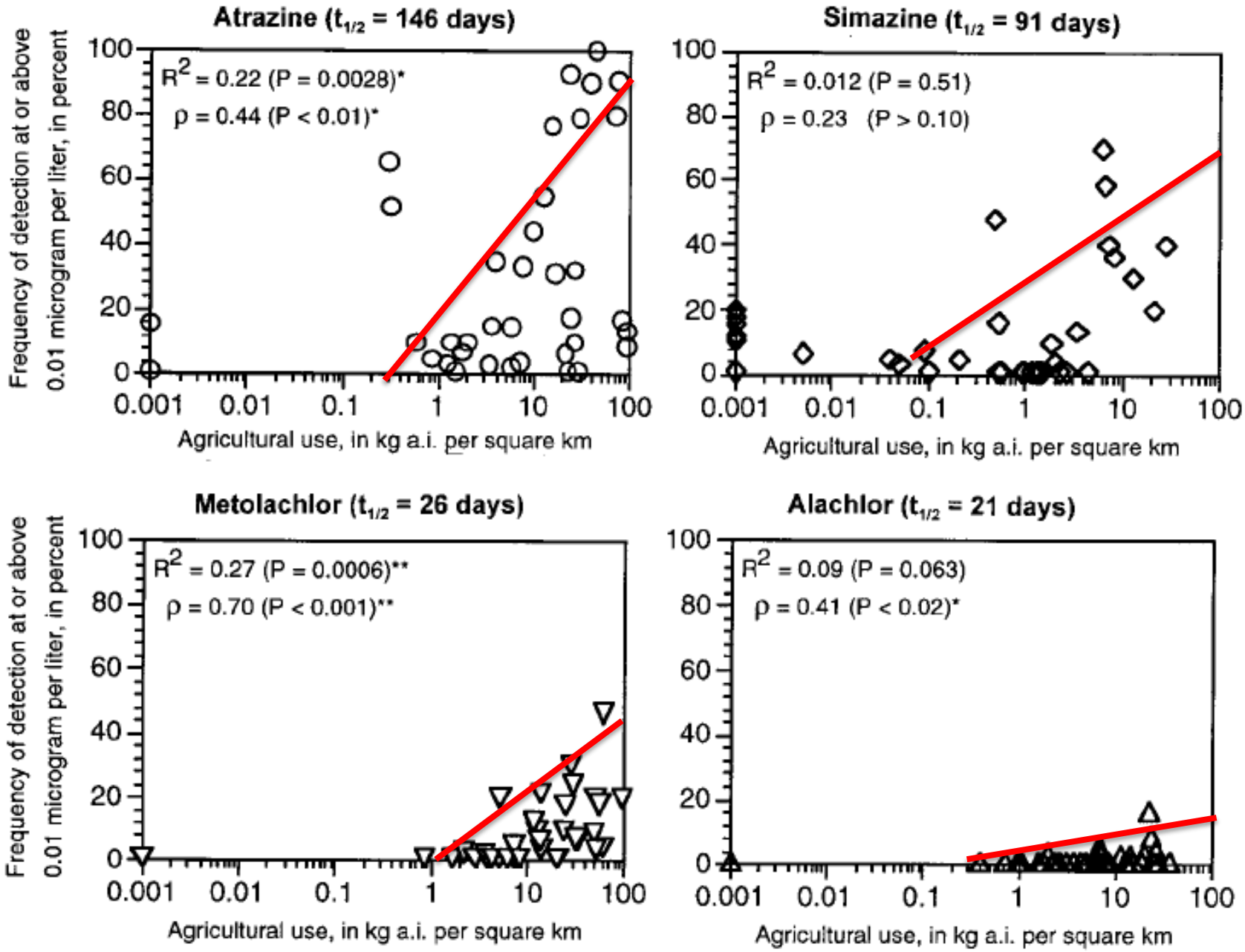
Spillover effects (non-target consequences of a doubling to tripling of herbicide use) could be profound




Smith, Pisani-Gareau, Mortensen, Curran and Barbercheck, 2011, Weed Tech. 25:680-687



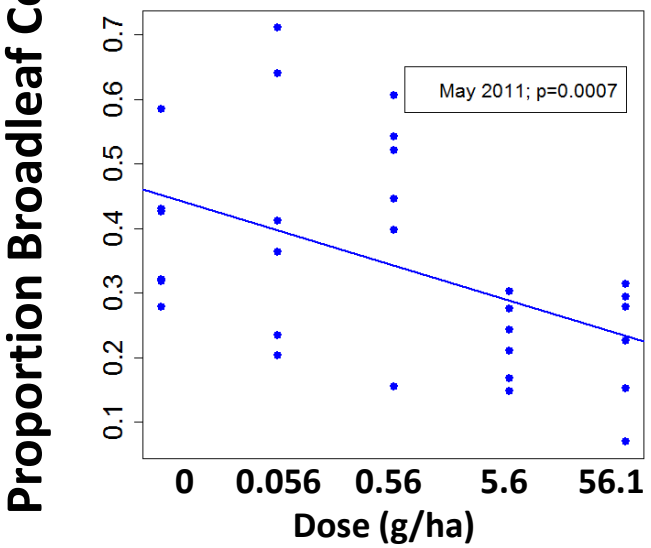

Barbash, Thelin, Kolpin, and Gilliom. 2001. J. Env. Qual. 30:831-845




Barbash, Thelin, Kolpin, and Gilliom. 2001. J Env. Qual. 30:831-845

# Broadleaf crop and field edge plant communities don't like herbicide drift ……

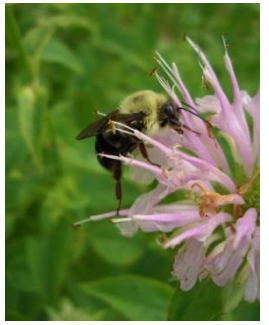
The scientists found that application of dicamba inhibited or delayed flowering in common boneset (Eupatorium perfoliatum), resulting in significantly reduced visitation by insect species, including honeybees (pollinators) and syrphid flies (natural enemies). The image shows a damaged E. perfoliatum plant that received a rate of 56 grams of dicamba per hectare.s

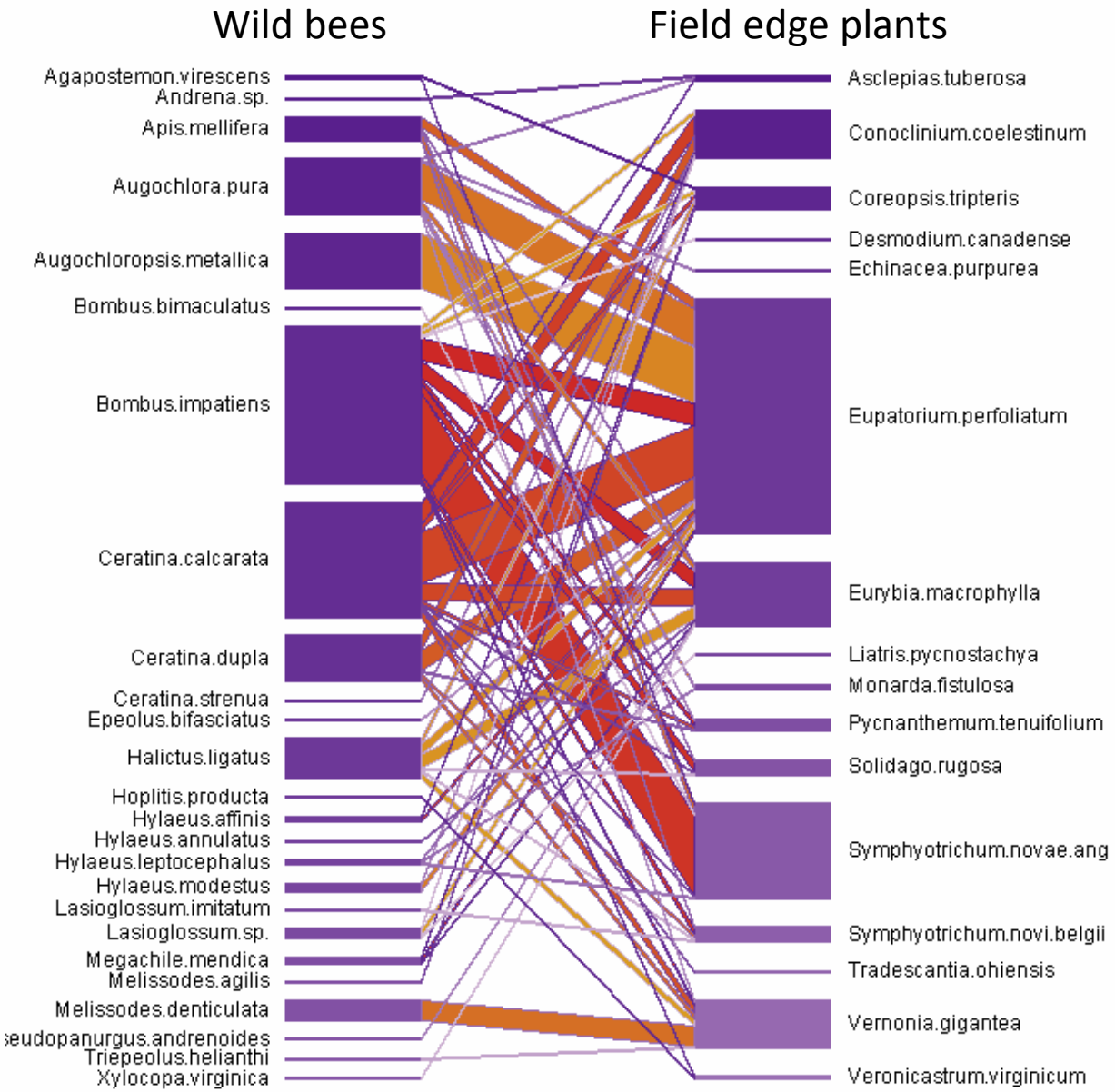



Egan, Bohnenblust , Goslee, Mortensen, and Tooker. 2014. Herbicide drift can affect plant and arthropod communities. *Agriculture, Ecosystems, and Environment*

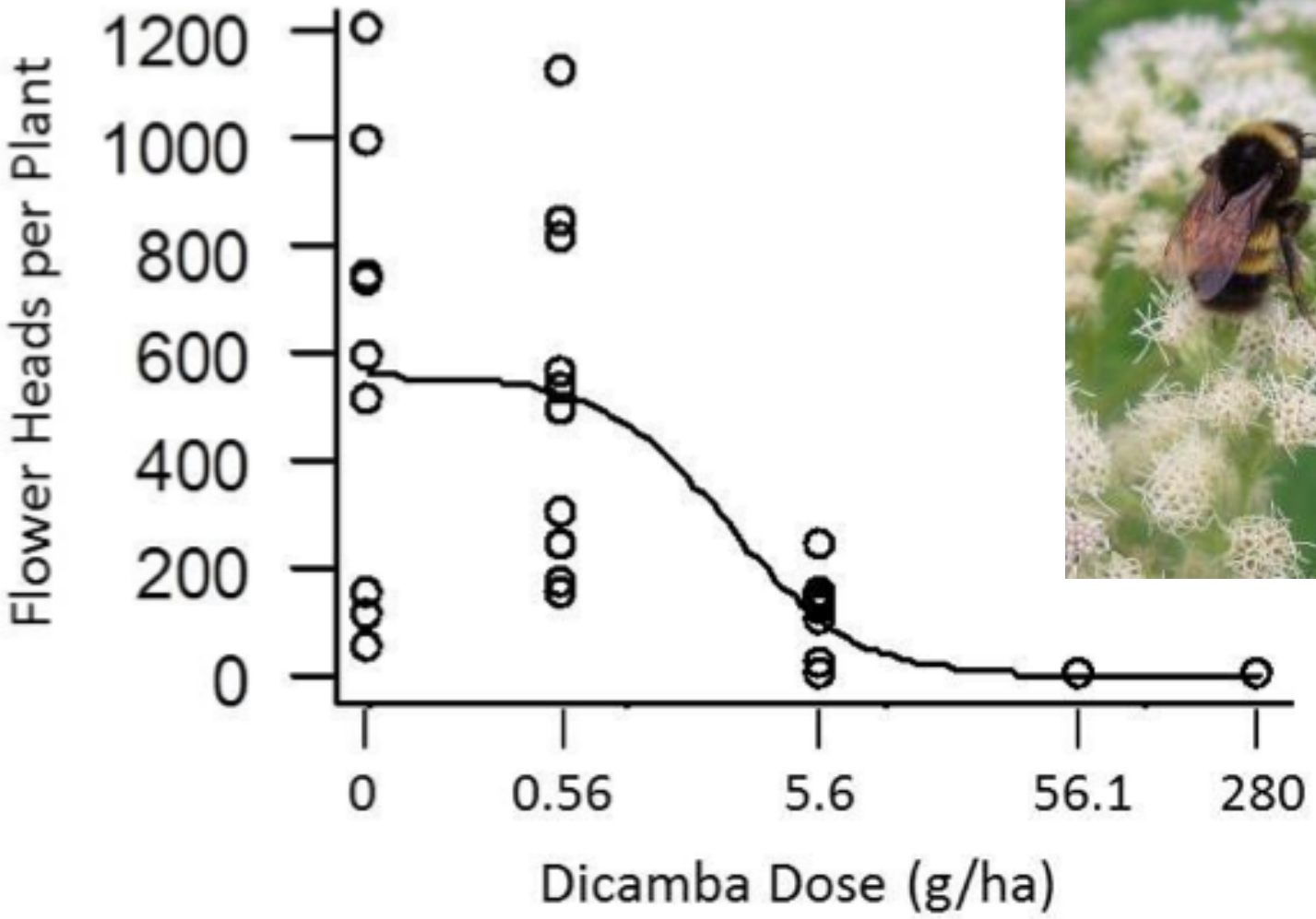
Egan, Graham, and Mortensen. 2014. A comparison of the herbicide tolerances of rare and common plants in an agricultural landscape. *Environmental Toxicology and Chemistry*

# Landscaping with native plants



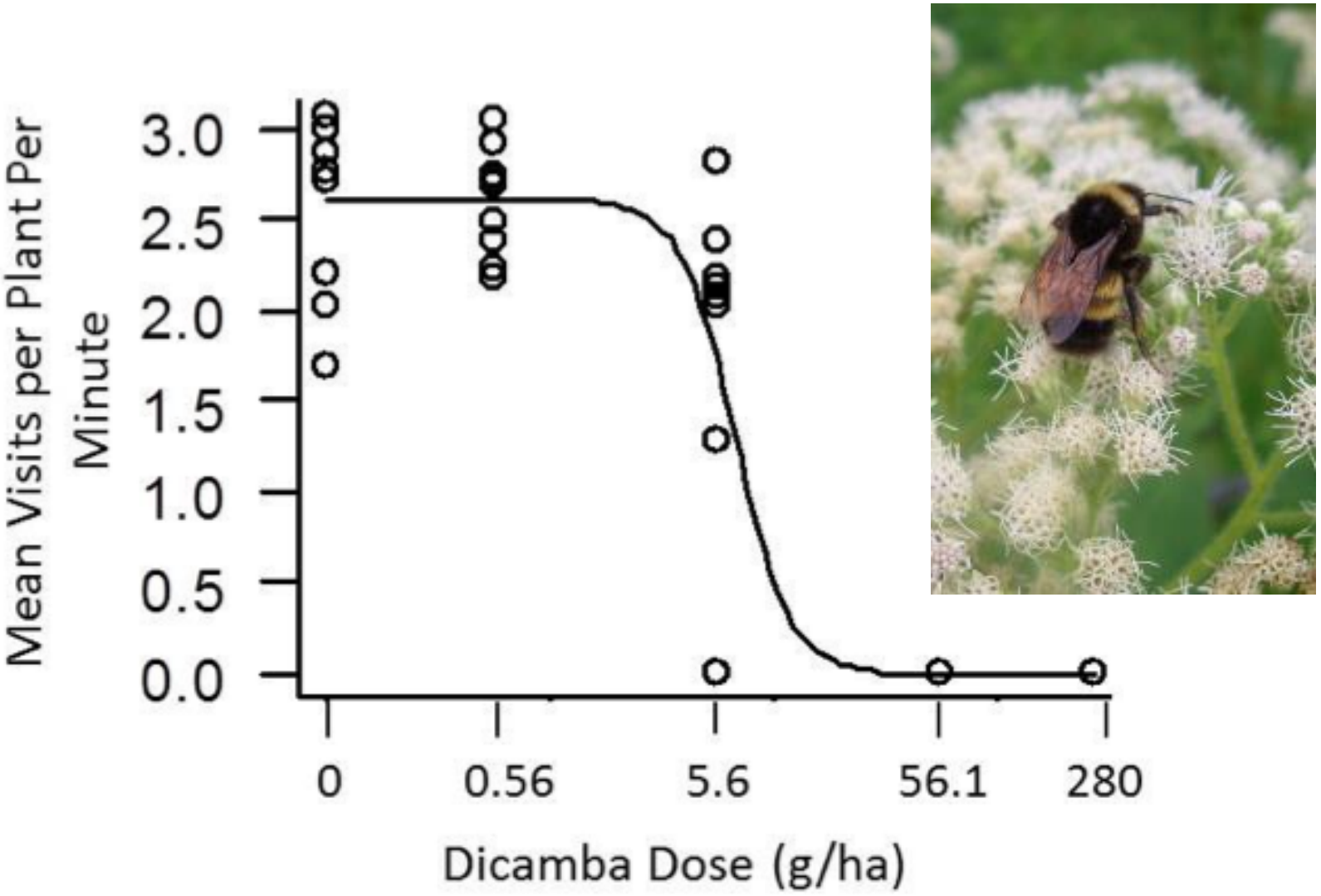



Russo, L, N DeBarros, S Yang, K Shea, and D Mortensen. 2013. Supporting crop pollinators with floral resources: network-based phonological matching. Trends in Ecology and Evolution, 1-16






Bohnenblust, Vaudo, Egan, Mortensen, and Tooker. 2016. Effects of the herbicide dicamba on non-target plants and pollinator visitation. *Environmental Toxicology and Chemistry, Journal of Pest Science,* 35:144-151.

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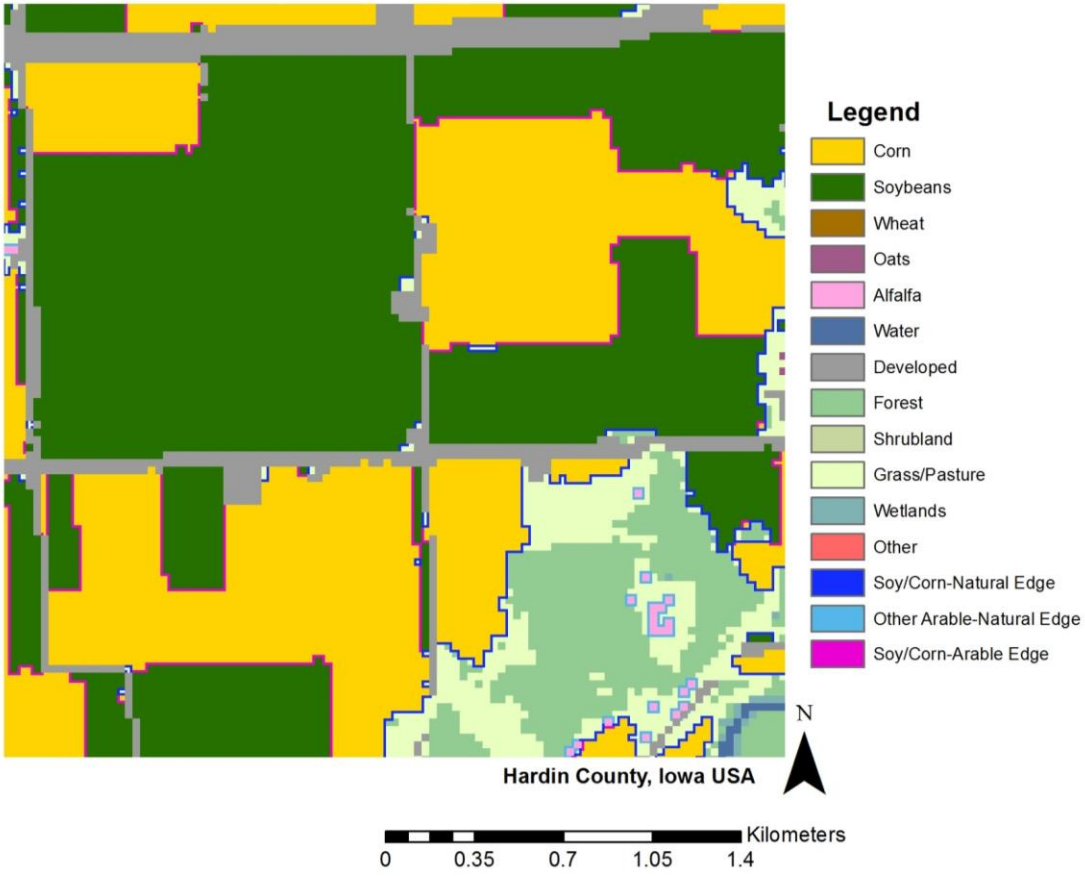
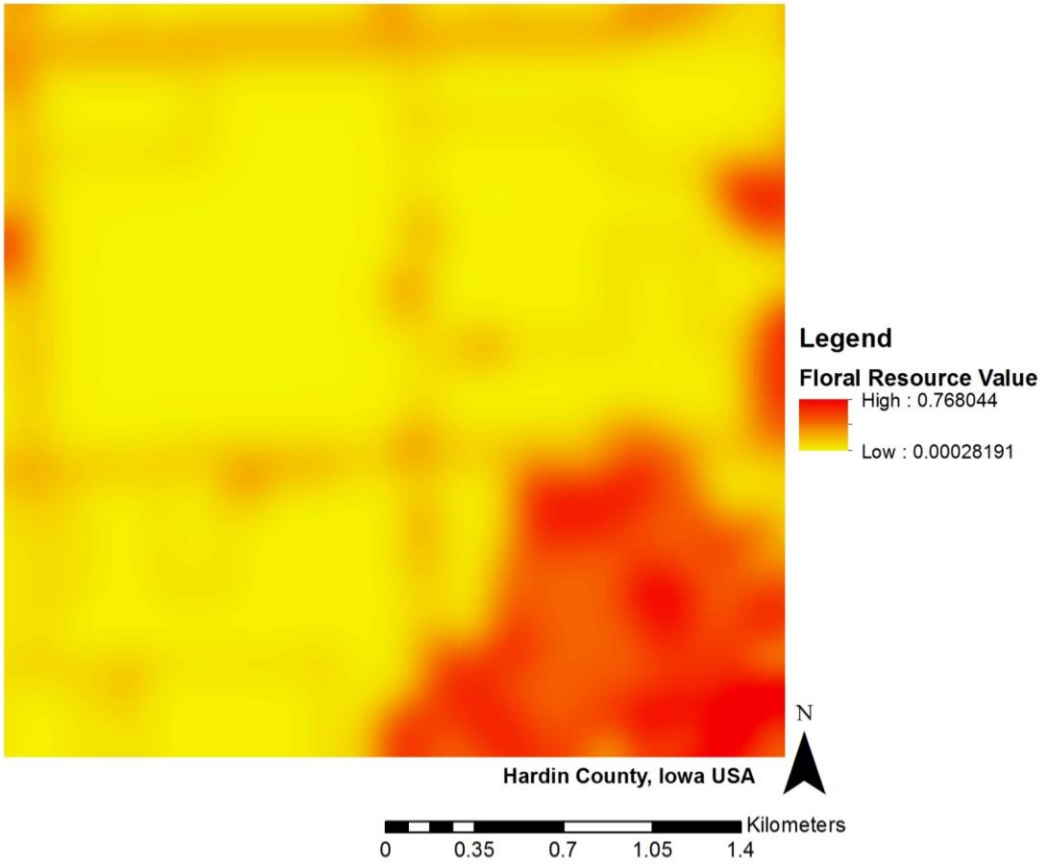

Legend
Corn
Soybeans
Wheat
Oats
Alfalfa
Water
Developed
Forest
Shrubland
Grass/Pasture
Wetlands
Other
Soy/Corn-Natural Edge
Other Arable-Natural Edge
Soy/Corn-Arable Edge
N
Hardin County, Iowa USA
Kilometers
0
0.35
0.7
1.05
1.4

# Pollinator Accessible Spring Floral Resources



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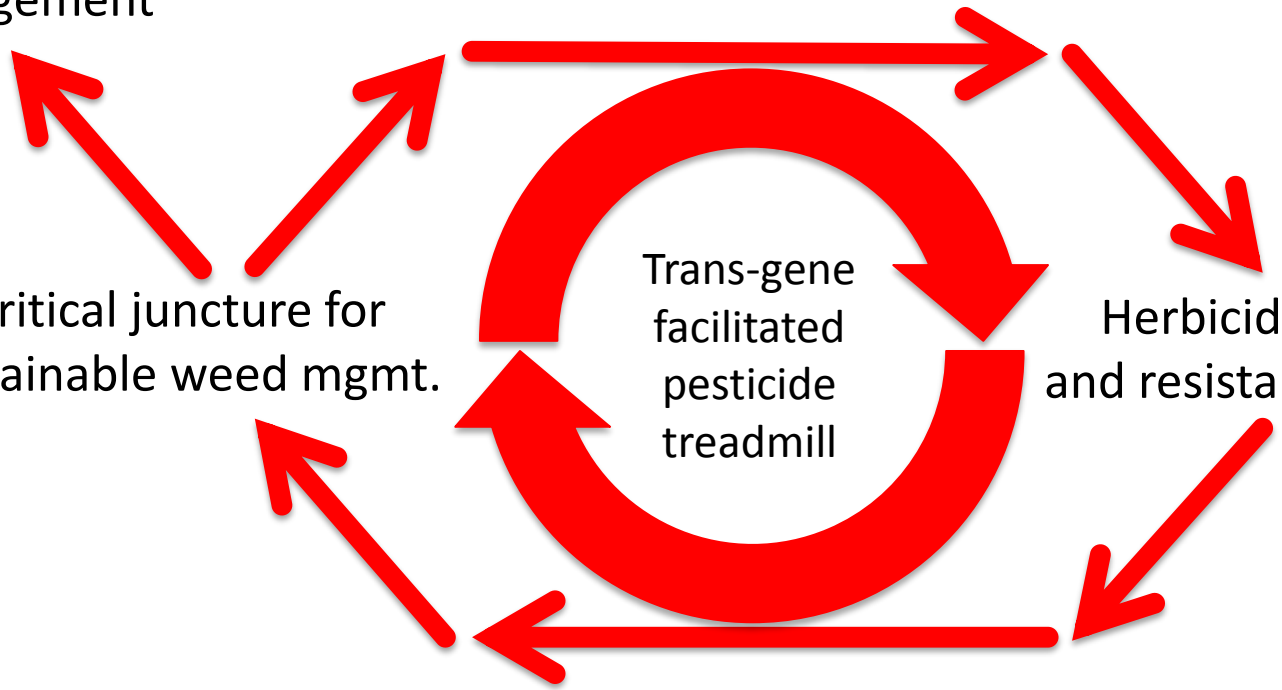


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# A more hopeful path…….

Cover crops – a case in point

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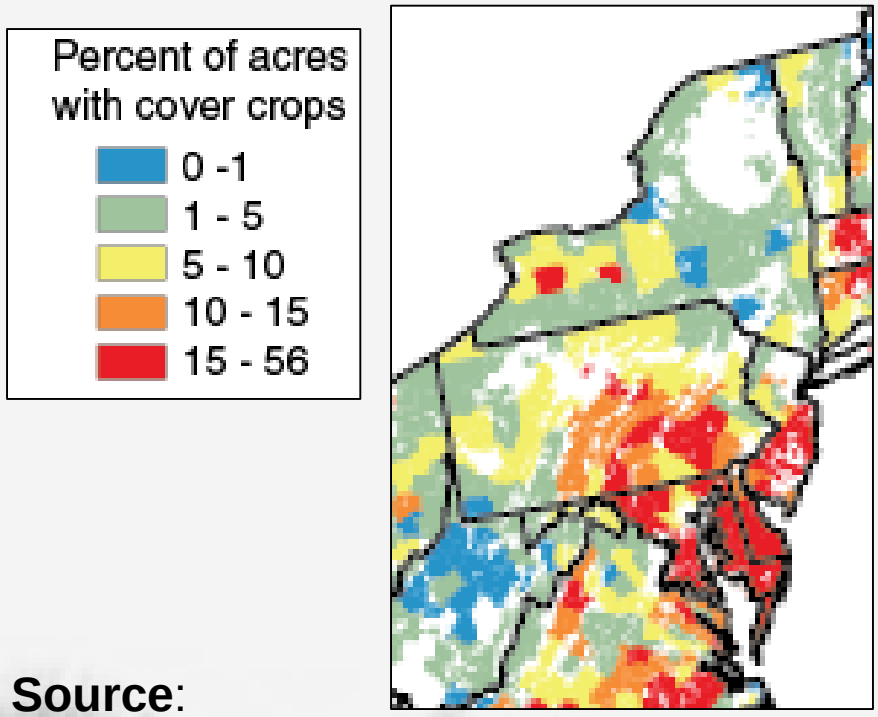
- Farmer facilitated learning and citizen science accelerates adoption

# Regional Trends

Cover cropping in annual croplands on the increase…….




**Source**:

USDA, Economic Research Service, 2012.

**Reasons for using cover crops**

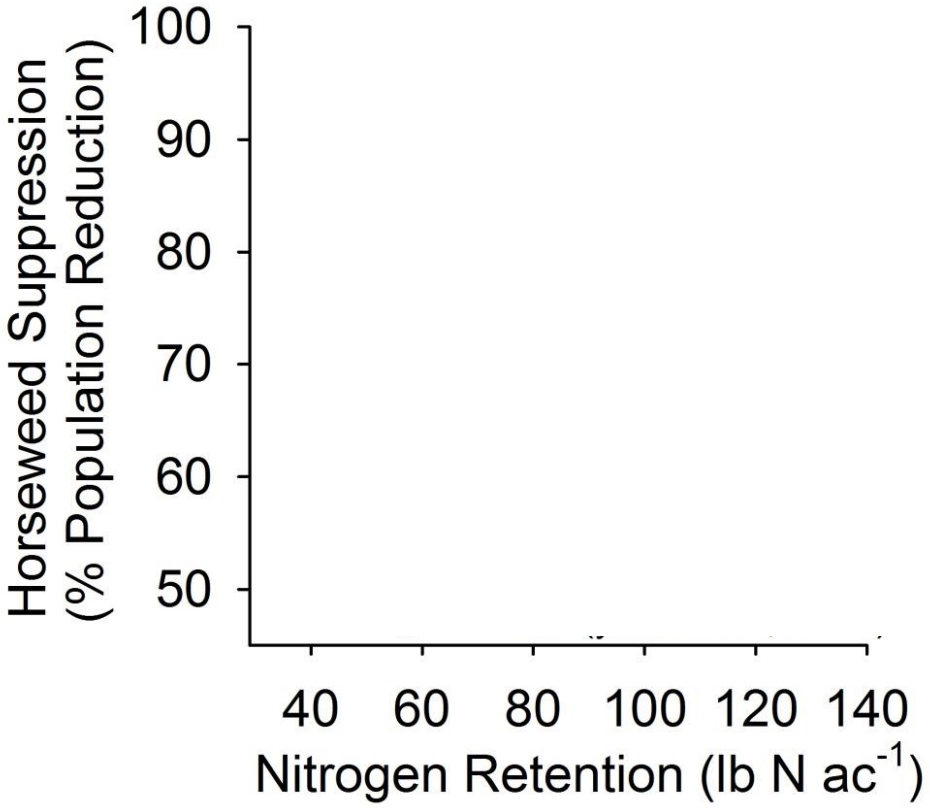
1. Improve soil health
2. **Reduce soil erosion**
3. Weed management
4. **Nutrient retention**
5. Water infiltration & storage

**Source**: Abbe Hamilton (2016)

# How do we measure success?

## Integrate weed control into multi-criteria assessment.

| Treatment | Rate | Seed |
|---|---|---|
| | lb ac$^{-1}$ | $ ac$^{-1}$ |
| Spring Oats | 120 | 42 |
| Spring Oats/Forage Radish | 60/5 | 33 |
| Spring Oats/Hairy Vetch | 60/20 | 57 |
| Cereal Rye | 120 | 36 |
| Cereal Rye/Forage Radish | 60/5 | 29 |
| Cereal Rye/Hairy Vetch | 60/20 | 53 |



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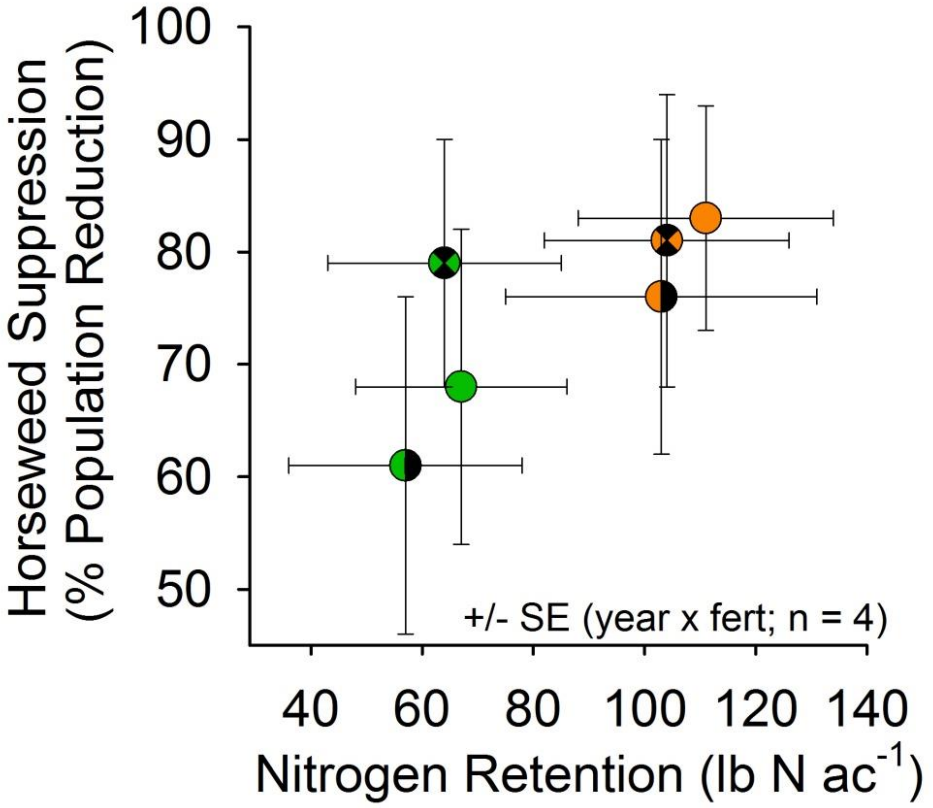


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# How do we measure success?

## Selection pressure diversification….not weed control efficacy

**Assumptions**

CONCA density (100 – 200 plt $m^{-2}$)

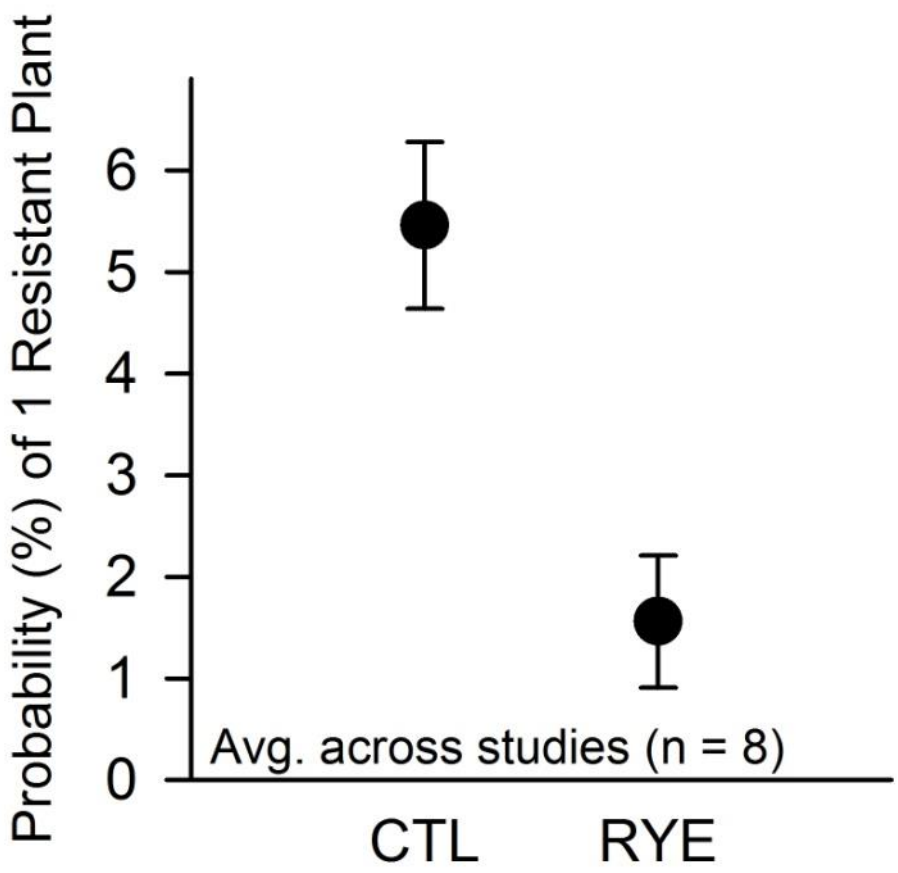
Infestation size: 30 ha

Mutation rate: 1 x $10^{-9}$

*Jasieniuk and Maxwell (1994)*

*Mortensen et al (2012)*

**Probability of 1 Resistant Horseweed Plant**



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- “Alternative”, ecologically-based approaches can and are addressing pest management problems in a multi-functional way

- Our role as facilitators in farmer-to-farmer learning will accelerate development of “alternative” practices as well as help us to better understand the constraints to their adoption