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

Tscharntke et al. Ecology Letters 2005
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
Focus: Agricultural Ecology

Central Question

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

- Main site
- Scale up fields
Previous Studies

Mean Adults/Trap/Week

Year


Native

Exotic

H. axyridis
Soybean Aphid (*Aphis glycines*)

- Exotic (Asia)
- 40 to 50% yield losses
- Rapid landscape spread
Soybean Aphid Food Web

Tri-trophic Interactions

Coccinellids → Predators Parasitoids

Herbivore

Plant

Costamagna et al. Biol. Cont. 2007
Costamagna et al. Agr. and For. Entomol. 2007
Landscape Interactions
Predator Impacts

EXCLUSION CAGE

OUTBREAK 13%

SUPPRESSED 17%

CONTROLLED 70%

Mean # aphids/plant

250 aphids/plant

Economic Threshold

Time
Landscape Impacts

Biocontrol Services Index (BSI)
BSI versus Landscape

Simpson’s Diversity (D) at 1.5 km scale

Biocontrol Services Index (BSI)

$r^2 = 0.31$

$P < 0.01$

Proportion Corn at 1.5 km scale

$r^2 = 0.39$

$P < 0.001$

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

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

Landis, Gardiner, van der Werf, Swinton. PNAS 2008
Cellulosic Biofuel Landscapes

Production

Processing

Ecosystem services
Biofuel Crops and Biodiversity

**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

average across sites

by bee family

abundance

Tuell, Isaacs unpub. data
State listed (MI) species found in biofuel crops:

- Northern Harrier
- Henslow’s Sparrow
- Dickcissel
- Grasshopper Sparrow

Robertson, Doran, Schemske, unpub data
• # of species per transect increases with patch size in prairie and switchgrass
Grassland birds are area-sensitive during migration, too!

**Switchgrass ≈ Prairie for Fall Migrants**

- ANCOVA:
  - habitat type: $F_{2,43} = 0.80, P = 0.45$
  - area: $F_{1,43} = 10.80, P = 0.02$
  - habitat x area: $F_{1,43} = 6.83, P = 0.03$

- 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
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