It’s Not Just Dirt Anymore
by Jay Fuhrer
FIGURE 12.3 A simplified representation of the global carbon cycle emphasizing those pools of carbon which interact with the atmosphere. The numbers in the boxes indicate the petagrams (Pg = $10^{15}$ g) of carbon stored in the major pools. The numbers by the arrows show the amount of carbon annually flowing (Pg/yr) by various processes between the pools. Note that the soil contains almost twice as much carbon as the vegetation and the atmosphere combined. Imbalances caused by human activities can be seen in the flow of carbon to the atmosphere from fossil fuel burning (7.5) and in the fact that more carbon is leaving ($62 + 0.5$) than entering (60) the soil. These imbalances are only partially offset by increased absorption of carbon by the oceans. The end result is that a total of 221.5 Pg/yr enters the atmosphere while only 215 Pg/yr of carbon is removed. It is easy to see why carbon dioxide levels in the atmosphere are rising. [Data from IPCC (2007); soil carbon estimate from Batjes (1996)]
Dust Storms Still Causing Damage in N.D.

The greatest export of phosphate is due to wind erosion.

Few people are aware that North Dakota has exported phosphate since the 1880s, according to Dave Fransen, North Dakota State University Extension Service soil science professor and soil specialist.

When settlers came to North Dakota, many wanted to farm but lacked the skills or tools to do so. Some migrated to the state from the East, where the soils and environment were very different. Those who came to North Dakota in the 1880s found an area that had few roads, no infrastructure, few neighbors and little source of income.

“Across the prairie were scattered millions of pounds of buffalo bones,” Fransen says. “Some of these bones contained ‘buffalo bone ash,’ from the salting of buffalo during the earlier migration of hunters looking for buffalo to shoot.”

The bones were gathered by the settlers and taken to railroad depots at Killendale, Port Totten and other locations.

The bone was shipped in a barrel of up to 8,125 lbs, which was only a few days’ journey in those days,” Fransen says. “The settlers used the bone for food to survive or upgrade their household items.” From about 1880 to 1890, when the trade was at its height, an estimate is that about 30 million pounds of bone was shipped out for fertilizer and industrial use from the Dakota Territory.

The nutrient content of bone is about 3-15-0, or about 15 percent phosphate (P). Using these figures, we can estimate that about two years of phosphate applications were shipped at a cost of $400 per ton.

“Today, the greatest export of P is due to wind erosion,” Fransen says. “North Dakota is one of the windiest regions on Earth. Settlers used farming techniques from the old country or the eastern U.S., which did not consider wind erosion. So when the soil was dry, the soil blew.”

Dust storms were very common in the 1930s, ‘40s and even today. The dust doesn’t just settle on the fields from the 1930s. It can be washed into our streams from the 1930s. It doesn’t settle like dust clouds to 14,000 feet in elevation, so dust can travel thousands of miles.

The P content of the dust settled in East Coast states was 19 times that of what remains today in the prairie, and the wind still blows today.

During the 1930s, North Dakota lost the equivalent of 40 years of P application at present rates.

Des Moines struggling with nitrate levels in drinking water

By DAVID PITTMAN
Associated Press

DES MOINES, Iowa —

Two rivers that flow through a city of 500,000 people in the Des Moines area show nitrate levels high enough to make it unsafe for some to drink, a concentration experts haven’t seen in the full that likely stems from especially wet weather in recent months.

The utility that supplies Des Moines and most of its suburbs had workers blending river water with other sources to lower the nitrate levels, but the situation may be nearing the point at which the city starts a process that costs about $7,000 a day to remove them. If that happens, the utility has threatened to raise its rates.

On Friday, the nitrate level in the Des Moines River was at 12.8 parts per million and the Raccoon River was at 13.7. The U.S. Environmental Protection Agency requires officials to inform the public about safety risks at 10 parts per million.

Iowa and other states often have problems with nitrates in the spring, when rain washes un specialists from farm fields. But it’s unheard of to have spikes so high in November, said Des Moines Water Works CEO Bill Stowe. Scientists believe the current problem is caused by the wet weather in the late summer and fall, which sent nitrogen remaining in the soil washing downstream.

“What we’re seeing are numbers late into the fall and into the early winter like we’ve never seen before.”

Bill Stowe, Des Moines Water Works CEO

“What we’re seeing are numbers late into the fall and into the early winter like we’ve never seen before,” Stowe said.

Stowe said far farmers were keeping the drinking water at just over 8 ppm. Water above 10 ppm can be deadly to children younger than 6 months because the chemical can reduce the amount of oxygen carried in their blood. Pregnant women and adults with reduced stomach acidity are advised not to drink water above this limit.

In spring 2013, nitrate levels hit all-time highs on both rivers when a wet spring washed nitrogen from fields after a severe drought. Water Works mechanically cleaned the water at a cost of $900,000 until nitrate levels subsided more than two months later. If it happens again, Stowe said the utility likely will sue, alleging the state is violating the Clean Water Act by failing to reduce the nitrogen levels in rivers.

Monitors in rivers throughout the nation show no other sites with such high nitrate levels. But the issue is especially severe in parts of Iowa given the intense farming and tilting of land. More than 2 million acres in west-central Iowa drain into the Raccoon River, most of it cropland or livestock farms. An estimated 78 percent uses man-made drainage tiles to quickly move water downstream.

Although Iowa began a voluntary program in May 2013 that encourages farmers to make changes to reduce runoff, Stowe and environmental groups argue that strategy is toothless and lacks measurable benchmarks or a timeline for improvement.

For years, environmental groups have called for the state to regulate livestock farms, much as they already do for city wastewater treatment plans, which must have permits that limit release of contaminants into rivers. They’re also seeking ways to measure and limit the release of nitrates from fields where tile has been laid underground.

Iowa DNR spokesman Kevin Baskins said the state acknowledges the need to improve its waterways, but that it will take time for voluntary efforts to work. He said farmers are beginning conservation practices and government grants are giving them incentives.

“But isn’t something where you just get instant results?” Baskins said. “We didn’t get into the kind of situation we have today in terms of excess nutrients overnight and we won’t get out of it overnight.”

Significantly reducing nitrogen levels likely requires slowing the flow of water into rivers by setting up wetlands or planting grasses or other cover crops on harvested fields, allowing the plants to retain water and consume excess chemicals.

“We have millions of acres on which we need to implement this stuff,” said Chris Jones, an environmental scientist with the Iowa Soybean Association who has studied the Raccoon River.
BISMARCK WSFO AP, NORTH DAKOTA (320819)

Period of Record Monthly Climate Summary

Period of Record: 7/1/1948 to 12/31/2007

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
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</thead>
<tbody>
<tr>
<td>Average Max. Temperature (°F)</td>
<td>20.1</td>
<td>26.6</td>
<td>38.2</td>
<td>55.4</td>
<td>68.1</td>
<td>77.2</td>
<td>84.6</td>
<td>83.4</td>
<td>71.8</td>
<td>58.6</td>
<td>39.4</td>
<td>26.2</td>
<td>54.1</td>
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<tr>
<td>Average Min. Temperature (°F)</td>
<td>-1.5</td>
<td>5.5</td>
<td>17.3</td>
<td>30.7</td>
<td>42.4</td>
<td>51.9</td>
<td>57.0</td>
<td>54.8</td>
<td>44.0</td>
<td>32.4</td>
<td>18.2</td>
<td>5.4</td>
<td>29.8</td>
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<tr>
<td>Average Total Precipitation (in.)</td>
<td>0.47</td>
<td>0.47</td>
<td>0.78</td>
<td>1.39</td>
<td>2.33</td>
<td>2.94</td>
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<td>1.02</td>
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<td>Average Total SnowFall (in.)</td>
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<td>7.2</td>
<td>8.5</td>
<td>3.6</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>1.6</td>
<td>6.5</td>
<td>7.6</td>
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<tr>
<td>Average Snow Depth (in.)</td>
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<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
The Soil Food Web
Working Toward A Higher Quality No-till
The “Below Ground” Players...

• **Bacteria** -
  Decomposer of simple carbon chains (low carbon residue).
  Little bag of fertilizer.
  One bacterium can produce 5 billion offspring in 12 hours (food available).
  Feed on root exudates.
The Soil Food Web
Working Toward A Higher Quality No-till
The “Below Ground” Players...

• **Fungi**-

  *Saprophytic*-primary decomposer of complex carbon chains (high carbon chains).

  *Mycorrhizal*-transports nutrients.

  Little bag of fertilizer.

  Forms the soils glue (glomalin) along with the plant roots exudates.

Soil Biology Primer
The Soil Food Web
Working Toward A Higher Quality No-till
The “Below Ground” Players...

- **Protozoa** - Mineralize nutrients by eating the little guys (fungi and bacteria).
  - Consumes an average of 10,000 bacteria per day.
- Amoebae – large
- Ciliates – medium
- Flagellates - small
The Soil Food Web
Working Toward A Higher Quality No-till
The “Below Ground” Players...

- **Nematodes**
  - Mineralize nutrients by eating the little guys (fungi and bacteria).
  - Taxi for the bacteria & fungi.
  - Locate food by temperature.
  - Types: Herbivore, Bacterivores, Fungivores, and Predator.
  - Large in size, compacted soil restricts their travel.
The Soil Food Web
Working Toward A Higher Quality No-till
The “Below Ground” Players...

• **Actinomycetes**-
  - Source of antibiotics: tetracycline, neomycin, streptomycin.
  - Controls bacteria in the soil and in humans.
  - Convert dinitrogen gas to ammonia.
  - Decompose SOM.
  - Cure compost.
What Do They Weigh?

- Bacteria  
  2,000 - 2,500 Lbs/Ac  
  2,200 - 2800 Kilograms/Hectare

- Fungi  
  1,000 - 15,000 Lbs/Ac  
  1,200 – 17,000 Kilograms/Hectare

- Protozoa  
  20 - 300 Lbs/Ac

- Nematodes  
  10 - 300 Lbs/Ac  
  13 – 340 Kilograms/Hectare

- Microbes in Humans  
  3 lbs/Person

Source:
- The Nature and Properties of Soils  
  Brady and Weil, Fourteenth Edition.  
  Soil Biology Primer.  
  National Geographic, Nathan Wolfe, January 2013.
The “Above Ground” Players Include the Menoken Farm plus....

Gabe Brown
Brown’s Ranch

Glenn Bauer
Bacon Heights Farms

Marilyn Richter
Richter Farms

Jerry Doan
Black Leg Ranch
Soil Health: the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.

Soil Health Principles:

• Soil armor - keep the soil covered
• Minimize soil disturbance
• Maximize diversity of plants in the rotation – 4 crop types
• Maintain living roots in the soil - cover crops
• Integrate livestock
Soil Health Principle
Number 1:
Armor – Keep The Soil Covered
High Carbon Residue
Missed Opportunities

Biomass Production
Annual Cropping Systems

Missed opportunities for resource assimilation and dry matter production

Dry matter production or resource loss (mass/time)

Spring Summer Autumn Winter

Annual grain crop Winter cover crop

Additional opportunities for resource losses

after A.H. Heggenstaller

A. H. Heggenstaller, University of Alberta
Living Armor - Low Carbon Residue
Especially Helpful In Wet Springs
The Menoken Farm
Cover Crop Combination – Mid Carbon Residue
SOM’S Revolving Nutrient Bank Account.

- A furrow slice is 6 7/8 inches = 2,000,000 lbs of soil per acre.
- 1.0% SOM X 2,000,000 lbs = 20,000 lbs of SOM per acre.
- 1.0% SOM = approximately 10,000 lbs Carbon, 1,000 lbs Nitrogen, 100 lbs Phosphorous, and 100 lbs of Sulfur.
- Mineralization Rate = 2-3% from Organic N to Inorganic N, which does not stop at harvest time.
Nutrient Cycling

Carbon/Nitrogen Ratios

• Soil Microorganisms, Bacteria * 5/1
• SOM, Mollisol Ap horizon * 11/1
• Rotted barnyard manure * 20/1
• Mature Alfalfa Hay * 25/1
• Protozoa ** 30/1
• Corn Stover * 57/1
• Wheat Straw * 80/1
• Newspaper * 120/1
• Deciduous Wood ** 300/1

Source:
   DR. Nyle C. Brady and DR. Ray R. Weil
** DR. Elaine R. Ingham, Soil Food Web
Soil Health Principle
Number 2: Minimize Soil Disturbance
Compaction’s Big Three

- Tillage
- No armor
- Traffic
Glenn Bauer – Bacon Heights Farms
Two Tillage Compaction Layers
Using Cover Crops to address Resource Concerns

- Infiltration
- Compaction
- Surface Saturation
Soil Aggregates on a millet root. Richter Farms

Glomalin and hyphae show well with a green color in the lab.

Dr. Kris Nichols, Microbiologist, ARS, Mandan, ND
Enlarged Soil Aggregates

Glomalin and hypae

Dr. Kris Nichols, Microbiologist, ARS, Mandan, ND, 2006
The Menoken Farm
Infiltration – Silt Loam Soil – 5 Years Of No-till Seeding
Minimal Disturbance Allows Soils To Rebuild

6 Inch Ring (15 Centimeters)
Stop Watch
Hammer & Block Of Wood

Plastic Wrap
500 ML Water
Apply and Time 500 ML’s Twice

Healthy Soils With Good Soil Aggregates Have Rapid Infiltration
Degraded Soils With Poor Soil Aggregates Have Slow Infiltration
The Menoken Farm Infiltration

Poor Infiltration
Bottom Of The Ring Is Mostly Dry
Water Ponds On Top Of The Soil Profile

Good Infiltration
Bottom Of The Ring Is Wet
Water Enters The Soil Profile Rapidly

First 500 ML of Water Average Infiltration Time = 6 Minutes – 57 Seconds
Second 500 ML of Water Average Infiltration Time = 18 Minutes – 54 Seconds
## The Menoken Farm
### No-Till Cropping System. 2009 - 2014

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Soy/CC</td>
<td>Canola/CC</td>
<td>Triti/Vetch</td>
<td>Corn</td>
<td>Canola/Pea</td>
<td>Pasture</td>
<td>0.93</td>
</tr>
<tr>
<td>2</td>
<td>Pea/CC</td>
<td>Cover Crop</td>
<td>Corn</td>
<td>Wht/Lentil</td>
<td>Corn</td>
<td>Cover Crop</td>
<td>0.95</td>
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<tr>
<td>3 Fert</td>
<td>Wheat</td>
<td>Wheat</td>
<td>Wheat</td>
<td>Wheat</td>
<td>Wheat</td>
<td>Wheat</td>
<td>1.26</td>
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<tr>
<td>4</td>
<td>Pea/CC</td>
<td>Corn</td>
<td>Pea/CC</td>
<td>Cover Crop</td>
<td>Corn</td>
<td>Yellow Pea</td>
<td>0.90</td>
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<tr>
<td>5</td>
<td>Pea/CC</td>
<td>Corn</td>
<td>Pea/CC</td>
<td>Wheat/CC</td>
<td>Cover Crop</td>
<td>Corn/CC</td>
<td>1.11</td>
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<tr>
<td>6</td>
<td>Pea/CC</td>
<td>Corn</td>
<td>Cover Crop</td>
<td>Corn</td>
<td>Cover Crop</td>
<td>Corn</td>
<td>1.06</td>
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<tr>
<td>7</td>
<td>Pea/CC</td>
<td>Corn</td>
<td>Pea/CC</td>
<td>Wheat/CC</td>
<td>Sunfl/CC</td>
<td>Cover Crop</td>
<td>0.90</td>
</tr>
<tr>
<td>8</td>
<td>Canola</td>
<td>Pea/CC</td>
<td>Wheat</td>
<td>Cover Crop</td>
<td>Corn</td>
<td>Sunfl/cc</td>
<td>0.81</td>
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<tr>
<td>9</td>
<td>Flax/Lentil</td>
<td>Cover Crop</td>
<td>Corn</td>
<td>Canola/Pea</td>
<td>Wheat/CC</td>
<td>Sunfl/cc</td>
<td>0.89</td>
</tr>
<tr>
<td>10</td>
<td>3 Sisters</td>
<td>3 Sisters</td>
<td>Triti/Vetch</td>
<td>Triti/Vetch</td>
<td>Sunfl/CC</td>
<td>Pasture</td>
<td>1.03</td>
</tr>
</tbody>
</table>
Soil Health Principle
Number 3: Crop Diversity
“The type and diversity of organic residues added to a soil can influence the type and diversity of organisms that make up the soil community. “ The Nature and Properties of Soils, 14th Edition; Chapter 12.5
## Diversity - Crop Types.

<table>
<thead>
<tr>
<th>Cool Season Grass</th>
<th>Cool Season Broadleaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Canola</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>Crambe</td>
</tr>
<tr>
<td>Oat</td>
<td>Flax</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>Lentils</td>
</tr>
<tr>
<td>Winter Rye</td>
<td>Oilseed Radish</td>
</tr>
<tr>
<td>Winter Triticale</td>
<td>Mustard</td>
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<tr>
<td>Winter Wheat</td>
<td>Forage Canola</td>
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<tr>
<td></td>
<td>Red Clover</td>
</tr>
<tr>
<td></td>
<td>Sweet Clover</td>
</tr>
<tr>
<td></td>
<td>Turnip</td>
</tr>
<tr>
<td></td>
<td>Pasja</td>
</tr>
<tr>
<td></td>
<td>Pea</td>
</tr>
<tr>
<td></td>
<td>Lupin</td>
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</table>
## Diversity - Crop Types

<table>
<thead>
<tr>
<th>Warm Season Broadleaf</th>
<th>Warm Season Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Corn</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>Proso Millet</td>
</tr>
<tr>
<td>Chick Pea</td>
<td>Pearl Millet</td>
</tr>
<tr>
<td>Amaranth</td>
<td>Sorghum</td>
</tr>
<tr>
<td>Cowpea</td>
<td>Sudan</td>
</tr>
<tr>
<td>Soybean</td>
<td></td>
</tr>
<tr>
<td>Safflower</td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td></td>
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</table>
The Menoken Farm
Cover Crop Monocultures 2006
Pounds Of Production
1260 lbs To 2070 lbs Per Acre
The Menoken Farm
Cover Crop Cocktails 2006
Pounds Of Production
4350 lbs To 4785 lbs Per Acre
Team Work Above And Below The Soil Surface

2006: June 1 – August 15 = 1.97 Inches (5 Centimeters) Precipitation
North Dakota Agricultural Weather Network
The Menoken Farm 2006
We Manage Soil Temperatures
With Armor and Crop Canopy.

Cover Crop Combination

Cover Crop Monoculture
### Professional Soil Test Interpretation

**Based on the Drying-Rewetting Pulse**

<table>
<thead>
<tr>
<th>Test Result ppm CO₂-C</th>
<th>N-Mineralization Potential</th>
<th>Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 100</td>
<td>High N-Potential soil. Likely sufficient N for most crops.</td>
<td>Soil very well supplied with organic matter. Biomass &gt; 2,500 ppm</td>
</tr>
<tr>
<td>61 - 100</td>
<td>Moderately-high. This soil has limited need for supplemental N.</td>
<td>Ideal state of biological activity and adequate organic matter level.</td>
</tr>
<tr>
<td>31 - 60</td>
<td>Moderate Level. Supplemental N is most likely indicated.</td>
<td>Requires new applications of stable organic matter. Biomass &lt; 1,200 ppm</td>
</tr>
<tr>
<td>6 - 30</td>
<td>Moderate-Low - will not provide sufficient N for most crops</td>
<td>Low in organic structure and microbial activity. Biomass &lt; 500 ppm</td>
</tr>
<tr>
<td>0 - 5</td>
<td>Little biological activity; requires significant fertilization.</td>
<td>Very inactive soil. Biomass &lt; 100 ppm. Consider long-term care.</td>
</tr>
</tbody>
</table>

*Note: N-mineralization and microbial biomass can be estimated based on the 24h soil CO₂ burst as shown in the instance at the right. The quantity of soil microbial biomass is generally about 20-times the CO₂-C rate. The net nitrogen release varies per unit of CO₂ burst and is generally 0.7-1.0 times the indicated CO₂-C rate, and is higher with better humus quality. A conservative but reliable estimate for N release in lb/a is to take half the CO₂-C rate as indicated by the Solvita test. This amount of N can be subtracted from fertilizer rates.*

**The response of soil to additions of manure or compost generally results in linear CO₂ increases so long as the C:N of the additives is below 20. The effect will decline slowly over time. Research trials show that each added 10-ton/a of stable compost increases soil respiration by about 0.1 Solvita Unit or about 2-3 ppm expressed as CO₂-C. For an acre slice of soil, weighing 1 million kg (2-million lbs) this is 2kg (4 lbs) of carbon or 7.5kg (15 lbs) of CO₂.**
The Menoken Farm
2012 Wheat Yields
Field 7 = 38.3 Bu/ac

High Crop Diversity With Covers
Field 7 (No Commercial Fertility
2009 Pea/Cover Crop
2010 Corn
2011 Pea/Cover Crop
2012 Wheat/Cover Crop

38.3 Bu Wheat Yield Requires
N = 46 lbs   P2O5 = 19 lbs

Soil Test – May 15, 2012
Field 7
Solvita 55 PPM
Inorganic N 41.7 lbs
Organic N 50.5 lbs
Total N 92.2 lbs

Inorganic P2O5 50.1 lbs
Organic P2O5 16.2 lbs
Total P2O5 66.3 lbs

Note
The Menoken Farm
2012 Wheat Yields
Field 3  45.4 Bu/Ac

Low Crop Diversity Without Covers
Field 3 Full Commercial Fertility
2009 – 2012 Wheat

Soil Test – May 15, 2012
Field 3
Solvita 43.8 PPM
Inorganic N 94.4 lbs/ac
Organic N 32.0 lbs/ac
Total N 126.4 lbs/ac

Note

45.4 Bu Wheat Yield Requires
N = 55 lbs  P2O5 = 23 lbs

Inorganic P2O5  39.6 lbs
Organic P2O5  13.3 lbs
Total P2O5  52.9 lbs
Seeded the Cool Season Species - November 2013
Seeded the Warm Season Species – June 2014

Side Oats Grama 1.5
Switch Grass 1.7
Blue Flax .05
Yellow Coneflower .05
Maximilian Sunflower .05
Alfalfa 1
Sweet Clover .75
Black Eyed Susan .05
Sainforn 2.25
Canada Milkvetch .05
Evening Primrose .05
Plains Coreopsis .05
Big Bluestem 1.5
Indian Grass .4
Little Bluestem .25
Blue Grama .2
Meadow Brome 2
Western Wheat 2
Green Needle 2
Green Wheat 2
Intermediate Wheat 2
Total of 21 Species

New Pasture for 2015
Soil Health Principle
Number 4:
Continual Live Plant
(Finding the Fit)
Nurture Nature with System Synergies

No Tillage
Minimum carbon loss

Cover Crops
Maximum carbon input

Carbon management

Sustainability

Dr. Don Reicosky
ARS – Morris, MN
Triticale and Hairy Vetch

Rolling the Cover

Good Kill with the Roller
Mob Grazing Sheep
90 Dry Ewes
Approximately 1/5 Acre Per Day

90 Ewes X 165 Lbs Each = 14850 Total Lbs
Divided by 0.20 Acres = 74,250 Lbs /Ac

Warm Season Cover Crop Mixture Seeded
July 11, 2011 South Half

We Demand
Cover Crop Combinations
Or Else!
Sunflower and 10 Broadleaf Covers
Fall Seeded Cover Crop
Passive Armor and Active Armor
Both are food sources
<table>
<thead>
<tr>
<th></th>
<th>High Crop Diversity With Cover Crops</th>
<th>High Crop Diversity Without Cover Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Biology</td>
<td>1999 ng/g soil</td>
<td>1528 ng/g soil</td>
</tr>
<tr>
<td>Actinomycetes</td>
<td>191 ng/g soil</td>
<td>133 ng/g soil</td>
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<tr>
<td>Bacteria</td>
<td>1625 ng/g soil</td>
<td>1251 ng/g soil</td>
</tr>
<tr>
<td>Fungi</td>
<td>138 ng/g soil</td>
<td>115 ng/g soil</td>
</tr>
<tr>
<td>Ratio Bacteria:Fungi</td>
<td>11.7</td>
<td>11</td>
</tr>
<tr>
<td>Mycorrhiza</td>
<td>38 ng/g soil</td>
<td>41 ng/s soil</td>
</tr>
</tbody>
</table>

Richter Farms 2011
Richter Farms
High Crop Diversity With Cover Crops
2012 Corn Yields - Fertilized
SE31-138-78 Middle Field
Yield = 100 Bu/Ac

Crop History
2009 Oat & Pea/Cover Crop
2010 Corn
2011 Triticale & Vetch/Cover Crop
2012 Corn

100 Bu Corn Yield Requires
N = 100 lbs   P2O5 = 50 lbs

Note
Solvita & Inorganic N
With Covers

Soil Test – May 10, 2012
SW31-138-78
Solvita 49.6 PPM
Inorganic N 18.2 lbs
Organic N 49.1 lbs
Total N 67.3 lbs

Inorganic P2O5 73.9 lbs
Organic P2O5 18.5 lbs
Total P2O5 92.4 lbs
Richter Farms
High Crop Diversity Without Cover Crops
2012 Sunflower Yields - Fertilized
SW36-138-79
Yield = 2371 lbs

Crop History
2009 Corn
2010 Lentil
2011 Corn
2012 Sunflower

Soil Test – May 10, 2012
Field SW36-138-79
Solvita 38.8 PPM
Inorganic N 42.3 lbs
Organic N 34.6 lbs
Total N 76.9 lbs

Note
Solvita & Inorganic N Without Covers

2371 lb Sunflower Yield Requires
N = 119 lbs  P2O5 = 53 lbs

Inorganic P2O5 40.5 lbs
Organic P2O5 19.8 lbs
Total P2O5 60.3 lbs
Soil Health Principle
Number 5: Livestock Integration
Mob Grazing On Cropland
Gabe Brown - Before
Mob Grazing On Cropland
Gabe Brown - After
Low Carbon
Mob Grazing On Cropland
Gabe Brown - Before
Mob Grazing On Cropland
Gabe Brown - After
High Carbon Material
<table>
<thead>
<tr>
<th>Two Years Mob Grazing</th>
<th>No Mob Grazing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>West Side of Shelterbelt</strong></td>
<td><strong>East Side of Shelterbelt</strong></td>
</tr>
<tr>
<td>Total Biology – 6105 ng/g soil</td>
<td>Total Biology – 4228 ng/g soil</td>
</tr>
<tr>
<td>Actinomycetes – 213 ng/g soil</td>
<td>Actinomycetes – 418 ng/g soil</td>
</tr>
<tr>
<td>Bacteria – 4417 ng/g soil</td>
<td>Bacteria – 3349 ng/g soil</td>
</tr>
<tr>
<td>Fungi – 786 ng/g soil</td>
<td>Fungi – 386 ng/g soil</td>
</tr>
<tr>
<td>Ratio Bacteria : Fungi – 5.6</td>
<td>Ratio Bacteria : Fungi – 8.7</td>
</tr>
<tr>
<td>Mycorrhiza – 230 ng/g soil</td>
<td>Mycorrhiza – 145 ng/g soil</td>
</tr>
</tbody>
</table>

Gabe Brown
Brown Ranch
2012 Corn Yields
West Side of WB
142 Bu/Ac

Soil Test – May 15, 2012
West Side of WB
Solvita 65.6 PPM
Inorganic N 56 lbs
Organic N 103 lbs
Total N 159 lbs

Crop History
Mob Grazed in 2010 and 2011
2009 Corn
2010 Cover Crop/Cover Crop
2011 Triticale & Vetch/Cover Crop
2012 Corn

142 Bu Corn Yield Requires
N = 142 lbs  P2O5 = 71 lbs

Inorganic P2O5 230.1 lbs
Organic P2O5 19.0 lbs
Total P2O5 249.1 lbs
Season Long Cover Crops
Added To High Crop Diversity Rotation

Jerry Doan – Black Leg Ranch
Field 1
Corn 2010
Season Long Cover Crop 2011

- Total Biology – 1774 ng/g soil
- Bacteria – 1473 ng/g soil
- Actinomycetes – 123 ng/g soil
- Fungi – 147 ng/g soil
- Ratio Bacteria:Fungi – 10.0
- Mycorrhiza – 37 ng/g soil

Field 2
Season Long Cover Crop 2010
Season Long Cover Crop 2011

- Total Biology – 3312 ng/g soil
- Bacteria – 2510 ng/g soil
- Actinomycetes – 249 ng/g soil
- Fungi – 513 ng/g soil
- Ratio Bacteria:Fungi – 4.9
- Mycorrhiza – 251 ng/g soil

Jerry Doan
Biological Soil Tests
2014 Cover Crop Mix

- #/acre Species
- 5 Super sweetsorg / sudan
- 5 BMR grazing corn
- 3 Soybean
- 1 Cowpea
- 1 Mong bean
- 2 Forage collards
- 1 Hunter turnips
- 1 Wildlife grain sorghum
- 1 German millet
- 1 Berseem Clover, Crimson Clover, Arrowleaf Clover
- 1 Sunflower
- 1 Buckwheat, Oats, Safflower

Total 23# Cost $27.00/ acre
Native Rangeland - Nitrogen Balance
Inorganic and Organic

<table>
<thead>
<tr>
<th>Location</th>
<th>Inorganic</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Angus Ranch</td>
<td>6 lbs</td>
<td>57 lbs</td>
</tr>
<tr>
<td>Berg Ranch</td>
<td>21 lbs</td>
<td>67 lbs</td>
</tr>
<tr>
<td>Winkler Ranch</td>
<td>5 lbs</td>
<td>80 lbs</td>
</tr>
<tr>
<td>Black Leg Ranch</td>
<td>26 lbs</td>
<td>49 lbs</td>
</tr>
<tr>
<td>(Cropland)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# 2014 Sunflower Fertilization

## 71 Bushel Yield Goal – 2000 lbs

<table>
<thead>
<tr>
<th></th>
<th>Standard Production Model</th>
<th>Haney Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required</strong></td>
<td>50 lbs N &amp; 28 lbs P2O5</td>
<td>50 lbs N &amp; 28 lbs P2O5</td>
</tr>
<tr>
<td><strong>Available</strong></td>
<td>26 lbs N &amp; 10 lbs P2O5</td>
<td>48 lbs N &amp; 18 lbs P2O5</td>
</tr>
<tr>
<td><strong>Applied</strong></td>
<td>24 lbs N &amp; 18 lbs P2O5</td>
<td>2 lbs N &amp; 10 lbs P2O5</td>
</tr>
</tbody>
</table>

**Savings:** 22 lbs N & 8 lbs P2O5
## NutriSolutions

### Report Number: 14055
Sample Date: Aug 26 2014 2:53PM

<table>
<thead>
<tr>
<th>Result</th>
<th>Comparative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Normal: 3.0% - 5.00%</td>
</tr>
<tr>
<td>3.70% / N</td>
<td>Adequate</td>
</tr>
<tr>
<td>Potassium</td>
<td>Normal: 4% - 6%</td>
</tr>
<tr>
<td>4% / K</td>
<td>Adequate</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>Normal: 0.33% - 0.55%</td>
</tr>
<tr>
<td>0.38% / P</td>
<td>Adequate</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Normal: 0.33% - 1.0%</td>
</tr>
<tr>
<td>0.71% / Mg</td>
<td>Adequate</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Normal: 0.45% - 0.55%</td>
</tr>
<tr>
<td>0.42% / S</td>
<td>Responsive</td>
</tr>
<tr>
<td>Calcium</td>
<td>Normal: 2.0% - 3.0%</td>
</tr>
<tr>
<td>3.35% / Ca</td>
<td>Excessive</td>
</tr>
<tr>
<td>Zinc</td>
<td>Normal: 30 - 75 ppmppm</td>
</tr>
<tr>
<td>49ppm / Zn</td>
<td>Adequate</td>
</tr>
<tr>
<td>Boron</td>
<td>Normal: 45 - 60 ppmppm</td>
</tr>
<tr>
<td>111ppm / B</td>
<td>Excessive</td>
</tr>
<tr>
<td>Manganese</td>
<td>Normal: 70 - 150 ppmppm</td>
</tr>
<tr>
<td>102ppm / Mn</td>
<td>Adequate</td>
</tr>
<tr>
<td>Iron</td>
<td>Normal: 70 - 150 ppmppm</td>
</tr>
<tr>
<td>90ppm / Fe</td>
<td>Adequate</td>
</tr>
<tr>
<td>Copper</td>
<td>Normal: 9 - 30 ppmppm</td>
</tr>
<tr>
<td>26ppm / Cu</td>
<td>Adequate</td>
</tr>
</tbody>
</table>

Consult your local agronomist. The recommendations provided above are only recommendations. Excessive Nutrient Levels - above the level for optimum growth and development. Solutions control, such as weather and applicator factors; Winfield cannot predict or guarantee results.
Soil Test – May 15, 2012
Solvita  46 PPM
Inorganic P   21 lbs
Organic P      16 lbs
Total P            37 lbs

Inorganic N      17 lbs
Organic N         57 lbs
Total N              74 lbs

Crop History
2009 Sunflower
2010 Full Season CC Combination/W Grazed
2011 Full Season CC Combination/W Grazed

2012 Sunflower Yields
2200 lbs/ac
Jerry Doan
SW1/4
Reduced Fertility by 25%

Required (Nutrient Mgt Planner)
N = 110 lbs/ac  P2O5 = 50 lbs/ac
Forage Analysis April 14, 2014
Crude Protein 8.2%
TDN 56.1%

Nutrient Requirements 11 Months After Calving (University of Florida)
Crude Protein 7.78%
TDN 52.3%

Turn In Date: April 1, 2014
Hubbard Feeds Inc. Bismarck, ND
Forage Analysis Date: April 14, 2014
• Keep cattle on the land, out of corrals and watersheds
• Positive public perception
• Save costs

• **Quality of Life goes up/Profitability Improves**
Tying It All Together
What’s Happening In ND?
• “If the field has been in no-till five or more continuous years, subtract 50 lbs N/acre.”
“the difference in N recommendations between long-term no-till and conventional-till soils was between 40 and 50 pounds less N per acre for long term no-till soils”
Governor Jack Dalrymple signs a proclamation declaring January 6-12, 2013 as Soil Health Week.
North Dakota landowners, Chevrolet make nation's first carbon deal

November 17, 2014 1:00 am  •  By Brian Gehring

About 11,000 acres of North Dakota grasslands in six counties are at the center of a first-of-its-kind transaction to conserve grasslands while reducing carbon releases into the atmosphere.

In this groundbreaking deal, Chevrolet has purchased nearly 40,000 carbon credit reduction tons on working grasslands in the Prairie Pothole region of the state known as the Missouri Coteau, according to an announcement made today by the U.S. Department of Agriculture.

Robert Bonnie, USDA's undersecretary for natural resources and environment, said it's hoped the public-private partnership will open the door for additional grassland conservation in the future.

“Our hope is it serves as a model,” Bonnie said.

Innovative deal

The program allows private companies to buy carbon credits while private landowners are compensated for agreeing to not till grasslands.

When ground is tilled, underground carbon reserves are released into the atmosphere.

The land involved in the deal is located in Sheridan, Burleigh, Kidder, Emmons, McHenry and McIntosh counties, according to Billy Gascoigne, a Colorado economist and market specialist with Ducks Unlimited, which launched the project with the help of a $161,000 grant from USDA’s Natural Resources Conservation Service.

A total of 23 landowners are involved in the project, according to the NRCS.

Gascoigne said avoiding the conversion of grasslands to croplands benefits farmers and ranchers as well as the environment.

A new market

Carbon credits — a generic term for a tradeable certificate or permit as part of the American Carbon Registry — and carbon markets are part of national and international attempts to mitigate the growth of greenhouse gases thought to be linked to climate change.

The carbon storage potential of land can be scientifically measured, and the carbon credits are available to companies interested in purchasing carbon offsets.
New Soil Health positions for ND

- NDSU added 5 new Soil Health positions on April - 2012.
- NRCS added a new Soil Health position on August - 2014.
Factors Affecting the Balance between Gains and Losses of Organic Matter in Soils

<table>
<thead>
<tr>
<th>Factors Promoting Gains</th>
<th>Factors Promoting Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Green manures or Covers</td>
<td>• Erosion</td>
</tr>
<tr>
<td>• Conservation tillage</td>
<td>• Intensive tillage</td>
</tr>
<tr>
<td>• Return of plant residues</td>
<td>• Whole plant removal</td>
</tr>
<tr>
<td>• Low temperatures &amp; shading</td>
<td>• High temperatures &amp; exposures to sun</td>
</tr>
<tr>
<td>• Controlled grazing</td>
<td>• Overgrazing</td>
</tr>
<tr>
<td>• High soil moisture</td>
<td>• Low soil moisture</td>
</tr>
<tr>
<td>• Surface mulches</td>
<td>• Fire</td>
</tr>
<tr>
<td>• Application of compost &amp; manure</td>
<td>• Application of only inorganic materials</td>
</tr>
<tr>
<td>• Appropriate nitrogen levels</td>
<td>• Excessive mineral nitrogen</td>
</tr>
<tr>
<td>• High plant productivity</td>
<td>• Low plant productivity</td>
</tr>
<tr>
<td>• High plant root:shoot ratio</td>
<td>• Low plant root:shoot ratio</td>
</tr>
</tbody>
</table>

SOM’S Revolving Nutrient Bank Account.

- A furrow slice is 6 7/8 inches = 2,000,000 lbs of soil per acre.
- 1.0% SOM X 2,000,000 lbs = 20,000 lbs of SOM per acre.
- 1.0% SOM = approximately 10,000 lbs Carbon, 1,000 lbs Nitrogen, 100 lbs Phosphorous, and 100 lbs of Sulfur.
- Mineralization Rate = 2-3% from Organic N to Inorganic N, which does not stop at harvest time.
## Soil Organic Matter and Available Water Capacity

Inches of Water/One Foot of Soil

<table>
<thead>
<tr>
<th>Percent SOM</th>
<th>Sand</th>
<th>Silt Loam</th>
<th>Silty Clay Loam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>2</td>
<td>1.4</td>
<td>2.4</td>
<td>1.8</td>
</tr>
<tr>
<td>3</td>
<td>1.7</td>
<td>2.9</td>
<td>2.2</td>
</tr>
<tr>
<td>4</td>
<td>2.1</td>
<td>3.5</td>
<td>2.6</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>4.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Berman Hudson  
Journal Soil and Water Conservation 49(2) 189-194  
March – April 1994  
Summarized by:  
Dr. Mark Liebig, ARS, Mandan, ND  
Hal Weiser, Soil Scientist, NRCS, Bismarck, ND
## Cover Crop Energy Conservation – 1800 Lb Yield Goal

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Applied Per Acre Actual Pounds</th>
<th>Diesel Fuel EQ Gal/Lb N</th>
<th>Diesel Fuel EQ Gal/Ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Urea</td>
<td>90</td>
<td>0.129</td>
<td>11.6</td>
</tr>
<tr>
<td>Phosphorous P205</td>
<td>40.5</td>
<td>0.042</td>
<td>2.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Applied Per Acre Pounds AI</th>
<th>Diesel Fuel EQ Gal/Lb Insect.</th>
<th>Diesel Fuel EQ Gal/Ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>** Warrior</td>
<td>0.01125</td>
<td>0.881</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Applied Per Acre Pounds AI</th>
<th>Diesel Fuel EQ Gal/Lb Fung.</th>
<th>Diesel Fuel EQ Gal/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>*** Headline – 2 Aps</td>
<td>0.1463</td>
<td>2.172</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**Total Diesel Fuel EQ Gal Per Acre = 14.4**

10% Never Changed
70% No-till Systems
Increased SOM a minimum of 1%.
60% Grazing Systems
Leave more grass at the end of the year than they used to produce.
25% Use Cover Crops
As a bridge to connect the cropping and grazing system together with livestock.
Crop Diversity
4 Crop Types

Pollinators

Nutrient Cycle

People

Sunlight
Harvest

Continual
Live Plant
Cover Crops

Soil Armor
Residue
C:N Ratio

Soil Disturbance

Livestock
Integration

IPM
insects
diseases
weeds

Water Cycle
Quality &
Quantity

Soil Biology
It's A Balance

Nature
Self Education

  [www.bcscd.com]
- Buffalo Bird Women’s Garden : by Gilbert Wilson
  [www.dakotalakes.com]
- The One Straw Revolution: by Masanobu Fukuoka
  [www.sustainableranching.com]
- Managing Cover Crops Profitably 3rd Edition
  [www.mandakzerotill.org]
- Guns, Germs, and Steel: by Jared Diamond
- Soil Biology Primer: by Elaine Ingham
- Life in the Soil: by James Nardi
Thank You

www.bcscd.com
Bee Basics – Moisset & Buchmann
Conserving Bumble Bees – Hatfield, Jepsen, Mader, Black, & Shepherd
Beneficial Insect Habitat Planning – The Xerces Society
Attracting Native Pollinators – Mader, Shepherd, Vaughan, Black, & LeBuhn
Life in the Soil – James Nardi
Undaunted Courage – Stephen Ambrose
Dirt – David Montgomery