Dirt To Soil

As Producers We Are Told That We Need To Produce More To Feed An Ever-growing Population

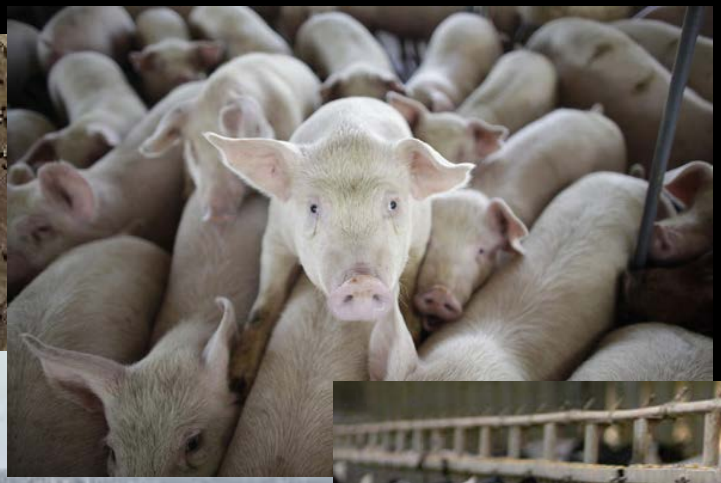
- We are told to focus on YIELD and POUNDS.

So, We Produce, Corn

Soybeans

Wheat, All Monocultures

Livestock In Confinement



- As farmers we tend to think that we have no control over our soils, our water or the nutrients we have available
- We think that what we have is what we have.
-
- BUT IS IT?

Can We Regenerate Soils?

- Can we take control of our own destiny?

Loss of Our Soil Resource


I Came To The Realization That Through Poor Management I Had Degraded My Resources.

I had come to accept a degraded resource

Symptoms of a Degraded Resource

- Lack of Moisture
- Poor Fertility
- Compaction
- Weeds
- Low Yields
- High Input Costs
- Too Much Moisture
- Salinity
- Disease
- Pests
- Litter: Too Much/Too Little
- Labor
- Erosion
- Poor Infiltration

I needed to “unlearn”
and “relearn”
This sent me on a 25+ year journey of “Dirt to Soil”

A Soil Owner's Manual

How to Restore and Maintain Soil Health

Jon Stika

Conventional Practices

1994 Purchased A 750 No-till Drill

LESSON #1

- Least amount of mechanical disturbance possible.

1994 First Year No-Till

1994 Added Peas for N Fixation

Nitrogen

- Approximately 34,000 Tons of Atmospheric Nitrogen Above Every Acre.

- Is There Any Reason Why We Convert Fossil Fuels Into Nitrogen?

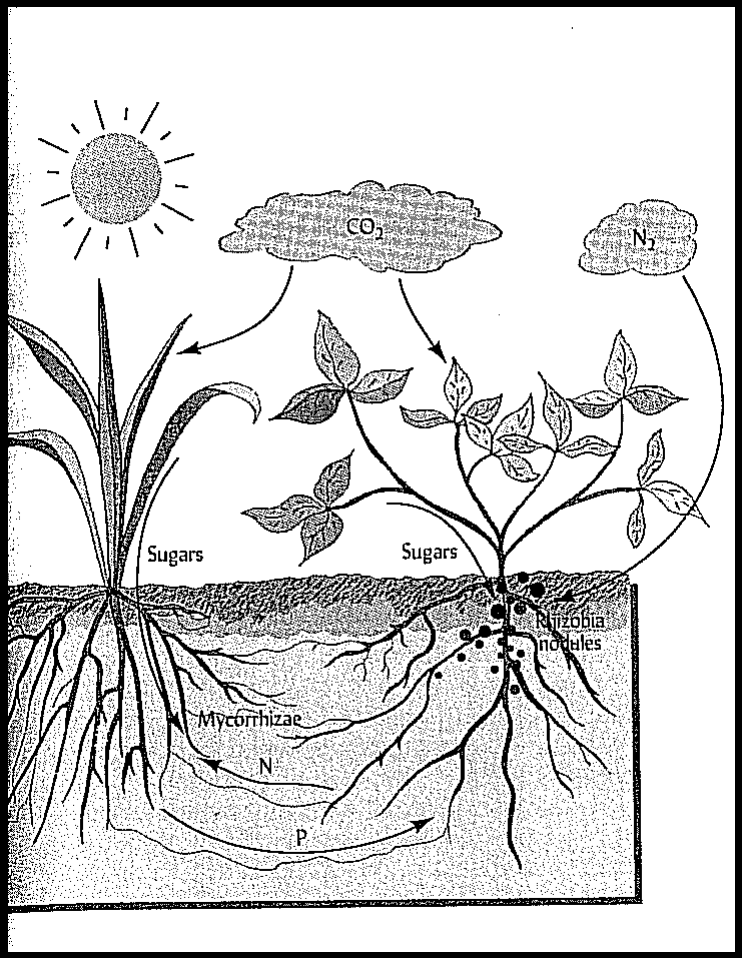
1995 Hail

Lesson #2

- Armor on the soil.

Winter Triticale & Hairy Vetch

Plants Interacting with Mycorrhizal Fungi



- Assists with P uptake from the soil
- Moves P from the non-legume plant to the legume plant
- Moves N from the legume plant to the non-legume plant

The Nature and Property of Soils, Brady and Weil

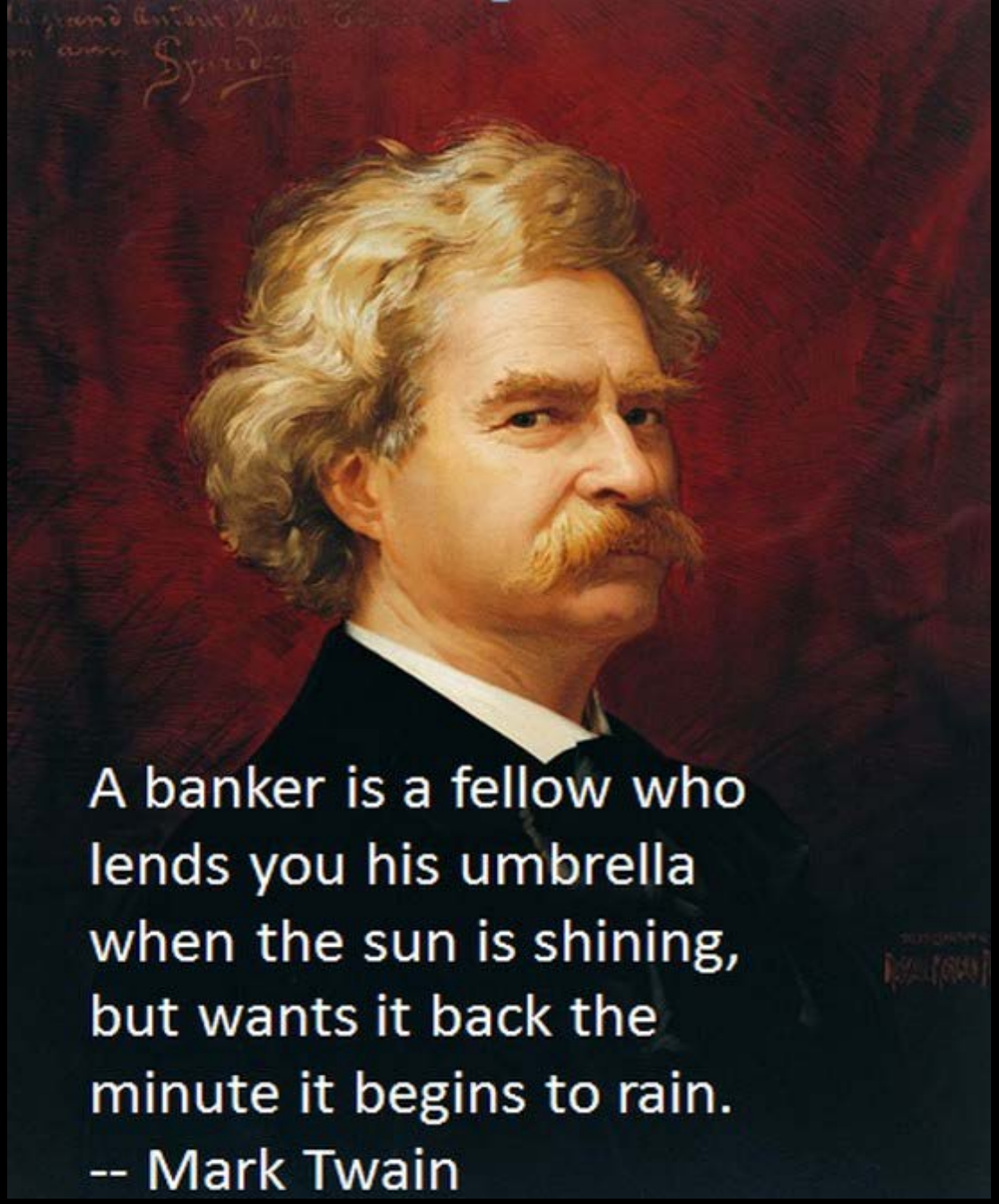
1996 Added Corn to the Rotation

Lesson #3

- Diversity.

Again…

1997 Drought


A banker is a fellow who
lends you his umbrella
when the sun is shining,
but wants it back the
minute it begins to rain.
-- Mark Twain


1998

And yet again…


NEVER EVER GIVE UP !

Cowpea & Sudan Grass

Lesson #4

- Living root in the soil as long as possible throughout the year.

Livestock Integration

Lesson #5

- Animal integration

Tracking Organic Matter…

Upward Trend

1999

- Oats .99 cents/bu.

Lesson #6

- Financial reward is up to you.

- “If you want to make small changes, change how you do things. If you want to make major changes, change how you SEE things!”

- Don Campbell

The greatest roadblock in solving a problem is the human mind!

Gabe and Paul Brown: ND Rancher

How Did Our Operation Grow Soils?

- Simply By Following The Principles Of Nature!!!

Nature's Way

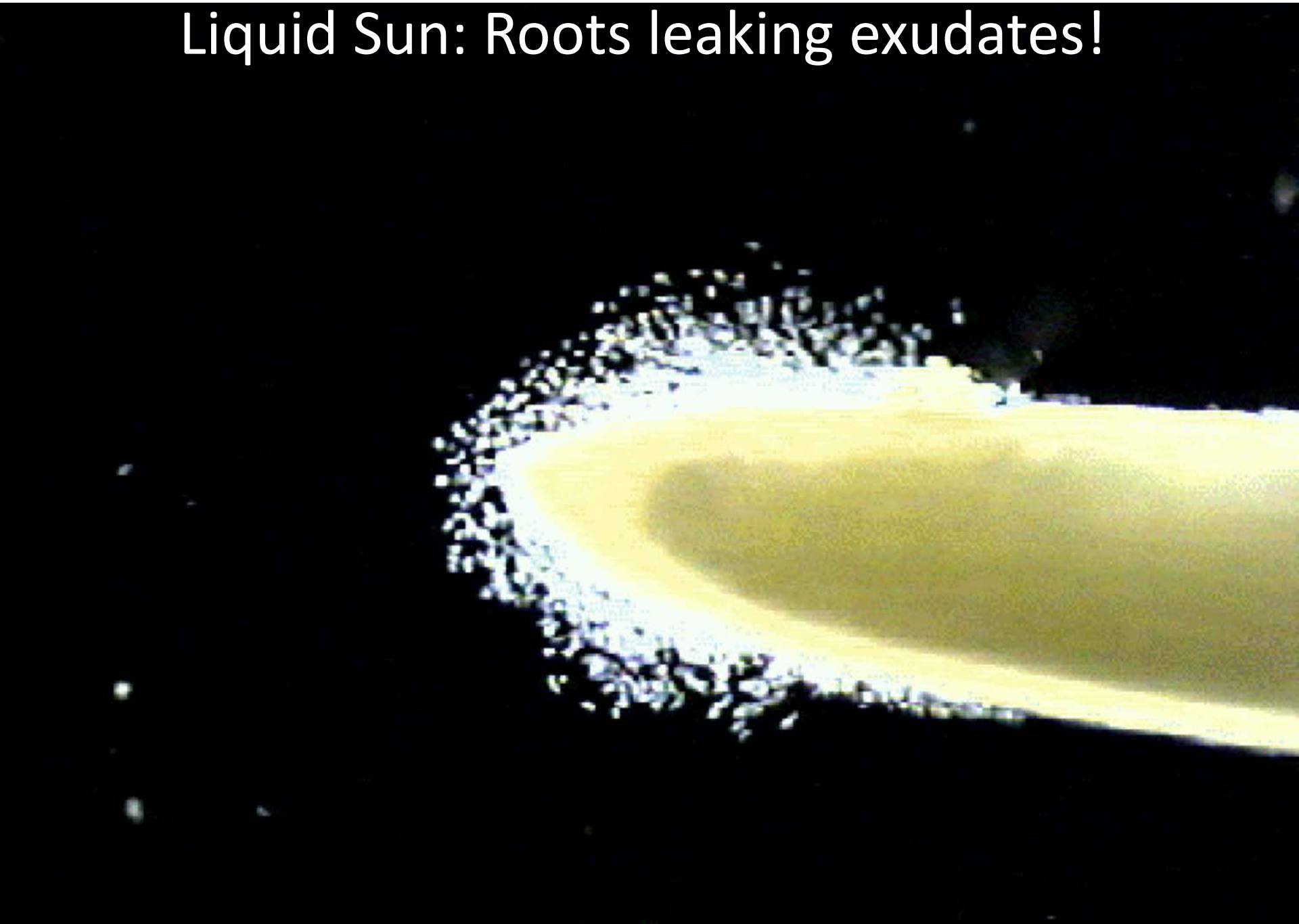
- No mechanical disturbance
- Armor on the soil surface
- Cycles water
- Living plant-root networks
- Nutrient cycling via biology
- Thousands of years of
  R & D

Greatest Geological Force: LIFE!

Photosynthesis

- Plants take in CO_2
- Photosynthesis occurs
- Converted to sugars, amino acids and other compounds
- A portion of this is translocated to the roots
- Exuded into the soil

Liquid Sun: Roots leaking exudates!



Soil is a living, breathing, sub-aquatic ecosystem.

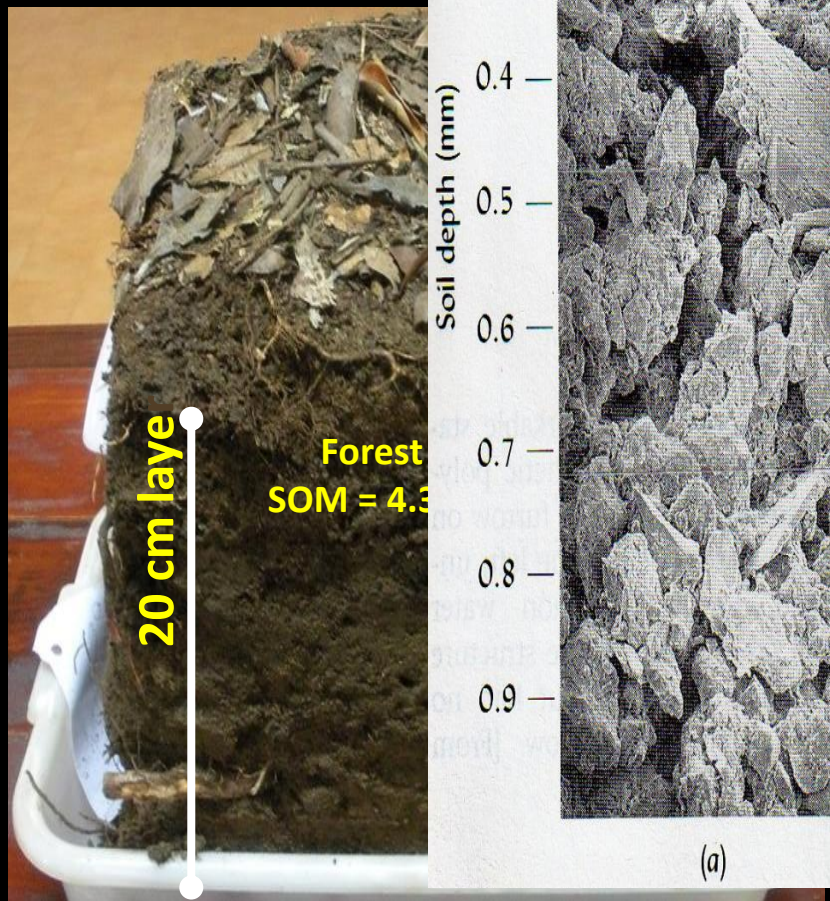
Soil Food Web
(Soil Livestock)

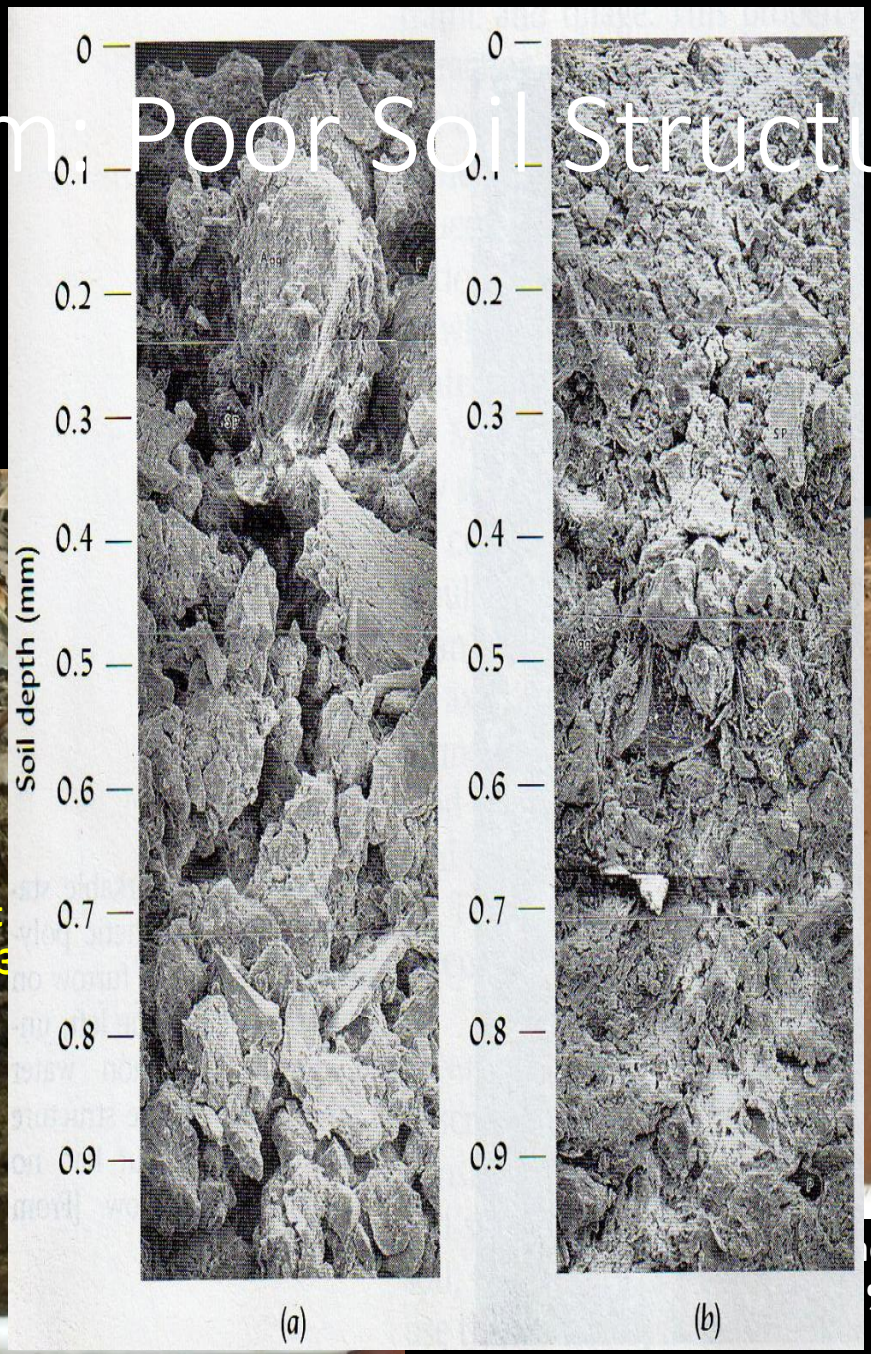
Plant Exudates

- A large part of this is consumed by microbes
- Part is converted to carbonic acid
- This mild acid breaks down rocks, OM, etc.. Helping to make nutrients available for the plants.

1) Least Amount of Mechanical And Chemical Disturbance Possible

Symptom: Poor Soil Structure





onoculture
%

- In order to advance soil health we must reduce tillage.

1994 Purchased A 750 No-till Drill


Zero-Till

- The amount of moisture one receives is IRRELEVANT!

- What is relevant is EFFECTIVE rainfall!

- EFFECTIVE rainfall is the amount that can be infiltrated and stored in the soil.


I question the rational?

½” of rainfall cannot infiltrate

June 15, 2009

Adequate Infiltration: 13.6” in 22 Hours

Spaces Are Essential For Biology And Water Infiltration

Too Much Or Too Little

- If you have too much water you need to increase your crop intensity to use more water, in other words grow covers!!

- If you do not have enough water you need to increase the water holding capacity of your soils, in other words grow covers!!

- This is only going to happen with good soil aggregation/structure.
- One must have high populations of mycorrhizal fungi!

2003 Dr. Kris Nichols

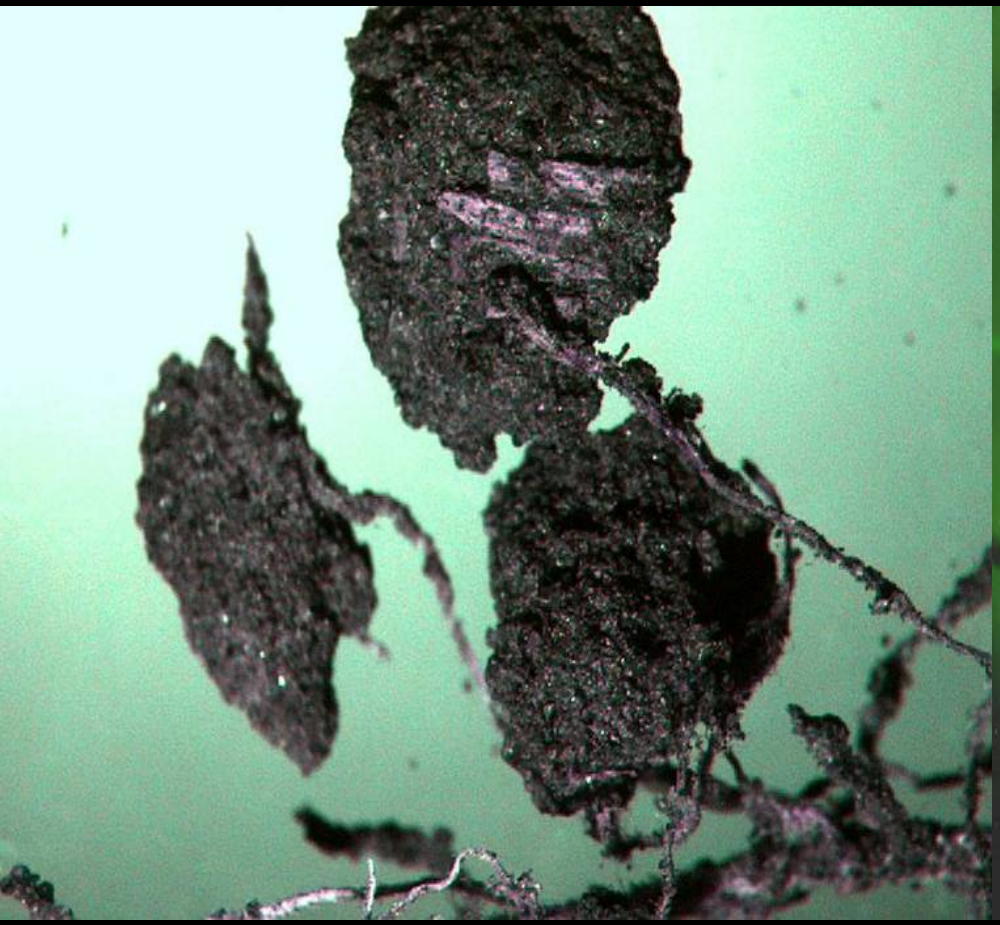
"Your soils will never become sustainable as long as high rates of synthetic fertilizers are used"

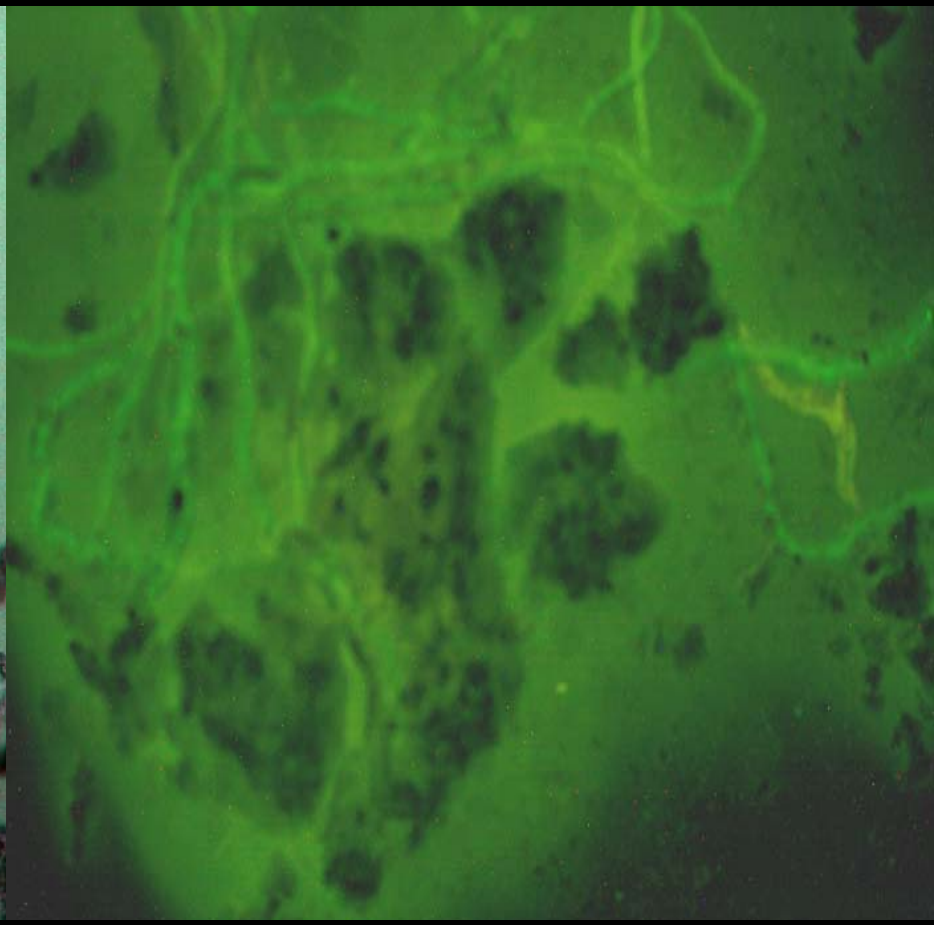
- We Eliminated All Synthetic Fertilizer On Our Owned Land in 2008
- On Rented Land In 2010

- We noticed an immediate improvement in the aggregation of our soils when I removed synthetic fertilizers.

Enlarged Soil Aggregates

Glomalin and hyphae

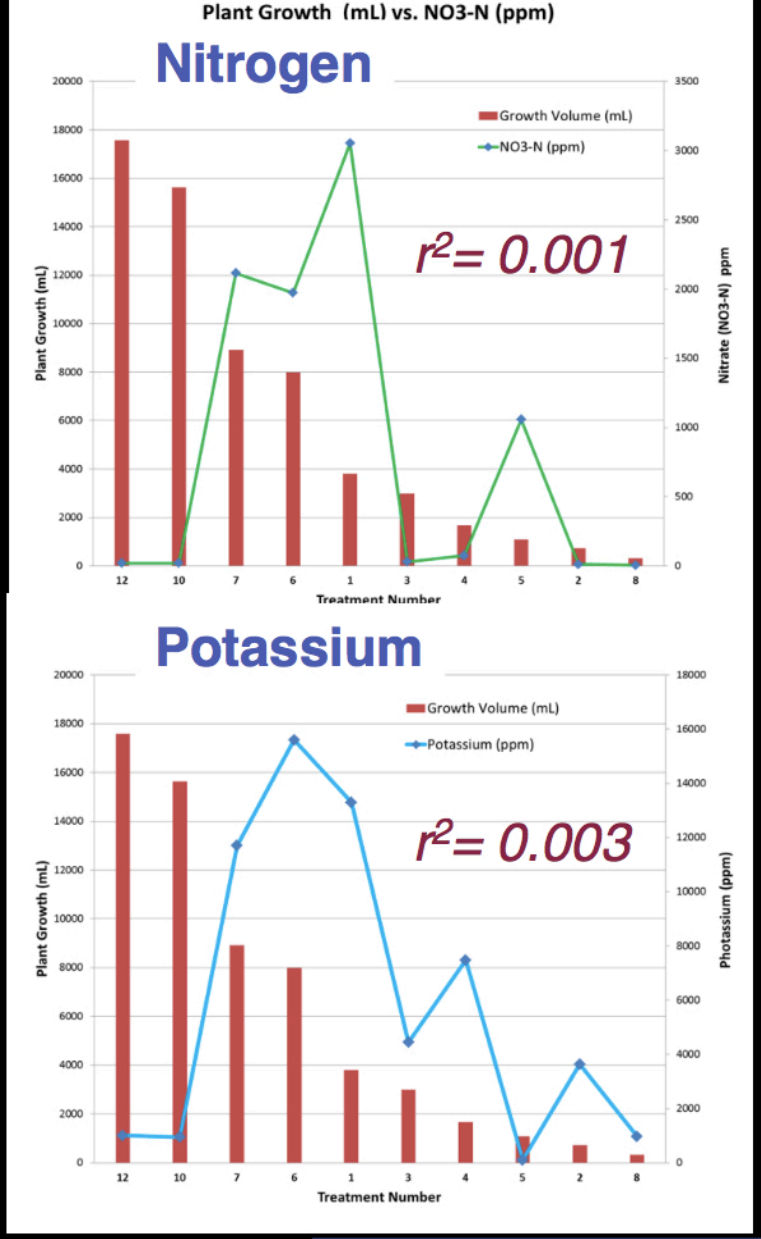


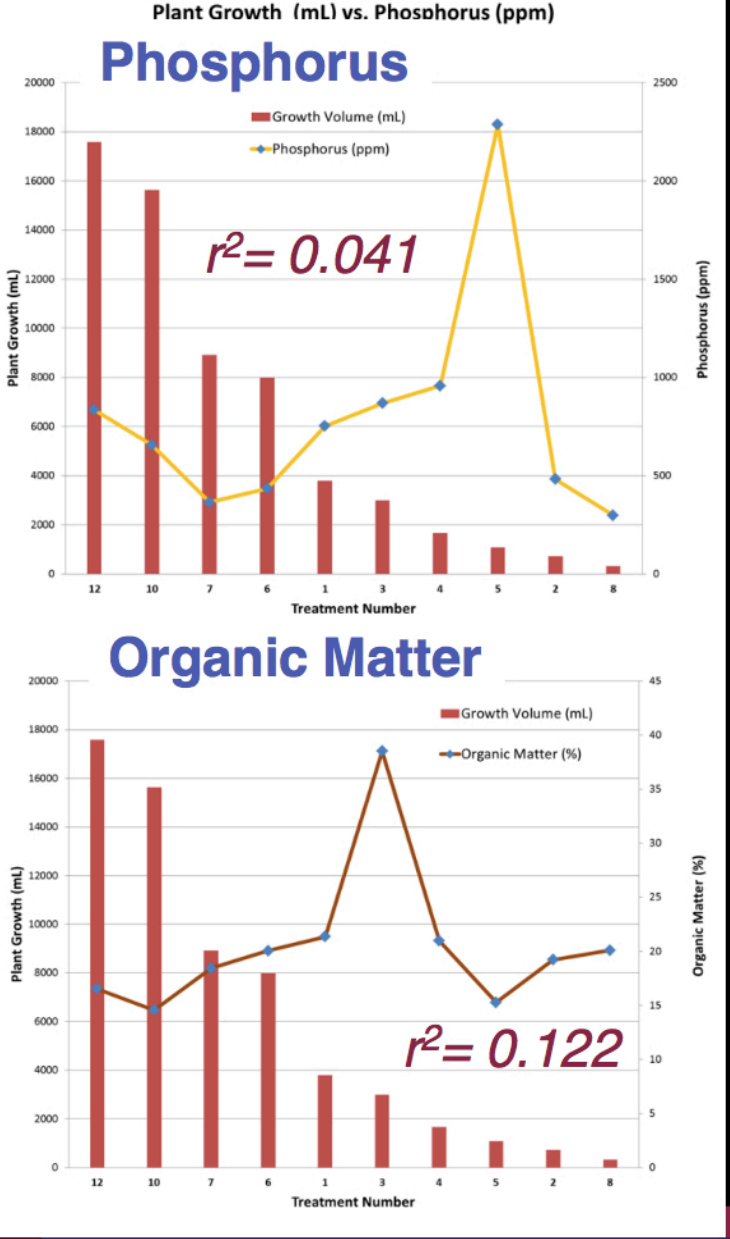


Dr. Kris Nichols, Microbiologist, ARS, Mandan, ND

David C. Johnson- NMSU Institute for Sustainable Agricultural Research (ISAR)
davidcjohnson@nmsu.edu

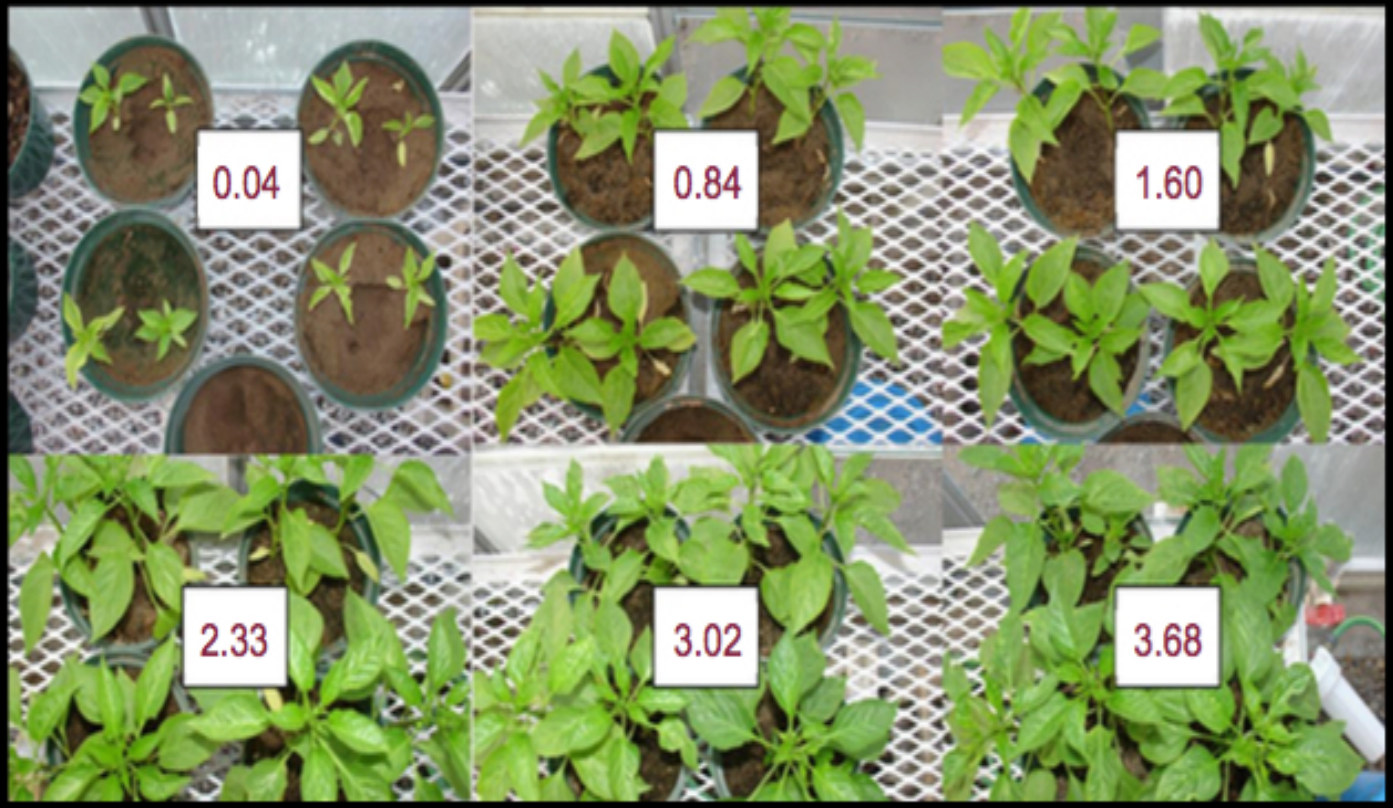
New Mexico State University





David C. Johnson- NMSU Institute for Sustainable Agricultural Research (ISAR)
davidcjohnson@nmsu.edu

New Mexico State University



F:B Ratio

David C. Johnson- NMSU Institute for Sustainable Agricultural Research (ISAR)
davidcjohnson@nmsu.edu

New Mexico State University

Soil Foodweb Analysis

Report prepared for:

Burleigh Co. Soil Conservation
Vicki Bailey
1511 E. Interstate Avenue
Bismarck, ND 58503-0560 US
(701) 250-4363
vicki.bailey@nd.nacdnet.net

Report Sent: 07/29/2005
Sample#: 01-100980
Unique ID: [redacted]
Plant: Wheat
Invoice Number: 8357
Sample Received: 07/14/2005

For interpretation of this report please contact:
Local Advisor: or regional lab
Soil Foodweb, Inc
info@soilfoodweb.com
(541) 752-5066
Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacterial (µg/g)	Total Bacterial (µg/g)	Active Fungal (µg/g)	Total Fungal (µg/g)	Hyphal Diameter (µm)
Results	0.850	44.2	2243	**7.02**	205	2.5
Comments	In Good Range	Excellent	Excellent	Low	Good	
Expected Range Low	0.45	15	100	15	100	
Expected Range High	0.85	25	300	25	300	

	Protozoa Numbers/g			Total Nematodes #/g	Percent Mycorrhizal Colonization	
	Flagellates	Amoebae	Ciliates		ENDO	ECTO
Results	**5020**	**2520**	**32**	**1.98**	**2%**	**0%**
Comments	Low	Low	Low	Low	Low	Low
Expected Range Low	10000	10000	50	20	40%	40%
Expected Range High			100	30	80%	80%

Organism Biomass Ratios	Total Fungal to Total Bacterial	Active to Total Fungal	Active to Total Bacterial	Active Fungal to Active Bacterial	Plant Available N Supply
Results	**0.09**	**0.03**	**0.02**	**0.16**	25-50
Comments	Low	Low	Low	Low	
Expected Range Low	0.8	0.25	0.25	0.75	
Expected Range High	1.5	0.95	0.95	1.5	

Nematodes per Gram of Soil
Identification to genus

Bacterial Feeders		
Acrobeles		0.13
Acrobeloides		0.04
Cephalobus		0.18
Eucephalobus		0.04
Panagrolaimus		0.04
Rhabditidae		0.27
Fungal Feeders		
Eudorylaimus		0.04
Mesodorylaimus		0.13
Microdorylaimus		0.04
Fungal/Root Feeders		
Aphelenchoides	Foliar nematode	0.04
Aphelenchus		0.27
Ditylenchus	Stem & Bulb nematode	0.18
Filenchus		0.04
Root Feeders		
Helicotylenchus	Spiral nematode	0.04
Meloidogyne	Root-Knot nematode	0.09
Paratylenchus	Pin nematode	0.09

Soil Foodweb Analysis

Report prepared for:

Burleigh Co. Soil Conservation
Vicki Bailey
1511 E. Interstate Avenue
Bismarck, ND 58503-0560 US
(701) 250-4363
vicki.bailey@nd.nacdnet.net

Report Sent: 07/29/2005
Sample#: 01-100984
Unique ID: GB1
Plant: Corn
Invoice Number: 8357
Sample Received: 07/14/2005

For interpretation of this report please contact:
Local Advisor: or regional lab
Soil Foodweb, Inc
info@soilfoodweb.com
(541) 752-5066
Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacterial (µg/g)	Total Bacterial (µg/g)	Active Fungal (µg/g)	Total Fungal (µg/g)	Hyphal Diameter (µm)
Results	**0.850**	46.3	405	**5.24**	274	2.5
Comments	To Wet	Excellent	Excellent	Low	Good	
Expected Range Low	0.45	15	100	15	100	
Expected Range High	0.85	25	300	25	300	

	Protozoa Numbers/g			Total Nematodes #/g	Percent Mycorrhizal Colonization	
	Flagellates	Amoebae	Ciliates		ENDO	ECTO
Results	178500	**9736**	331	**4.45**	**31%**	**0%**
Comments	High	Low	High	Low	Low	Low
Expected Range Low	10000	10000	50	20	40%	40%
Expected Range High			100	30	80%	80%

Organism Biomass Ratios	Total Fungal to Total Bacterial	Active to Total Fungal	Active to Total Bacterial	Active Fungal to Active Bacterial	Plant Available N Supply
Results	**0.68**	**0.02**	**0.11**	**0.11**	200+
Comments	Low	Low	Low	Low	
Expected Range Low	0.8	0.25	0.25	0.75	
Expected Range High	1.5	0.95	0.95	1.5	

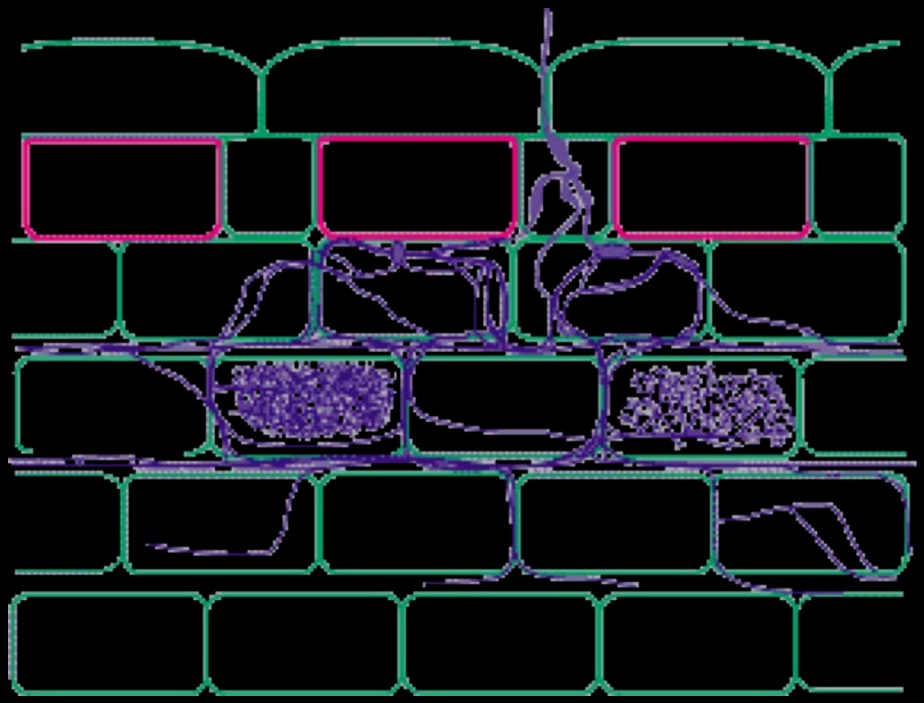
Nematodes per Gram of Soil
Identification to genus

Bacterial Feeders		
Acrobeles		0.81
Acrobeloides		0.18
Cephalobus		0.45
Cervidellus		0.18
Rhabditidae		0.45
Fungal Feeders		
Eudorylaimus		0.09
Fungal/Root Feeders		
Aphelenchoides	Foliar nematode	0.54
Aphelenchus		0.45
Ditylenchus	Stem & Bulb nematode	0.54
Filenchus		0.09

Mycorrhizal Fungi and Biology Build Soil Aggregates

Photo courtesy Aberdeen Mycorrhiza Research Group

AMF – Protect their host plants from pathogens and nematodes in the soil



Mycorrhizal Friendly Species

- Oats
- Barley
- Flax
- Clovers
- Sunflowers


High Mycorrhizal Mix


3 Year No-till vs. Conventional Till
Michael Thompson
Farm

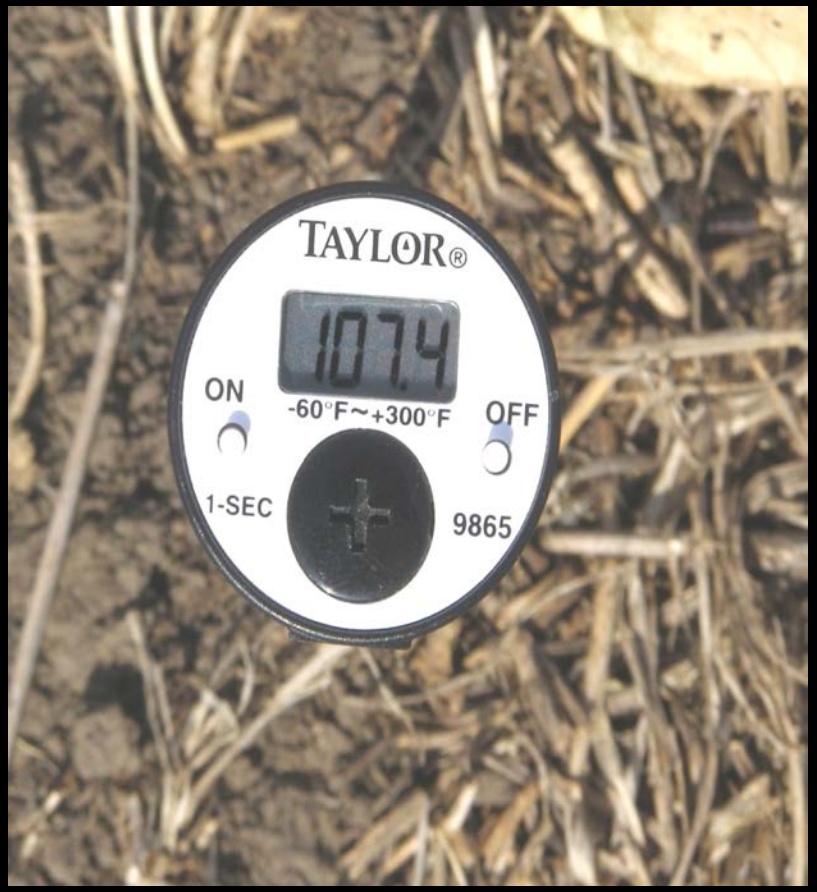
2) Armor On The Soil

Disrupted Soil Ecosystem

Dysfunctional Soil Ecosystem-Crust


No-Till Planting Through Heavy Residue

Soil Temperatures



Residue buffers August heat

SOIL TEMPERATURES

- 70 Degrees: 100% of moisture can be used for growth.
- 100 Degrees: 15% of moisture is used for growth, 85% is lost to evaporation and transpiration.
- 130 Degrees: 100% of moisture is lost through evaporation and transpiration.
- 140+ Degrees: Soil Biology is severely affected.


Soil Temperatures Are Acceptable

3)Diversity

The Importance Of Diversity

2006 Dr. Ademir Calegari

"Cover crops should be seeded as multi-species cocktails"

2006 Burleigh Co. ND

Turnip July 31

Oilseed Radish July 31

Cover Crop Mix July 31

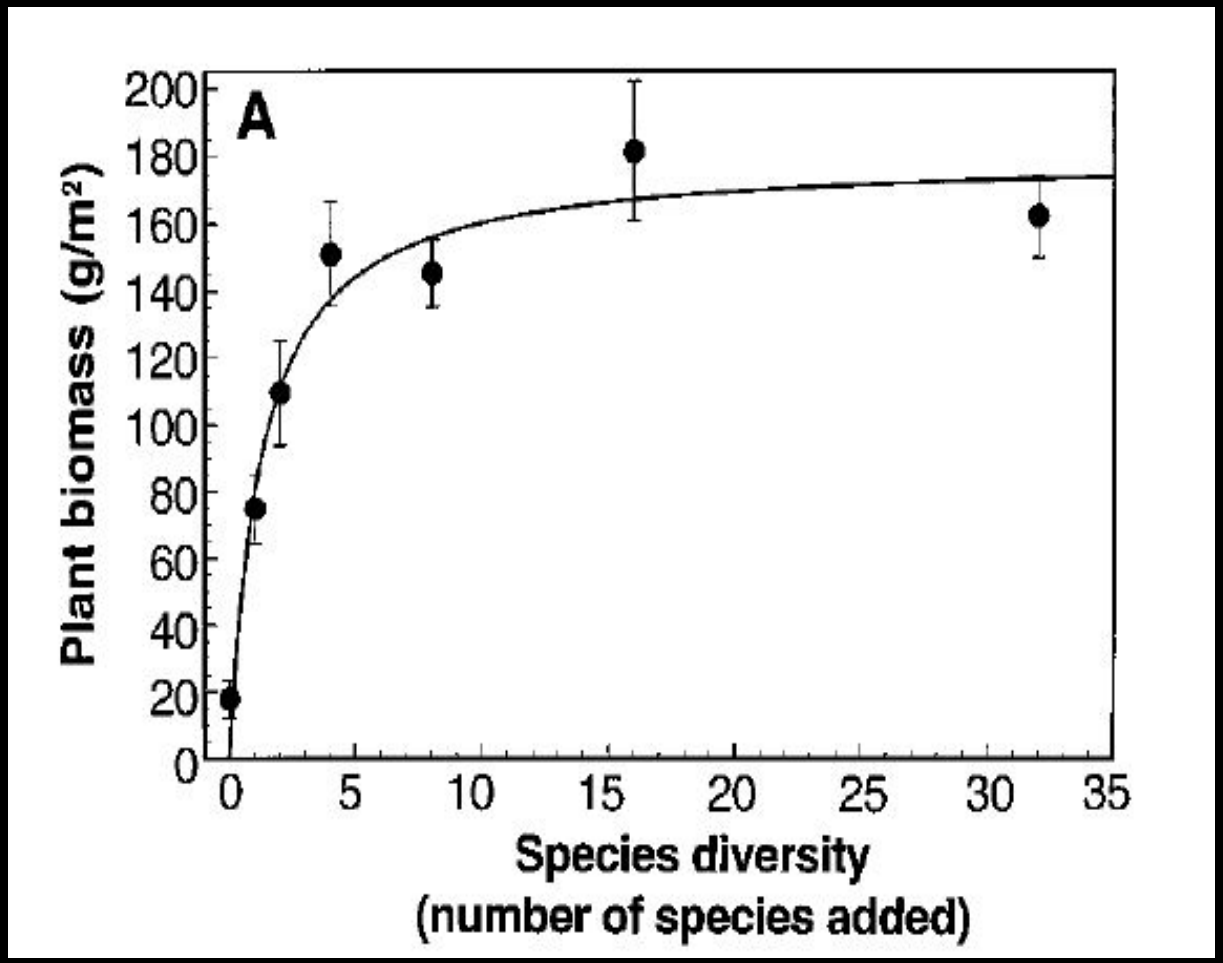
Production On District Plot

- Oilseed Radish 1260 Lbs.
- Purple Top Turnip 1513 Lbs.
- Pasja Turnip 2070 Lbs.
- Soybean 1496 Lbs.
- Cowpea 1914 Lbs.
- Lupin 1232 Lbs.
- Cocktail Mix (1/2 Rate) 4785 Lbs.
- Cocktail Mix (Full Rate) 4350 Lbs.

- “Not only do the fungi provide for the needs of one plant but the fungal/hyphae pipeline connect to multiple plants… This helps satisfy the nutritional and energy needs of microorganisms and the plants”
- Dr. Kris Nichols, ARS Mandan, ND

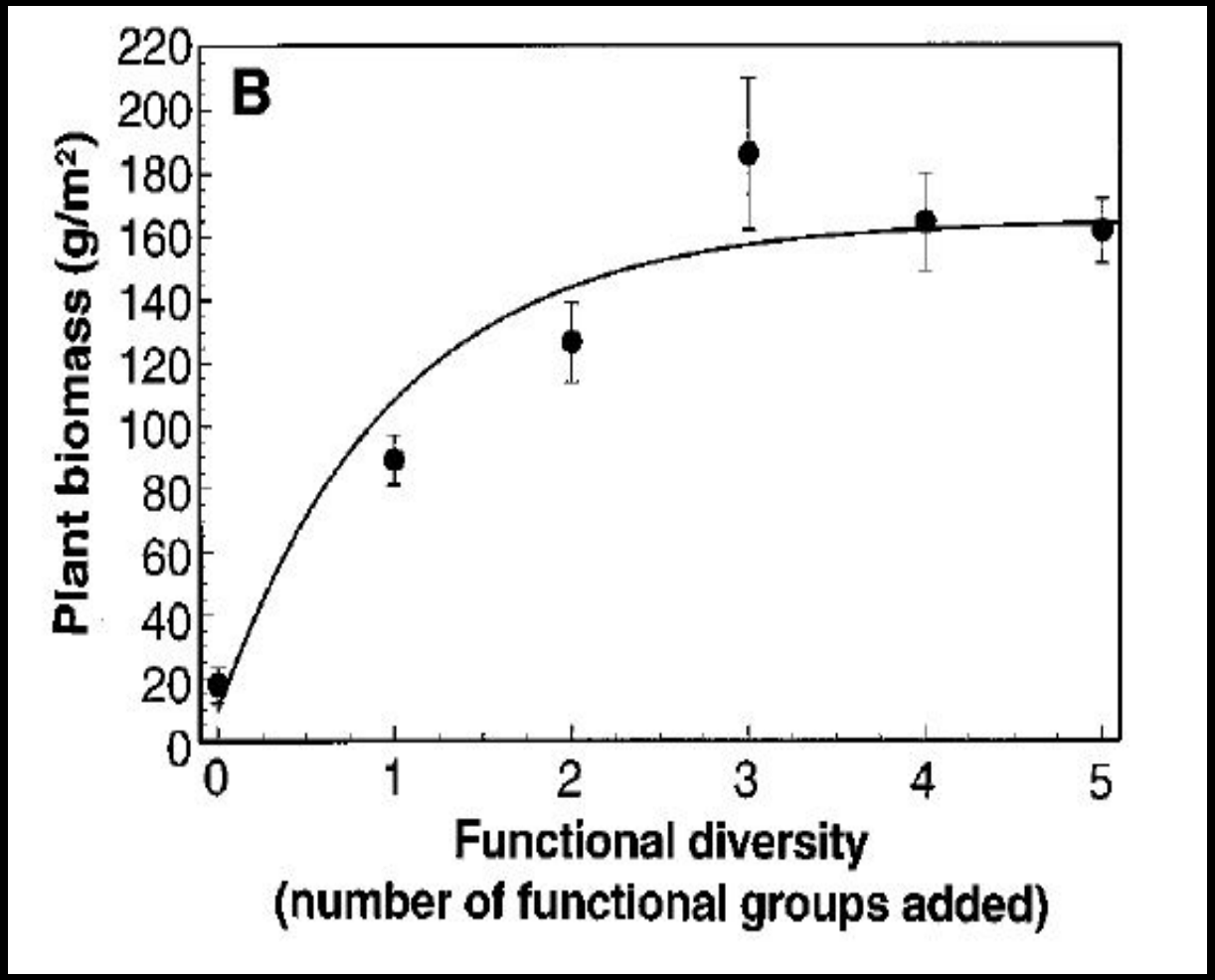
Monocultures: A Detriment to Soil Health

The Influence of Functional Diversity and Composition on Ecosystem Processes



David Tilman,* Johannes Knops, David Wedin, Peter Reich,
Mark Ritchie, Evan Siemann

The Influence of Functional Diversity and Composition on Ecosystem Processes



David Tilman,* Johannes Knops, David Wedin, Peter Reich,
Mark Ritchie, Evan Siemann

- A key strategy in sustainable agriculture is to restore functional biodiversity of the agricultural landscape (Altieri, 1994).
- Biodiversity performs key ecological services and if correctly assembled in time and space can lead to agroecosystems capable of sponsoring their own soil fertility, crop protection and productivity. (Altieri, 1994)

Optimizing Solar Energy Collection

- Increasing Photosynthetic:
- Capacity
- Rate

Diversity Drives Soil Health

Brown's Ranch Cash Crops

Wheat – CSG **Oats – CSG** **Triticale - CSG** **Barley – CSG** **Rye - CSG**	**Hairy Vetch – CSB** **Peas - CSB**
Corn – WSG **Millet-WSG**	**Sunflower – WSB**

Diversity in the Cropping System

Fall Seeded Biennials

Winter Triticale/ Hairy Vetch

Income

- Yield: 55 x $7.00 =$385.00
- Yield: 450# x $1.75=$787.50
- Total Income: $1,172.50

Expense

Land Cost:	$50.00
Seed:	40.
Seeding:	24.
Herbicide:	24.
Combining:	35.
Trucking:	6.
Storage:	18.
Cleaning:	26.
Marketing Labor:	32.50
Total Expenses:	$257.50

Net Profit/Acre
$915.00


Oats:
No Fertilizer, Pesticides or Fungicides

Oats

Income

- Yield: 112
- Price/bu.: $5.50
- Total Crop Income: $588.
- Grazing Income: $110.
- Total Income: $698.

Expense

Land Cost:	$50.
Seed:	$16.
C/C Seed:	4.45
Seeding:	24.
Herbicide:	23.
Combining:	25.
Trucking:	22.40
Storage:	11.20
Cleaning:	15.
Marketing Labor:	25.
Total Expenses:	$216.05

Net Profit/Acre: $481.95

Cost of Production Including Land Cost 2008-2018

- Corn $1.44/bu
- Oats .97
- Peas 2.78
- Wheat 1.82

Yields: 2008-2018

	Brown's	County Average
Corn	127	98
Spring Wheat	62	39
Oats	112	62
Barley	72	48

Cropland Acres

- We Grow Cash Crops on 70-80% of Our Cropland Acres Every Year.
- On Those Acres We Also Grow a Cover Crop Either Before, Along With or After the Cash Crop.
- The Other 20-30% Is Double Crop Cover Crop, grazed by livestock.

New Paradigm

- Oats
- Barley
- Peas
- Flax
- Lentils

$$$

- I will take profit over yield any day!

4) Living Root As Long As Possible

Never Pass Up The Opportunity To Cycle Carbon

- It All Begins With Photosynthesis!
- The More Photosynthesis, The More Liquid Carbon Being Pumped Into The System!

Plant and Soil are One

Ray Archuleta

Brown's Ranch Cover Crops

Annual Ryegrass – CSG
Oats – CSG
Barley – CSG
Winter Triticale – CSG
Forage Winter Wheat - CSG
Rye - CSG

Canola – CSB
Radish – CSB
Turnip – CSB
Lentil – CSB
Sweet Clover – CSB
Phacelia – CSB
Sub Clover – CSB
Buckwheat – CSB
Kale – CSB
Flax - CSB
Crimson Clover - CSB
Berseem Clover - CSB
Persian Clover - CSB
Hairy Vetch - CSB
Winter Pea - CSB
Collards - CSB

Hybrid Pearl Millet – WSG
German Millet – WSG
Sorghum/Sudangrass – WSG
Brown Millet – WSG
Egyptian Wheat – WSG
Teff – WSG

Sugarbeet – WSB
Cowpea – WSB
Soybean – WSB
Sunn Hemp – WSB
Ethiopian Cabbage – WSB
Safflower – WSB
Fava Bean – WSB
Mung Bean – WSB

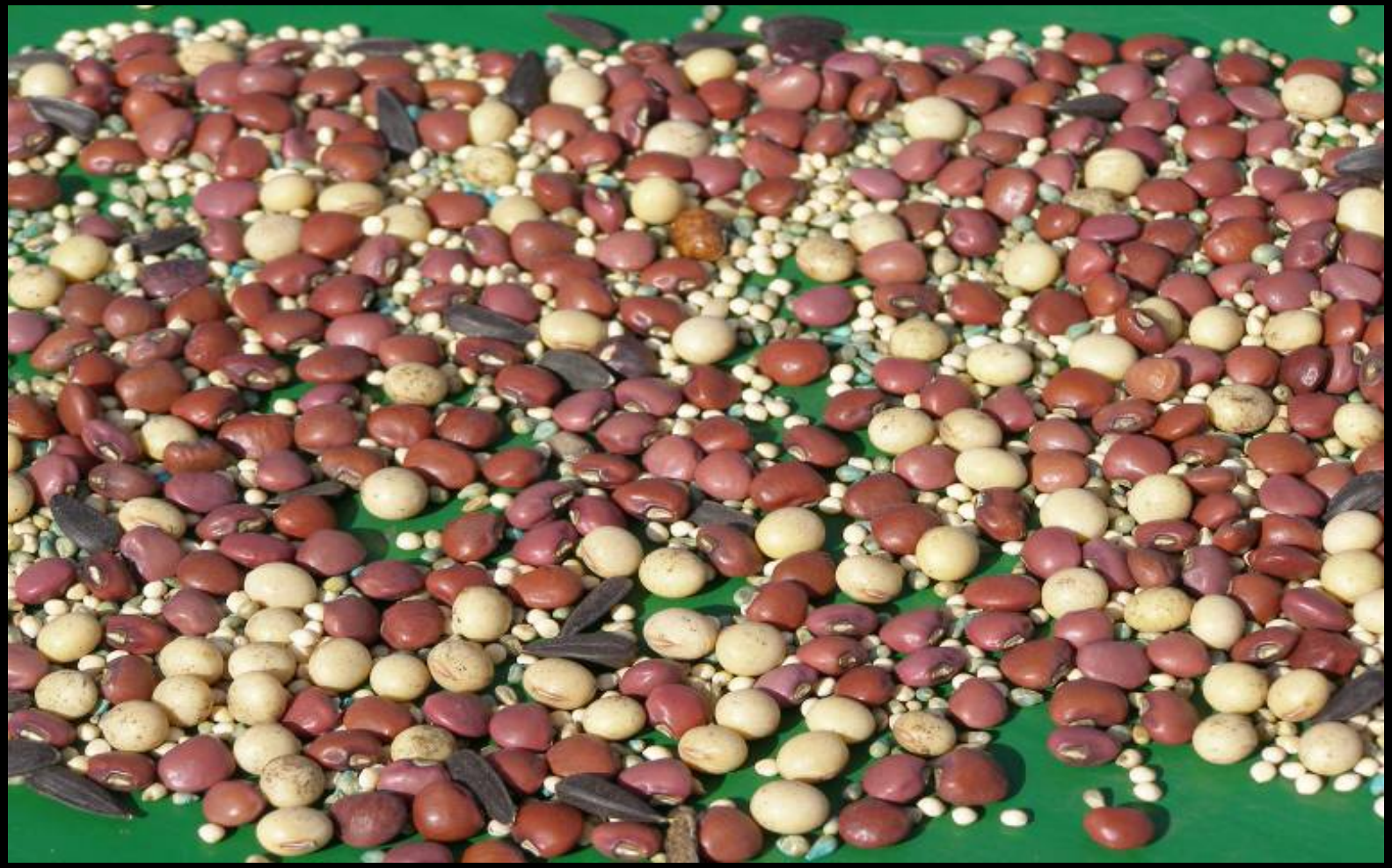
Cover Crops

Designing for your resource concern!

Resource Concerns

Provide crop diversity
Provide soil surface armor
Build soil aggregates
Improve the water cycle
Integrated Pest Management
Build soil organic matter
Nutrient cycling
Enhance pollinators
Adjust carbon/nitrogen ratios
Wildlife winter food & shelter
Livestock integration

Cover Crop Seed



Diversity!

- Sunflower
- Sorghum/Sudangras
- German Millet
- Soybean
- Cowpea
- Kale
- Radish
- Turnip
- Sunn Hemp
- Safflower
- Buckwheat
- Fava Bean

Persian Clover
Berseem Clover
Hairy Vetch
Hybrid Pearl Millet
Crimson Clover
White Millet
Oats
Flax

Optimizing Solar Energy Collection

Cover Crop 9/14

Roots: Build OM, and Cycle Nutrients

Photograph by Jim Richardson

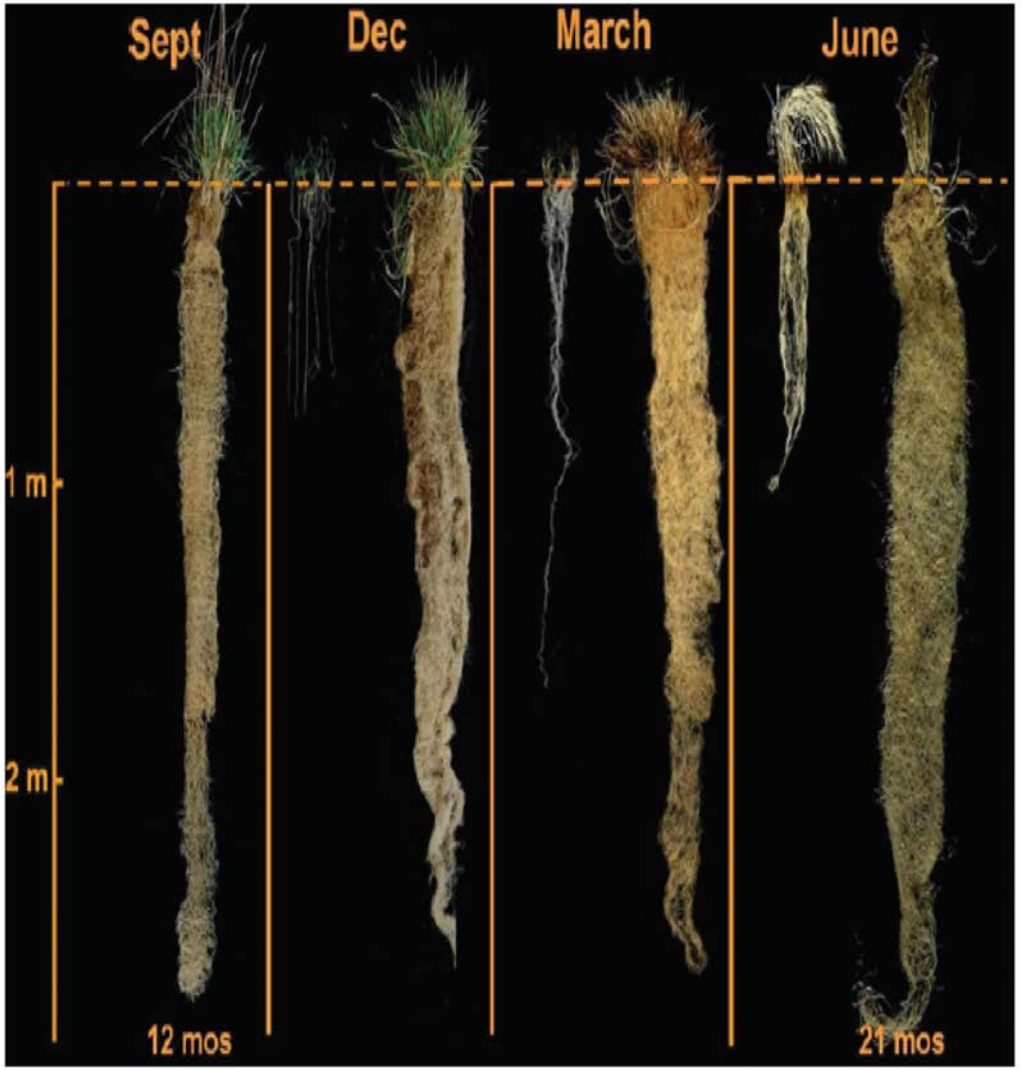


Figure 1. Root systems of annual wheat (on the left in each panel) and intermediate wheatgrass, a perennial, at four times of the year. Although roughly 25% to 40% of the wheatgrass root system dies off and must grow back each year, its longer growing season, and consequently greater access to resources, results in greater above- and belowground productivity than its annual counterpart.

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

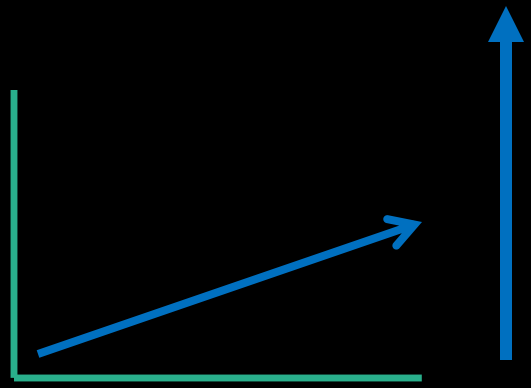
March – April 1994

Summarized by:

Dr. Mark Liebig, ARS, Mandan, ND

Hal Weiser, Soil Scientist, NRCS, Bismarck, ND

Soil Organic Matter



1993	1.7 to 1.9%
Present	5.3 to 7.9%

Value of SOM

Assumptions: 2,000,000 pounds of soil in top 6”.

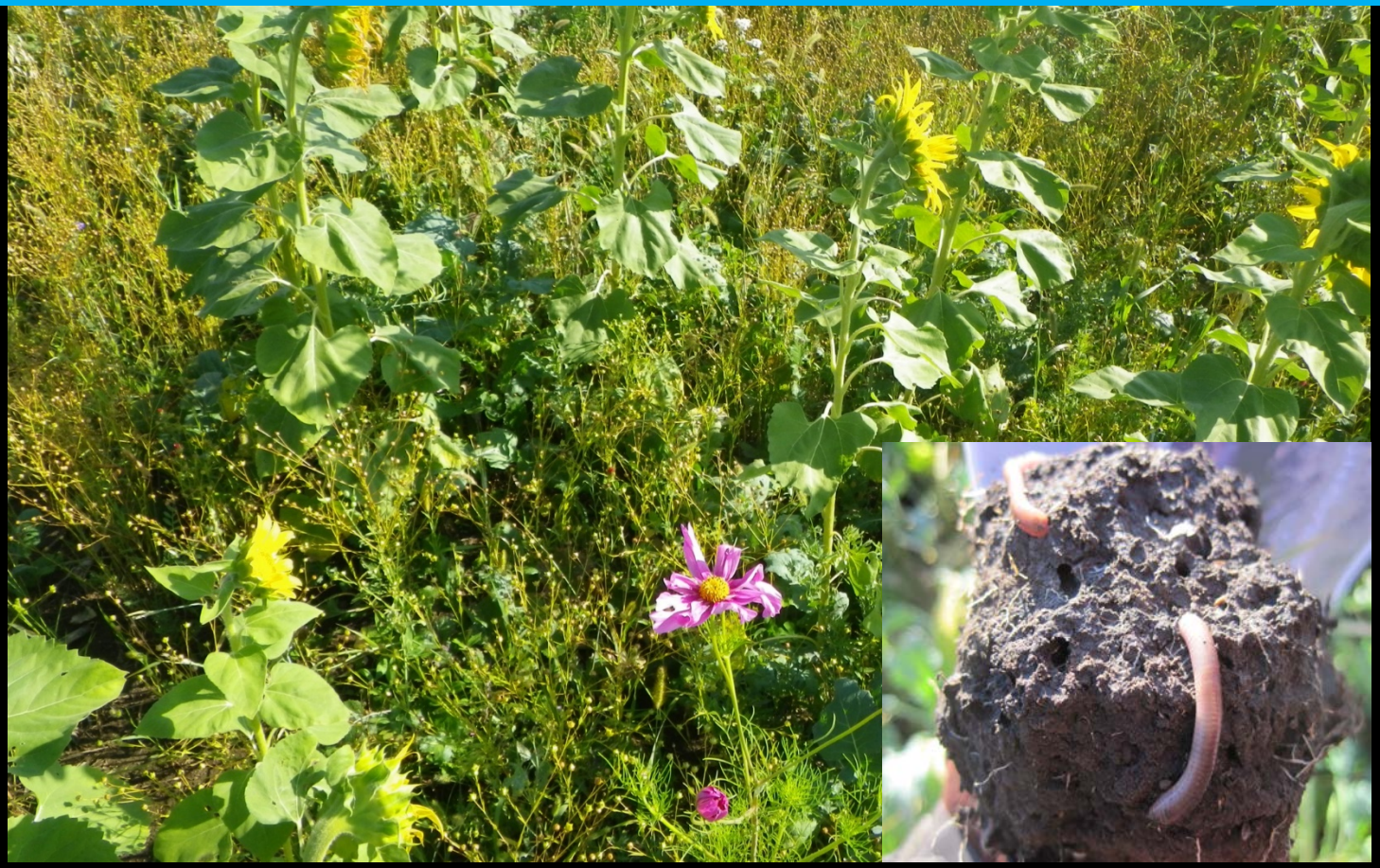
1% OM = 20,000 pounds.

Nutrients:

Nitrogen:	1000# $.56/lb.	N = $560
Phosphorus:	100# $.67/lb.	P = $ 67
Potassium:	100# $.54/lb.	K = $ 54
Sulfur:	100# $.50/lb.	S = $ 50
Value of 1% SOM nutrients/acre		= $731

5% SOM = **$3,655**

Feeding the Whole



Wildlife!

Insects

Iowa Cornfield

Native Prairie

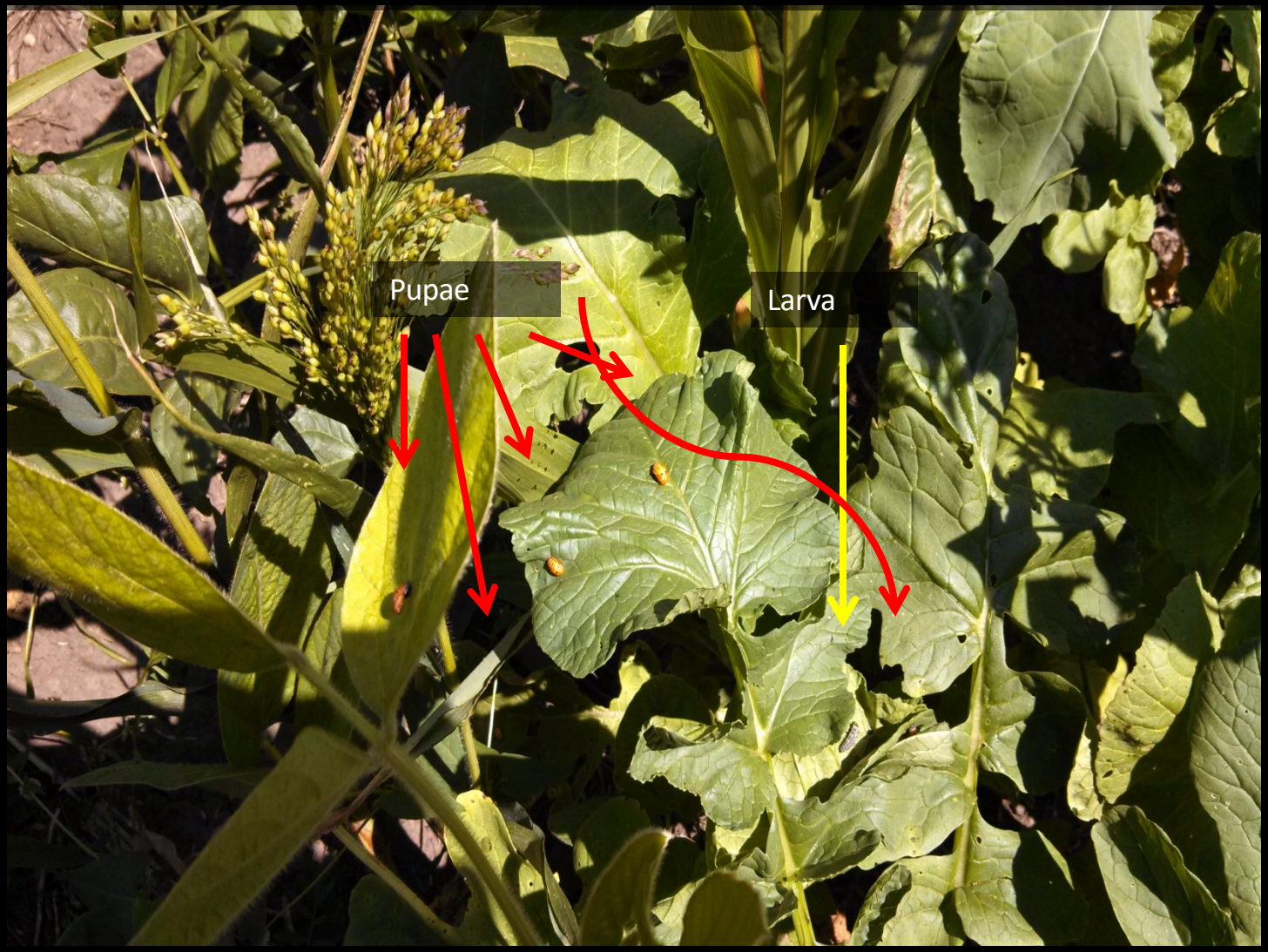
- The Reason Producers Have Pest Problems Is Because Of A Lack Of DIVERSITY!
- (No Home For The Predators)

Fruit Trees

Bees

Phacelia and a Native Pollinator

Lady Beetles (Predators)



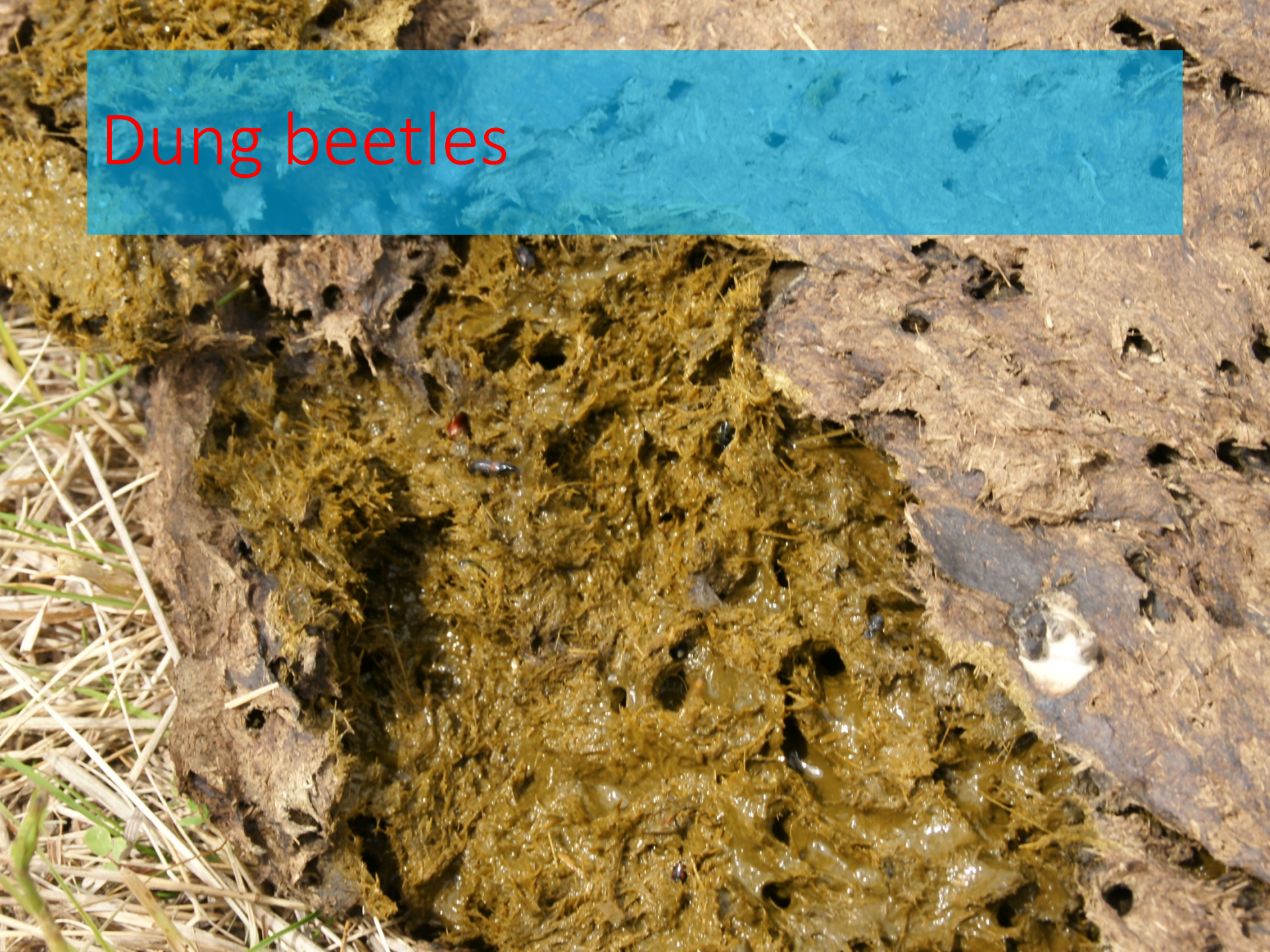
Predators

Hister beetles

Rove beetles

(Ontholestes cingulatus)

Dung beetles



17 Species and Counting!


Yellow Dung Flies

Dragonflies

Orb Weavers

For Every Insect Species That Is A Pest,
There Are 1,700 Species That Are Beneficial!

- We Have Not Used A Pesticide Since Before The Turn Of The Century With The Exception Of Treated Seed Corn And That Was Discontinued In 2010.
- No Need To As The Predator Insects Take Care Of The Pests For Us!

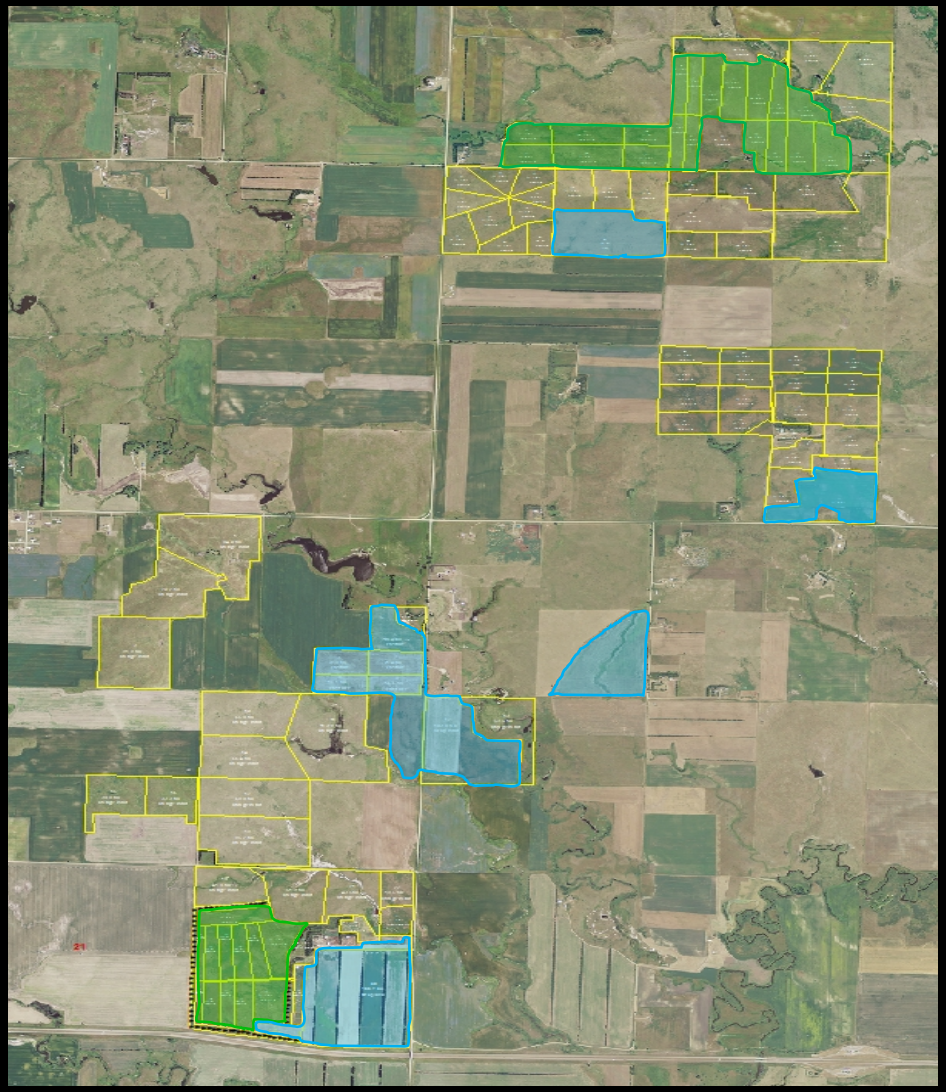
Build it… they will come!

162,000 weed seeds/ 1 sq. meter of a farm field. 137,000 to 161,000 predators per acre of corn canopy.

Approximately 10 percent of weed seeds are eaten per day by Millipedes, Small crickets, Isopods, Field Crickets an Carabid Beetles.

Jan 9, 2015. Dr. Jonathan Lundgren SD ARS/USDA.

5) Animal Impact



Diverse Primer Ready To Graze

BMR S/S, Cowpea, Soybean, Millet

- ADG 3.0+
- Brix 20+

Converting Cover Crop to Dollars

Brown's Ranch

Topsoil Depth

3”

14”

1993

No-till

1.7% OM

1995

Cash Crop Diversity

2.0% OM

2013

Plot including high diversity of plants, livestock and carbon. High nutrient densities

11.1% OM

Carbon

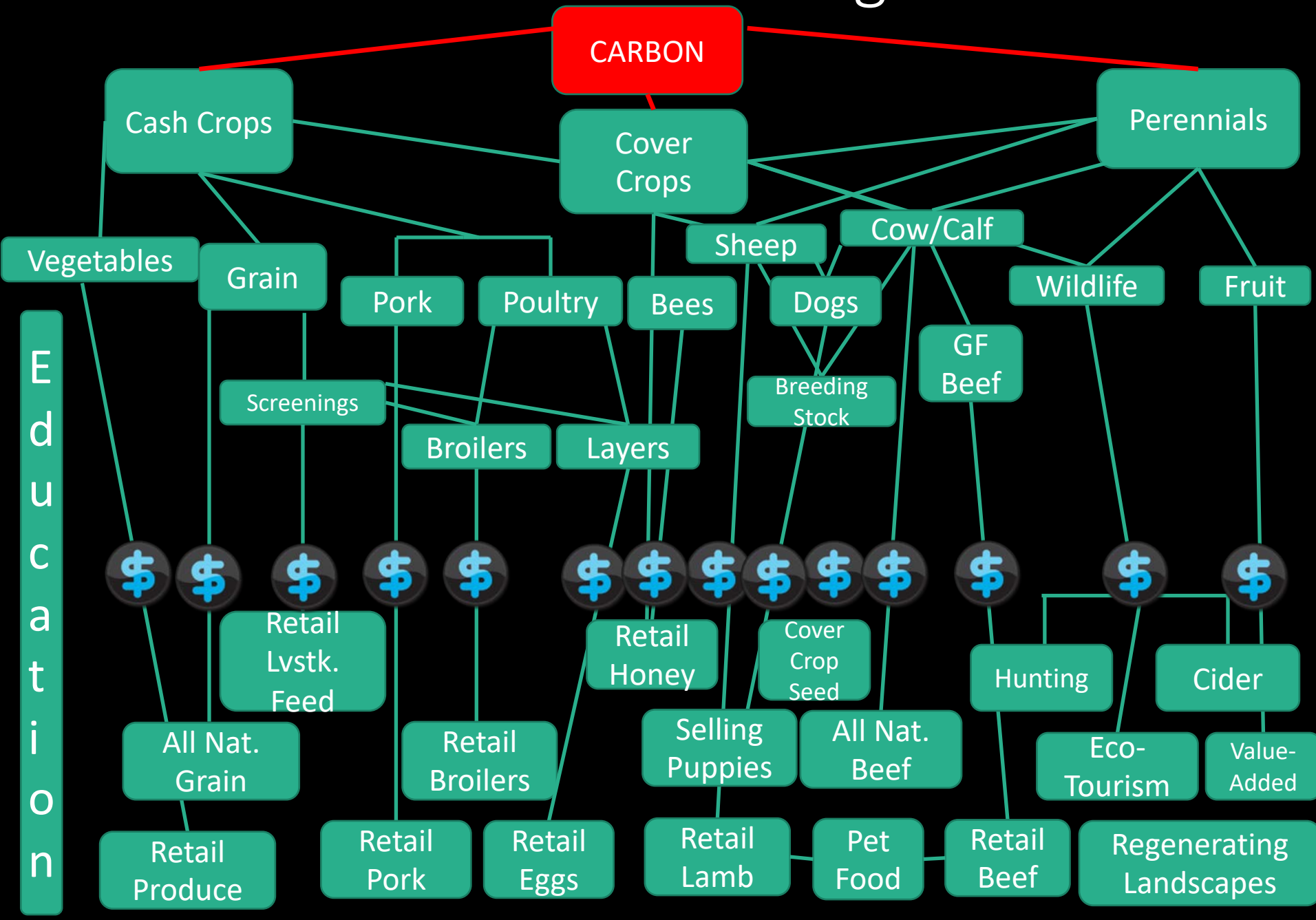
- Carbon is the key driver for the nutritional status of plants---and therefore the mineral density in animals and people.
- Carbon is the key driver for soil moisture holding capacity.
- CARBON is the key driver for farm PROFIT!

- I used to wake up every morning trying to decide what I was going to kill that day; a weed, a pest, a fungus…

- Now I wake up every morning trying to decide how I can get more LIFE on my ranch!

- It is much more fun working with LIFE than death!

Soil-Water-Sunlight




Three Years Regenerative
Michael Thompson
Farm

- It’s not change that we are looking for, it’s understanding; through understanding, change will occur.

Questions?

Diminished Water Cycle