

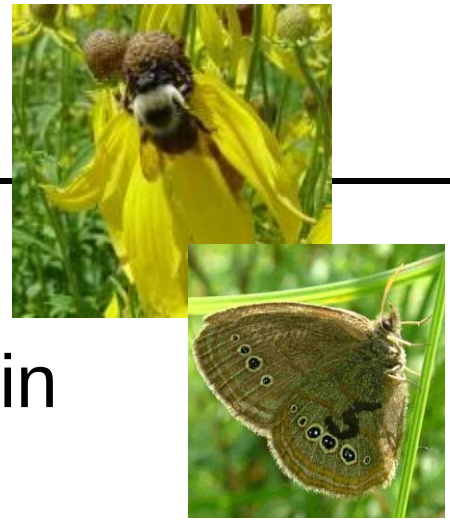
Biofuels and Biodiversity: Linking Landscape Change & Ecosystem Services



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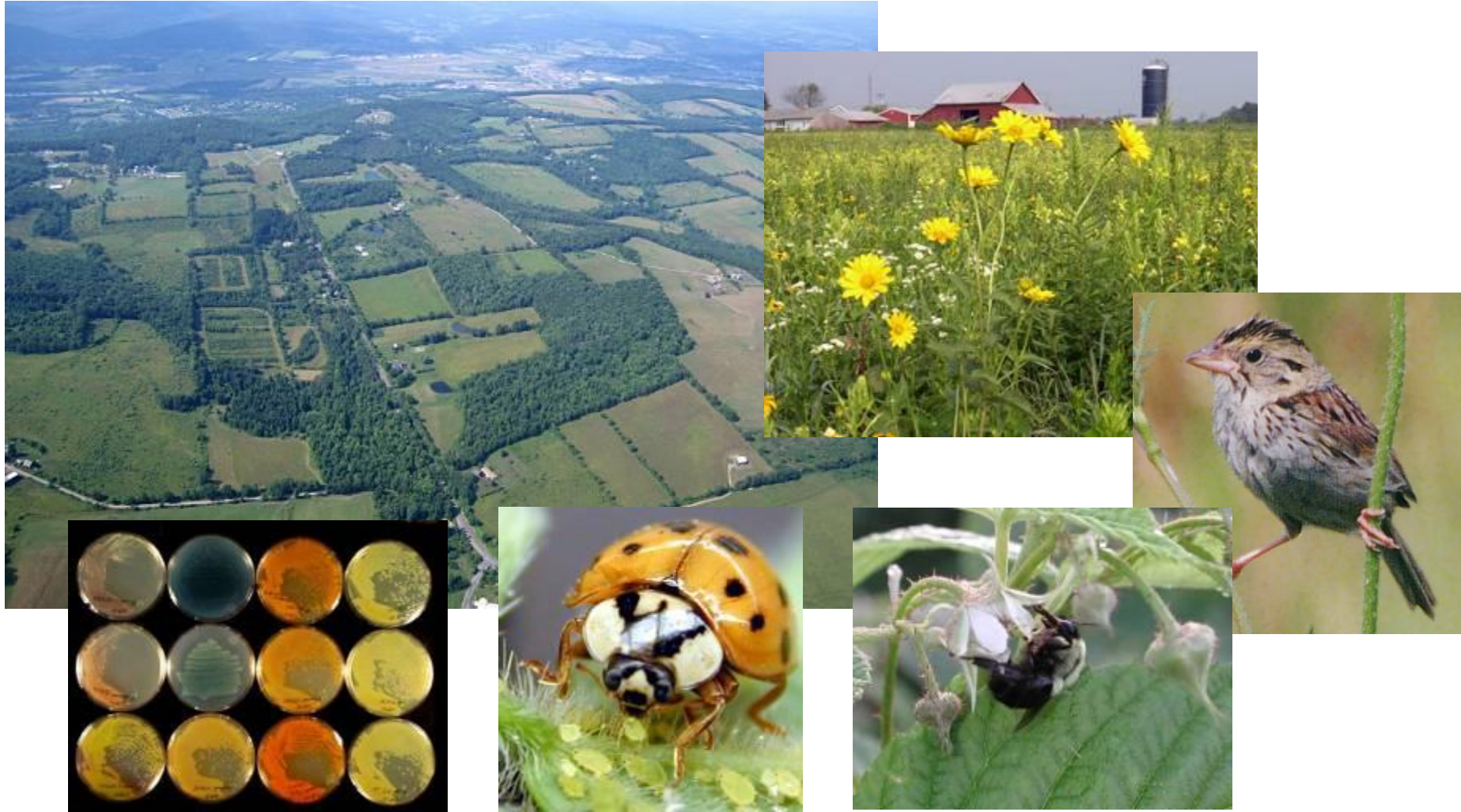


Outline



- Biodiversity & ecosystem services in agricultural landscapes
- Aphid-enemy interactions
 - Long-term research is critical in a changing world
 - Site - regional - national scaling
- Implications for biofuels and ecosystem services

Agricultural Landscapes



Ecosystem Services

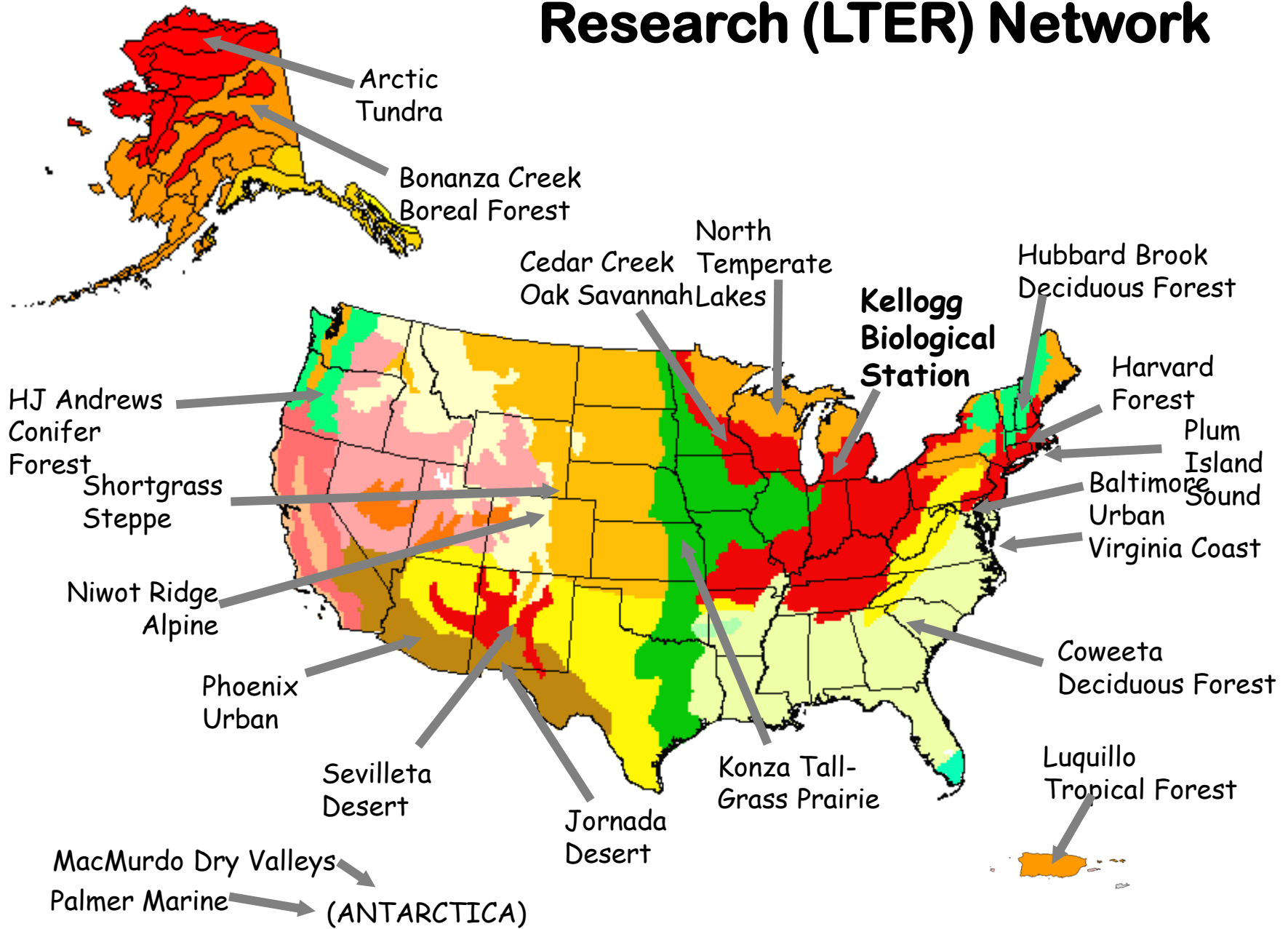
The benefits people obtain from ecosystems

- Supporting
 - Nutrient cycling, soil formation...
- Provisioning
 - Food, fuel...
- Regulating
 - Pollination, pest suppression...
- Cultural
 - Recreation, aesthetic...



Costanza *et al.* Nature 1997
Millennium Ecosystem Assessment 2005
Swinton *et al.* Am. J of Agric. Econ. 2006

The National Long-Term Ecological Research (LTER) Network



KBS LTER

- Focus: Agricultural Ecology
- Central Question

“Can agronomic management based on ecological concepts effectively substitute for chemical subsidies?”



Annual



Perennial

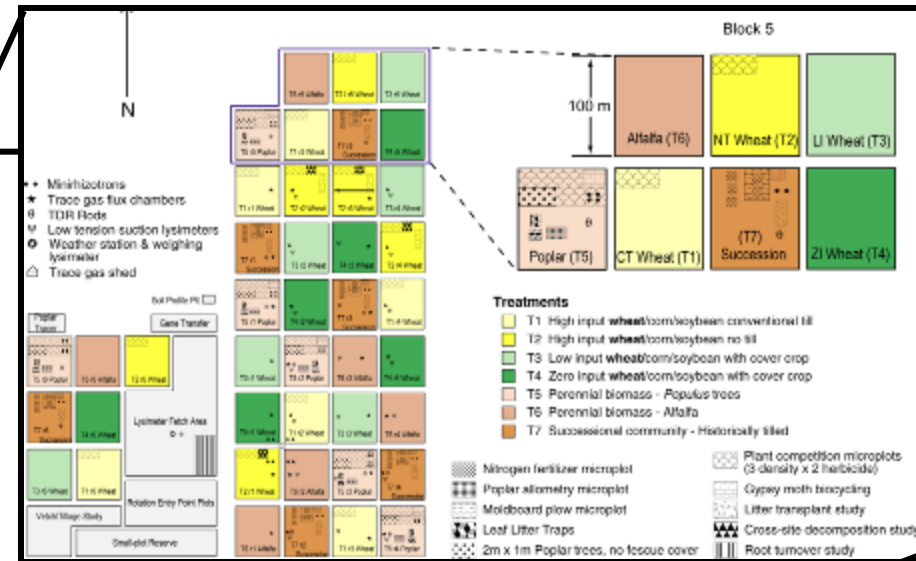


Successional



KBS LTER

- Main site
- Scale up fields



Kellogg Biological Station
LTER Scale-Up Fields

Management

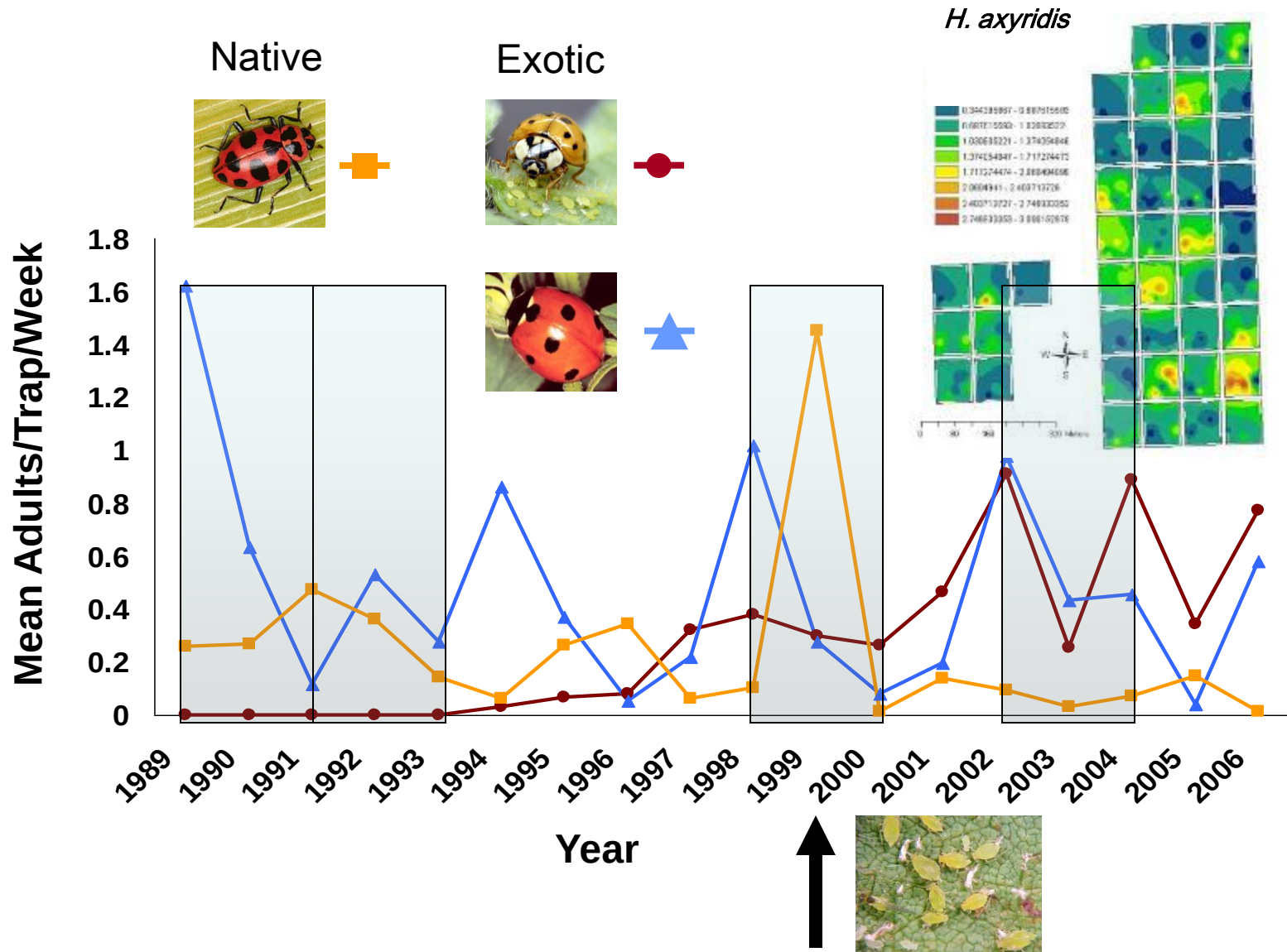
- T1 treatment
- T3 treatment
- T4m treatment
- KBS property border

Key

A, B, C, D - Replicate Block
1, 2, 3 - Size Class (1 = large)
T1, T3, T4m - Management Treatment
crop = initial entry point (2008) - corn, soybean or wheat
E.G.: C1 T1 corn = Rep. C, Size class 1, Treatment T1, with corn as initial entry point

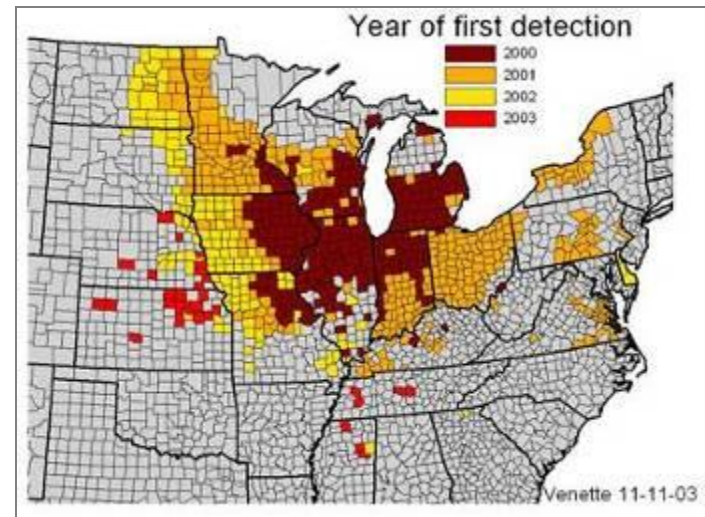
0 0.25 0.5 km

Previous Studies

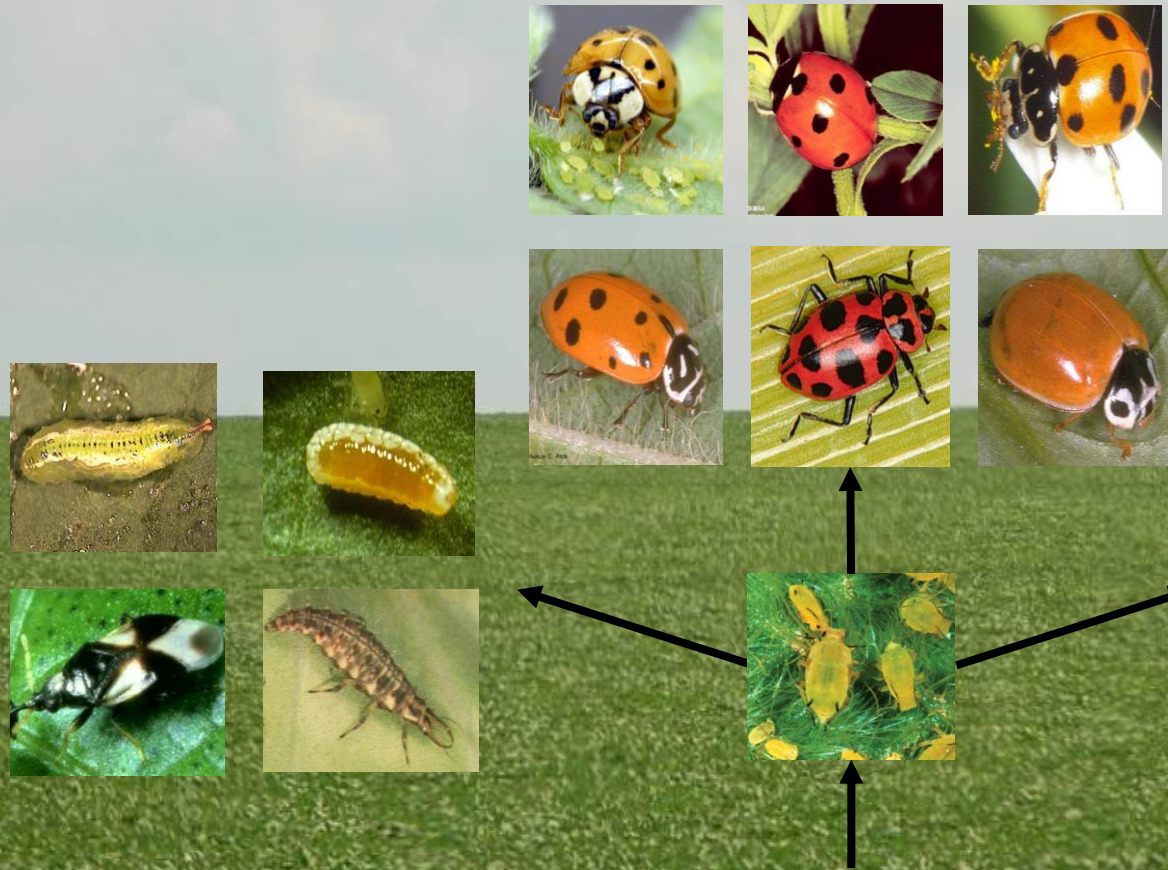


Soybean Aphid (*Aphis glycines*)

- Exotic (Asia)
- 40 to 50% yield losses
- Rapid landscape spread



Soybean Aphid Food Web

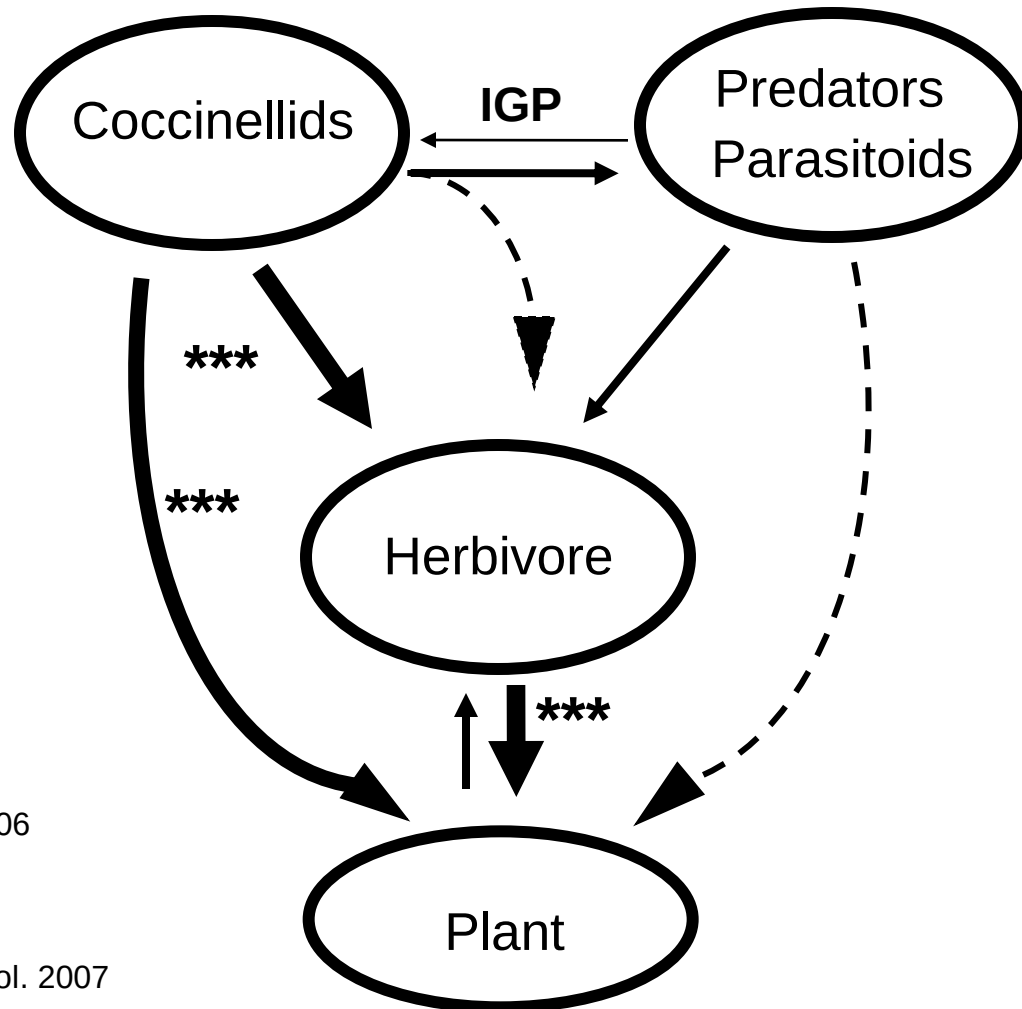


Fox and Landis. Proc. Int. Symp. Bio. Cont. Arth. 2003

Rutledge *et al.* Annals Ent. Soc. Am. 2004

Fox *et al.* Environ. Entomol. 2004, BioControl 2005

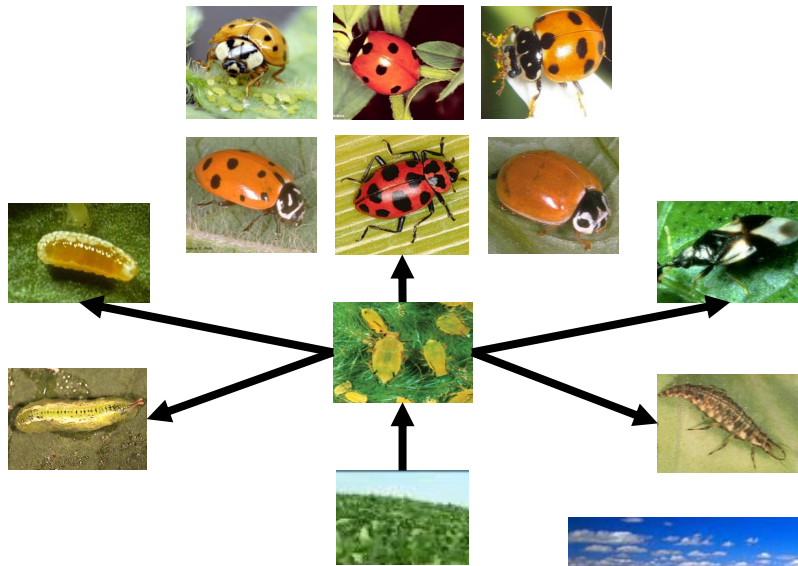
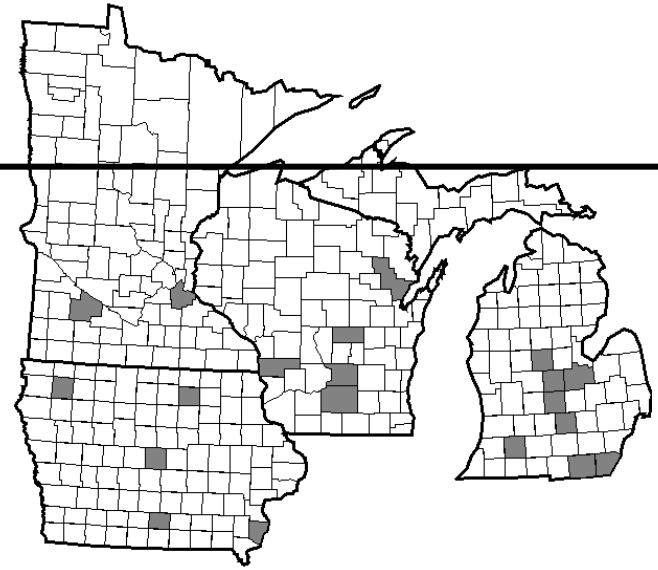
Tri-trophic Interactions



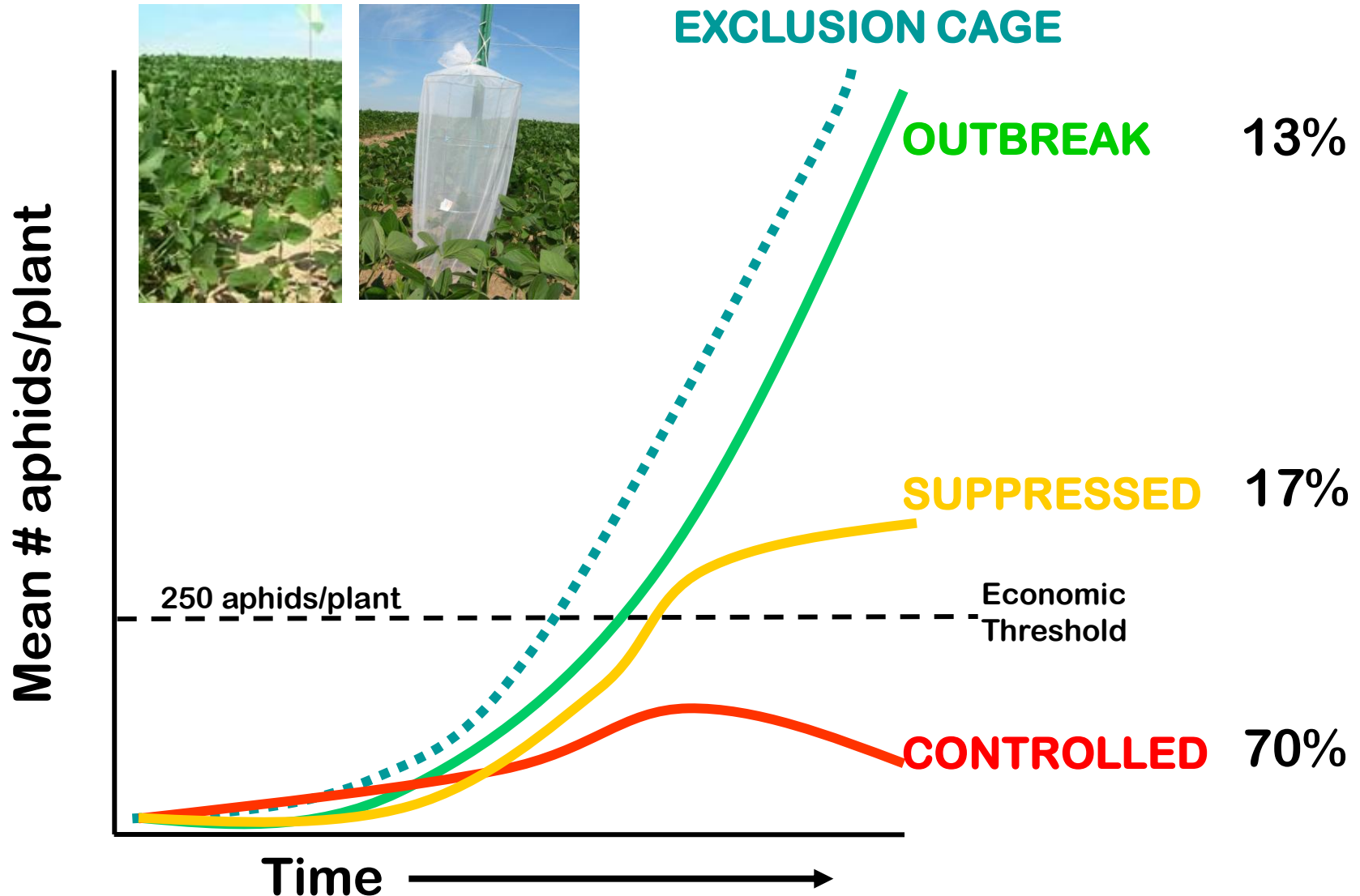
Costamagna & Landis. Ecol. Applic. 2006
 Costamagna *et al.* Ecol. Applic. 2007
 Gardiner & Landis. Biol. Cont. 2007
 Costamagna *et al.* Biol. Cont. 2007
 Costamagna *et al.* Agr. and For. Entomol. 2007
 Costamagna *et al.* Biol. Cont. 2008



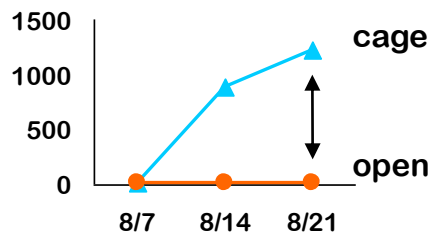
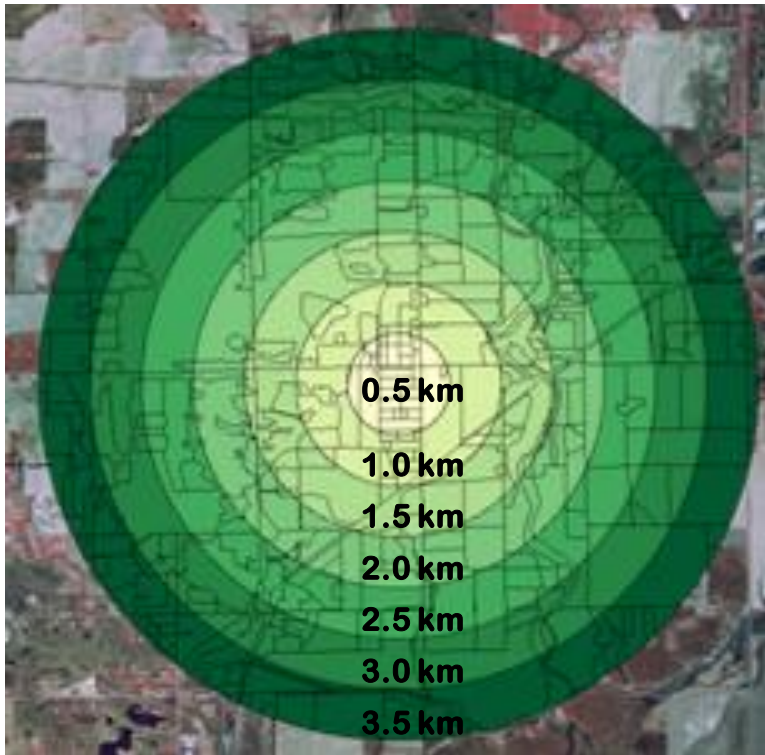
Landscape Interactions



Predator Impacts



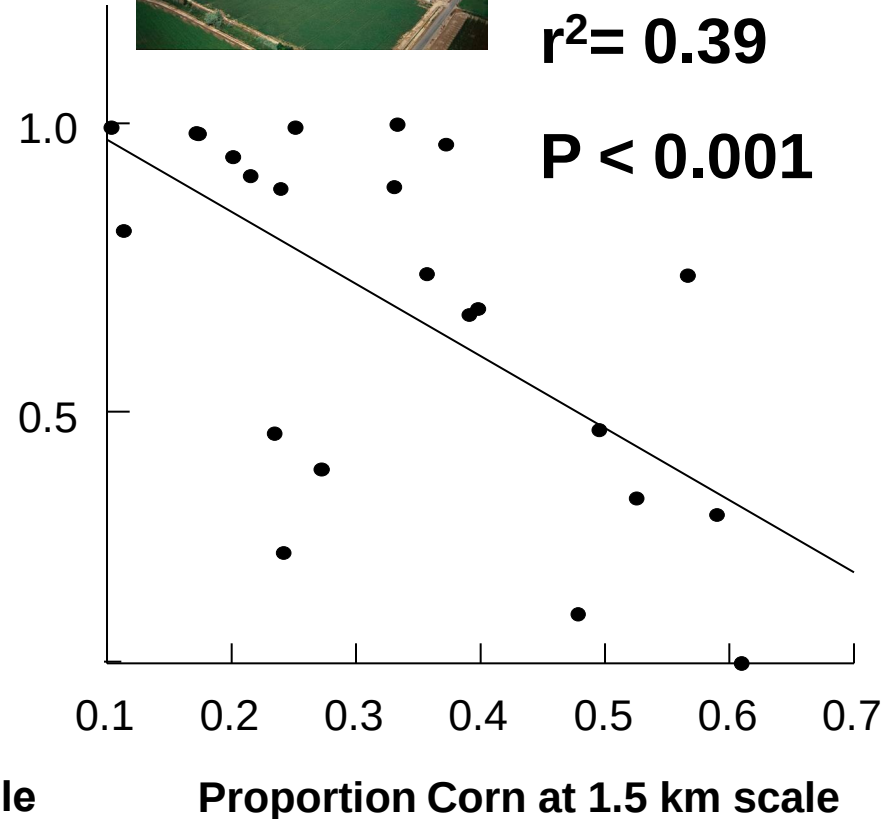
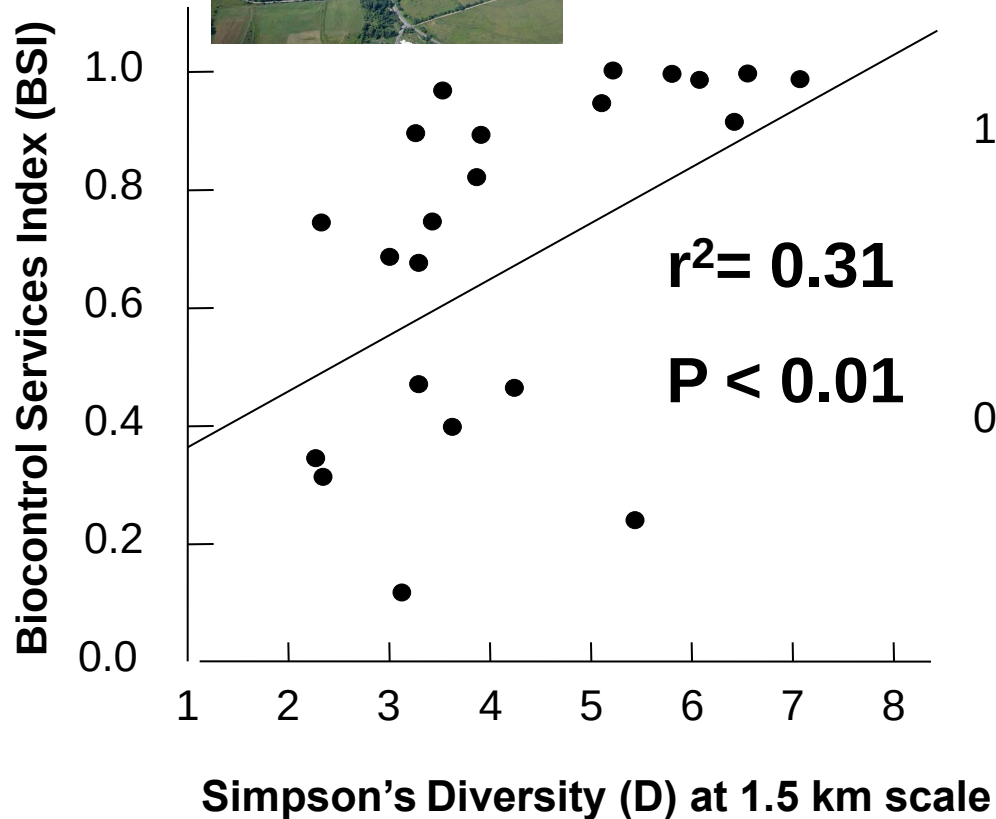
Landscape Impacts



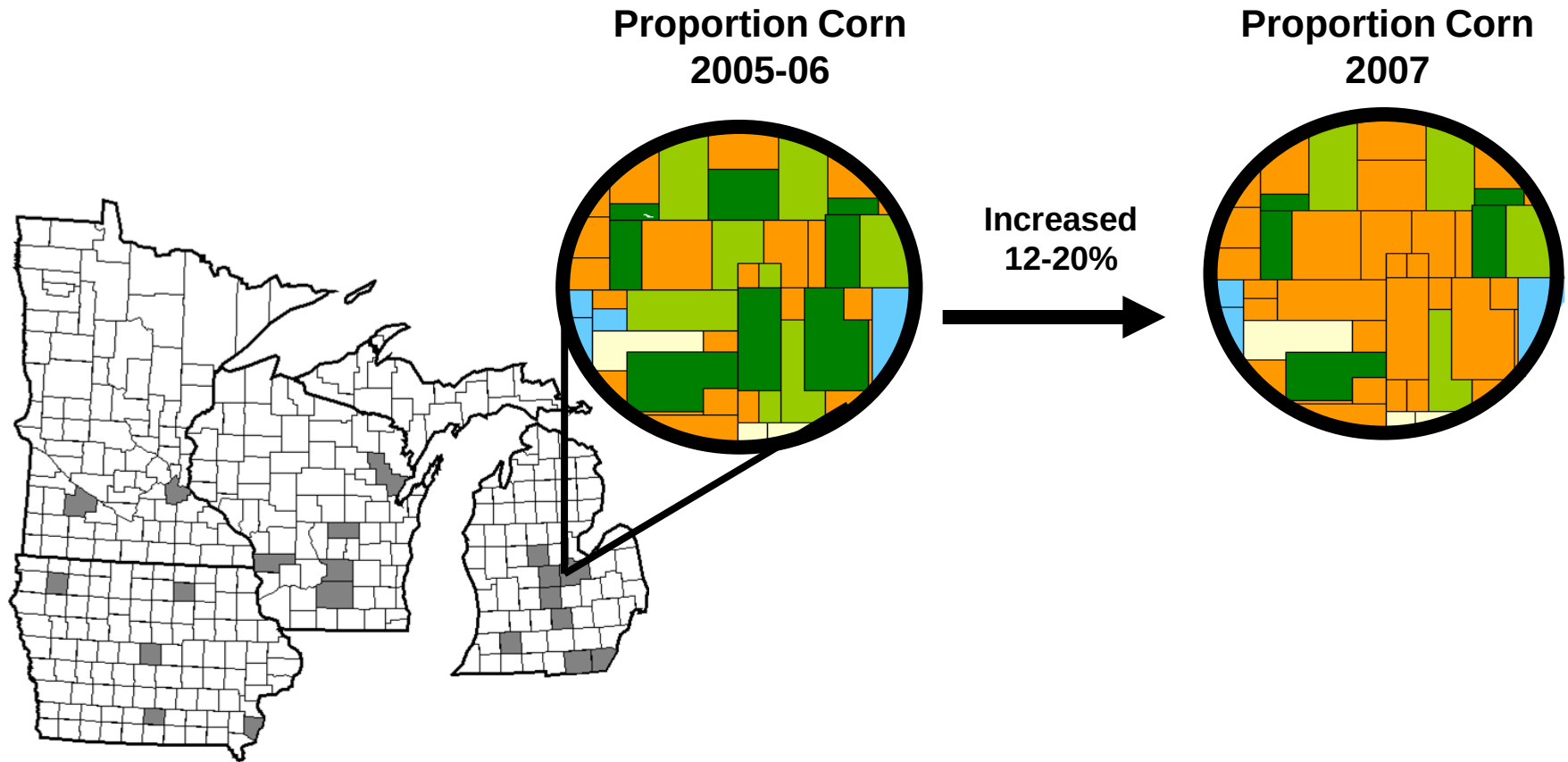
Biocontrol
Services
Index (BSI)



BSI versus Landscape



Landscape Change & Ecosystem Services



Due to increased demand for ethanol, corn acreage increased 19% nationally from 2006-2007.

Value of Biocontrol Services

- \$239 M y⁻¹ in Michigan, Wisconsin, Minnesota and Iowa alone
- Loss of \$58 M y⁻¹ in biocontrol services
- Implications for biofuel landscapes



Cellulosic Biofuel Landscapes



Production

Processing



Ecosystem
services



Biofuel Crops and Biodiversity H_o

Lower Biodiversity

- Annual
- Monoculture
- Exotic
- High input

Higher Biodiversity

- Perennial
- Polyculture
- Native
- Low input



Corn

Switchgrass

Mixed prairie

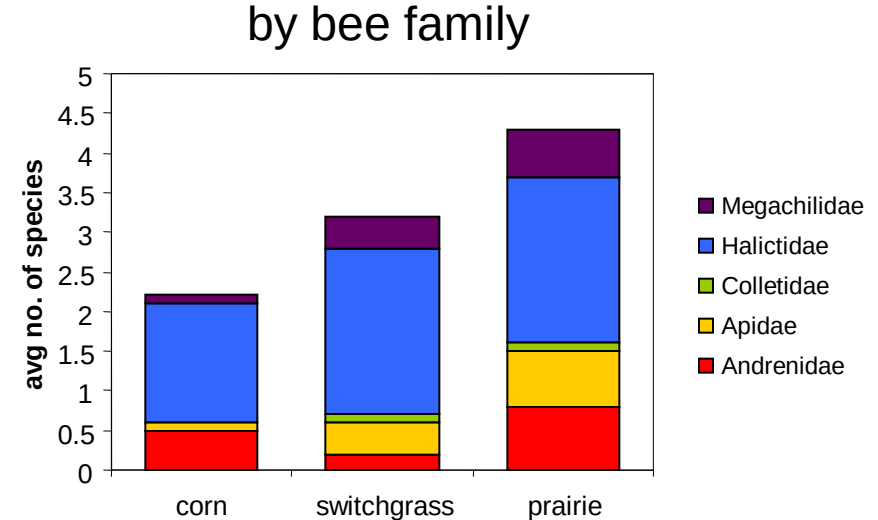
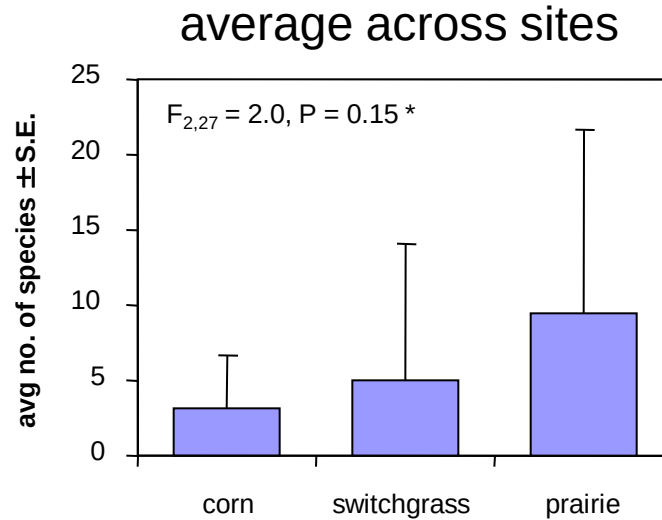


Biodiversity Sampling

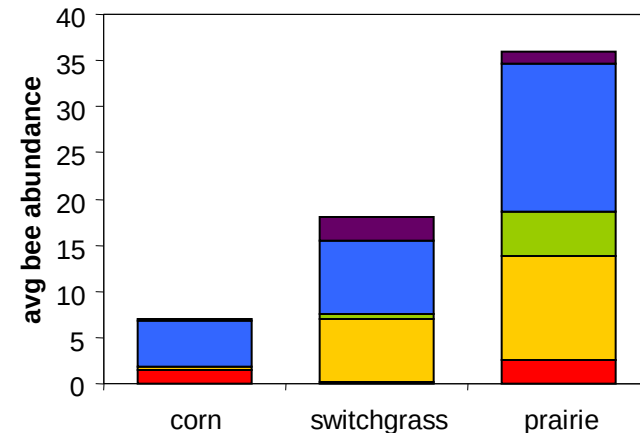
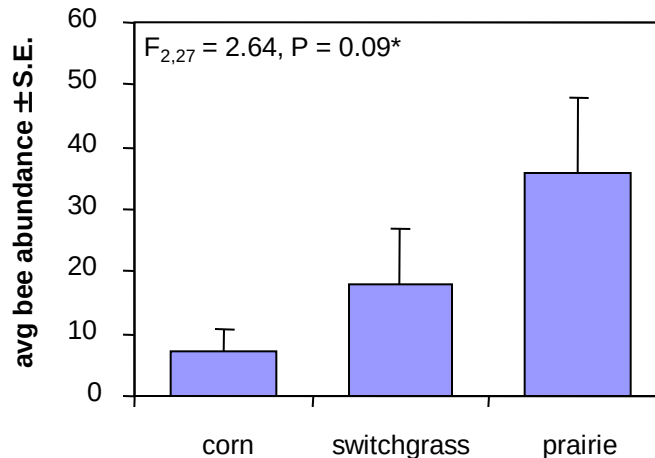


Bee Abundance & Richness 2008

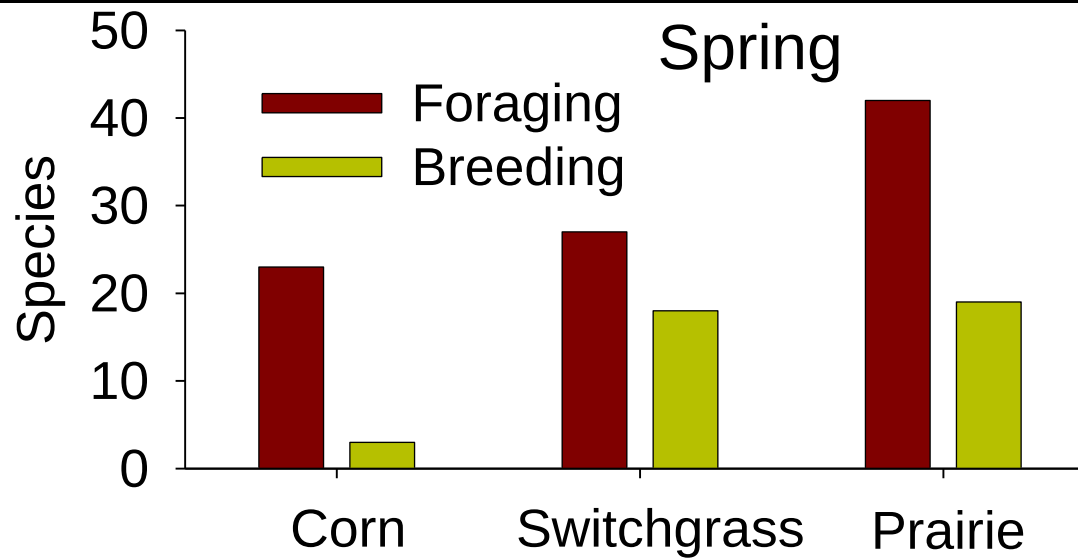
species
richness



abundance



Habitat Use



State listed (MI) species found in biofuel crops:



Northern Harrier

Prairie



Henslow's Sparrow

Prairie



Dickcissel

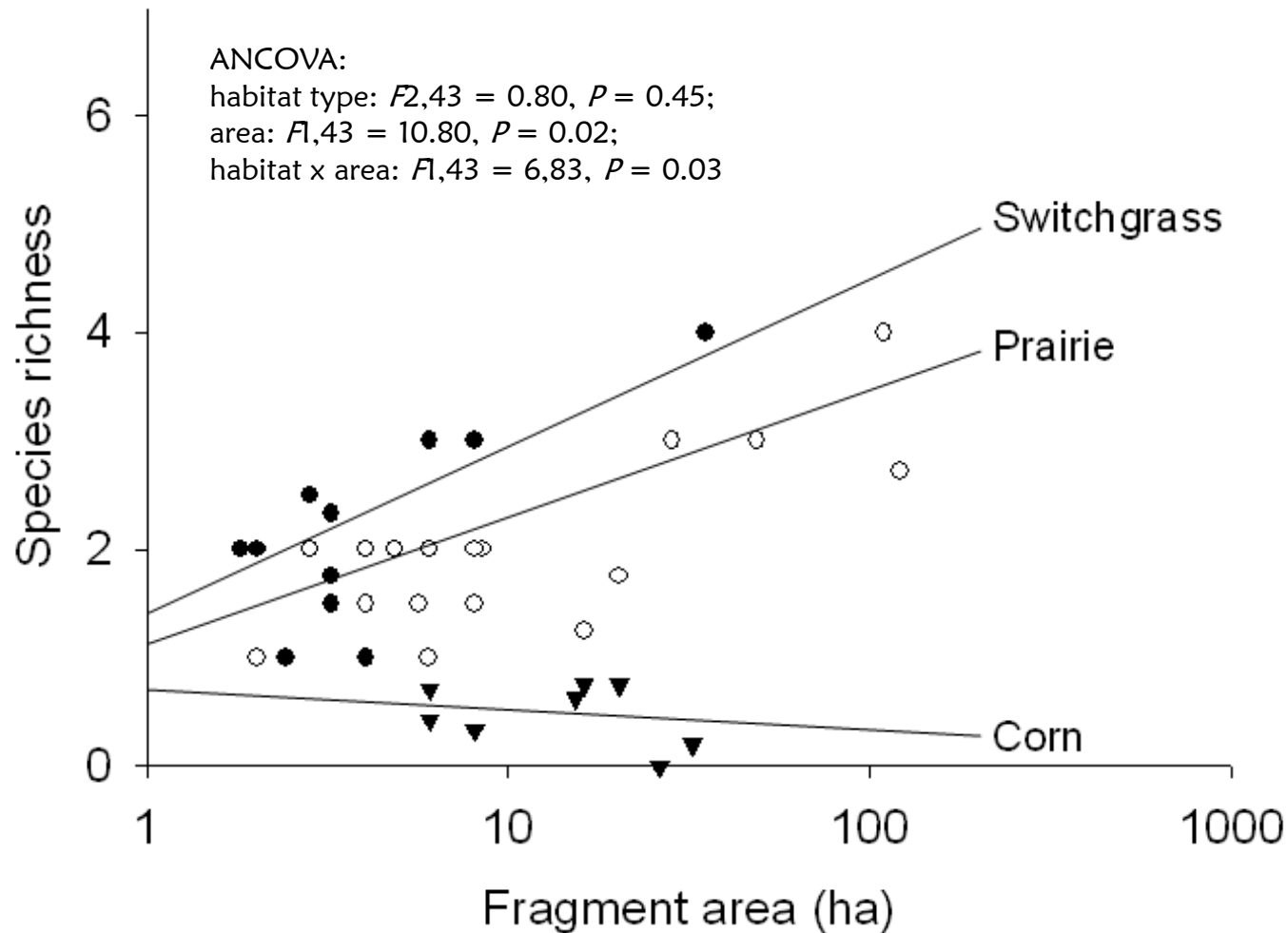
Prairie



Grasshopper Sparrow

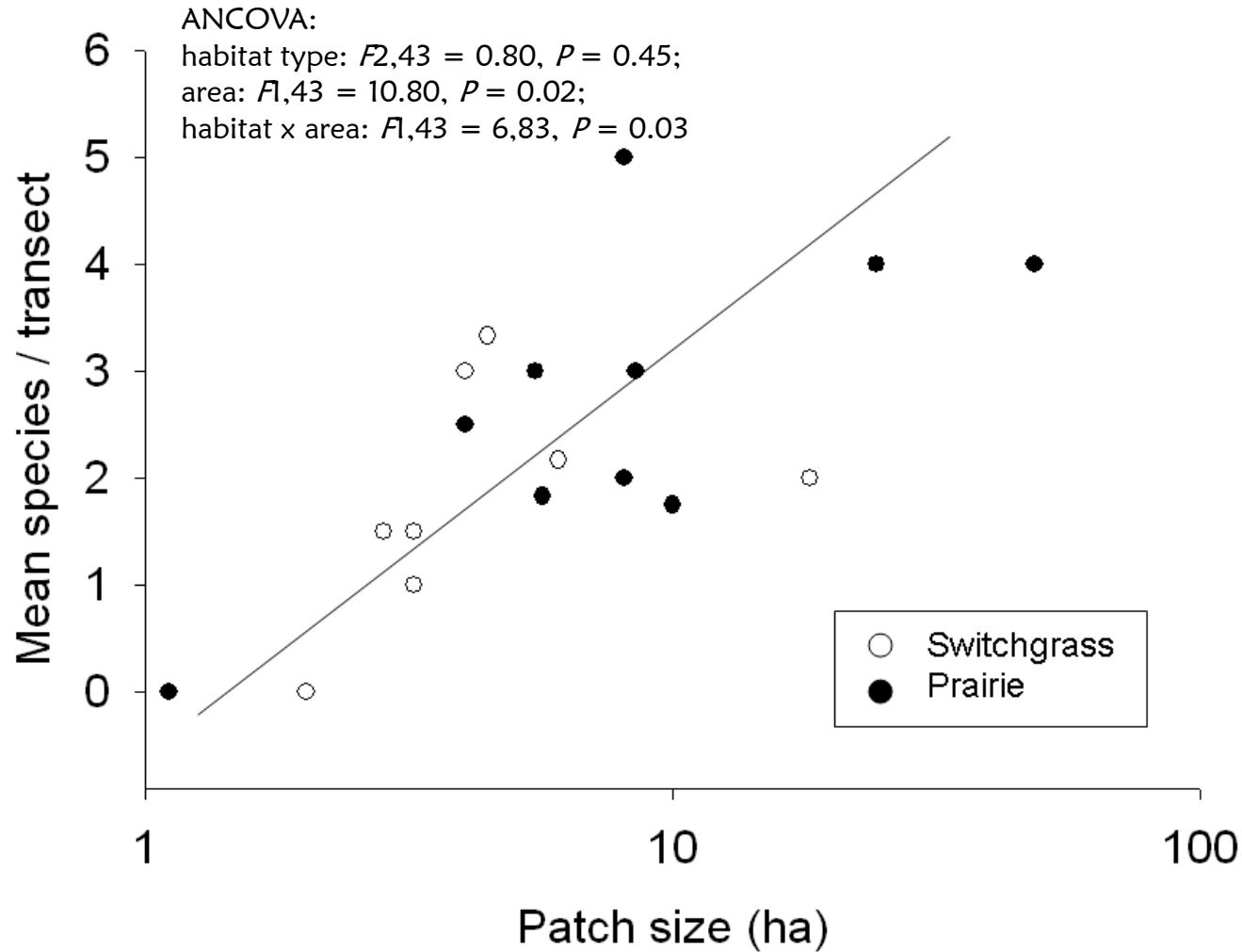
Prairie
Switchgrass

Perennial Grasses > Corn for Breeding Birds



- # of species per transect increases with patch size in prairie and switchgrass

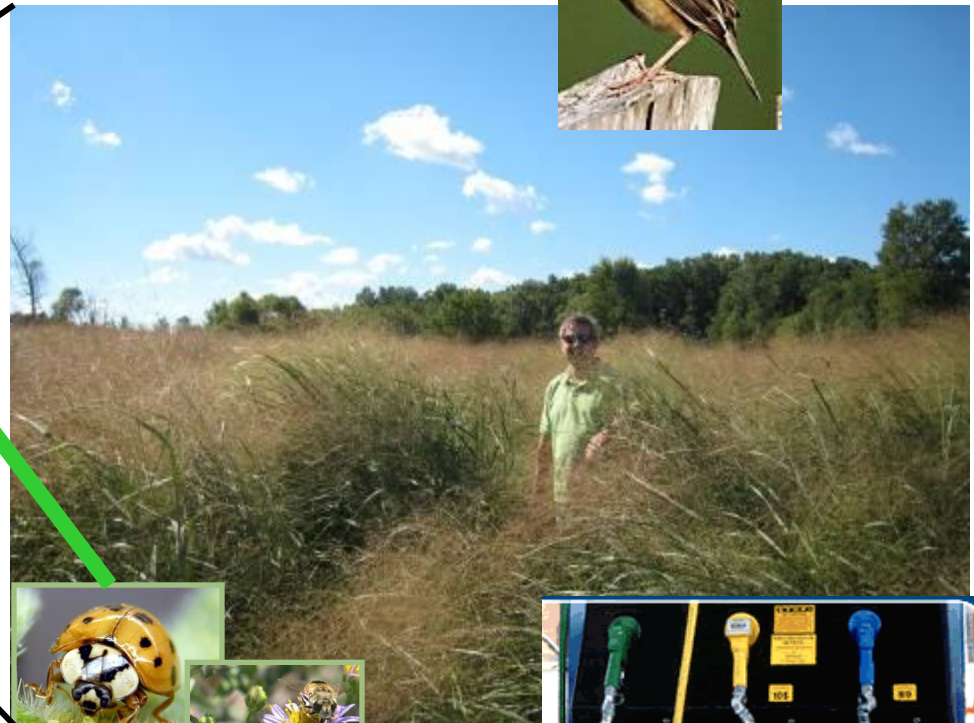
Switchgrass $\approx$ Prairie for Fall Migrants



- Grassland birds are area-sensitive during migration, too!

Are There Win-Win Scenarios?

- Increase biodiversity and ecosystem services



Are There Win-Win Scenarios?

- Improve marginal lands



Conclusions

- Biodiversity supports critical ecosystem services in agricultural landscapes
- Protect and enhance that biodiversity through informed landscape management
- Cellulosic biofuels offer a unique opportunity to rethink agriculture to maximize ecosystem services and enhance sustainability



Acknowledgements

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Pam Mosley	MSU

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Alejandro Costamagna	UMN
David Ragsdale	UMN

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