

Soil Health In Burleigh County “It’s Not Just Dirt Anymore”

By
Jay Fuhrer



BISMARCK WSFO AP, NORTH DAKOTA (320819)

Period of Record Monthly Climate Summary

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

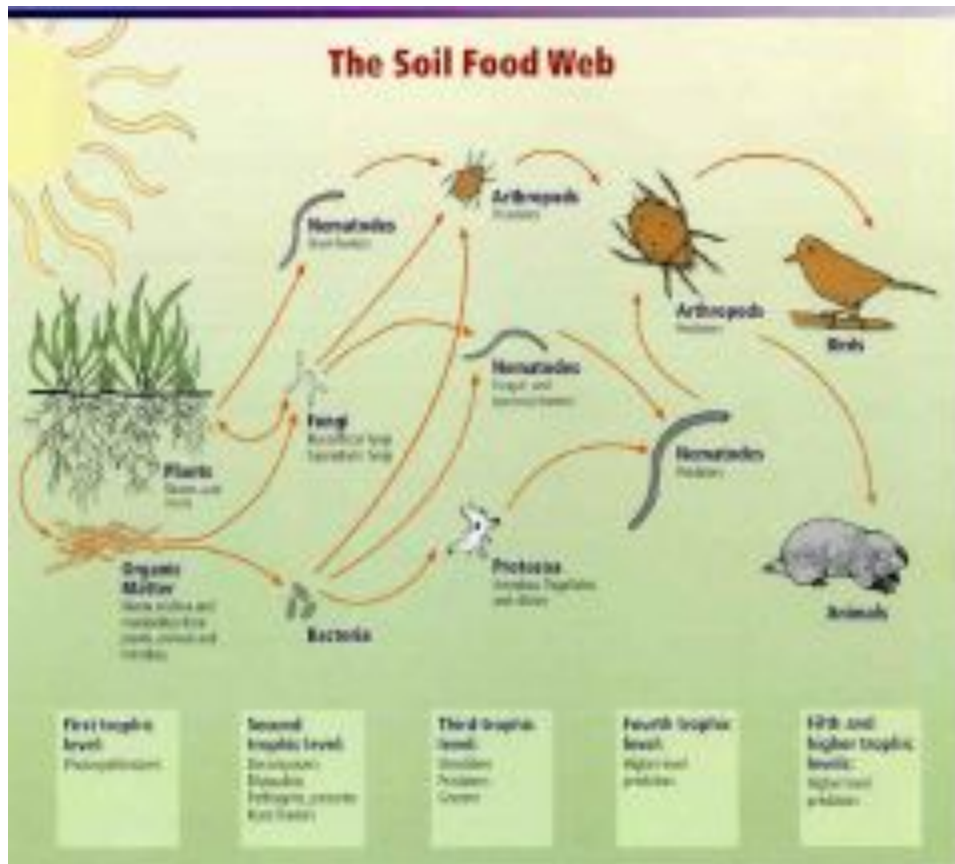
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	20.1	26.6	38.2	55.4	68.1	77.2	84.6	83.4	71.8	58.6	39.4	26.2	54.1
Average Min. Temperature (F)	-1.5	5.5	17.3	30.7	42.4	51.9	57.0	54.8	44.0	32.4	18.2	5.4	29.8
Average Total Precipitation (in.)	0.47	0.47	0.78	1.39	2.33	2.94	2.44	2.00	1.40	1.02	0.58	0.46	16.28
Average Total SnowFall (in.)	7.9	7.2	8.5	3.6	0.8	0.0	0.0	0.0	0.1	1.6	6.5	7.6	43.8
Average Snow Depth (in.)	4	4	2	0	0	0	0	0	0	0	1	2	1

40 Centimeters Annual Precipitation

The Soil Food Web

Working Toward A Higher Quality No-till

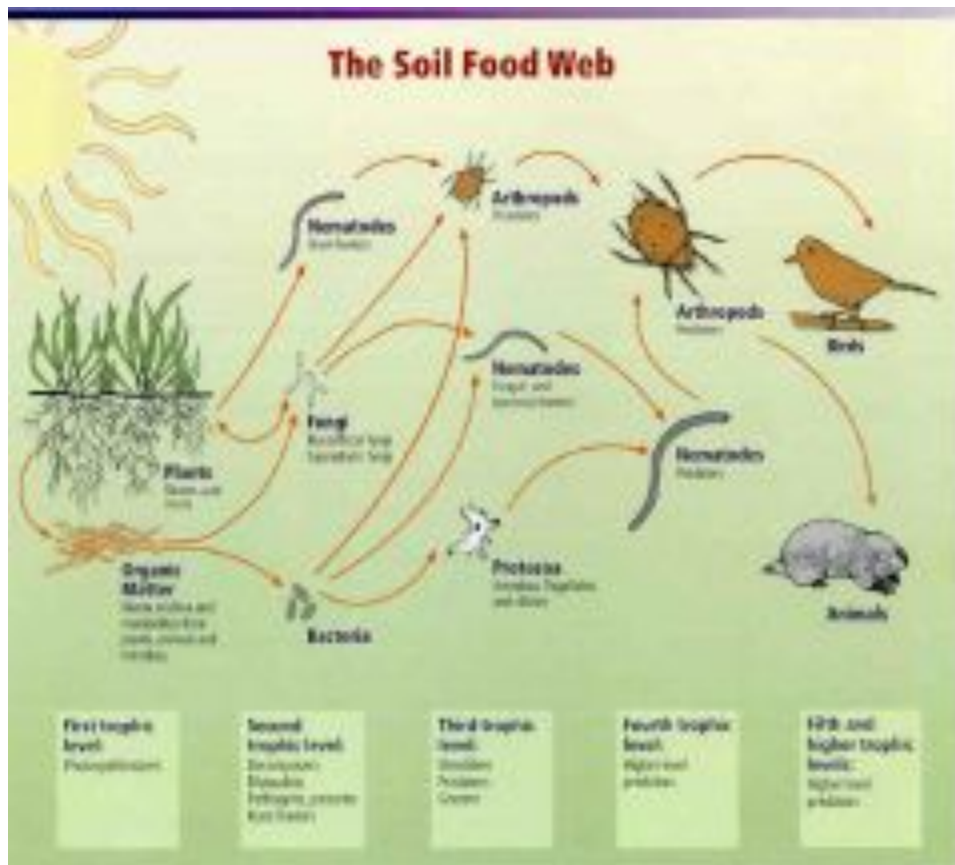
The “Below Ground” Players...



- **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...

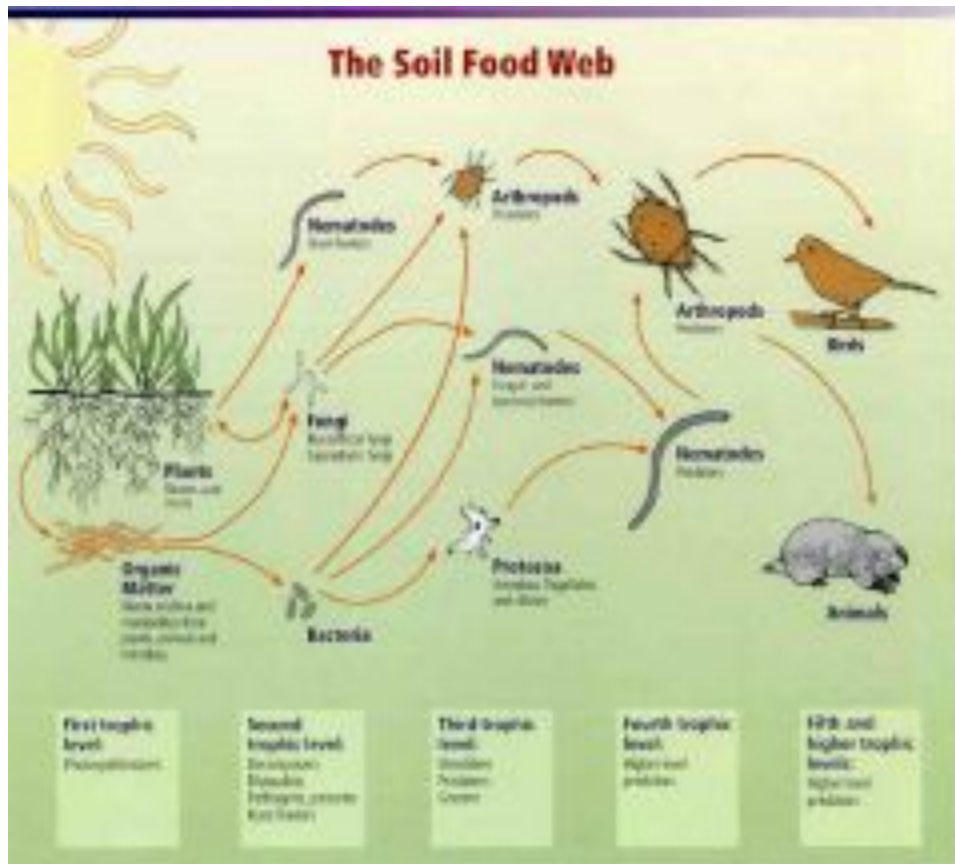


- **Fungi-**
 - Saprophytic*-primary decomposer of complex carbon chains (high carbon chains).
 - Mycorrhizal*-transports nutrients.
 - Little bag of fertilizer.
 - Forms the soils glue (glomalin) along with the plant roots exudates.

The Soil Food Web

Working Toward A Higher Quality No-till

The “Below Ground” Players...

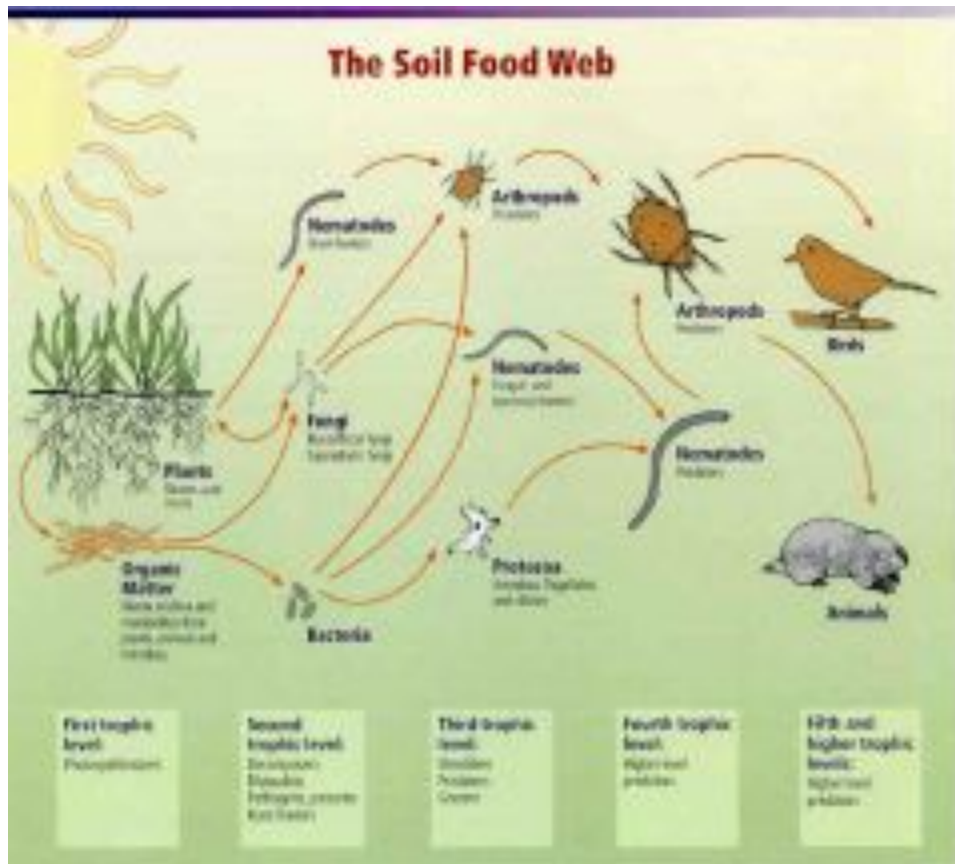


- **Protozoa-**
 - Mineralize nutrients by eating the little guys (fungi and bacteria).
 - Consumes an average of 10,000 bacteria per day.
 - Amoebae – large
 - Ciliates – medium
 - Flagellates - small

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.

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
23 – 340 Kilograms/Hectare
- Nematodes
10 - 300 Lbs/Ac
13 – 340 Kilograms/Hectare

Source:

- The Nature and Properties of Soils
Brady and Weil, Fourteenth Edition
- Soil Biology Primer

The “Above Ground” Players



Gabe Brown
Brown's Ranch



Glenn Bauer
Bacon Heights Farms



Marlyn Richter
Richter Farms



Jerry Doan
Black Leg Ranch



All Biology Soil Tests Were Sent To:
Ward Laboratories, Inc
www.wardlab.com

Soil Health Principles

Raising the Soil Health Bar

- (1) Armor - Keep The Soil Covered
- (2) Minimize Soil Disturbance
- (3) Crop Diversity
- (4) Continual Live Plant
- (5) Livestock Integration



Soil Health Principle Number 1: Armor – Keep The Soil Covered



2007 National Resources Inventory Soil Loss In Tons Per Acre Per Year

North Dakota

Wind 5.1

Water 1.5

Total 6.6 Tons/Ac/Yr

Montana

Wind 4.3

Water 1.7

Total = 6.0 Tons/Ac/Yr

Minnesota

Wind 3.9

Water 2.0

Total = 5.9 Tons/Ac/Yr

Gabe Brown High Carbon Residue



Gabe Brown
Living Armor - Low Carbon Residue



The Menoken Farm

Cover Crop Combination – Mid Carbon Residue



SOM'S Revolving Nutrient Bank Account.

- A furrow slice is $6 \frac{7}{8}$ 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:

*The Nature and Properties of Soils, fourteenth Edition.

DR. Nyle C. Brady and DR. Ray R. Weil

** DR. Elaine R. Ingham, Soil Food Web

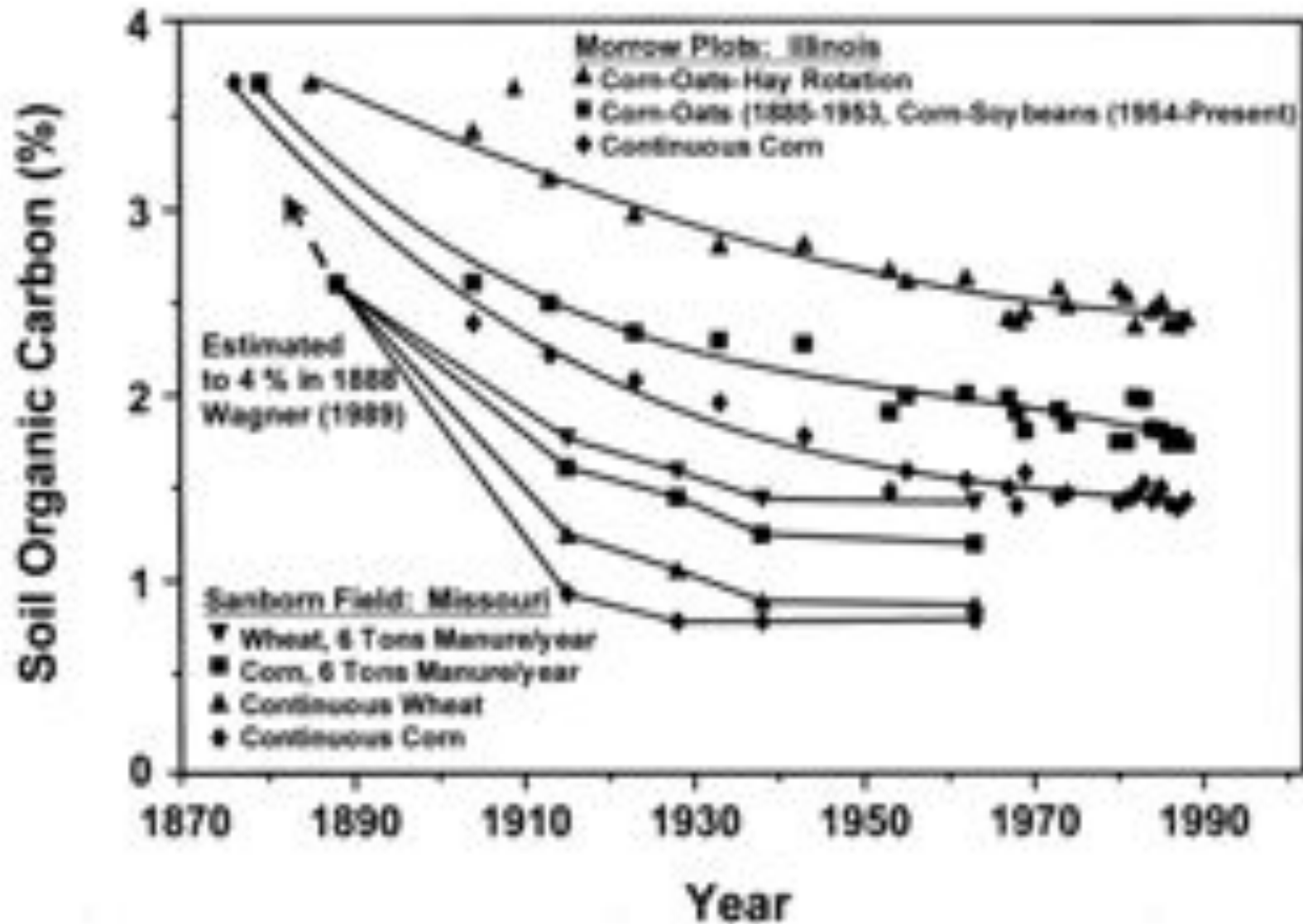
We Manage Soil Temperatures With the Armor.



Soil Health Principle Number 2: Minimize Soil Disturbance



SOM Decline from Conventional Farming



SOM'S Revolving Nutrient Bank Account.

- A furrow slice is $6 \frac{7}{8}$ 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

Percent SOM	Sand	Silt Loam	Silty Clay Loam
1	1.0	1.9	1.4
2	1.4	2.4	1.8
3	1.7	2.9	2.2
4	2.1	3.5	2.6
5	2.5	4.0	3.0

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

Glenn Bauer – Bacon Heights Farms

Two Tillage Compaction Layers



Using Cover Crops to address Resource Concerns

- Infiltration
- Compaction
- Surface Saturation



Sweep layer

Plow layer

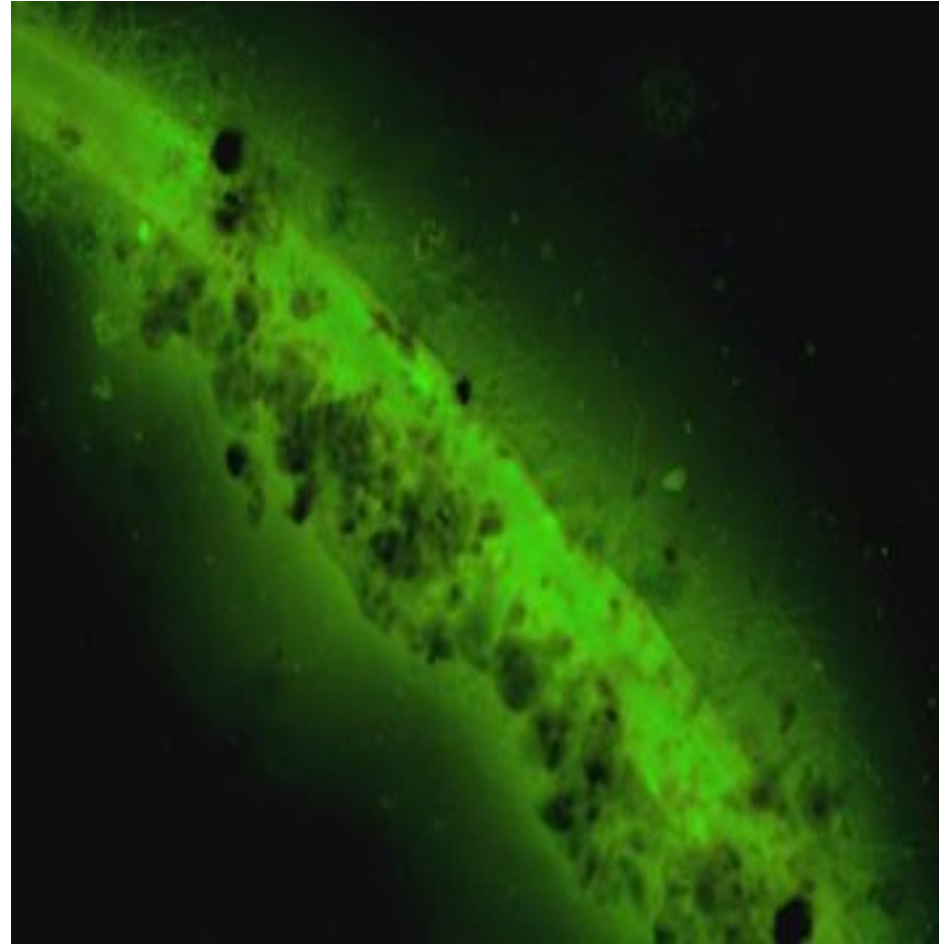
Root breaking
compaction layer



Soil Aggregates
on a millet root.
Richter Farms

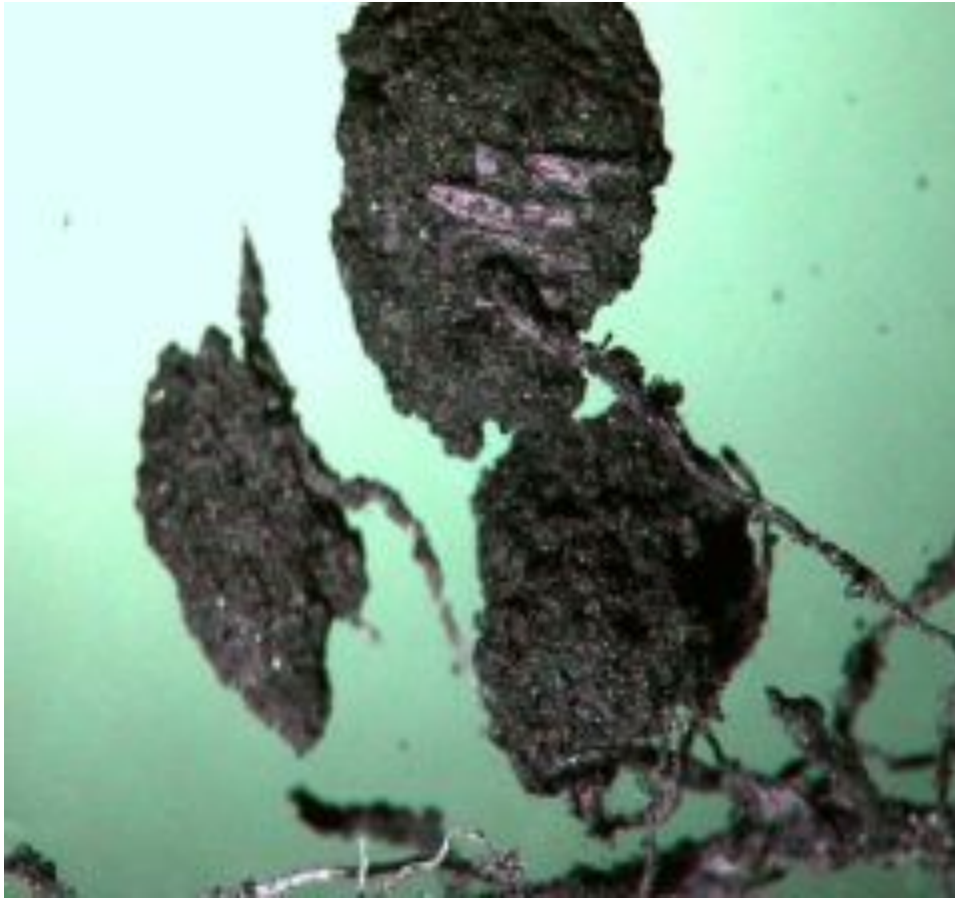


Glomalin and hyphae
show well with a green
color in the lab.

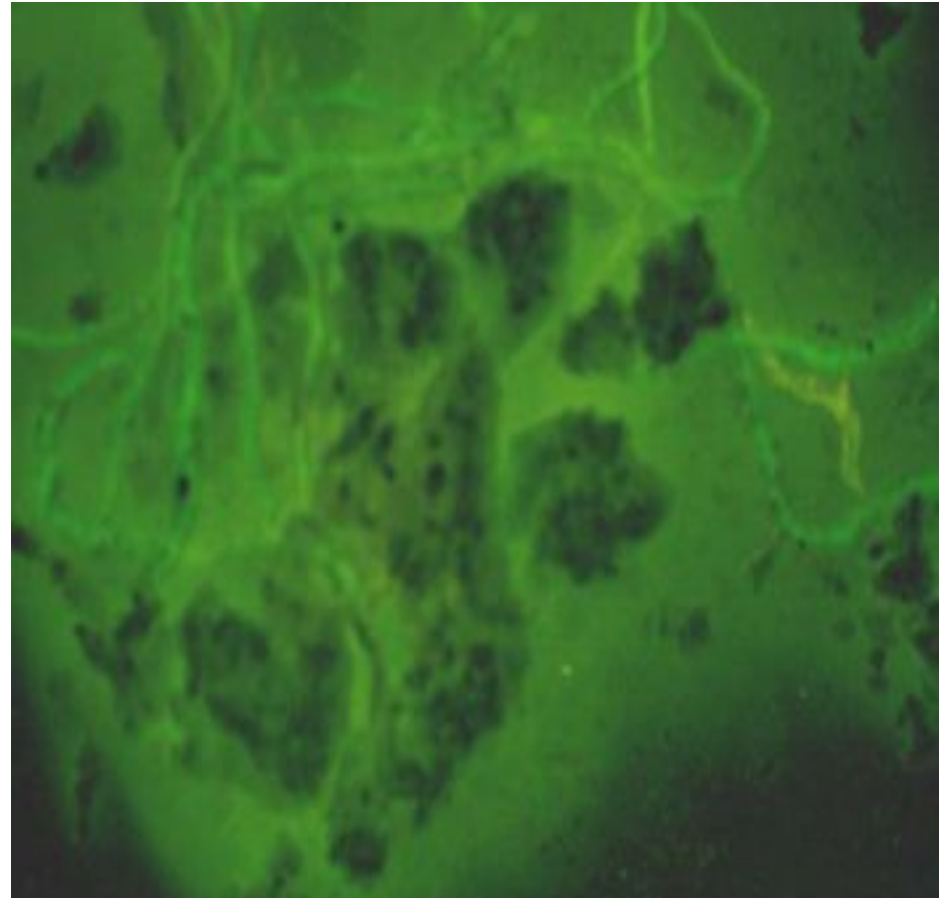


Dr. Kris Nichols, Microbiologist, ARS, Mandan, ND

Enlarged Soil Aggregates



Glomalin and hyphae



Dr. Kris Nichols, Microbiologist, ARS, Mandan, ND , 2006

Soil Health Principle Number 3: Crop Diversity



Crop Diversity



Diversity - Crop Types.

Cool Season Grass

Barley
Durum Wheat
Oat
Spring Wheat
Winter Rye
Winter Triticale
Winter Wheat

Cool Season Broadleaf

Canola
Crambe
Flax
Lentils
Oilseed Radish
Mustard
Forage Canola
Red Clover
Sweet Clover
Turnip
Pasja
Pea
Lupin

Diversity - Crop Types

Warm Season Broadleaf

Alfalfa

Buckwheat

Chick Pea

Amaranth

Cowpea

Soybean

Safflower

Sunflower

Warm Season Grass

Corn

Proso Millet

Pearl Millet

Sorghum

Sudan

- 
- No Till
 - High Crop Diversity
 - Cover Crops
 - Livestock
 - No Commercial Fertilizer

- No Till
- Low Crop Diversity
- No Cover Crops
- No Livestock
- Full Fertility

The Menoken Farm 2009 – 2012
High Quality No-till Versus Low Quality No-Till

Field 7
High Crop Diversity
With Cover Crops
No Commercial Fertilizer

Total Biology – 2180 ng/g

Bacteria – 1006 ng/g

Fungi – 226 ng/g

Mycorrhiza – 138 ng/g

Ratio Bacteria:Fungi-4.5

Protozoa – 153 ng/g

Field 3
Low Crop Diversity
Continual Wheat
Full Fertility Applied

Total Biology 1901 ng/g

Bacteria – 963 ng/g

Fungi – 195 ng/g

Mycorrhiza – 102 ng/g

Ratio Bacteria:Fungi-4.9

Protozoa – 152 ng/g

The Menoken Farm - Biology Soil Tests

	Solvita 1-day CO2-C	Organic C	Organic N	Organic C:N	Yield
Menoken Farm Field 3 – Full Fertility Low Diversity History Wheat 2012	44	229	16	15	45 Bu
Menoken Farm Field 5 – No Fertilizer High Diversity History Wheat 2012	50	267	22	12	41 Bu
Menoken Farm Field 7 – No Fertilizer High Diversity History Wheat 2012	55	262	25	10	39 Bu
Gabe Brown South of Headquarters No Fertilizer High Crop Diversity and Livestock Integration Corn 2012 (Unharvested)	62	455	43	11	Unharvested

Dr. Rick Haney; USDA – ARS; Temple, Texas

	Total N	Inorganic N	Organic N	Yield
Menoken Farm Field 3 – Full Fertility Low Diversity History Wheat 2012	161	94	32	45 Bu
Menoken Farm Field 5 – No Fertilizer High Diversity History Wheat 2012	104	61	45	41 Bu
Menoken Farm Field 7 – No Fertilizer High Diversity History Wheat 2012	95	42	51	39 Bu
Gabe Brown South of Headquarters No Fertilizer High Crop Diversity and Livestock Integration Corn 2012 (Unharvested)	145	56	86	Unharvested

Dr. Rick Haney; USDA – ARS; Temple, Texas

Season Long Cover Crops Added To High Crop Diversity Rotation



Jerry Doan – Black Leg Ranch

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**

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

The Menoken Farm

Field 9
Corn Row

Field 9
Between Corn Rows

Living Microbial Biomass, ng/g

2416

1686

Total Fungi

216

153

Soil Health Principle Number 4: Continual Live Plant





The Menoken Farm
Integrated Pest Management

05/01/2012

Field 3: Full fossil fuel inputs. Weeds: Downy Brome, Wild Oat, Tansy Mustard
Crop History 2009 Wheat 2010 Wheat 2011 Wheat



The Menoken Farm
Photo Date 4/30/12
Herbicide Applied 5/1/12
Seeding Date 5/1/12

04/30/2012

Field 4 No Fungicides, Insecticides, or Commercial Fertilizer

Crop History 2009 Full Season Cover Crop 2010 Corn 2011 Pea + Cover Crop

The Menoken Farm
Photo Date 4/30/12
Herbicide Applied 5/1/12
Seeding Date 5/1/12

04/30/2012

Richter Farms

Spring Of 2008 Weed Suppression



Cover Crop seeded 7/2007
Good Weed Suppression



No Cover Crop Seeded 2007
Heavy Weed Pressure

**Cover Crop
Previous Year**

**No Cover Crop
Previous Year**



Richter Farms

High Crop Diversity
With Cover Crops

Total Biology - 1999 ng/g soil

Actinomycetes - 191 ng/g soil

Bacteria - 1625 ng/g soil

Fungi - 138 ng/g soil

Ratio Bacteria:Fungi – 11.7

Mycorrhiza – 38 ng/g soil

High Crop Diversity
Without Cover Crops

Total Biology - 1528 ng/g soil

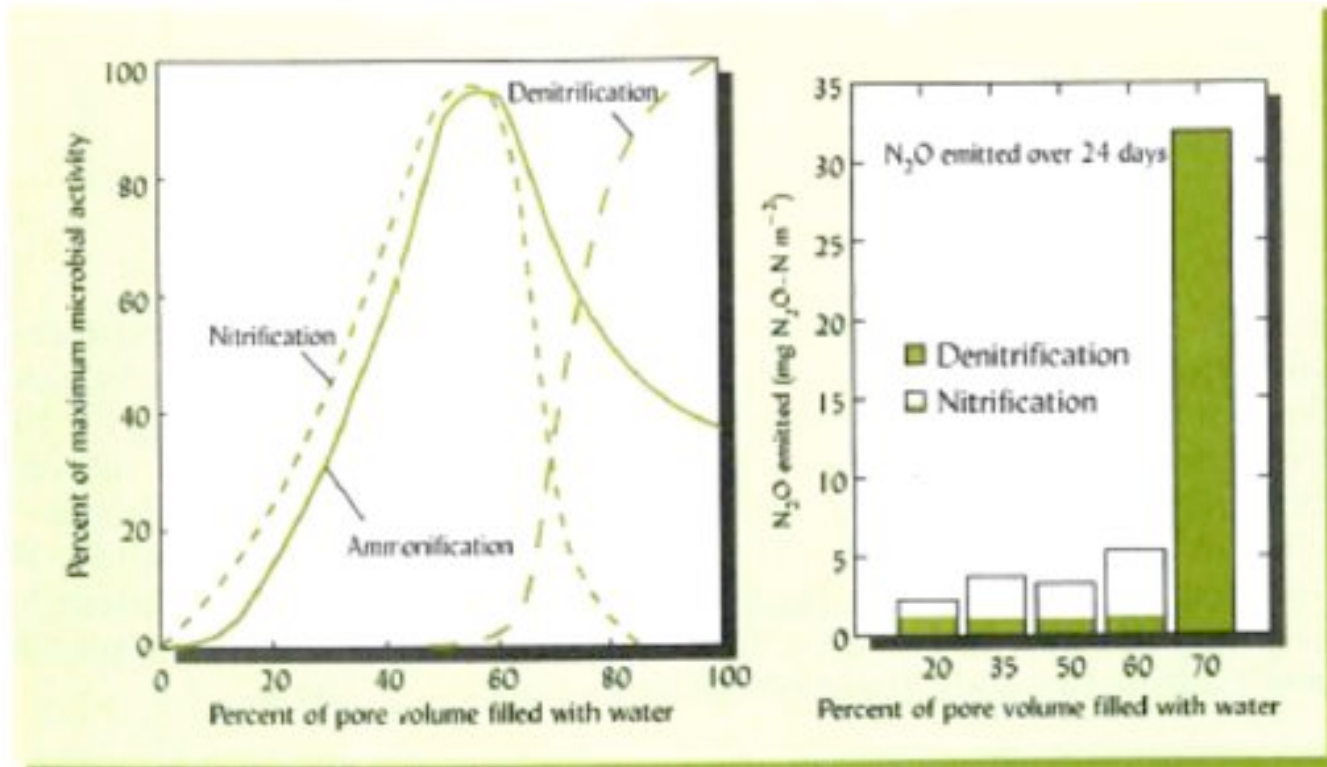
Actinomycetes -133 ng/g soil

Bacteria – 1251 ng/g soil

Fungi – 115 ng/g soil

Ratio Bacteria:fungi – 11

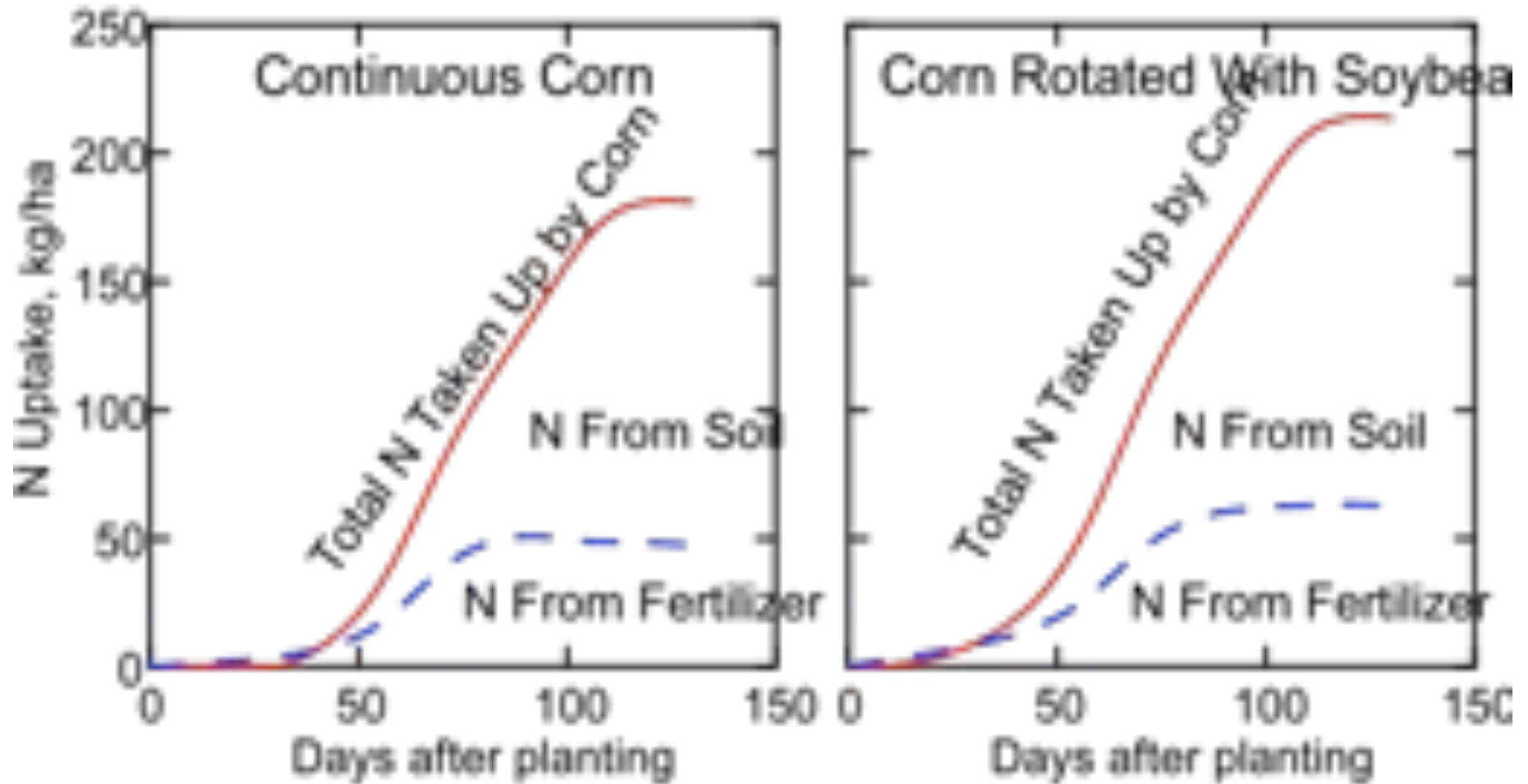
Mycorrhiza – 41 ng/s soil



The Nature and Properties of Soils, 14 edition 2008
 Nyle Brady and Ray Weil

Denitrification

Even where normal rates of fertilizer are used, soil organic matter and rotation residues are the main source of N taken up by corn.



From Omay, et al. 1998. SSSAJ 62:1596-1603

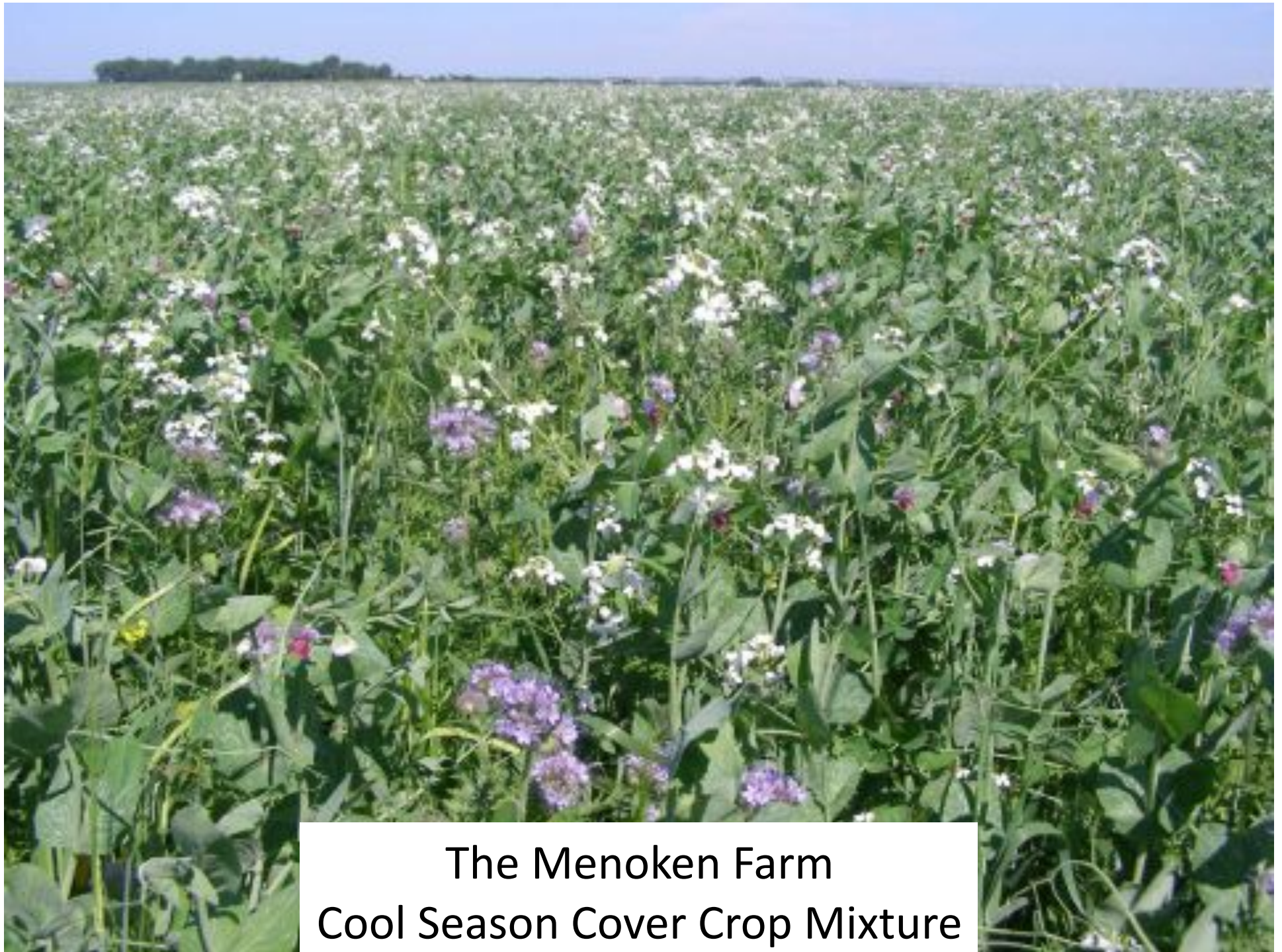
Bacon Heights Farm

Cover Crops Seeded After Wheat Harvest



The Menoken Farm Warm Season Cover Crop Mixture



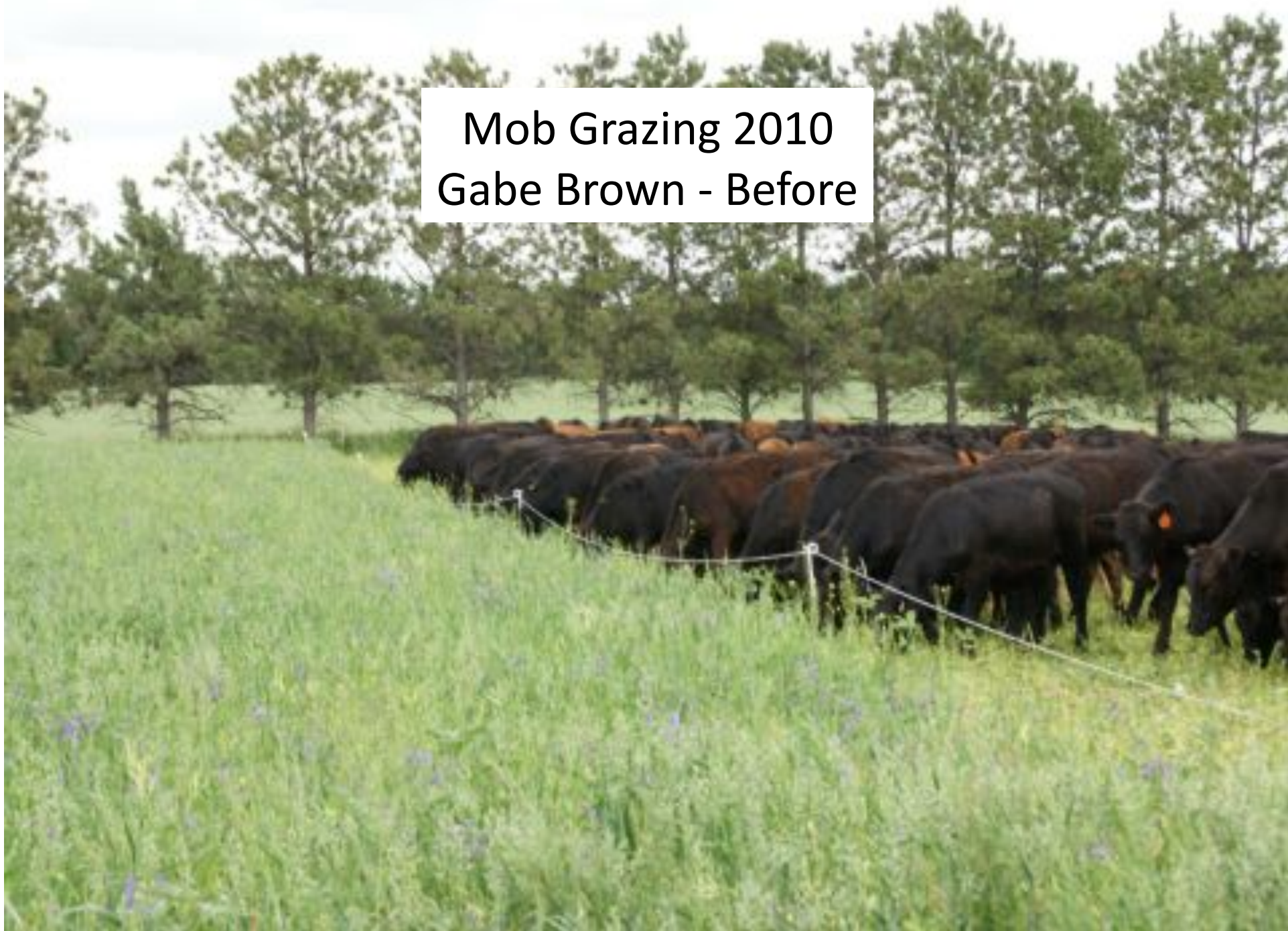



The Menoken Farm
Cool Season Cover Crop Mixture

Soil Health Principle Number 5: Livestock Integration



Mob Grazing 2010
Gabe Brown - Before



A photograph of a grassy field, likely a pasture, showing a mix of green and yellowish-brown grasses. A white rectangular text box is overlaid in the upper-middle portion of the image. The text inside the box reads: "Mob Grazing 2010", "Gabe Brown - After", and "Low Carbon".

Mob Grazing 2010
Gabe Brown - After
Low Carbon

Mob Grazing 2011
Gabe Brown - Before



Mob Grazing 2011
Gabe Brown - After
High Carbon Material



Two Years Mob Grazing
West Side of Shelterbelt

Total Biology – 6105 ng/g soil

Actinomycetes – 213 ng/g soil

Bacteria – 4417 ng/g soil

Fungi – 786 ng/g soil

Ratio Bacteria : Fungi – 5.6

Mycorrhiza – 230 ng/g soil

No Mob Grazing
East Side of Shelterbelt

Total Biology – 4228 ng/g soil

Actinomycetes – 418 ng/g soil

Bacteria – 3349 ng/g soil

Fungi – 386 ng/g soil

Ratio Bacteria : Fungi – 8.7

Mycorrhiza – 145 ng/g soil

Gabe Brown

The Menoken Farm
Burleigh County Soil
Conservation District

www.bcscd.com

Livestock Integration
Continued
Mob Grazing Sheep



A photograph of a flock of sheep in a green field. The sheep in the foreground are looking towards the camera. Two blue speech bubbles are overlaid on the image. The first speech bubble, on the left, contains the text "We Demand Cover Crop Combinations...". The second speech bubble, on the right, contains the text "Or Else!".

We Demand
Cover Crop
Combinations...

Or Else!




Electric Ribbon &
Step-In Posts



Cover Crop Mixture Seeded September 2010
Winter Triticale 70 lbs/Acre and Hairy Vetch 20 lbs/Acre
Grazed June 16 – Aug 5, 2011



Clipping Data
10,421 Lbs Per Acre

A photograph showing a large group of sheep grazing in a field. The sheep are clustered together, and the foreground is dominated by tall purple lupine flowers. The background shows a green field under a clear blue sky.

Mob Grazing Sheep
90 Dry Ewes
Approximately 1/5 Acre Per Day



Field 1 – 11 Acres
June 16 – August 5
90 Ewes X 51 Days = 4590 Grazing Days
4590 Grazing Days/11 acres = 417 GD/ac

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





100% of The Soil Surface Is Covered



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

More Biology



- Grazing with 85 cow/calf pairs
- November 20 – 22
- 85 pair x 3 days/11 acres = 23 GD/A

Ready For A Corn Crop – 2012

Note: Two Layers Of Residue

Grazing Summary
Sheep = 417 GD/A
Cattle = 23 GD/A

11/25/2011



2012 Non GMO Corn Crop
No Seed Treatment



06/22/2012

NIRS Results

Grazingland Animal Nutrition Lab
Texas AgriLife Research

Prepared For:

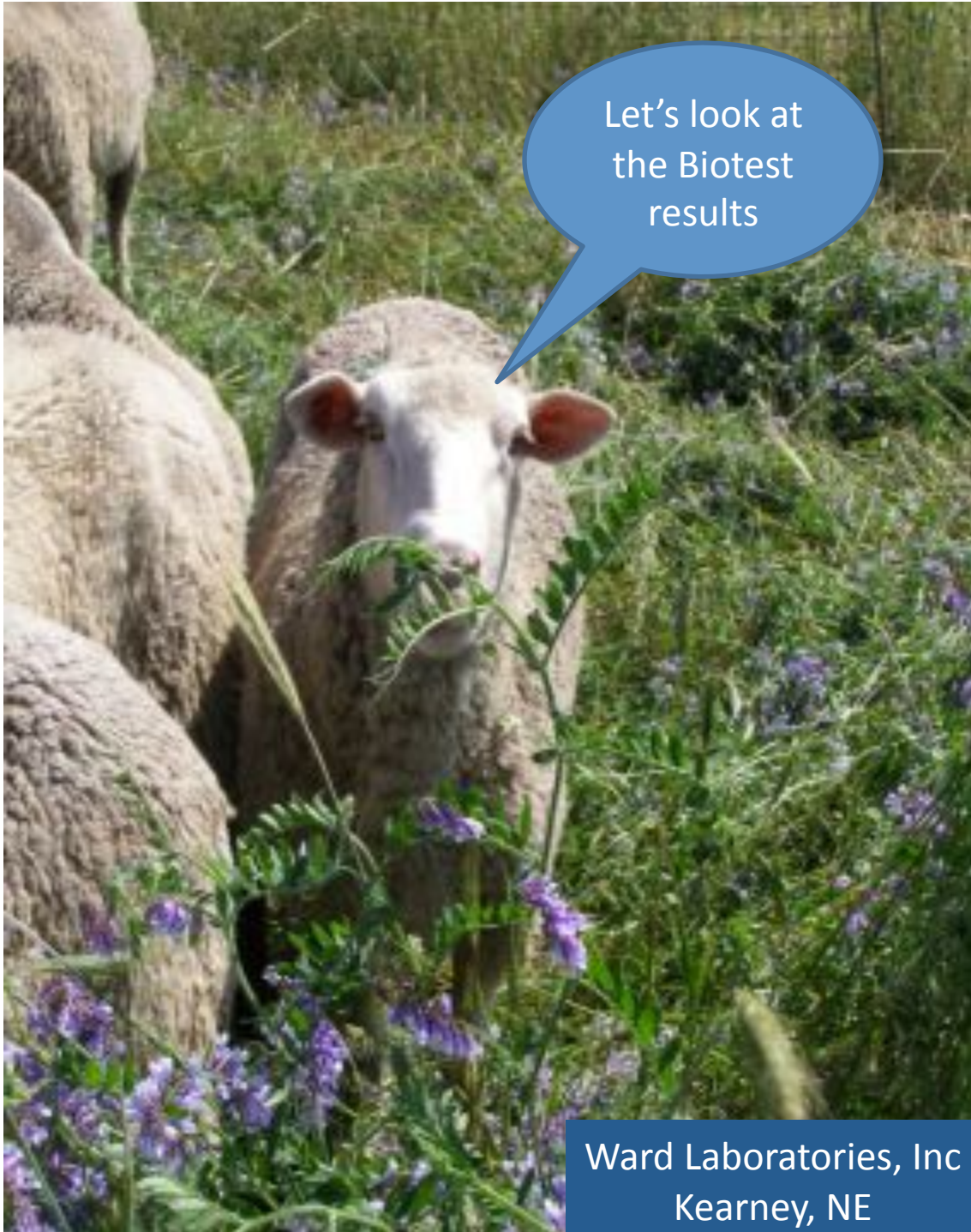
BCSCD

Ken Miller

916 E Interstate AVE

Bismarck, ND

Sample #:	A0093
Profile(s):	Dry Ewes
Pasture Name:	Menoken Farm
Date Collected:	Thurs, 07 Jul 2011
Date Received:	Tues, 12 Jul 2011
% Crude Protein:	14.79
% Digestible Organic Matter:	67.90
% Fecal Nitrogen:	2.19
% Fecal Phosphorus:	0.77



Let's look at the Biotest results

Ward Laboratories, Inc
Kearney, NE

With Livestock -- Without Livestock

Total Fungi	
ng/gram dry weight soil	
300	242

Total Bacteria	
ng/gram dry weight soil	
2005	2818

Ratio	
Bacteria/Fungi	
6.7	11.6

Menoken Farm
Field 10
October 21, 2011

What's New

The Menoken Farm
Burleigh County Soil
Conservation District

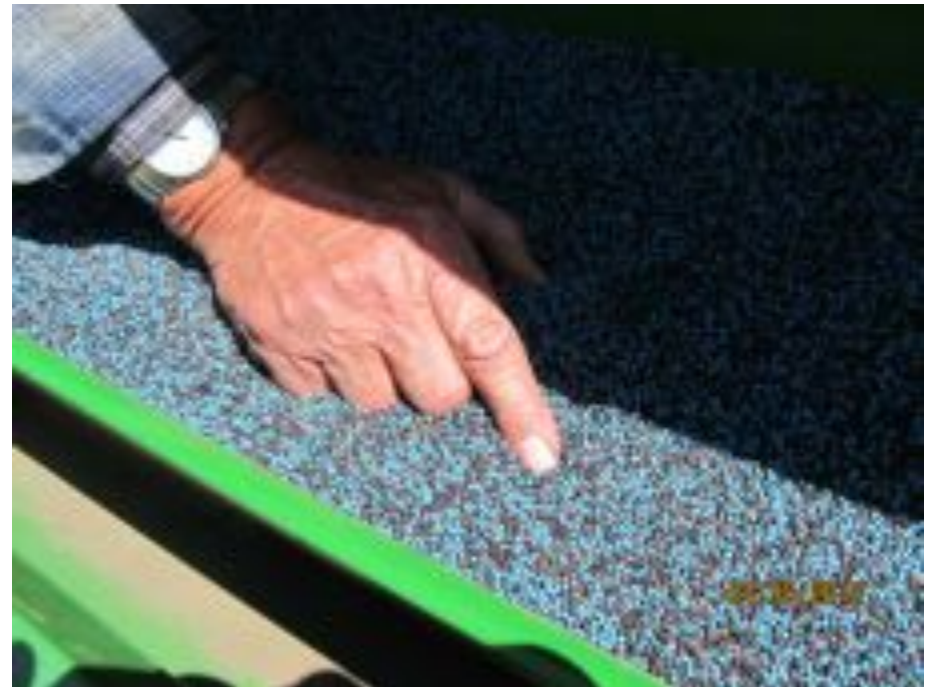
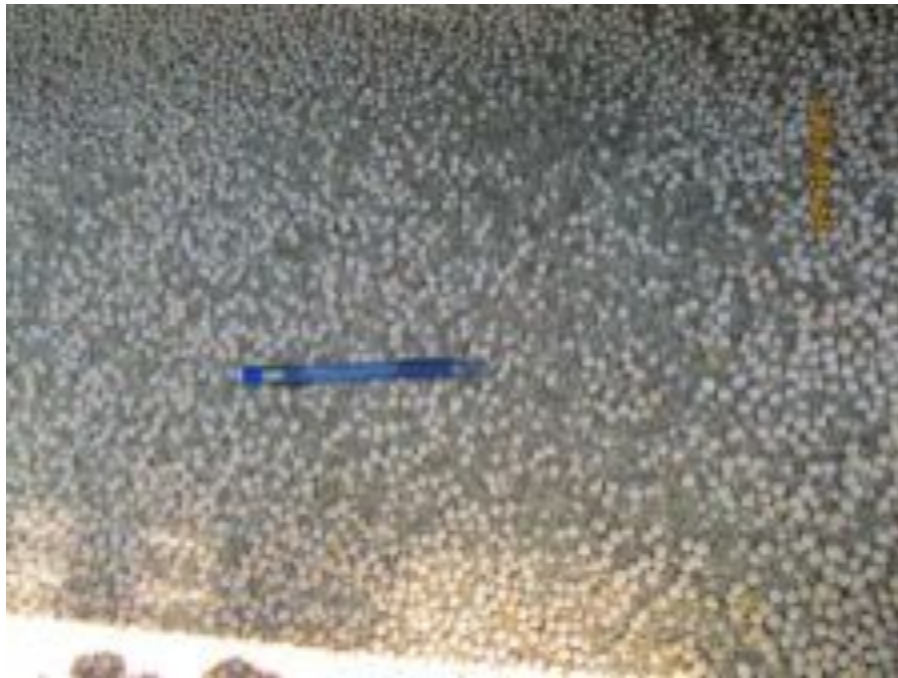
www.bcscd.com

Part II

Poly Grain Cover Crops



Cash Crops: Pea and Canola
Cover Crops: Turnip, Annual Ryegrass,
and Sub Clover





No Herbicide Applied
After Spring Seeding



Cover Crops Build Soils All Summer



Cover Crop Understory



Pea Stand Was Good
Canola Stand Was Fair

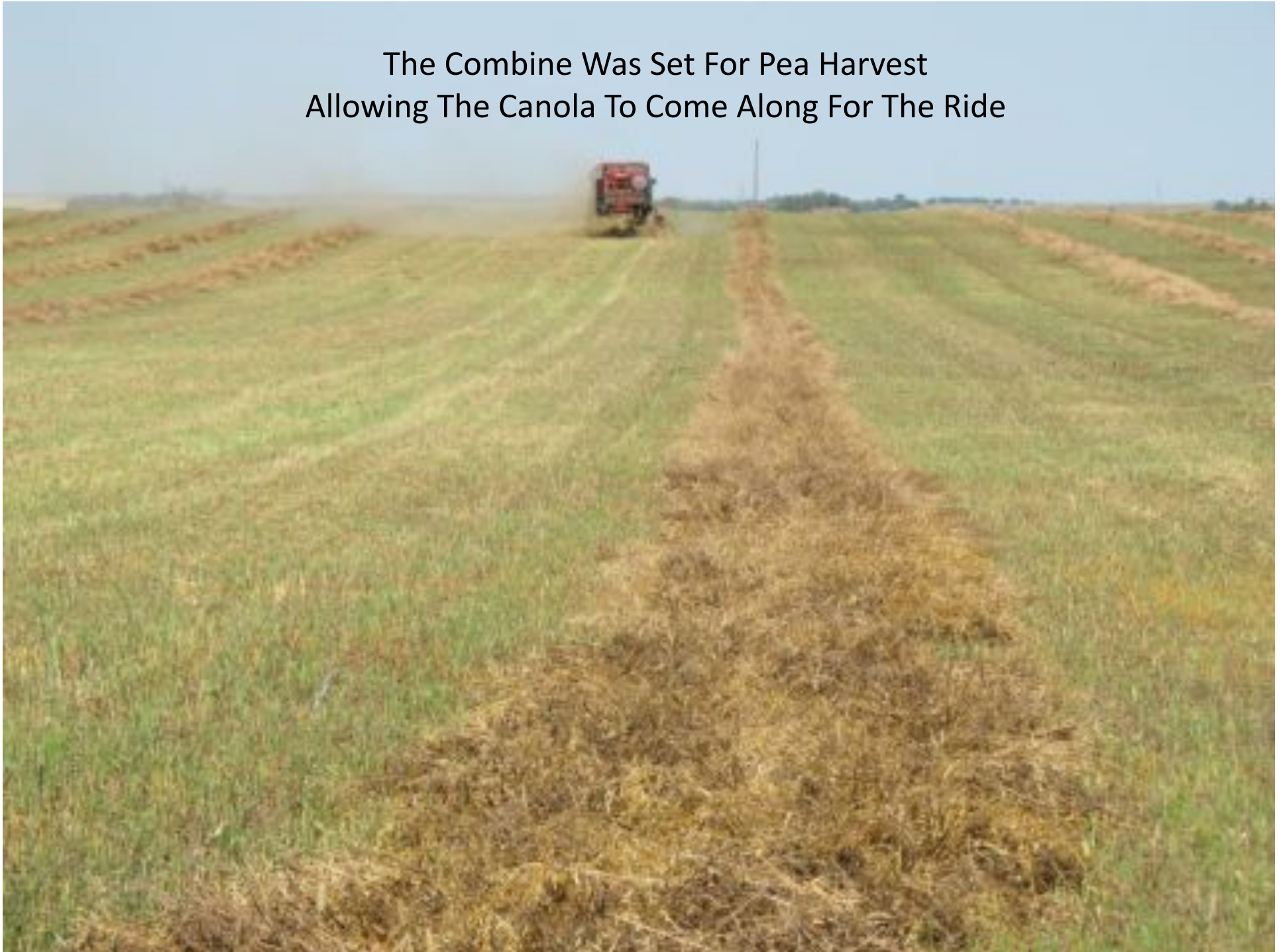
Poly Grain Cover Crop Temperature 71.4 Degrees
Bare Soil Temperature 97.9 Degrees



The Field Was Windrowed To Allow The Crops To Dry




The Combine Was Set For Pea Harvest
Allowing The Canola To Come Along For The Ride



Ready To Be Cleaned And Separated



A close-up photograph of a sheep's head as it grazes on green corn plants. The sheep has thick, light-colored wool and is looking down towards the leaves. The background is filled with vibrant green corn leaves and stalks.

Thank You!
Soil Health Workshop
Burleigh County
Soil Conservation District
Jan 8, 2013

08/16/2012