Today's Webinar Moderator
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US Department of Agriculture
Agricultural Marketing Service

USDA Natural Resources Conservation Service
Science and Technology

2015 Conservation Webinars

Today's Webinar Presenter
John Quinn, Assistant Professor of Biology
Furman University
Department of Biology

Date	2015 Conservation Webinars Topics
June 17	**Environmental Benefits of Organic Agriculture: Biodiversity**
August 27	Environmental Benefits of Organic Agriculture: Soil
Sept 23	Environmental Benefits of Organic Agriculture: Water Quality

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The Role of Biodiversity in Organic Farm Systems

JOHN QUINN
BIOLOGY @ FURMAN UNIVERSITY



Biodiversity and Organic Farming

- USDA National Organic Program Standard 205.2
  - A production system that ….. promote(s) ecological balance, **and conserve(s) biodiversity.**
  - Compliance with the requirements to conserve biodiversity requires that a producer incorporate practices in his or her organic system plan that are beneficial to biodiversity on his or her operation

- **Over 125 comparisons to conventional farming systems**

Outline for today

- Define and measure biodiversity
- How organic farming benefits biodiversity
- How organic farming benefits **from** biodiversity

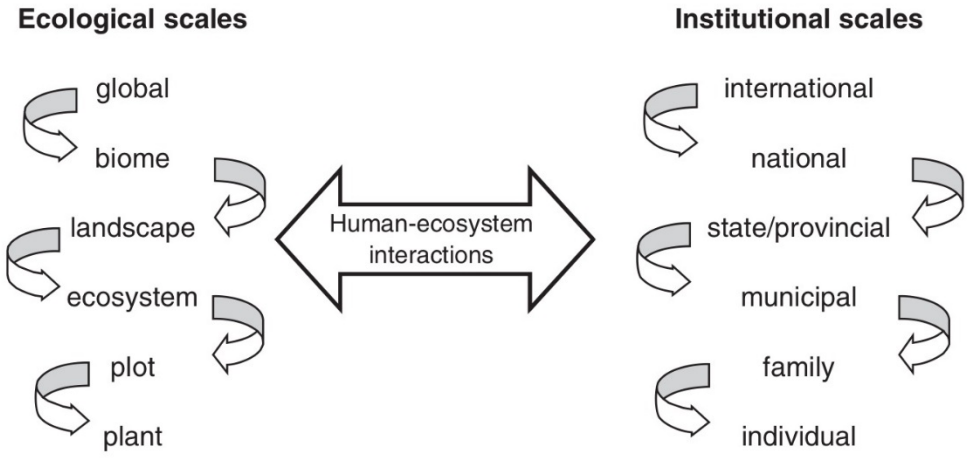


Fig. 2. Selected ecological and institutional scales (adapted from Leemans, 2000).

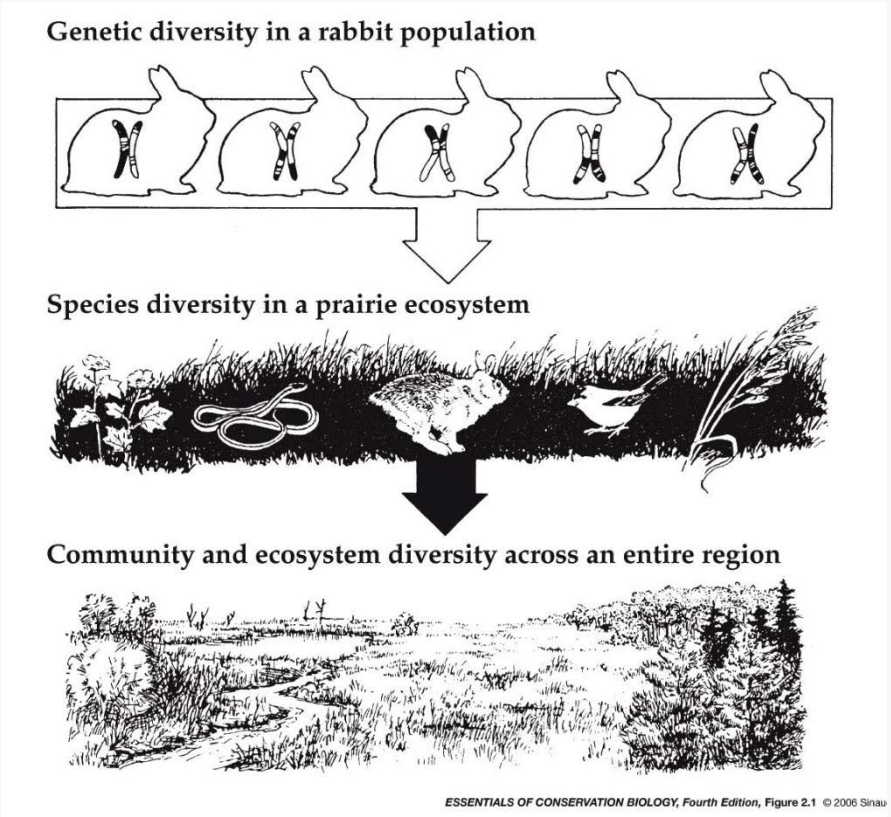
What is biodiversity?

What is biodiversity?

- Biodiversity is the sum total of all biotic variation from the level of genes to ecosystems.

- Genetic Diversity
- Species Diversity
- Ecosystem Diversity

- Endemism, species turnover, rarity, functional diversity, ecosystem resilience, trophic interactions, ecological redundancy.....



Biodiversity classification in farm systems

Associated Biodiversity

- Birds
- Insects
- Weeds
- Soil Biota
- Riparian areas
- Natural areas

Planned Biodiversity

- Crops
- Livestock
- Cover Crops
- Windbreaks
- Grass Margins

Genetic Diversity

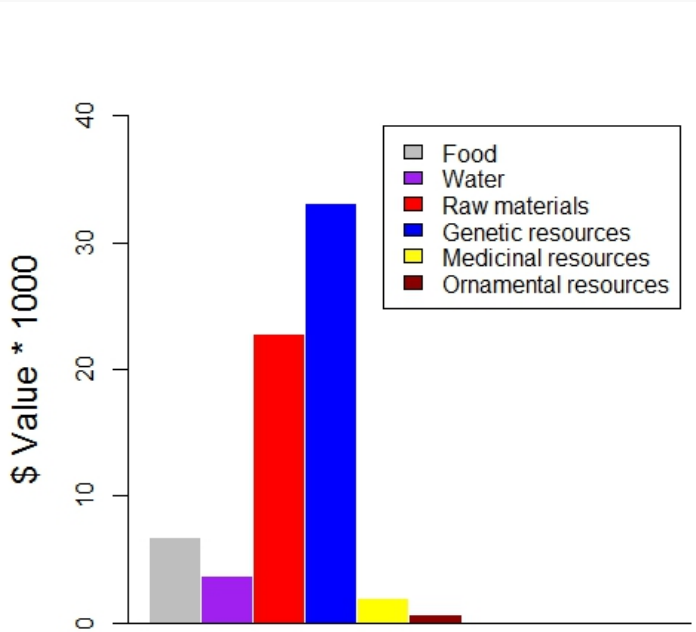
FEATURE

Pity the banana. Despite its unmistakably phallic appearance, it hasn't had sex for thousands of years. The world's most erotic fruit is a sterile, seedless mutant—and therein lies a problem. The banana is genetically old and decrepit. It has been at an evolutionary standstill ever since humans first propagated it in the jungles of Southeast Asia at the end of the last ice age. And that is why some scientists believe that the banana could be doomed. It lacks the genes to fight off the pests and diseases that are invading the banana plantations of Central America and the small holdings of Africa and Asia.

The banana needs a pick-me-up fast. But science has set the bar it down. For decades, plant breeders have all but ignored it, because developing new plant varieties without the help of sexual reproduction is expensive and time-consuming. As a result, most people in the

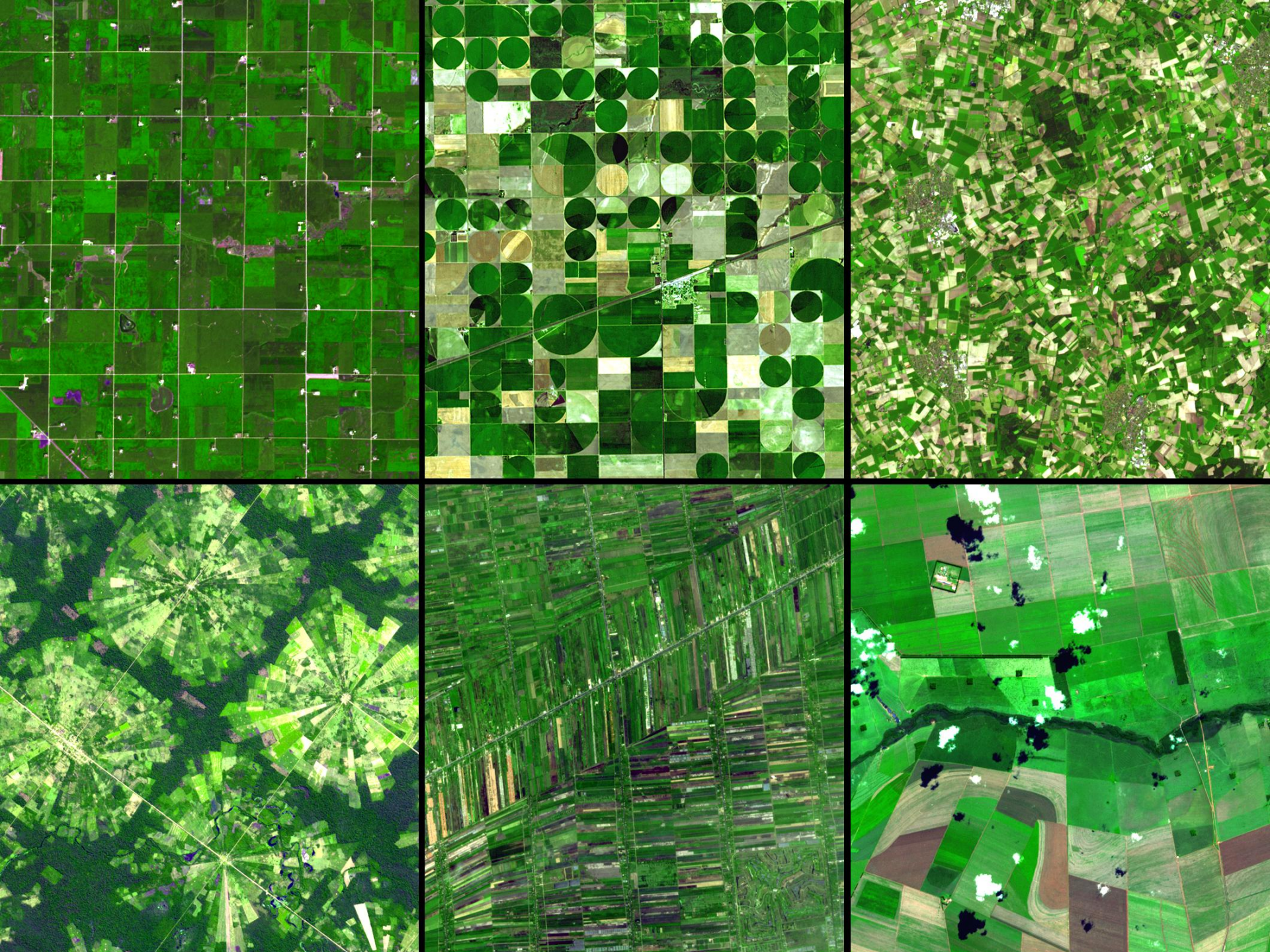
the sterile banana

By Fred Pearce



Costanza et al. 2010

Species Diversity

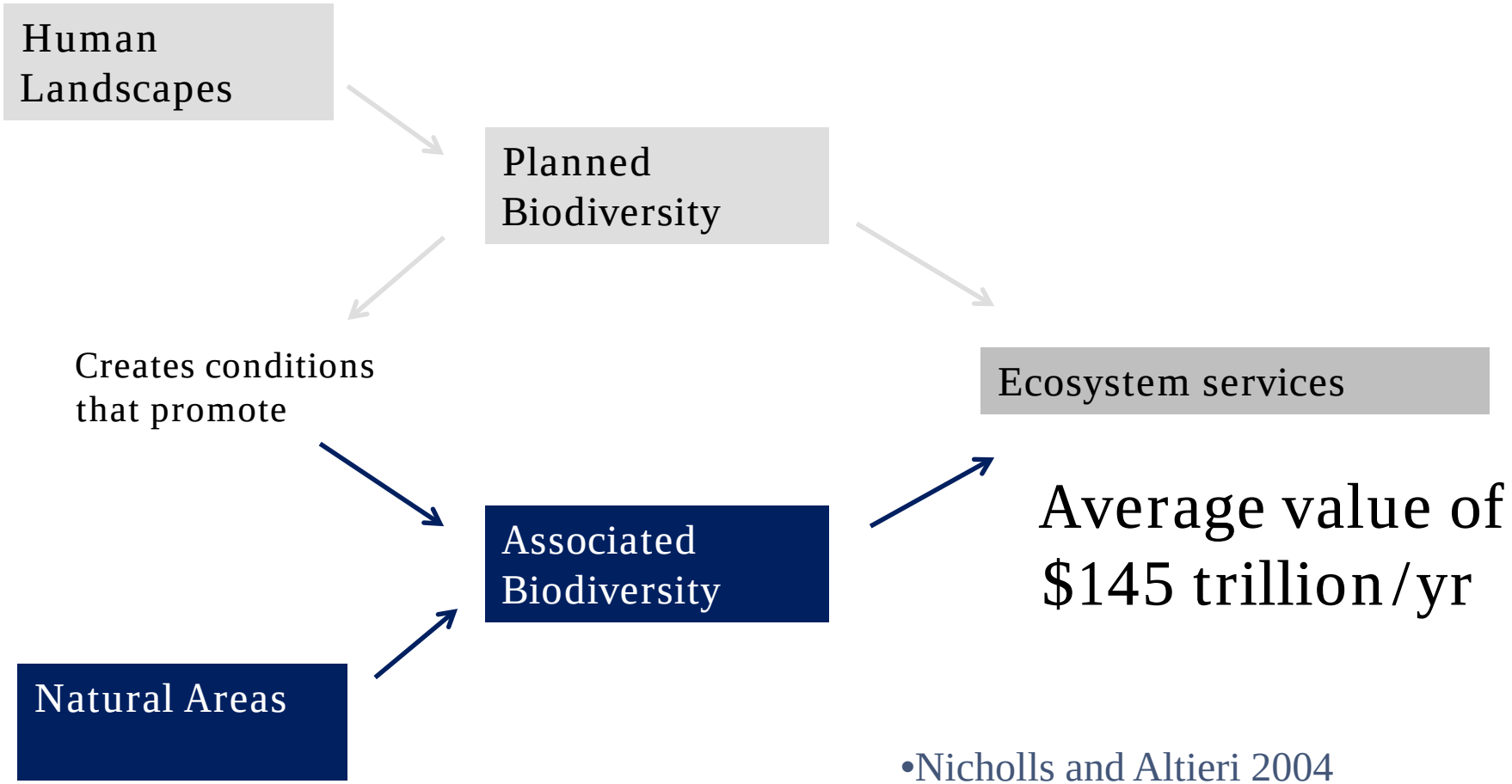


It is about more then just birds!

"IT ISN'T JUST ABOUT THE LOVE OF BIRDS AND BUTTERFLIES; IT'S ABOUT OUR SURVIVAL"

IUCN DIRECTOR GENERAL

Why is Biodiversity Important?



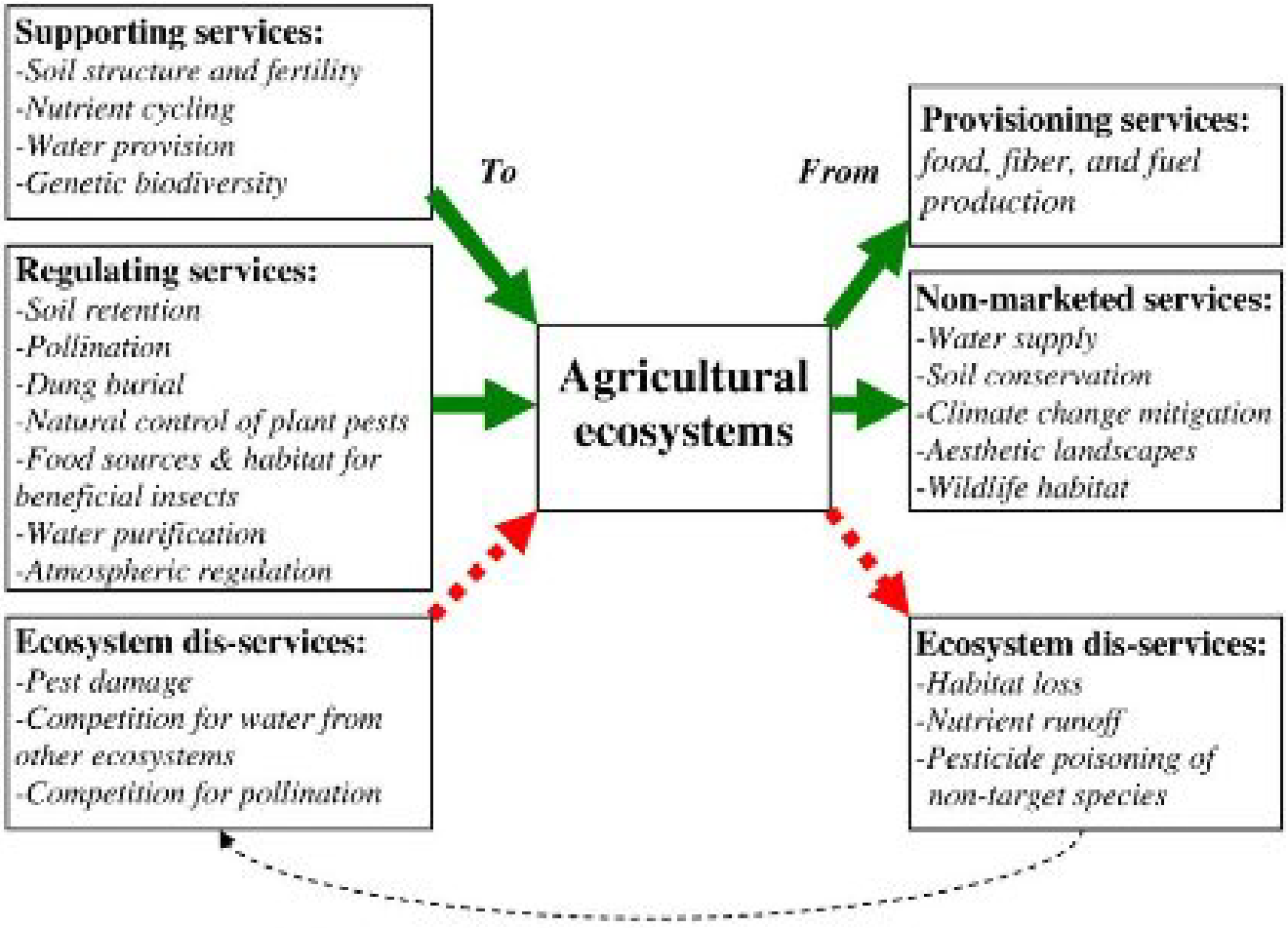
- Nicholls and Altieri 2004
- Costanza et al 2014

Ecosystem Services

Costanza et al 1997, MA 2005

- Food production
- Climate regulation
- Gas regulation
- Disturbance regulation
- Water regulation
- Water supply
- Erosion control
- Soil formation
- Nutrient cycling
- Waste treatment
- Raw materials
- Genetic resources
- Recreation
- Cultural
- Pollination
- Biological control

Ecosystem Services and Dis-services



Zhang et al. 2007

Organic farming and ecosystem services?

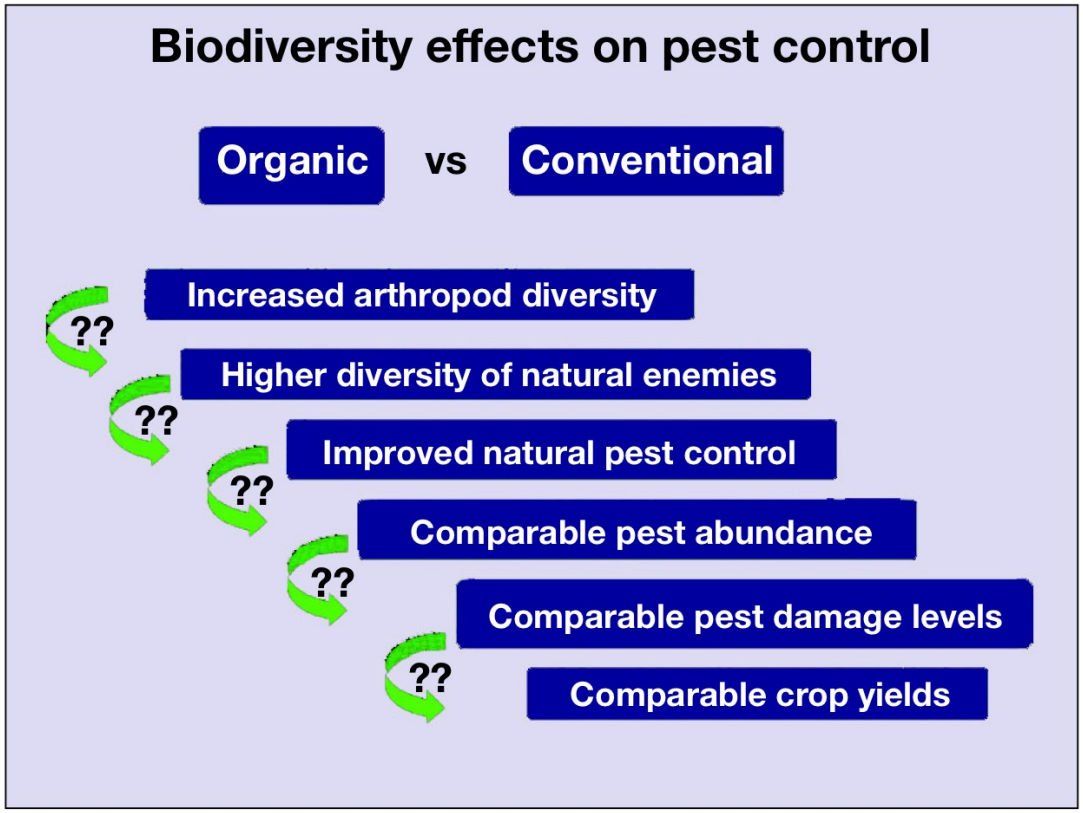
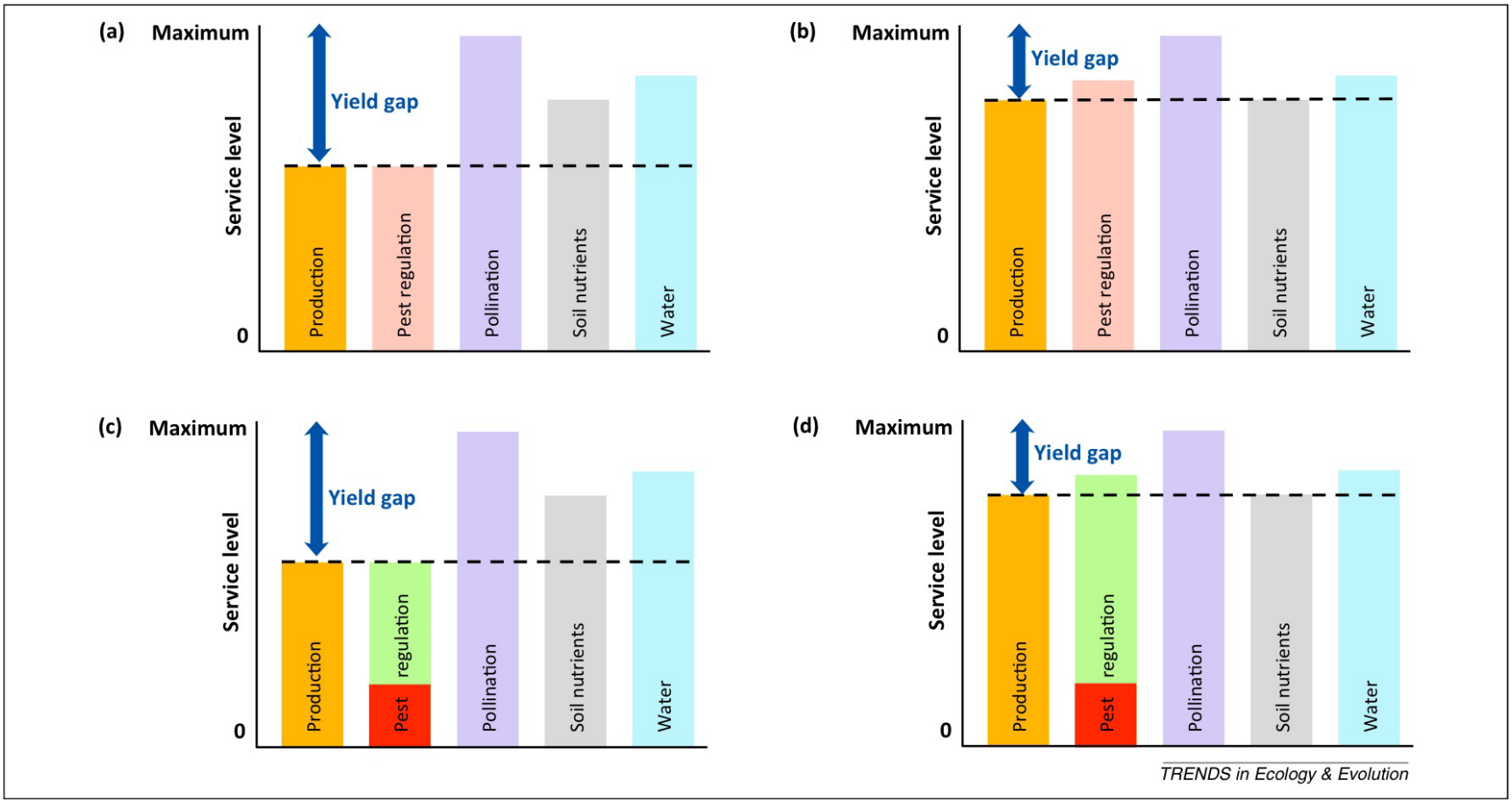


Figure 4. *Step-by-step procedure required to link an increase in biodiversity with the effectiveness of pest control as an ecosystem service for organic and conventional growers.*

Letourneau and Bothwell 2008

Relationship between services

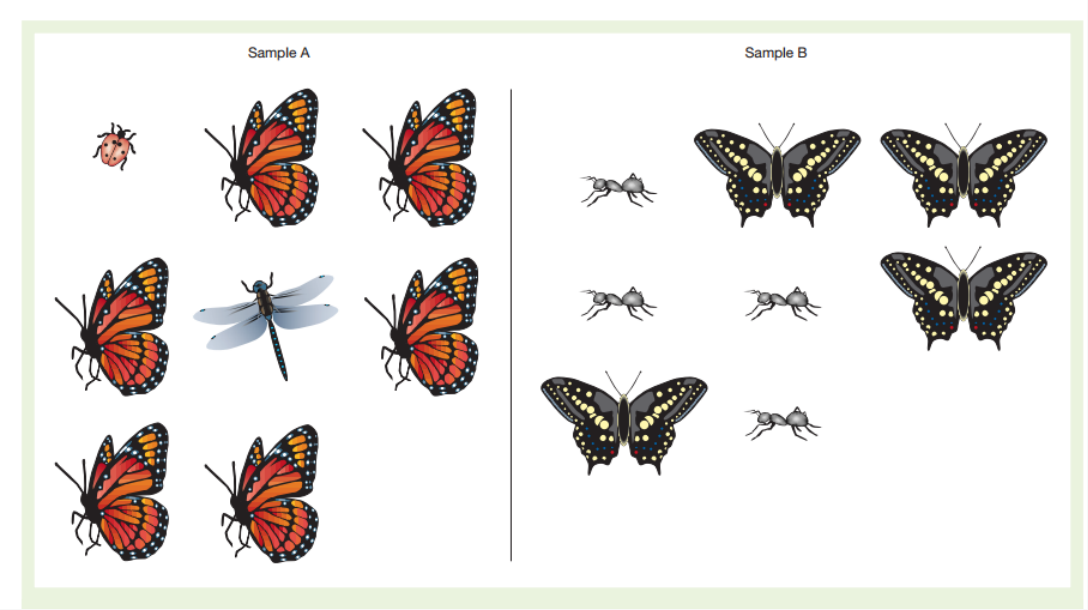


Bommarco et al. 2012

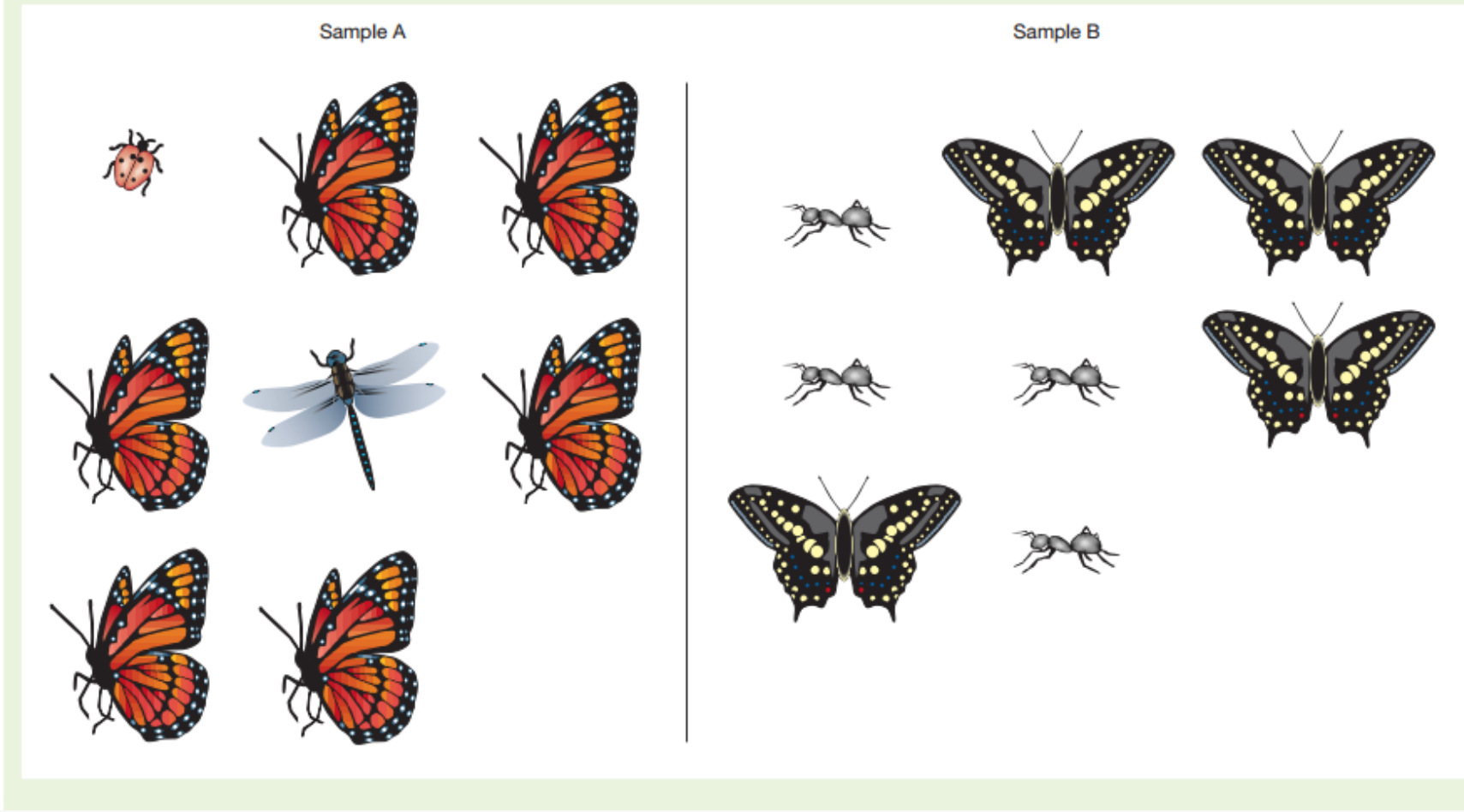
How do we measure biodiversity

How is biodiversity measured?

- Richness
- Abundance
- Evenness
- Diversity Indices

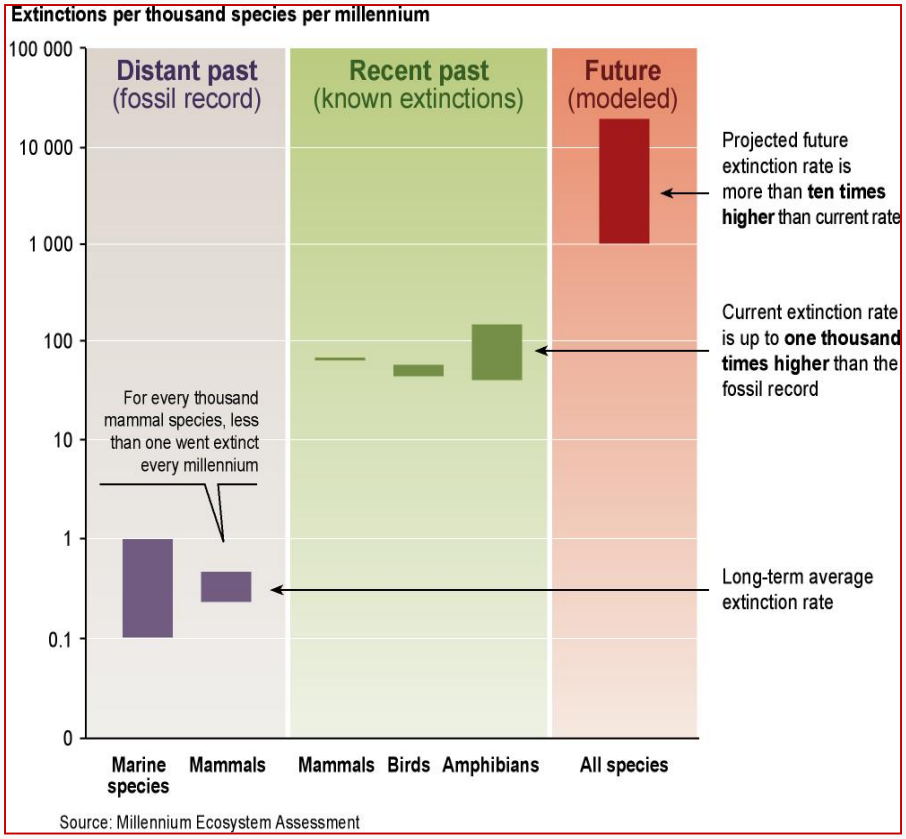


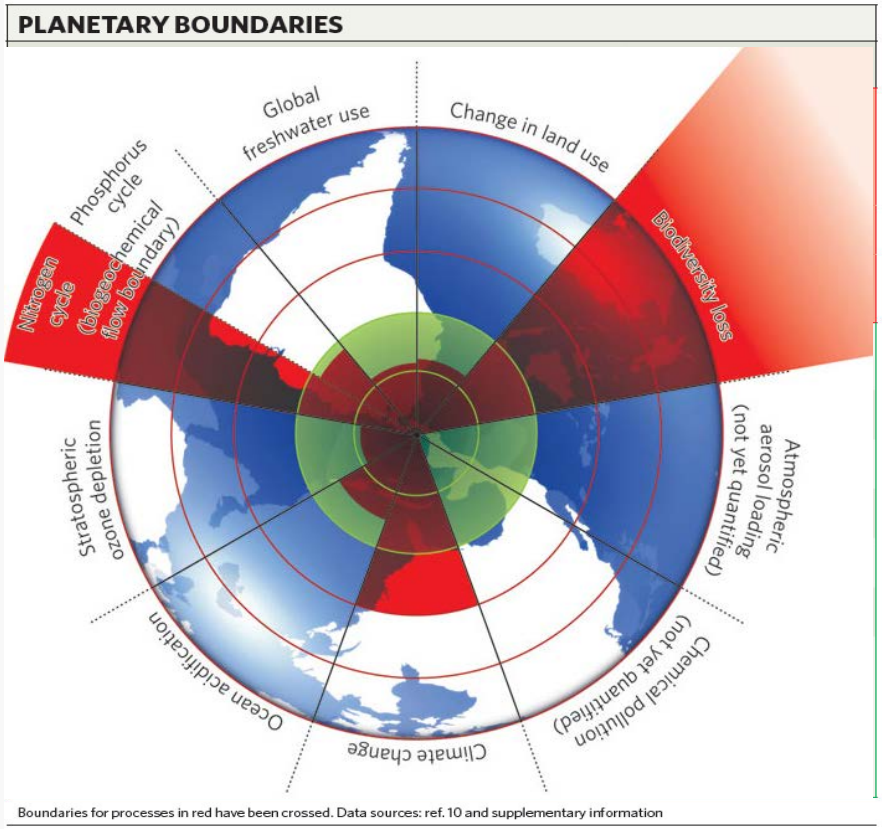
How is biodiversity measured?



Loss of Biodiversity

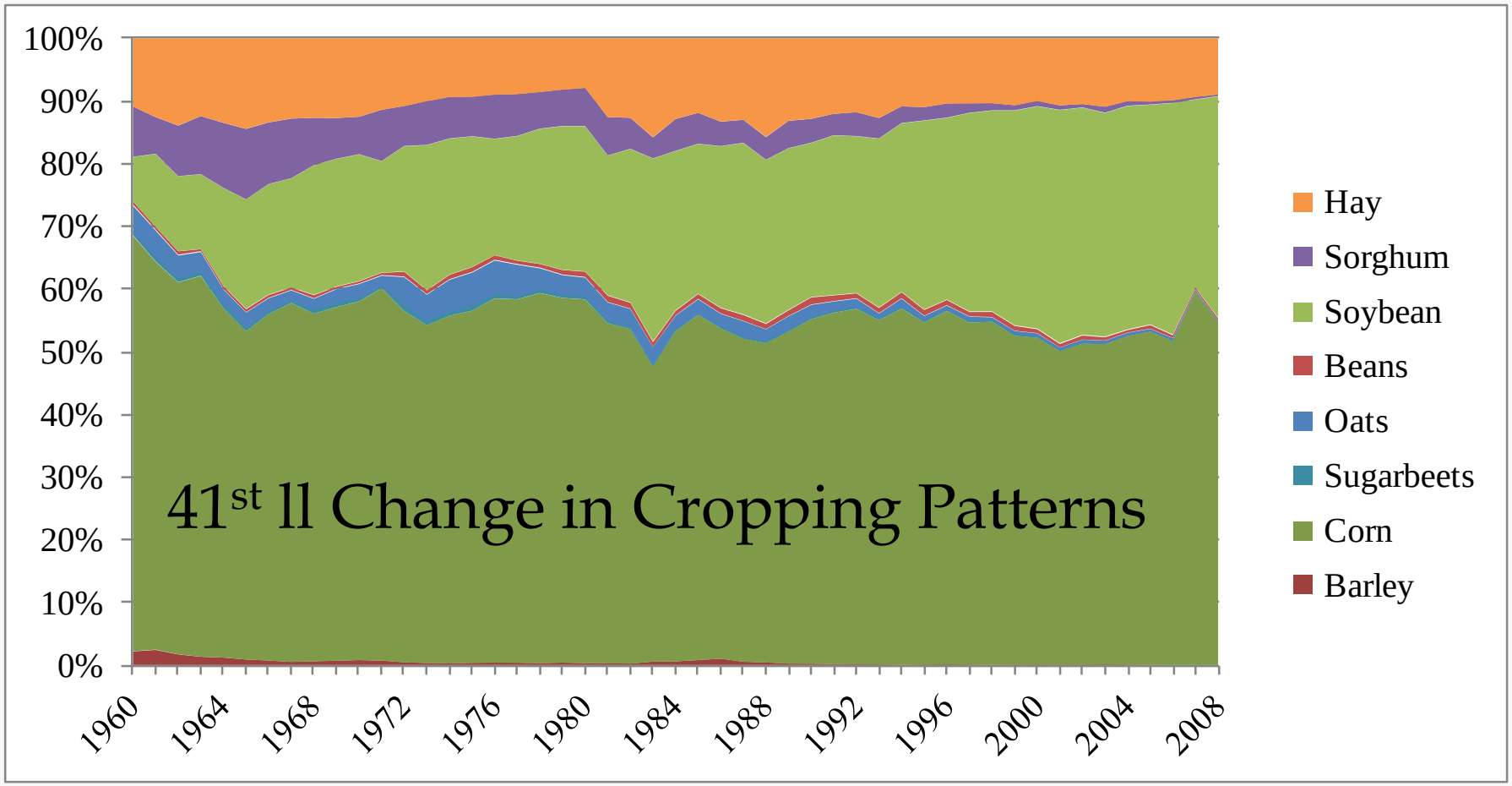
Changes in biodiversity



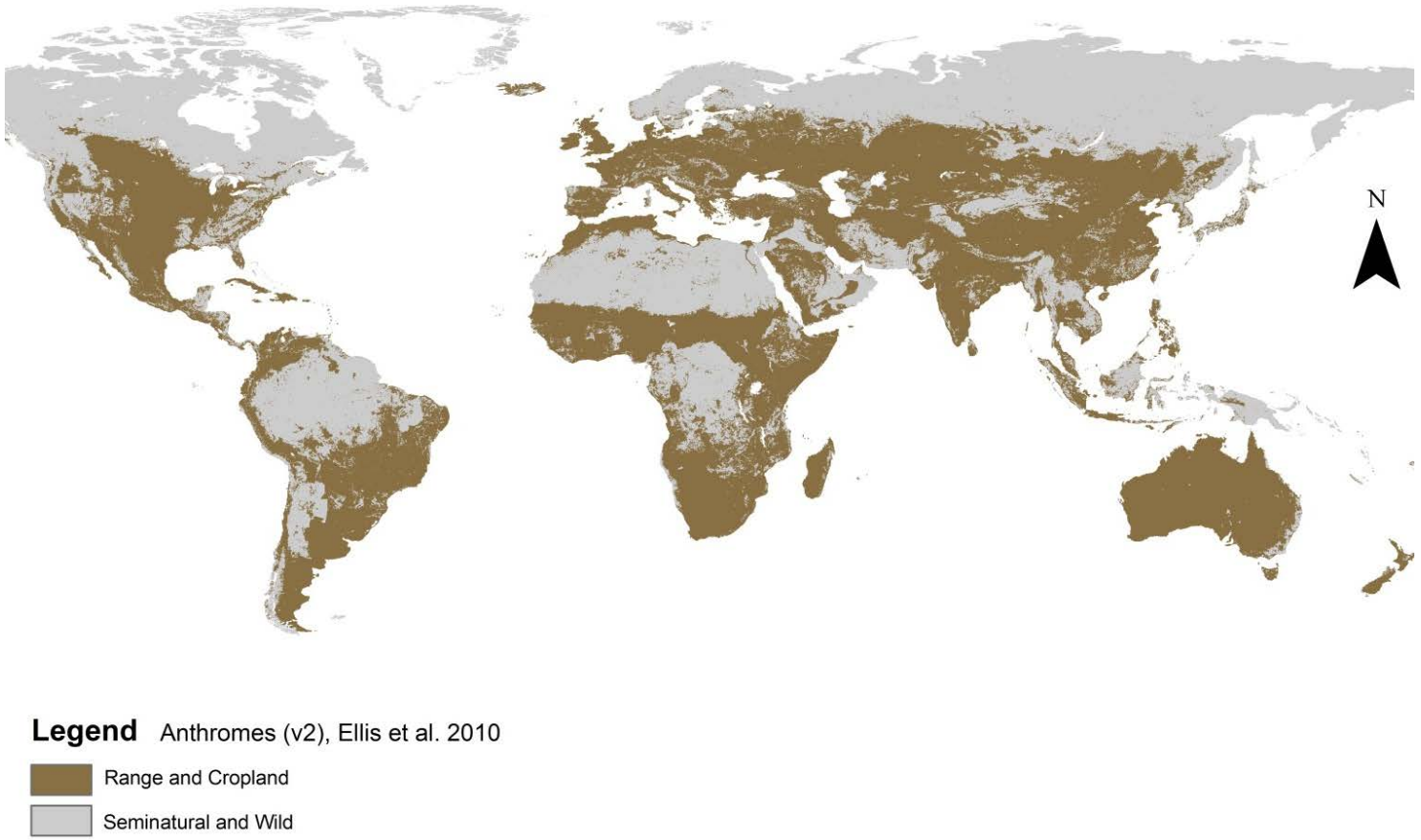


MEA 2005, Rockström et al. 2009

Loss of crop richness



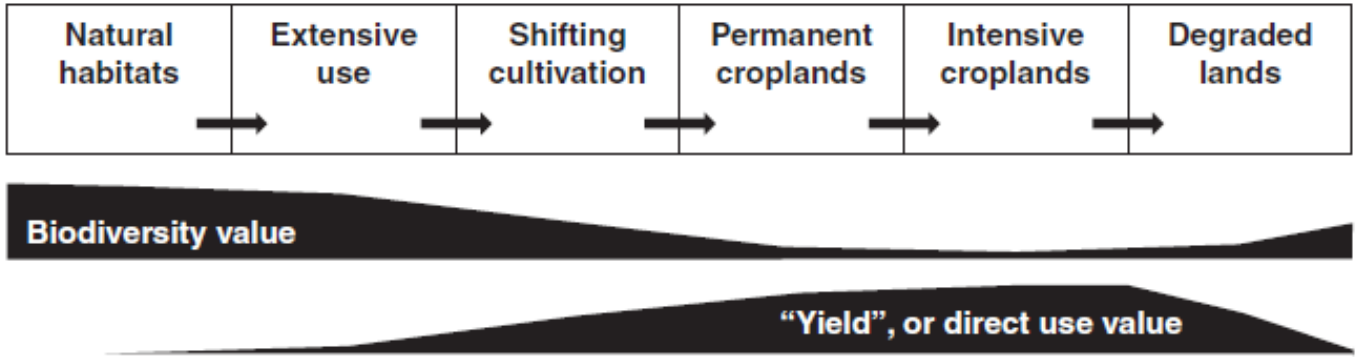
Global Land Cover



"Why should conservationists have a positive interest in, for example, farming? There are many reasons, but the plainest is: **Conservationists eat**."

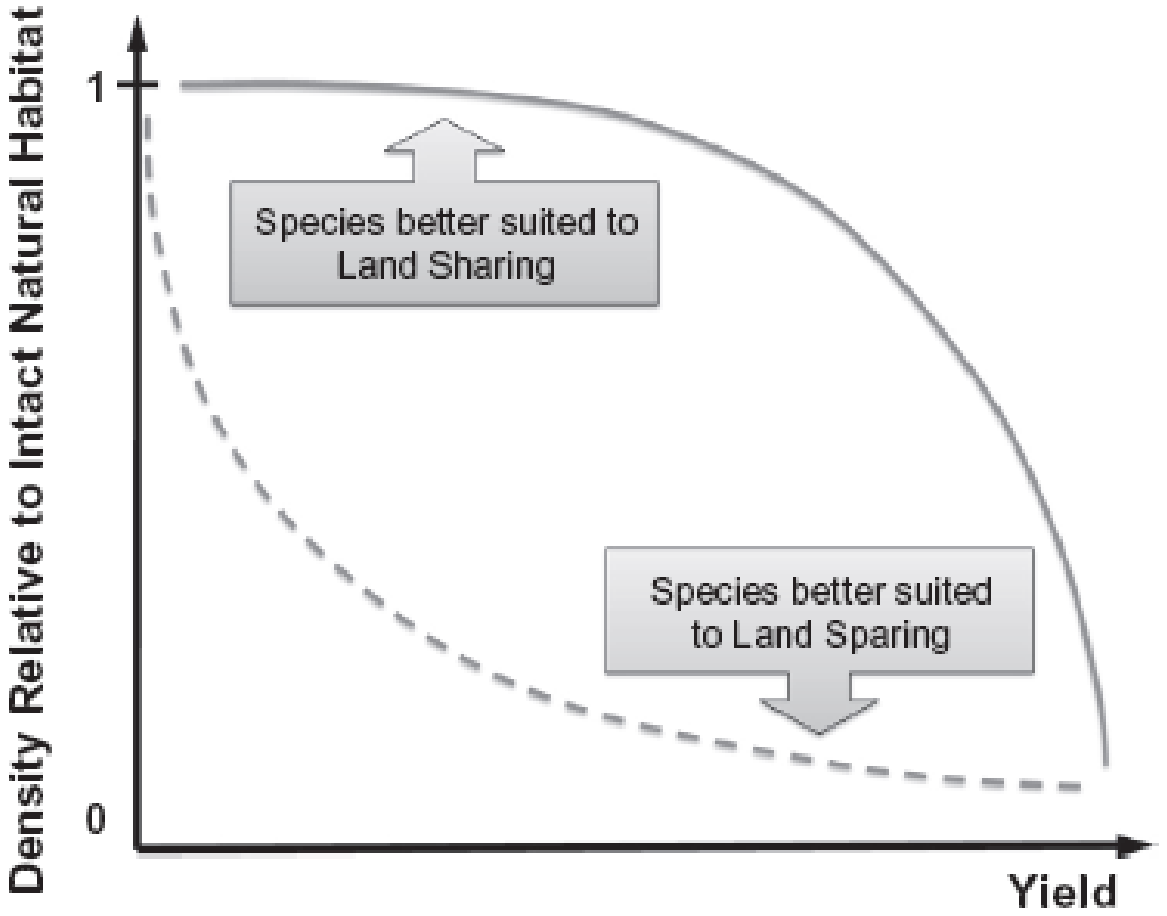
- Wendell Berry

Conservation theory -
Maintain biodiversity and food production



Phalan et al, 2011

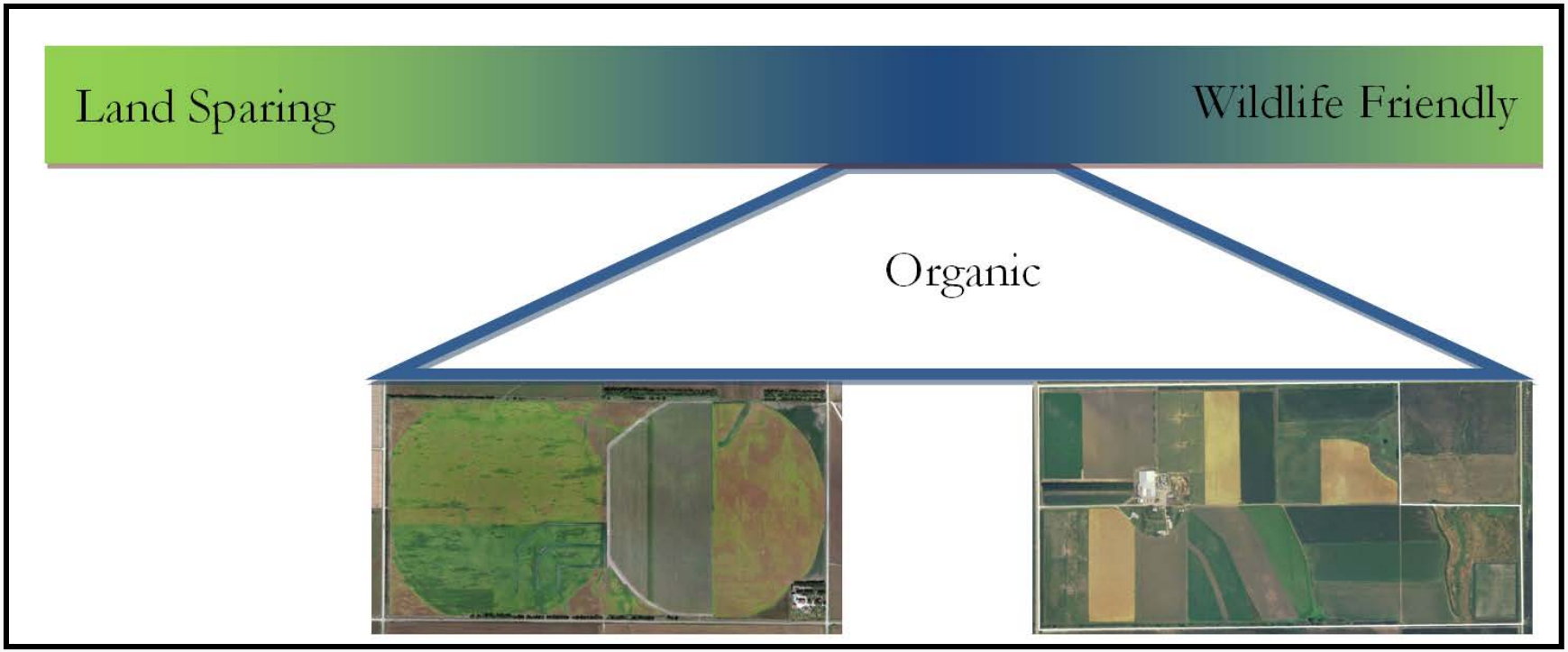
Biodiversity and Yield Tradeoffs



Phalan et al, 2011

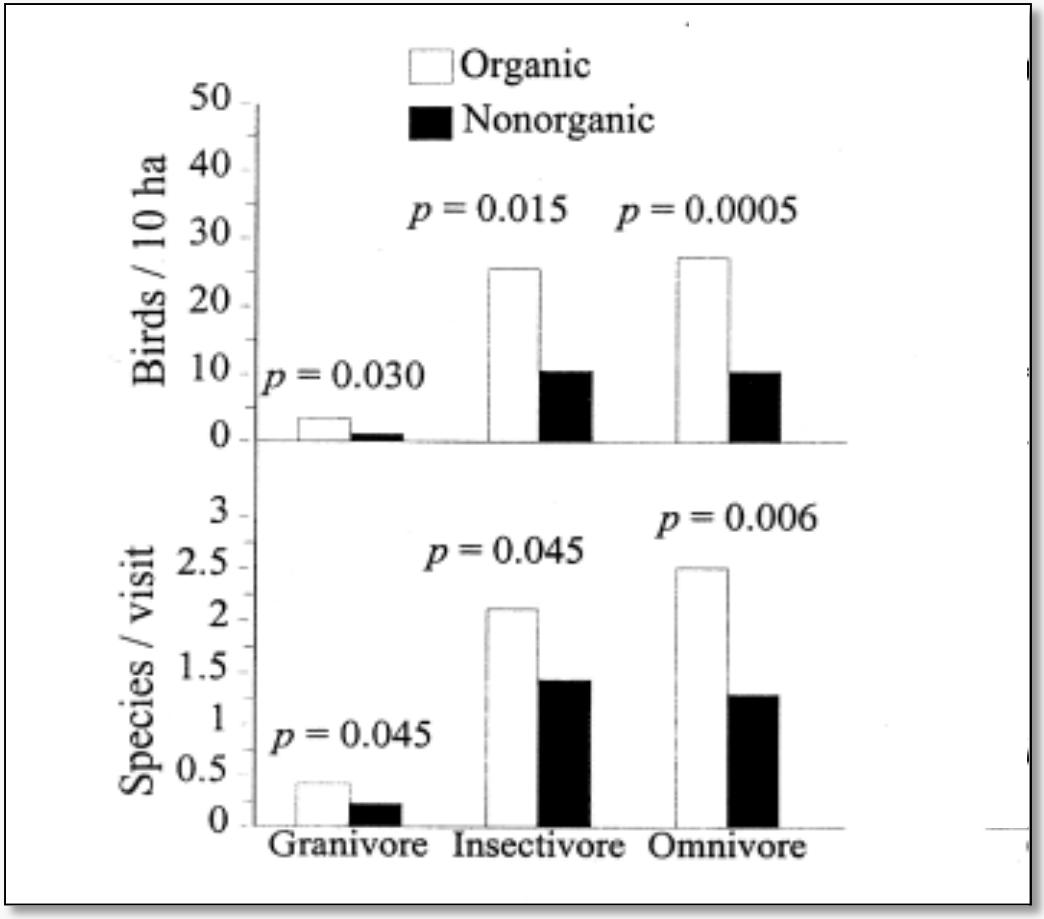
Linking Question

- Is organic farming better identified as Land Sparing or Land Sharing (Wildlife-friendly)?



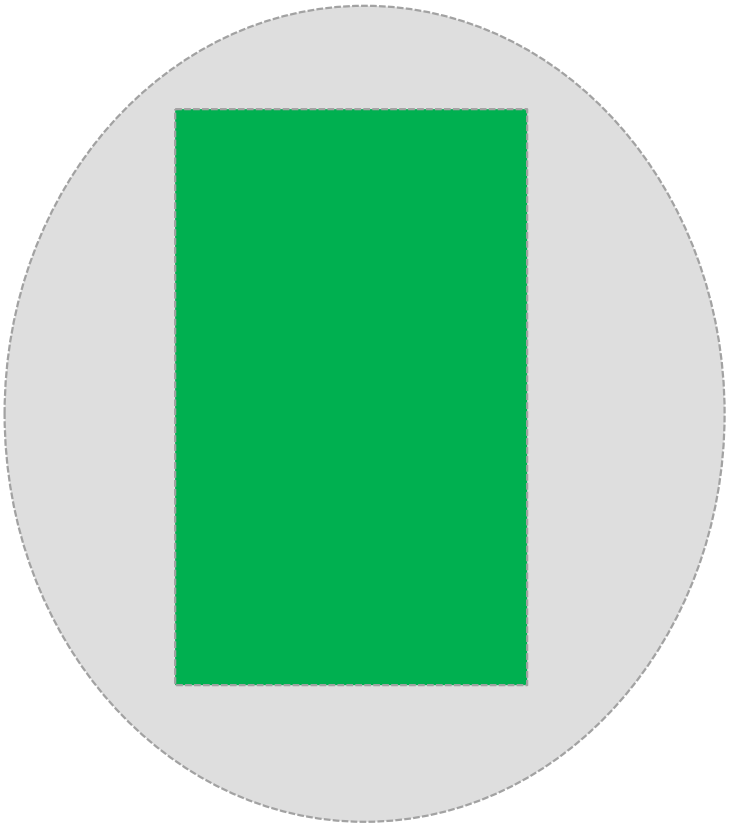
How does organic farming benefit biodiversity

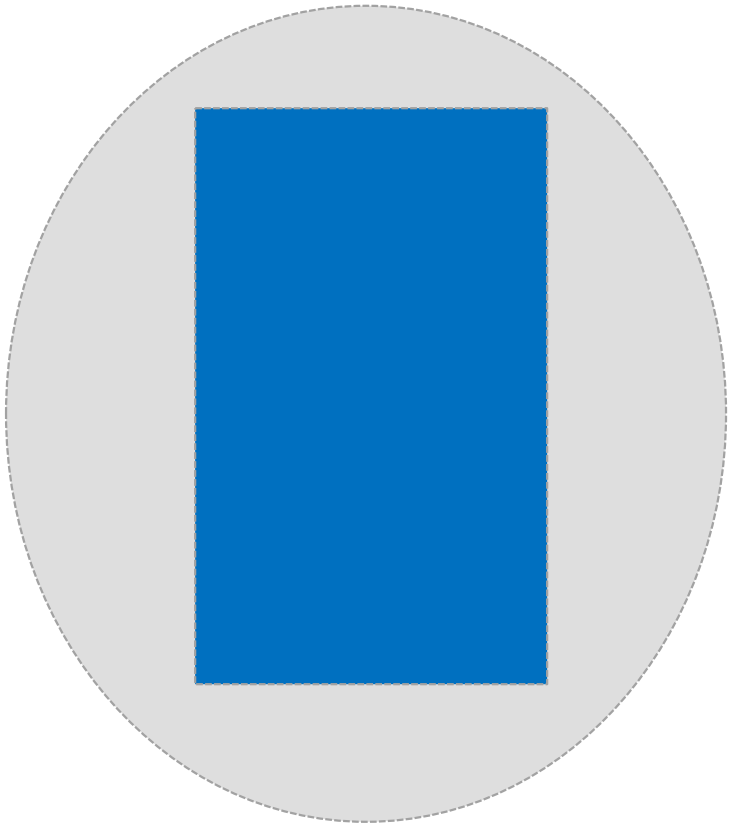
Greater richness and abundance on organic farms



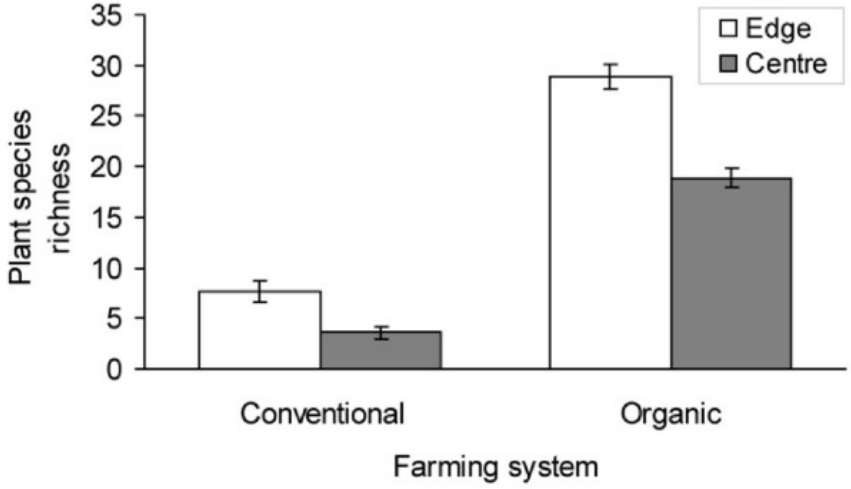
Beecher et al. 2002

Study Design in key





Greater richness of plants and pollinators



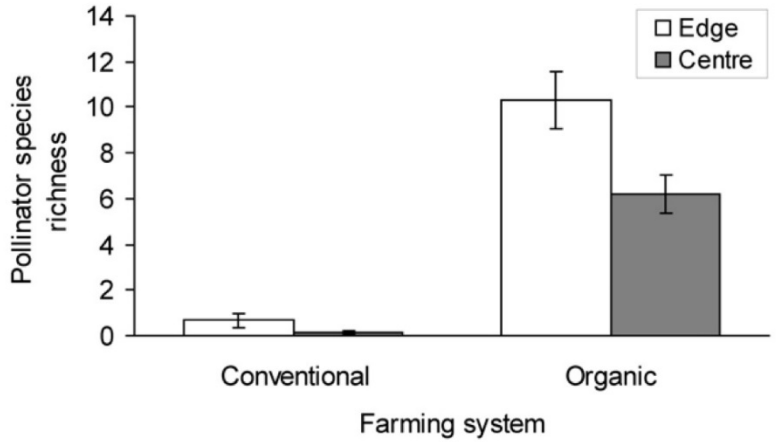
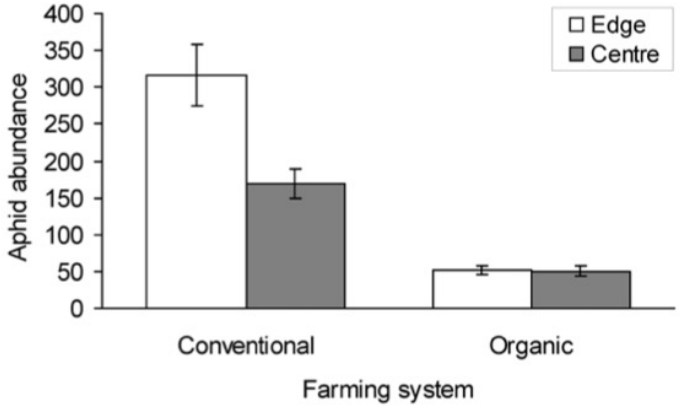
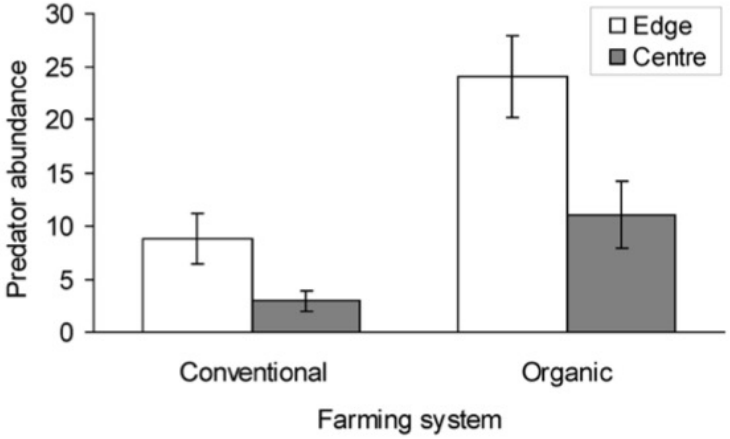
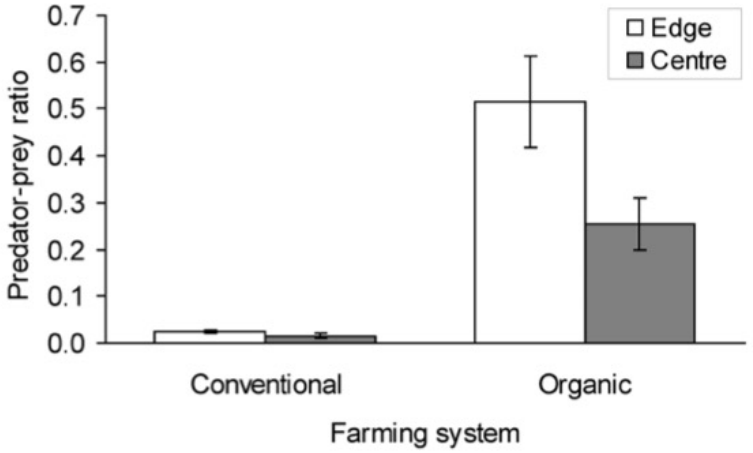


Figure 2. Species richness of (a) vascular plants and (b) pollinators in conventional and organic triticale field edges and centres (mean ± se). C/O: conventional/organic fields, E/C: edge/centre in field, Int: Interaction term. **** $p \leq 0.0001$, ** $p \leq 0.01$, ns $p > 0.1$. Statistics see Table 3.
doi:10.1371/journal.pone.0019502.g002

Fewer pests and great abundance of predators







gure 3. Abundances of (a) aphids, (b) aphid-predators and (c) redator-prey ratio in conventional and organic triticale field dges and centres (mean ± se). C/O: conventional/organic fields, E/ edge/centre in field, Int: Interaction term. **** p≤0.0001, * p≤0.001, ** p≤0.01, * p≤0.05, ns p>0.1. Statistics see Table 3.
oi:10.1371/journal.pone.0019502.g003

Greater fungal richness

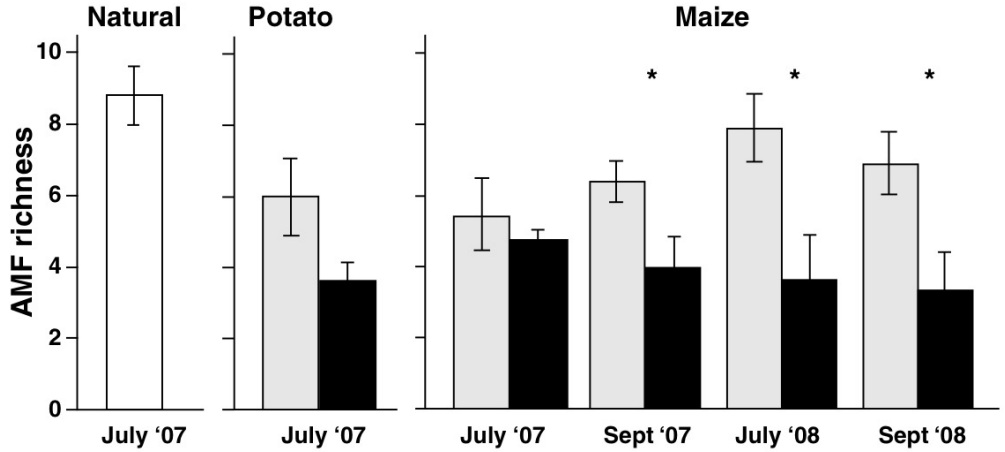
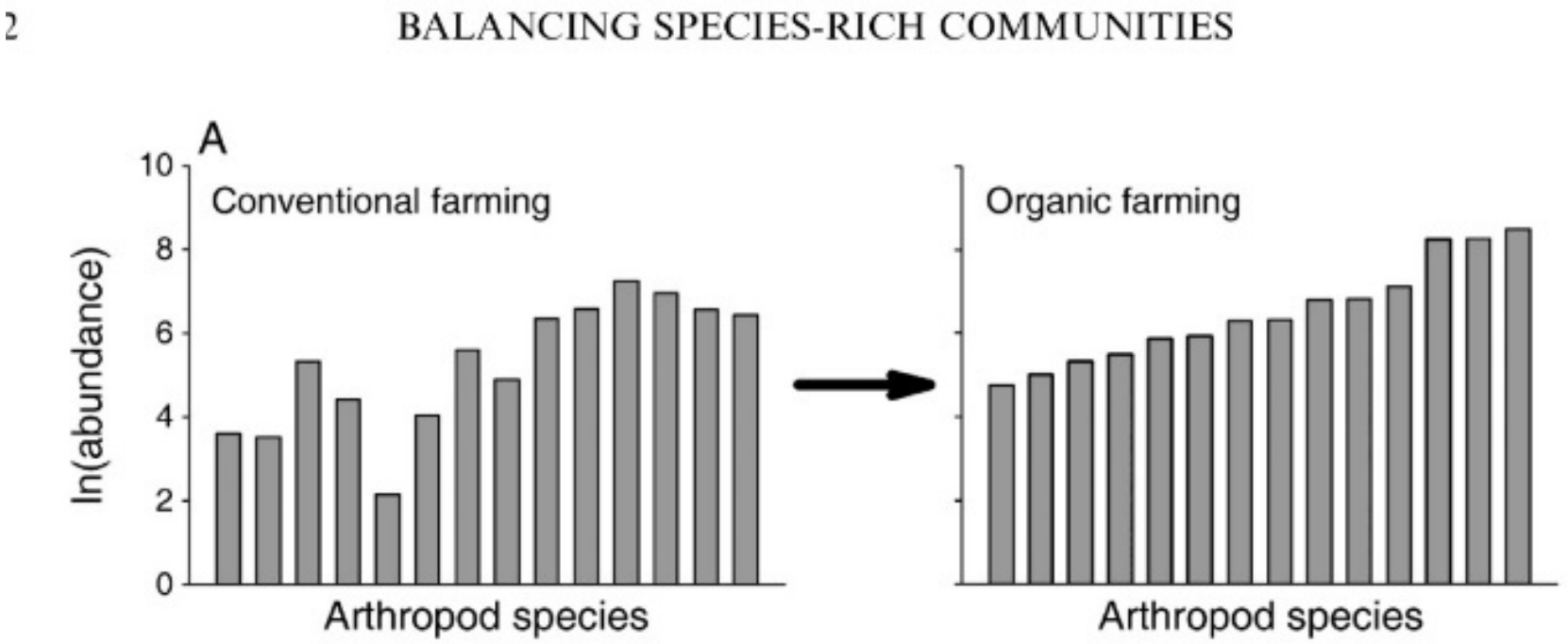


Fig. 1 Mean arbuscular mycorrhizal fungal (AMF) richness ± SE in grasslands (natural) and in organic (grey bars) and conventional (black bars) potato and maize fields sampled at various sampling dates (July '07, July' 08, Sept. '07 and Sept. '08). The significance ($P < 0.05$) of pair-wise comparisons of organic vs conventional treatments is indicated by an asterisk. July 2007: maize ($n = 16$; $t = 0.703$; $P = 0.501$); potato ($n = 10$; $t = 1.986$; $P = 0.082$); September 2007: maize ($n = 16$; $t = 2.353$; $P = 0.034$); July 2008 ($n = 10$; $t = 2.722$; $P = 0.026$); September 2008 ($n = 10$; $t = 2.595$; $P = 0.032$). AMF richness is assessed as the number of forward and reverse terminal restriction fragments (T-RFs) divided by two

Verbruggen et al. 2010

Greater arthropod evenness

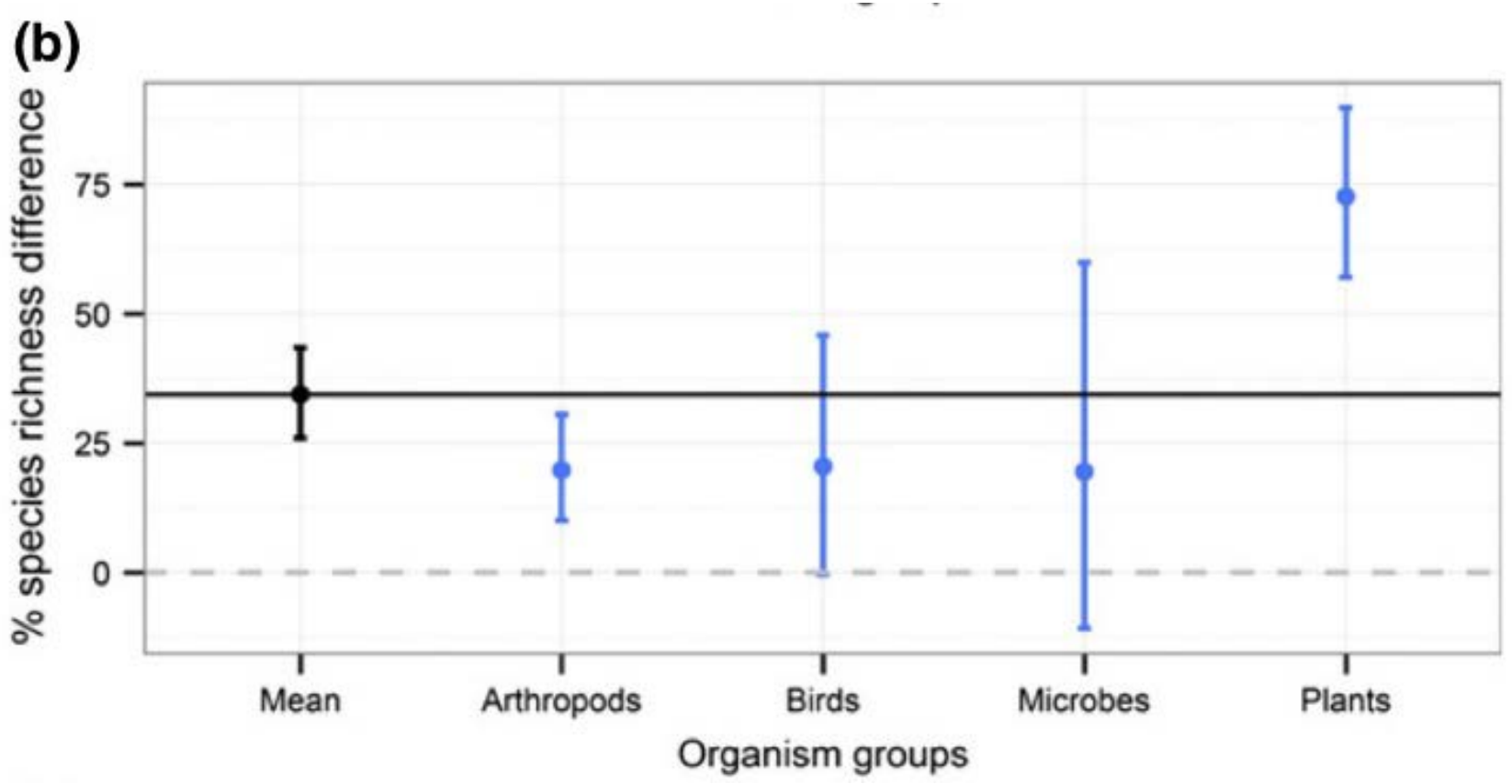


Crowder et al. 2004

Increased biodiversity in organic systems

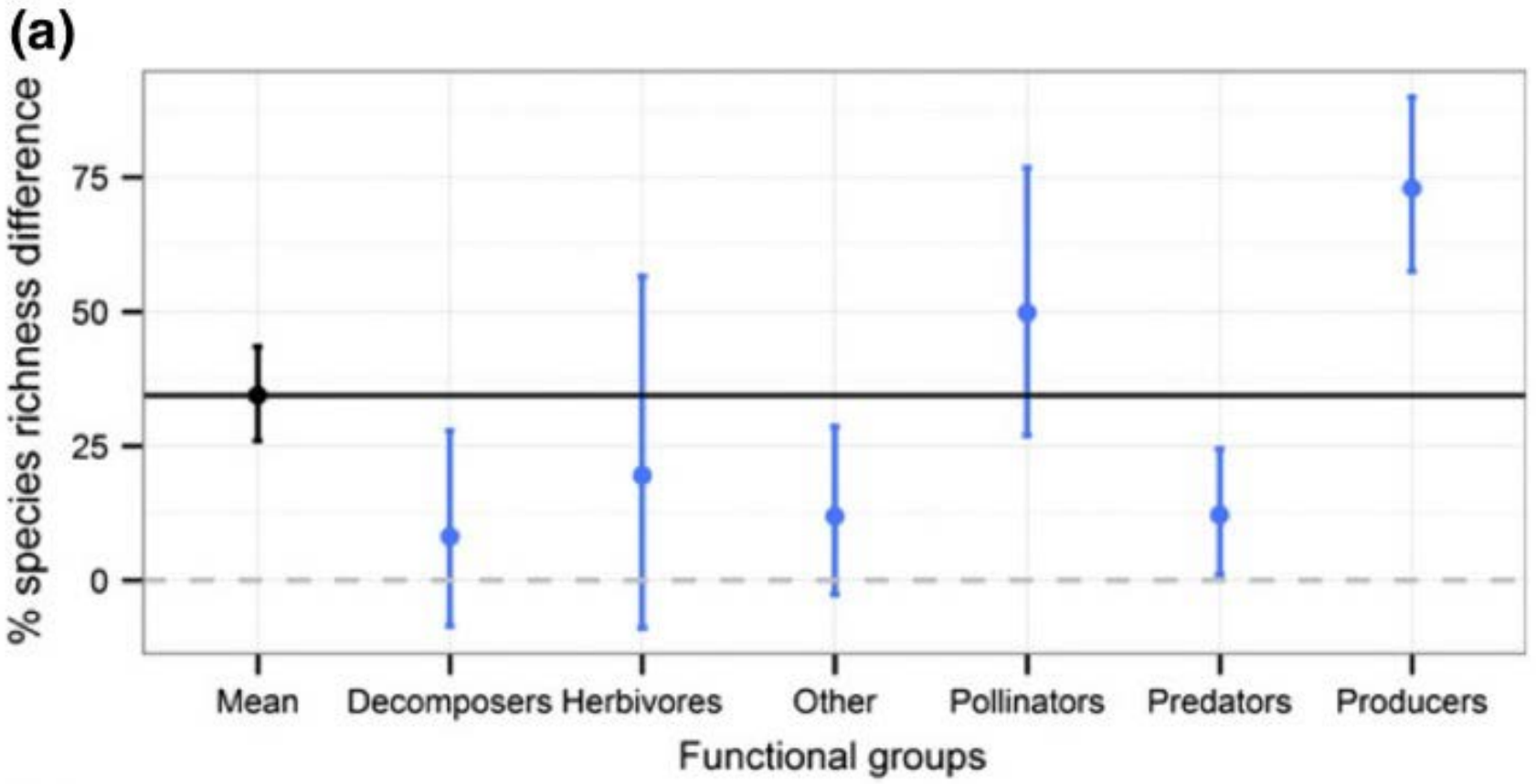
	Positive	Negative	No Difference
Birds	10	0	4
Mammals	3	0	0
Butterflies	4	0	3
Spiders	8	0	3
Earthworms	8	0	6
Beetles	16	2	5
Arthropods	10	5	4
Plants	23	1	3
Soil microbes	18	1	11
Total	100	9	39

Greater richness across organisms



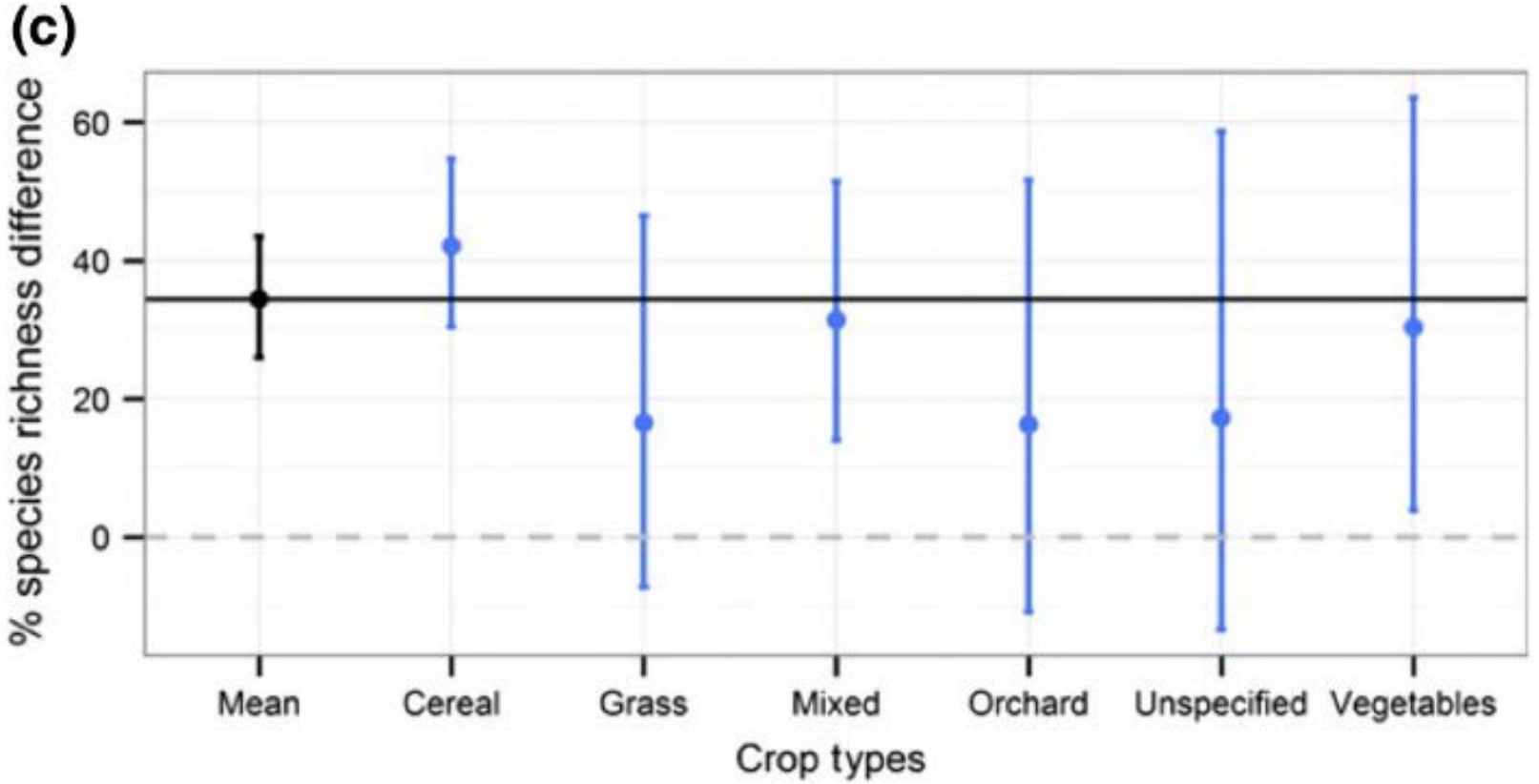
Tuck et al. 2014

Greater richness across functional groups



Tuck et al. 2014

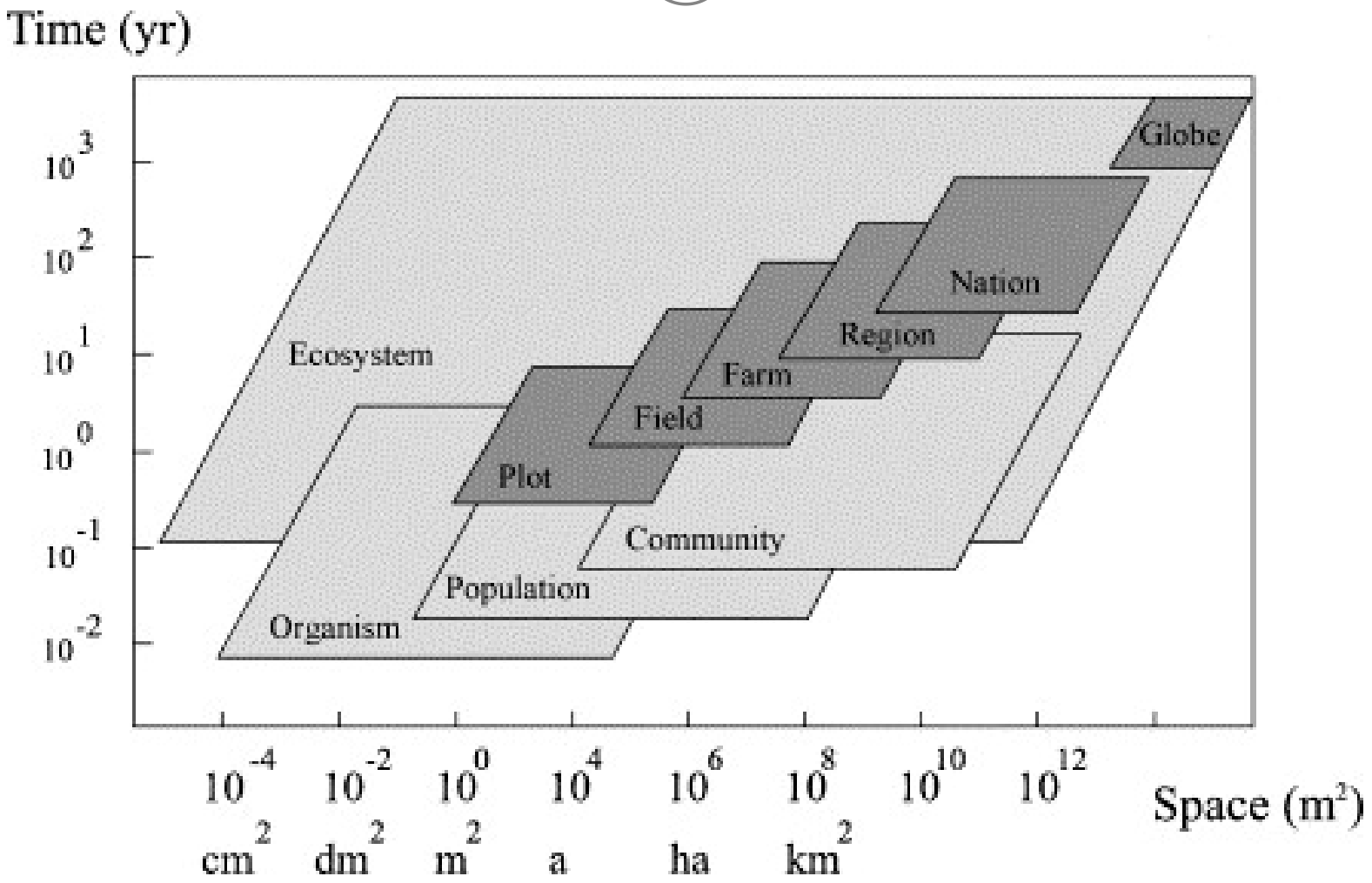
Greater richness across cover types



Tuck et al. 2014

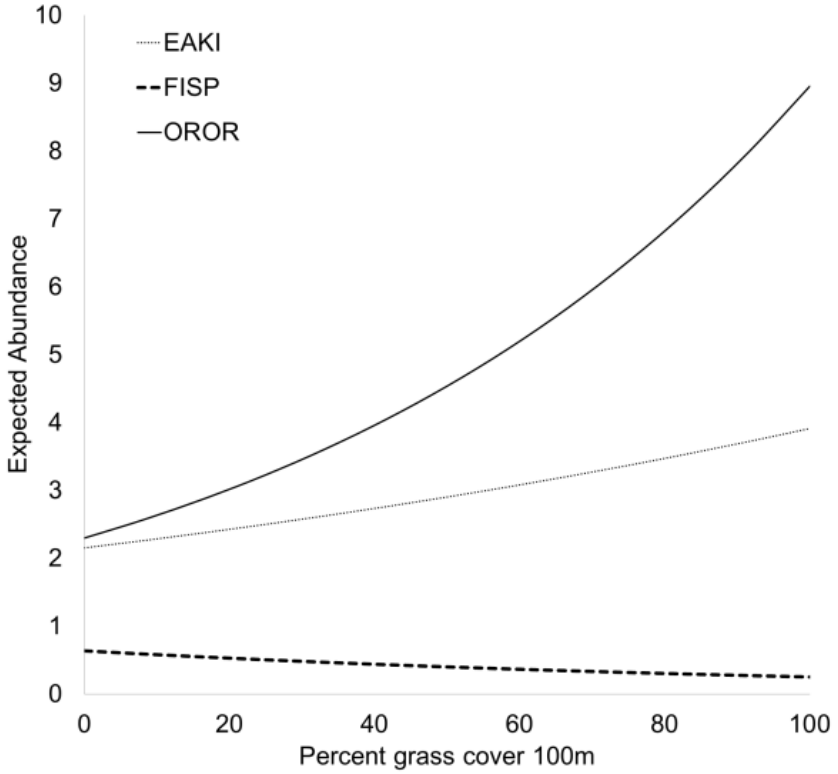
Questions?

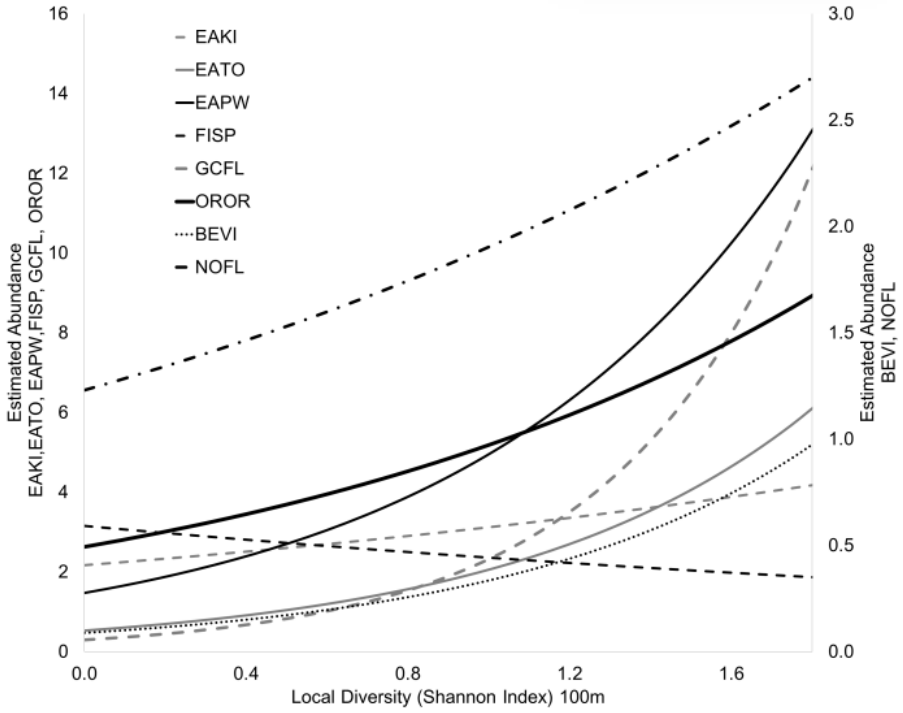
Measuring biodiversity across space and time



Dalgaard et al. 2003

Within organic

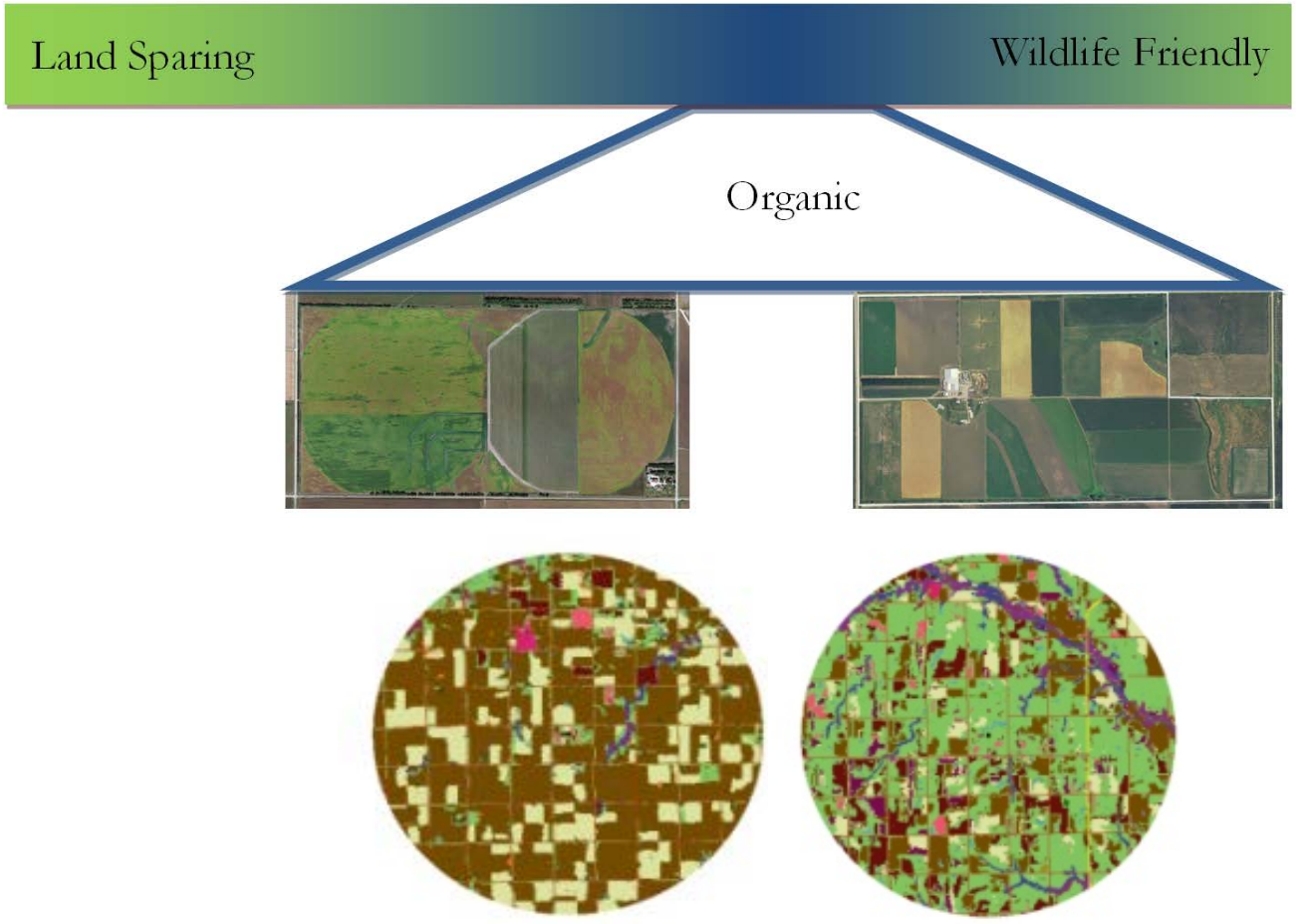




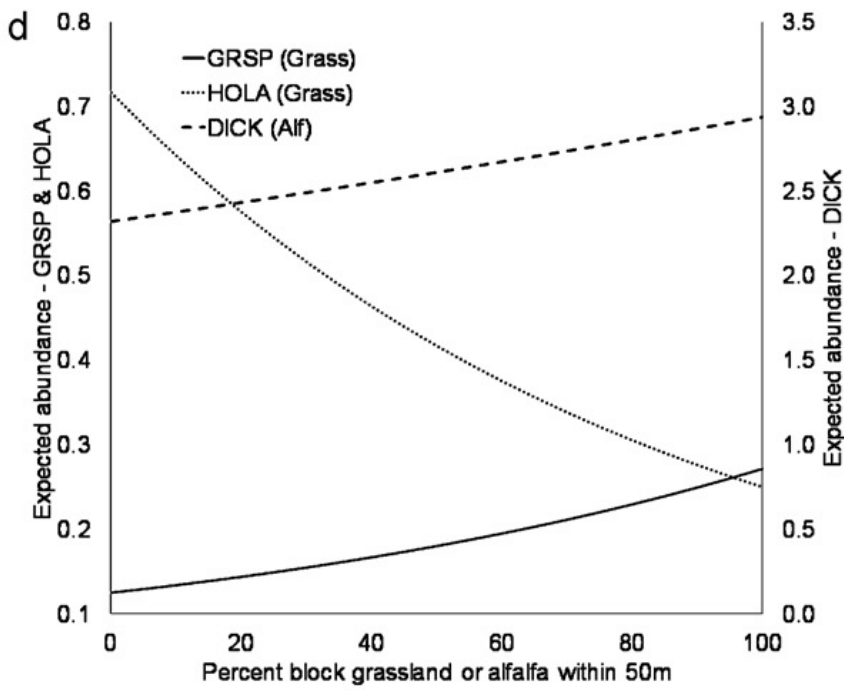
Shrubland birds

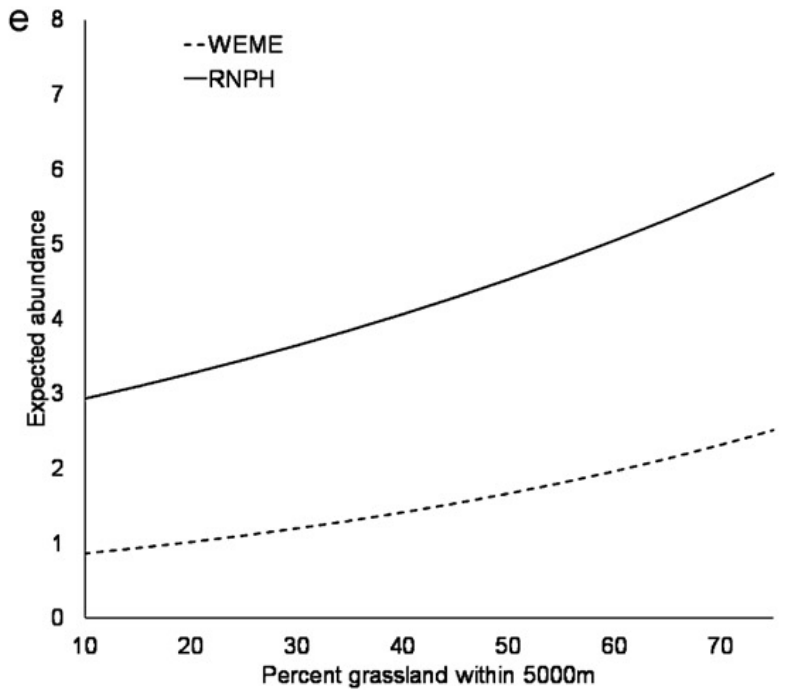
Quinn et al. 2014

The landscape context of organic farms



Response to organic farm practice vary by scale





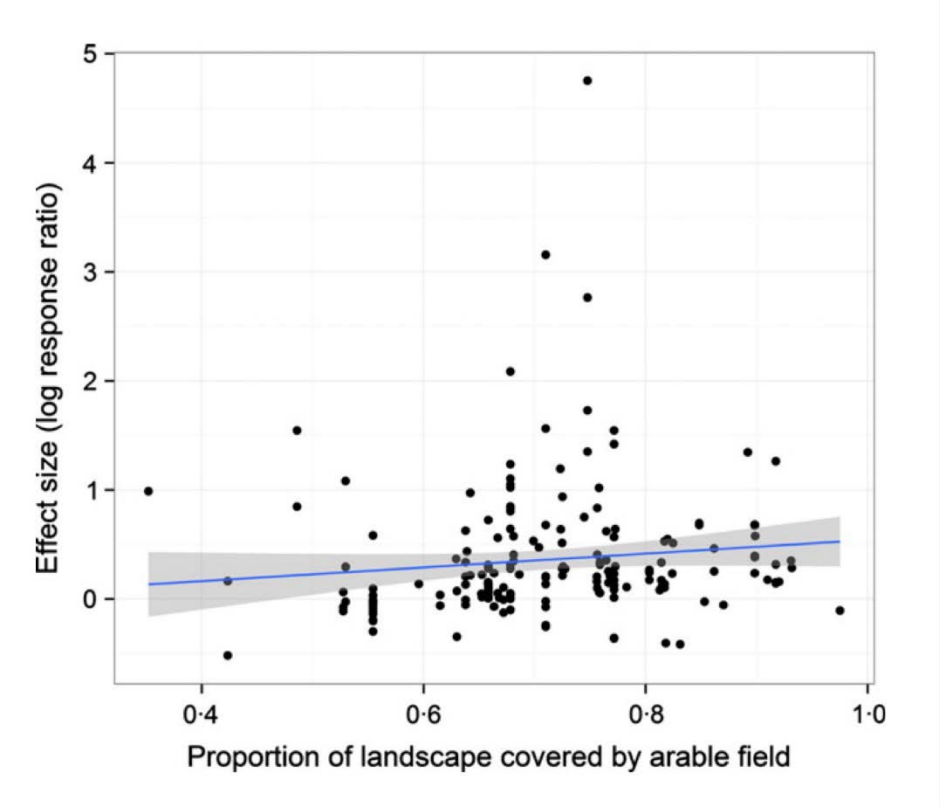
Local Scale

Grassland Birds

Landscape Scale

Quinn et al. 2012

A greater effect in more simple landscapes



Tuck et al. 2014

Reduced richness in more simple landscapes

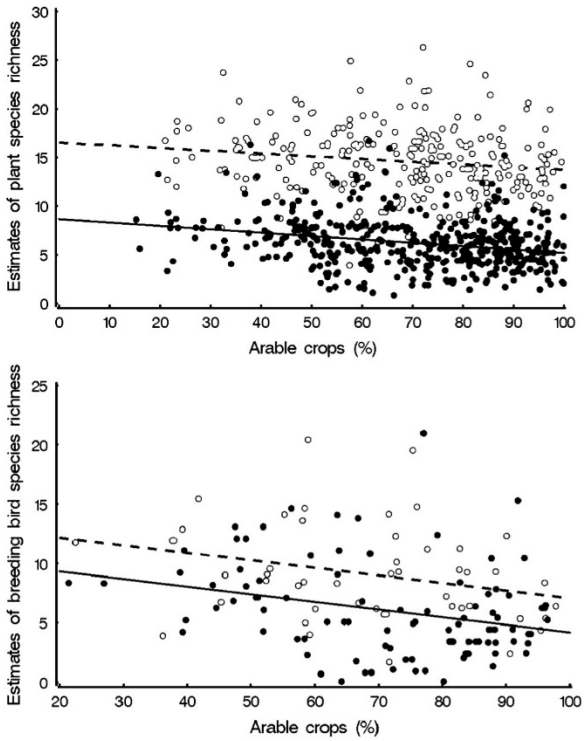
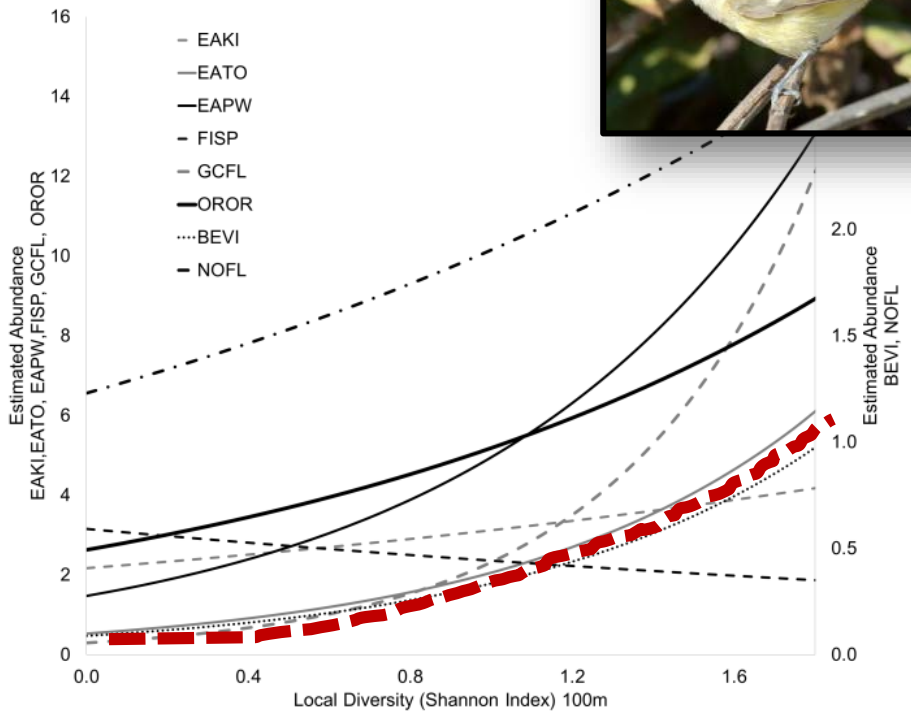


Fig. 1. Plant species richness and breeding bird species richness model estimates and residuals plotted against landscape complexity (percentage of arable crops in a buffer zone with 1000-m radius). Organic fields: open circles and dotted line. Conventional fields: filled circles and solid line.

Winqvist et al. 2011

Other measures of conservation success



Quinn et al. 2014

Bell's Vireo Conservation – Breeding Success

Number of nests

2012 & 2013

Percent nest success

2012 & 2013

Bell's Vireo nesting success

Fig. 7. Bell's Vireo DSR as a funtion of %Soybean

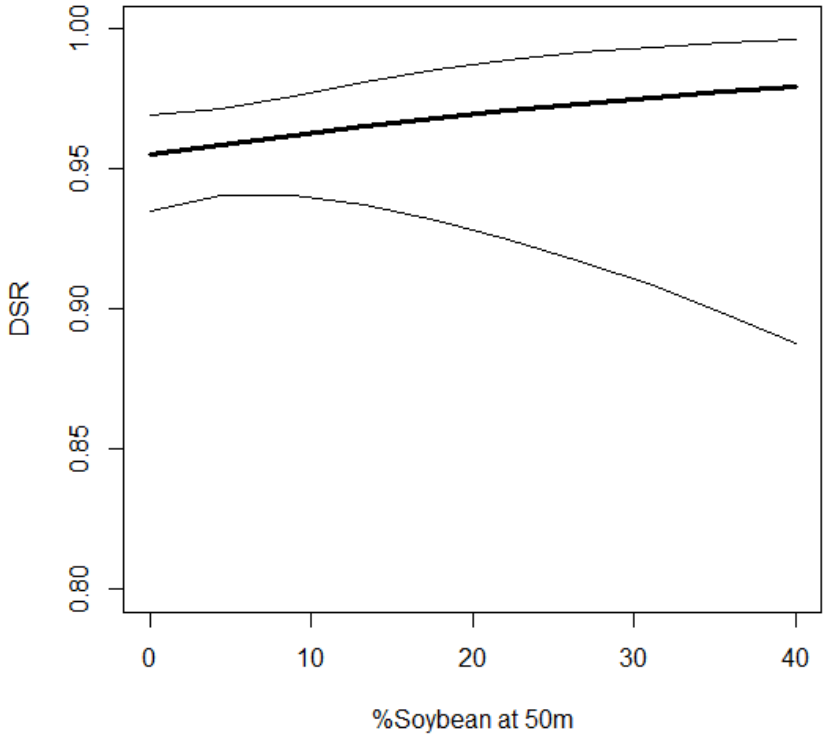
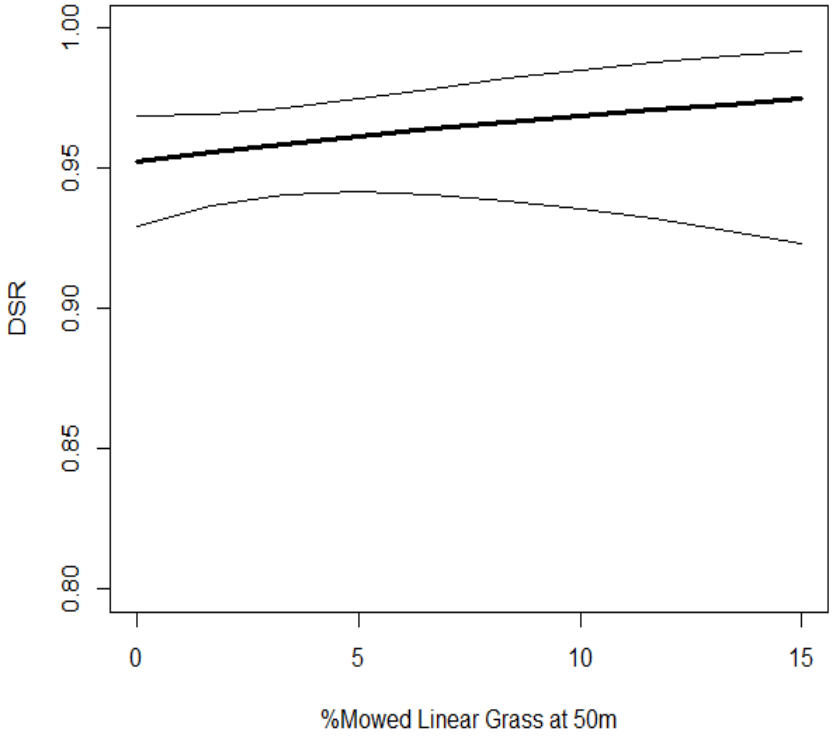


Fig 8. Bell's Vireo DSR as a funtion of %Mowed Linear Grass



Bell's Vireo nesting success

Fig 9. Bell's Vireo DSR as a funtion of %Alfalfa

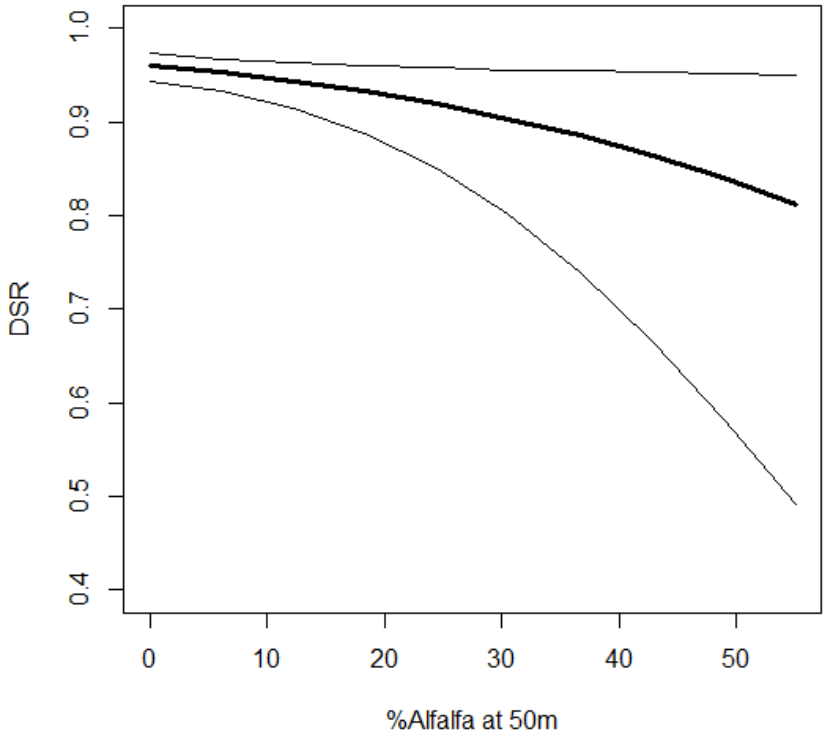
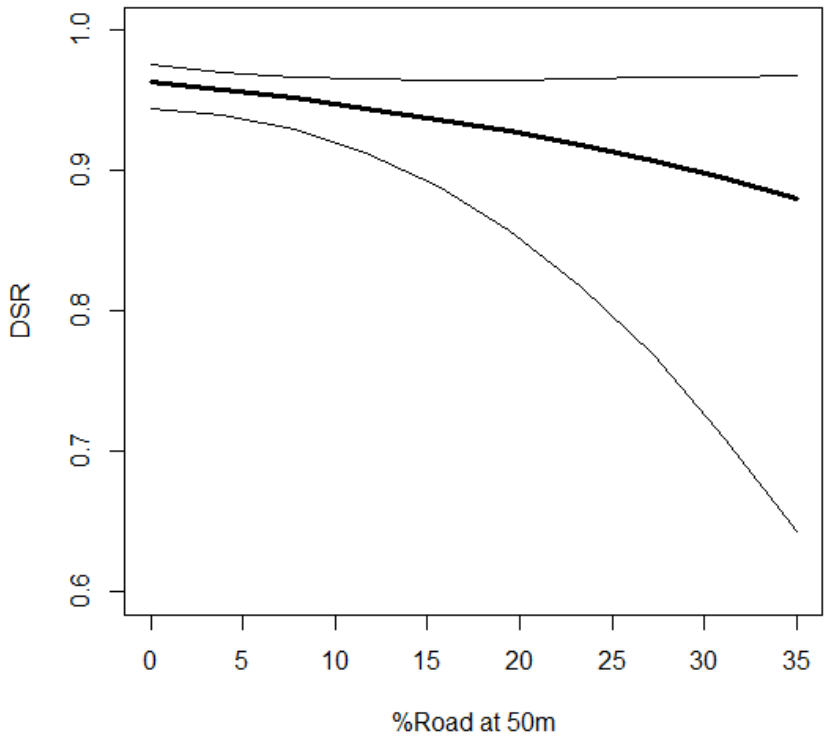
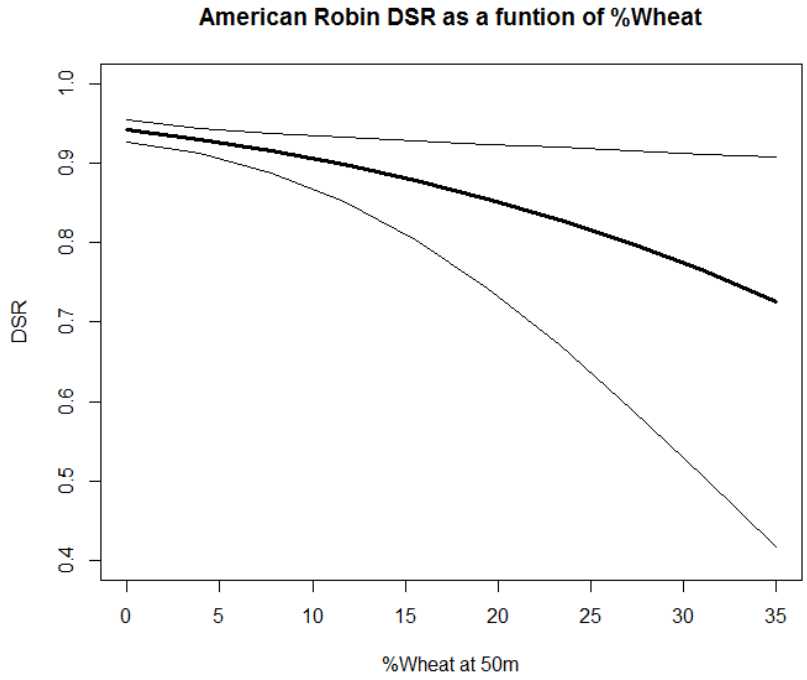
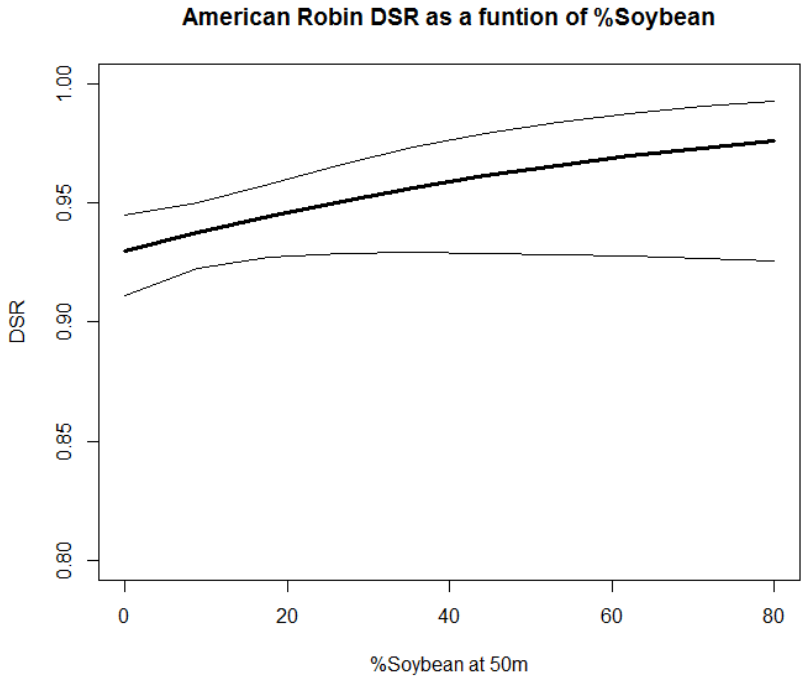


Fig 10. Bell's Vireo DSR as a funtion of %Road



The organic matrix and DSR





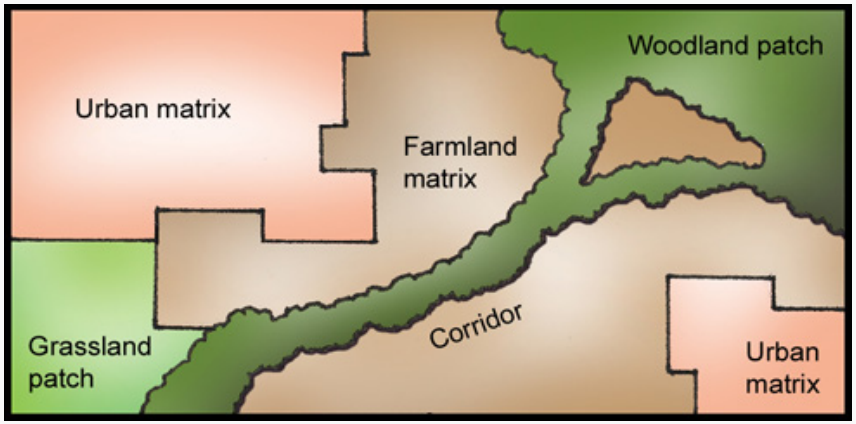
Estimated Daily Survival Rate (DSR) for American Robins as a function of percent wheat and percent soybean within 50 meters of the nest.

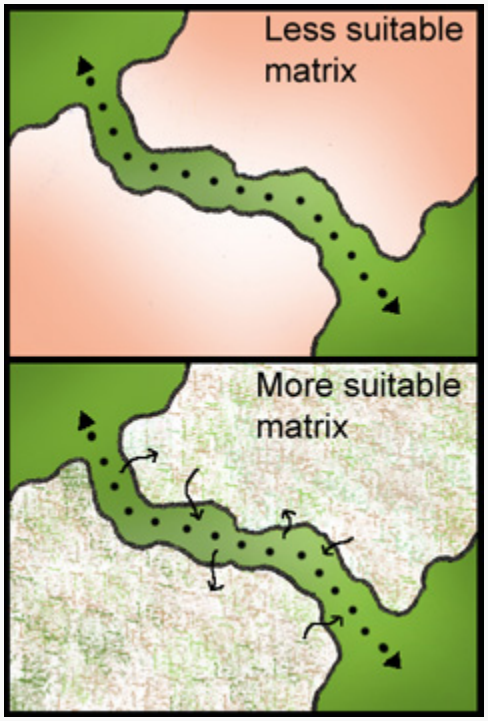
Quinn et al. 2013

Going Forward

FURTHER RESEARCH AND PRACTICE

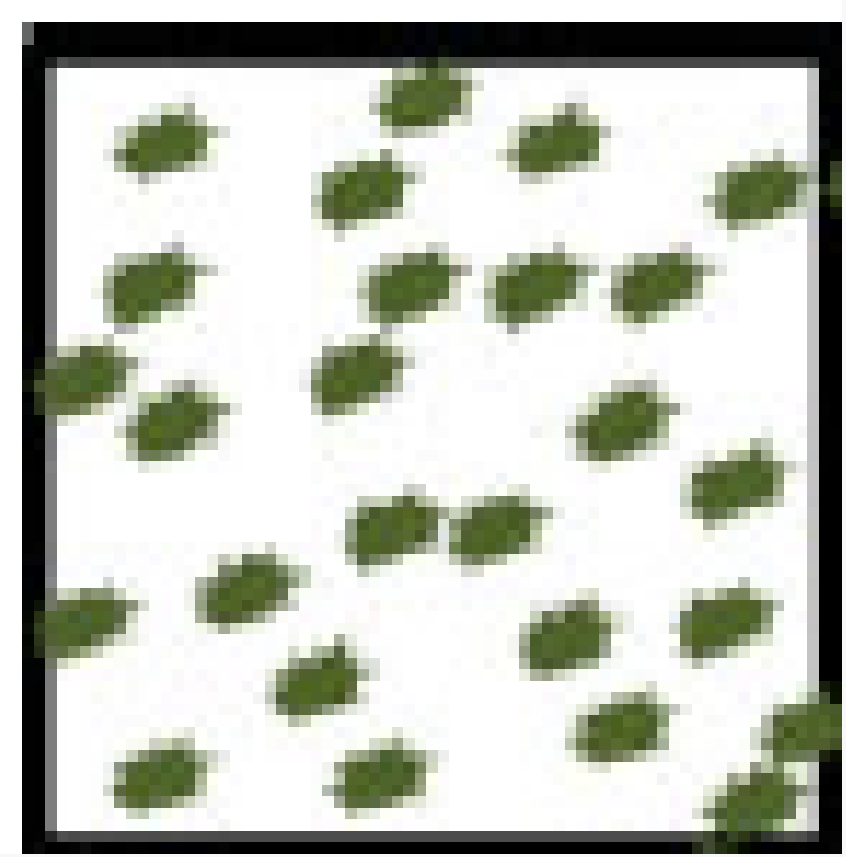
Patch-Matrix interactions





USDA National Agroforestry Center

Scale is important



Linking local and landscape

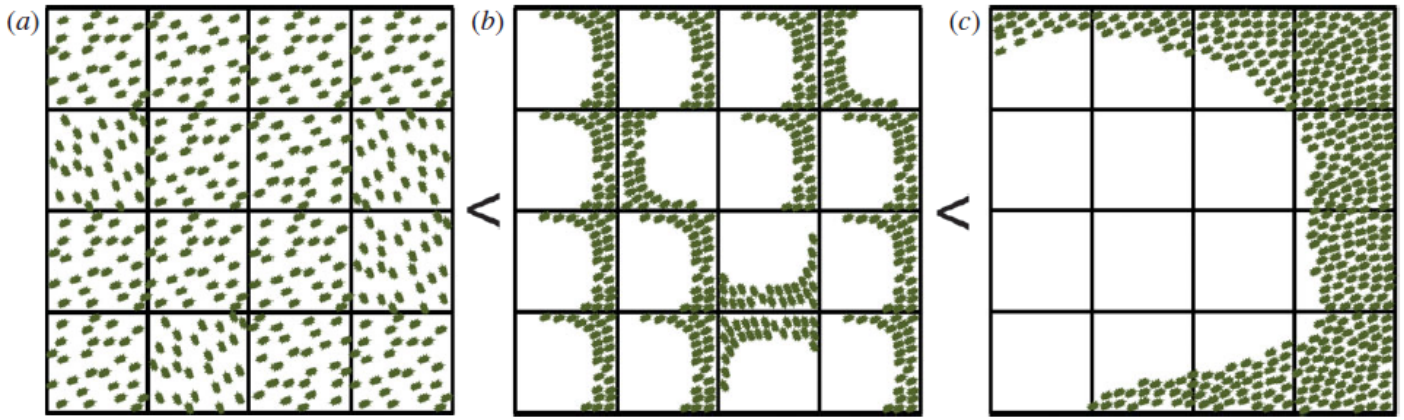
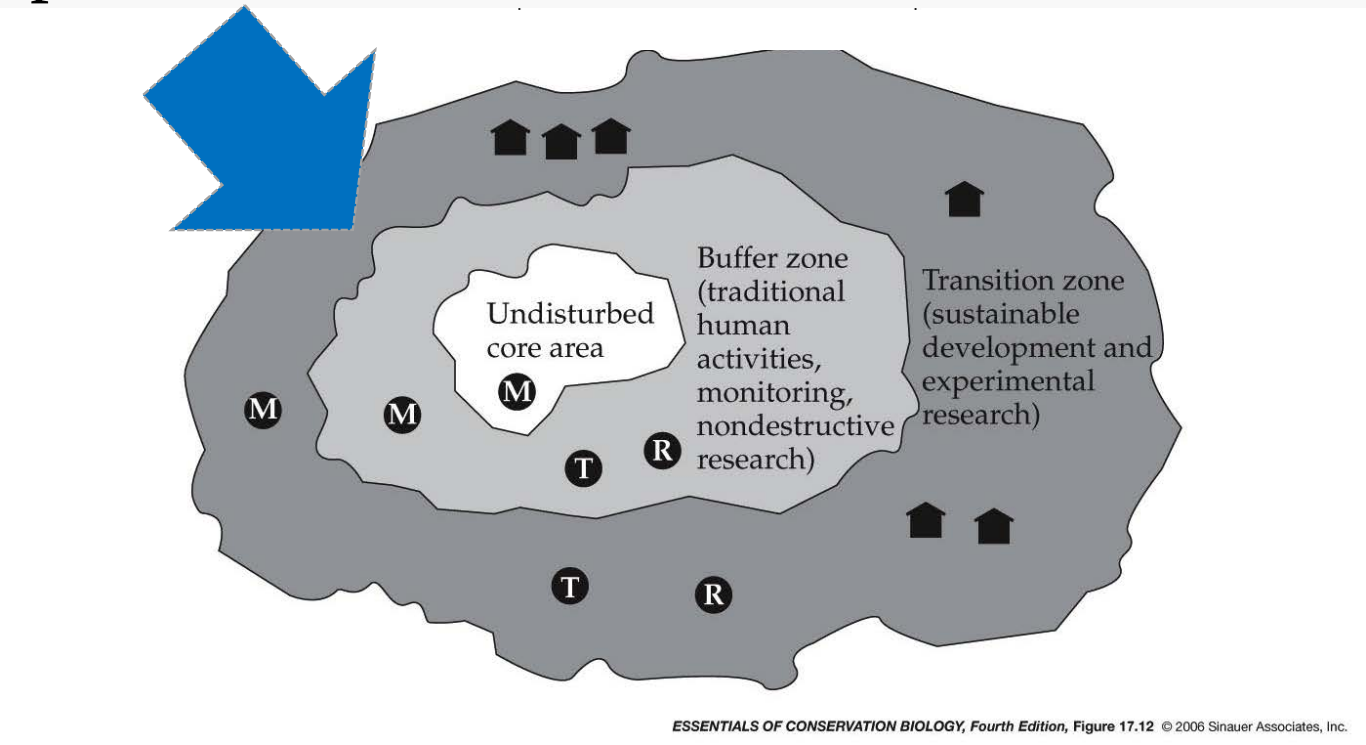


Figure 5. Schematic summarizing what some 'biodiversity-friendly' certification schemes currently endorse (*a*) compared with landscapes that involve land sparing within large farms (*b*) or across a group of farms (*c*). In each landscape, the same total area (denoted by the green shapes) is given over to wild nature, but recent evidence suggests that its value for other species and for ecosystem services might increase from left to right, raising the question of whether certification could be realigned towards incentivizing high-yield farmers to collectively set aside adjacent areas of land for conservation. Developed from ideas in Edwards *et al.* [92] and Komar [97].

Organic farming can complement protected areas

Organic farming around protected areas



ESSENTIALS OF CONSERVATION BIOLOGY, Fourth Edition, Figure 17.12 © 2006 Sinauer Associates, Inc.

Organic farming and ecosystem services?

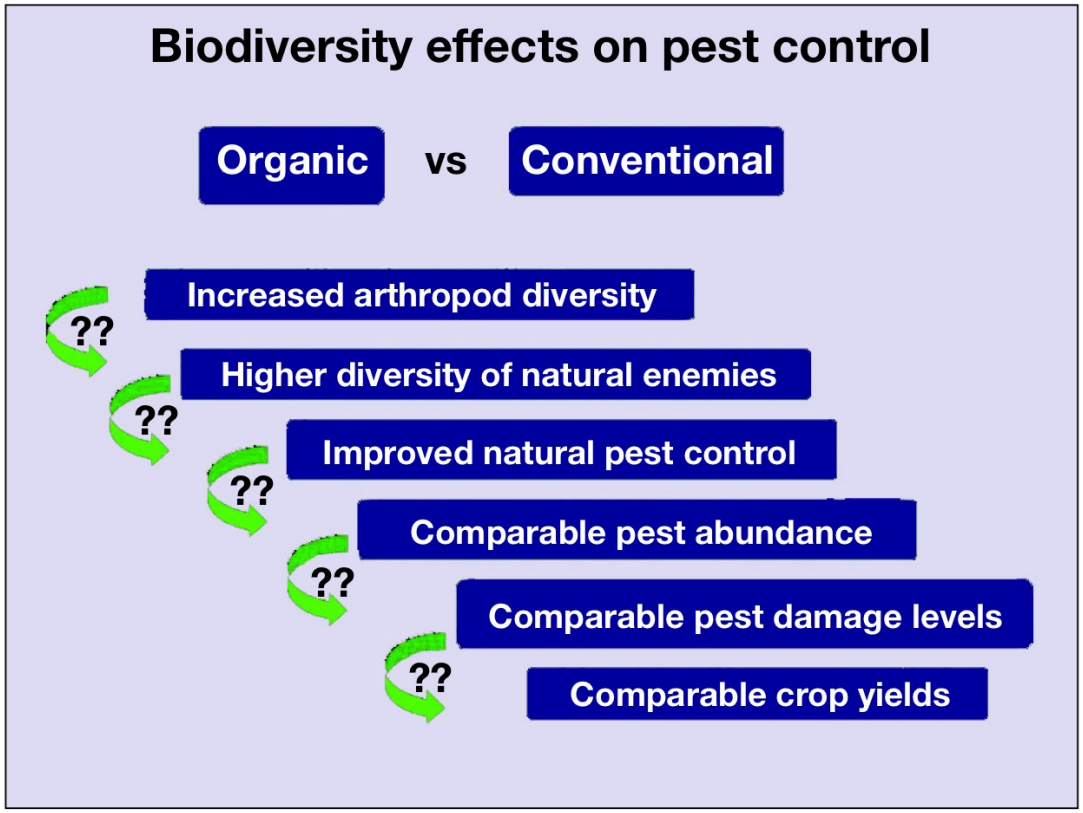


Figure 4. *Step-by-step procedure required to link an increase in biodiversity with the effectiveness of pest control as an ecosystem service for organic and conventional growers.*

Letourneau and Bothwell 2008

Organic farming and ecosystem services

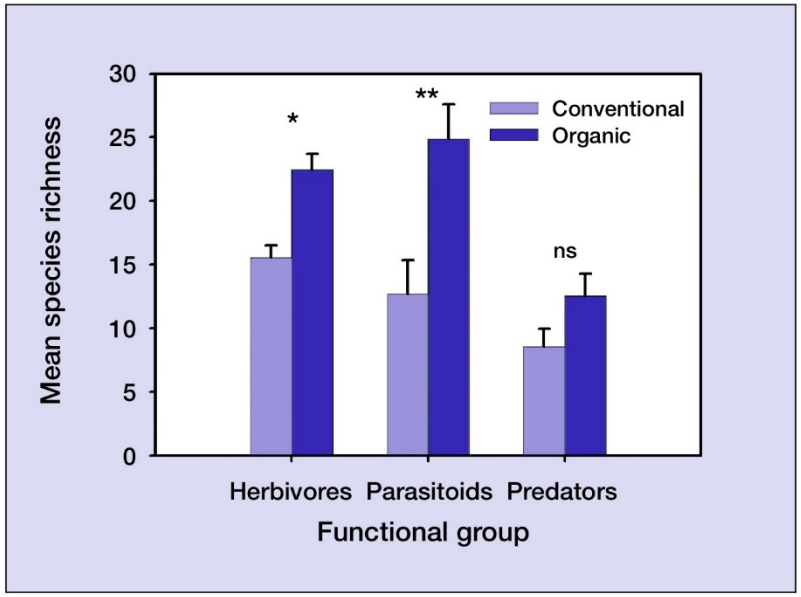


Figure 2. *Species richness (determined as morphospecies counts of arthropods in vacuum samples) of herbivores (ANOVA, $F_{1,16} = 18.3$, P = 0.0006) and parasitoids (ANOVA, $F_{1,16} = 6.12$, P = 0.0249) was significantly greater on organic than conventional farms, whereas predator richness among management types was more similar (ANOVA, $F_{1,16} = 3.25$, P = 0.0903, each analysis using as the error term farm nested in type of management practice: organic or conventional). * = < 0.05, ** = < 0.001, ns = not significantly different.*

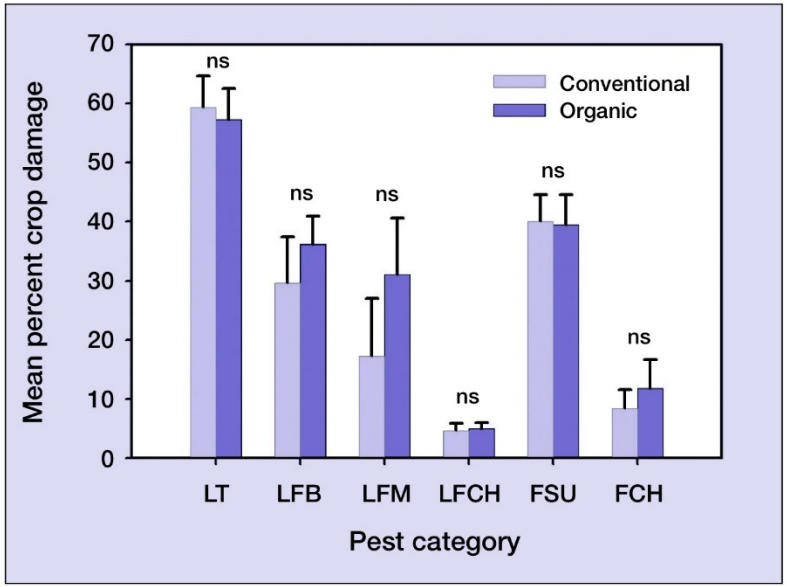


Figure 3. *Neither damage to tomato foliage by thrips (LT), flea beetles (LFB), leafminers (LFM), or chewing insects (LFCH), nor fruit damage by sucking insects (FSU) and chewing insects (FCH), was significantly different on organic versus conventional tomato crops (ANOVAs, $F_{1,16}$-values < 1.4, P-values > 0.2, with error term farm nested in type of management practice: organic or conventional). NS = not significantly different.*

Letourneau and Bothwell 2008

Organic farming and ecosystem services?

Table 2. **Results from recent studies on the effect of organic farming, landscape complexity, and their interaction on the ecosystem services in the arable landscape. For information regarding the definition of landscape in each study, see the main text**

Ecosystem service	Organic	Landscape	Interaction	References
Biological control (b)	ns	*	0.057	Winqvist *et al.*[9]
Pollination (a)	ns	ns	0.054	Brittain *et al.*[18]
Seed predation	*	ns	ns	Diekötter *et al.*[35]
Seed removal	ns	ns	**	Fischer *et al.*[7a]
Litter decomposition	ns	ns	ns	Diekötter *et al.*[35]

$P < 0.1$ (ns), $P < 0.05$ (*), $P < 0.01$ (**), $P < 0.001$ (***).

[a]Additional effects were significant in the model: seed species (***) and predator exclusion (***), (a) = abundance of visits, (b) = removal of aphids from plastic labels placed in the field for 24 h.

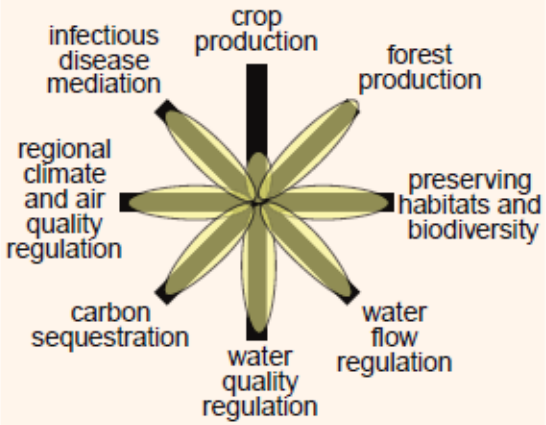
Winqvist et al. 2011

Diversified farming and ecosystem services

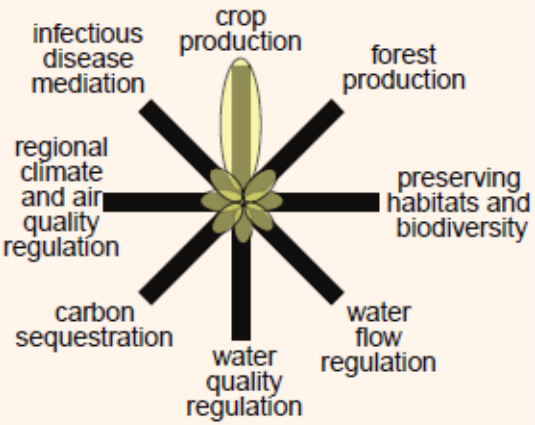
- Improved soil quality
- Carbon sequestration
- Water-holding capacity
- Energy Use
- Climate resilience
- Control of weeds & pests*
- Pollination*

Kremen and Miles 2012

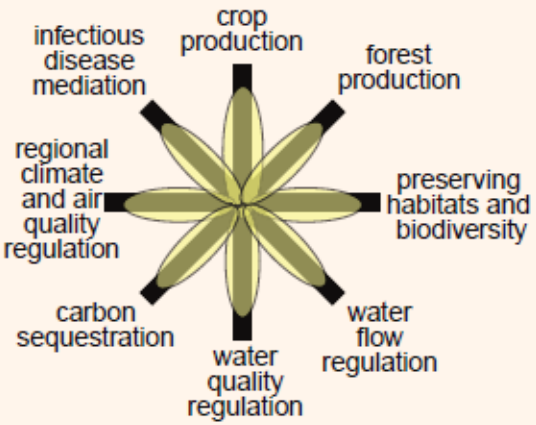
Managing tradeoffs



natural ecosystem



intensive cropland

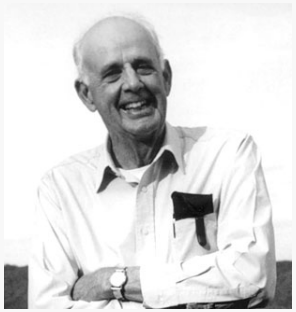


cropland with restored ecosystem services

Foley et al 2005

The End

- *"My sorrow in having been for so long on two losing sides (conservation and agrarian) has been compounded by knowing that those two sides have been in conflict with each other."*
  - Wendell Berry, Conservationist and Agrarian



-- Questions --

Healthy Farm Index

Farm Assessment – Missing Biodiversity and Eco Serv

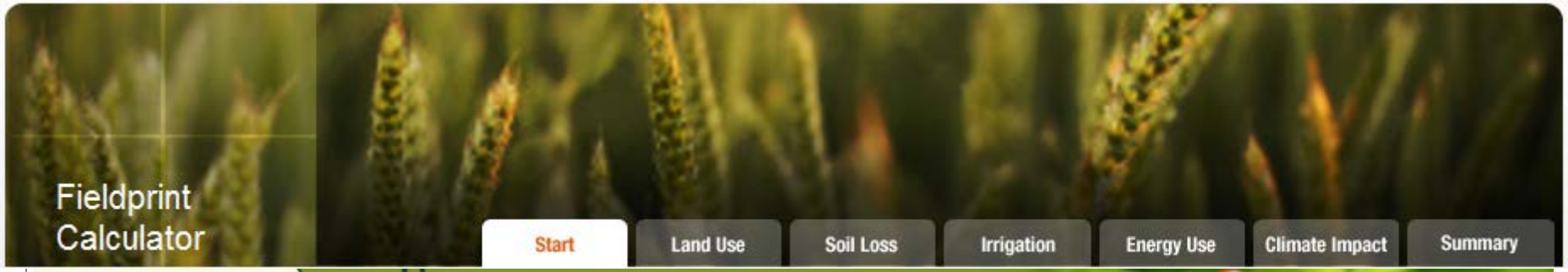
Soil & Water Assessment Tool | SWAT

LAND STEWARDSHIP PROJECT

HOME | ABOUT US | JOIN US | CONTACT US | CALENDAR | RESOURCES | SEARCH

A Guide to the Art and Science of On-Farm Monitoring

The Monitoring *Tool Box*



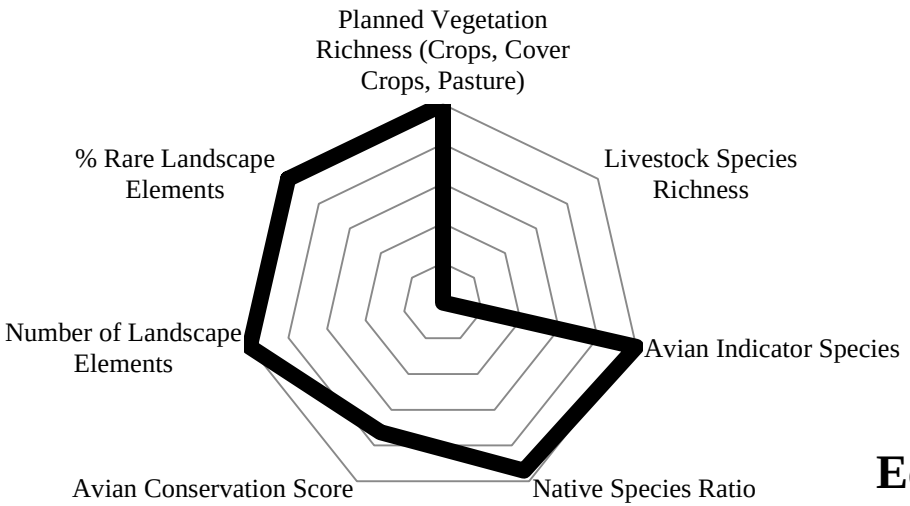
Health Farm Index

- A farm scale monitoring tool
- Biodiversity
  - What should farms maintain
  - Agriculture for Biodiversity

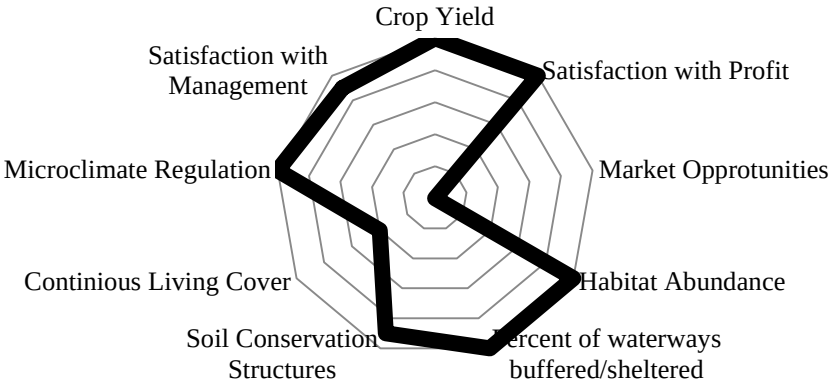
- Ecosystem services
  - What processes should farms provide
  - Biodiversity for Agriculture

Individual Indicator Evaluation

Biodiversity State (88)



Ecosystem Services (91)



Natural vs Agroecosystems

Important structural and functional differences between natural ecosystems and agroecosystems (Gliessman 2000)

	Natural Ecosystems	Agroecosystems
Net Productivity		
Trophic interactions		
Species Diversity		
Genetic Diversity		
Nutrient cycles		
Stability (resilience)		
Human control		
Temporal permanence		
Habitat heterogeneity		

Natural vs Agroecosystems

Important structural and functional differences between natural ecosystems and agroecosystems (Gliessman 2000)

	Natural Ecosystems	Agroecosystems
Net Productivity	Medium	High
Trophic interactions	Complex	Simple, linear
Species Diversity	High	Low
Genetic Diversity	High	Low
Nutrient cycles	Closed	Open
Stability (resilience)	High	Low
Human control	Independent	Dependent
Temporal permanence	Long	Short
Habitat heterogeneity	Complex	Simple