1. Surprising Strength of Biodiversity and 2. Biodiversity Preservation by Reducing Global Need for Agricultural Land Clearing

What Determines Ecosystem Functioning?

Nitrogen Phosphorus Water Fire Herbivory Disease Climate (temperature) Biodiversity **Species Composition** CO2

Nitrogen Addition Experiments N addition (1982), N and Fire (1993) N and Herbivory (2004), N and Water (2007)



No Nitrogen Addition



Biodiversity Experiment (1994)



CO₂ Enrichment (1997)



Many Collaborators: Peter Reich Sarah Hobbie Johannes Knops Jennifer Powers David Wedin Clarence Lehman

Climatic warming and biodiversity (2007)



Aboveground Biomass



(Tilman and Reich, in preparation)

Biodiversity and Ecosystem Services





Diverse plots store more C in Soil



Biodiversity and ecosystem stability in a decadelong grassland experiment

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Community Biomass is More Stable at Greater Diversity



Because of Greater Resource Use at Higher Diversity, Invader Success was Much Lower at Higher Diversity

(Fargione and Tilman 2005 Ecology Letters)

Plant Diversity & Foodweb Structure

At high plant diversity, foodwebs are predatordominatedAt low plant diversity, they are herbivoredominated

> (Haddad et al. 2009 Ecology Letters)



New Biodiversity and Ecosystem Services Experiments 1. **Biofuel Production** (2002 NSF) ("Carbon Negative Biofuels" Science 2006) with C. Lehman and J. Hill 2. Water Purification (2007 USGS) Leaching of nitrate and agrichemicals into groundwater (with C. Lehman, J. Trost) 3. Control of Agricultural Pests Insect Pests of Maize, Soybeans and Wheat (with M. Kozmala)

Biodiversity and Ecosystem Services

- Greater Productivity
- Greater Stability of Productivity
- Greater Nutrient Use and Higher Water Quality
- More biofuel production & greater GHG reductions
- Lower Disease Incidence
- Lower Rates of Invasion by Novel Competing Species
- Diversity is predicted to matter because species have complementary traits, the same traits and interspecific tradeoffs that lead to multi-species coexistence

How Can We Preserve Biodiversity?

- Use Biodiversity as a Tool to Provide Greater Ecosystem Services to Society
- Decrease the Rate of Land Clearing by

 a) Optimizing Crop Yields on Current
 Agricultural Lands

b) Meeting Global Demand for Forest Products with More Sustainable Practices Global Food Demand Will Double by 2050 How Will The World Meet this Demand?

- Extensification: GHG release, biodiversity loss, loss of other ecosystem services from land clearing or
- Intensification: GHG and water/environmental quality impacts of increased agrichemical and energy use

Yields Have Grown Most in Richer Nations



A=Highest Income Nations B-D=Middle E-G=Lowest

What Factors Influence Yield Differences Among Nations?

Overall Regression: R² =0.85, N=1614, F=1132, P<0.0001

Source	DF	F Ratio	Prob > F
SQRT (N Use)	1	765.0	<.0001*
Tractors /Ha	1	86.4	<.0001*
Per Capita GDP	1	257.0	<.0001*
Human Capital	1	35.8	<.0001*
AET (mm/year)	1	13.0	0.0003*
Soil Organic C	1	16.6	<.0001*
Polity Score	1	20.0	<.0001*
Infras	structure	is also	highly importa

Diminishing Returns as More Nitrogen is Used



Nitrogen Use Intensity (N: t/ha)

Four Yield Scenarios that Could Meet Projected 2050 Global Food Demand

A.Business as Usual Trajectory

B.Pure Extensification

C.Moderate and Strategic Intensification – Increasing National Yields Where Benefits:Costs Are Higher

D.Moderate and Strategic Intensification and Investment in Improved Agricultural Technology Continuation of Past Practices to Meet 2050 Global Food Demand

> >800 million hectares of new land cleared and farmed

Large increases in N pollution and Greenhouse gas releases

If 2050 Global Food Demand Had to Be Met with No Yields Improvements

2,000 million hectares cleared Massive greenhouse gas release

Reduce N pollution, GHG release and Land Clearing By Helping People Bring Underperforming Croplands Up to Their Potential

300 million haNo LandCleared

Encourage farmland mosaics – Satoyama Use Biodiversity As a Tool

 Eliminate the need for agricultural land clearing by optimizing yields on existing croplands through Moderate & Strategic Intensification

Use Biodiversity as a Tool to Increase Carbon Storage Improve Water Quality Provide pollinators Provide pest control