Comparing Biologically Diversified with Conventional Farming Systems: what is known about environmental benefits, externalities and tradeoffs among crop productivity and ecosystem services?

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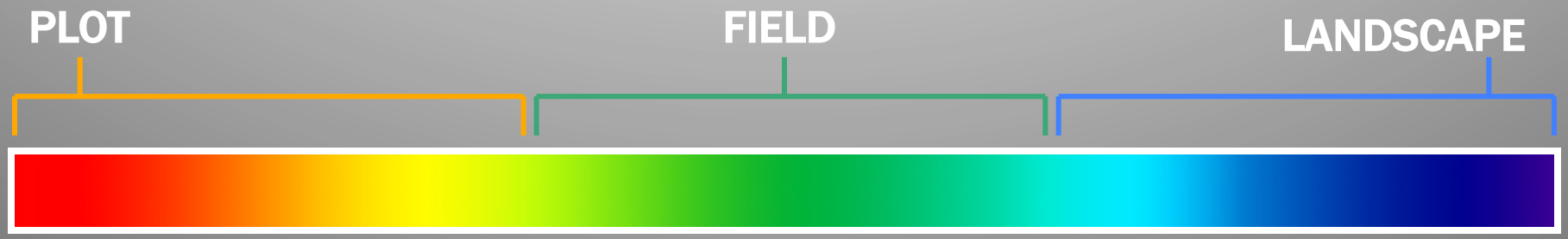
Objectives & Scope of Paper

To provide a quantitative summary of a *representative* scientific literature measuring differences in the provisioning of important ecosystem services (ES) to and from biologically diversified as compared to conventionally managed and biologically simplified farming systems.

Ecosystem services assessed in the study:

- Biodiversity
- Soil quality enhancement
- Water use efficiency
- Control of weeds, diseases and arthropod pests
- Pollination services
- Carbon sequestration
- Energy use
- Global warming potential
- Resistance and resilience to severe weather conditions
- Food productivity/yield

Diversified Farming Systems



NUTRIENTS | WATER | SOILS | PEST CONTROL | POLLINATION









Crop monocultures

Research Methods

- Web of Science search:
- Literature review focus:
  - meta-analyses or quantitative syntheses
  - review articles including “vote counts”
  - long-term studies (7+ years)
- Proxies:
  - For some services, the only available studies were comparisons of organic to conventional farming systems
  - Studies across agricultural intensification gradients

Classification of Findings

- Summary Table:
  - 'Strong Effect': > 25% change and ($p<0.05$)
  - 'Weak Effect': $\leq$ 25% change, OR weak significance ($p>0.05$)
  - 'Equivocal': data indicate no clear trend at present. Resulting from: non-significant results (ns), or strong studies showing both positive (+) and negative (-) trends, or too few studies to clearly determine any disadvantage/advantage of DFS when compared to conventional farming systems.
- Positive and Negative Findings:
  - Positive Findings (X) = diversified farming practices provided *greater* benefits for the service or indicator than conventional practices.
  - Negative Findings (X) = diversified farming practices provided *fewer* benefits for the service or indicator than conventional practices.

Summary: Bio-physical

Service	Equivocal	Weak Effect	Strong Effect
Soil Quality [SOM, physical, chemical and biological characteristics, erosion reduction]			X
N leaching [org-conv comparison]		X heterogeneous	
P leaching [org-conv comparison]	X ns		
N + P leaching [riparian buffer]			X
Water use efficiency (Available Water Capacity)			X

Strong Effect: >25% change and ($p<0.05$)
Weak Effect: $\leq$ 25% or weak significance ($p>0.05$)
Equivocal: ns, mixed results, or too few studies conducted

Blue X = Positive findings
Red X = Negative findings

Summary: Biotic Interactions

Service	Equivocal	Weak Effect	Strong Effect
Biodiversity [abundance and richness of plants, beneficial arthropods, birds]			X local scale
Control of Weeds [seed and plant]			X
Control of Plant Pathogens -aerial -soil		X	X
Control of Arthropod Pests -field-scale -landscape scale	X ns for pest response	X	
Pollination Services		X few studies on serv.	

Strong Effect: >25% change and ($p<0.05$)
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Summary: Climate Change Adaptation (A) & Mitigation (M)

Service	Equivocal	Weak Effect	Strong Effect
Carbon sequestration (M) 0-30cm 30-1m	X		X org., n-t
Energy use (M)			X
Global warming potential (M)	X (N_2O)		
Resilience to drought (A)			X
Resistance to hurricane (A)			X

Strong Effect: >25% change and ($p<0.05$)
Weak Effect: $\leq$ 25% or weak significance ($p>0.05$)
Equivocal: ns, mixed results, or too few studies conducted

Blue X = Positive findings
Red X = Negative

Yield/Productivity

Service	Equivocal	Weak Effect	Strong Effect
Yield Developed country (org : conv.)		X	

Strong Effect: >25% change and ($p<0.05$)
Weak Effect: $\leq$ 25% or weak significance ($p>0.05$)
Equivocal: ns, mixed results, or too few studies conducted

Blue X= Positive findings
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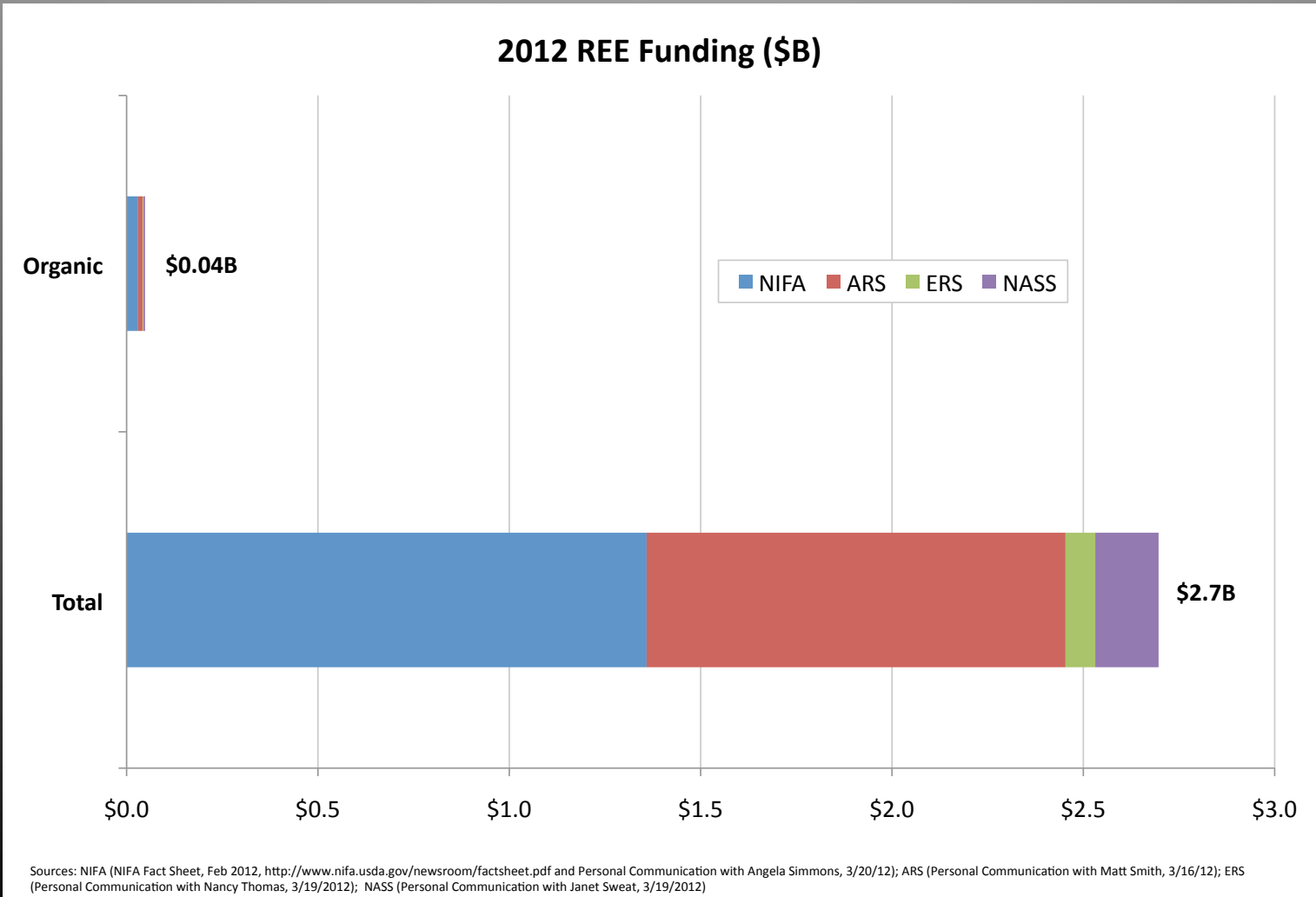
Conclusions

1. There is substantial quantitative evidence of significant advantages to ecologically based and DFS for the following ecosystem services:
    1. biodiversity conservation;
    2. control of arthropod pests, weeds and diseases;
    3. pollination services;
    4. soil quality enhancement and maintenance;
    5. water use efficiency, carbon sequestration;
    6. Increased energy use efficiency;
    7. Increased resistance and resilience of farming systems to extreme weather events.

Conclusions

2. Organic and DFS outperform conventional farming systems across a wide range of ES despite receiving only a fraction (1.68%) of USDA research & development funding (Miles and Carlisle in prep.)



Sources: NIFA (NIFA Fact Sheet, Feb 2012, http://www.nifa.usda.gov/newsroom/factsheet.pdf and Personal Communication with Angela Simmons, 3/20/12); ARS (Personal Communication with Matt Smith, 3/16/12); ERS (Personal Communication with Nancy Thomas, 3/19/2012); NASS (Personal Communication with Janet Sweat, 3/19/2012)

Conclusions

3. Need for multi-disciplinary 'whole-system' studies: to refine DFS management strategies and optimize the provisioning of multiple ES for specific cropping systems and regions;
4. Key areas for agroecological research and development:
   - Crop breeding
   - Nutrient leaching (P)
   - Plant disease and arthropod pest management
   - Pollination services
   - Global warming potential
   - Productivity/yield (esp. accounting for yield impacts of crop rotation and complementary inter-cropping)
5. Multiple structural obstacles to DFS: Need for significantly increased international, federal, state funding for agroecological research.

Conclusions

With significant public investment in research and development, society would realize even greater performance from ecologically based diversified farming systems.

Thank you!

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Kremen, Claire, Miles, Albie. 2012. *Comparing Biologically Diversified with Conventional Farming Systems: what is known about environmental benefits, externalities and tradeoffs among crop productivity and ecosystem services?* Ecology and Society (in press).