How Agroecological Farming Practices Can Help Improve Crop Production & Grazing Systems... & Create a More Resilient Future

Kansas Rural Center
2017 Farm & Food Conference, November 17 – 18
Manhattan, Kansas
Science and for a healthy planet safer world.
The facts are coming! The facts are coming!
Toward Healthy Food and Farms
Transforming our food system to ensure healthy, sustainably grown food for all.
A broken food system

40% of food is wasted

50% of Our Plate that Should Be Filled by Fruits and Vegetables

2% of U.S. Fruit and Vegetable Acreage Relative to Total U.S. Farm Acreage

% US Adults

Overweight

Obese

Diabetes
Losing ground
The Gulf of Mexico dead zone is larger than ever. Here’s what to do about it.

By Jenna Gallegos
August 4

At 8,776 square miles, this year’s dead zone in the Gulf of Mexico is the largest ever measured. (Courtesy of N. Rabalais, LSU/LUMCON)

Scientists just measured the largest dead zone ever recorded for the Gulf of Mexico, a whopping 8,776
Soils: at the roots of many challenges
Soil science basics

Water, CO₂, and N, P are essential for plants to produce glucose (C₆H₁₂O₆).
Soil science basics

Water

$\text{CO}_2$

N, P, C

$\text{C}_6\text{H}_{12}\text{O}_2$

Sun
Soil science basics

N_2O \rightarrow \text{CO}_2

N, P, C

C_6H_{12}O_2

water

N, P, C

Sunlight
Healthy soil
- High OM, C
- Not compact

[Diagram showing the processes involving water, CO\textsubscript{2}, and nutrients in healthy soil.]
Healthy soil
- High OM, C
- Not compact
- Holds water

CO₂

water

N, P
Healthy soil
- High OM, C
- Not compact
- Holds water
- “Full of life”

Source: NRCS
Science is showing how various practices can build soil health

- Perennials: Perennial grasses, Agroforestry, Forestry
- Crop Rotation
- Integrated crop-livestock systems
- Grazing Management: Reduced rates, Rotational grazing
- Cover Crops
- No-Till
Management practices can sequester soil carbon

Cropland: 0.3-0.5 Mg C/ha/y

Grassland, grazing land: 0.04-0.2 Mg C/ha/y

Forest land: 0.1-0.4 Mg C/ha/y

Land restoration: 0.1-0.5 Mg C/ha/y

Chambers et al. 2016
Management practices can deliver agronomic & ecological benefits

Crop Rotation (e.g. Marsden Farm)

Perennials (e.g. STRIPS)

Hunt et al. 2017
Photo: PR Westerman

Helmers et al. 2012
Photo: L Schulte Moore
On-farm research is key!
Editorial: To clean up our water, go 'nuts' like this Iowa farmer

Shifting from two-crop cycle can produce profits and environmental benefits

Seth Watkins has impressive Iowa agriculture bona fides. He's a fourth-generation farmer. He raises 600 cows and tends 3,200 acres east of Clarinda in southwest Iowa. His grandmother, Jessie Field Shambaugh, founded 4-H.

Yet some Iowans have called him "nuts" for sowing grass where he could plant more corn, he told the Register.

Watkins has broken out of the two-crop cycle in which so many farmers are caught. He grows corn but also oats, alfalfa and cover crops. He grazes his cattle on pastureland, and about 400 acres of his land have been restored to prairie or set aside for ponds and protection of wildlife and streams. And he's seen better financial returns as a result, he said, even if it comes at the cost of huge corn yields.

"My job as farmer is not to produce; my job is to care for the land. And when I do this properly, this provides for all of us," Watkins, 48, told an audience this month at the National Marine Sanctuary Foundation's Capitol Hill Ocean Week in Washington, D.C.

Why is an Iowa farmer talking to marine scientists about his farming practices?

Because they know what Watkins does in the Nodaway River valley affects places like the Gulf of Mexico. The "dead zone" — a region of oxygen-depleted water that harms shrimp and other sea life — is expected to be more than 50 percent larger than average this summer, according to the National Oceanic and Atmospheric Administration. This spring's heavy rains washed excess fertilizer from Midwestern fields down the Mississippi River into the gulf.
Can management practices improve climate resilience & adaptation?
Floods are expensive.

Severe Flooding in Cedar Rapids in 2008: $5 billion
Risks of heavy rainfall are increasing

Decadal Change in Heavy Rainfall
(relative to 1901-1960)

Source: National Climate Assessment
What was the cost of damages from flooding in 2016?

• $500 million
• $3 billion
• $10 billion
• $20 billion
What was the cost of damages from flooding in 2016?

- $500 million
- $3 billion
- $10 billion
- $20 billion
What percentage of crop insurance payouts resulted from flood and drought events from 2011-2016?

• 10%
• 25%
• 66%
• 95%
What percentage of crop insurance payouts resulted from flood and drought events from 2011-2016?

• 10%
• 25%
• 66%
• 95%
How do agricultural practices in crop & grazing lands make soil spongier (e.g., higher infiltration rates) on individual fields?
Meta-analysis of >120 field experiments
Conservation practices improve infiltration rates, especially “continuous living cover”

Similar findings for porosity & water retained at field capacity

UCS, Basche 2017

Basche & DeLonge 2017
DeLonge & Basche, in press
Basche & DeLonge, in revision
How do agricultural practices in crop & grazing lands impact water on a landscape scale?
a. Current Farm Landscape

b. Hypothetical Soil Improvements on Today's Most Erodible Acres

c. Hypothetical Soil Improvements on Today's Least-Probable Acres

Union of Concerned Scientists, Turning Soils into Sponges
Union of Concerned Scientists, Turning Soils into Sponges
• In severe droughts (1988, 2012) up to 16% greater crop water use
• Up to a 20% reduction in flood frequency
• Similar magnitude benefits with future climate
Can ecological practices improve the sustainability of beef?
Why beef?

Opportunity for improvement
**Cow/Calf**
0-4/7 mo; 400-700 lb

**Backgrounding/Stocking**
4-6/8 mo; 600-800 lb

**Finishing:**
- **Grass**
  12-30/36 mo; 1100–1400 lb
- **Feedlot**
  12-16/24 mo; 1100–1400 lb
Feed crops & beef linked to commodity crops

Exhibit ES1: U.S. Corn Use by Segment (2013)

- Beef: 10%
- Pork: 11%
- Poultry: 13%
- Milk: 4%
- Cereals & Other: 7%
- HFCS: 4%
- Glucose & Dextrose: 2%
- Starch: 2%
- Beverage & Alcohol: 1%
- Corn Dry-mill: Ethanol & By-products: 35%
- Animal Feed/Residual: 38%

Ethanol & By-products:
- Corn dry-mill ethanol production also generates a co-product sold as livestock feed.

Source: USDA, ERS, Feed Grains Database
Commodity crops linked to grassland loss

Lark et al. 2015
What are the on-farm economic & ecological impacts of transitioning conventional crops to ecological grass & crops?
Economic Methods

Chippewa 10% Cropping Systems Calculator

When thinking about switching to a different farming system, one of the first questions many farmers want answered is: “How will this work financially?” The Chippewa 10% Project developed the Cropping Systems Calculator to help answer this question by allowing farmers to plug in various planting and grazing scenarios and weigh the financial pros and cons of each option.

Average Yearly Costs and Returns from the Two Rotations

Returns are seen as wages for the farm owner in this tool and aren’t factored into labor costs.

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop 1</th>
<th>Crop 2</th>
<th>Crop 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Corn</td>
<td>Soybeans</td>
<td>AlfalfaHay</td>
</tr>
<tr>
<td>2</td>
<td>Soybeans</td>
<td>SpringWheat</td>
<td>Grazing</td>
</tr>
<tr>
<td>3</td>
<td>AlfalfaHay</td>
<td></td>
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<td>SpringWheat</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Total Overhead Expenses</th>
<th>Per Acre</th>
<th>Whole Farm</th>
</tr>
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<tbody>
<tr>
<td>Total</td>
<td>$148.59</td>
<td>$74,294.62</td>
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<table>
<thead>
<tr>
<th>Total Crop Expenses</th>
<th>Per Acre</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>$384.77</td>
<td>$15,516.80</td>
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<tr>
<td>New Crop</td>
<td>$456.58</td>
<td>$21,863.14</td>
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<tr>
<td>Percent Difference</td>
<td>-41%</td>
<td>41%</td>
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<table>
<thead>
<tr>
<th>Total Crop Income</th>
<th>Per Acre</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Original</td>
<td>$514.08</td>
<td>$20,963.03</td>
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<tr>
<td>New Crop</td>
<td>$684.93</td>
<td>$27,797.10</td>
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<tr>
<td>Percent Difference</td>
<td>-33%</td>
<td>33%</td>
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</table>

<table>
<thead>
<tr>
<th>Other Income</th>
<th>Per Acre</th>
<th>Total</th>
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<tr>
<td>Original</td>
<td>$53.07</td>
<td>$2,122.77</td>
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<tr>
<td>New Crop</td>
<td>$42.30</td>
<td>$1,692.04</td>
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<tr>
<td>Return to Management</td>
<td>-27%</td>
<td>27%</td>
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</tbody>
</table>

- Percent difference shows the percent increase in the new crop when compared to the old crop.
Environmental Impacts
Productivity Estimates

On-Farm: Custom Grazing Operations

Cow/Calv 0-4/7 mo.; 400-700 lb.

Backgrounding/Stocking 4-6/8 mo.; 600-800 lb.

Finishing:
- Grass 12-30/36 mo.; 1100–1400 lb.
- Feedlot 12-16/24 mo.; 1100–1400 lb.

Off-Farm: Grain feeding
Model Scenarios

Original

Scenario 1 (a) (b)

Scenario 2 (a) (b) (c)

Legend:
- Yellow: Corn
- Light Brown: Feedlot
- Orange: Oats
- Green: Soy
- Greenish: Grass
- Greenish: Alfalfa
Farmer Profits

Return on original + added value new system

[$/acre]

NRCS Ecosystem Payment
Addl Value, Alt System
Orig System

Conversion Scenario

1a 1b 2a 2b 2c

Conversion Scenario

[$(200.00) $(100.00)$- $100.00 $200.00 $300.00 $400.00]
Crop, Soil, Water Benefits

Ecosystem services new system [$/acre]

- NRCS Ecosystem Payment
- Reduced N2O Value
- Soil C Value

Water savings [mill. gall./ac/y]

- Green water saved (mill gall/ac/y)
- Grey water saved (mill gall/ac/y)

Conversion Scenario

1a  1b  2a  2b  2c
Scaling up these farming scenarios to larger regions could bring additional benefits per ha…

... but more challenging to obtain benefits per lb beef

Lark et al. 2015, USDA NASS
Support farmers to adopt & improve ecological practices
Obstacles & opportunities for agroecology

R&D, Metrics

Tools

Markets

Training

Miles et al. 2017
Leveraging agroecology for solutions in food, energy, and water

Narcia DeLange and Andrea Basche

Global agriculture is facing growing challenges at the nexus of interconnected food, energy, and water systems, including but not limited to: persistent food insecurity and diet-related diseases; growing demands for energy and consequences for climate change; and declining water resources, water pollution, floods and droughts. Further, soil degradation and biodiversity loss are both triggers for and consequences of these problems. In this commentary, we argue that expanding agroecological principles, tools, and technologies and enhancing biological diversity can address these challenges and achieve better socio-economic outcomes. Agroecology is often described as multi- or transdisciplinary, and applies ecological principles to the design and management of agricultural systems through scientific research, practice and collective action. While agroecology has roots in the study of food systems, agricultural land use has many direct and indirect linkages to water and energy systems that could benefit from agroecological insights, including use of water resources and the development of bio-based energy products. Although opportunities from the science and the practice of agroecology transcend national boundaries, obstacles to widespread adoption vary. In this article, we therefore focus on the United States, where key barriers include a shortage of research funds, limited supporting infrastructure, and cultural obstacles. Nevertheless, simply scaling up current models of agricultural production and land use practices will not solve many of the issues specific to food-related challenges nor would such an approach address related energy and water concerns. We conclude that a first critical step to discovering solutions at the food, energy, water nexus will be to move past yield as a sole measure of success in agricultural systems, and call for more holistic considerations of the co-benefits and tradeoffs of different agricultural management options, particularly as they relate to environmental and equity outcomes.

Keywords: sustainable agriculture; systems science; biological diversity

Introduction

New pressures for interdisciplinary research on food, energy, and water systems is emerging driven by an increasing recognition that food, energy, and water systems are inextricably linked in nature, as well as by concerns about population growth, climate change, water resources, and deficiencies in food and agriculture. To this effect, this research area develops, the scientific community can work to identify the most critical questions, tools, and approaches to effectively uncover sustainable solutions. In this article, we propose that the field of agroecology is poised to effectively address these challenges, but we also highlight several obstacles that may need to be overcome to enable broader application of agroecological solutions.

A commonly used definition of agroecology is that it is “the science of applying ecological concepts and principles in the design and management of sustainable food systems” (Gliessman, 2014) and many authors have credited the importance of defining agroecology more broadly as “a scientific practice and commitment (Danns-Cuadrado et al. 2013).” While definitions of agroecology vary (Turner et al. 2014 and the 2019), we have interpreted that a core feature is that it involves a systems-based study of the agricultural system— from crop production to product use—and drawn on the biological and social sciences to develop ecologically, economically, and socially sustainable agricultural practices. It is noteworthy that agroecology is often defined in terms of food systems, but the field includes tools and perspectives that are highly relevant to agricultural systems broadly, which are tightly linked to water and energy systems.

Agroecology involves multi-disciplinary, and often trans-disciplinary, approaches that can lead to solutions that serve the public good by simultaneously fostering food system productivity and resilience, reducing energy consumption, and supporting bio-energy production, as well as conserving water resources (Kremen and Vadez 2013; Fenner et al., 2015; Gliessman 2014; Sathorni...
Scientist and Expert Statement of Support
For Public Investment in Agroecological Research

We support greater public investment in agricultural research that applies ecological principles and relies, to the greatest extent possible, on ecological processes ("agroecology") to address current and future farming challenges.

Agroecology regards farms as ecosystems embedded in broader landscapes and society. Agroecological approaches are based on understanding and managing ecological processes and biological functions to increase and sustain crop and livestock productivity, efficiently recycle inputs, and build soil fertility, while minimizing harmful impacts on soil, air, water, wildlife, and human health. Hallmarks of agroecological farming practices include increasing the types of crops rotated on fields from year to year; controlling pests and weeds with fewer chemical pesticides; enhancing soil health while reducing the need for synthetic fertilizers; and valuing non-cropped areas of farms for the services they provide.

Agroecology has a proven track record of meeting farming challenges in a cost-effective manner. Research has found that applying agroecological methods, like those detailed above, can result in high yields for each crop in a rotation sequence. In addition, long-term studies have found that organic practices—a specific set of agroecological practices that eschew the use of all synthetic chemical inputs—typically improve soil health compared to plots where conventional practices are applied, and may produce comparable yields. This research also demonstrated that economic returns for organic crops can be greater than for conventional crops, despite higher labor costs.

These findings indicate that additional research has the potential to increase our understanding of agroecological methods and increase their adoption. Farmers could benefit from this added knowledge to produce a wide range of crops in many different regions, with greater resilience to variation in pests, weather conditions, markets, and other factors.

While other approaches may also yield promising solutions, they are more likely to already benefit from private sector support. Agroecology is less likely to be supported by the private sector since these farming methods often reduce requirements for purchased inputs. This leaves the public sector the responsibility to fund agroecological research that serves the interests of farmers and society.

At present, however, public research into agroecology is drastically inadequate. Land grant universities were once guided by their original missions to enhance understanding of agriculture that served the public interest. But these institutions have fallen victim to budget cuts that have driven them to rely upon private dollars to fund research, leveraging public investment largely for the benefit of the private sector. And past analyses have found that funding for agroecology is a very small part of the federal research budget.

Agroecological research can further our understanding of productive and profitable farming methods that will minimize harmful impacts on human health, the environment, and rural communities. These methods will...
Quantifying opportunity... by quantifying sustainable agriculture research funding

Level 1: Input efficiency
Level 2: Input substitution
Level 3: Agroecology Practices
Level 4: Socioeconomic support
Level 5: Global sustainable food system

Gliessman 2015
Agroecological practices & social support for transformation are found in relatively few projects.

- More efficiency, less waste
- Substitute better materials
- Redesign based on agroecology

DeLonge et al. 2015
Gliessman 2015
New survey identifies specific needs for agroecology

1. **Grants** at wider range of scales

2. **Interdisciplinary, systems-level research**, emphasizing economics, human health, equity

3. **Programs that train & encourage communication**
Lots of opportunity... 
but much work to do

A better farm future starts with the soil

Within the next year Congress will reauthorize the massive amalgamation of legislation we commonly refer to as “the farm bill.” The farm bill, which is reauthorized every five years, has major implications for every part of the rural economy.
Crop & Soil Climate Value

NRCS Ecosystem Payment
- Reduced N2O Value
- Soil C Value

Conversion Scenario

1a         1b         2a        2b          2c

Climate value new system
[\$/acre]
Water Footprint Savings

- Conversion Scenario

Water savings [mill. gall./ac/y]

- Green water saved (mill gall/ac/y)
- Grey water saved (mill gall/ac/y)
Reduction in beef production?

Conversion Scenario

10% of 1 standard serving (3 oz.)

- 1b
- 2a
- 2b

- 5.7 mill. ac.
- 2.6 mill. ac.
- 1.3 mill. ac.
- 0.2 mill. ac.