Keys to the kingdom of improving soil health

- **Understand your context**
- **Protect the Soil Habitat**
- **Provide Diverse Food (carbon)**
- These are the 'keys to the kingdom' of improving soil health and sustainable agriculture because they focus on soil biology and soil ecology; what really runs the soil and all that it does.

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Auburn Alabama, Corn planted into crimson clover cover crop

Auburn, Alabama 2007

Cotton planted in rye cover crop

What do you want the cover crop to accomplish?

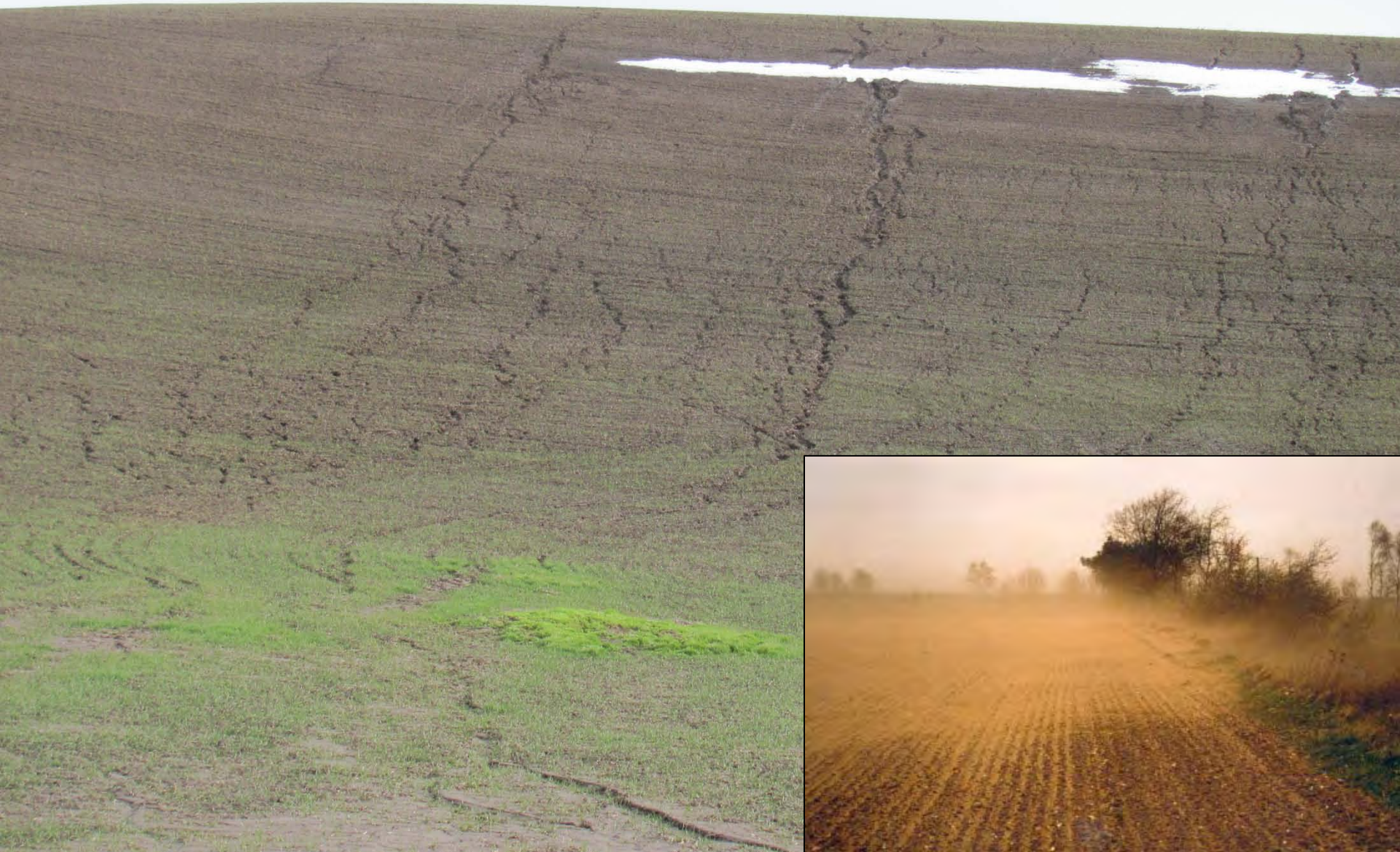
- natural resource concerns?

- Provide adequate soil armor (residue)
- Crop diversity
- Improve organic matter
- Improve infiltration
- Increase nutrient cycling
- Pest Suppression

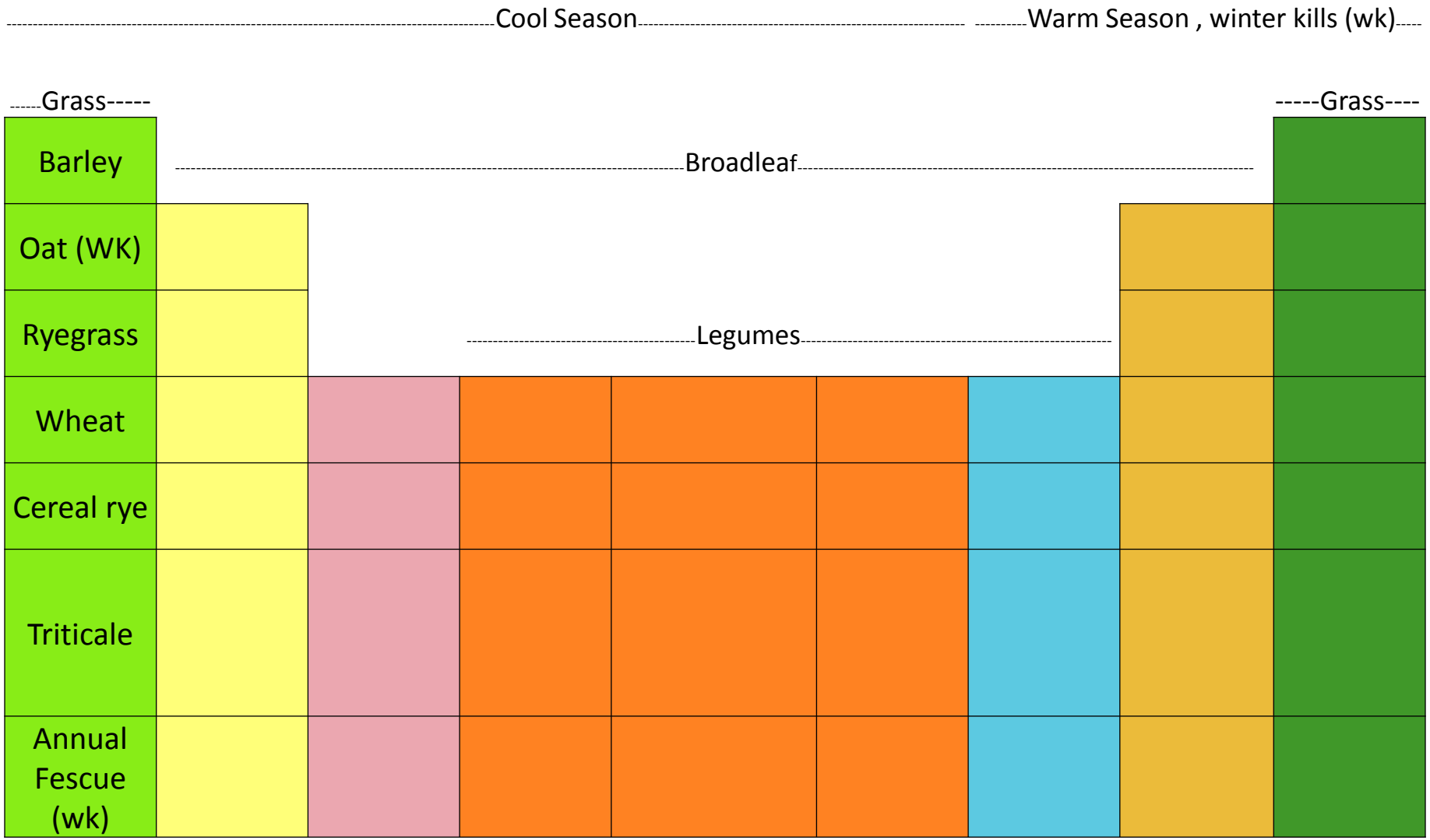
- “It’s not just preventing the soil from washing away or blowing away, but improving the soil right down to the microscopic level”

“No-till has stopped soil degradation and now we’re moving in the other direction”

No –Till Farmer magazine May 2012



Cover Crop Chart



Cover Crop Chart

Cool Season

Warm Season winter kills (wk)

Grass

Grass

Barley

Broadleaf

)

Oat (WK)

Phacelia

Ryegrass

Flax (wk)

Legumes

Wheat

Rape

Cereal rye

Kale

Triticale

Canola

Annual Fescue (wk)

Mustard (wk?)

Cover Crop Chart

			----------Cool Season----------				----------Warm Season winter kills (wk)----------	
---------Grass----------								----------Grass---------
Barley	----------Broadleaf----------							
Oat (WK)	Phacelia							
Ryegrass	Flax		----------Legumes----------					
Wheat	Rape	Turnip (wk)						
Cereal rye	Kale	Radish (wk)						
Triticale	Canola	Beet (wk)						
Annual Fescue (wk)?	Mustard	Tyfon (WK)						

Cover Crop Chart

Cool Season							Warm Season winter kills (wk)	
Grass	Broadleaf							Grass
Barley								
Oat (WK)	Phacelia							
Ryegrass	Flax (wk)	Legumes						
Wheat	Rape	Turnip (wk)	Field Pea	Chickling vetch (WK)	Medic			
Cereal rye	Kale	Radish (wk)	Lentil	Red Clover	Ladino clover			
Triticale	Canola	Beet (wk)	Clover	Crimson clover	Bean (WK)			
Annual Fescue (wk)?	Mustard	Tyfon (WK)	Vetch	Sweetclover	Alfalfa			

Cover Crop Chart

----------Cool Season----------							----------Warm Season winter kills (wk)----------	
---------Grass----------								----------Grass----------
Barley	----------Broadleaf----------							)
Oat (wk)	Phacelia							
Ryegrass	Flax (wk)	----------Legumes----------						
Wheat	Rape	Turnip (wk)	Field Pea	Chickling vetch (wk)	Medic	Chickpea (wk)		
Cereal rye	Kale	Radish (wk)	Lentil	Red Clover	Ladino clover	Cowpea (wk)		
Triticale	Canola	Beet (wk)	Clovers	Crimson clover	Bean (wk)	Soybean (wk)		
Annual Fescue (wk)	Mustard	Tyfon (wk)	Vetch	Sweetclover	Alfalfa	Sun Hemp(wk)		

Cover Crop Chart

Cool Season							Warm Season winter kills (wk)	
Grass								Grass
Barley	Broadleaf							
Oat (wk)	Phacelia						Amaranth (wk)	
Ryegrass	Flax (wk)	Legumes					Buckwheat (wk)	
Wheat	Rape	Turnip (wk)	Field Pea	Chickling vetch (wk)	Medic	Chickpea (WK)	Sunflower (wk)	
Cereal rye	Kale	Radish (wk)	Lentil	Red Clover	Ladino clover	Cowpea (WK)	Safflower (wk)	
Triticale	Canola	Beet (wk)	Clovers	Crimson clover	Bean (wk)	Soybean (WK)	Chicory	
Annual Fescue (wk)	Mustard	Tyfon (WK)	Vetch	Sweetclover	Alfalfa	Sun Hemp(wk)		

Cover Crop Chart

Cool Season						Warm Season winter kills (wk)		
Grass								Grass
Barley	Broadleaf							Pearl Millet (wk)
Oat (wk)	Phacelia						Amaranth (wk)	Foxtail Millet (wk)
Ryegrass	Flax (wk)	Legumes					Buckwheat (wk)	Proso Millet (wk)
Wheat	Rape	Turnip (wk)	Field Pea	Chickling vetch (wk)	Medic	Chickpea (wk)	Sunflower (wk)	Sudan grass (wk)
Cereal rye	Kale	Radish (wk)	Lentil	Red Clover	Ladino clover	Cowpea (wk)	Safflower (wk)	Teff (wk)
Triticale	Canola	Beet	Clovers	Crimson clover	Bean (wk)	Soybean (wk)	Chicory	Grain Sorghum (wk)
Annual Fescue (wk)	Mustard	Tyfon (wk)	Vetch	Sweetclover	Alfalfa	Sun Hemp(wk)	Squash	Corn (wk)

2nd Most Important Biological Function

Hairy vetch

Forage Radish yield data PMC, Aberdeen, ID 2011

Radish planted 8/17/11

Harvested 11/17/11 (90 days after planting)

60 day yield

	Soil Buster		Daikon	
	leaf	root	leaf	root
	#/ac dry	#/ac dry	#/ac dry	#/ac dry
Pearl Farm	1806	892	1784	892
Home Farm	1516	714	1450	647
avg	1661	803	1617	770

90 day yield

	Soil Buster		Daikon	
	leaf	root	leaf	root
	#/ac dry	#/ac dry	#/ac dry	#/ac dry
Pearl Farm	2587	1717	2565	2118
Home Farm	1516	1204	1695	1427
avg	**2052**	**1461**	**2130**	**1773**

Ada county:
Transition to organic.
Cover crop, Diakon forage radish grazed with livestock

Emmett:
Cover crops, Organic Producers.
3 way mix Austrian pea, Hairy vetch, Oats

Cover crops - Price, UT

Planted Sept 9, Harvested May 15 & June 4

Forage Species	Tons /Acre 100% DM
Rape	5.1
Kale	4.5
Cereal Rye	4.3
Triticale	4.0
Austrian W. Peas	3.6
Winter Wheat	3.1
Hairy Vetch	2.3
Italian Ryegrass	2.1

Legume cover crops

- Biological nitrogen fixation
  - N 4,000 lbs x .04% =160 lbs N /A
- Generally planted in fall
- Specific Rhizobium

Peas

Hairy vetch

Crimson clover

Cover Crops (irrigated)

Aberdeen, ID PMC 2010-11

Planted Aug 19, 2010

Harvested: Nov 12, 2010

Forage Species	Tons /Acre 100% DM
Rape, Sterling	5.3
Forage Radish, Daikon	5.2
Turnip, Purple Top	5.2
Mustard, Pacific Gold	4.9

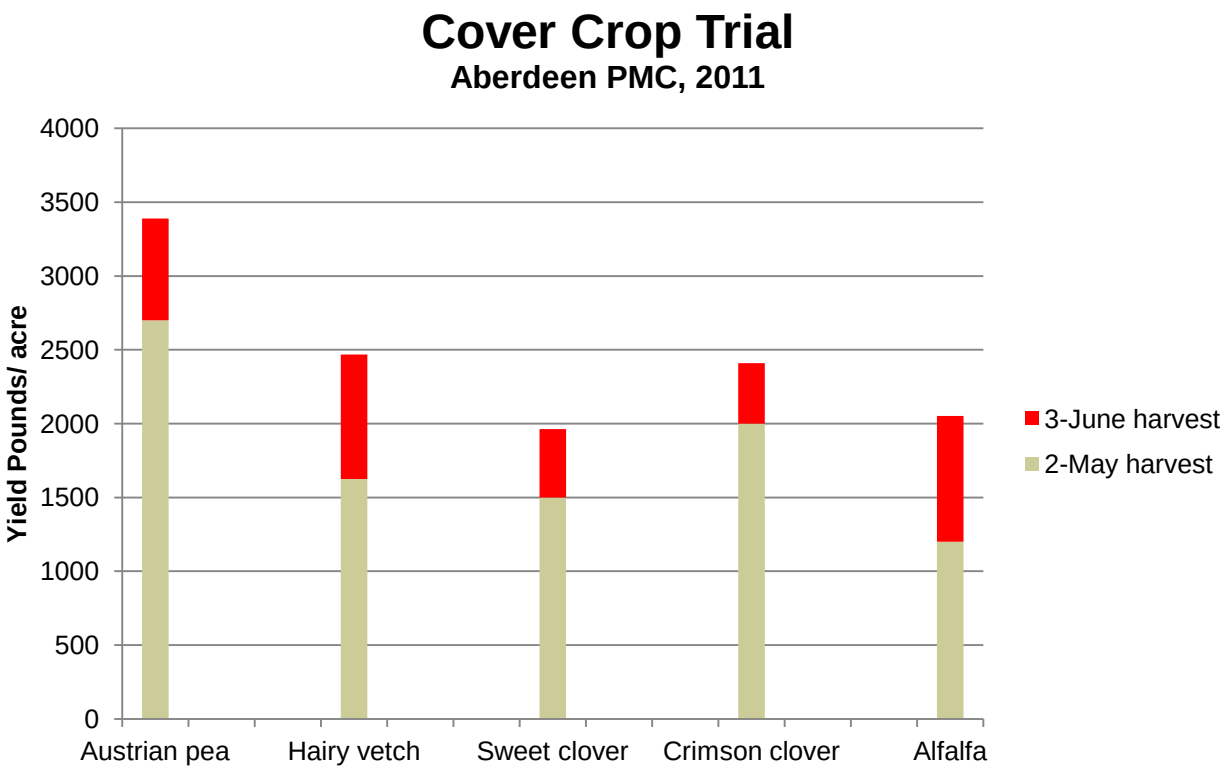
Radish

Turnip

Mustard

Cover crops –

PMC Aberdeen, ID



Crimson clover

Pea / Nodules

Soil Health

Sept 19, 2011

Bismarck, ND

- NRCS employees & few ranchers
- Visited with producers
- Rotation: Crop / Fallow
  - Corn, Soybean, Wheat, Pea, Cover crop
- Cattle / grazing
- Get “N” into some DNA
- Grass water ways ($.$)
- (couldn’t get water in the soil)
- Wind breaks
- Dealing with the symptom for 15 years

Full season, Warm season CC 8 way mix
Weans calves , on CC planting
BM rotation: corn soybean: Corn, Cover crop, soybean

As warm season CC die, cool season mix grows in the fall

New Producer: 8 way warm season mix, less warm season grass

Treat the Symptom or the Problem
Soil Health is the KEY

Why wind breaks?

- Radish

- Soil OM
- Benchmark 1.7% OM
- Now 3.7 to 4.3 % OM

Hairy vetch under story: no fertilizer on cover crop mixes

New producer: more diversity in the mix added sunflower, 3 warm season grasses

Although root systems (especially of grasses) can be extensive and explore vast areas of soil, the root exudates from one single crop will attract only a few different microbial species.

Journal soil & Water Cons 49:(2)

Pearl millet, Sudangrass, Proso millet

New Producer: Rancher not a farmer. BM 30 yr conventional crops – 40 yr pasture, needs to renovate . Using full season CC to transition.

Diversity spreads out the risk
- As the seasons change so does the mix

Platy soil, from years of conv. tillage

“our tillage is now the radish plant”

Nitrate test. Where is the nitrate in a no-till / cover crop system

Gabe Brown: 13 way cover crop mix, Rotation: peas, spring wheat /cover crop, soybean, full season cover crop that is grazed in the winter, grain corn:
Live plants growing in the field as long as possible.

When radish hits a hard spot

Brown's Ranch

Same Field

June 16, 2009
Corn planted into previous years' cover crop residue

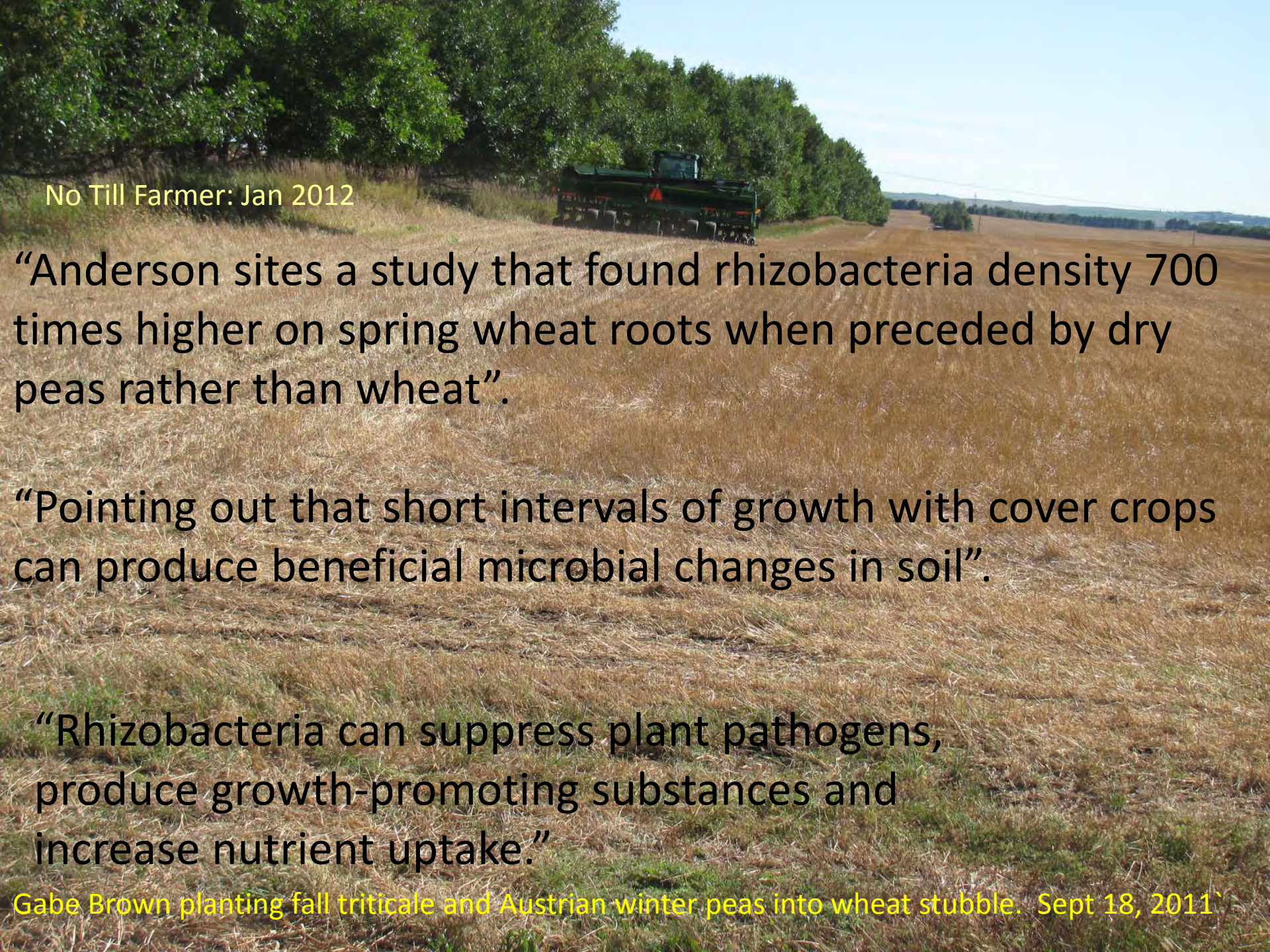
July 1, 2009
Rapid residue decomposition

Earthworms – ecological engineers

- Improve water infiltration, aeration
- Slime stimulates microbial activity

- Reduce soil disturbance to increase worm population. Tillage allows for increased bird predation.
- Oil seed crops & legumes increase worm population compared with cereals

Nature’s residue managers



No Till Farmer: Jan 2012

"Anderson sites a study that found rhizobacteria density 700 times higher on spring wheat roots when preceded by dry peas rather than wheat".

"Pointing out that short intervals of growth with cover crops can produce beneficial microbial changes in soil".

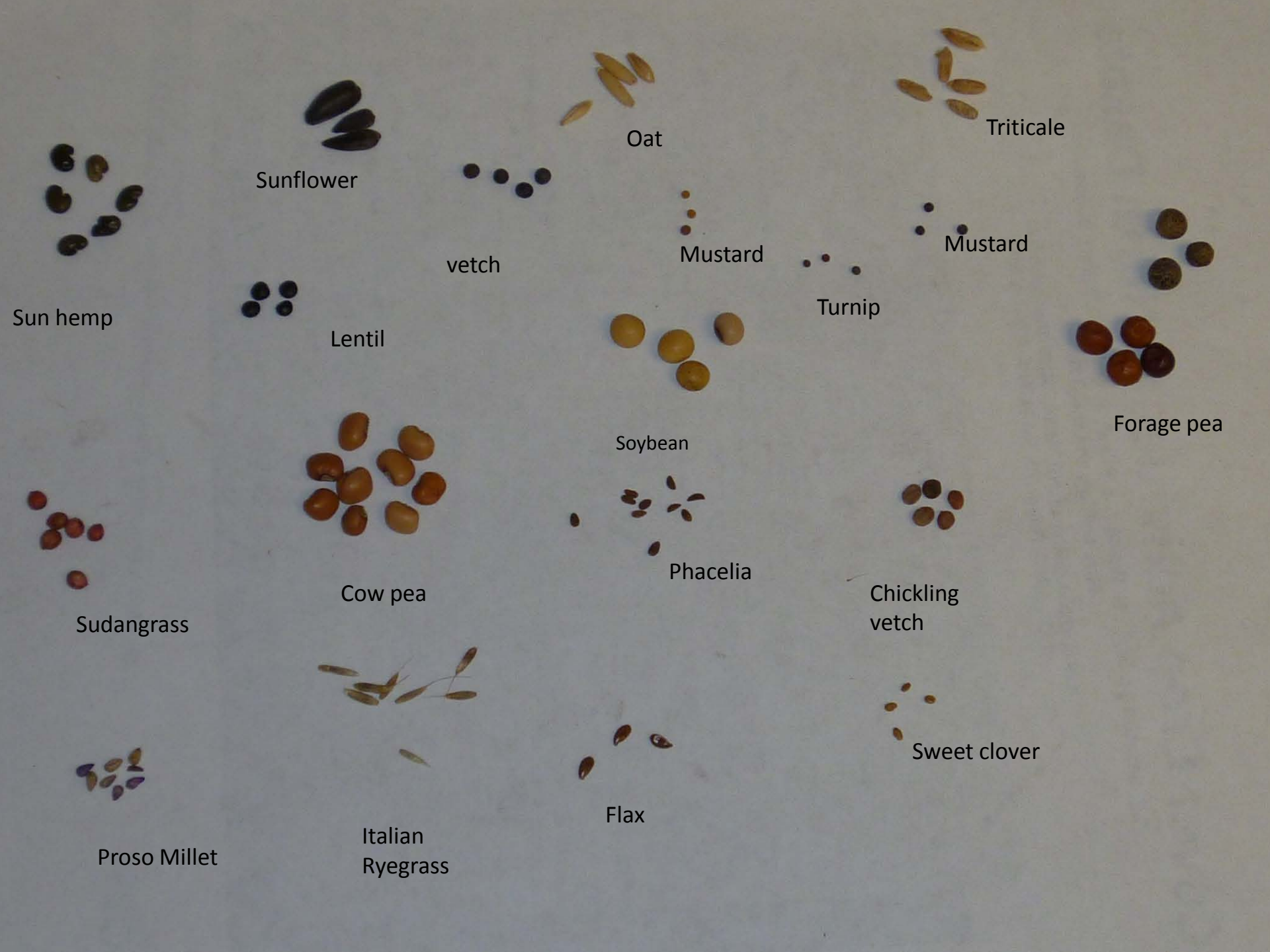
"Rhizobacteria can suppress plant pathogens, produce growth-promoting substances and increase nutrient uptake."

Gabe Brown planting fall triticale and Austrian winter peas into wheat stubble. Sept 18, 2011`

Soil health is the capacity of a soil to function.

“if you can or can’t your probably right”

Above ground diversity = below ground diversity


Sun hemp
Sunflower
Lentil
vetch
Oat
Mustard
Turnip
Mustard
Triticale
Soybean
Forage pea
Sudangrass
Cow pea
Phacelia
Chickling vetch
Proso Millet
Italian Ryegrass
Flax
Sweet clover

“Just try something,” he says. “Start small and build from there.”

5 Way mix

Cover Crop	Seeding Rate
Turnip	1
Radish	2
Austrian Pea	15
Hairy Vetch	5
Small grain	20
Total	43

3 way mix
Emmett, Id

Oats, Vetch, Peas

Crimson clover: St. Anthony , 150 lbs /A

A. Peas: St. Anthony 650 lbs /A

Egin Bench, St.Anthony, ID
4/11/11

St. Anthony, ID
SW 2 yr, Potato, sw cover crop planted in fall
Photo: April 17, 2012

WW cover crop fall planted,
Beets strip till planted in spring
Arena Valley, Id 2012

WW cover crop fall planted,
Corn strip till planted in spring
Arena Valley, Id 2012

WW fall cover crop,
Alfalfa seed strip tilled,
Nampa, Id 2012

Emmett, Id Cover crop mix in Vineyard: Vetch, Peas, Radish, Turnip Wheat
Planted March 15, 2012

Warm Season Mix

Crop	Seeding rate Lbs/ac	? $/Ac
Pearl Millet	1	1.25
Proso Millet	2	1.00
Sudangrass	4	4.00
Sunflower	1	0.6
Radish	2	2.25
Turnip	1	2.05
Pea	15	6.75
Vetch	5	9.2
Clover	1	1.4
Total	43	$ 28.5 /ac

Marsing, ID
Planted end of July 2012
Legumes: soybean and cowpeas

Cool Season Mix

Crop	Seeding rate Lbs/ac	? $/Ac
Barley	10	2.00
Oat	5	1.00
Pea	15	6.75
Vetch	3	5.1
Lentil	5	2.25
Clover	1	1.5
Radish	2	5.1
Turnip	1	2.2
Rape	1	0.5
Total	43	$ 26.0 /ac

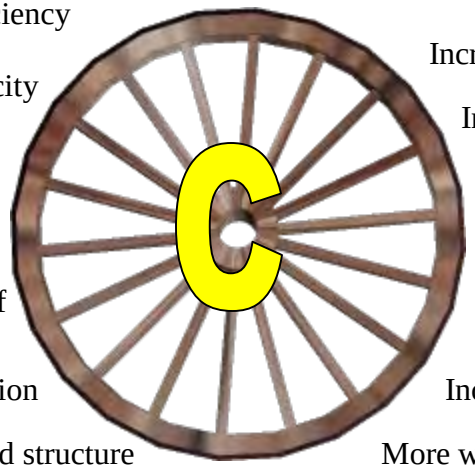
North Dakota, Black Leg Ranch 10 way mix Warm Season Cover Crop

Cover crop	Seeding rate	$/ pound
Pearl Millet	1	.74
Proso Millet	2	.25
Sudan grass	4	.45
Soybean Cowpea	15 10	.53
Sunflower	1	4.0
Radish	2	1.53
Turnip	1	1.53
Sweet clover	1	1.4
Corn	1	1.25
TOTAL	38	$ 33.53 per

Took off the residue managers, no coulters

“Environmental benefits are spokes that emanate from the Carbon hub of the Environmental Sustainability Wheel”

D.C. Reicosky, USDA-ARS



Reduce fertilizer inputs

Increased soil buffer capacity

Increased water holding capacity and use efficiency

Increased biological activity

Increased cation exchange capacity

Increased nutrient cycling and storage

Reduced soil erosion

Increased diversity of microflora

Improved water quality

Improved infiltration, less runoff

Increased adsorption of pesticides

Decreased soil compaction

Increased capacity to handle manure and other wastes

Improved soil tilth and structure

More wildlife

Reduced air pollution