Cover Crop Mixes
Getting the Cover Crop You Want

"You can tell whether a man is clever by his answers. You can tell whether a man is wise by his questions."

–Naguib Mahfouz

48 lb. cereal rye and 3 lb. tillage radish broadcast into standing corn at a cost of $32.27 per acre ($21.27 seed + $11 application) in Ohio.

What is your goal?

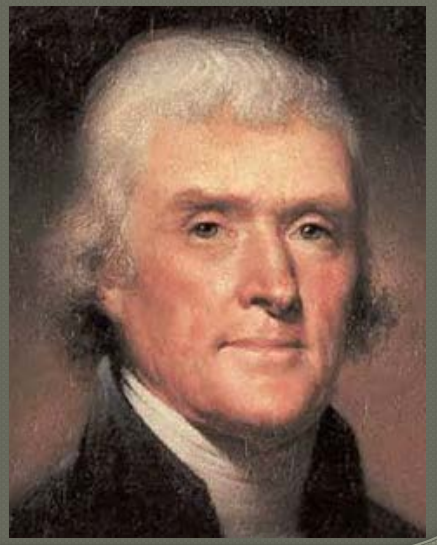
- Do not make the use of a cover crop your goal.
- Cover crops can be a tool to help restore soil health.
- Restoring and building soil health is a worthy goal in which cover crops can play a part.

A New Look at an Old Practice

- Thomas Jefferson used turnip, buckwheat and vetch as cover crops at Monticello in 1794.

"…I think it important to separate my exhausting crops by alternations of ameliorators."

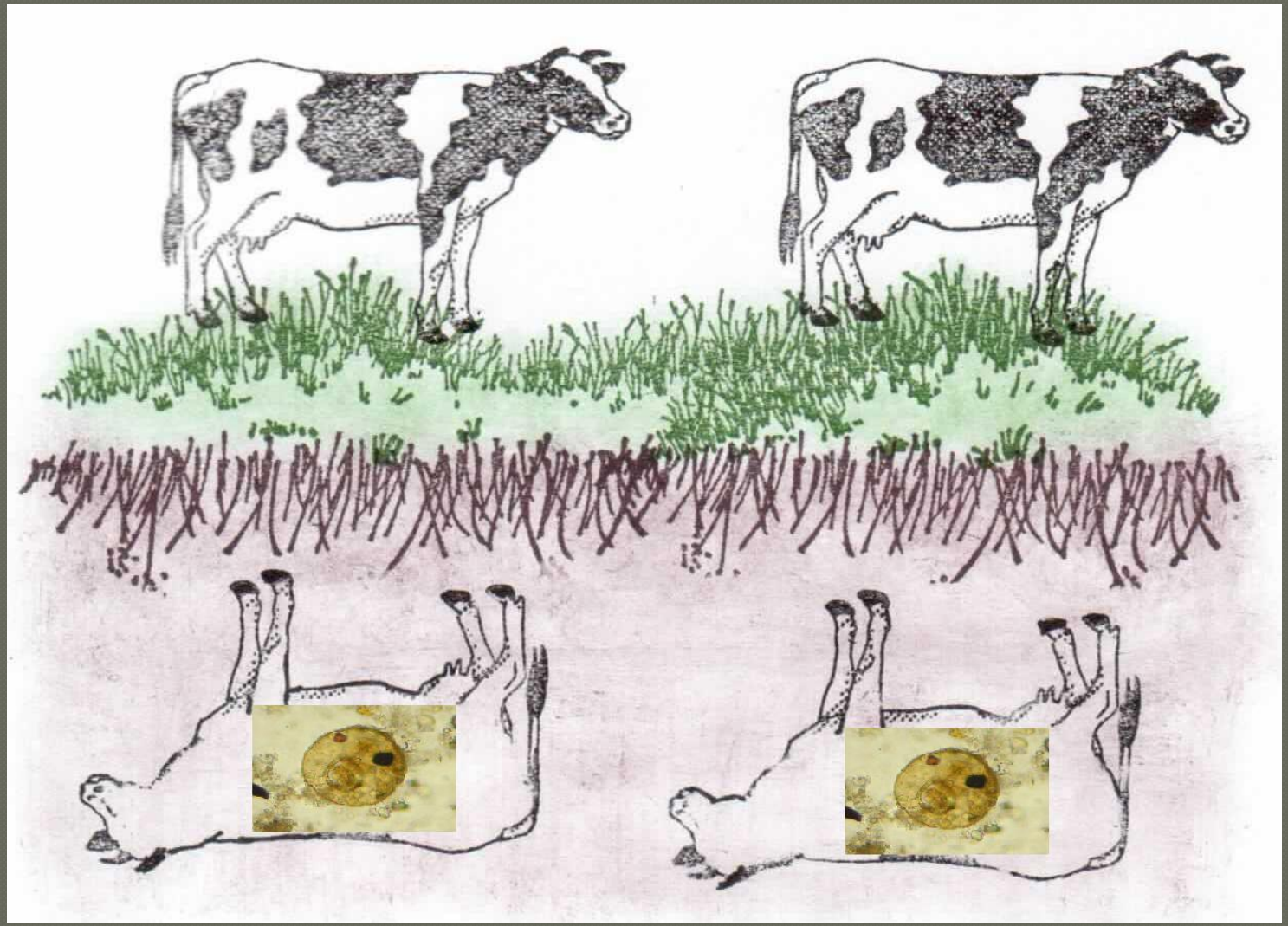
Thomas Jefferson in a letter to John Taylor, December 29, 1794.



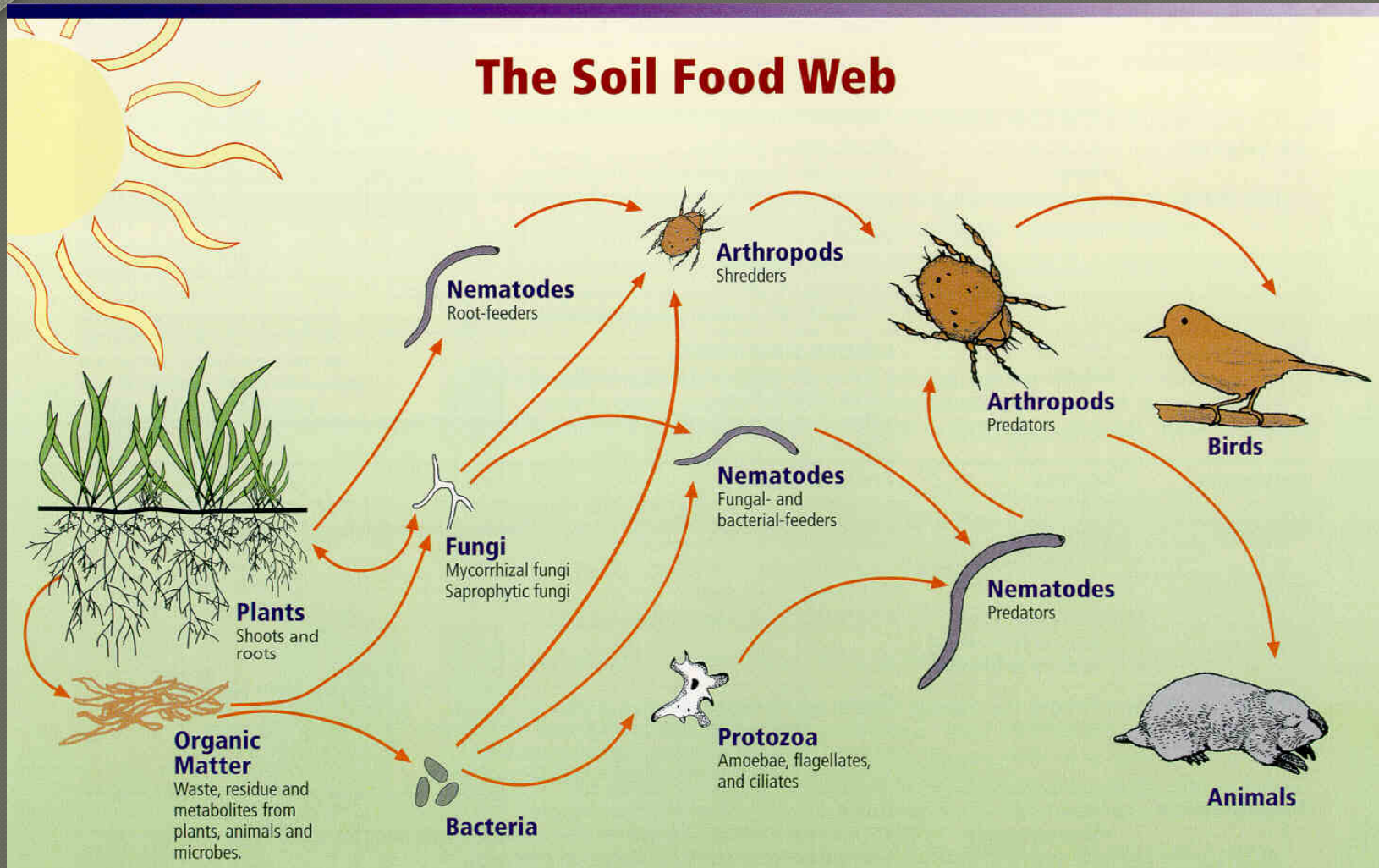
Soil Health

- The continued capacity of the soil to function as a vital living system that sustains plant, animal, and human health.
- Cover crops are "primers" of soil biology.

Feed the Underground Herd!



The Soil Food Web



First trophic level:
Photosynthesizers

Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

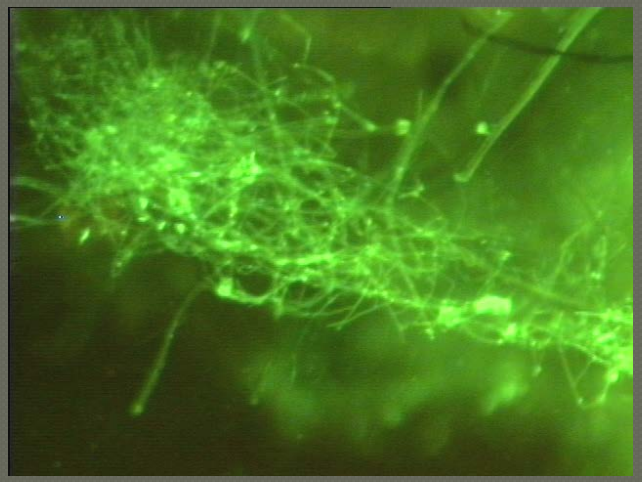
Fourth trophic level:
Higher level predators

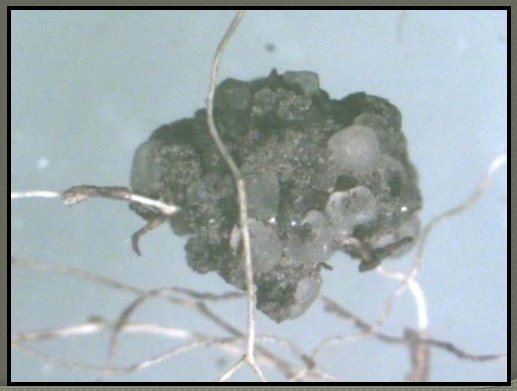
Fifth and higher trophic levels:
Higher level predators

This is our Toolbox

Glue-makers

- It's all about the Food
- Bacteria – stick it to me.
  - microaggregation
- Fungi – seal the pipes.
  - Micro & Macroaggregation
- Aggregates are habitat
- Microbes must be fat to make good soil aggregates.





Soil Aggregate stability… an indicator of soil health

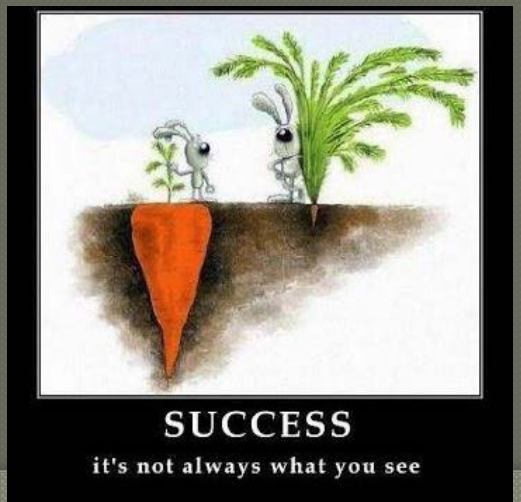
Rhizosphere…where roots meet soil

Zone of concentrated biological activity adjacent to the root.

- Bacteria
- Fungi
- Protozoa
- Nematodes
- Microarthropods
- Earthworms

Managing for Soil Biology & Soil Health

- Minimize Disturbance of the soil
- Maximize Diversity of plants in rotation
- Keep Living Roots in the soil as much as possible
- Keep the soil covered with plants & plant residues
- Create the most favorable habitat possible for the soil food web



Cover Crops… what for?

- Feed the Soil Foodweb
- Provide supplemental forage
- Provide soil cover (water, temperature, armor…)
- Provide wildlife food/cover
- Capture/cycle crop nutrients
- Fix atmospheric nitrogen
- Catch snow
- Support pollinators
- Create pores through compacted soil

How do Cover Crops improve soil health?

- **Cover crops are food and habitat for soil biology**
- Food
  - Diversity of plants = diversity of organisms
  - Living roots (approx. 6 weeks for significant benefits)
  - Residue/biomass
- Soil cover
  - Growing plants and their residues

Plan for purpose

- Planting – When? How?
- Species – How many? Which ones?
- Termination – When? How?
- Cover on soil – When? How much?

A Sunflower, sorghum-sudan, rapeseed, turnip, radish, millet, pea, lentil @ 25 lbs/ac no-tilled into wheat stubble to feed the soil foodweb & build soil health in Montana.

Planting

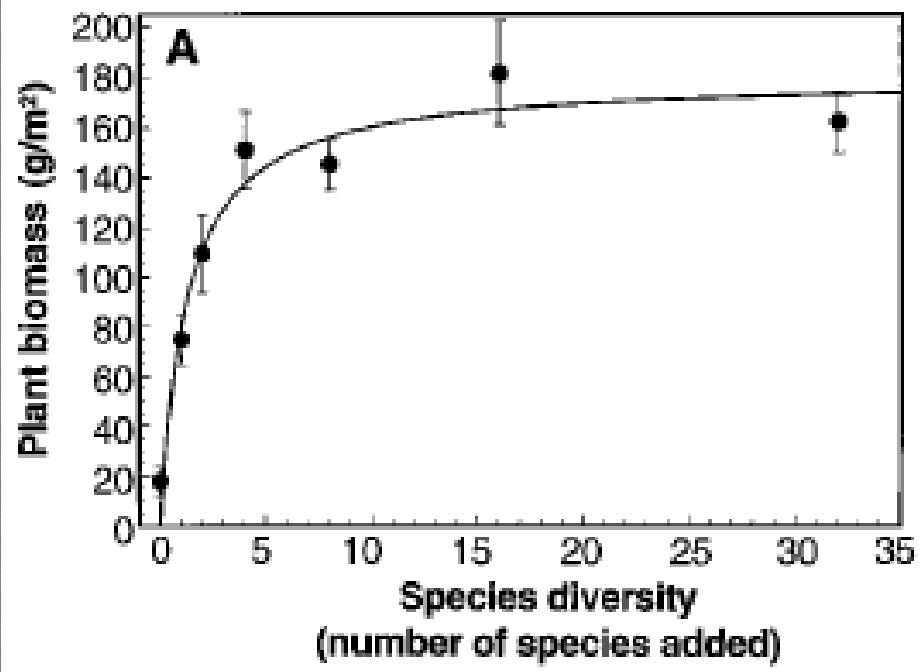
- Pre-harvest or post-harvest of cash crop?
- Drill, planter or broadcast?
- Planting depth and seed size.
- Mix different seed prior to planting.
- Inoculants for each legume.
- Pre-plant burndown?
- Fertilizer?

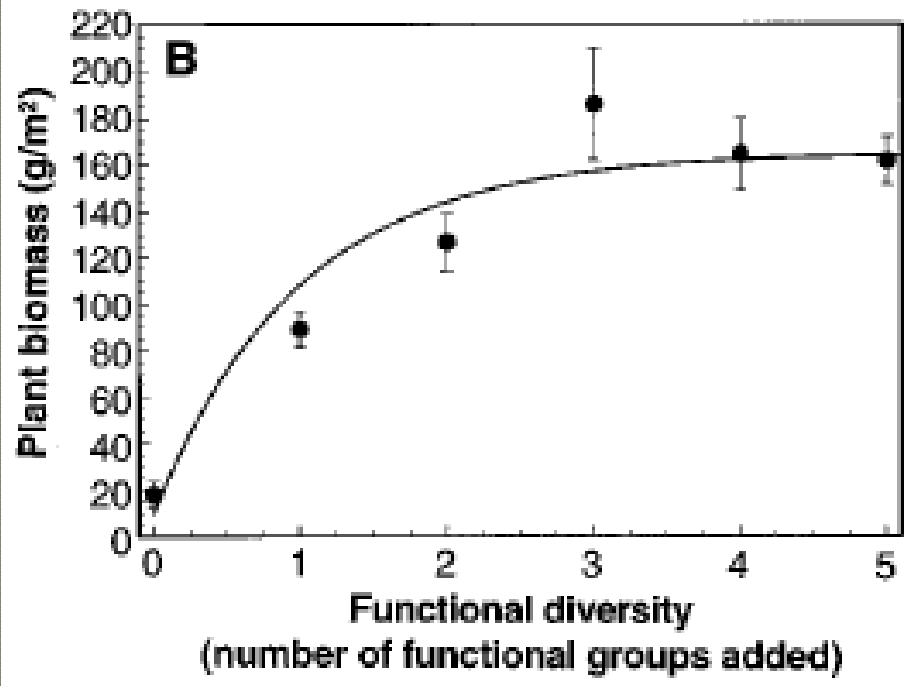
Daikon radish, White Clover, Winter Rye cover crop broadcast into silage corn stubble on a continuous no-till field in Connecticut.

Species

- At least 5 species
- At least 3 functional groups
- Season of growth
- Moisture conditions
- Temperature conditions
- Annual, biennial, perennial
- Cost/availability
- Carbon:Nitrogen ratio
- Herbicide carryover

A multi-species cover crop in the San Luis valley of Colorado





Ken Miller filling and mixing cover crop seed in a JD 750 no-till drill at Menoken, ND

D. Tillman et. Al., Science, Vol. 277, pp. 1300-1302, 1997.

Termination

- Frost
- Dry
- Grazing
- Roller
- Herbicide
- Maturity

Sheep grazing a multi-species cover crop in Burleigh County, North Dakota

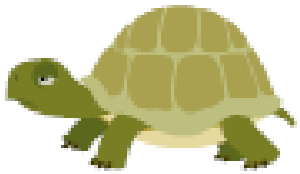
Cover

- During growth
- After termination
- During fallow/over winter period
  - Rate of decomposition
  - Consumption by wildlife
  - Living roots feeding SFW
- After grazing

A cover crop of winter wheat planted into corn residue in Callaway County, MO. Right half of the field was chopped as silage and left half was grazed as green standing forage. Note nitrogen deficit in the area that was chopped and removed for silage.

Carbon : Nitrogen Ratios

Material	C:N ratio
Rye Straw	82:1
Wheat Straw	80:1
Oat Straw	70:1
Corn Stover	57:1
Rye Cover Crop (anthesis)	37:1
Pea Straw	29:1
Rye Cover Crop (vegetative)	26:1
Mature Alfalfa Hay	25:1
Ideal Microbe Diet	24:1
Rotted Barnyard Manure	20:1
Legume Hay	17:1
Beef Manure	17:1
Young Alfalfa Hay	13:1
Hairy Vetch Cover Crop	11:1
Soil Microorganisms (average)	8:1



Slow Decomposition / Lasting Cover

Rapid Decomposition / Disappearing Cover

High carbon cover crops…

- Armor the Soil
- Increase soil organic matter
- Capture and recycle nutrients
- Manage soil moisture
- Moderate soil temperature

Ohio cover crops

Low carbon cover crops…

- Nitrogen fixation (legumes)
- More efficient use of nutrients and pesticides
- Help break down high carbon crop residues

Ohio cover crops

Combinations of high and low carbon cover crop species

- Improve soil structure / tilth / reduce compaction
- Increase biodiversity
- Pest Management - weeds / diseases / insects
- Increase plant and organism diversity





Plan for Diversity

- Crop types not already in crop rotation
  - Cool season grass
  - Warm season grass
  - Cool season broadleaf
  - Warm season broadleaf

- Multi-species out-produce single species
  - The more the better – Nature wants diversity!
- Multi-species feed the soil foodweb

What about water?

- Dickinson Research & Extension Center study showed cover crop after short season crop would experience soil moisture at permanent wilting point 8% to 18% of years.
- November to April average precipitation at Dickinson 4.02”. Best soils hold 2” of water per foot of soil.
- Historically, 4” of stored soil water at planting has resulted in average wheat yields in western North Dakota.
- Cash crop successful 80% of years after cover crop has used soil moisture in previous season.

Competition or Collaboration?

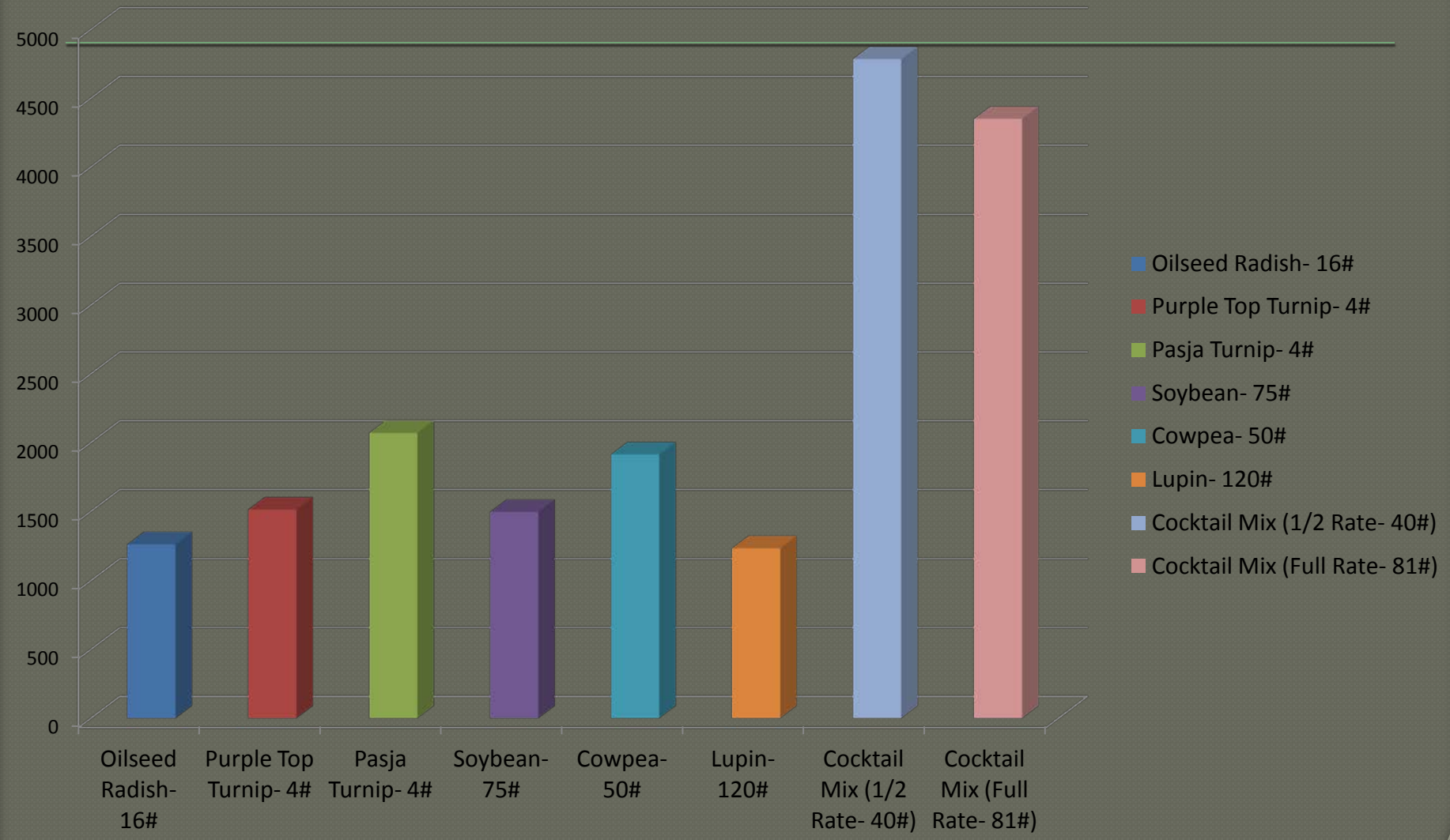
- **Stress Gradient Hypothesis** (Bertness and Callaway , TREE, vol. 9, no. 5, 1994)
  - As environmental stress increases, plants in a community collaborate rather than compete.
  - Diverse cover crop mixes are more productive under good or bad conditions.

Turnip cover crop July 2006 Bismarck, ND

Radish cover crop

Six specie cover crop July 2006 Bismarck, ND 1.8" growing season precip to date

Biomass - lbs/ac



Developing Cover Crop Mixes

- What is the purpose to be served?
- Include crop types not already in rotation.
- Minimum of 5 species and 3 functional groups.
- Minimum of 20 pounds per acre seed.
- Time and method of planting?
- Time and method of termination?

A multi-species cover crop in Bowman County, ND

Cover Crop	Erosion Reduction	Increase soil organic matter	Capture, recycle, redistri-bute nutrients in the soil profile	Promote biologi-cal nitrogen fixation	Weed suppres-sion	Provide supple-mental hay	Provide supple-mental grazing	Rooting Depth / Plant Water Use /1	Minimize / reduce soil compaction	Seed size (Large or Fine)	Crop Type /2	Seeding rate, lbs/acre	Seeding depth, inches	Salinity tolerance	C:N Ratio	Attract Beneficial Insects	Mycorrhizal fungi association
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
barley	G	G	F	N	G	F	F	MM	F	L	CG	50	0.75 - 2.0	G	M	Y	L
buckwheat	G	F	G	N	G	P	P	SL	P	F	WB	48	0.5 - 1.5	P	L	Y	N/A
millet	G	G	F	N	G	G	F	SL	F	L	WG	25	0.25 - 0.75	F	M	N/A	H
sorghum	G	G	G	N	G	G	F	MM	G	L	WG	35	0.5 - 1.5	P	M	Y	H
spring rye or wheat	G	G	G	N	G	F	F	MH	F	L	CG	60	0.5 - 1.5	F-G	M	Y	L
sudangrass, sudan-sorghum hybrid	G	G	G	N	G	G	G	MM	G	L	WG	35	0.5 - 1.5	F-G	M	Y	H
triticale	G	G	G	N	G	F	F	MH	F	L	CG	60	0.5 - 1.5	G	M	Y	L
winter rye or wheat	G	G	G	N	G	F	F	MH	F	L	CG	60	0.75 - 2.0	P	M	Y	L
mustard, tame	F	F	F	N	G	F	F	MH	F	F	CB	5	0.25 - 0.75	P	L	Y	N/A
oat	G	G	F	N	F	G	F	MM	F	L	CG	80	0.5 - 1.5	P	M	N	L
sweet clover	G	F	F	Y	F	P	F	MM	F	F	CB	6	0.25 - 1.0	F	L	Y	M
corn	G	G	G	N	P-G**	F	F	DH	G	L	WG	20	1.0 -1.5	P	H	N/A	H
cowpea	P	P	F	Y	G	F	F	SL	F	L	WB	30	1.0 - 1.5	P	L	Y	M
hairy vetch	G	F	F	Y	P	F	F	SM	F	L	WB	15	0.5 - 1.5	P	L	Y	M
radish	P	P	G	N	G	P	G	DH	G	F	CB	8	0.25 - 0.5	P	L	Y	N/A
safflower	F	F	G	N	F	F	G	DH	F	L	WB	30	1.0 - 1.5	F	M	N	H
sunflower	F	F	G	N	F	P	G	DM	F	L	WB	4	0.5 - 1.0	F	M	N/A	H
turnip	P	P	G	N	G	P	G	DH	G	F	CB	8	0.25 - 0.5	P-F	L	N/A	N/A
berseem clover	P	P	F	Y	F	F	G	MH	F	F	CB	8	0.25 - 1.0	F	L	Y	L
canola	F	F	G	N	P-G**	F	F	MM	G	F	CB	5	0.25 - 0.75	G	L	Y	N/A
flax	F	F	F	N	P	P	P	SM	P	F	CB	50	0.25 - 0.75	P	H	N/A	H
medic	P	P	G	Y	F	F	F	MM	F	F	CB	8	0.25 - 0.75	P	L	N/A	M
pea	P	P	P	Y	F	G	F	SL	P	L	CB	50	1.5 - 3.0	P	L	Y	M
Red beet	P	P	G	N	F	P	F	DM	G	L	CB	8	0.5 - 0.75	F	L	N	L
sugarbeet	P	P	G	N	F	P	G	DH	G	F	CB	8	0.25 - 0.5	G	L	N/A	L
lentil	P	P	F	Y	P	F	F	SL	P	F	CB	80	1.0 -1.5	P	L	N/A	M
soybean	P	P	F	Y	P-G**	F	F	SM	P	L	WB	45	1.0 - 1.5	P	L	N/A	M

/1 Rooting Depth/Water Use

SL=Shallow rooted/Low water use
SM=Shallow rooted/Medium water use
SH=Shallow rooted/High water use
ML=Medium rooted/Low water use
MM=Medium rooted/Medium water use
MH=Medium rooted/High water use
DL=Deep rooted/Low water use
DM=Deep rooted/Medium water use
DH=Deep rooted/High water use

Shallow =6 - 18 inches
Medium =18 - 24 inches
Deep =24 + inches

/2 Crop types

CG =cool season grass
CB =cool season broadleaf
WB =warm season broadleaf
WG =warm season grass

Ratings

L =Low
M =Medium
H =High
N/A =Not Available
G =Good
F =Fair
P =Poor

**Poor weed competitor, but herbicide-tolerant varieties are available.

Table 1 was compiled from several sources listed in the Cover Crop Design and Installation Guide reference section and field observations.

Where are you located? North of I70

What rainfall zone are you in? (Avg Inch/Yr) 16

What maturity stage will the cover crop achieve? Reproductive

How will this crop be seeded? Drilled

GREEN COVER SEED

SmartMix Calculator

Use the yellow areas to select your species and your seeding rate per acre. Use the drop down boxes to select the species you want to include

Cover Crop Mix Potential Ratings (scale of 1-10)

C:N Ratio	Nitrogen Fix	Grazing	Drought	Frost	Winter	Diversity	Salinity
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

		Type	Full Rate	lbs per acre	% full rate	% by wt	% by # seed	Effect %	Seeds/lb	Seeds per acre	Cost per lb	Seed Cost/acre
TOTALS				0	0%					0		$0.00
Legumes						0%	0%	0%				$0.00
	?											
	?											
	?											
	?											
	?											
	?											
Grasses						0%	0%	0%				$0.00
	?											
	?											
	?											
	?											

Plevna, MT cover crop

Goals: soil health, nutrient cycling & grazing

Warm season mix

Seeded 6/6/2012

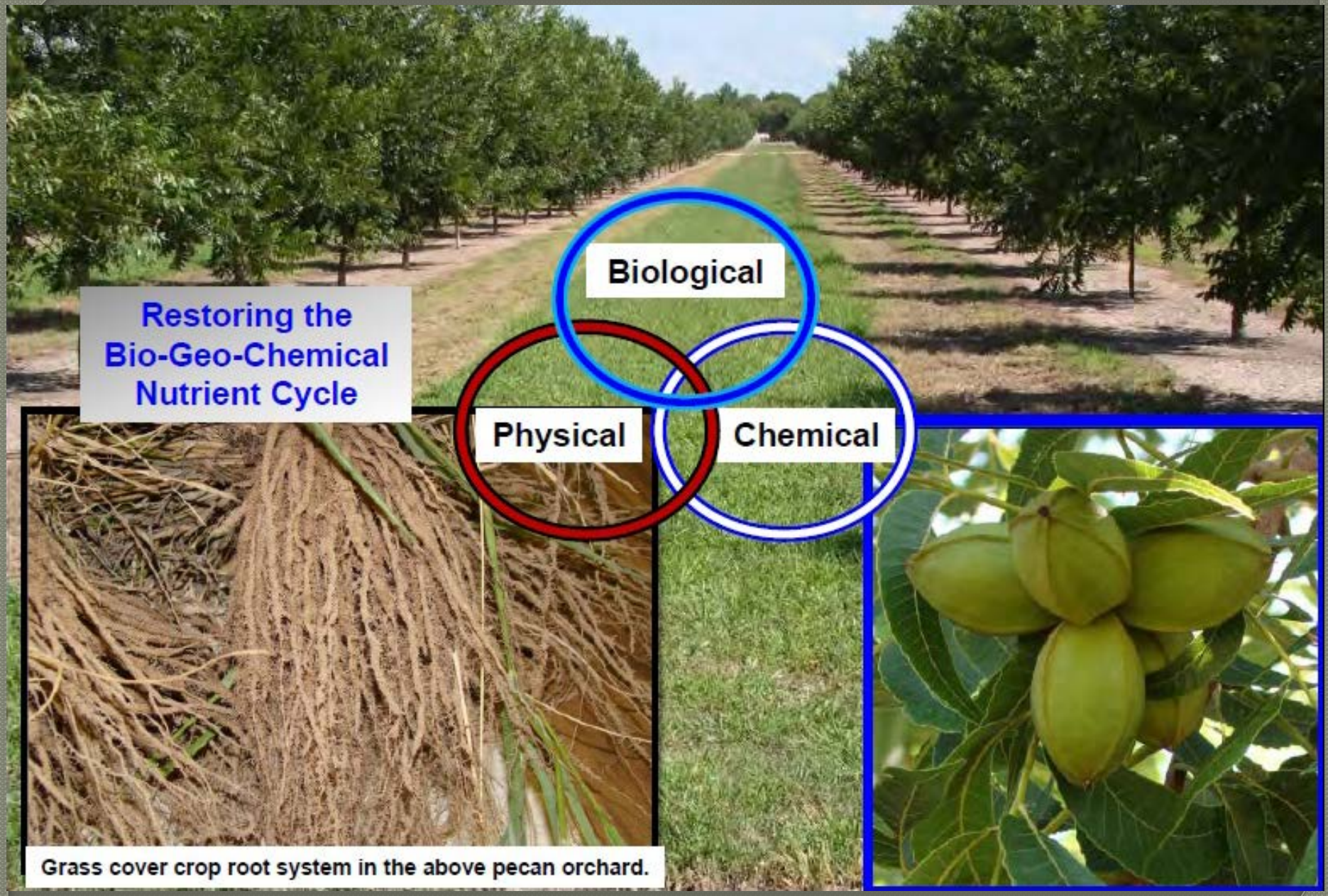
Seed Mix	lbs/ac
Proso Millet	3.3
German Millet	3.3
Hairy Vetch	3.3
Sunflowers	1.6
Radish	.8
Turnip	.8
Western WG	.8
Green Needle Gr	1.6
Blue Bunch WG	.8
Alfalfa	1.6
Alsike Clover	1.6
Total	19.5 lbs/ac

$96/ac less expensive to graze than to buy equivalent hay in a drought year.

New Mexico

Conventional Tillage in Pecans

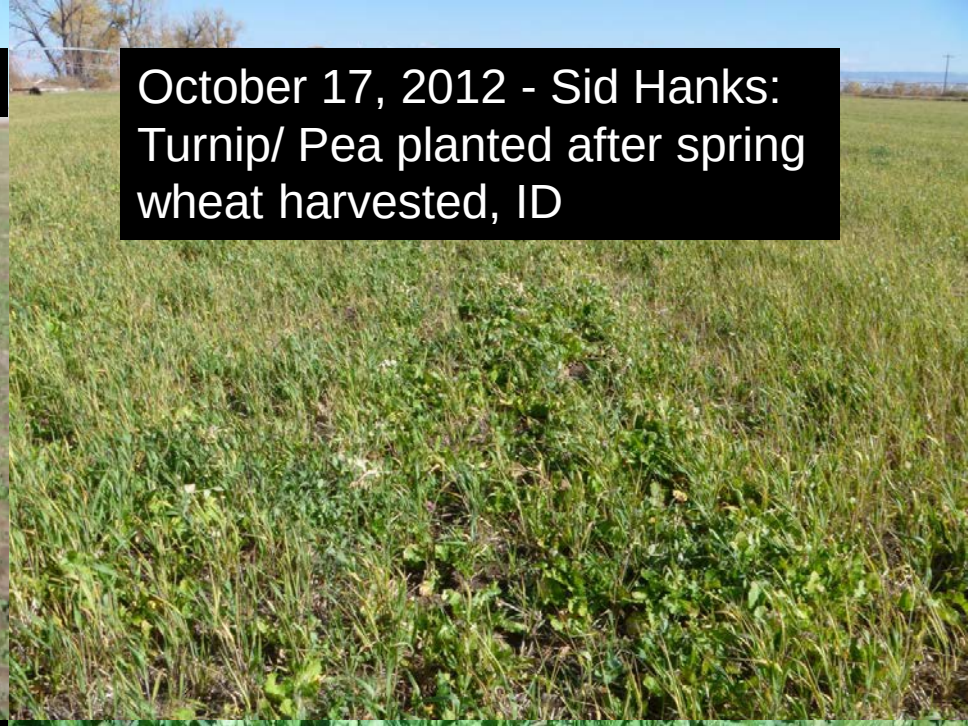
Restoring the Bio-Geo-Chemical Nutrient Cycle



Grass cover crop root system in the above pecan orchard.

Arugula / Turnip Planted after potato harvest, ID

October 17, 2012 - Sid Hanks: Turnip/ Pea planted after spring wheat harvested, ID



Jaron, Raybould, St. Anthony, ID Planted 9/7/12 Photo on Oct 17 Cereal cover crop after potato harvest. Next crop will be no-tilled into winter-killed cover crop.

Peas &Turnips August 10, 2012 St. Anthony, ID

Richter Farms, Burleigh County, ND

Resource Concerns

- Soil Armor
- Diversity
- Soil Organic Matter
- Infiltration
- Nutrient Cycling

Cover Crop Mixture

Millet 8 lbs.	WS Grass
Cowpea 10 lbs.	WS Broadleaf
Soybean 15 lbs.	WS Broadleaf
Turnip ½ lb.	CS Broadleaf
Oilseed Radish 1 lb.	CS Broadleaf
Sunflower 1 lb.	WS Broadleaf
Sweet Clover 1 lb.	WS Broadleaf

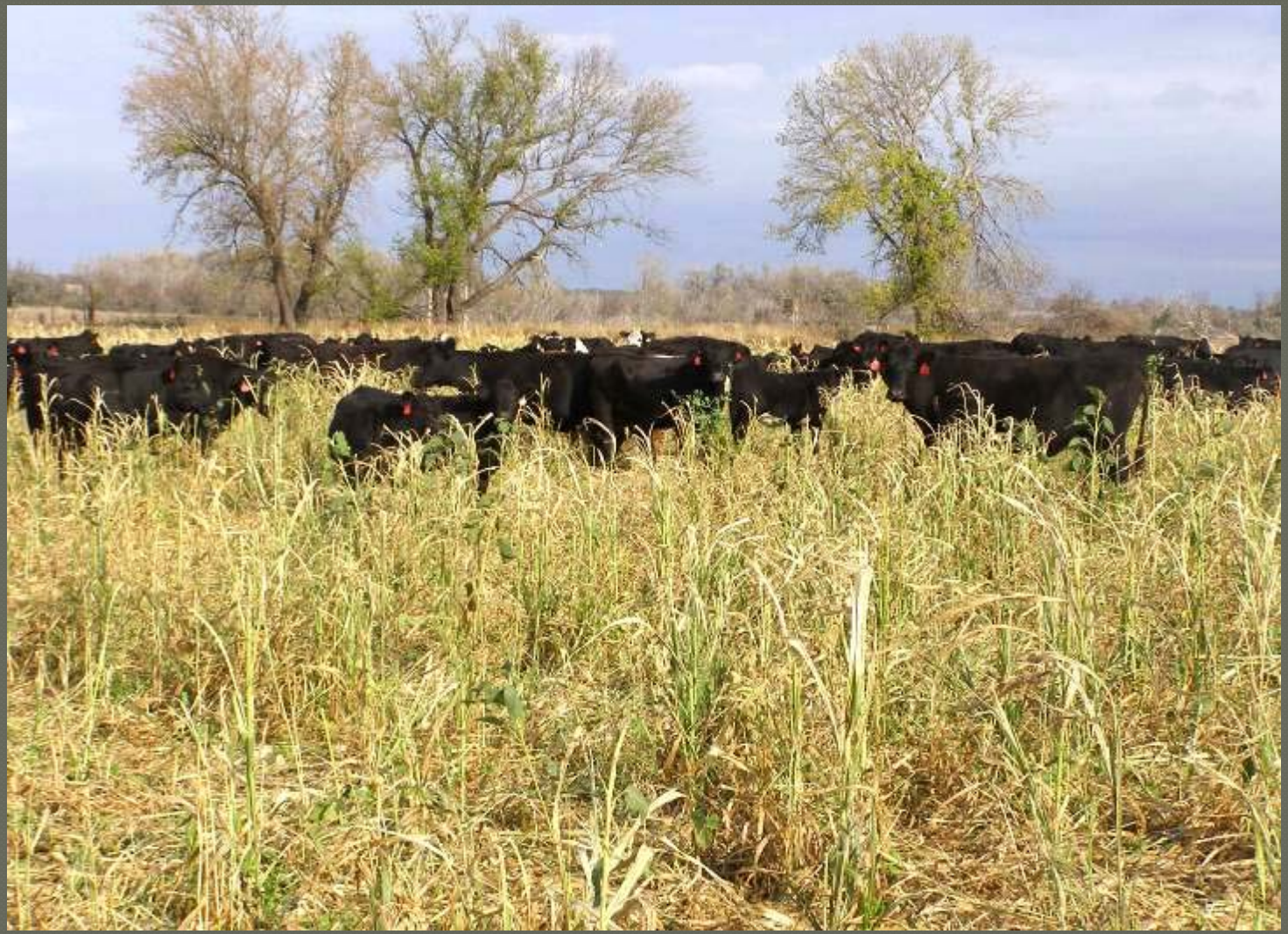
Cover Crop Mixture
August 2, 2007

Soil Health Tour
August 30, 2007

Farmers talking to farmers about soil health

Weighing Calves
Average Starting Wt 580 lbs.

141 Pair – Turned In 10/1/07. Pulled Out 10/17/07.



Dual Feeding System of above and below ground herds.

Average Starting Wts 580 lbs.
Average Ending Wts 632 lbs.

52 lbs Average Gain/Calf

3.1 lbs Average Daily Gain/Calf

Improved body condition on cows

Income of Grazing Cover Crop

52 lbs/Head Gain
X 141 Calves
7,332 Total lbs Gained
X $1.09 Sale Price Per Lb.
$7,992 Total Income
Divided By 72 Acres =
$111.00/Acre Gross Return

Expenses of Grazing Cover Crops

$20.00 - Seed Cost
$13.00 - Seeding Cost
$12.00 - Herbicide Apply & Chemical
$45.00 - Total Per Acre Expense

Net Profit of Grazing Cover Crops

Gross Income Per Acre	= $111.00
Expense Per Acre	= $45.00
Net Income Per Acre	**= $66.00**

Value of increased recovery time on Native Rangeland?

Value of Improved Soil Health?

Value of Increased Body Condition on Cows before Winter?

NRCS Taking Soil Samples For Available Water Capacity - 5/6/08.

Soil Samples Heading For The Oven At The ARS Station In Mandan

Estimated Inches of Available Water

Sampled on May 6, 2008

Richter Farms, LLP

Menoken, North Dakota

Inches of Available Water

Parshall Fine Sandy Loam

Depth (inches)	Cover Crop	No Cover Crop	AWC*
0-6	0.44	0.37	0.95
6-12	0.58	0.51	0.95
12-24	0.84	0.89	1.56
24-36	0.74	0.73	1.44
36-48	0.47	0.61	1.20
Total (0-48)	**3.07**	**3.11**	**6.10**

*** AWC - Available Water Capacity (Inches) @ Field Capacity**

Timeline

July 1, 2007	**Harvested Field Peas**
July 7, 2007	**Planted Cover Crop Cocktail Mix**
October 1-17, 2007	**Grazed Cover Crop Cocktail Mix**

Inches of Available Water on 5/6/08 Following the 2007 Cover Crop.

Summary

No Cover Crop 3.11 Inches

Cover Crop 3.07 Inches

Difference 0.04 Inches

Half For The Critters Below The Ground & Half For Those Above The Ground.

Questions / Discussion