Cropping system diversification for yield, profit and environmental health

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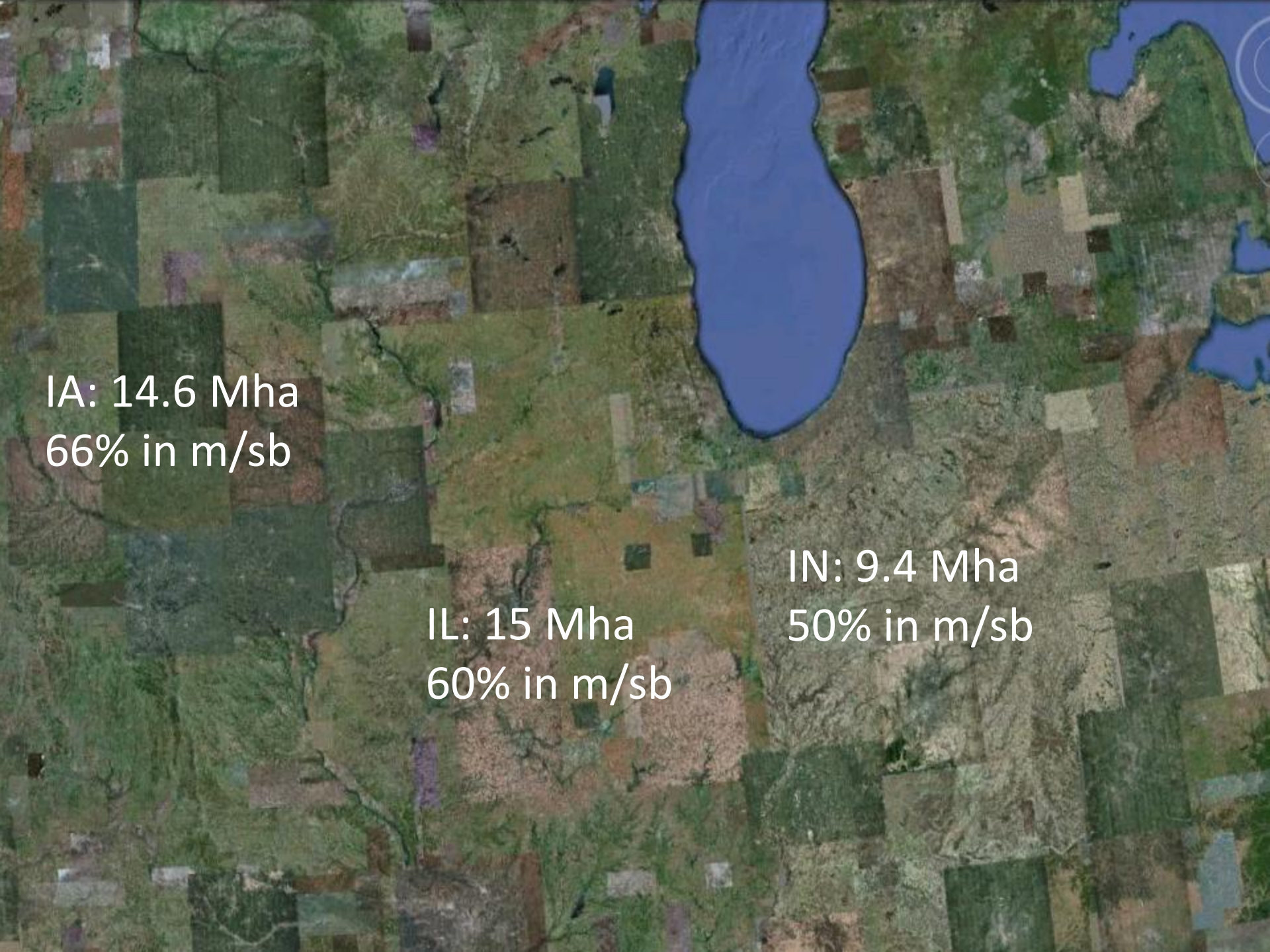
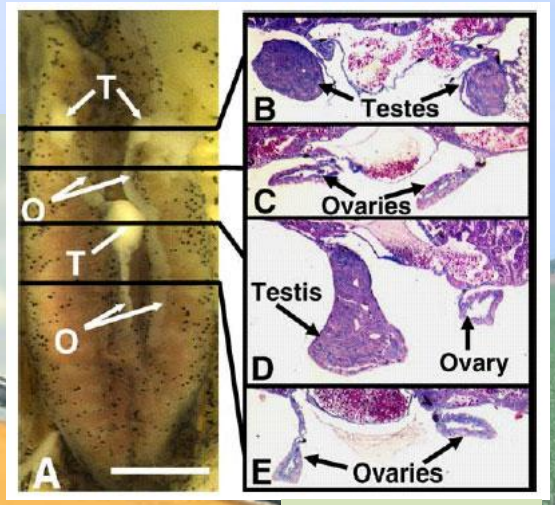
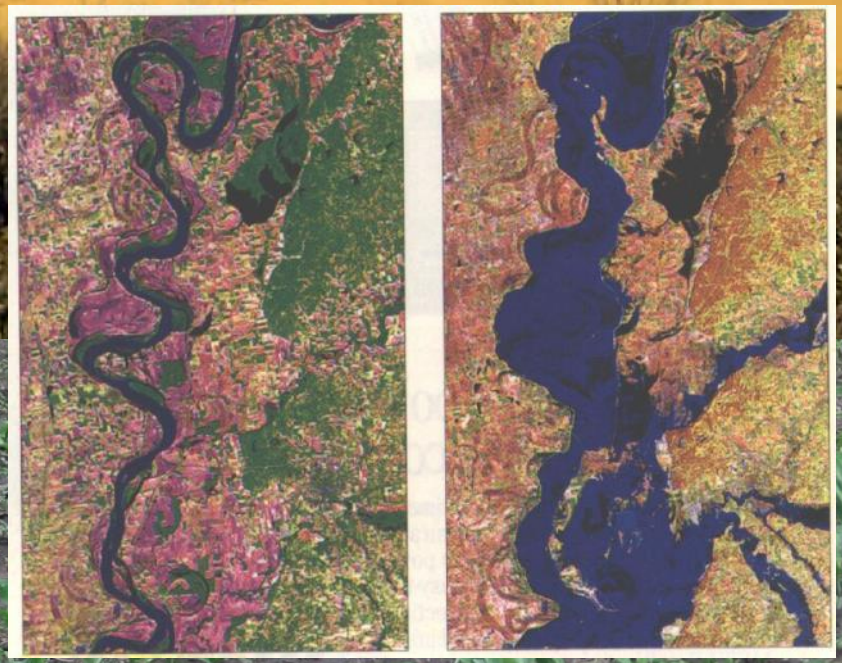

IA: 14.6 Mha
66% in m/sb
IL: 15 Mha
60% in m/sb
IN: 9.4 Mha
50% in m/sb

NRCS

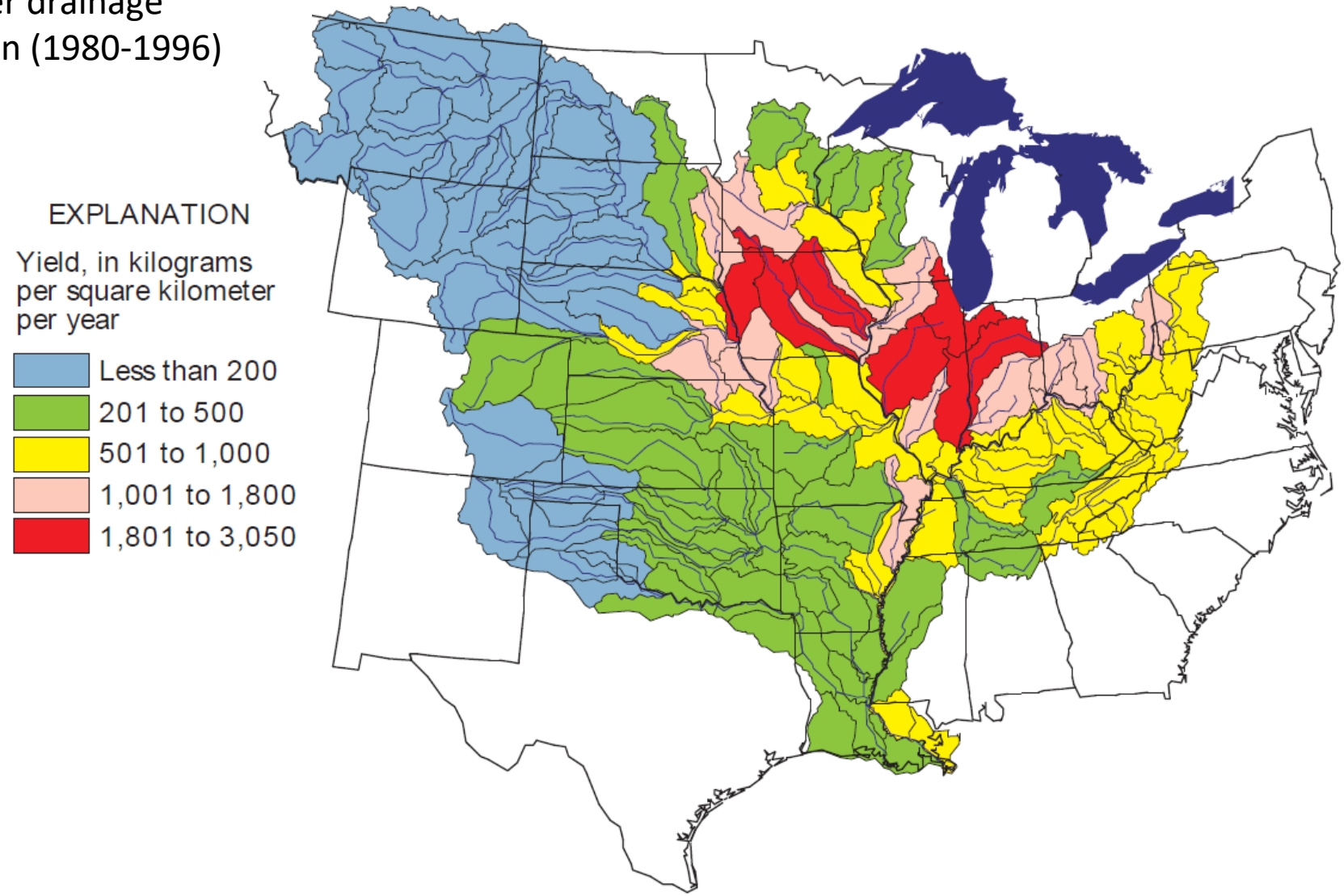


Hayes et al, 2002



USGS

Annual efflux of N into streams in Mississippi River drainage basin (1980-1996)



Goolsby et al. 1999

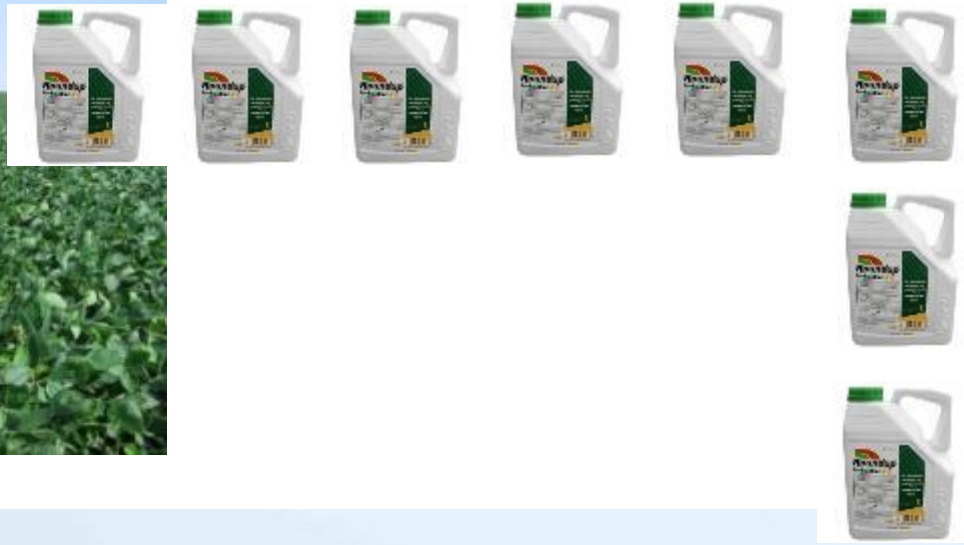


Photo: A. Hager

Farm-scale crop diversity has declined over time

w-t-b/o&cl&rg-ley

m/b/sq

w-ley-ley

m-sg/a-a

m-sb-o/a-a

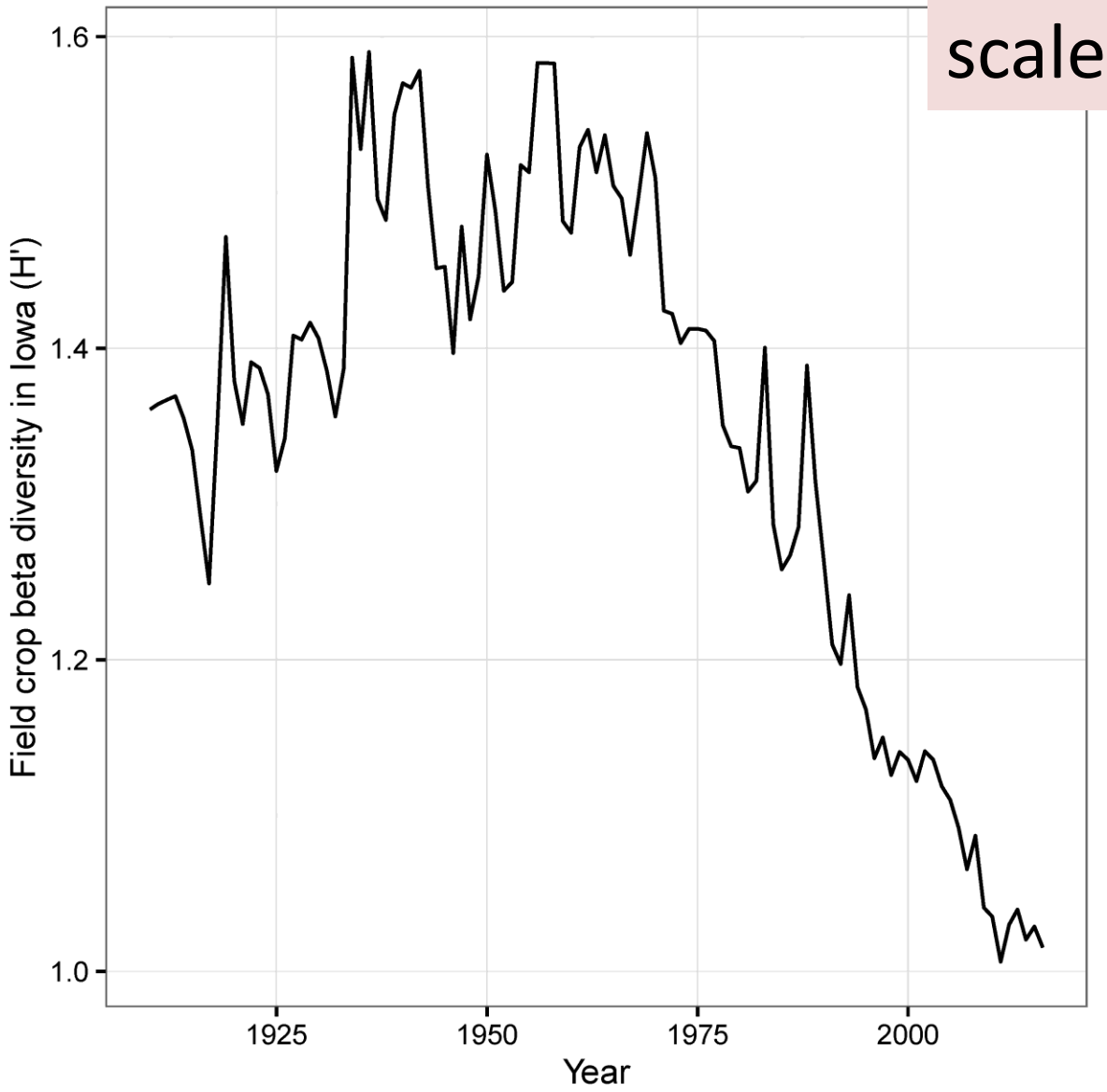
m-sb-w/rc

m-sb

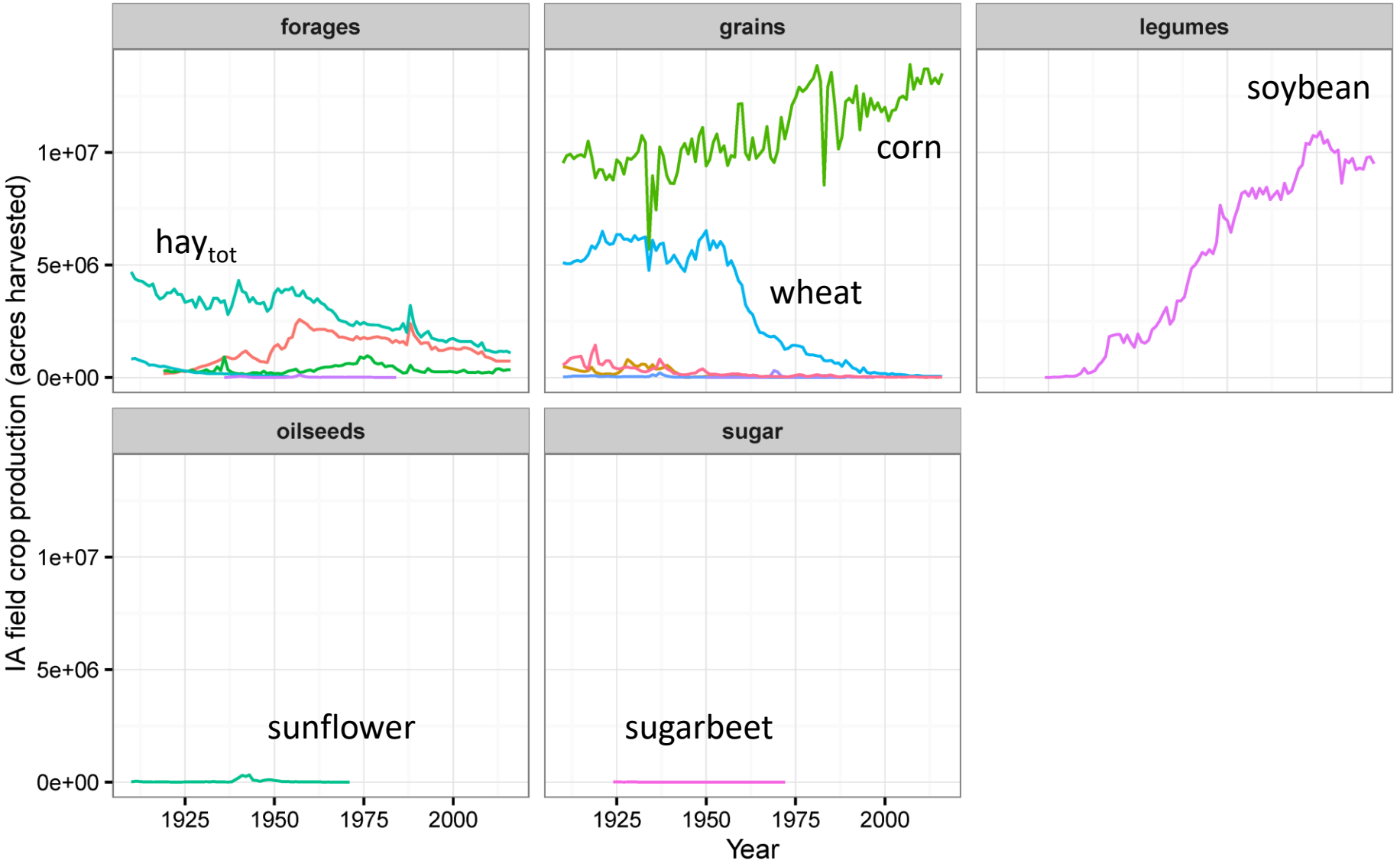
m

Bidwell and Falconer, 1925

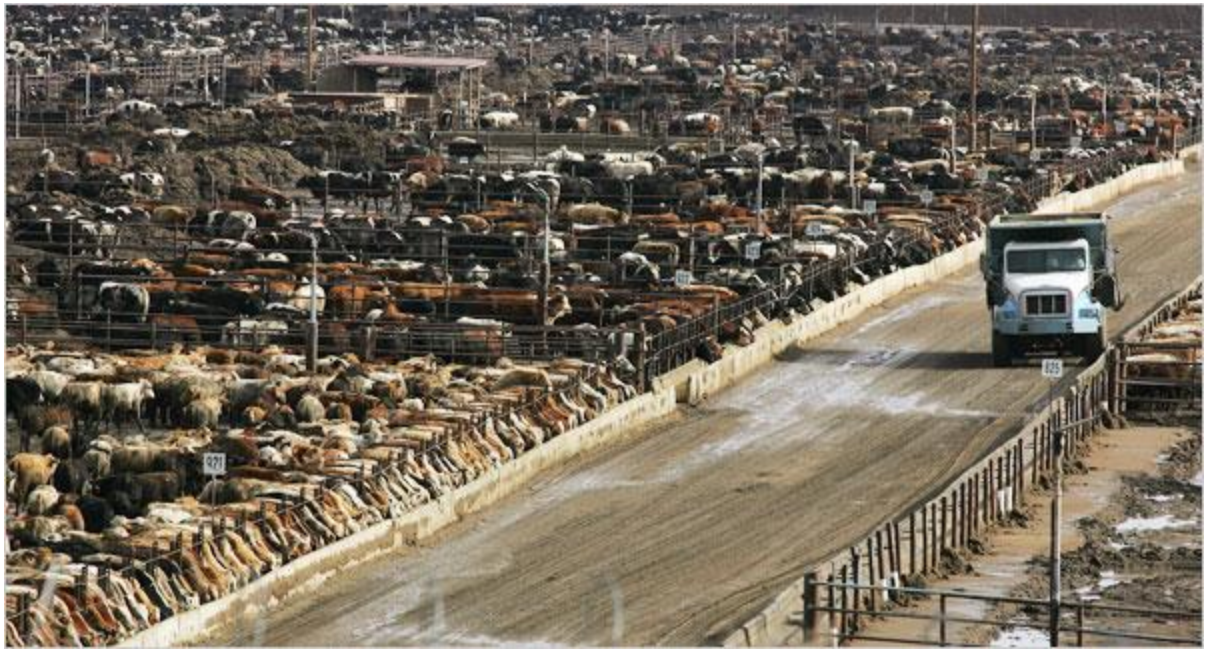
So has landscape scale crop diversity

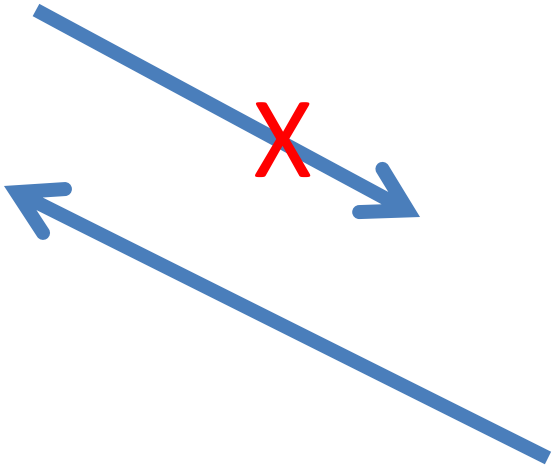


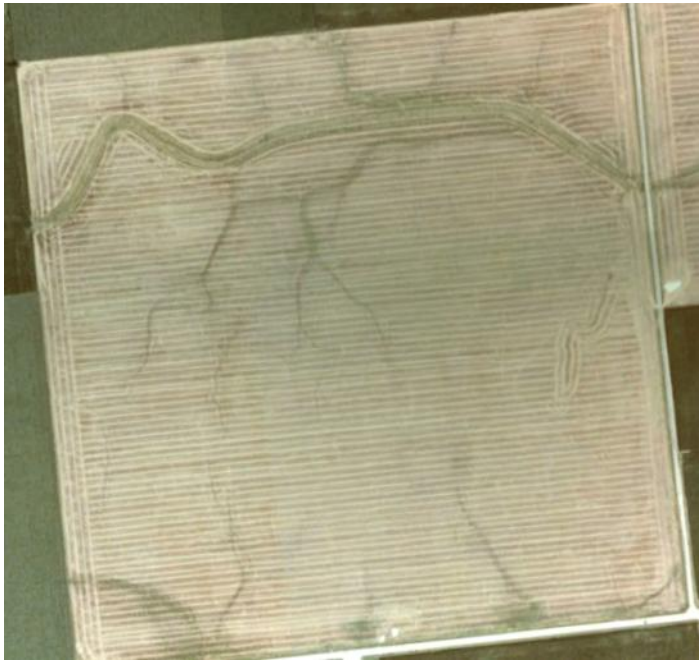
Data source: USDA-NASS, 2016



Data source: USDA-NASS, 2016




X



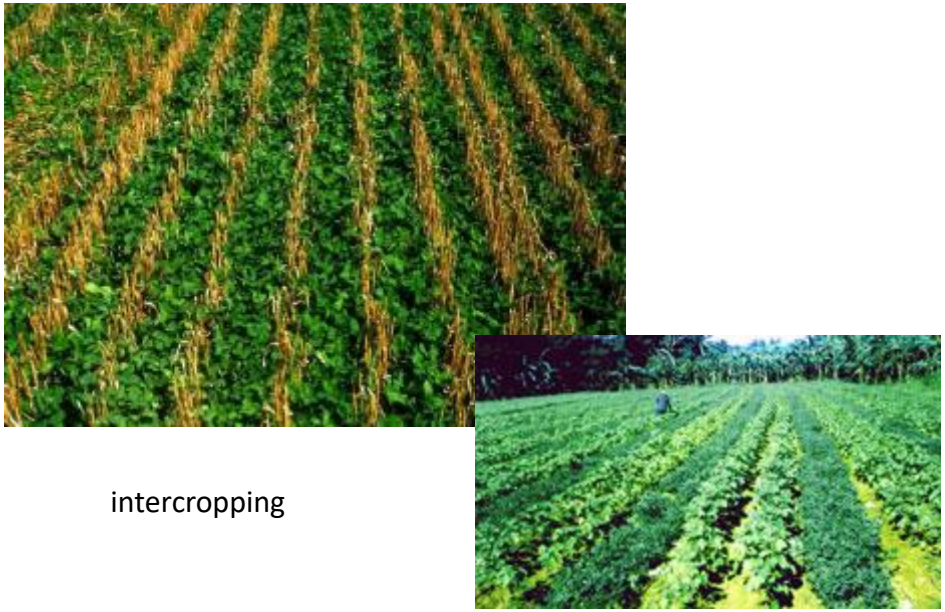
Some types of diversity in agroecosystems

- Crop species diversity
  - temporal
  - spatial
- Genetic diversity
  - individual: breeding, conservation
  - population: multi-lines
- Management diversity
- Non-crop species diversity
- Landscape-level diversity

Cropping system diversification: both spp. and mgt diversity

crop rotation, integrated crop-livestock production

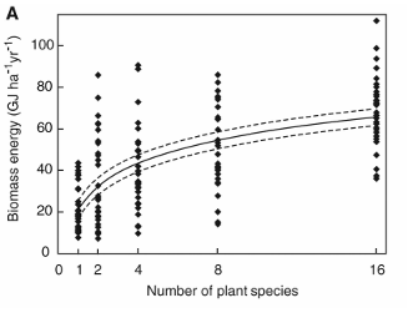
agroforestry



intercropping

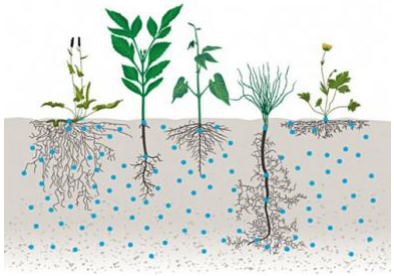
Potential ecosystem services from cropping system diversification

Diversity-productivity



Tilman et al. 2006

Resource partitioning

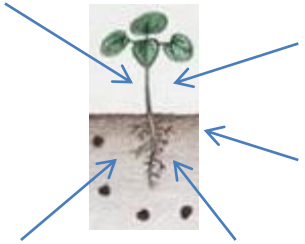


spatial, temporal
e.g. nutrient type, depth

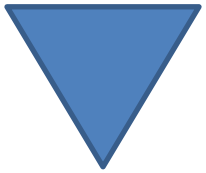
Mutualisms

Soil health/quality

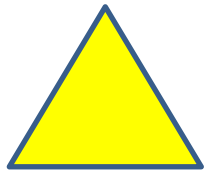
Multiple stresses for pest control



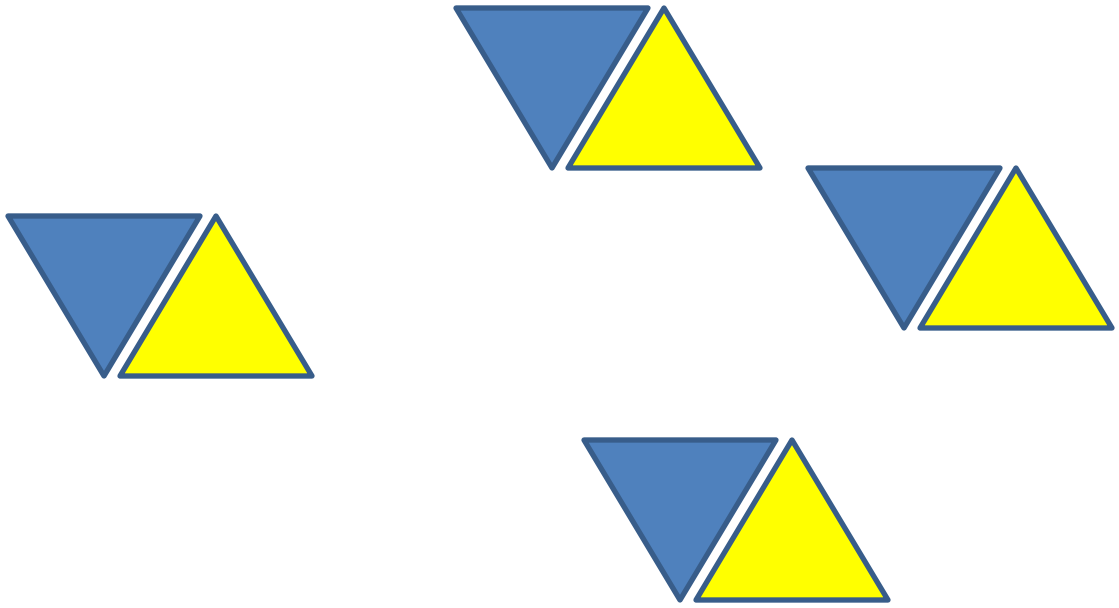
Landscape-scale complementarity



potato/grain
(N-poor/C-rich)



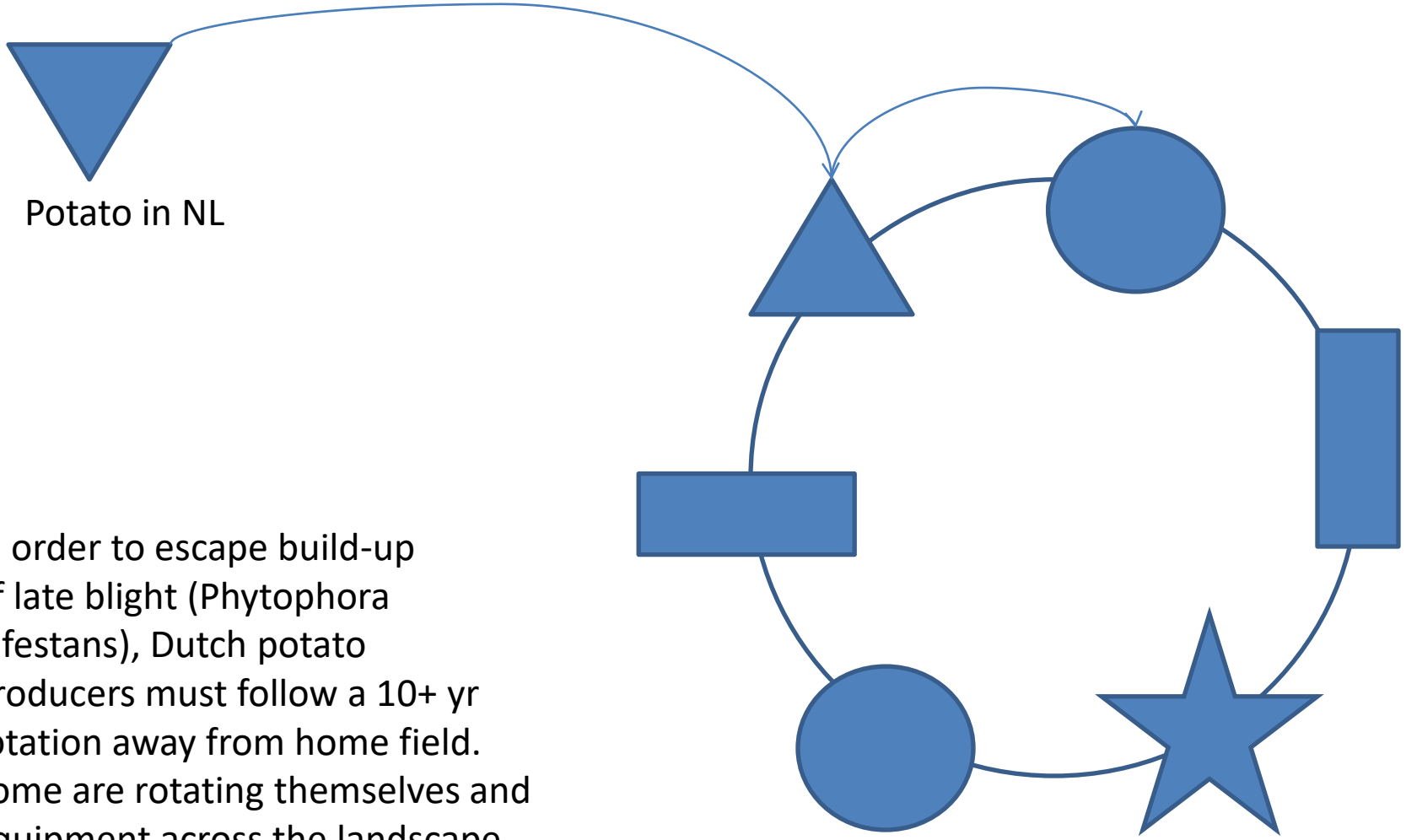
dairy
(N-rich/C-poor)



Diversity partners

Mallory et al. (2010)

Landscape-scale crop rotation



In order to escape build-up of late blight (Phytophora Infestans), Dutch potato producers must follow a 10+ yr rotation away from home field. Some are rotating themselves and equipment across the landscape.

No market? Make your own

Photo: A. Davis

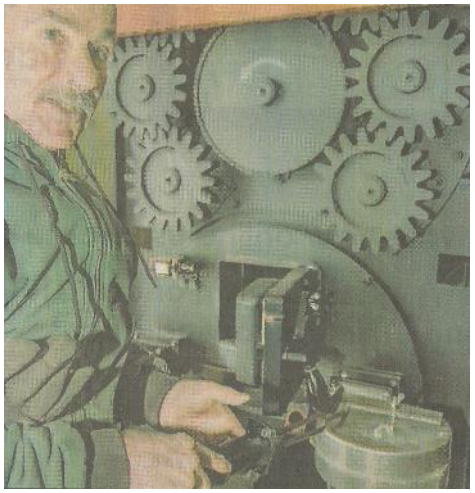


Photo: H. Coit

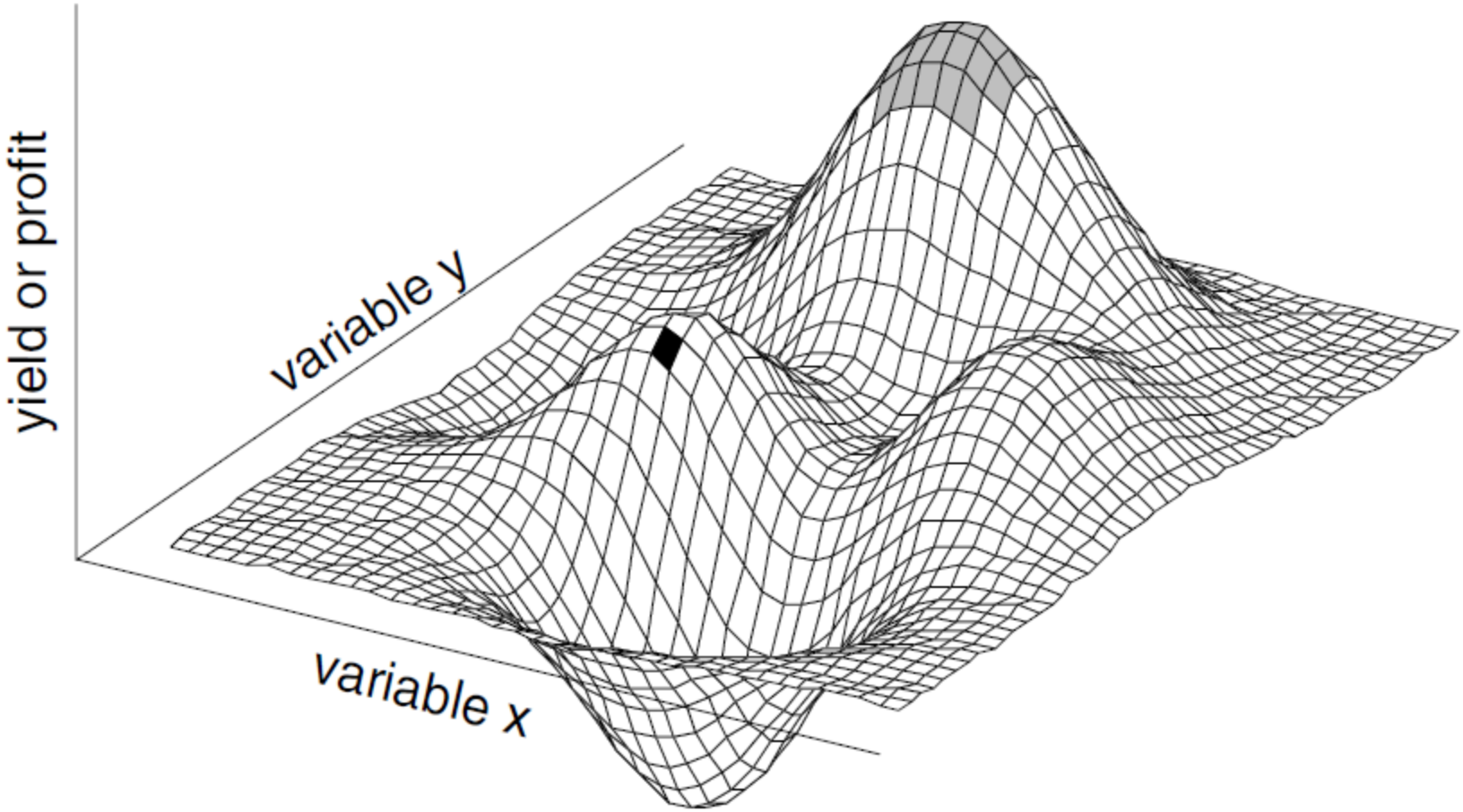
Central IL farmer (E. Rund) added perennial bioenergy crops to farming operation

1. Researched production BMPs
2. Visited with other growers (EU)
3. Used BCAP to cover conversion
4. Made contract with local school district (2010) and UIUC (2016) to install biomass furnaces and supply pelletized fuel.

Increasing diversity on your farm

- Identify main objectives
  - New market? Reduce inputs? Improve profit? Better pest mgt.? Soil conservation? Wildlife?
- Identify resources
- Identify obstacles
- Start small
- Be creative!

How did we get here? Do we have a choice?



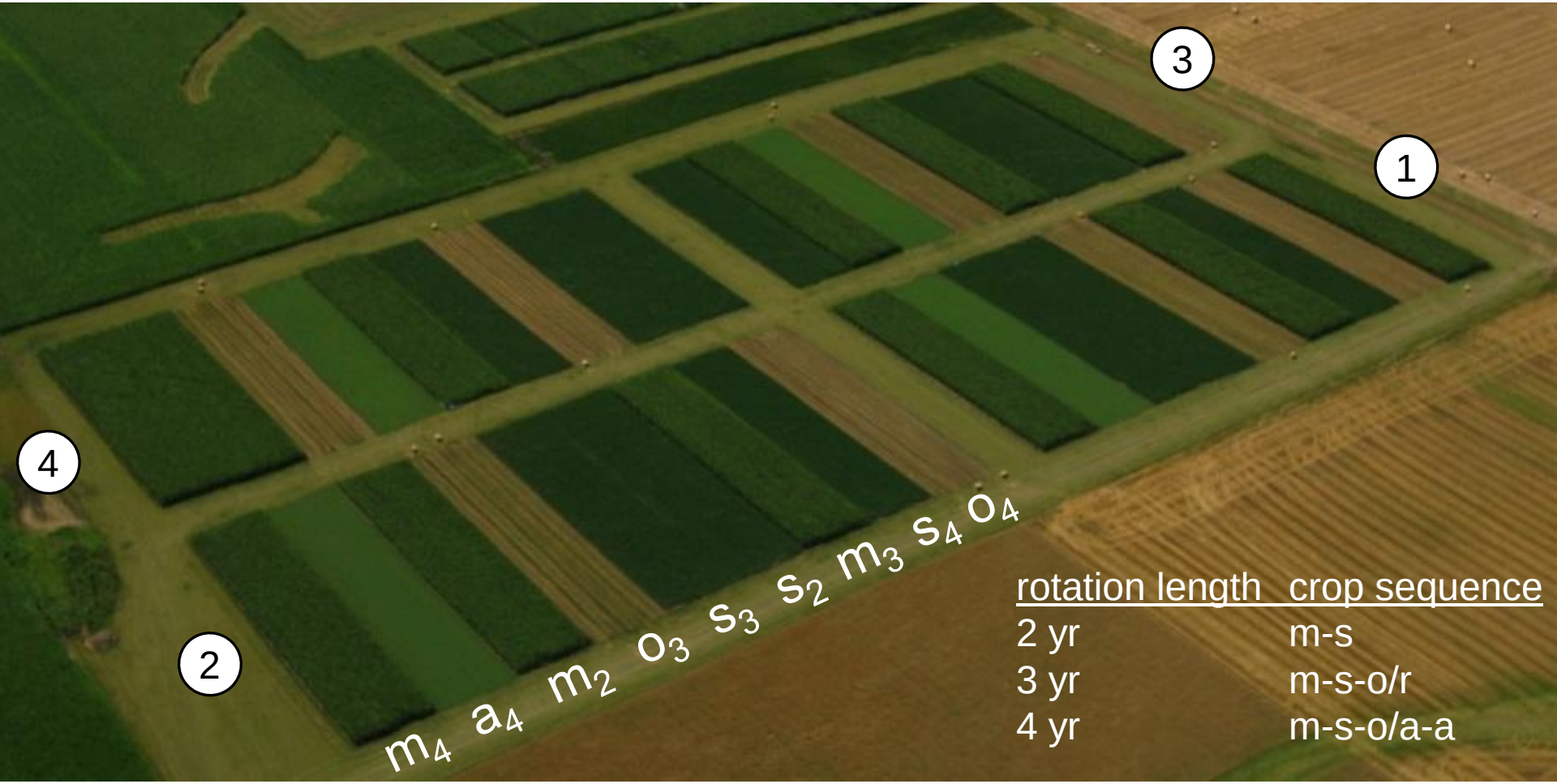
Weiner, 2003

Marsden Farm study

(2002- present; Dr. Matt Liebman, PI)

Central hypothesis: cropping system diversification will promote development of ecosystem services over time, supplementing or eventually displacing role of synthetic inputs in promoting crop productivity and profitability

Experimental design



rotation length	crop sequence
2 yr	m-s
3 yr	m-s-o/r
4 yr	m-s-o/a-a

Davis et al. 2012 PLOS ONE 7(10): e47149


2-m
Photo: D. Sundberg


4-a
Photo: D. Sundberg

Crop management

- Maize and soybean:
  - cultivars: both GE and non-GE maize and sb cult. used after 2005; same genetic background
  - Seeds ha^{-1}: m 79.5K, sb 395K
  - 76 cm row spacing
- Small grains
  - 3yr: triticale through ‘05, oat thereafter; 4yr: oat (IN09201) 2003-2011
  - drilled in early spring; underseeded with red clover (3) or alfalfa (4)
- Forage legumes
  - red clover: Cherokee; 13 kg seed ha^{-1}; disked in as green manure
  - alfalfa: FSG 300LH; 17 kg seed ha^{-1}; baled for forage

Soil fertility management

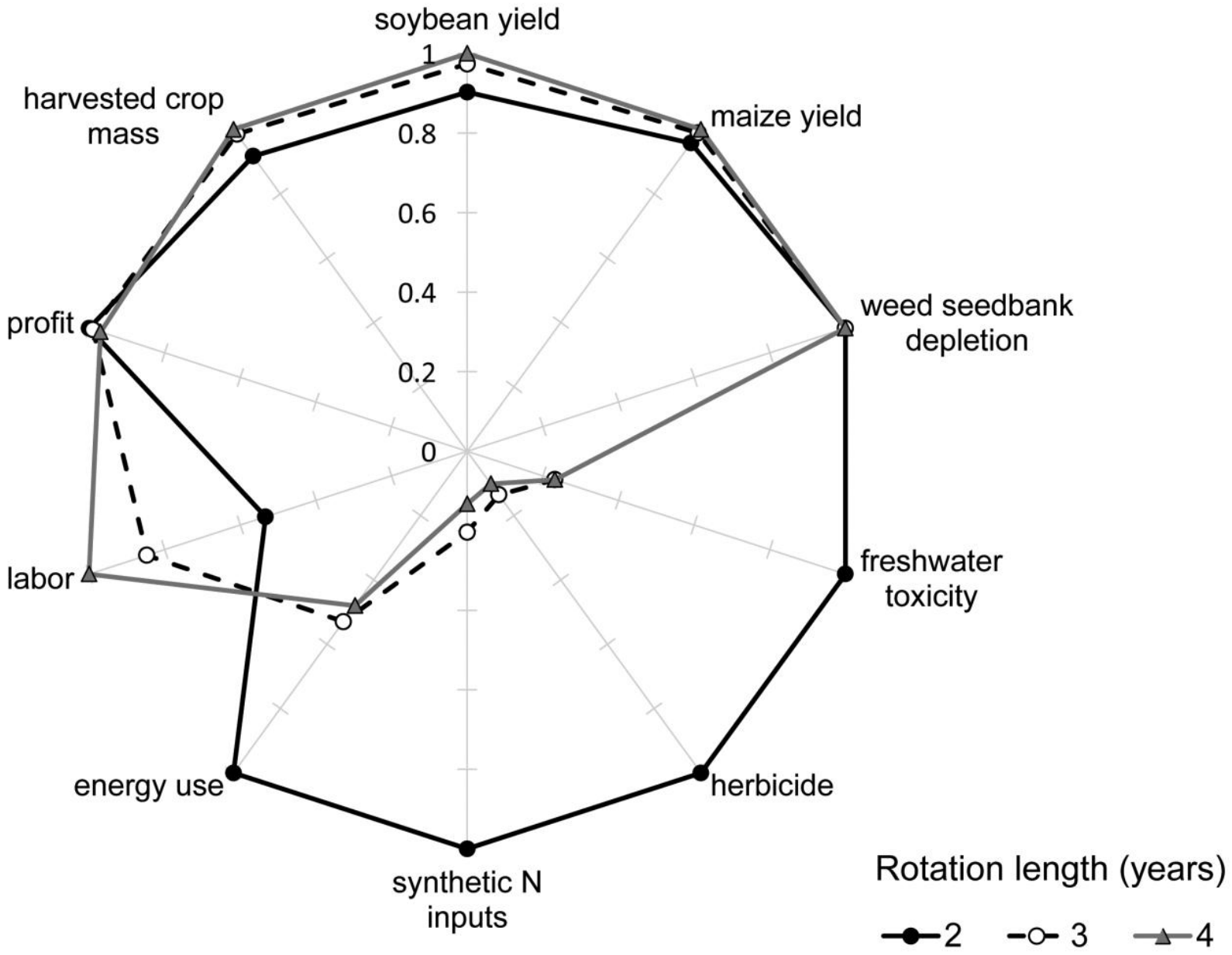
- 2 yr: NPK applied at maize planting based on soil test recommendations; sb: P&K sidedressed

- 3 & 4 yr:
  - Inorganic fertilizers: LSNT to guide sidedress N in maize phase; P & K from compost
  - Organic amendments:
    - forage legume residues disked in before maize
    - 8.3 Mg ha^{-1} (dry wt.) composted beef manure added in October of each year to red clover (3) or established alfalfa (4)

Weed Management

- Rates and MOA based on weed community, population density and size of weeds in plots

- 2 yr: POST herbicide applications, full row width
- 3 & 4 yr:
  - POST herbicide banded over row (38 cm band) in m & sb
  - interrow cultivation in m & sb
  - no weed control in small grain or forage legume



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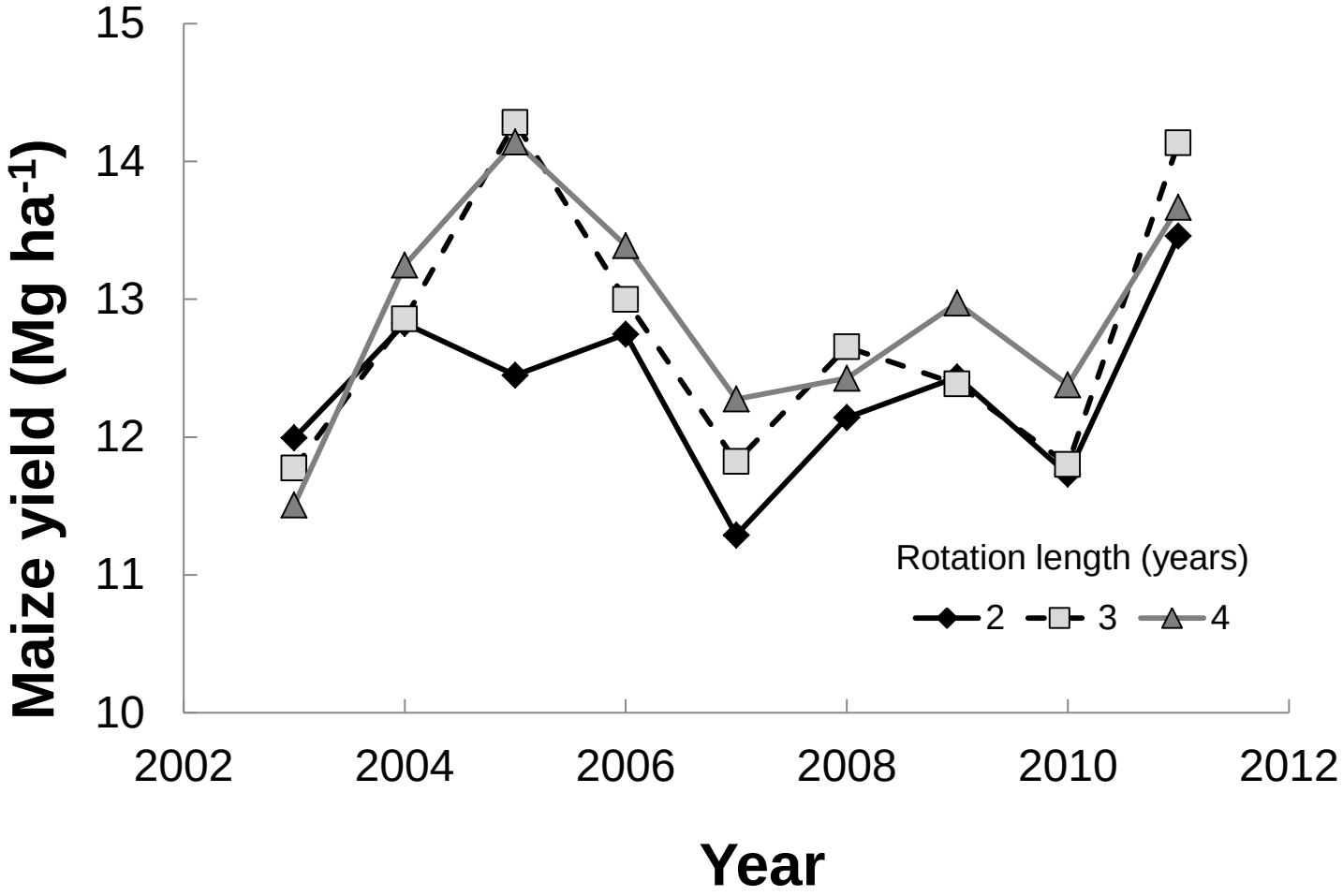
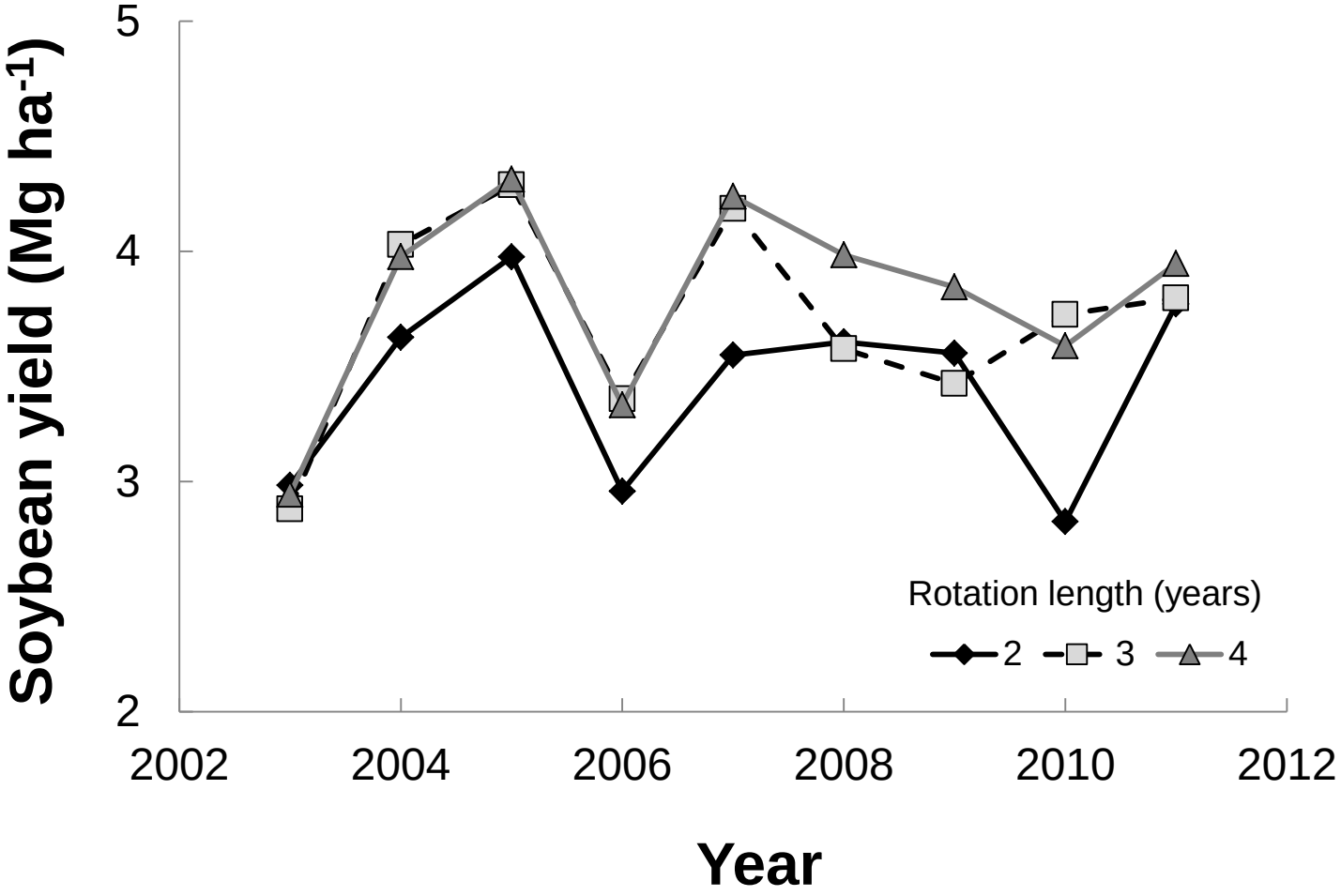


System: P < 0.05
1df: (3 & 4) > 2, p = 0.03
4% greater

Davis et al. 2012 PLOS ONE 7(10): e47149



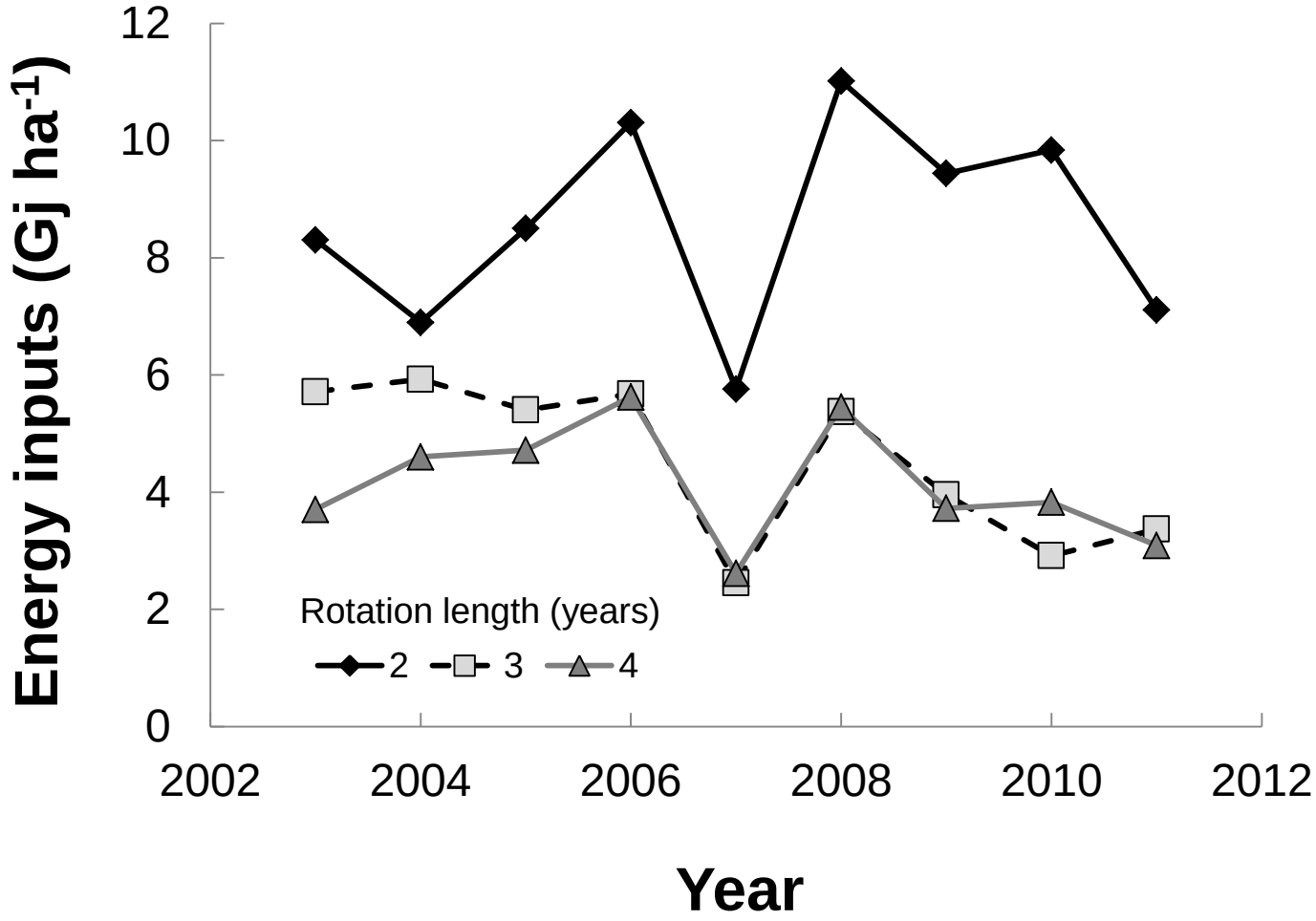
System: P < 0.05
1df: (3 & 4) > 2, p = 0.01
11% greater

Davis et al. 2012 PLOS ONE 7(10): e47149

Soybean sudden death syndrome, 2010:

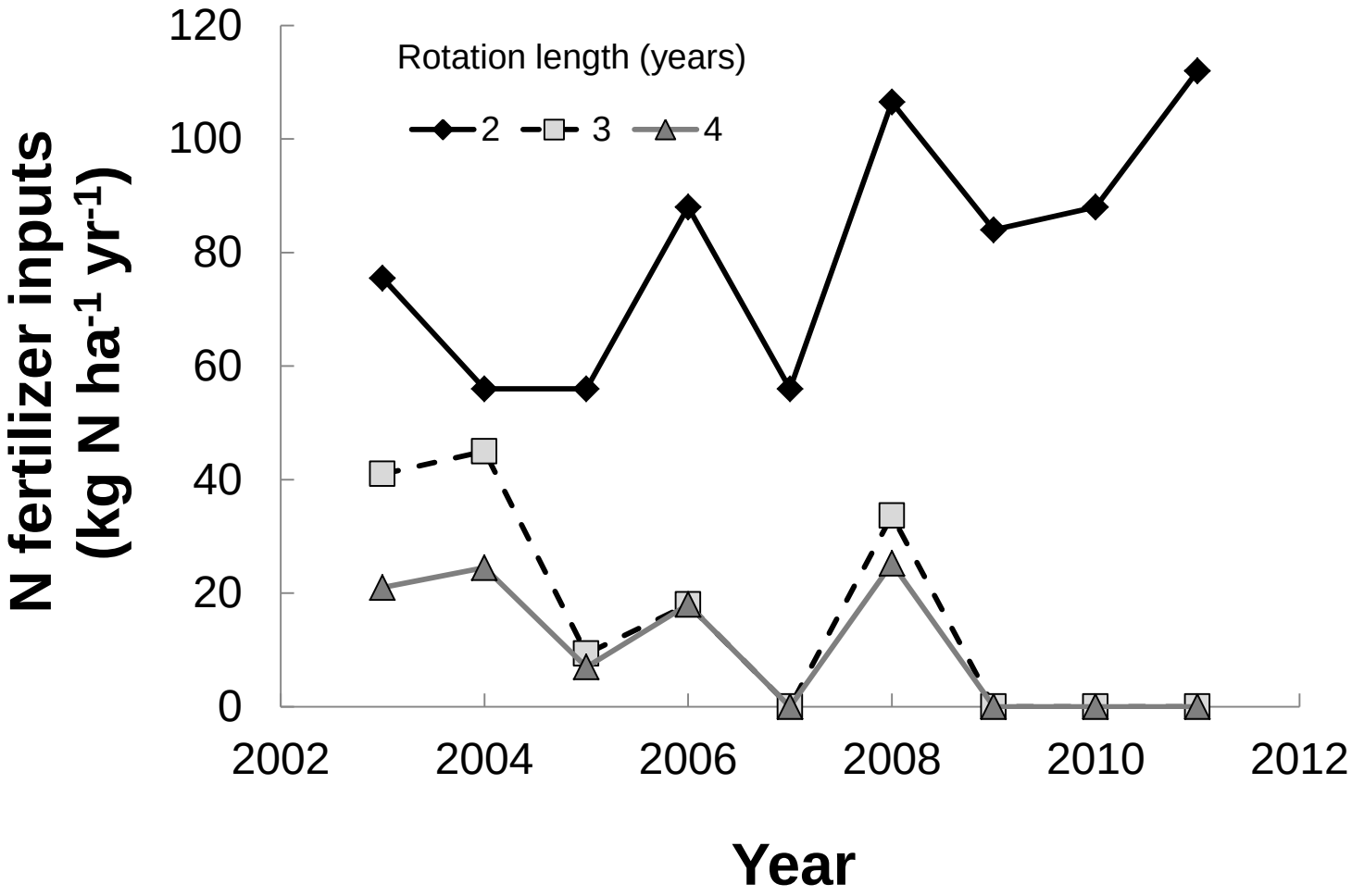
2 yr: 27-97% infected
3 & 4: < 9% infected

Photo: D. Sundberg



System: P < 0.0001
1df: (3 & 4) < 2, p < 0.0001
~50% less

Davis et al. 2012 PLOS ONE 7(10): e47149

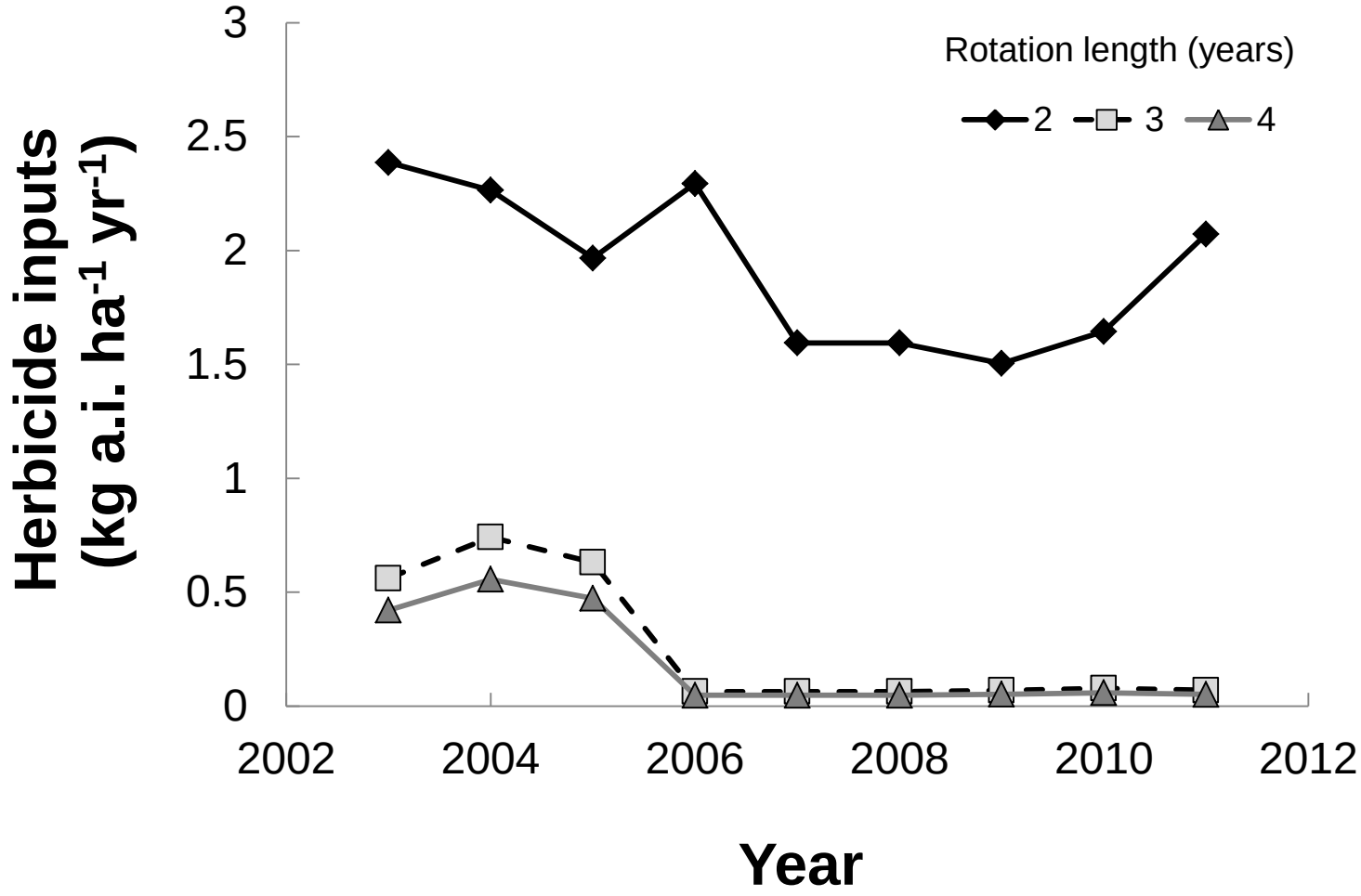


System: P < 0.001

1df: (3 & 4) < 2, p = 0.005

*difference increased over time

Davis et al. 2012 PLOS ONE 7(10): e47149

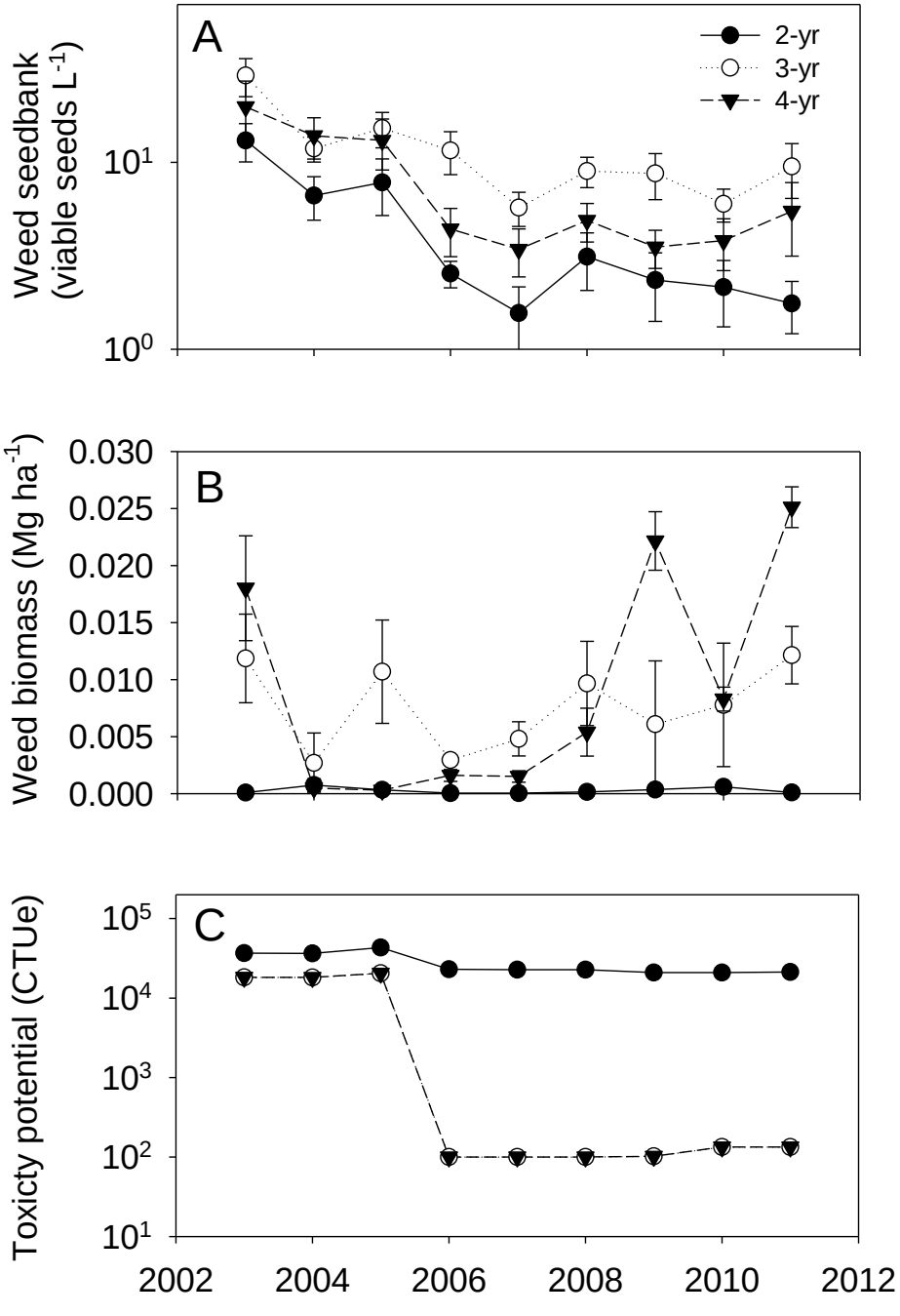


System: P < 0.0001

1df: (3 & 4) < 2, p < 0.0001

*difference increased over time

Davis et al. 2012 PLOS ONE 7(10): e47149



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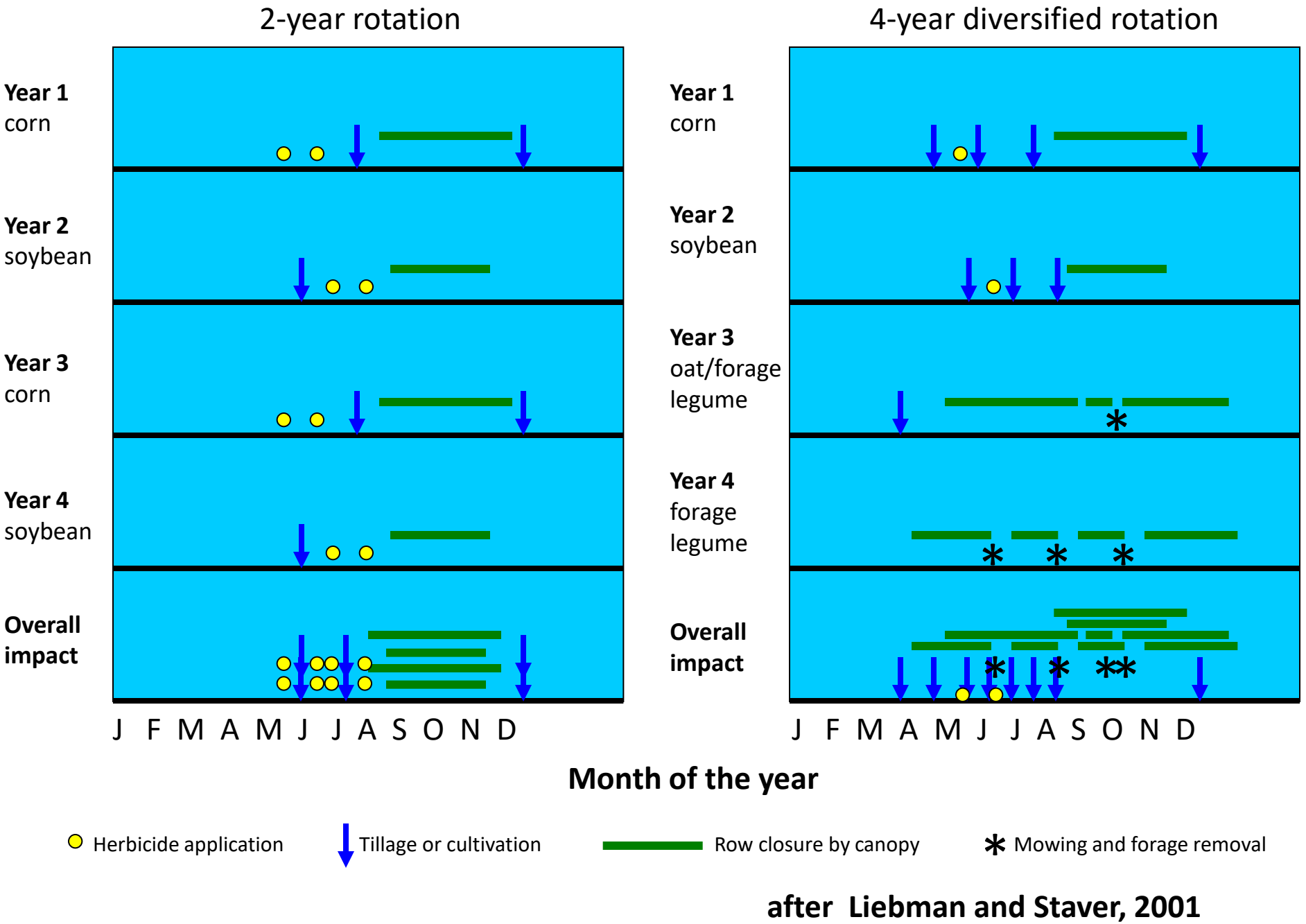
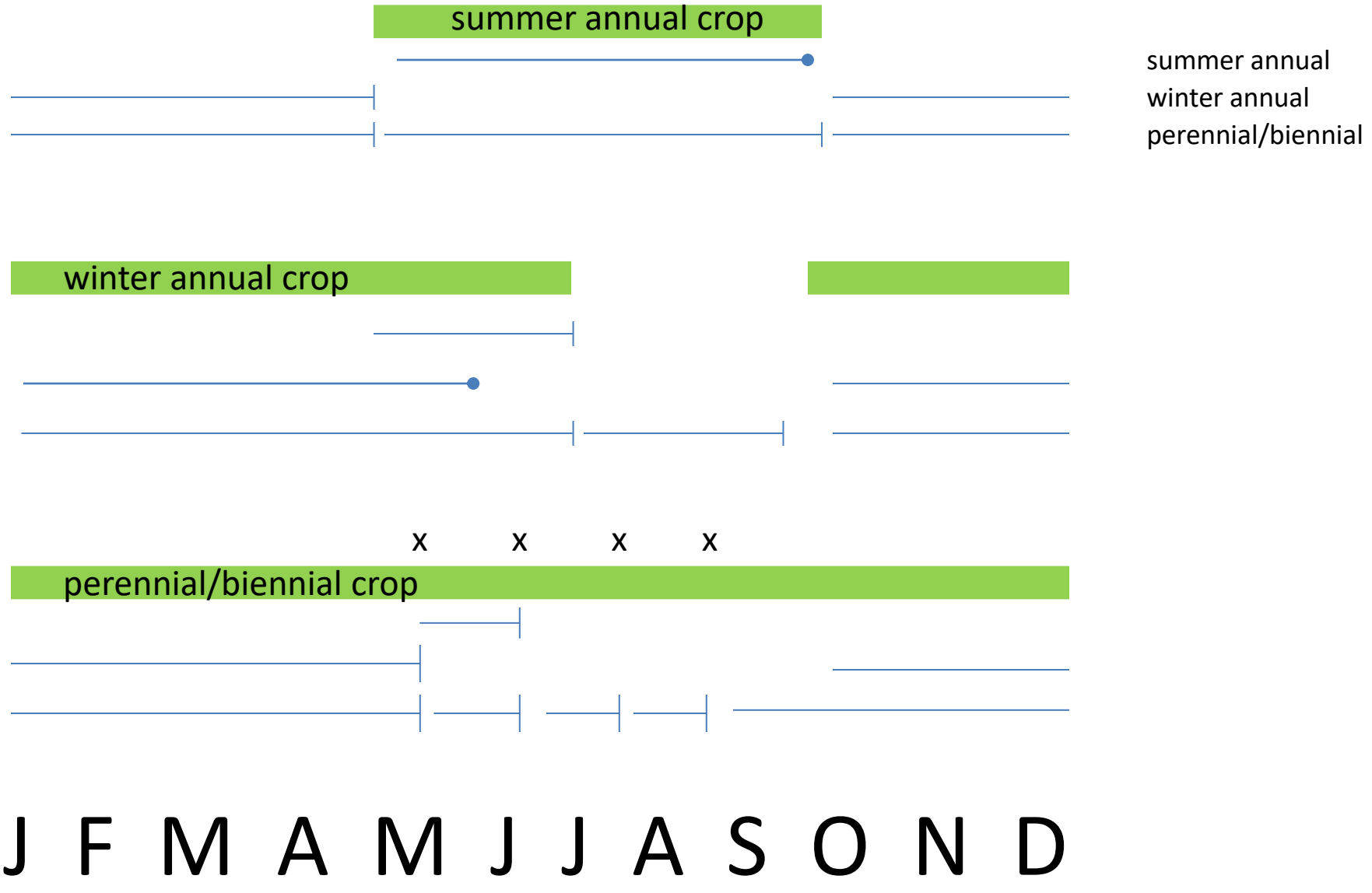
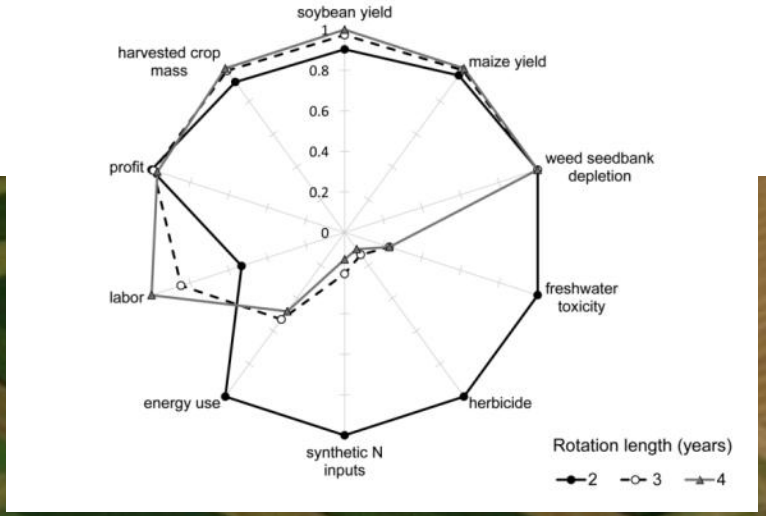


after Liebman and Staver, 2001

Disruption of weed life cycles



Acknowledgements



- Marsden Farm team
  - Matt Liebman (PI)
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