Making Diverse Rotations Work

Small Grains in the Corn Belt

2016 - present
Small Grains in the Corn Belt

Build soil health and improve farmer resilience in the US Corn Belt through diversifying the corn / soybean rotation.
Since 2016, project partners & funders have spanned the value chain

**Project Leads**
- Sustainable Food Lab
- Practical Farmers of Iowa

**Funders**
- USDA
- NRCS
- The McKnight Foundation
- The Walton Family Foundation

**Corporate Partners (Food & Feed)**
- Smithfield
- Cargill
- PepsiCo
- Mars
- Target
- General Mills
- Danone
- ADM
- Unilever
- The Original Oatly
- McDonald’s
- Seven Sundays
- Grain Millers
- Albert Lea Seed
Ground is covered 47% of the time, and bare when the heavy rains hit.

- Low plant diversity
- Homogenous root structures
- Less diverse soils
- Less resilient system
Ground covered with diverse roots in the soil storing nutrients & holding water **at least** ~70% of the time, with project data observing **continuous living cover** all 3 years.

Oat timing enables legume cover crop that fixes nitrogen in the soil.
Puts regenerative ag principles into practice

**Soil Health / Regenerative Ag Principles**

- **Increase Plant Diversity**
  Diverse rotations and cover crops diversify soil, providing habitat for more soil life

- **Keep Roots in the Ground**
  Plants growing throughout the year provide a steady source of food for organisms and take up nutrients so they don’t wash into waterways

- **Keep Soil Covered**
  Soil cover reduces erosion, evaporation and helps lower soil temperatures

- **Minimize Soil Disturbance**
  Avoiding plowing, overgrazing, and appropriately apply inputs keeps healthy soils functioning

- **Integrate Animals**
  Including animals in the farming system closes the nutrient loop and reduces the need for fertilizers

**A regenerative ag living case study**
We’re answering the “what” questions:

What’s the environmental impact?

What’s in it for the farmer?

What will it take?
What’s the environmental impact?

**Increased Soil Health**
- Diverse crop rotations grow diverse roots which provide more habitat for soil life.
- Compared to a 2-year rotation, a 3-year rotation has:
  - 31% more particulate organic matter carbon
  - 24% more microbial biomass
  - 21% less soil erosion
  - 10% lower bulk density

**Reduced GHG Emissions**
- Source reduction from synthetic inputs
  - Biological nitrogen from legume cover crop displaces 40-100 lbs. N/ac in corn
  - Reduced herbicides – 2-year rotation requires 6X more herbicide than a 3-year
  - Carbon sink from cover crops & ground cover
  - 21% fewer GHGs compared to corn/soy system - accounting for fertilizer reduction and cover crop sequestration alone
  - Bigger window for manure field spread, reducing NOX and CH4 of storage in hot months

**Water Improvements**
- Ground cover, root systems & increased soil water holding capacity stores water & retains pollutants
  - 1/2 to 1/3 of the nitrate concentration in tile water than corn/soy system
  - Herbicide ecotoxicity is up to 200X lower given reduced herbicides
  - 21% less erosion
  - Reduced phosphorous loads

*GHG and water benefits are material and measurable*

*Sources: PFI and Iowa State University*
A small grain in rotation makes low carbon corn possible

Synthetic nitrogen is more than 50% of the carbon footprint of corn grain.

Farmers can reduce synthetic N by $\frac{1}{3}$ to $\frac{1}{2}$ in corn year.

Legume cover crop displaces 40-100 lb N/ac with farmer-grown fertilizer.

Big GHG win & opportunity for livestock feed.

*Source: PFI Small Grains in the Corn Belt Farm Production Data*
What is the feed GHG impact at scale?

Small shifts in livestock rations will drive big GHG benefits on the landscape.

Reduced Feed Footprint

**PIGS**

40% GHG Savings
- 10% oat inclusion
- Save 5.47 billion lbs CO2e
- ~75 lbs CO2e per hog

**BEEF CATTLE**

70% GHG Savings
- 15% oat inclusion
- Save 2.25 billion lbs CO2e
- ~350 lbs CO2e per cow

Savings from across the rotation
- Decreased N fertilizer on corn yield
- Carbon sequestration from cover crops
- Decreased corn in animal diet (oats lower emitter)
- *Manure benefits* not included in analysis

*Modelled via U of MN FOODS3 and Cool Farm Tool*
**What’s in it for the farmer?**

**Implements Farmer Resilience**

**Receives Buffer**

- Additional crops diversifies revenue streams
- Additional planting times safeguard farmers from unpredictable events like extreme weather or market dips

**Reduces input costs**

- Nitrogen-fixing legume cover crops enable a farmer to “grow” biological fertilizer for use in corn crop, displacing synthetic nitrogen
- Diverse rotations and root structures break pest and disease cycles, reducing weed and pest management expenses
- Cover crops can serve as additional forage for cattle

**Addresses management concerns**

- Spreads out labor demands
- Provides an earlier opportunity to spread manure – key concern for livestock operations
- Improved soil health and water holding capacity enhances resilience of farming system to changing precipitation patterns and overtime can stabilize or increase yields
- Offers flexibility in farm management
What will it take? We are focusing our work on:

Farmer Support

Stable Market Demand

Small Grains in the Corn Belt

Enabling Conditions to Scale
## Farmer Support

*Make it easy for farmers to grow & gain from small grains*

### WHAT

Provide farmers the technical, social & financial support needed to change practices

### HOW

**Technical support**
- Agronomic coaching (PFI)

**De-risk practice change**
- Cost & risk share for desired management practices (i.e. to reduce fertilizer in corn year) or crops
- Financing mechanisms – i.e. long-term contracts

**Inspiration & culture**
- Farmer learning networks; make it “normal” (PFI)
Stable Market Demand

Give farmers a reason to grow small grains

**WHAT**

Create stable feed and food markets for small grains

**HOW**

Corporate supply chain programs to create markets

- Direct contracting small grains w/ legume cover crop
- Purchasing with cost share support
- Feeding trials and feasibility pilots

With impact measurement
As a pre-competitive collaboration, our partners are collectively identifying and seeking to address the enabling needed to scale small grains as part of an extended rotation: These include:

**Policy support** - particularly crop insurance

**Handling & infrastructure** – how to store, process, and move small grains in a system that has been optimized for corn and soy

**Financing mechanisms** to support farmer adoption and de-risk practice change

**Empowering farmers and advisors**: Growing farmer technical and peer learning support system across the region – SFL and PFI facilitate the new [Cover Crop Leadership Lab](#)
Work through the “HOW” with company partners to scale on the landscape & in supply chains

• Translate impact results into more corporate partner collaboration across rotations and supply chains
  ▪ How do buyers across multiple supply chains partner to support farmers’ whole-rotations?

• Test assumptions around what it would take to make this part of a company’s strategy
  ▪ Moving from pilots to buying practices
  ▪ How to balance high cost of data collection against need for documenting impact
  ▪ Valuing feed - when feed is valued by least-cost / optimization

• How to better motivate and de-risk practice change for the farmer
  ▪ Mechanisms to motivate the 50% who have yet to adopt fertilizer reductions (see new CIG proposal)
  ▪ More evaluation of what’s driving farmer behavior change (soil tests, neighbor experience, extension, etc.)

Answer new “WHATS” that are high-potential drivers for change

• Manure Management Benefits: Capture the GHG, water quality, farm management benefits of the small grain extended rotation in hog, dairy and beef livestock systems (see new CIG proposal and next slide)
Small grain system offers manure management benefits compared to corn / soy

Extended manure application window in hottest months when CH4 and N₂O from manure storage systems peak

Cover crop can hold 60-70% of manure nutrients

Our newly submitted CIG Proposal includes documenting these benefits on-farm in livestock operations
Appendix

Questions?
Contact Carol Healy: chealy@sustainablefood.org

Visit our small grains project [website] for more information
Small grains, like oats, once were common in the Corn Belt.
How much N fertilizer can be replaced by red clover “green manure” cover crop?

- Tim Sieren, Keota
N fertilizer replacement rate of clover & subsequent corn yields

*Clover + 100#N = No-clover + 190#N

*bushels per acre

- 23 lb N/ac
- 100 lb N/ac
- 143 lb N/ac
- 190 lb N/ac

*N FERTILIZER REPLACEMENT = 90 lb N/ac
Farmers can significantly reduce emissions without sacrificing yield – but coaching is key.

**Highest Emissions**
- Not reducing fertilizer
- No accounting for nutrients in manure
- Many pest management passes

**Lowest Emissions**
- Accounting for manure
- Reducing fertilizer
- Low input – transitional management

**Graph:**
- Y = 1837 + 1.034*X
- R² = 0.0630
- 56% reduction in GHG/A emissions
- 235 bu/acre corn
- 228 bu/acre corn
About $\frac{1}{2}$ of farmers in project are reducing synthetic fertilizer & all can increase reduction rate

- Of project population that grew corn in 2019 after small grain + legume cover ...
  - 48% **used less fertilizer** compared to two-year rotation corn
  - 36% **used the same fertilizer** compared to two-year rotation corn
  - 16% did not have a comparison field

- Farmers self-reported reducing an average of **46 lbs/ac** (median 50 lbs) if they indicated they applied less fertilizer

2020 Production Data Analyses (2019 corn after legume cover, N = 25)
GHG Impact from Fertilizer Reductions & only ½ cutting fertilizer

In six years:
- Spring small grains rotation result in **10% reduction in GHG**
- Winter small grains rotation results in **3% reduction in GHG**

From emissions only (and with only half cutting fertilizer)

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>GHG Emissions (lbs CO2e / acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn w/ CC</td>
<td>2607.79</td>
</tr>
<tr>
<td>Soy w/ CC</td>
<td>755.77</td>
</tr>
<tr>
<td>Corn-SG</td>
<td>2675.09</td>
</tr>
<tr>
<td>Soy-SG</td>
<td>686.01</td>
</tr>
<tr>
<td>Spring SG</td>
<td>1190.13</td>
</tr>
<tr>
<td>Winter SG</td>
<td>1544.41</td>
</tr>
<tr>
<td>Corn w/ cover crop</td>
<td>529</td>
</tr>
<tr>
<td>Soy w/ cover crop</td>
<td>651</td>
</tr>
<tr>
<td>Ex. Rotation Corn</td>
<td>41</td>
</tr>
<tr>
<td>Ex. Rotation Soy</td>
<td>11</td>
</tr>
<tr>
<td>Spring Small Grain</td>
<td>37</td>
</tr>
<tr>
<td>Winter Small Grain</td>
<td>21</td>
</tr>
</tbody>
</table>
GHG emissions reductions increase when accounting for carbon sequestration

Incorporating sequestration estimates from Cool Farm Tool would lead to:

- Spring small grains rotation result in **21% reduction in GHG**
- Winter small grains rotation results in **14% reduction in GHG**

(again with only half cutting fertilizer)

Crops from Extended Rotation Data Set

- Alfalfa: N=9
- Corn: N=29
- Spring Small Grain: N=28
- Winter Small Grain: N=17
Farmers in this system were more willing to experiment with cover crops across their entire rotation and keep the ground covered

90% of 2017 cohort farmers planted cover crops in non-small grain year when there was no external incentive to do so. These farmers had continuous living cover for 3 years straight*

<table>
<thead>
<tr>
<th>Rotation</th>
<th>2017 Crop</th>
<th>Cover Crop</th>
<th>2018 Crop</th>
<th>Cover Crop?</th>
<th>2019 Crop</th>
<th>Proportion Practicing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small Grain</td>
<td>Legume Cover Crop</td>
<td>Corn</td>
<td>100% (6/6)</td>
<td>Soybeans</td>
<td>60% (6/10)</td>
</tr>
<tr>
<td>2</td>
<td>Small Grain</td>
<td>Legume Cover Crop</td>
<td>Corn</td>
<td>50% (1/2)</td>
<td>Corn</td>
<td>20% (2/10)</td>
</tr>
<tr>
<td>3</td>
<td>Small Grain</td>
<td>Clover</td>
<td>Clover</td>
<td>100% (1/1)</td>
<td>Corn</td>
<td>10% (1/10)</td>
</tr>
<tr>
<td>4</td>
<td>Small Grain</td>
<td>Alfalfa</td>
<td>Alfalfa</td>
<td>100% (1/1)</td>
<td>Alfalfa</td>
<td>10% (1/10)</td>
</tr>
</tbody>
</table>

*From small grain planting in fall of 2016 or spring of 2017 until crop harvest in fall of 2019

2017 cohort, n=10
More roots in the ground in the small grain system resulted in lower nitrate concentrations in tile water below fields.
Corn yield data is promising, though still a risk for yield drag which must be considered

- Of population that grew corn in 2019 after small grain + legume cover ...
  - 44% reported higher yields compared to two-year rotation corn
    - Average +14.7 bushel/acre
  - 20% reported similar yields compared to two-year rotation corn
  - 16% reported lower yields compared to two-year rotation corn
    - Average -32.5 bushel/acre
  - 20% had no comparison for their yields

2019 corn after legume cover, N = 25
The system provides farmer instant benefits, and expected long-term benefits that will take time to realize.

- **Instant Gratification**: Corn grown in extended rotation uses 31 lbs N/acre less synthetic fertilizer (statistically significant).

Ex. Rotation Corn 2017-2019, N=41
Corn 2017-2019, N = 529

- **Delayed Gratification**: Corn yields statistically the same in extended rotation (but we expect yields to climb with longer practice of rotation).

Ex. Rotation Corn 2017-2019, N=41
Corn 2017-2019, N = 529
Additional farmer benefits are considerable

- Place to spread manure earlier
- Ability to tile, terrace
- Spread out labor throughout the year
- Forages during pasture slump
- Flexibility & resilience to extreme weather

One of the great things about small grains and cover crops is how long all those flowering plants provide food for migrating Monarchs. I'm still seeing them today in the clover as well as the diverse mix (Forage peas (8.1 lb/acre), Soybeans (2.5 lb/acre), Spring triticale (3.3 lb/acre), Buckwheat (3.3 lb/acre), Badger radish (1.7 lb/acre), Crimson clover (4.2 lb/acre), Berseem clover (4.2 lb/acre), Brown mustard (0.4 lb/acre)). Buchanan County, Iowa.

“Applying manure after a small grain, before planting a cover crop gives you a bigger window to apply manure and hold your nutrients.”

–Jeremy Gustafson, Boone
Farmers are interested, but need a market

Good info. Thanks for that :)

Our farms need the diversity that small grains offer, but we also have to sell it!

I would be interested in any other info you would have.
1. Consider the co-products
2. Cutback input costs
3. Count the whole rotation

Small grains are profitable when we …

Enterprise budget data on following slides from PFI Small Grains production data
1. Consider the co-products

<table>
<thead>
<tr>
<th>CROP:</th>
<th>2017 REVENUE</th>
<th>2018 REVENUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOYBEAN</td>
<td>$594</td>
<td>$1,007.81</td>
</tr>
<tr>
<td>CORN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OATS</td>
<td>$1,046</td>
<td>$1,147.46</td>
</tr>
<tr>
<td>CORN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Grain**
- 2017: $594
- 2018: $804.96

**Straw**
- 2017: $-
- 2018: $202.85

**Hay**
- 2017: $-
- 2018: $-

**Practical Farmers of Iowa**

<table>
<thead>
<tr>
<th>CROP:</th>
<th>2017 REVENUE</th>
<th>2018 REVENUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OATS</td>
<td>$389</td>
<td>$916.50</td>
</tr>
<tr>
<td>CORN</td>
<td>$280</td>
<td>$230.96</td>
</tr>
<tr>
<td></td>
<td>$377</td>
<td>$-</td>
</tr>
</tbody>
</table>
2. Cut back input costs

<table>
<thead>
<tr>
<th>YEAR:</th>
<th>2017</th>
<th>2018</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>CROP:</td>
<td>SOYBEAN</td>
<td>CORN</td>
<td>OATS</td>
<td>CORN</td>
</tr>
<tr>
<td>Inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>$93.45</td>
<td>$154.99</td>
<td>$344.40</td>
<td>$31.20</td>
</tr>
<tr>
<td>Application</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate</td>
<td>$14.96</td>
<td>$31.98</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>Potash</td>
<td>$20.75</td>
<td>$17.55</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>Manure</td>
<td>$-</td>
<td>$-</td>
<td>$190.40</td>
<td>$-</td>
</tr>
<tr>
<td>(Application)</td>
<td>$-</td>
<td>$-</td>
<td>$154.00</td>
<td>$-</td>
</tr>
<tr>
<td>Herbicide</td>
<td>$40.00</td>
<td>$48.36</td>
<td>$-</td>
<td>$27.00</td>
</tr>
<tr>
<td>Machinery</td>
<td>$8.40</td>
<td>$4.20</td>
<td>$-</td>
<td>$4.20</td>
</tr>
<tr>
<td>Insecticide</td>
<td>$-</td>
<td>$-</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>Fungicide</td>
<td>$-</td>
<td>$-</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>Lime</td>
<td>$9.34</td>
<td>$4.90</td>
<td>$-</td>
<td>$-</td>
</tr>
</tbody>
</table>
### 3. Count the whole rotation

<table>
<thead>
<tr>
<th>Year</th>
<th>Iowa State University</th>
<th>Practical Farmers of Iowa</th>
<th>Practical Farmers of Iowa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean</td>
<td>Corn</td>
<td>Oats</td>
</tr>
<tr>
<td><strong>Total Cost (Operating plus Overhead)</strong></td>
<td></td>
<td>$503.15</td>
<td>$827.24</td>
</tr>
<tr>
<td><strong>Net Return over Total Cost</strong></td>
<td></td>
<td>$90.47</td>
<td>$180.57</td>
</tr>
<tr>
<td><strong>Net Return over Operating Cost</strong></td>
<td></td>
<td>$351.88</td>
<td>$460.10</td>
</tr>
</tbody>
</table>

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**Summary:**

<table>
<thead>
<tr>
<th></th>
<th>Iowa State University</th>
<th>Practical Farmers of Iowa</th>
<th>Practical Farmers of Iowa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Two-Year Net Return over Total Cost</strong></td>
<td>$271.04</td>
<td>$609.72</td>
<td>$658.26</td>
</tr>
<tr>
<td><strong>Annual Net Return over Total Cost</strong></td>
<td>$135.52</td>
<td>$304.86</td>
<td>$329.13</td>
</tr>
<tr>
<td><strong>Annual Net Return over Corn-Soybean Rotation</strong></td>
<td>$-</td>
<td>$169.34</td>
<td>$249.11</td>
</tr>
</tbody>
</table>
Can it pay?? Yes!

## Iowa Enterprise Budget per Acre for Small Grain Rotation versus Corn-Soybean Rotation

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2018</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>YEAR:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CROP:</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>SOYBEAN</td>
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<tr>
<td>CORN</td>
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<td>OATS</td>
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</tr>
<tr>
<td>CORN</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td>$503.15</td>
<td>$827.24</td>
<td>$889.48</td>
<td>$694.60</td>
</tr>
<tr>
<td><strong>NET RETURN OVER TOTAL COST</strong></td>
<td>$90.47</td>
<td>$180.57</td>
<td>$156.86</td>
<td>$452.86</td>
</tr>
<tr>
<td><strong>NET RETURN OVER OPERATING COST</strong></td>
<td>$351.88</td>
<td>$460.10</td>
<td>$428.69</td>
<td>$728.59</td>
</tr>
</tbody>
</table>

### SUMMARY:

- **TWO-YEAR NET RETURN OVER TOTAL COST**: $271.04, $609.72
- **ANNUAL NET RETURN OVER TOTAL COST**: $135.52, $304.86
- **ANNUAL NET RETURN OVER CORN-SOYBEAN ROTATION**: $- $169.34
• While small grain + legume cover crop results in 50 lbs less fertilizer to following corn without sacrificing corn yields (instant gratification!), Farmers continue to see delay in increasing yields, require support in early years (delayed gratification)

• Farmer will need to work to establish reliable, profitable markets for grain, straw, hay if these are new enterprises

• Learning and fine-tuning cover crop management into a corn crop can lead to yield drag on corn

• Amount of fertilizer and herbicide that can be cut starts small and increases over time due to biological process limitations

• Farmer may have to invest in new equipment to plant and harvest small grains and hay
• Farmer-feeders are currently feeding small grains.

• **Infographic** outlines appropriate inclusion and corn replacement rates for various small grains in rations. Based on a 2017 **meta-analysis**.