Designing Bioenergy Landscapes for Wildlife

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U.S. DEPARTMENT OF ENERGY

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OAK RIDGE NATIONAL LABORATORY
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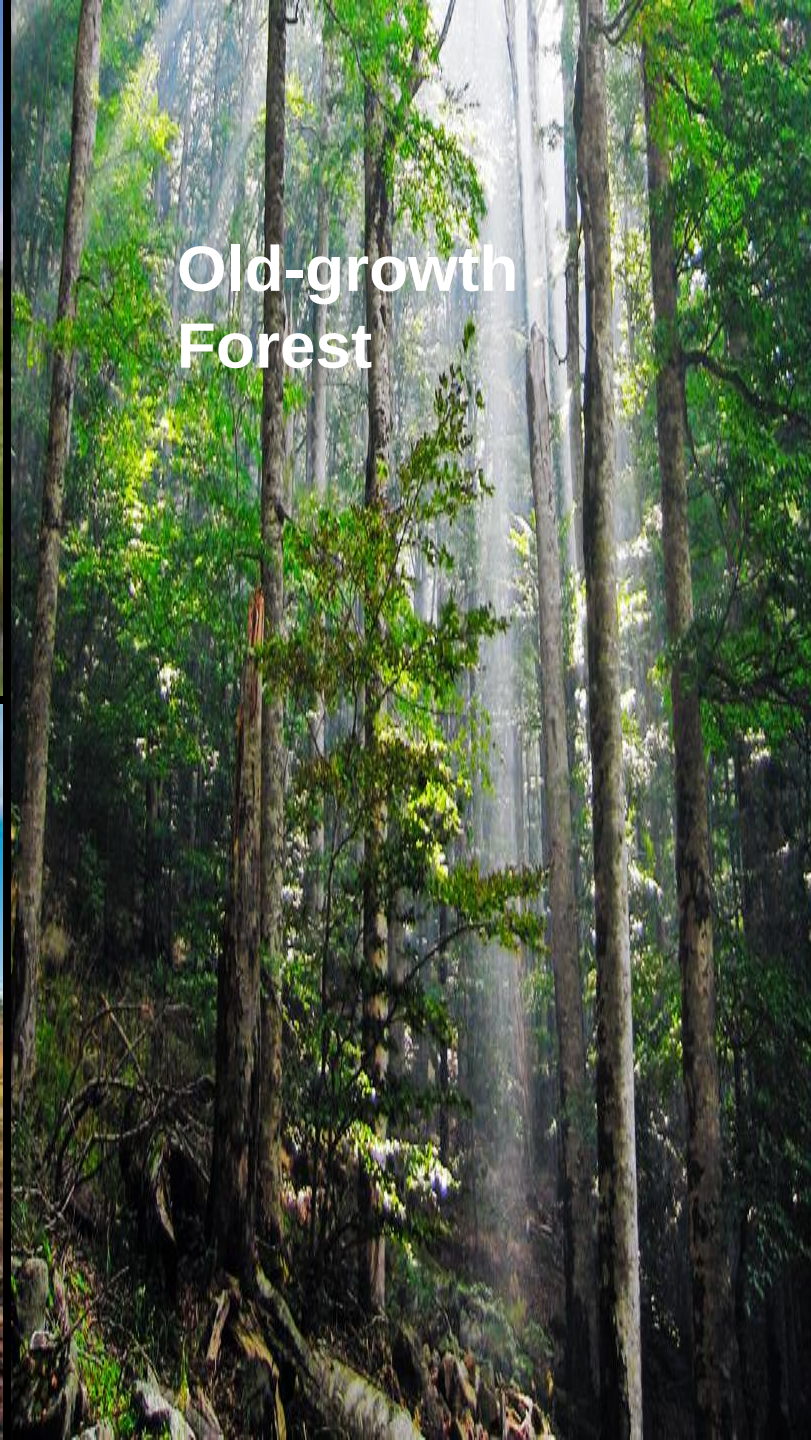
- Background
  - Ecosystems at risk
  - Biodiversity indicators
- Spatial ecology
  - Source-sink theory
  - Habitat size & shape influence wildlife
  - Habitat size & shape influence logistics
- Strategies for Landscape Design
  - Land sharing vs. land sparing
  - Time share
  - Trade-offs
- BT-2016 Biodiversity plan

BACKGROUND


Wetlands


Grassland
/ Prairie


Old-growth
Forest

Ecosystems


Wetlands


Agriculture

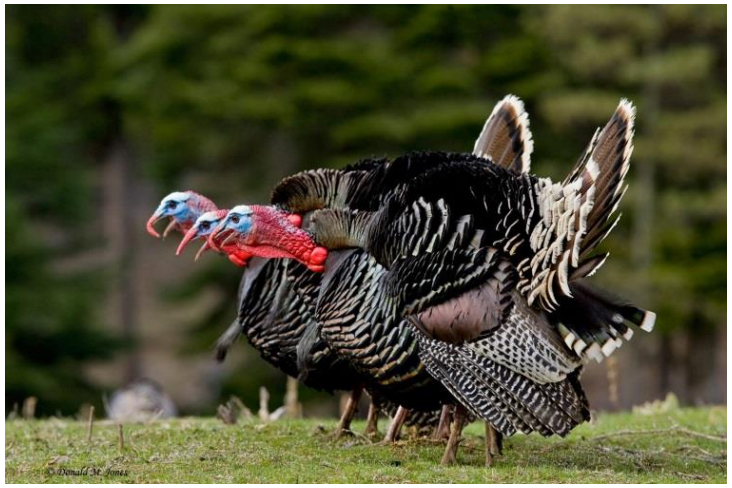

Grassland
/ Prairie

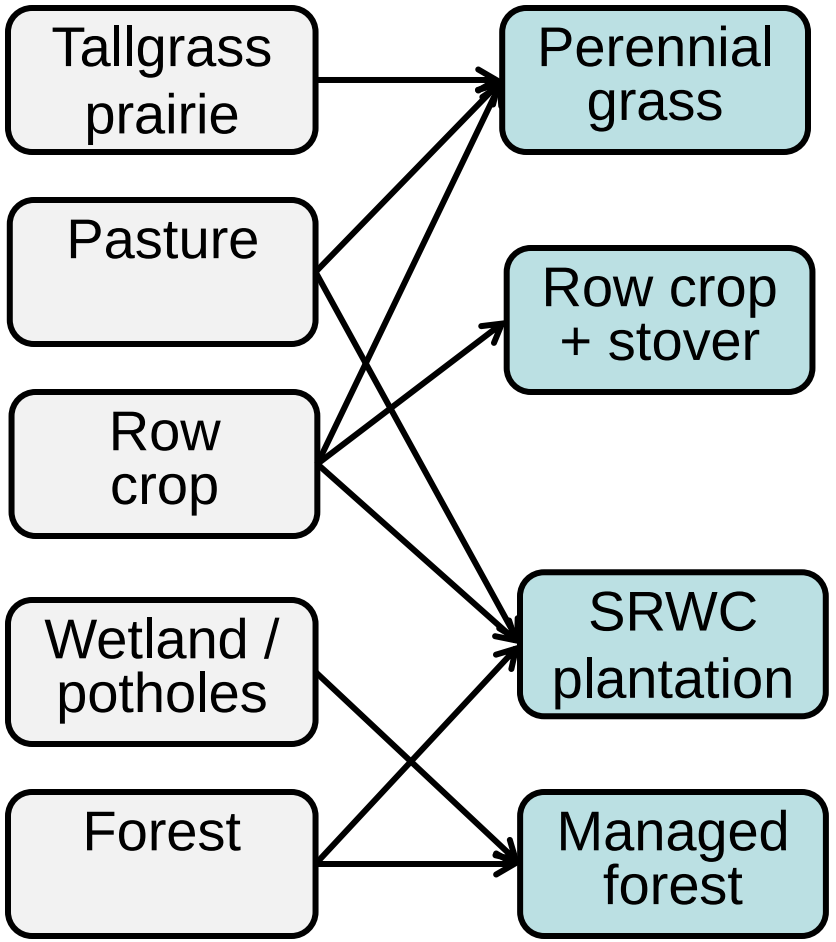

Rivers


Managed
Forest /
Plantation


Old-growth
Forest

Habitat Transitions





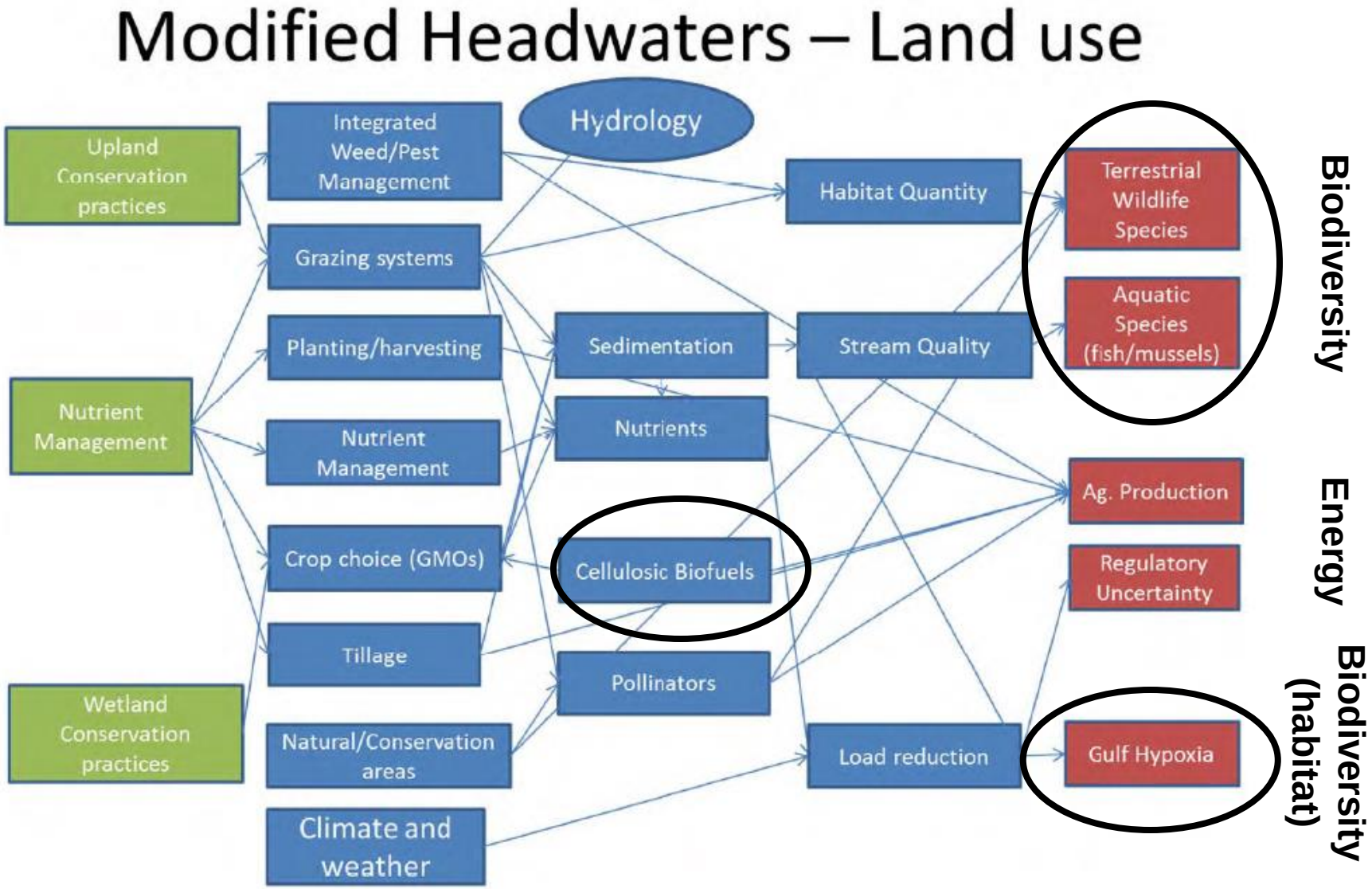
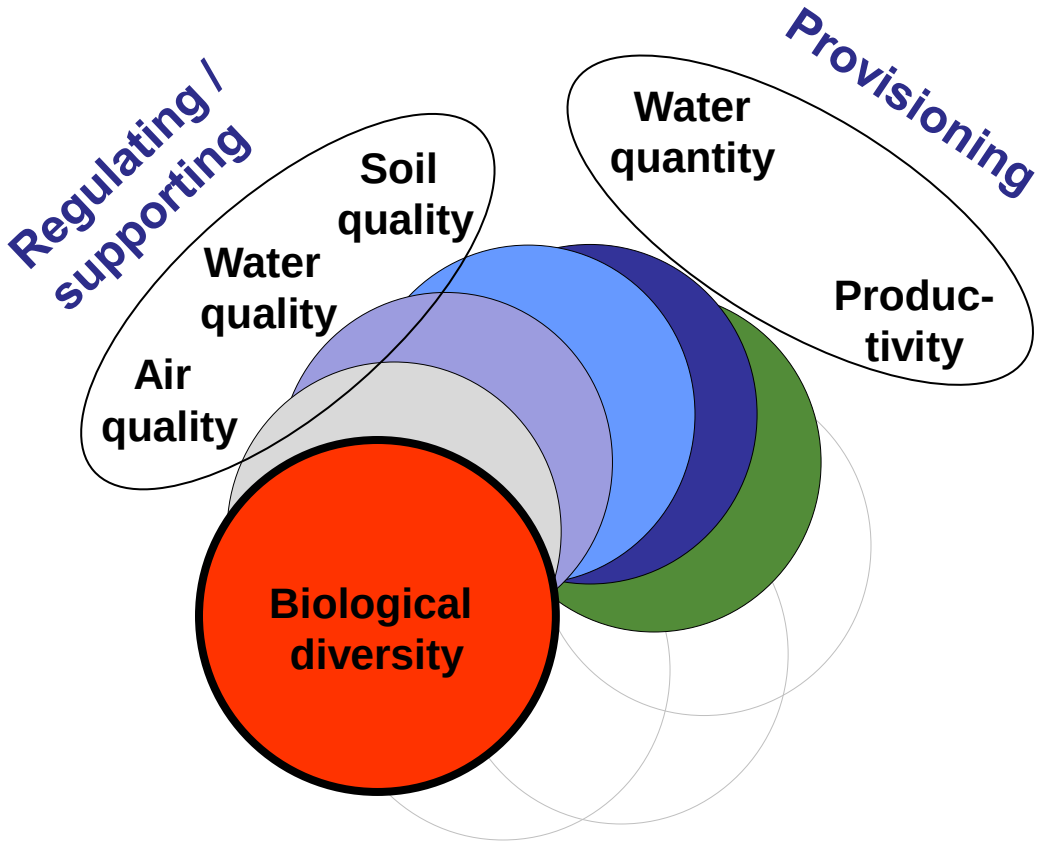


Figure 3. Draft influence diagram for land use in "modified headwaters", where green boxes represent action types, blue boxes represent system processes or uncertainties and red boxes represent fundamental objectives. The hydrology and land use models may be linked.

Dimensions of Sustainability

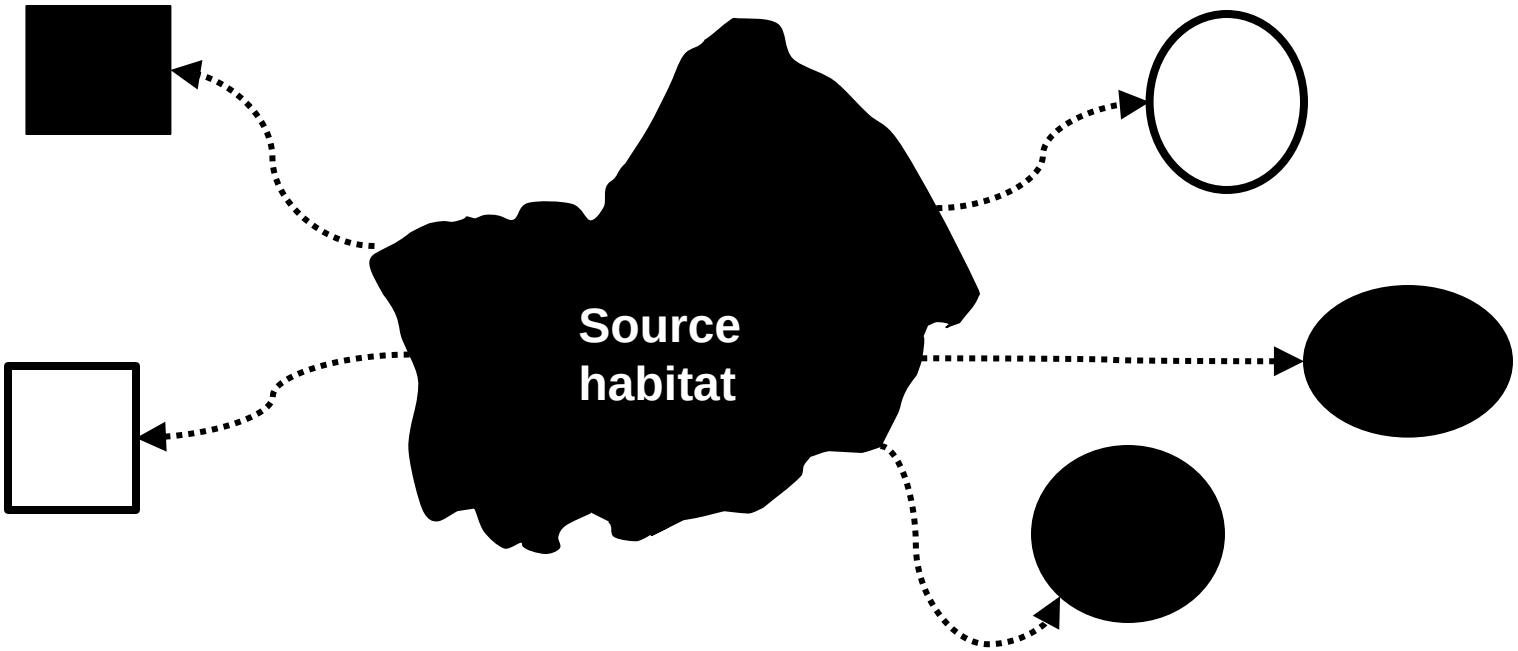


Biodiversity Indicators

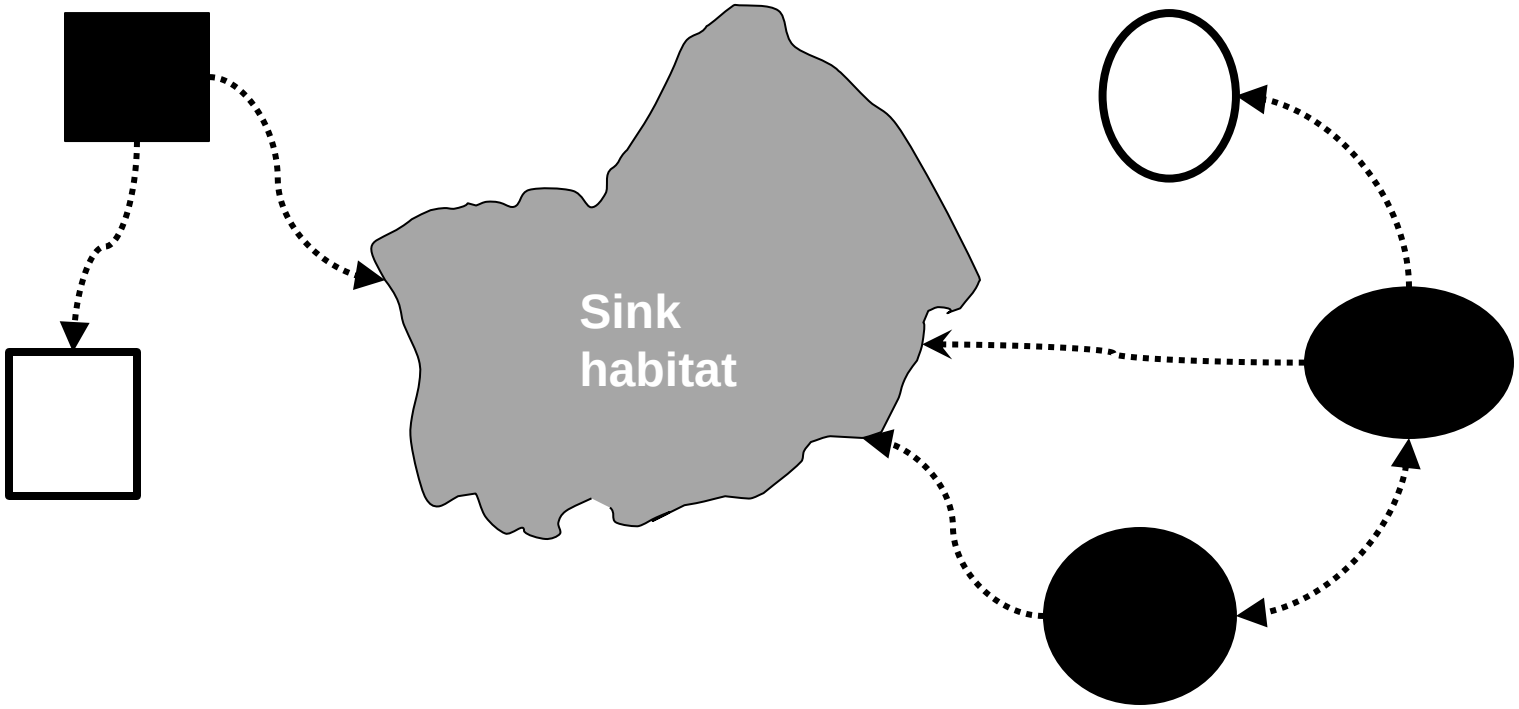
Taxa of concern

1. Count (presence)
2. Habitat / ecosystem

SPATIAL ECOLOGY



- **Source-sink dynamics**
- Matrix and dispersal risk
- Fragmentation & Minimum patch size



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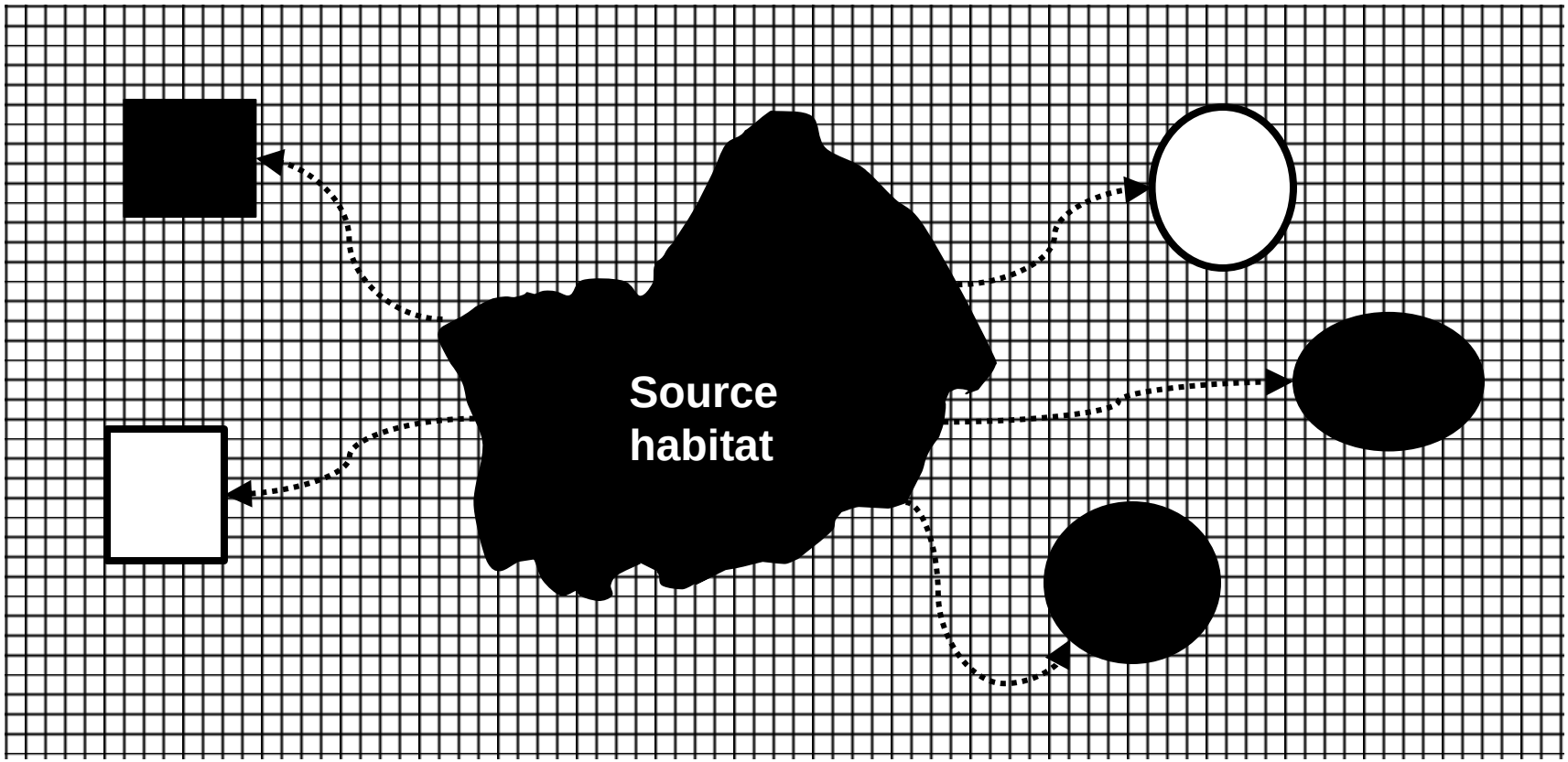
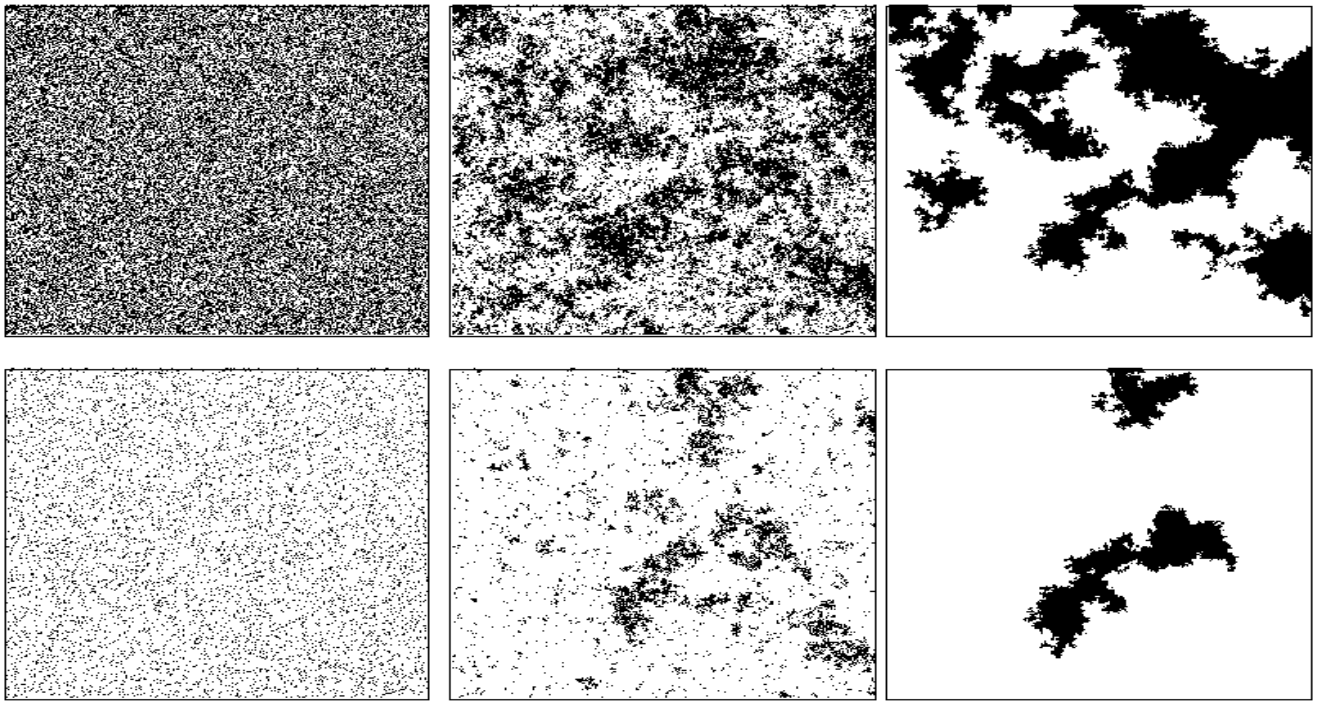


- Source-sink dynamics
- **Matrix and dispersal risk**
- Fragmentation & Minimum patch size

Matrix

Minimum Patch Size



Increasing fragmentation
Decreasing patch size

Source landscapes generated for each of six scenarios. White areas are unsuitable for all species. Landscapes have 50% (top row) or 90% (bottom row) suitable habitat. Spatial autocorrelation increases from left to right (Jager et al. 2000).

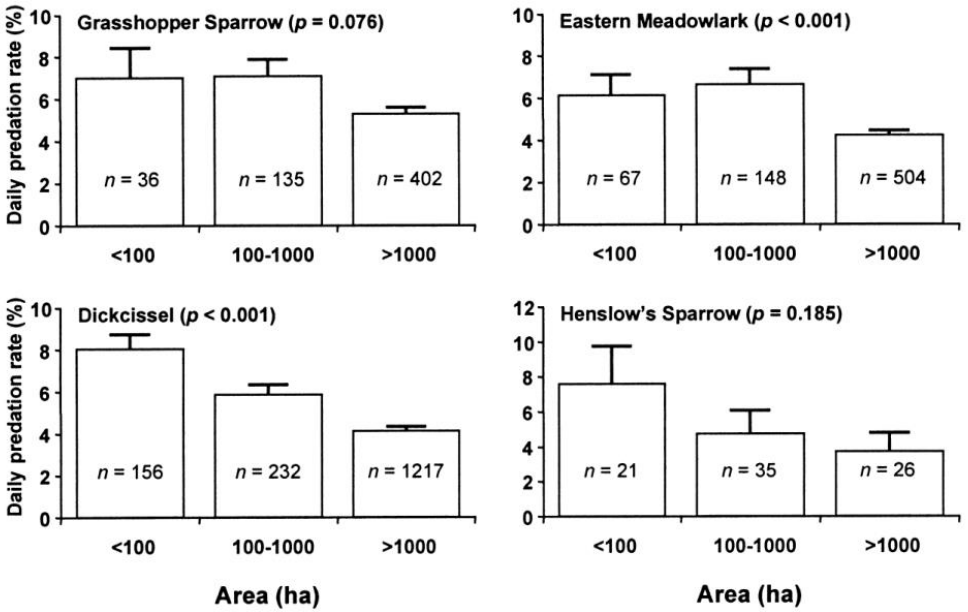
Habitat Size & Shape Matter

Interior vs. Edge Species

Dickcissel nest, McCarthy & Wolfenbarger, UN@Omaha

Cowbird – nest parasite

Habitat Size & Shape Matter



Daily predation rates for grassland birds in fragments of various sizes. Bars represent SE. The p *values from the comparison of nest-predation rates among size classes are also shown for each species. Sample sizes of nests are within bars. Herkert et al. (2003)*

Driving Patterns & Field Shape

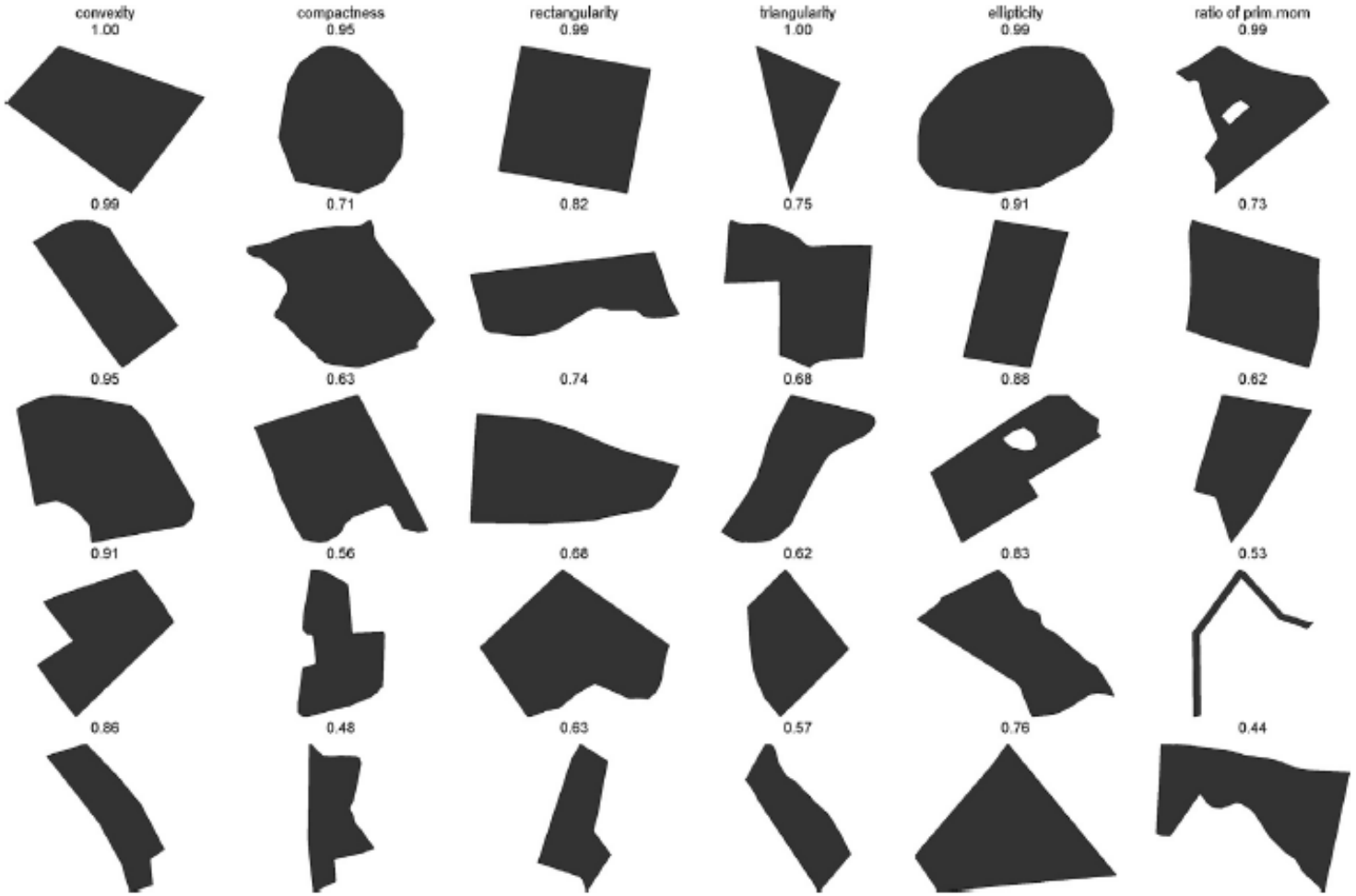
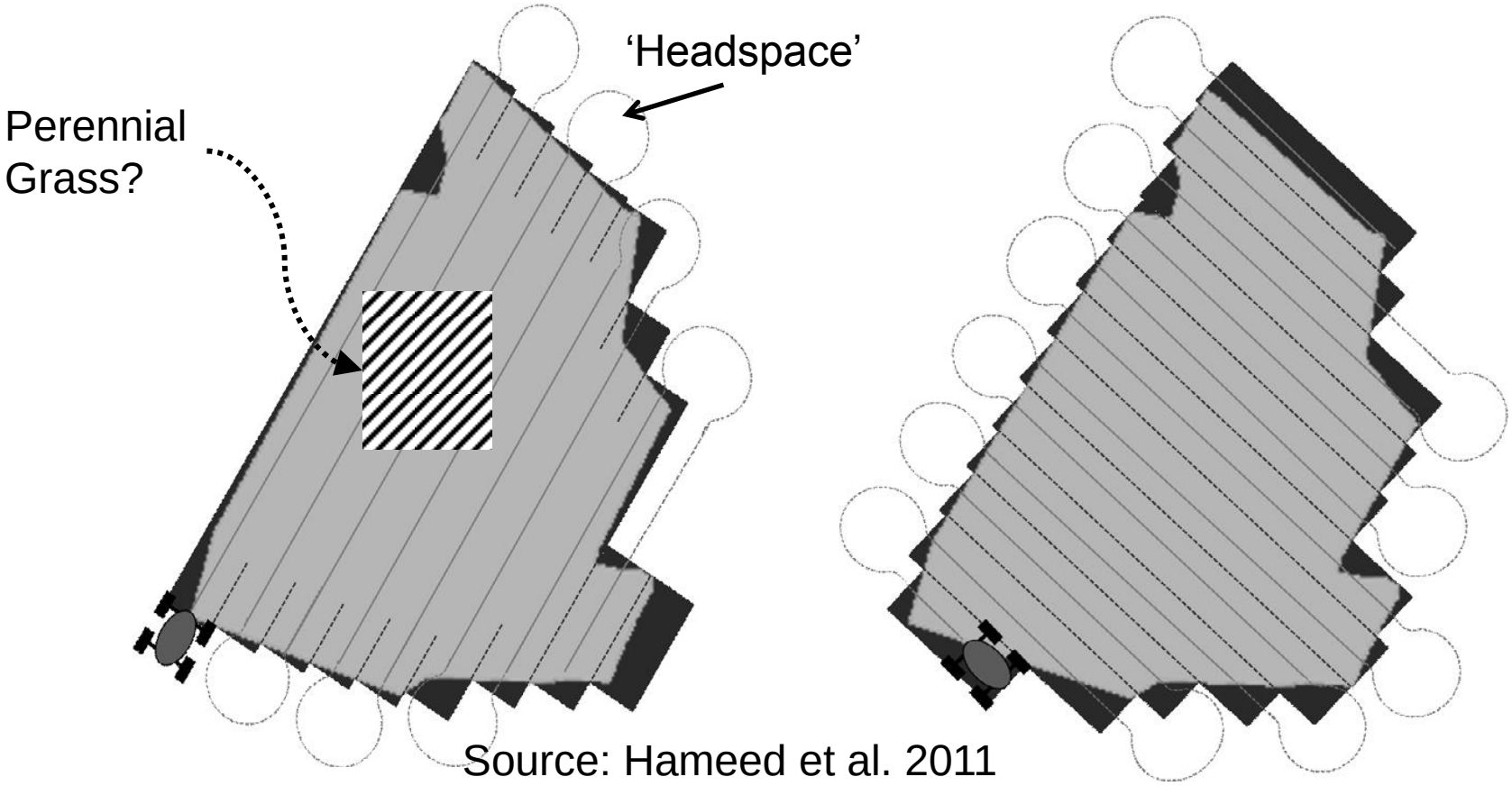


Fig. 5. Selected field plots and their index value. From top down the ranks are 100%, 85%, 70%, 55% and 40% of the shape index.

Source:Oksanen 2013

Shape Matters (Especially in Small Fields)

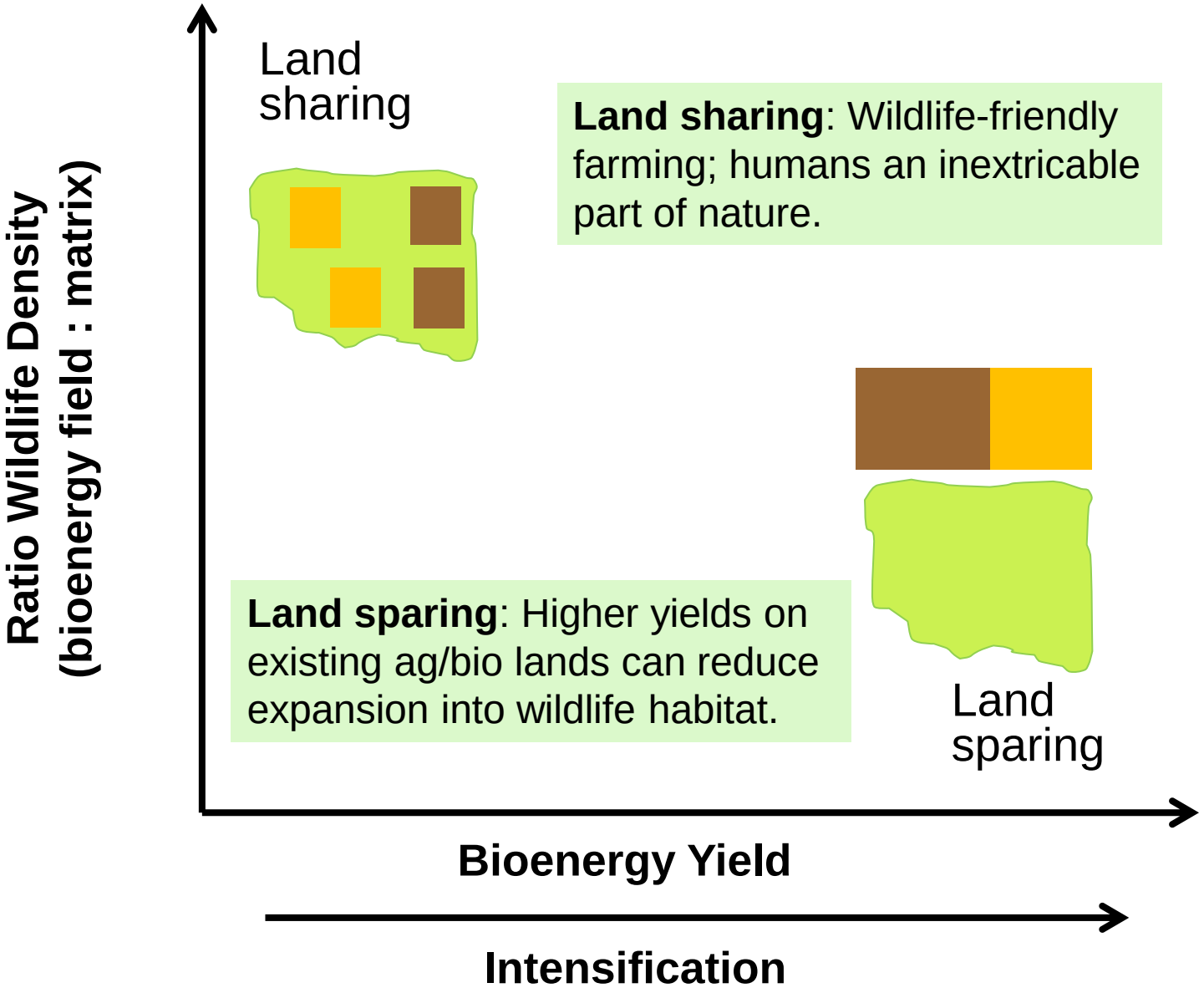
- Time spent on farming operations depends on # turns
- Overlap leads to excess application of fertilizer & pesticides



Source: Hameed et al. 2011

STRATEGIES FOR LANDSCAPE DESIGN

Sharing or Sparing?

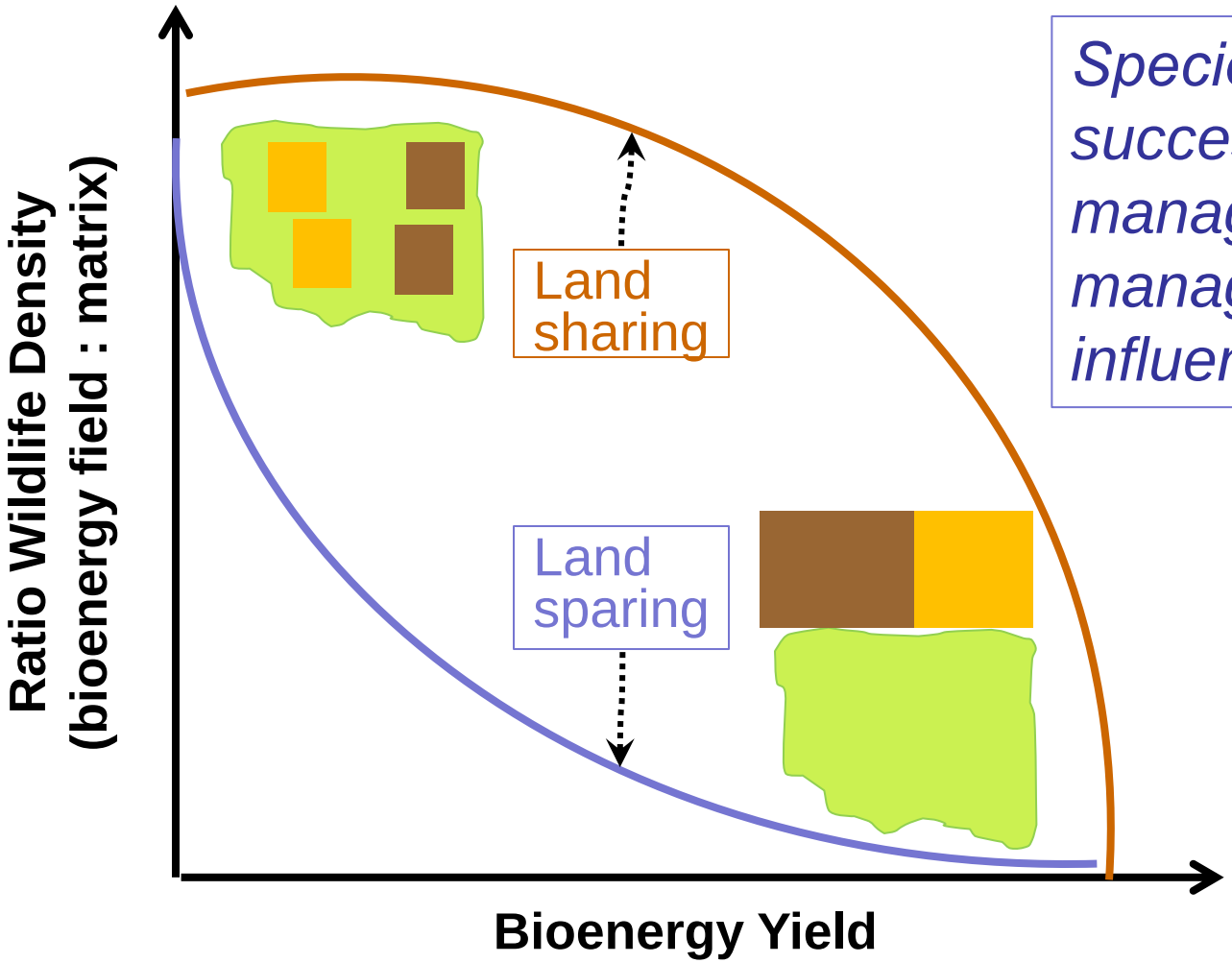


Land sharing: Wildlife-friendly farming; humans an inextricable part of nature.

Land sparing: Higher yields on existing ag/bio lands can reduce expansion into wildlife habitat.

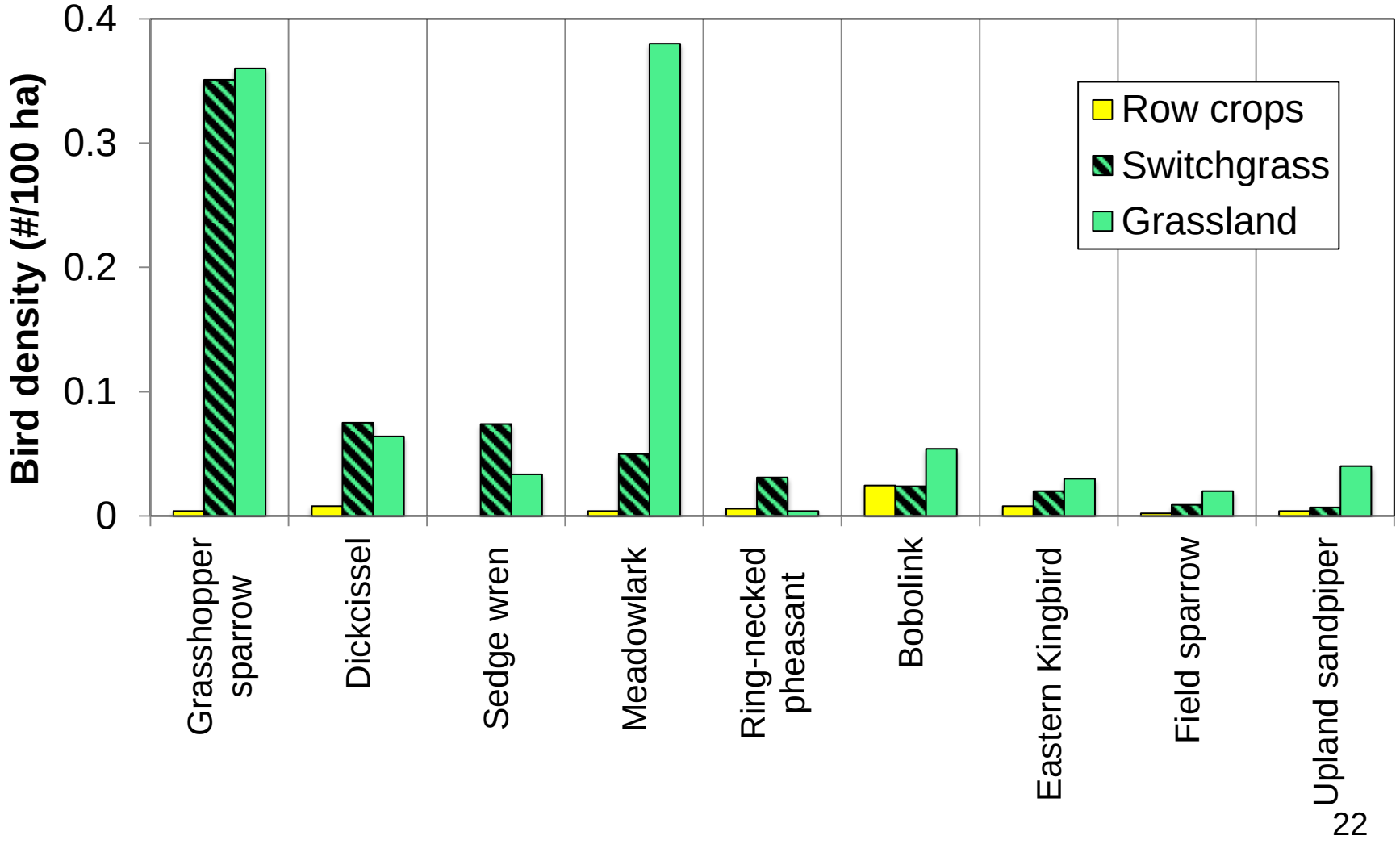
Land sparing	Land sharing
Intensively managed feedstocks offset by conservation of other lands.	Designed bioenergy landscapes with both residue or harvest for bioenergy managed to support wildlife.
Genetic yield improvement promising: • palm oil (southeast asia) • soybean, rapeseed, sunflower • sugar cane	Less potential for yield increases • Other bioenergy crops
Incentives exist • Conservation Reserve Program	Incentives are lacking • riparian buffers, perennial • wetlands or farm ponds • woodland edges, pollinators
Concerns: • GMO's • Increased fertilizer, pesticide, water use => lower environ. sustainability.	Concerns: • Creation of ecological traps • Logistic challenges of working around wildlife-friendly elements

Sharing or Sparing?

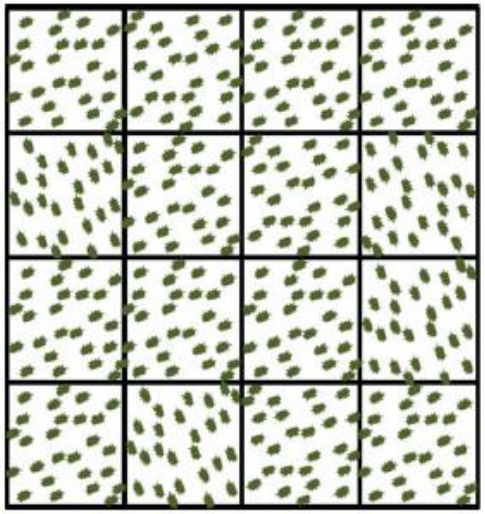


Species' relative success in managed and non-managed habitat influences choice

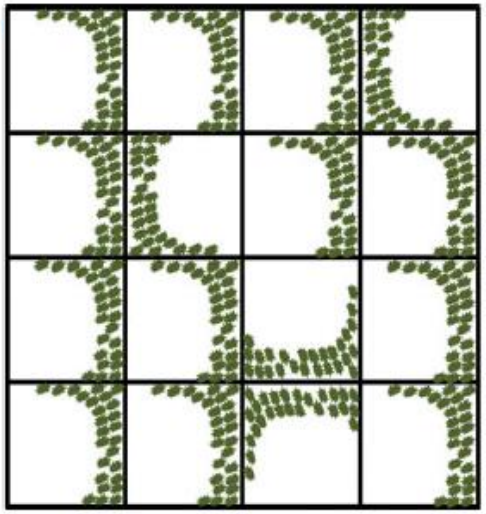
Habitat Preferences



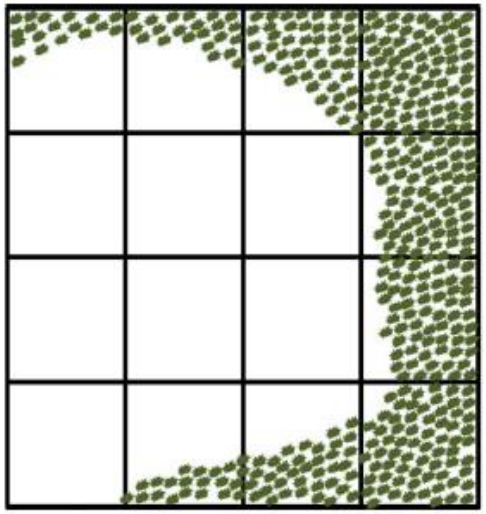
Sharing or Sparing?



land sharing



land sparing within each farm



land sparing across multiple farms

TIME SHARE

Potential Ecological Traps

- Habitat dangerous & attractive to wildlife
- Habitat size < minimum patch size
- Habitat embedded in dangerous matrix

Timing is Everything

- Natural disturbance regime (fire) in tallgrass prairie created spatial heterogeneity ➔ high bird diversity
- Can bioenergy harvest mimic natural disturbance patterns?

Practice	Birds	Amphibians	Mammals
No-till, residue not removed	Attractive to nesting birds ==> ecological trap?	Improved water quality & aquatic habitat	Attractive to nesting animals ==> ecological trap?
Removal of stover or woody debris	Less attractive to nesting birds	Increases risk of desiccation	Less attractive to small mammals
Tile drainage		Degraded water quality & aquatic habitat	
Rotations, cover crops	Cover for birds	Lower risk of dessication	Cover for small mammals

Harvest Management

- Goal: Heterogeneity in vegetation structure
- Means:
  - Harvesting schedule
  - Size of harvested patches
  - Connectivity constraints
- Species characteristics
  - Renesting species?

Ring-necked pheasant

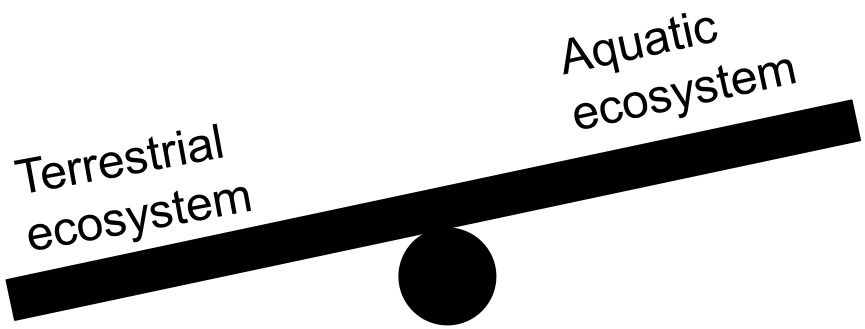
Dickcissel

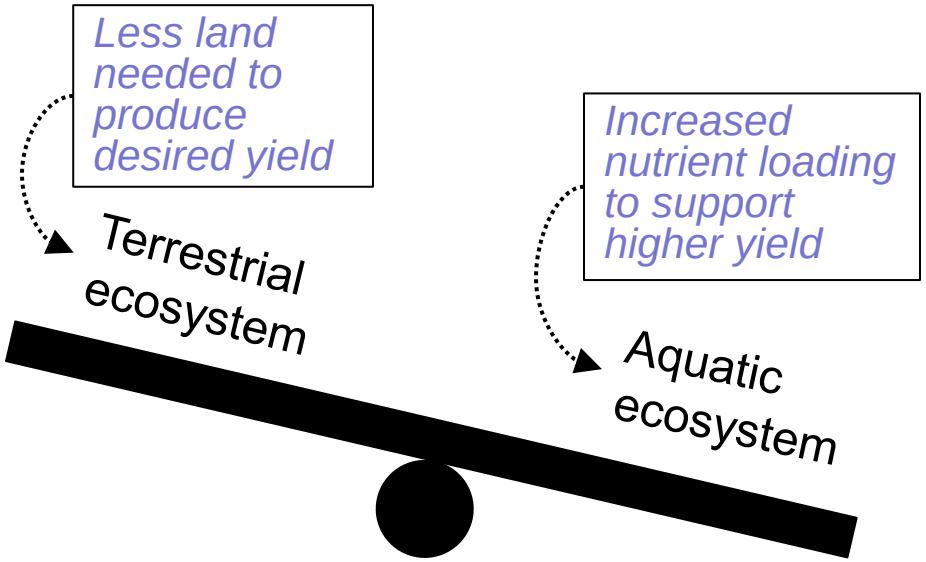
Landscape Design Principles

- Most species of concern in grassland biomes are interior species.
  - Set-aside large patches (land-sparing strategy)
  - High area to perimeter ratio (not linear elements)
  - Habitat quality can be improved by:
    - Planting perennial instead of annual crops
    - Managing to produce a diversity of plant heights
    - Timing operations to avoid creating ecological traps
- Principles for other ecosystems?

TRADE-OFFS & COMPLEMENTARITIES

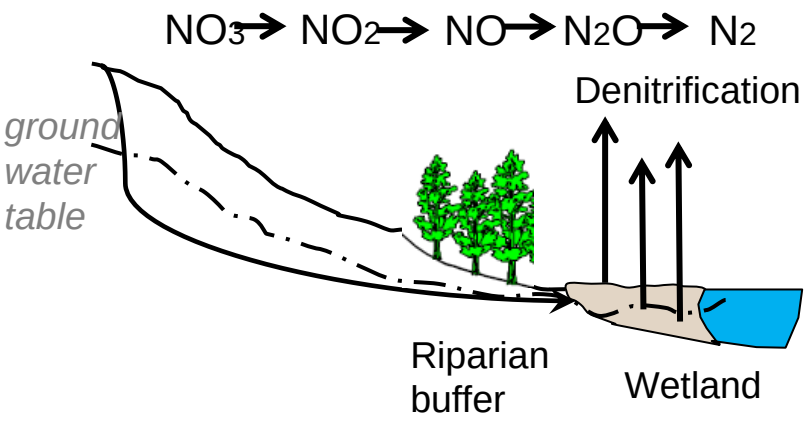
Aquatic vs. Terrestrial

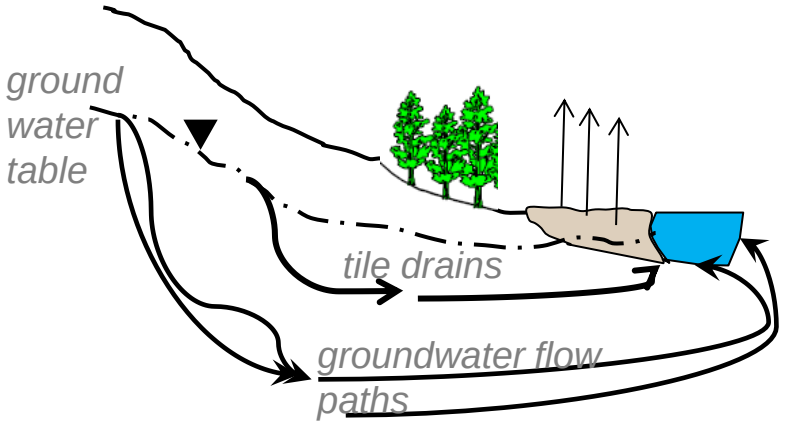




Water Quality & Biodiversity

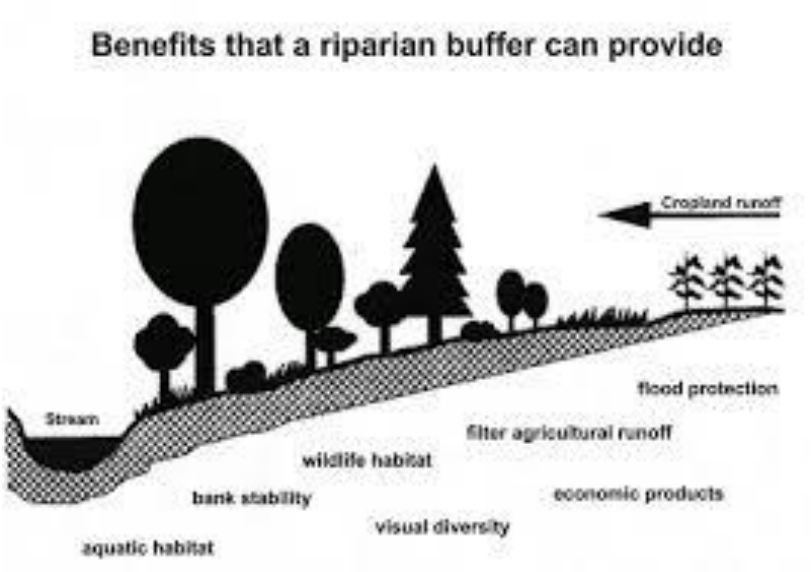
- In general, we expect spatial concordance between WQ and biodiversity outcomes for aquatic species
- Counter-example:
  - Water-table control of tile drained fields and wetlands both promote denitrification.
  - Only wetlands benefit wildlife.

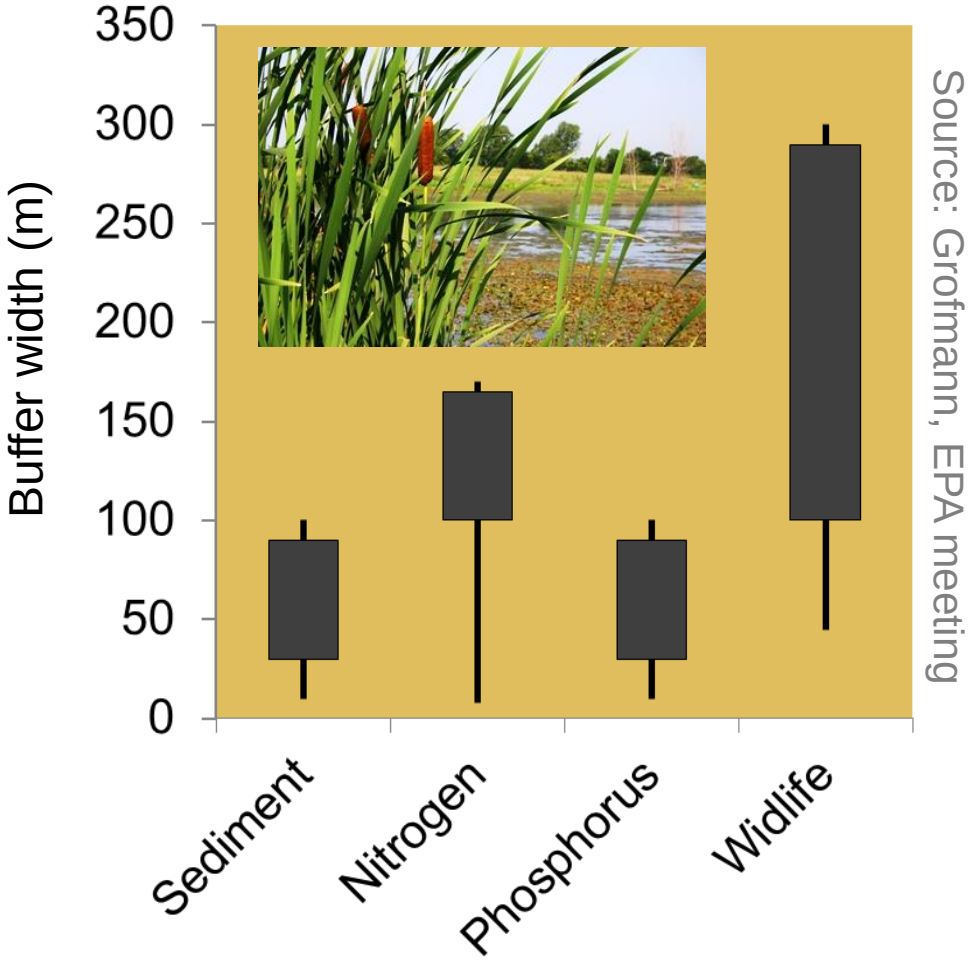




Riparian Buffers

- Most wildlife require wider riparian buffers than is required to protect water quality.
- Livestock management is important





Example 1.

Walnut Creek, IA

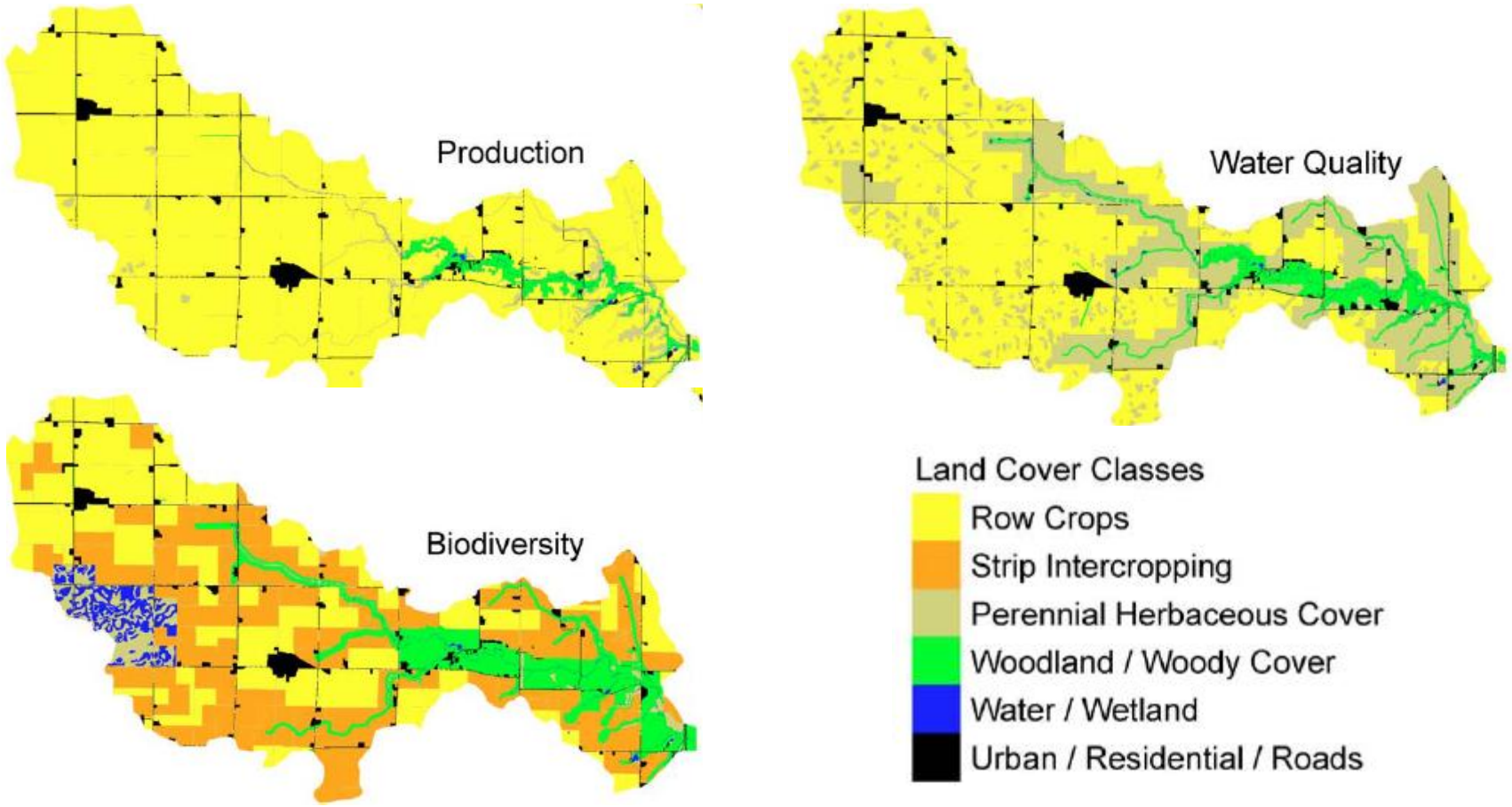


Figure 2. Present landscape (top right) and designed alternative future scenarios for Walnut Creek watershed. Note the increase in land area in row crops at the expense of perennial cover for the Production scenario; the increased amount of land in perennial cover (pasture and forage crops) as well as wider riparian buffers in the Water Quality scenario; and the strip intercropping, wide riparian buffers and extensive prairie, forest and wetland restorations in the Biodiversity scenario.

Santlemann et al. 2004

Example 2.

Buck Creek, IA

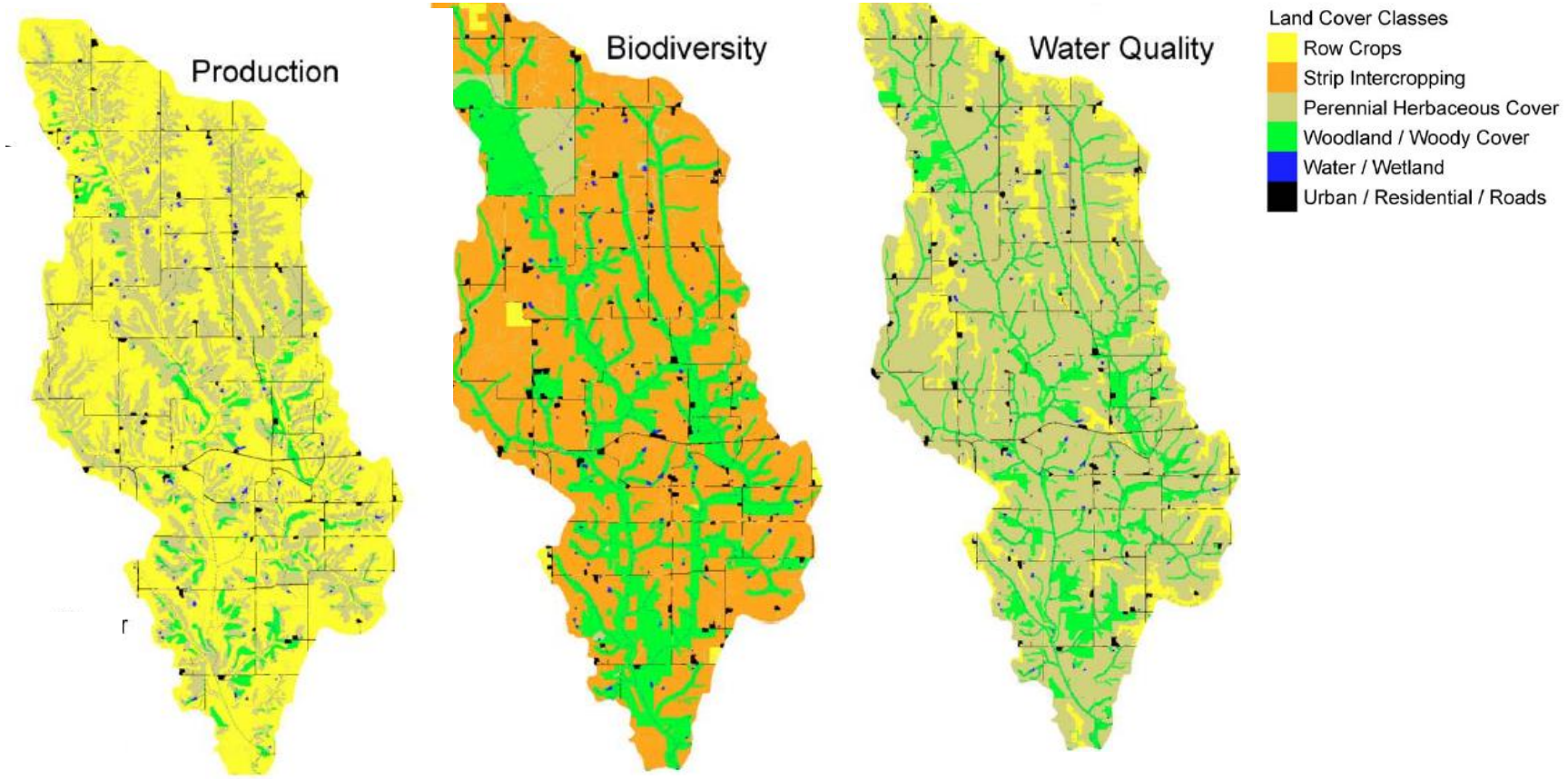
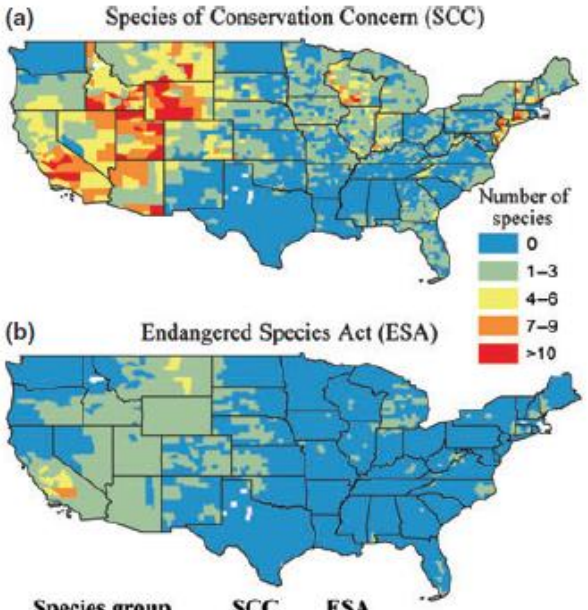


Figure 3. Present landscape (top left) and designed alternative future scenarios for Buck Creek watershed. Note scenario features similar to those for Walnut Creek but applied to a different landscape (e.g., the physiography of the watersheds led to the design of forest, savanna, and upland prairie reserves in Buck Creek rather than the riparian forest and prairie/ prairie pothole wetlands which comprised the reserves in Walnut Creek watershed).

Santlemann et al. 2004

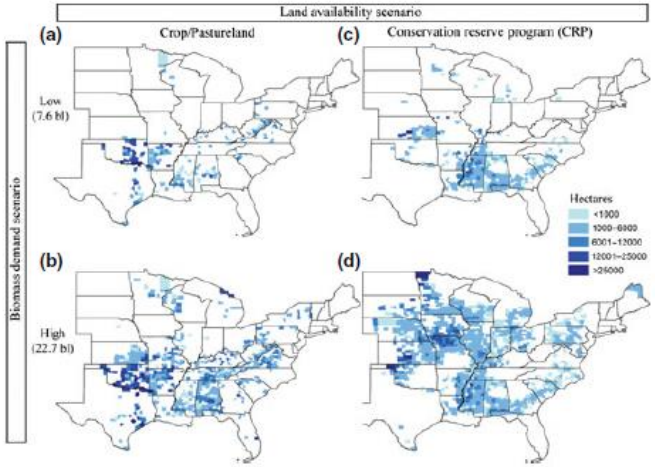
BILLION TON 2016

Billion Tons of Wildlife?



Species group	SCC	ESA
Birds	128	12
Mammals	93	17
Reptiles	71	5
Amphibians	30	3
Total	**322**	**37**

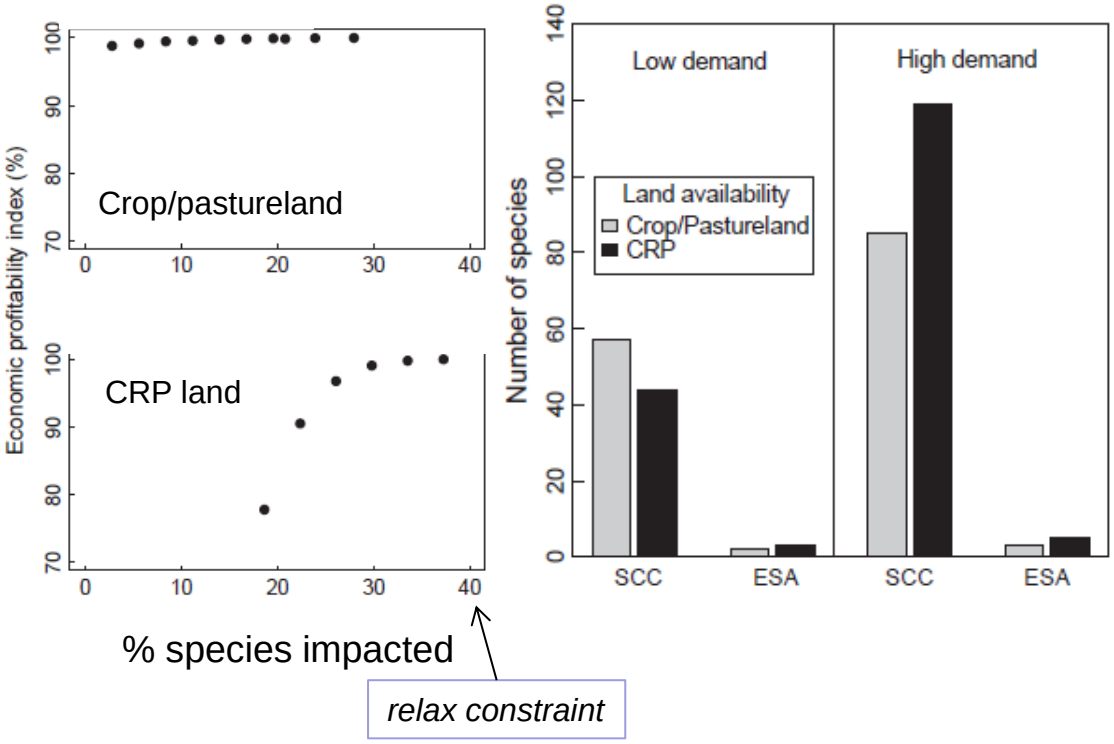
Consider biodiversity hotspots when siting bioenergy crops for BT-2016



Source of maps: Evans et al. 2013

Biodiversity Analysis

- Exclusion assumes all SCC fare worse in future bioenergy fields than replaced LULC.
- Many species fare better in bioenergy than agricultural croplands.
- Maintaining species' ranges is also an important conservation goal.



- National scale
- Species of conservation concern, SCC: *birds, amphibians, lizards, mammals*
- Habitat uses: *cropland or pastureland*

Evans et al. 2013

Questions?

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http://www.esd.ornl.gov/~zij/