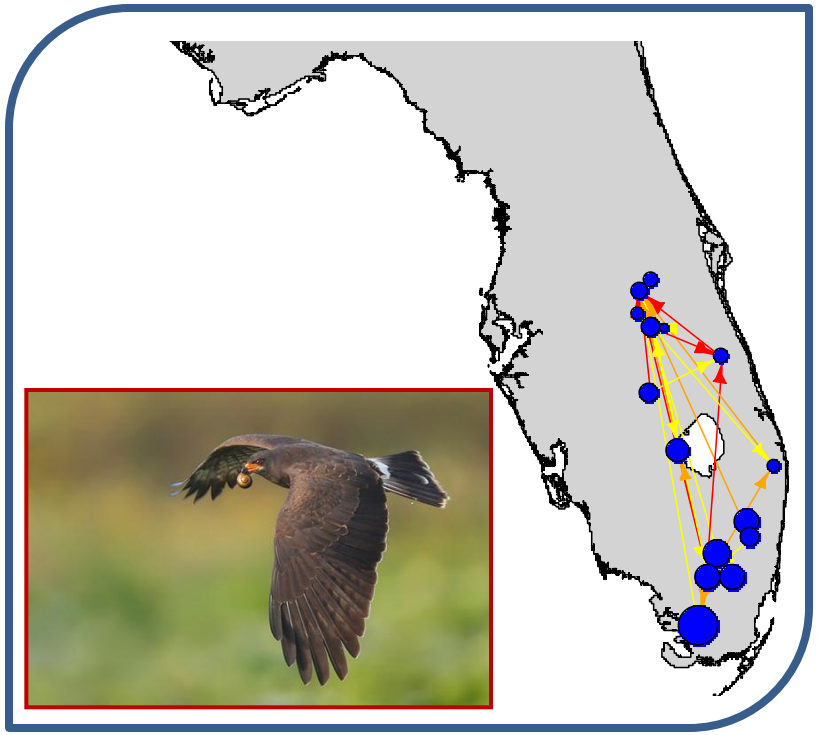
Bioenergy expansion:
A wildlife perspective

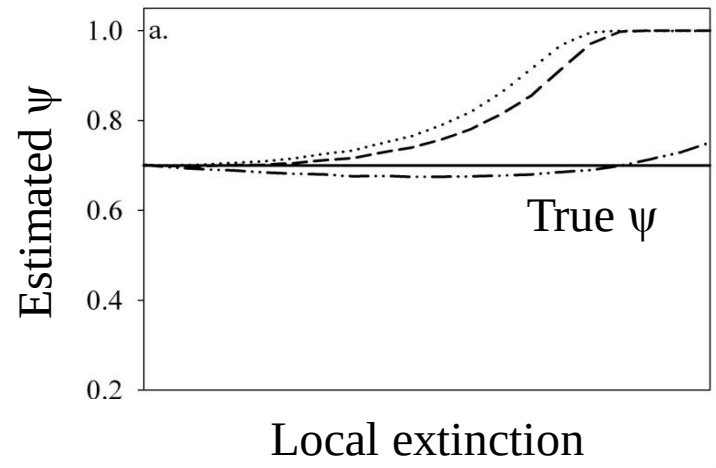
Rob Fletcher

Department of Wildlife Ecology and Conservation

UF UNIVERSITY of FLORIDA



$$L(\psi, p_1, p_2, \varepsilon, \gamma | j_{i1}, j_{i2}, y_{i1}, y_{i2}) = \prod_{i=1}^{N} \psi p_1^{y_{i1}} (1 - p_1)^{j_{i1} - y_{i1}}$$

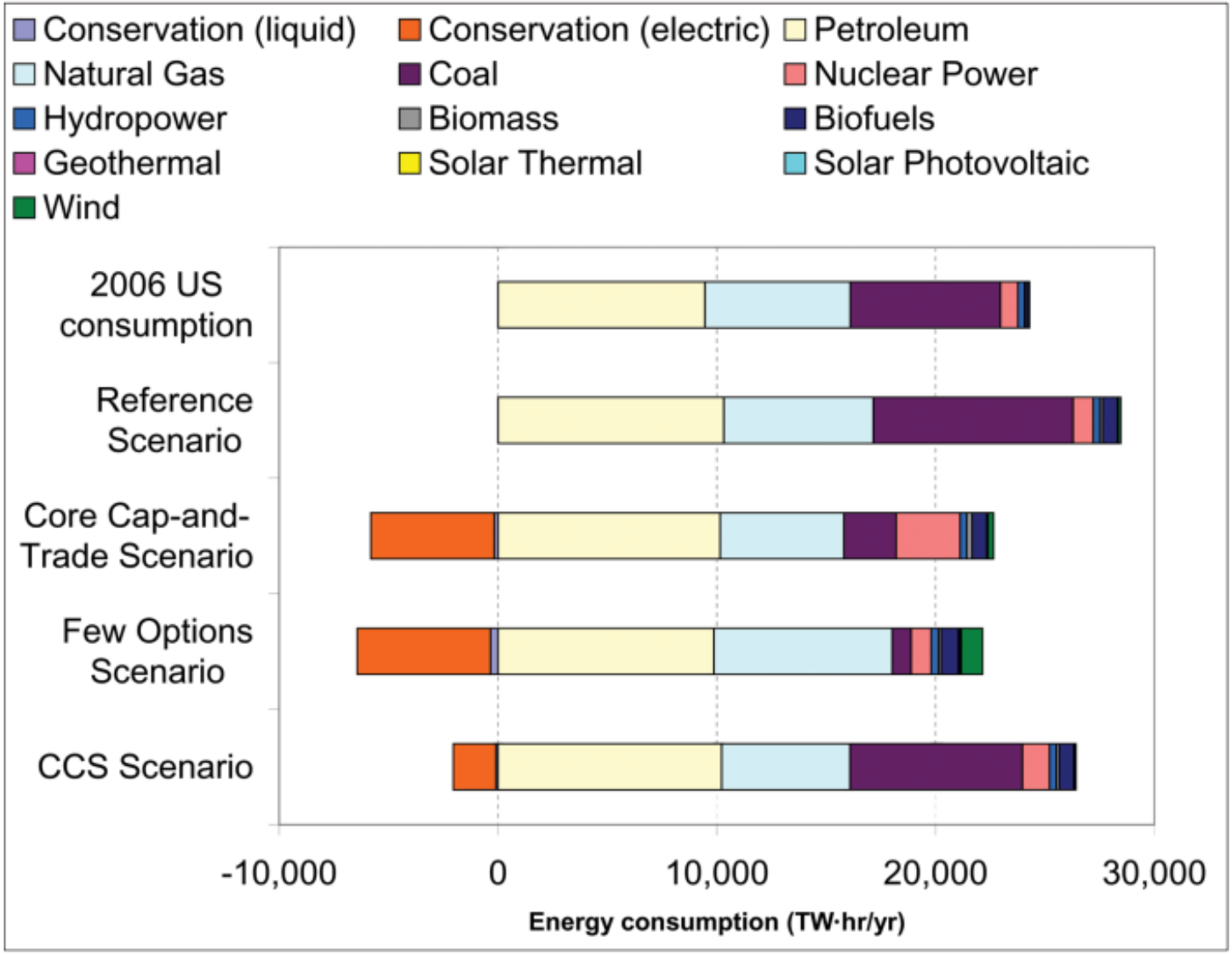


Outline

- ❑ Bioenergy, the environment, and wildlife
- ❑ What current biodiversity data *can and cannot* tell us about wildlife and bioenergy
- ❑ Large-scale impacts for wildlife
- ❑ Future directions and challenges

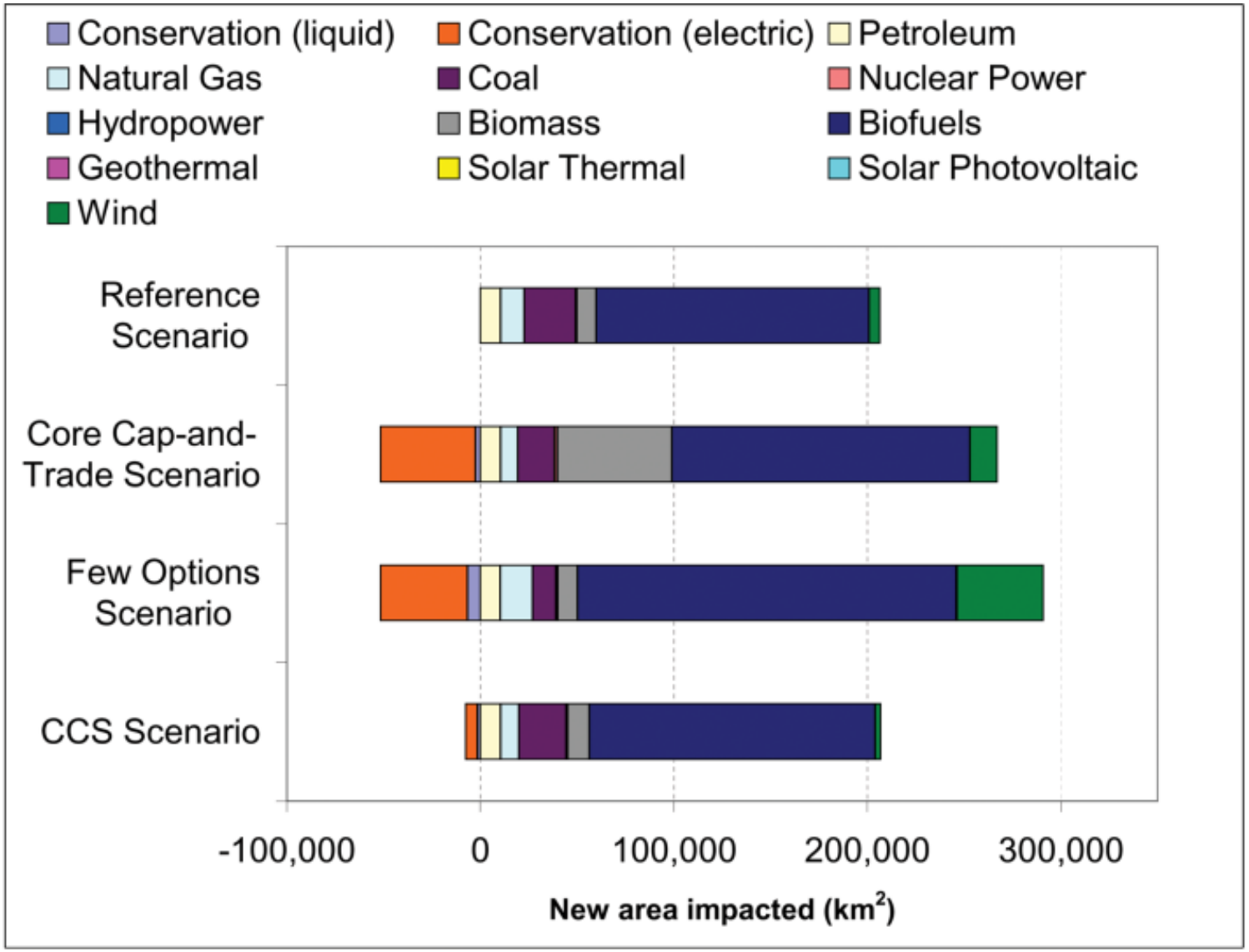
Energy and the environment

The energy consumption portfolio



McDonald et al. (2009)

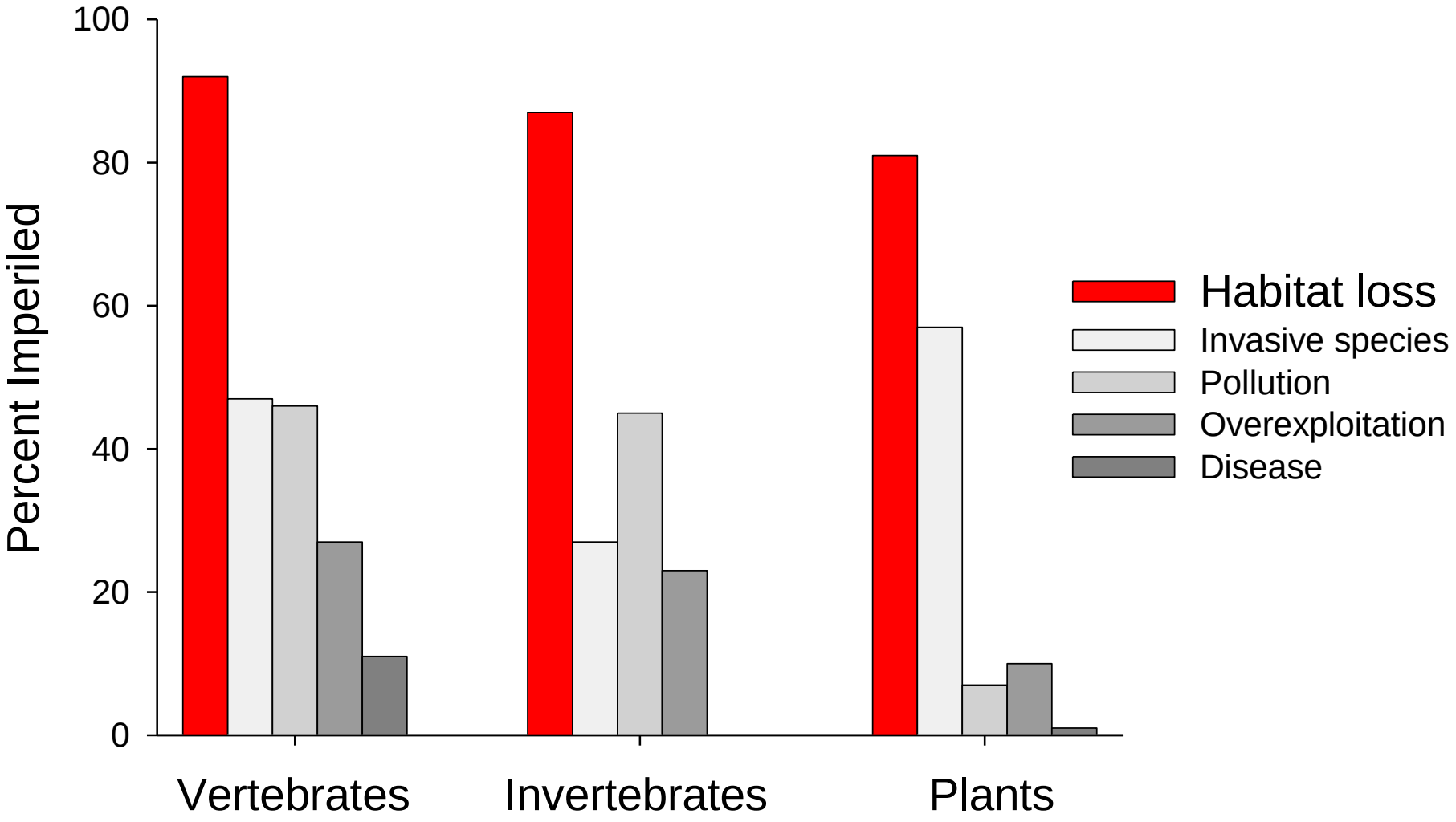
Energy consumption and new land area impacted



McDonald et al. (2009)

Why is this relevant to biodiversity?

In U.S., threats to imperiled species are:



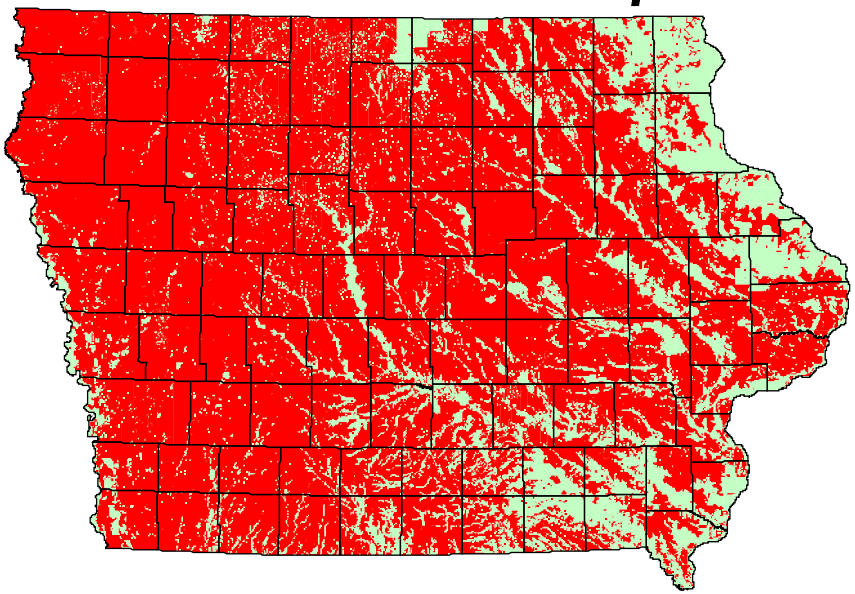
Wilcove et al. (1998)

Almost total habitat destruction in the Midwestern U.S. where intensive agriculture is prevalent

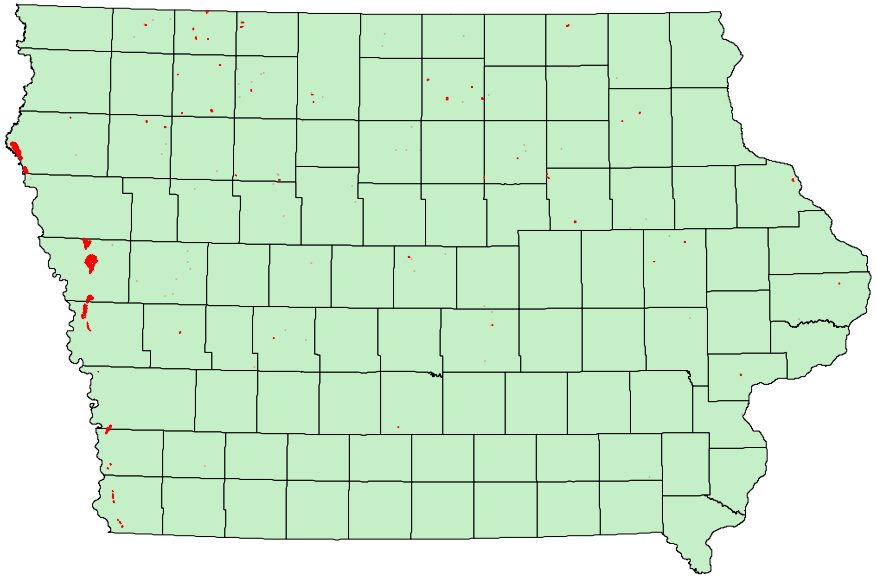
Tallgrass prairie habitat has declined:

< 0.1% remains

Historic Iowa Landscape



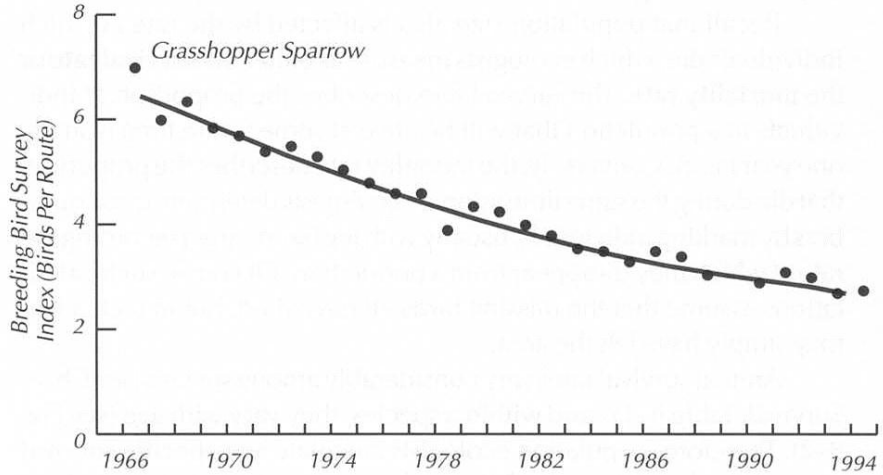
Current Iowa Landscape



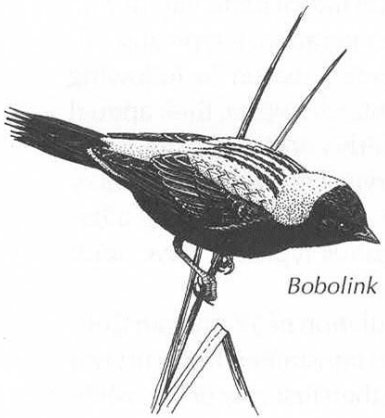
Native tallgrass prairie shown in RED

Habitat loss and vertebrate populations

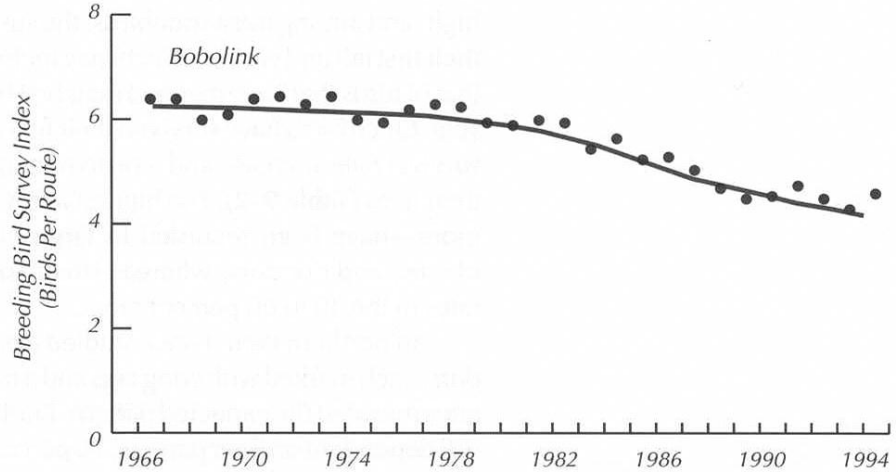
- **Grassland birds have experienced widespread declines**
- **Declines are often attributed to habitat loss**



Grasshopper Sparrow



Bobolink



Mandates for increased biofuels production across the U.S.

Mandates set by the Energy Security and Independence Act of 2007 include that biofuels use in the U.S. needs to increase from

6 billion in 2007 to ~36 billion gallons/year by 2022

Will increased biofuels production be a boon or bust for biodiversity?

How will changes in land management and land conversion influence wildlife?

Outline

- ❑ Bioenergy, the environment, and wildlife
- ❑ What current biodiversity data *can and cannot* tell us about wildlife and bioenergy
- ❑ Large-scale impacts for wildlife
- ❑ Future directions and challenges

Applied ecologists are in unfamiliar territory when it comes to bioenergy

"I'm going to need a Margin of Error or I can't publish your prediction of six more weeks of winter."

Making the best of what's available: Reviews, meta-analyses, and retrospective analyses

Biodiversity response to intensive biomass production from forest thinning in North American forests – A meta-analysis

Jake Verschuyl[a,*], Sam Riffell[b], Darren Miller[c], T. Bently Wigley[d]

The Condor 114(4):1–10
© The Cooper Ornithological Society 2012

ARE AGROFUELS A CONSERVATION THREAT OR OPPORTUNITY FOR GRASSLAND BIRDS IN THE UNITED STATES?

Bruce A. Robertson[1,2,3,10], Robert A. Rice[1], T. Scott Sillett[1], Christine A. Ribic[4], Bruce A. Babcock[5], Douglas A. Landis[2], James R. Herkert[6], Robert J. Fletcher Jr.[7], Joseph J. Fontaine[8], Patrick J. Doran[9], and Douglas W. Schemske[2]

GLOBAL CHANGE BIOLOGY BIOENERGY

GCB Bioenergy (2011) 3, 313–321, doi: 10.1111/j.1757-1707.2010.01089.x

A meta-analysis of bird and mammal response to short-rotation woody crops

SAM RIFFELL*, JAKE VERSCHUYL†, DARREN MILLER‡ and T. BENTLY WIGLEY§

Bioenergy and Wildlife: Threats and Opportunities for Grassland Conservation

JOSEPH E. FARGIONE, THOMAS R. COOPER, DAVID J. FLASPOHLER, JASON HILL, CLARENCE LEHMAN, TIM McCOY, SCOTT McLEOD, ERIK J. NELSON, KAREN S. OBERHAUSER, AND DAVID TILMAN

Biofuels and biodiversity

John Wiens,[1,4] Joseph Fargione,[2] and Jason Hill[3]

REVIEWS REVIEWS REVIEWS

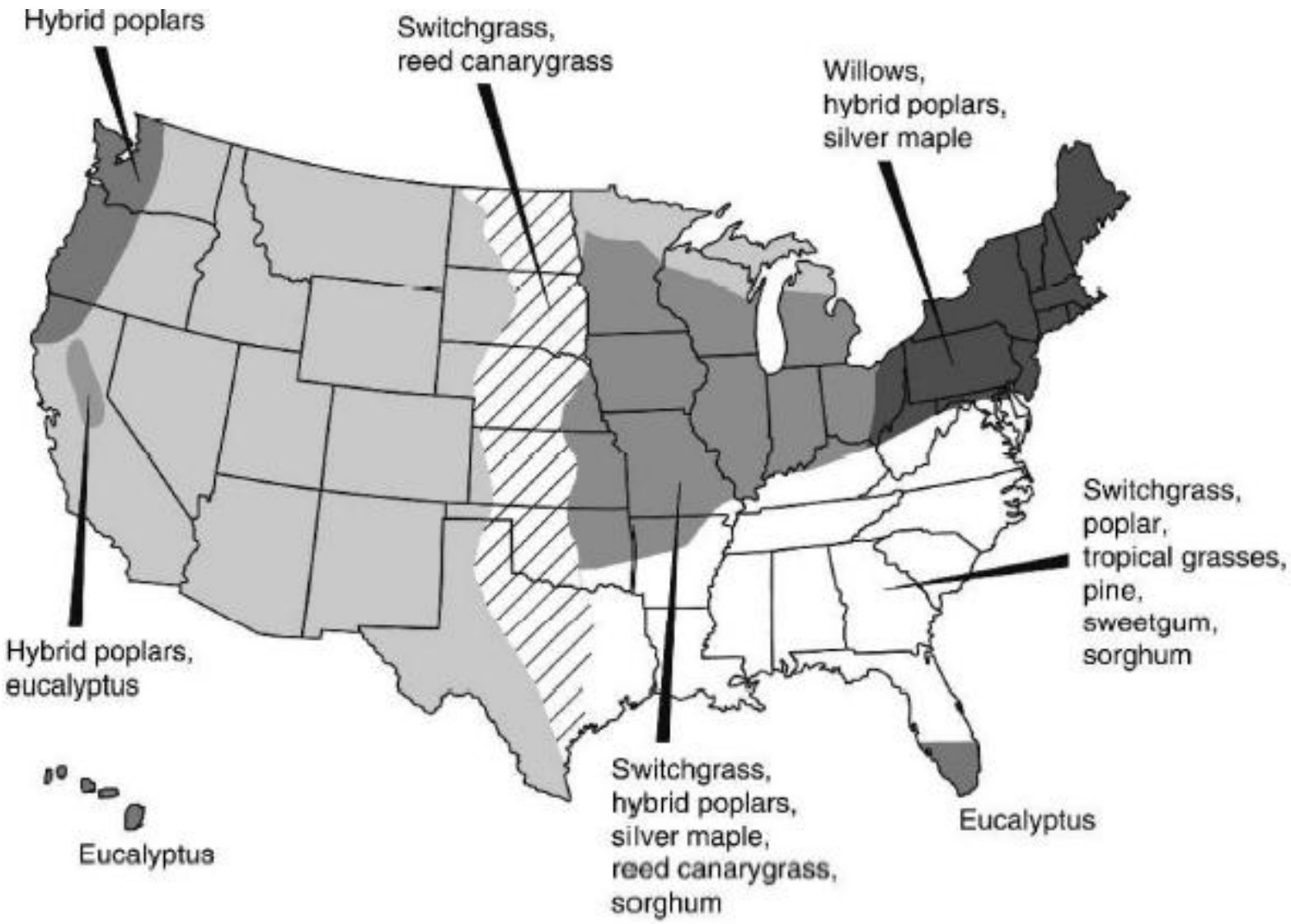
Biodiversity conservation in the era of biofuels: risks and opportunities

Robert J Fletcher Jr[1*], Bruce A Robertson[2,3], Jason Evans[1], Patrick J Doran[4], Janaki RR Alavalapati[5], and Douglas W Schemske[2,3]

Some general principles:

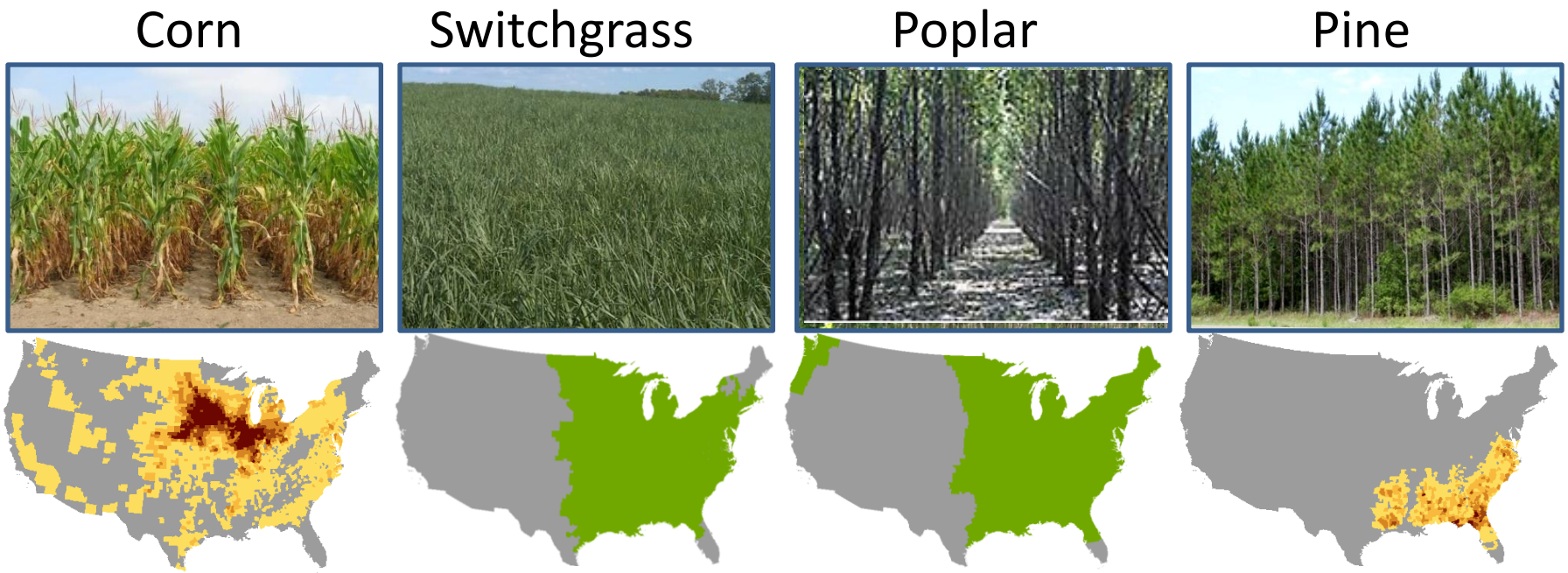
1) land-use change and bioenergy crops
2) Land management

To assess biodiversity effects, we need to understand land-use tradeoffs of different biofuel crops



Dale et al. (2011)

To assess biodiversity effects, we need to understand land-use tradeoffs of different biofuel crops



Fletcher et al. (2011)

Meta-analysis of diversity and abundance effects from potential biofuel crops

- *Wildlife in crop vs. reference*
- *430 articles/reports considered*
- *251 relevant responses*
- *65% on rowcrops*
- *No studies on switchgrass*
- *No studies on reptiles, amphibians*

Fletcher et al. (2011)

Meta-analysis of diversity and abundance effects from potential biofuel crops

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- *430 articles/reports considered*
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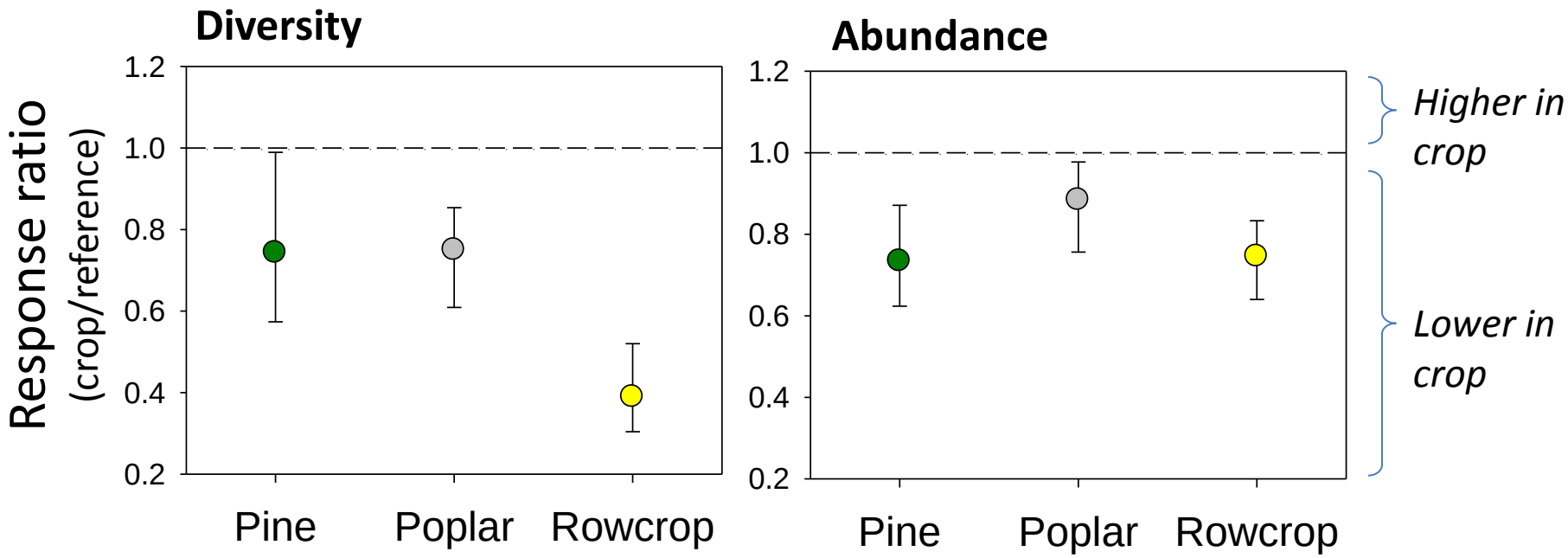
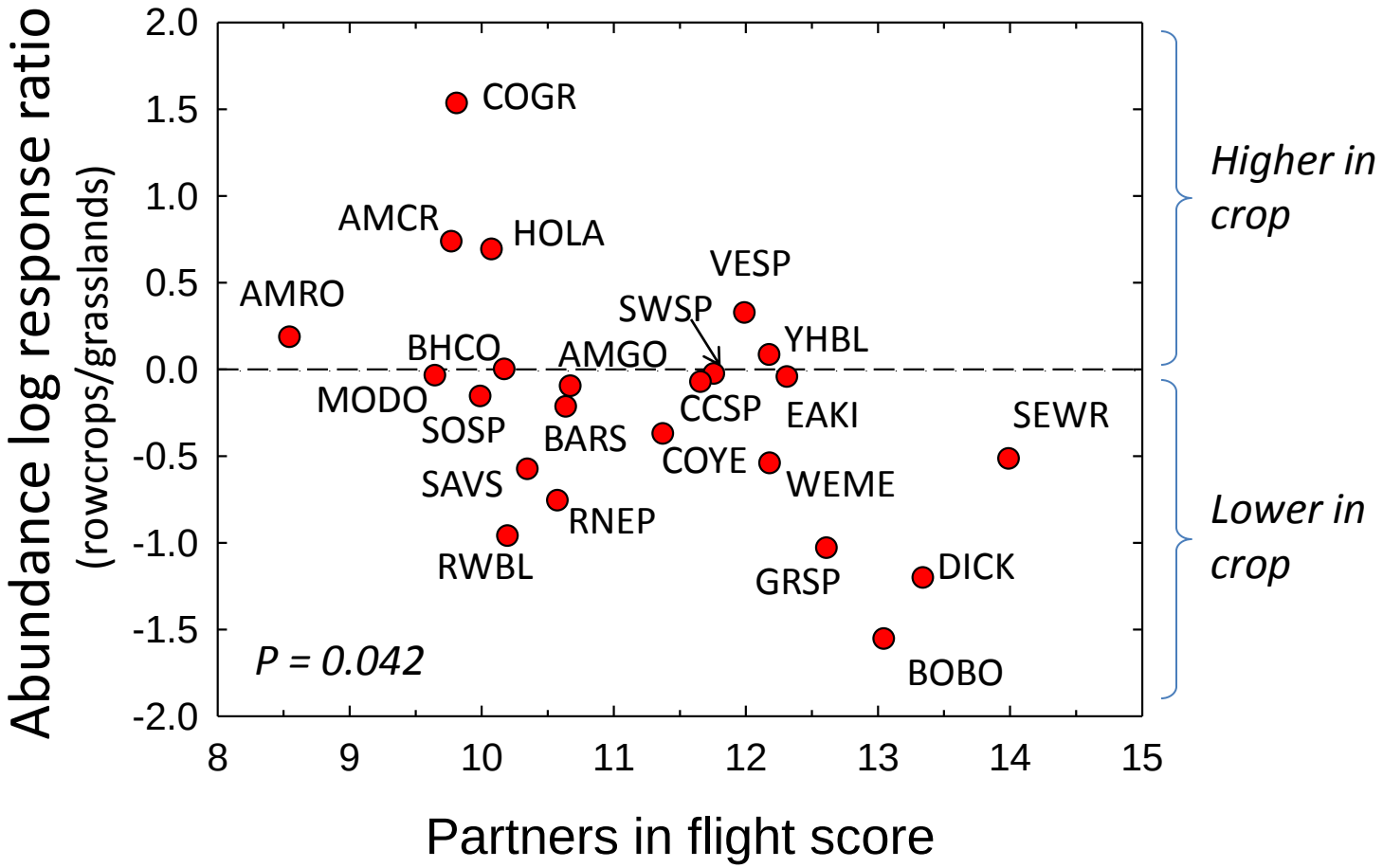
- *No studies on switchgrass*
- *No studies on reptiles, amphibians*
- *Each feedstock had negative effects*
- ***Rowcrops significantly worse***



Fletcher et al. (2011)

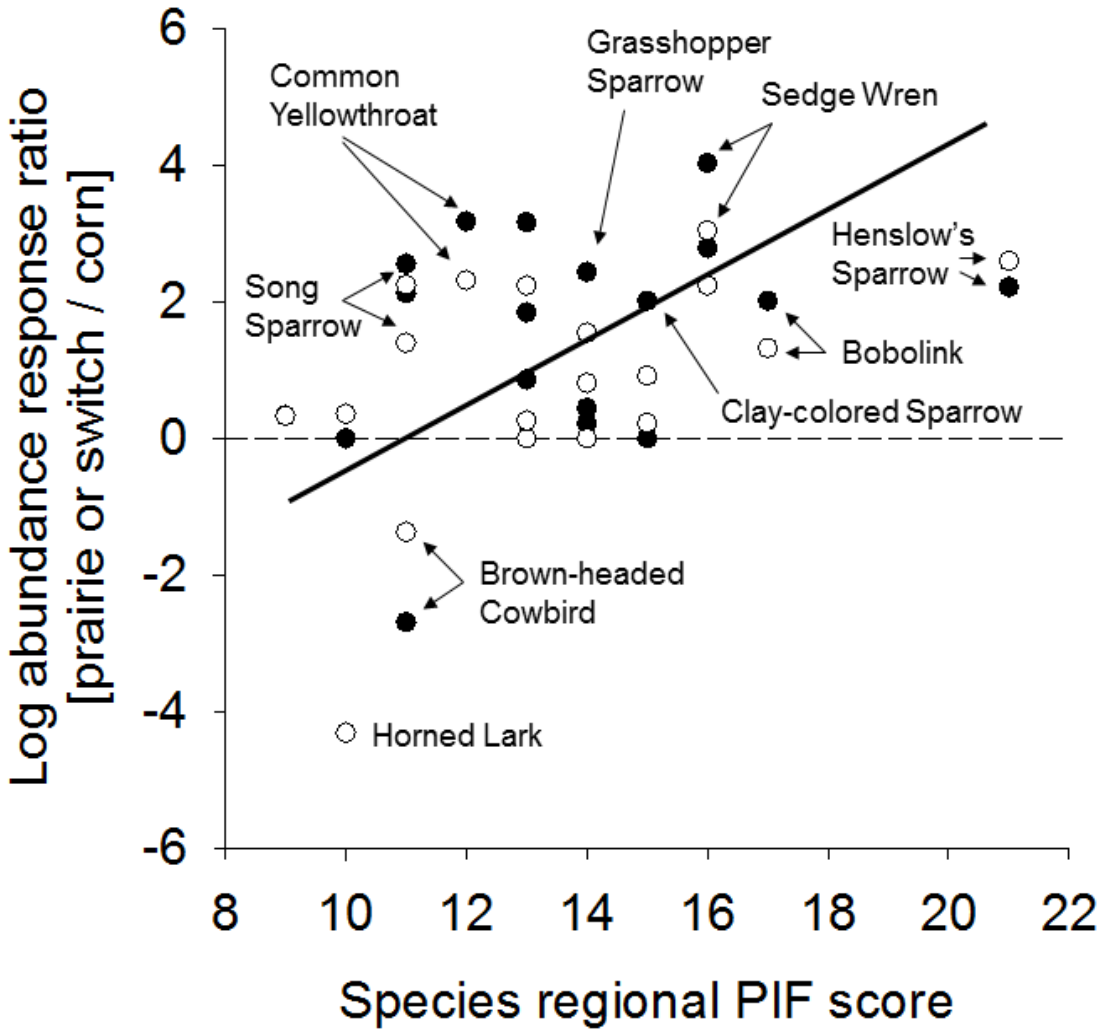
Meta-analysis of diversity and abundance effects from potential biofuel crops

Species of concern show stronger effects



Fletcher et al. (2011)

Conversion of corn to switchgrass or prairie could be beneficial for wildlife

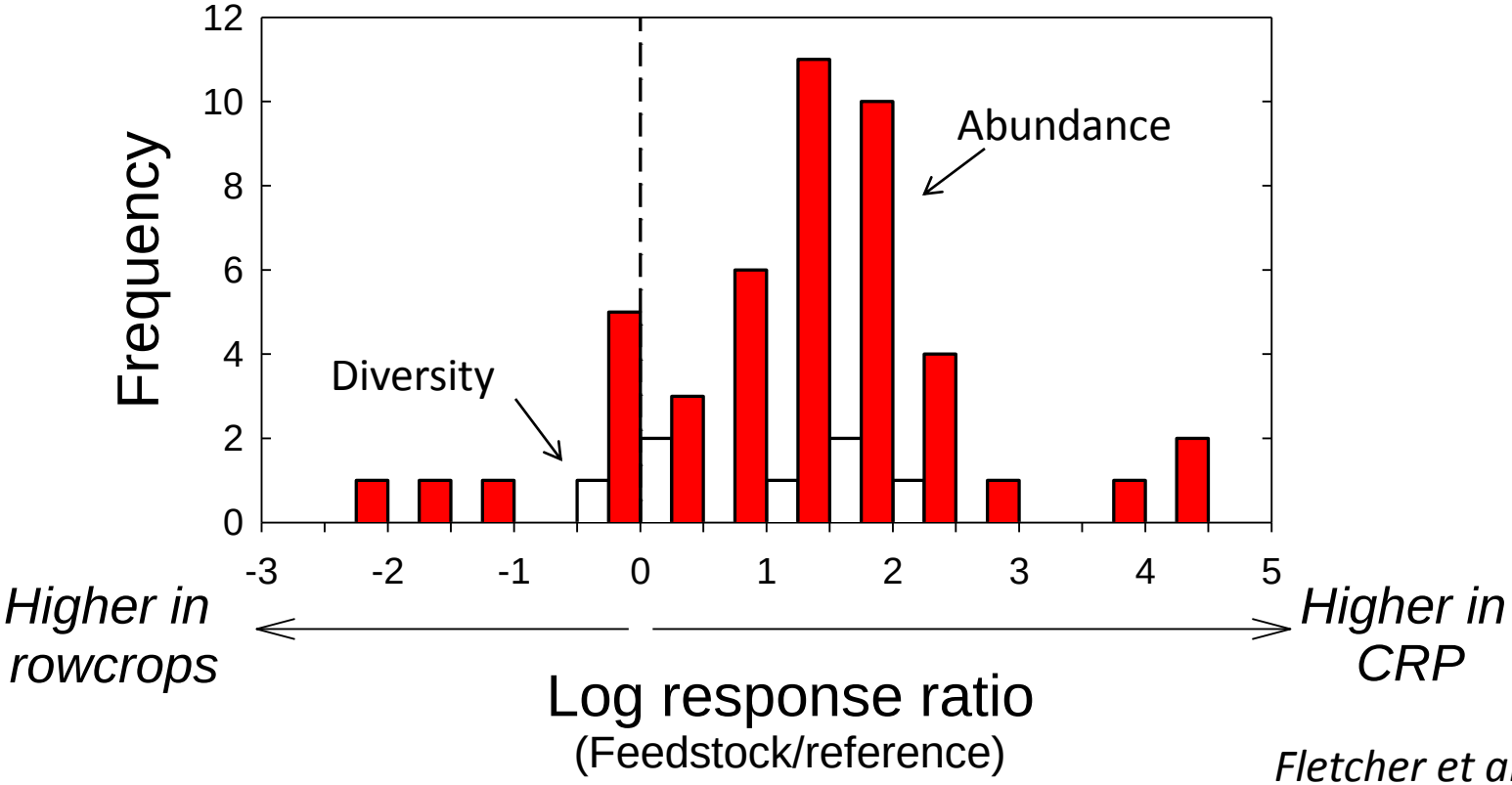


○ Prairie
● Switchgrass

Robertson et al. (2012)

Meta-analysis of diversity and abundance effects from potential feedstocks

- *Conversion of rowcrops to CRP for cellulosic biofuels may have net biodiversity benefits*
- *Conversion of marginal CRP to rowcrops would be detrimental*



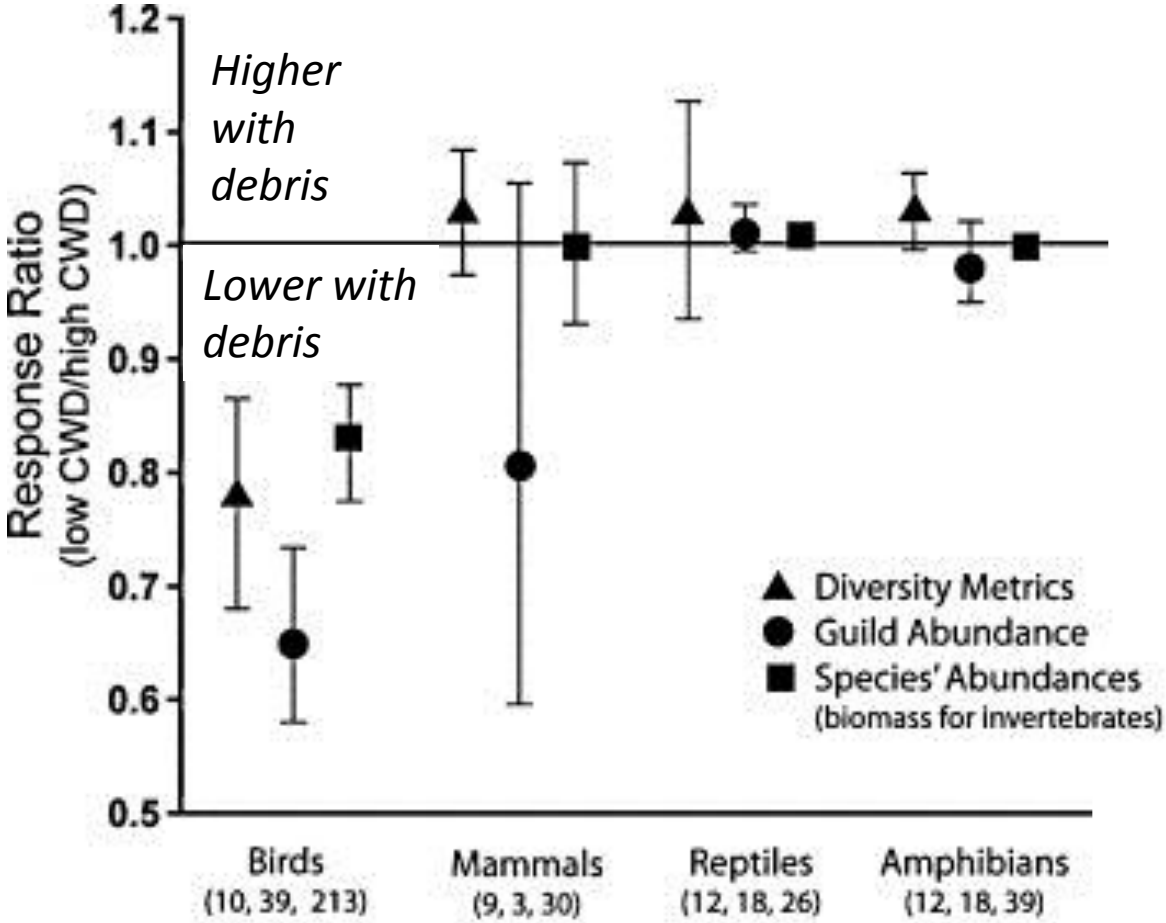
Fletcher et al. (2011)

Land management and biomass extraction:

Land management and biomass extraction:
an example with woody biomass

DOE (2011):

1) Residual debris
2) Thinning
3) Dedicated plantations



Riffell et al. (2011)

Land management and biomass extraction:
an example with woody biomass

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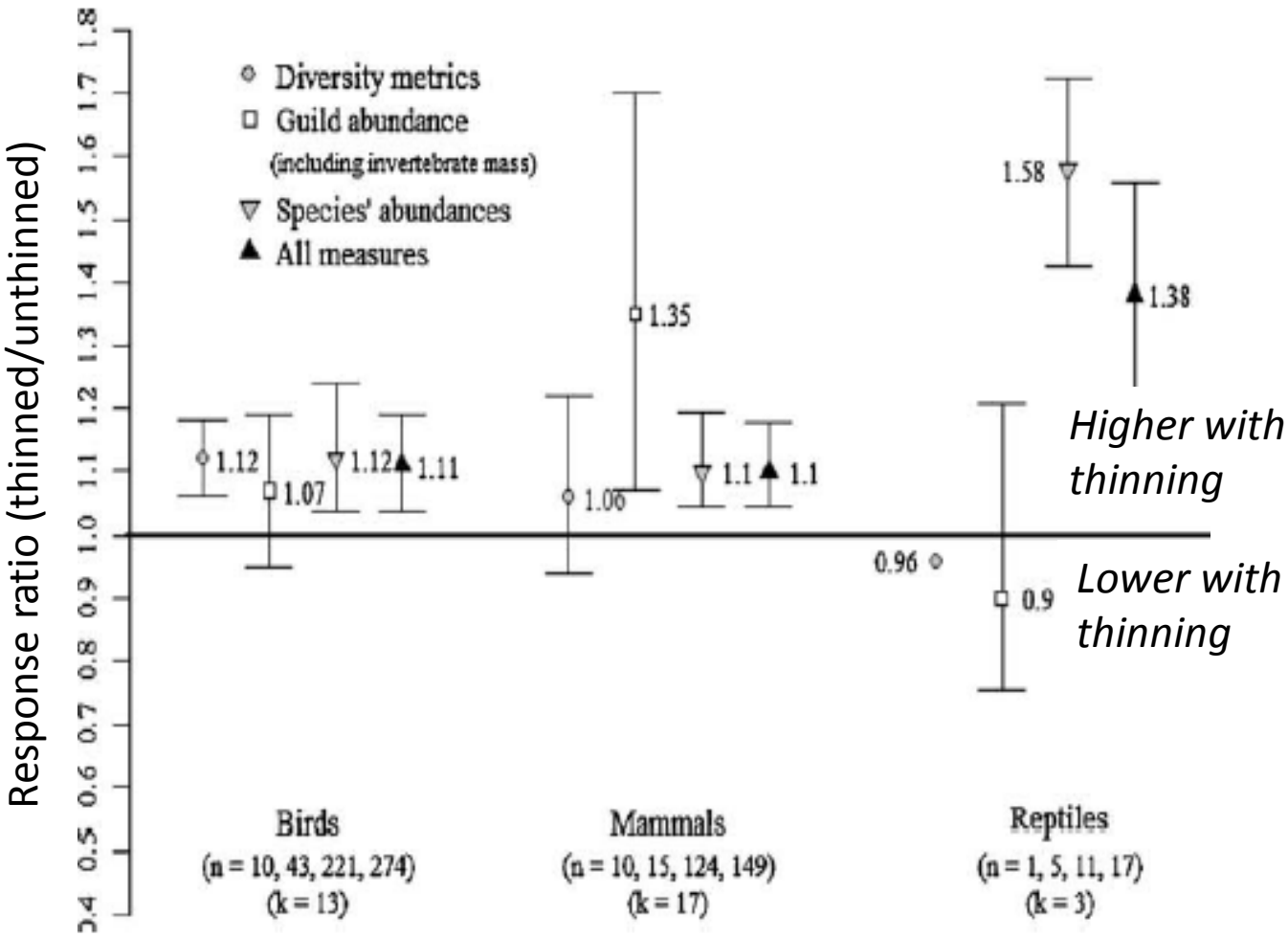


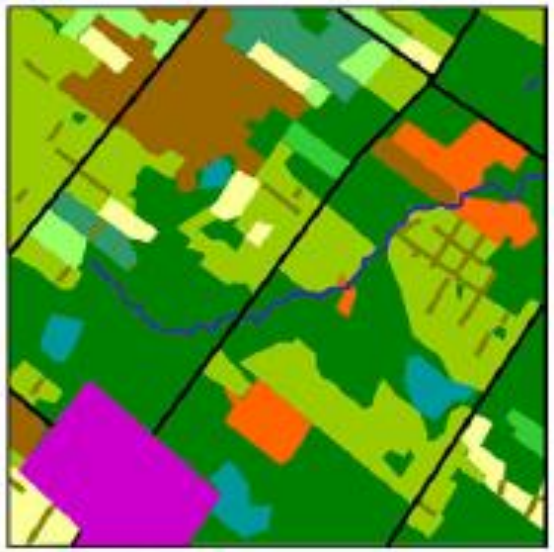
Verschuyl et al. (2011)

Some caveats

- None of these data come from areas of dedicated biomass production

- There is strong taxon bias, geographic bias

- All of these effects measured at the ‘site’ scale



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Assessing effects on wildlife at large scales

- Understanding land-use change tradeoffs across regions is essential

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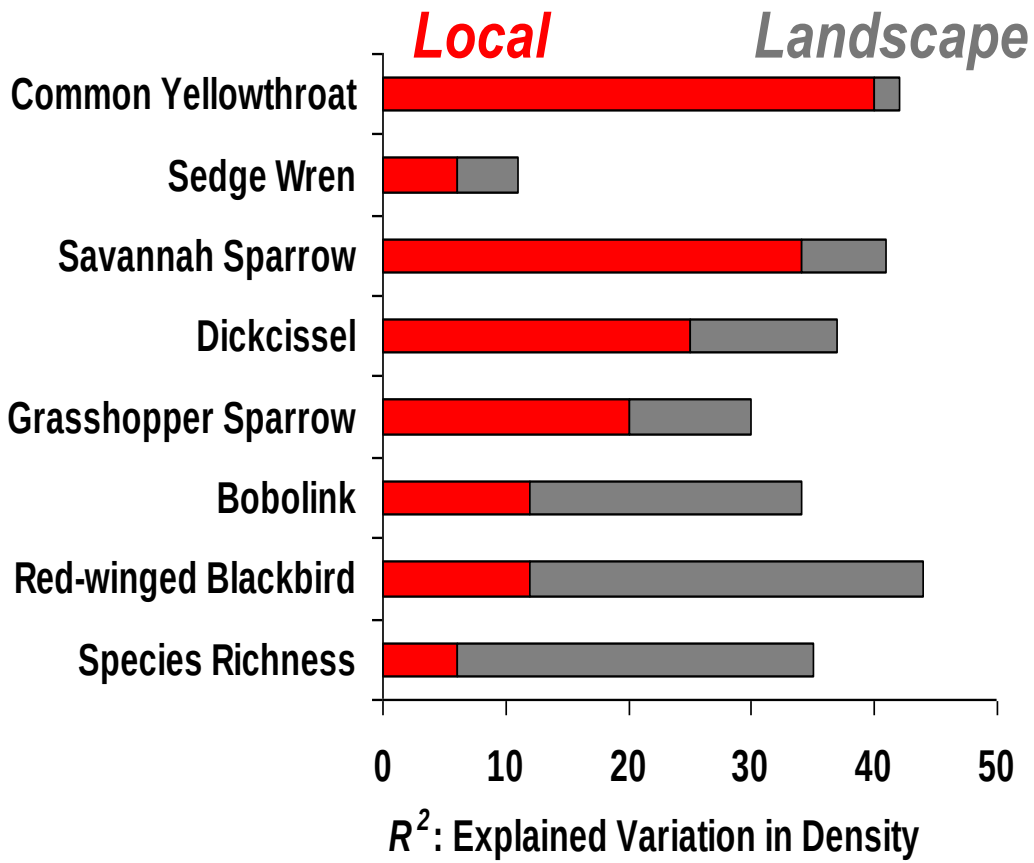
- Animals respond to land uses at different scales



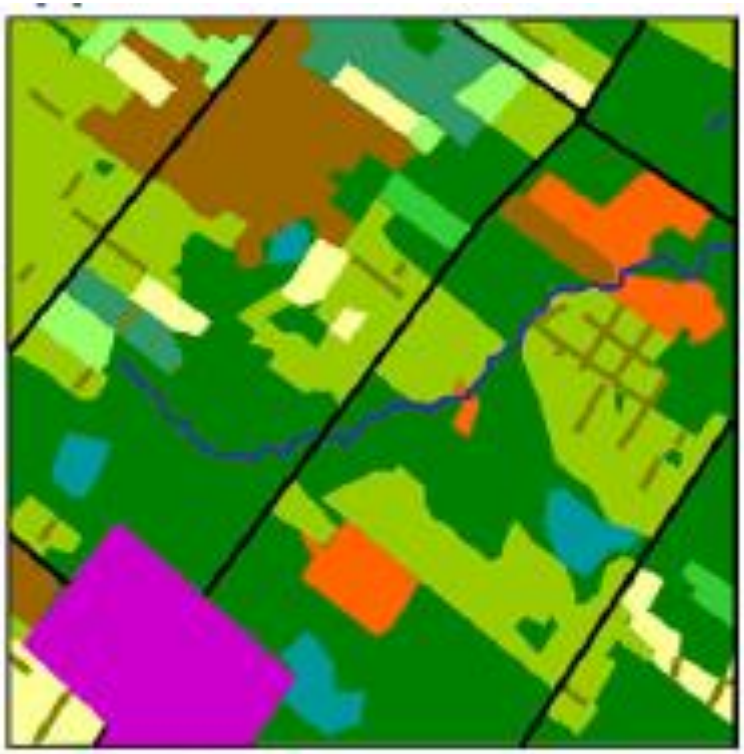
Fletcher and Koford (2002)

Assessing effects on wildlife at large scales

- ❑ Understanding land-use change tradeoffs across regions is essential

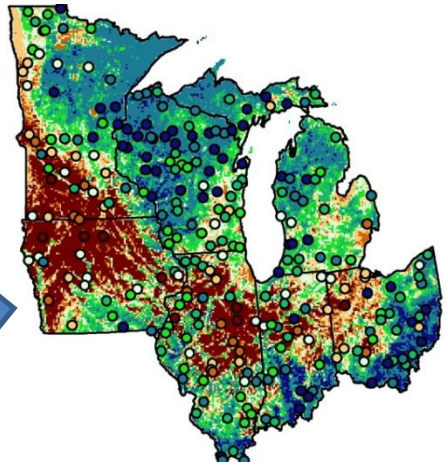
- ❑ Animals respond to land uses at different scales

- ❑ Consequently, landscape context may alter outcomes



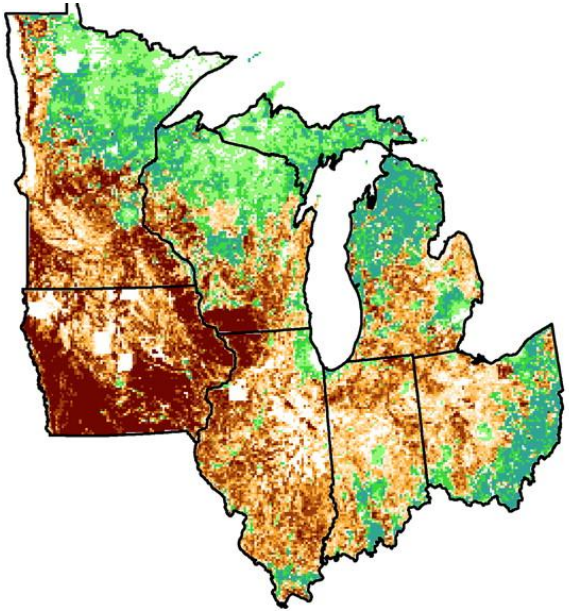
Assessing effects on wildlife at large scales

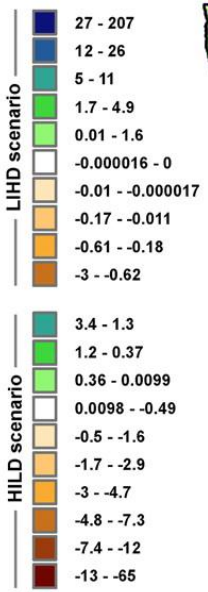
Current species richness

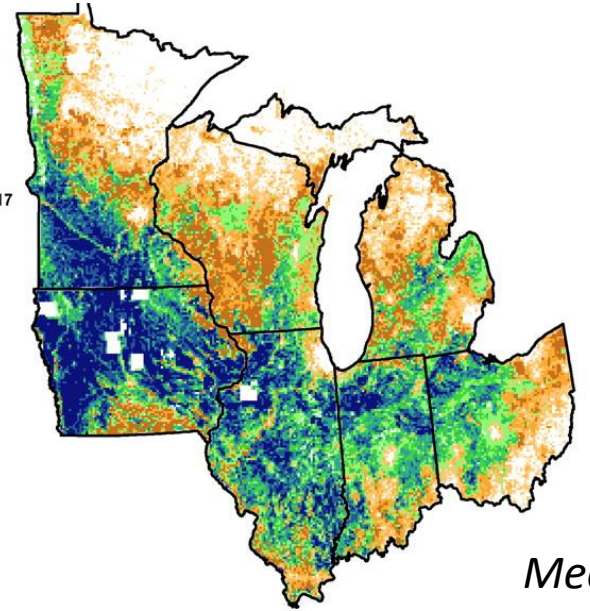


Conversion of marginal CRP and to rowcrops

Conversion of marginal rowcrops to low-input high-diversity grasslands







Meehan et al. (2010)

Some limitations

- None of these data come from areas of dedicated biomass production

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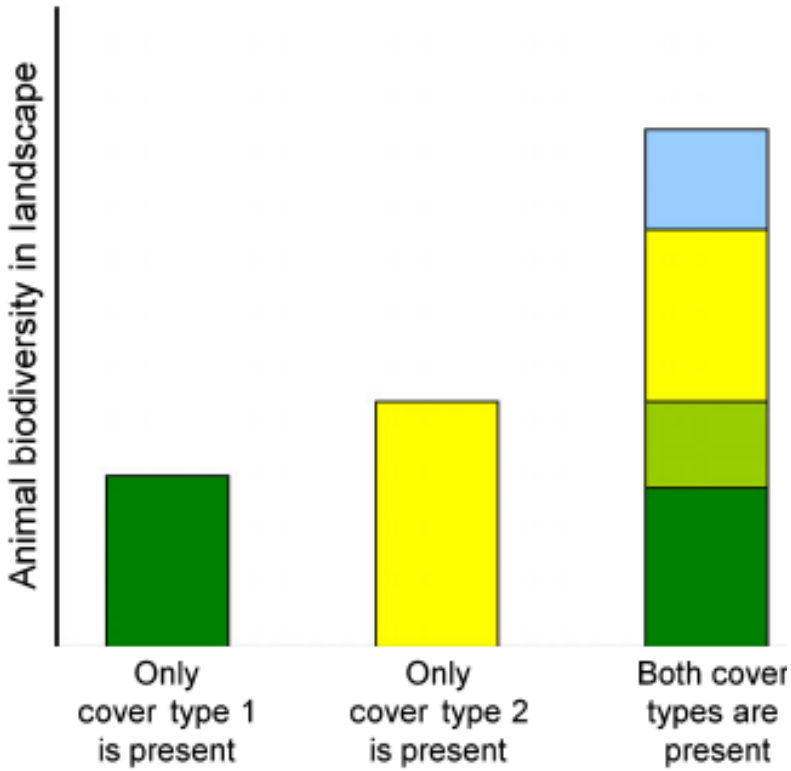
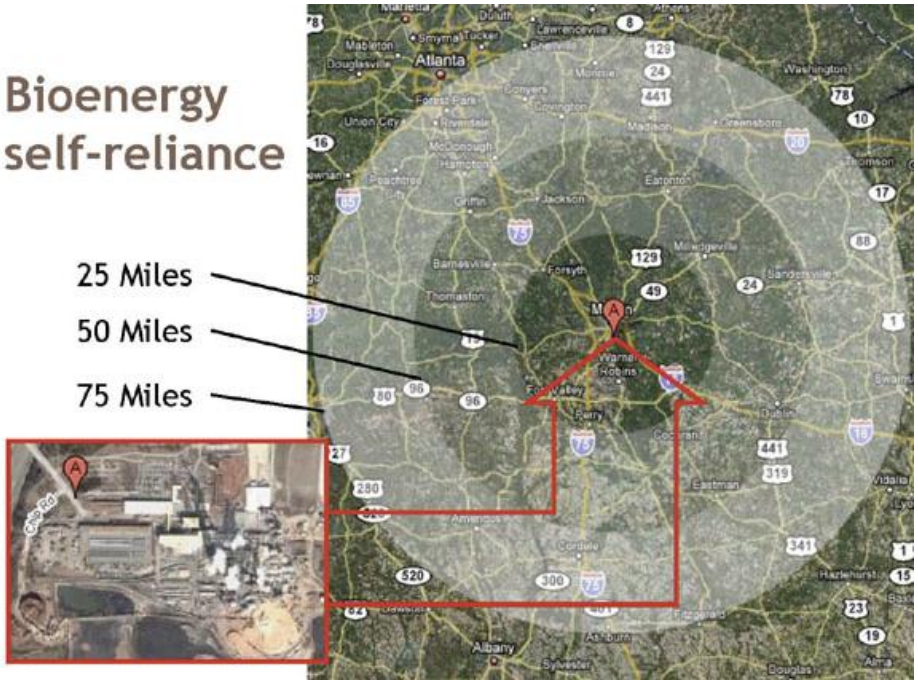
- None of these data come from areas of dedicated biomass production
- All of these effects measured at the 'site' scale (i.e., turnover is not considered)



Fahrig et al. (2010)

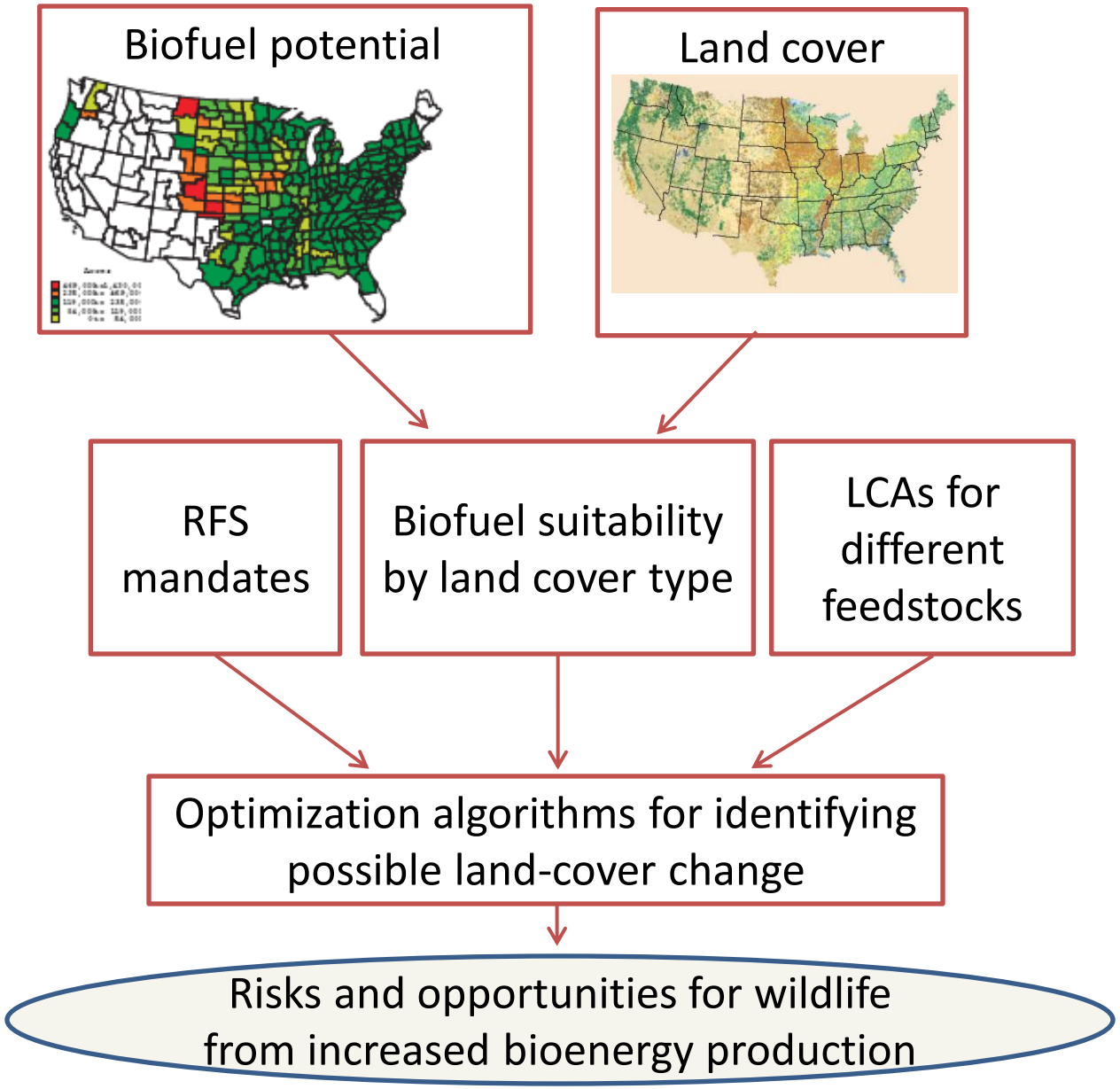
Some limitations

- ❑ None of these data come from areas of dedicated biomass production
- ❑ All of these effects measured at the 'site' scale (i.e., turnover is not considered)
- ❑ The aggregated footprint of land-use change is ignored



http://bioconversion.blogspot.com/2007/12/4-bioenergy-can-revive-depressed.html

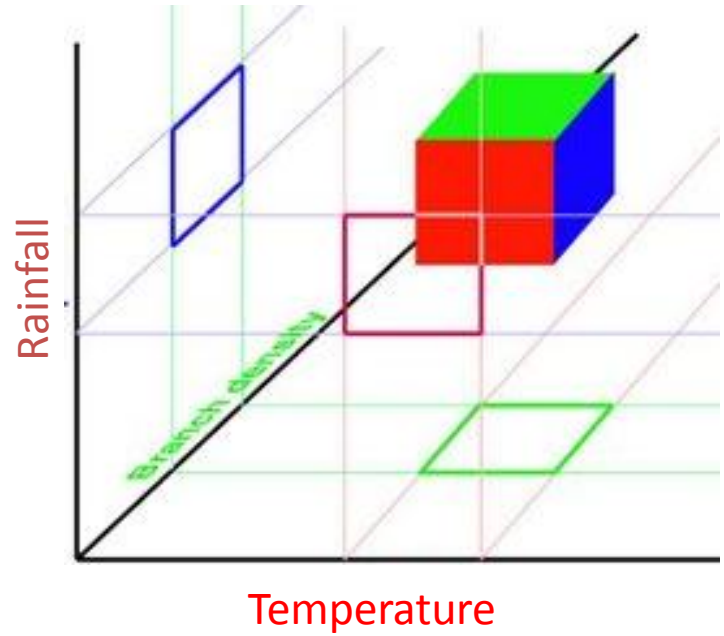
Identifying risks and opportunities for wildlife at large scales



Estimating biofuel crop suitability across the U.S.

Niche models for ‘presence only’ data

- ❑ Allow for objective estimates
- ❑ Potentially work well in situations where species don’t yet occur (e.g., invasives, new biofuel feedstocks)
- ❑ Can incorporate climate, topography, soils, societal issues (e.g., roads, existing ethanol plants)
- ❑ Complements agronomic models by providing a rapid, first-step assessment
- ❑ Provide geographic predictions of suitability with limited data

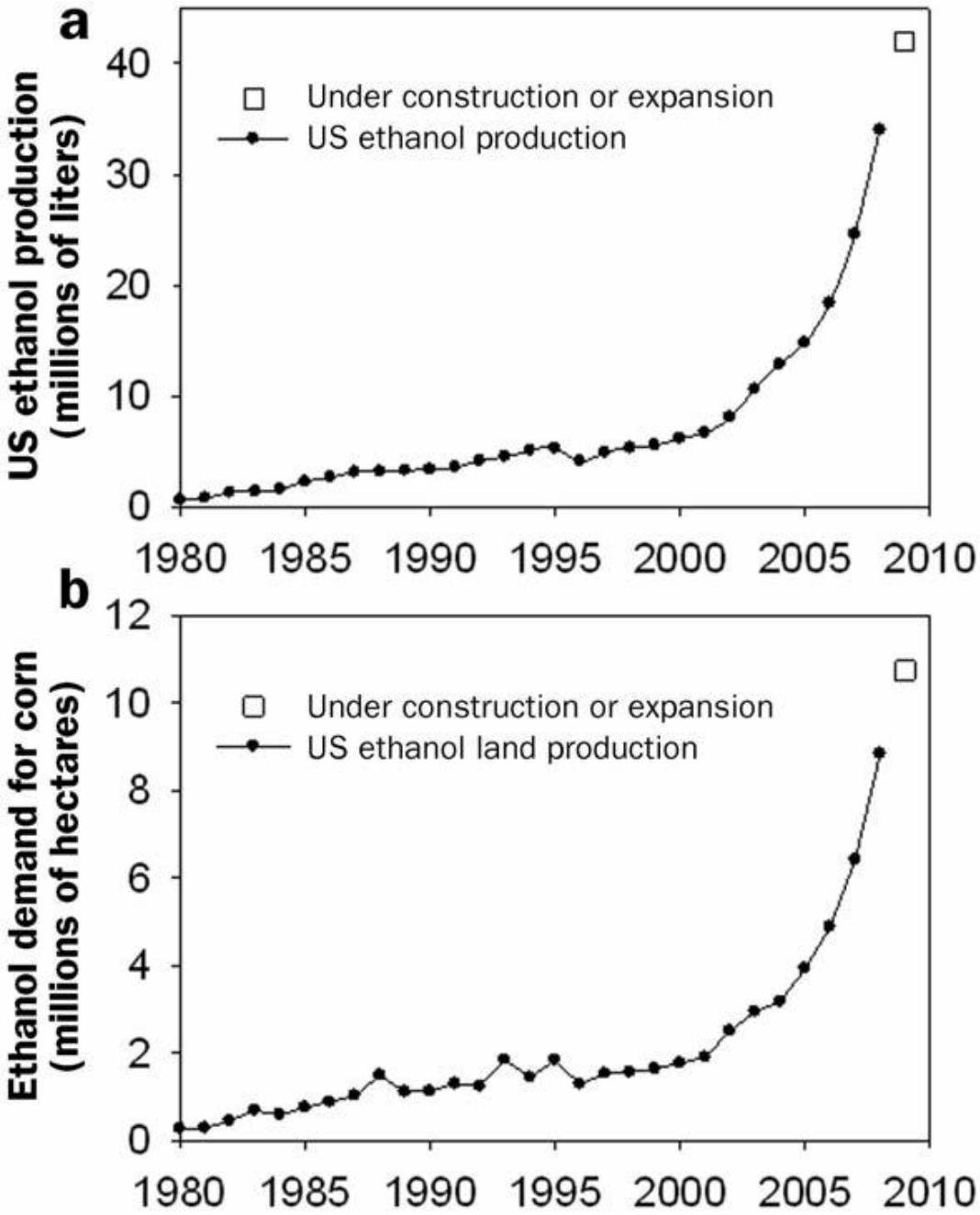


Estimating biofuel suitability across the U.S.

A test with corn production across the U.S.

- Developed models using data from 2006 production
  - *Maximum entropy*
  - *Support vector machines*
- Used climate, roads, population density information as explanatory variables
- *Can models predict the ~27% increased production in 2007?*

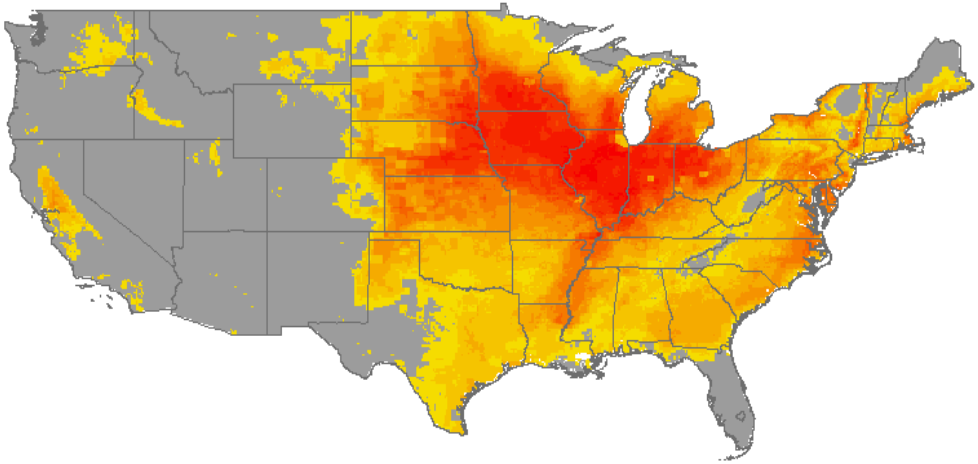
Can models predict the ~27% increased production in 2007?

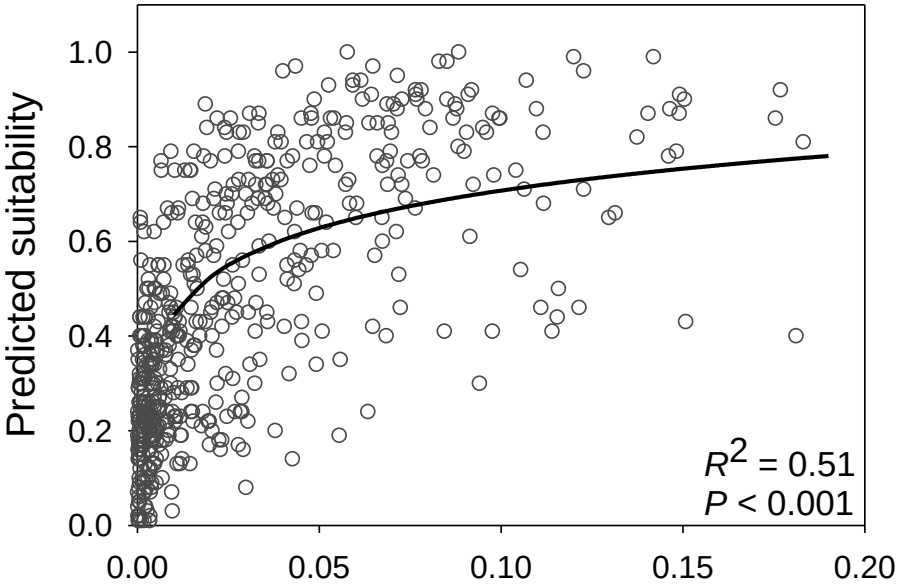


Estimating biofuel suitability across the U.S.

Evans, Fletcher and Alavalapati (2010)

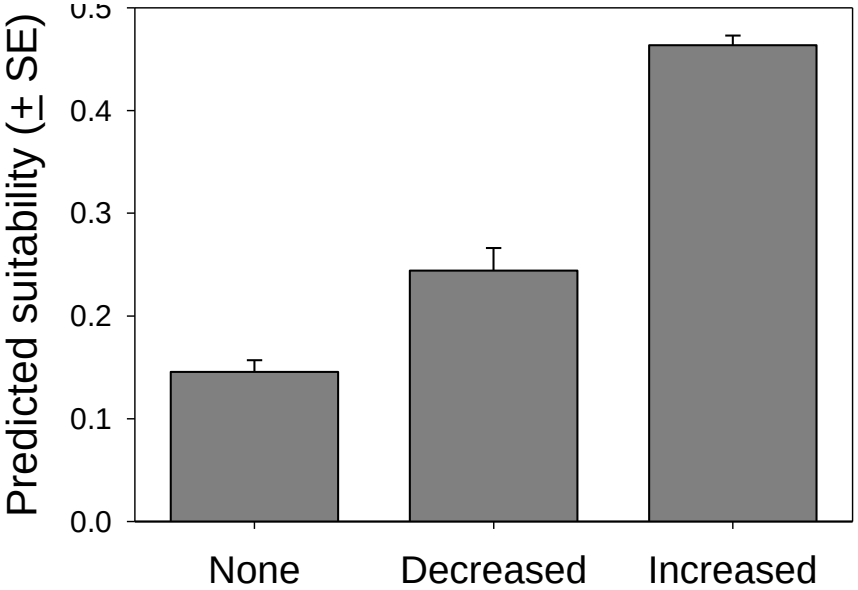
Corn Relative Suitability





Change in % available land area to corn production

(2007-2006)



Change in available land area to corn production

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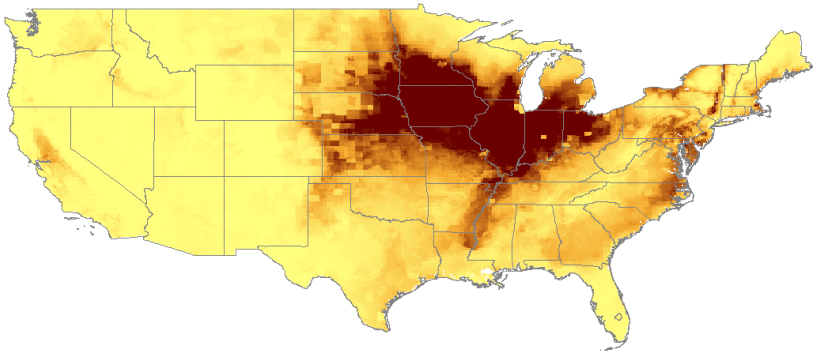
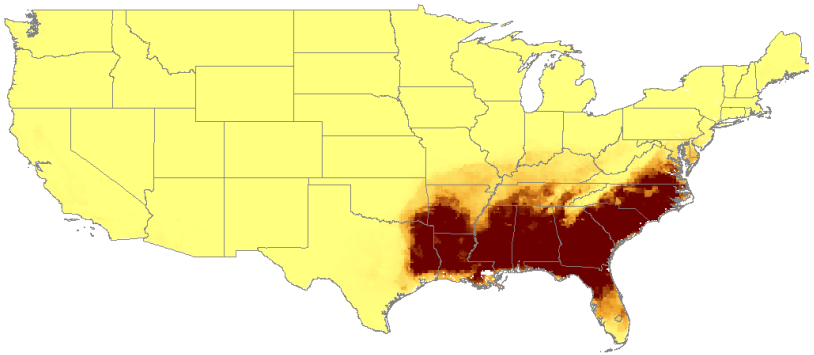
Estimating biofuel suitability across the U.S.

Evans, Fletcher and Alavalapati (2010)

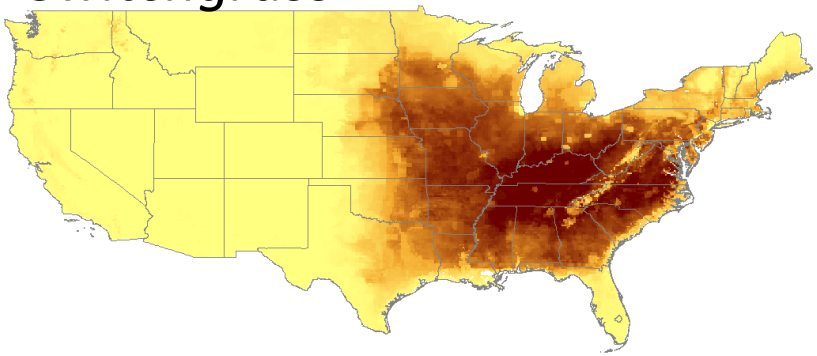
Corn



Pine

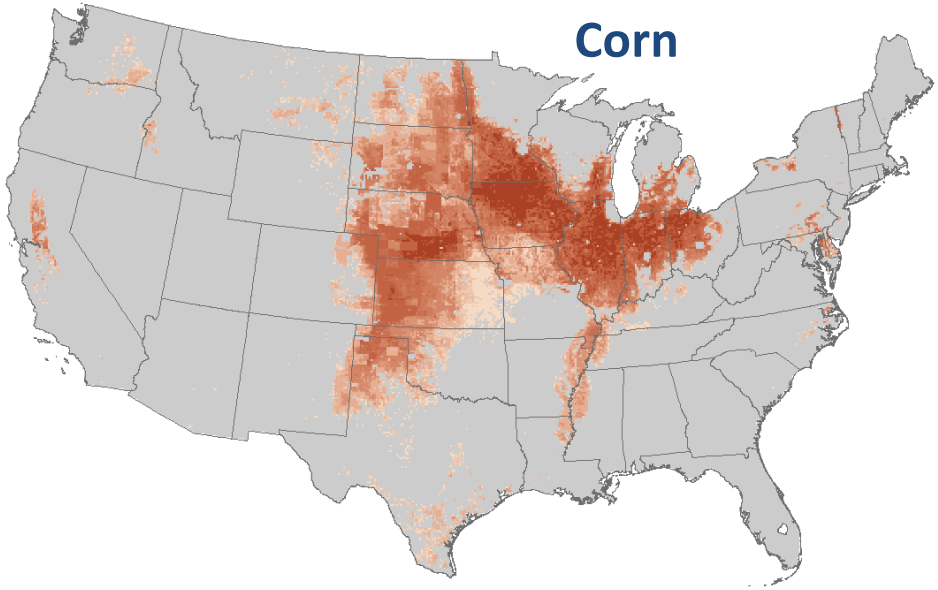


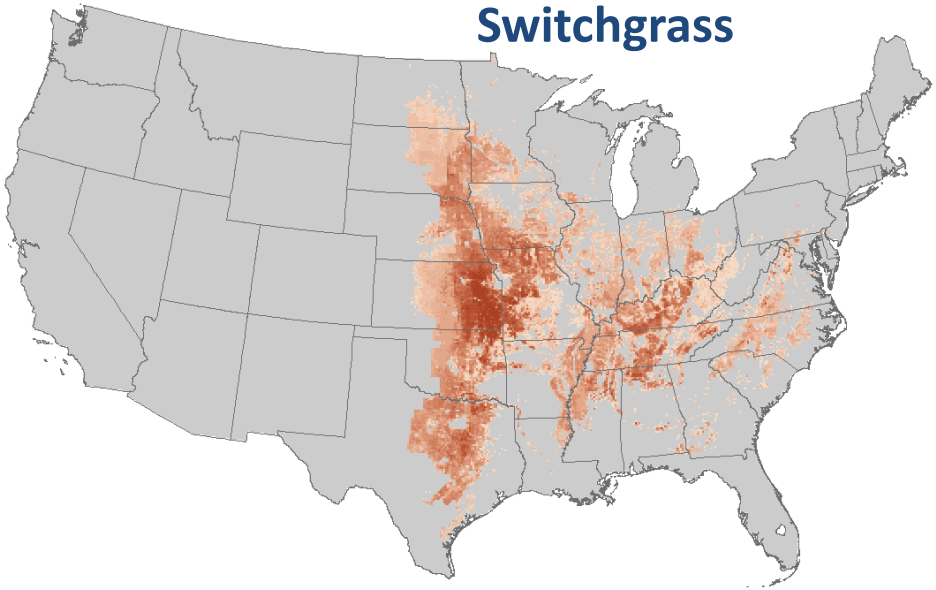
Switchgrass

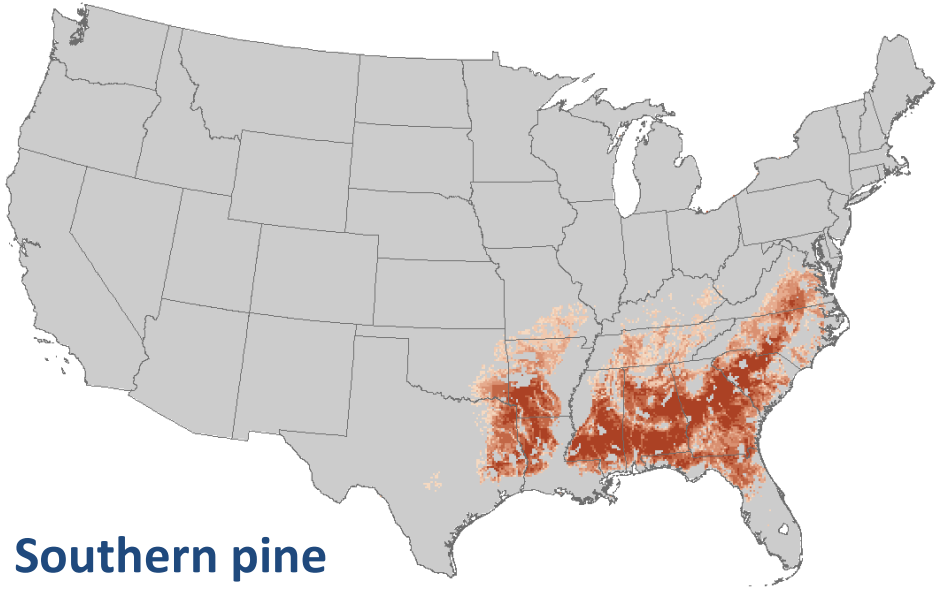


Niche models for biofuels

Aggregated results from multi-criteria objective functions to meet the 2022 mandate of 36 billion gallons



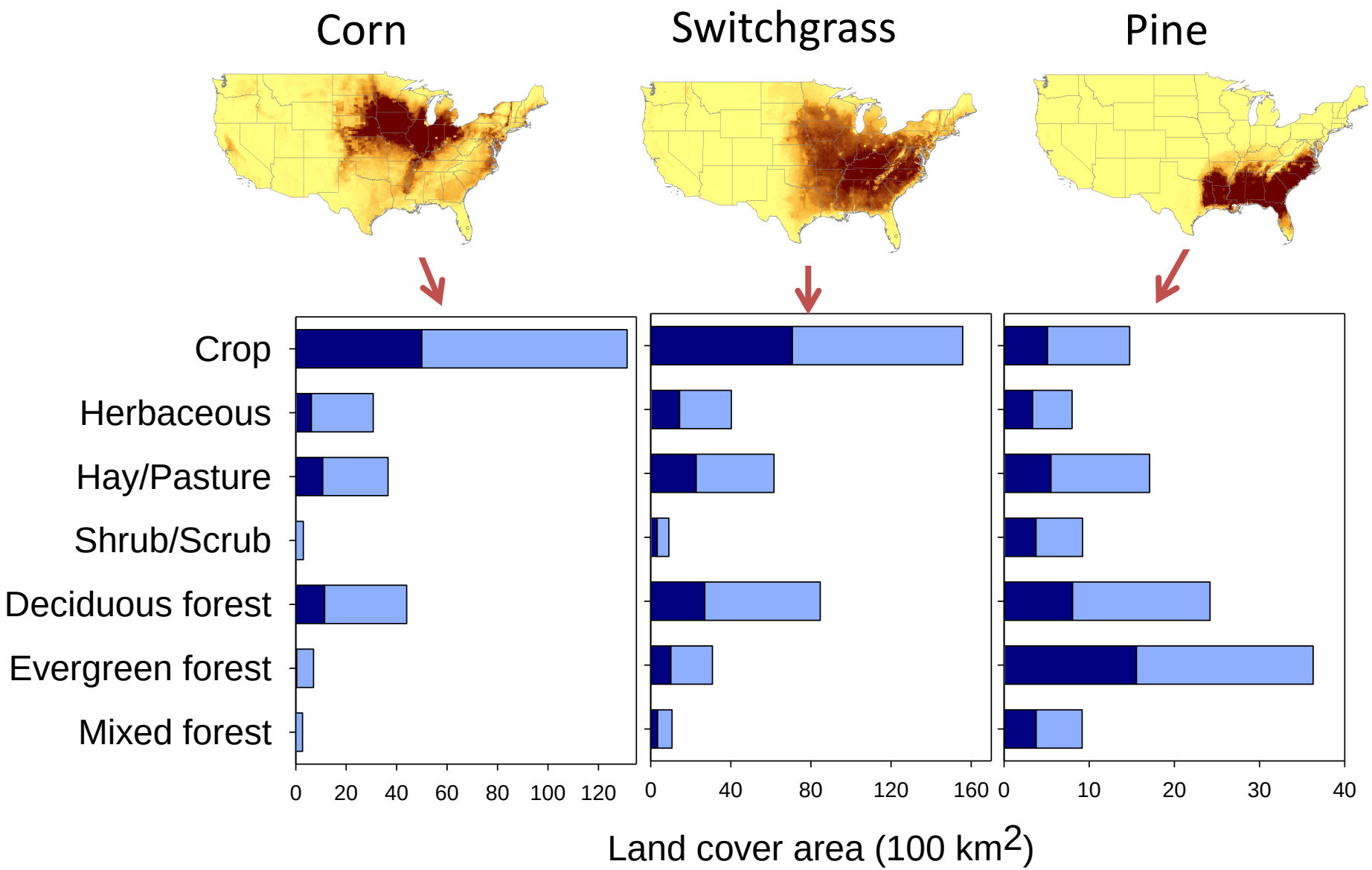




51 scenarios

- Addressed land-use change constraints (51 scenarios considered)
  - Federal lands, RFS2, etc.
- Variation in land-area objectives
- Variation in crop priorities

Current land cover in highly suitable areas



The relevance of spatial optimization algorithms designed for conservation planning to bioenergy

Problems addressed	***Bioenergy equivalent***
Minimum set problem	Minimum land required to meet production goal
Maximum coverage problem	Maximum production given a limit on land area, cost

Mauricio Nunez-Regueiro

The relevance of spatial optimization algorithms designed for conservation planning to bioenergy

Problems addressed	***Bioenergy equivalent***
Minimum set problem	Minimum land required to meet production goal
Maximum coverage problem	Maximum production given a limit on land area, cost

Attributes of analysis	***Bioenergy equivalent***
Complementarity	Efficiency in land allocation and contribution of different land uses
Compactedness	Account for an aggregated footprint of bioenergy

Mauricio Nunez-Regueiro

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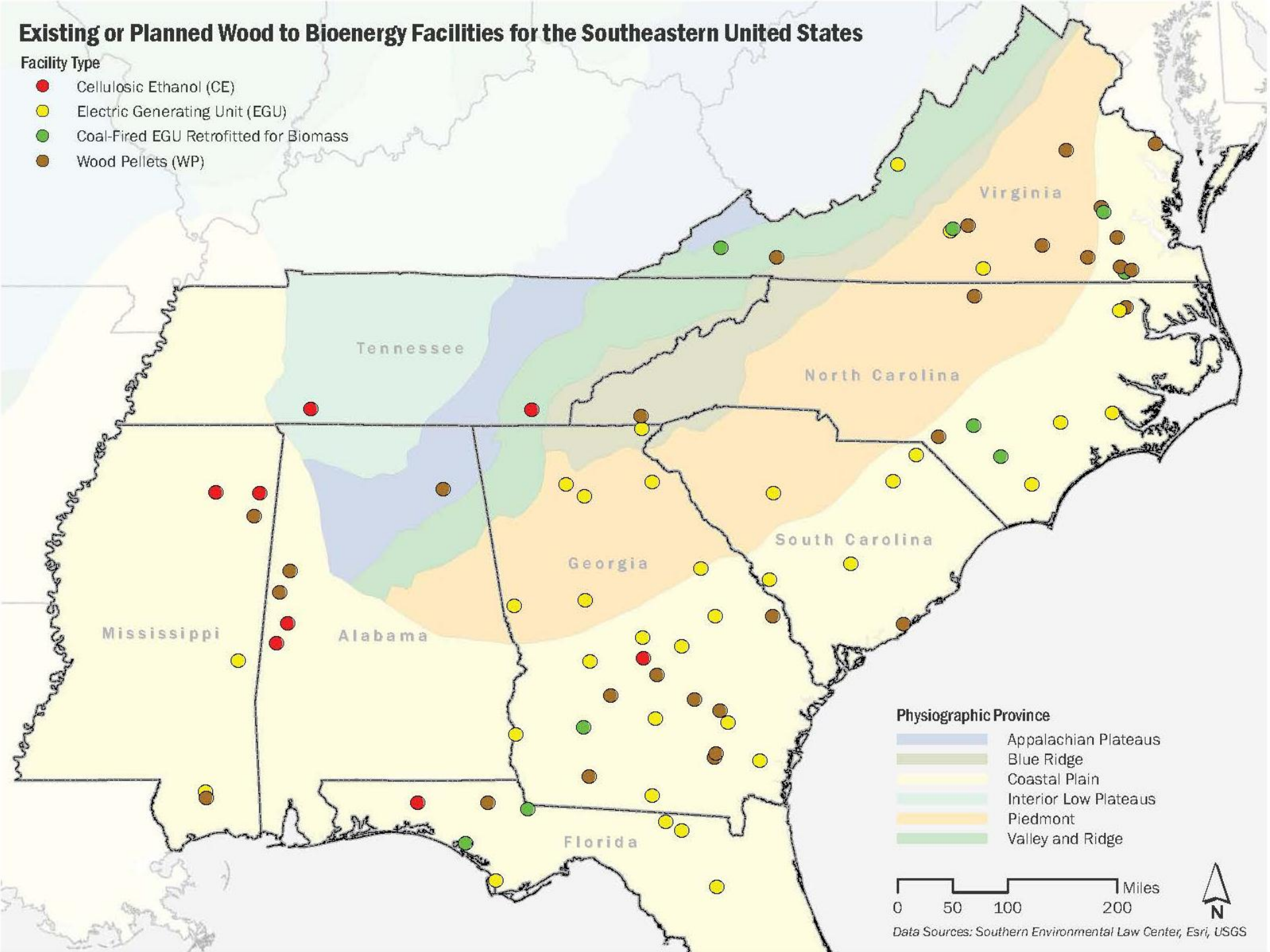
Forest biomass, wildlife and pollinators in the Southeast

- Initiating work to estimate site- and landscape-scale effects of harvesting forest biomass for bioenergy
- Residuals *versus* thinning *versus* dedicated plantations (DOE 2011)
- Bees, reptiles, birds, and bats as indicators
- Tradeoffs in land area, biodiversity, and ecosystem services
- We are looking for forestry and industry partners in this effort


Existing or Planned Wood to Bioenergy Facilities for the Southeastern United States
Facility Type
Cellulosic Ethanol (CE)
Electric Generating Unit (EGU)
Coal-Fired EGU Retrofitted for Biomass
Wood Pellets (WP)
Virginia
Tennessee
North Carolina
South Carolina
Georgia
Mississippi
Alabama
Florida
Physiographic Province
Appalachian Plateaus
Blue Ridge
Coastal Plain
Interior Low Plateaus
Piedmont
Valley and Ridge
0 50 100 200 Miles
N
Data Sources: Southern Environmental Law Center, Esri, USGS

Take-home points

- *We are in a unique situation to be environmentally proactive in the expansion of biofuels*

- *Wildlife may respond strongly to an increase in land-cover change from increased biofuel production*
  - *The type of change is crucial in causing positive / negative effects*

- *In general, greater negative effects from an increase in corn production than other biofuels*

- *Numerous management strategies for pine and grasslands to reduce impacts and increase sustainability*

Caveats and future endeavors

- *Most investigations to date are coarse, and rapid, first steps*
- *More detailed regional analyses are still needed*
- *We still know very little regarding the ecosystem and biodiversity consequences of many potential feedstocks*

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Students:

Kim Jones
Mauricio Nunez-Regueiro
Raya Pruner
Miguel Acevedo

Collaborators:

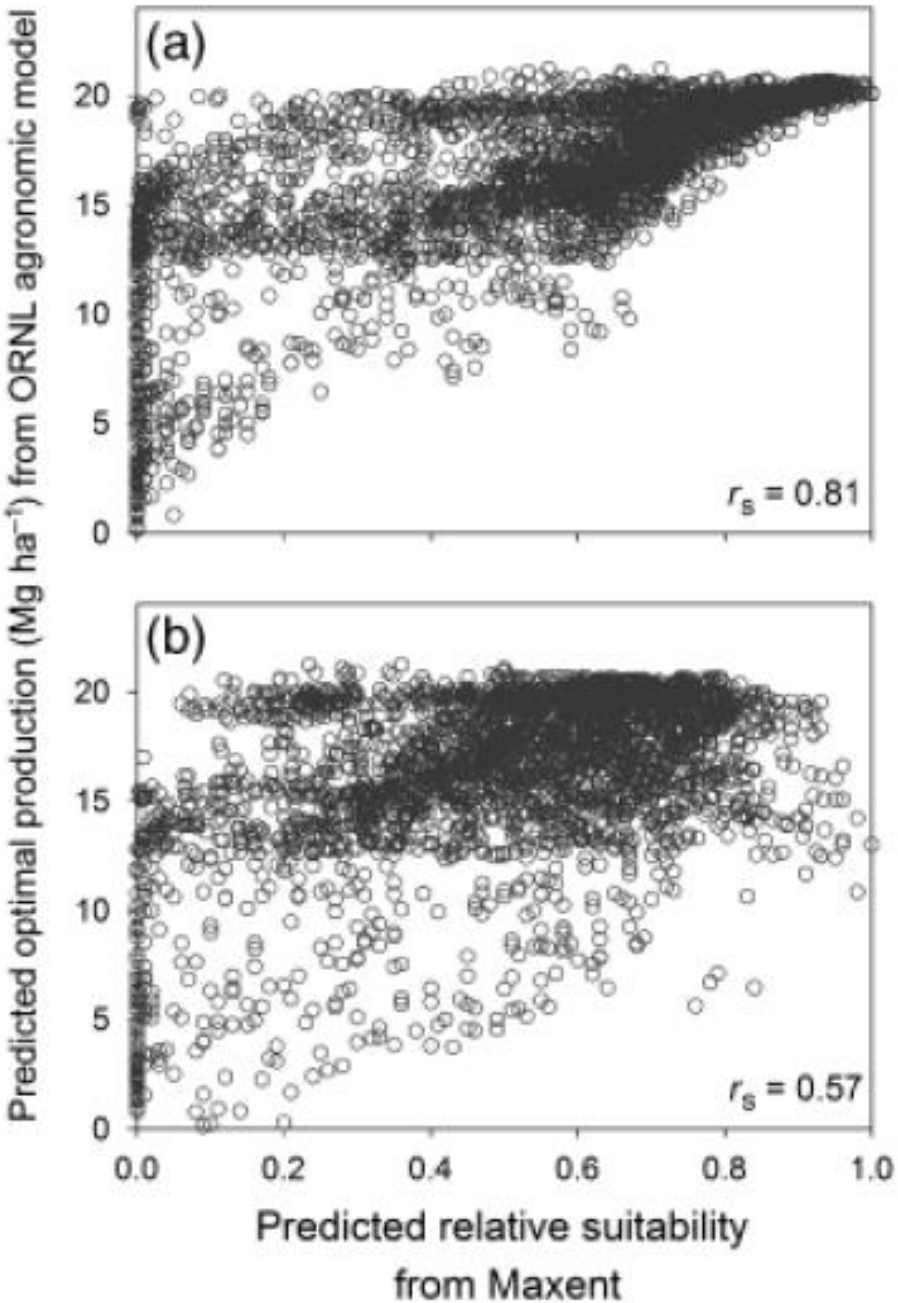
Janaki Alavalapati, Virginia Tech Univ.
Jason Evans, Univ. Georgia
Berry Brosi, Emory Univ.
Holy Ober, Univ. Florida
Lora Smith, Jones Center
Bruce Robertson, Bard College
Doug Schemeske, Michigan State Univ.
Patrick Doran, Nature Conservancy

Questions?

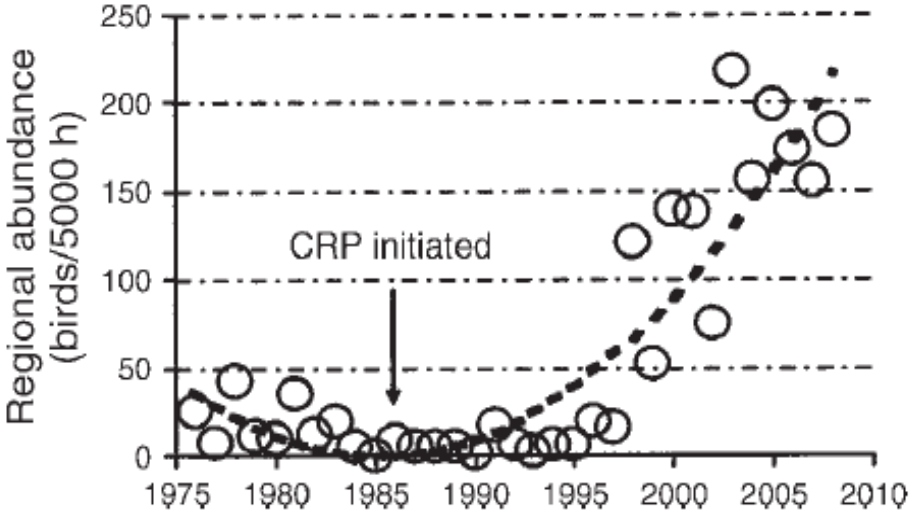
Managing planted pine forests to minimize biodiversity impacts

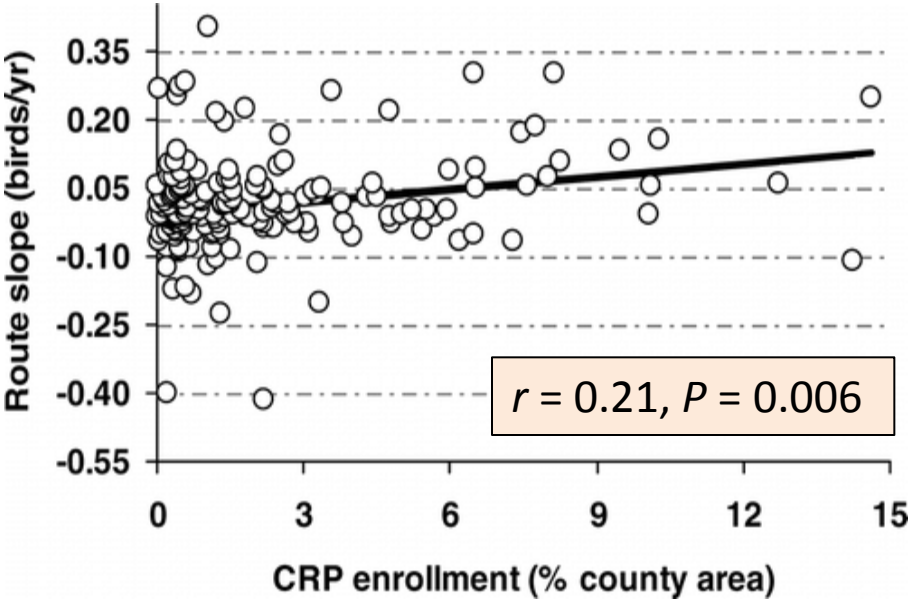
- Limit intensity of site preparation
- Limit inputs (e.g., fertilizer, herbicide)
- Promote structural heterogeneity
  - *Understory succession*
  - *Mixed species plantings*
  - *Snags*
- Harvesting
  - *Too short of rotation will limit diversity*
  - *Timing of harvest*
  - *Harvest pattern*

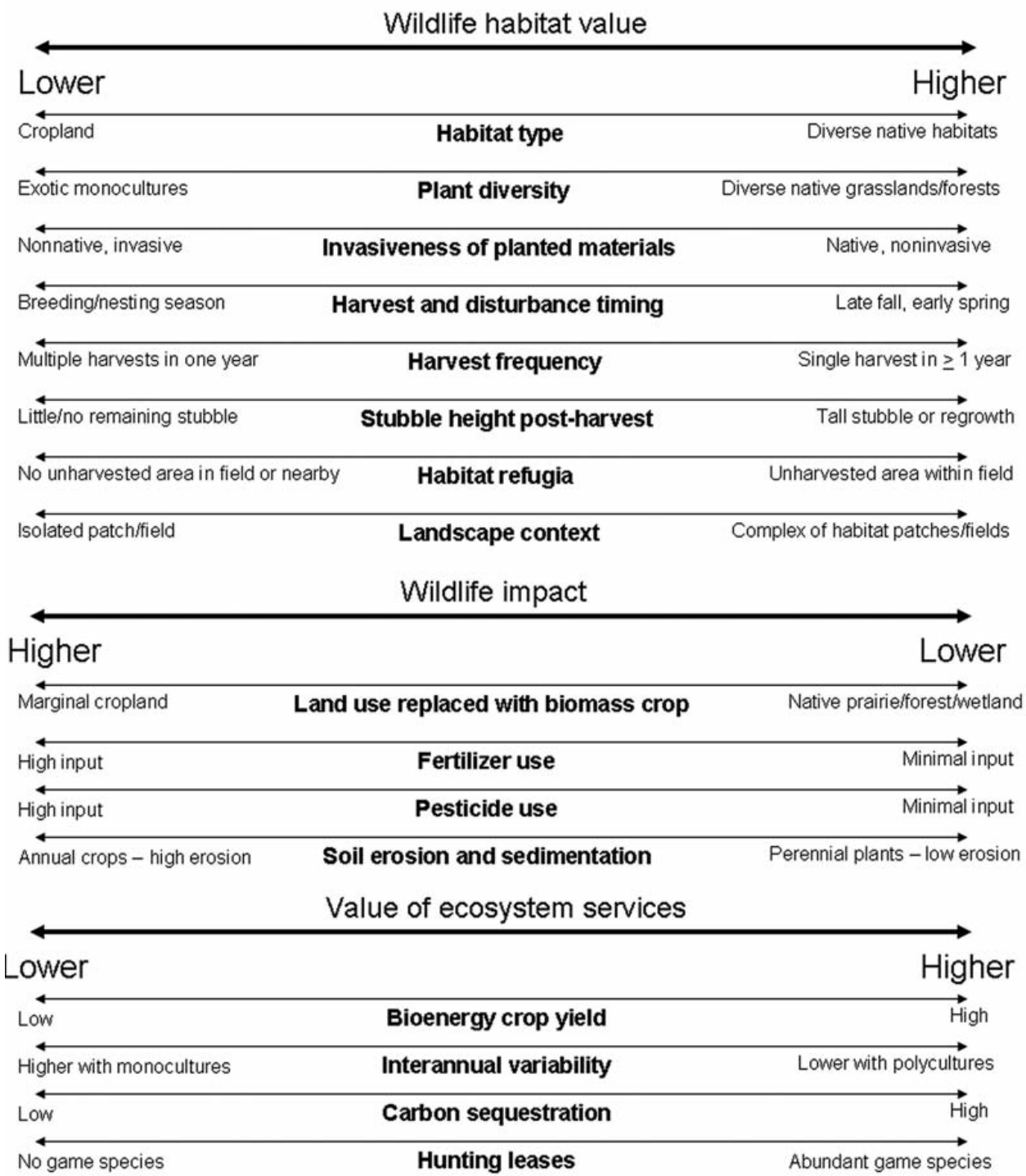
Comparison of predictions between niche model and ORNL agronomic model



Potential impacts of changing CRP





Herkert (2007)
Wiens et al. (2011)

Some general principles for wildlife and biofuels crops