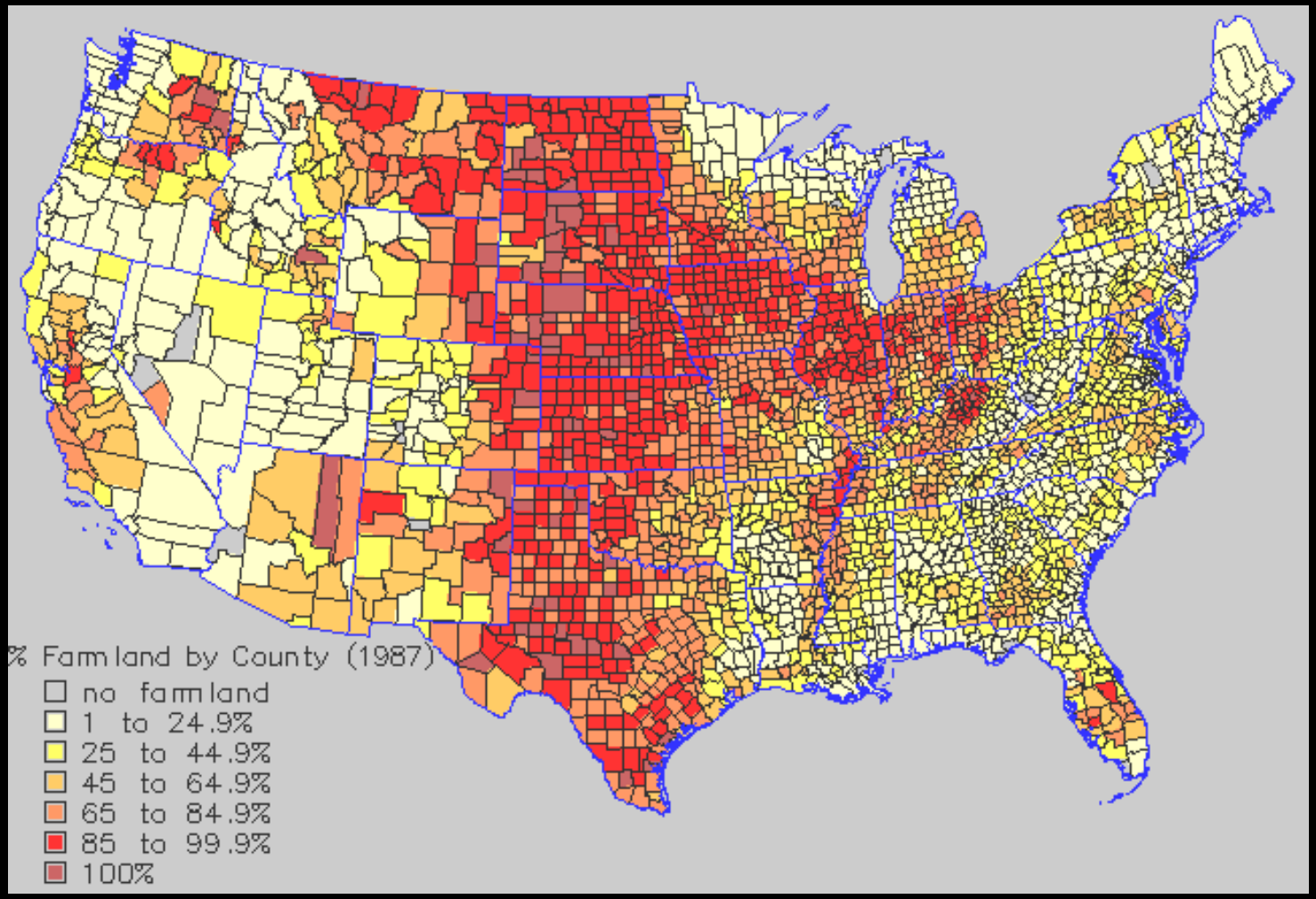
Agricultural systems and ecosystem services: trade-offs or synergies?

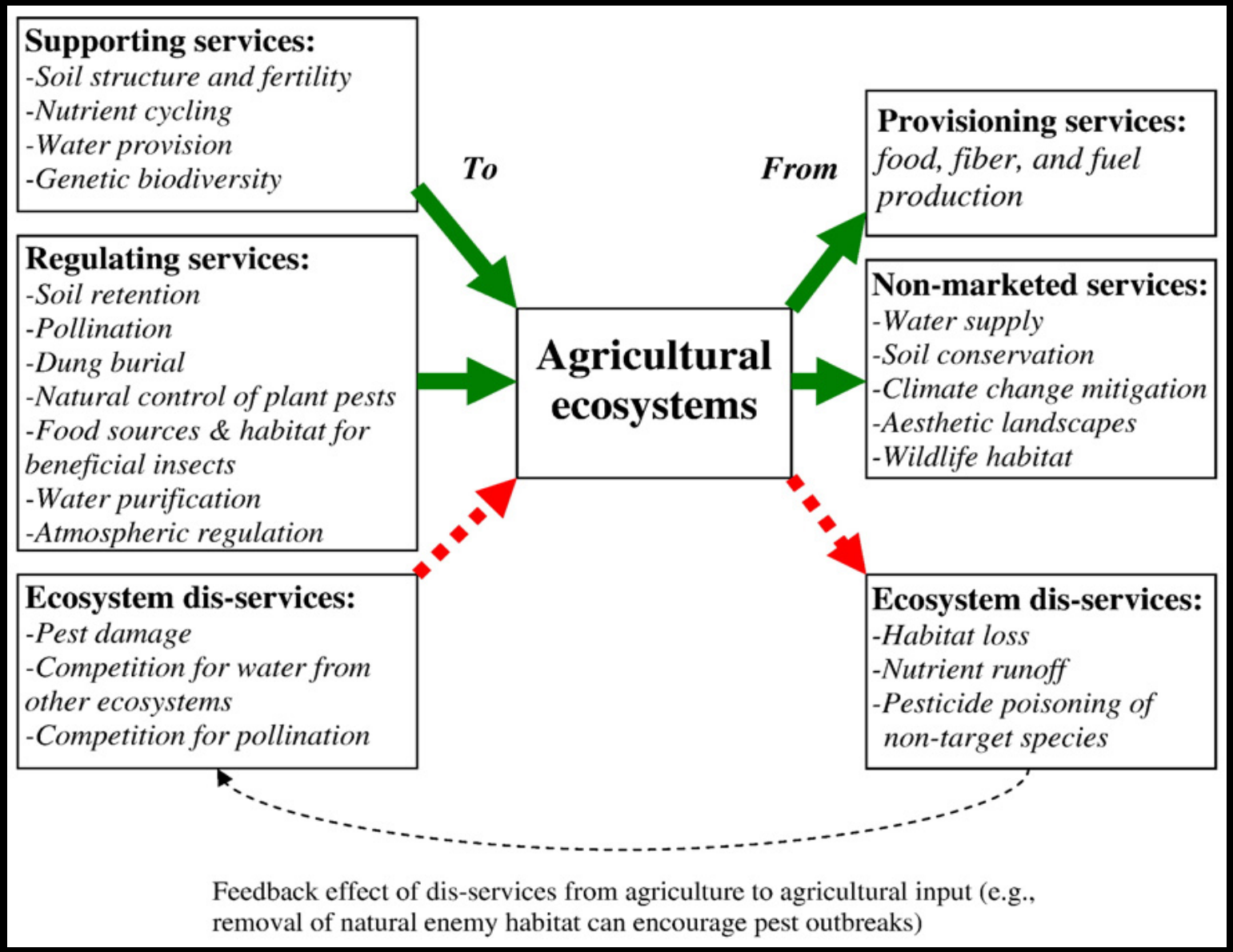
- Agricultural systems are managed by farmers and influenced by local, national, and international policies and markets
- Ecosystem services flow to and from agricultural systems
- Configuration of agricultural landscapes influences ecosystem services
- Ecosystem services affect food security in complex ways

Proportion of Land in Agriculture



Source: www.epa.gov/emap/gif/dataI/agro.gif

Ecosystem Services and Agriculture



(Zhang et al. 2007)

Diversity of Agricultural Systems

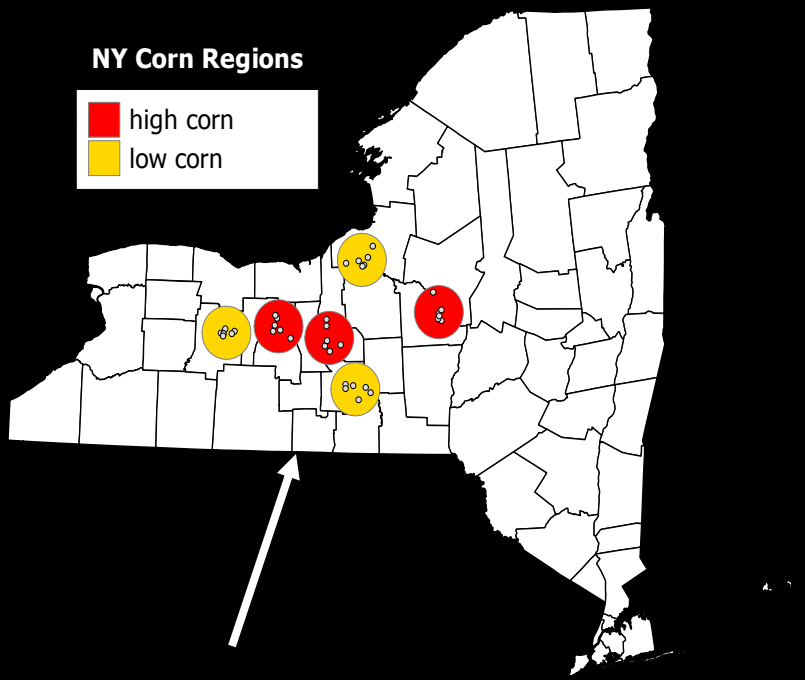
Threats to Ecosystem Services

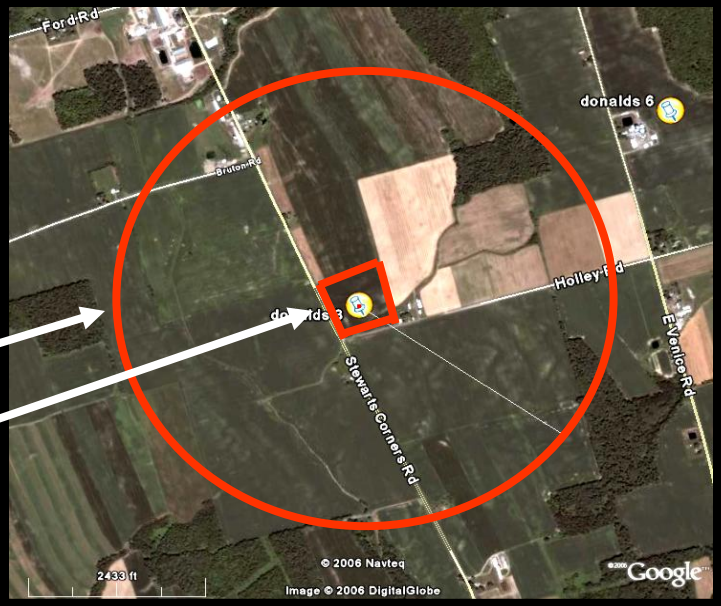
- Provisioning services influenced by:
  - Loss of biodiversity (pollinators, enemies)
  - Invasive species (pests, pathogens, weeds)
  - Climate change
  - Global markets
- Other ecosystem services influenced by:
  - All of the above
  - Impacts of agricultural practices

Landscape Configuration and Ecosystem Services

- Agroecosystems sit in a landscape, a matrix of land uses
- Ecosystem services to and from agriculture are influenced by the surrounding landscape

Landscape Configuration and Pest Control in Maize



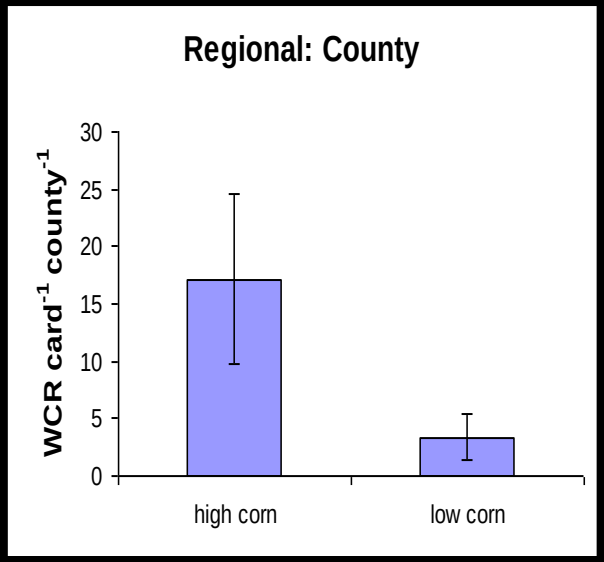


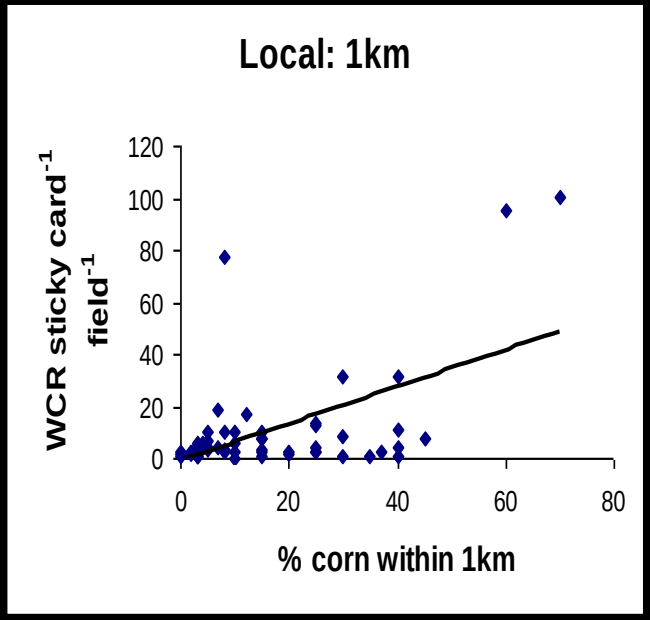
Regional scale: 20km radius

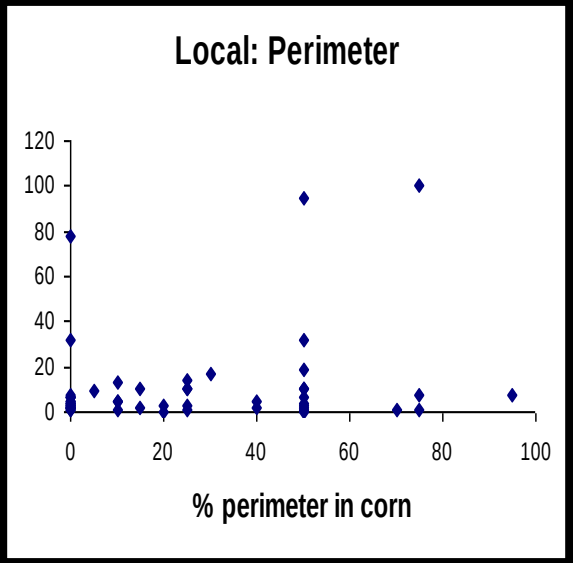
Local scale: 1 km radius

Neighborhood: field perimeter

Western corn rootworm *(Diabrotica virgifera)*







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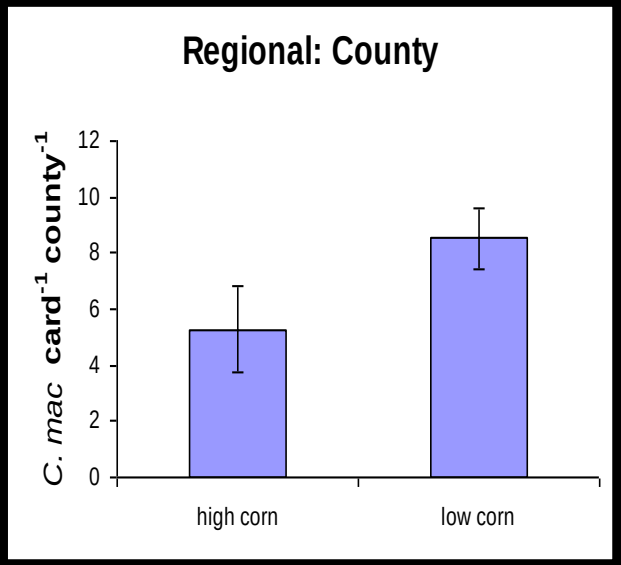
Predatory Beetle
Coleomegilla maculata



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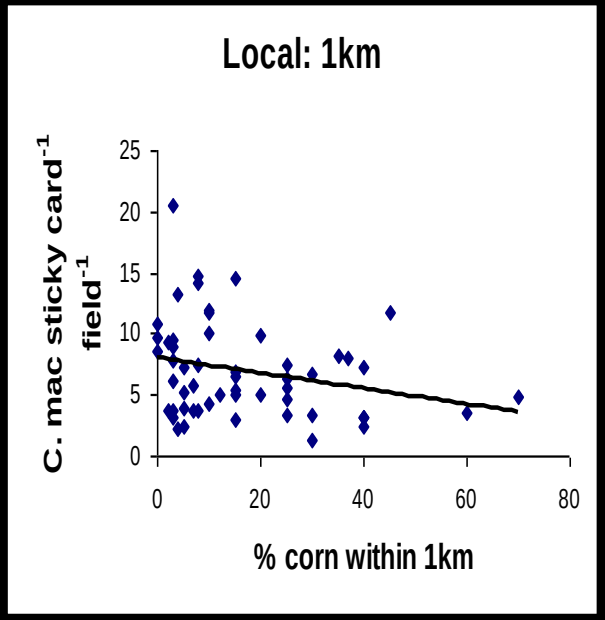

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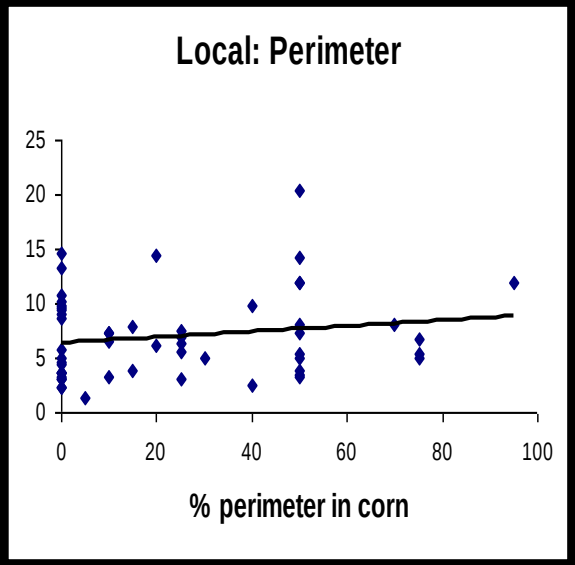

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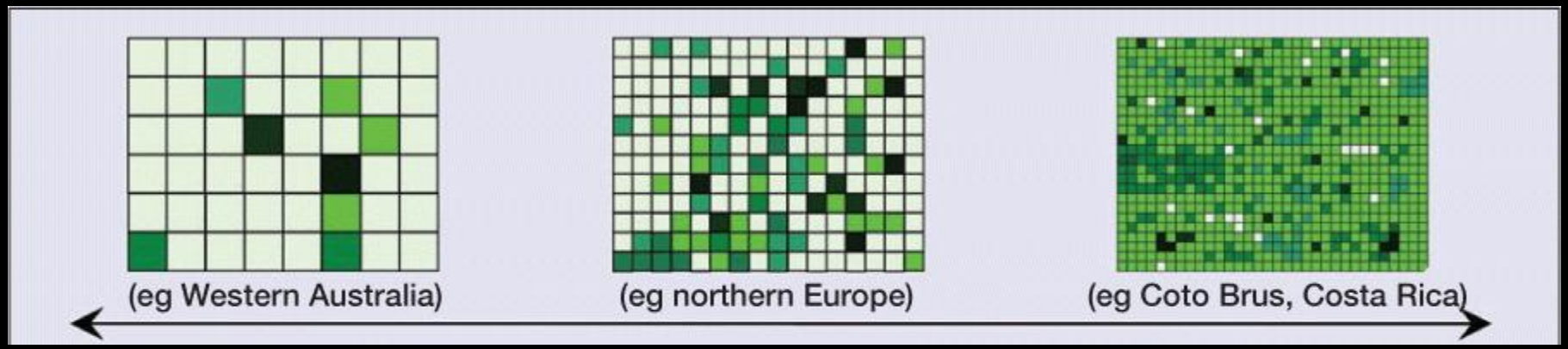
Landscape Configuration and Ecosystem Services

“Land sparing” agriculture:
coarse grain, abrupt change

“Wildlife-friendly” agriculture:
fine grain, spatial continuity



Tradeoff model

Synergy model

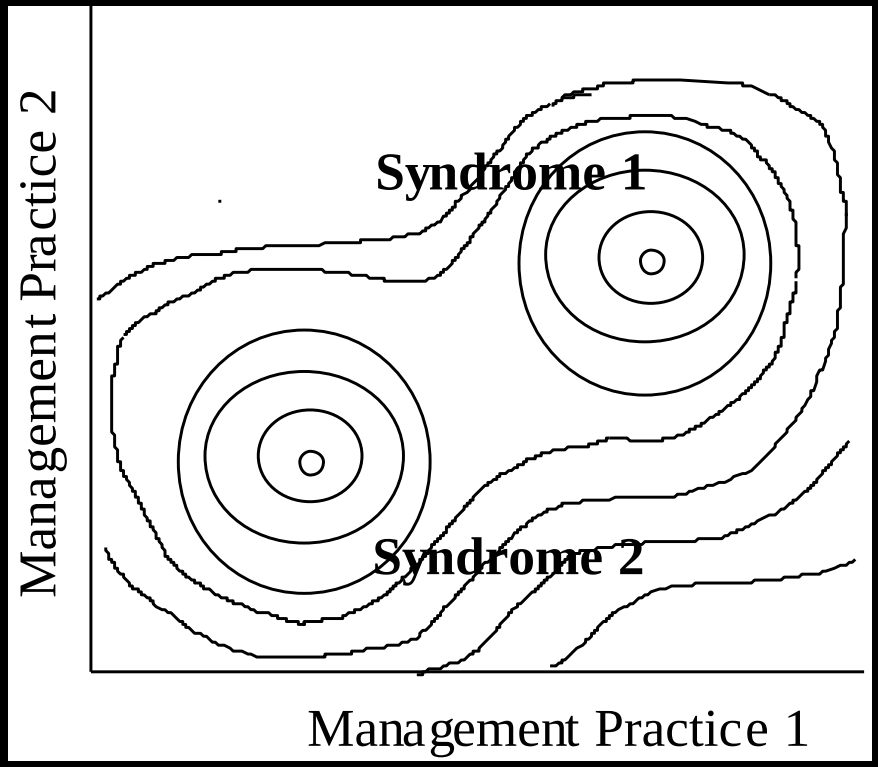
(Fischer et al. 2008)

Methods for Increasing Productivity

- Optimization of current practices
  - Crop improvement (breeding)
  - Integrated pest management
  - Integrated nutrient management
- Input substitution
  - Nitrogen fixing cover crops
  - Biological control or biopesticides
- System redesign
  - Planned and unplanned diversity
  - Syndromes of production

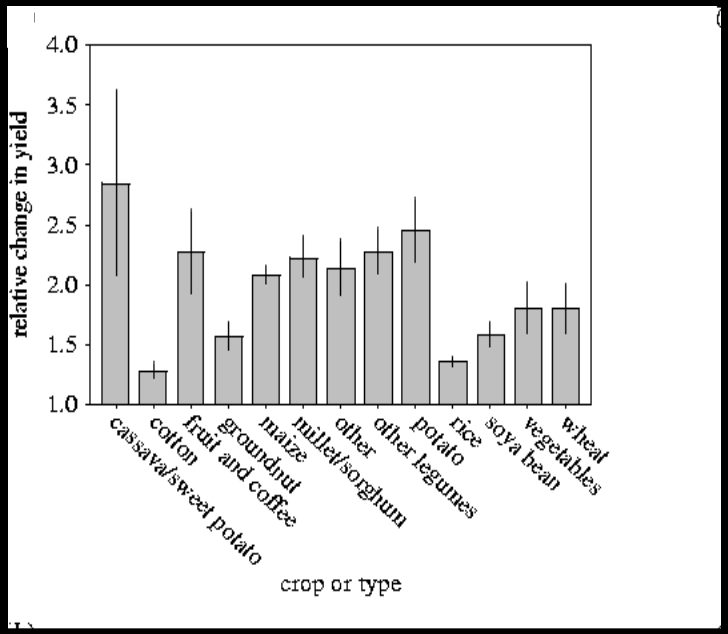
Syndromes of Production

- A set of management practices that are mutually adaptive and lead to high performance
- Practices might include:
  - crop and varietal selection
  - planting density
  - fertility source and quantity
  - management of insects, diseases and weeds
  - water management



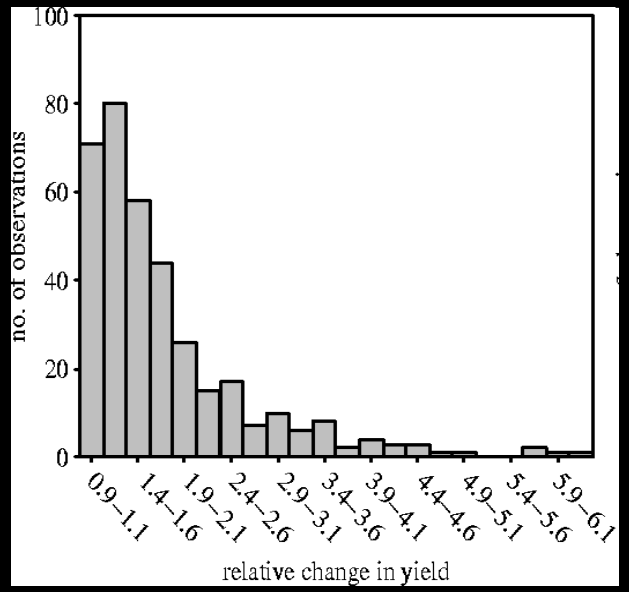
Andow & Hidaka 1989

Impacts of Development Projects



Projects based on:

- Integrated pest management
- Integrated nutrient management
- Conservation tillage
- Agroforestry
- Water harvesting
- Livestock integration



Change in crop yield with intervention, based on 360 yield comparisons in 198 projects in 57 countries (Pretty et al. 2006)

Private sector investment in agricultural research

	Commercial	Transition	Subsistence
Crop improvement	Medium	Low	Zero
Crop management	Low	Zero	Zero
Resource management	Zero	Zero	Zero

(Source: Pingali 2001)

Tradeoffs, Synergies and Food Security

Agricultural productivity

+

Access to food

+

Utilization of food

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Diversity of Agricultural Systems

- Low diversity
- Annual crops
- Frequent disturbance
- Low nutrient retention
- High subsidies

- Moderate to high diversity
- Annuals & perennials
- Infrequent disturbance
- High nutrient retention
- Low subsidies

Natural Ecosystems

Tropical rain forest

Temperate forest

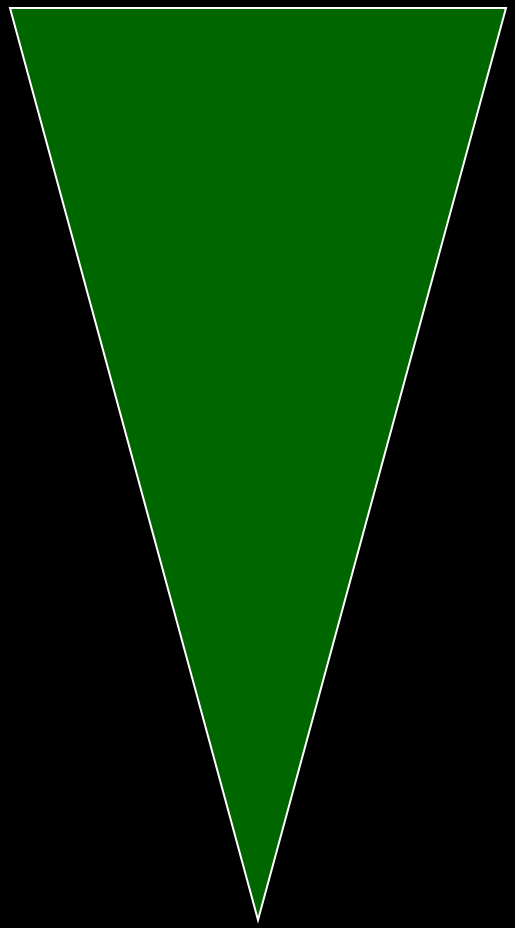
Natural grasslands

Boreal Forests

Spartina marshes

Geothermal pools

Maximum Diversity



Minimum Diversity

Agricultural Ecosystems

Shifting cultivation in humid forests

Home gardens

Traditional plantations

Polycultures

Genetic mixtures

Wheat varieties

Maize hybrids

(Adapted from Francis 1981)