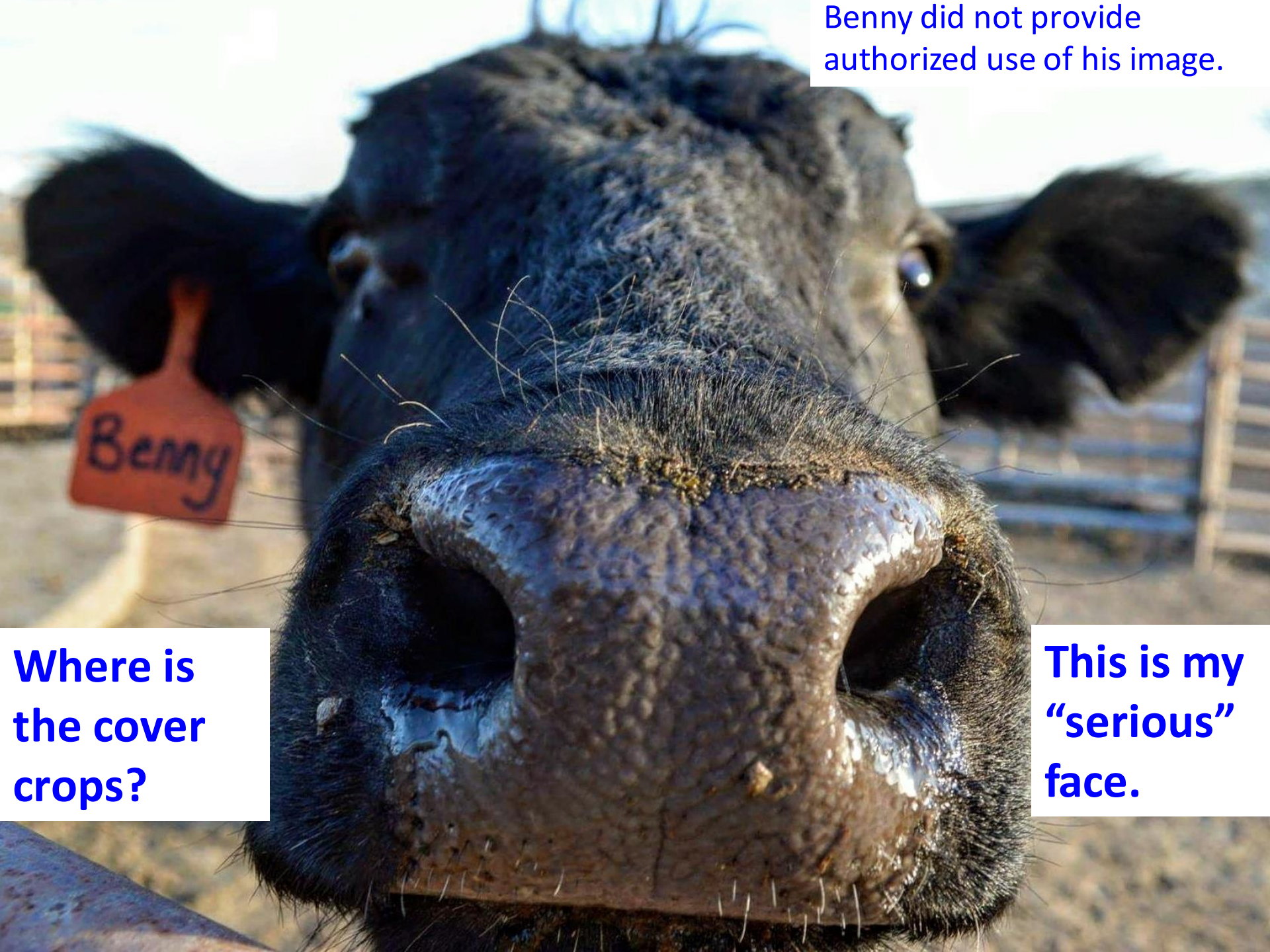
Benny did not provide authorized use of his image.
Benny
Where is the cover crops?
This is my “serious” face.

The Analysis of Cover Crops, Soil Health, the Role of Livestock and Impact on Moisture

Mike McDonald

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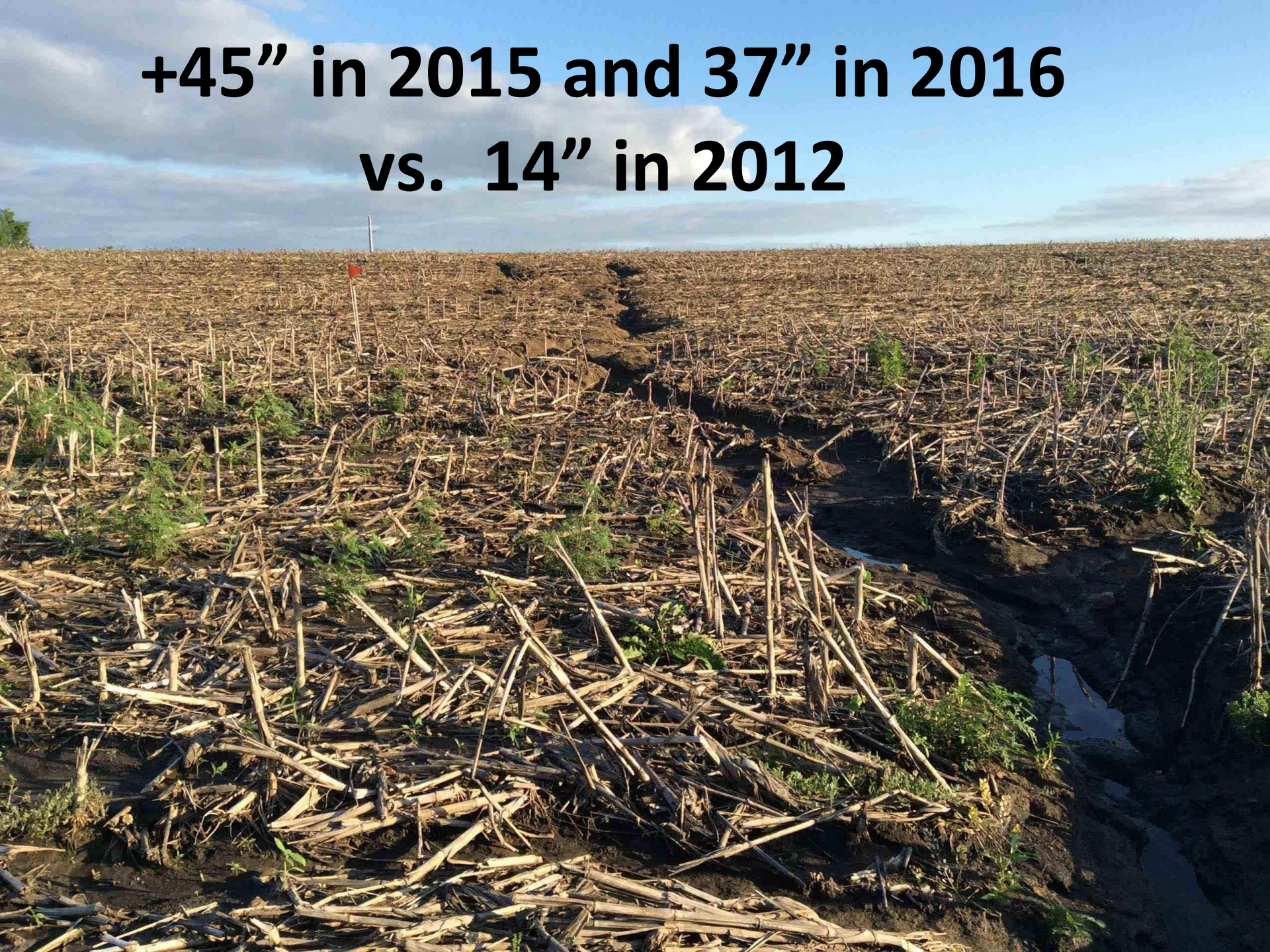
I--Producer focus:
corn, soybeans (non-GMO & GMO), wheat, grazing CCs, orchard, bees…increasingly value-added.

II—Educational Emphasis and Background.

- Fellow participants, *2014-2016:
  - Paul Ackley, Bedford, IA
  - Russel Moss, Burr, NE
- Rotations of corn, soybeans and wheat; min. of 4 acre plots; grazed vs. non-grazed cover crops (CCs) after the harvest of the cash crop


+45” in 2015 and 37” in 2016
vs. 14” in 2012

+45” vs. ~27” normal rain BUT when and HOW does it come? My neighbor’s gift of soil.

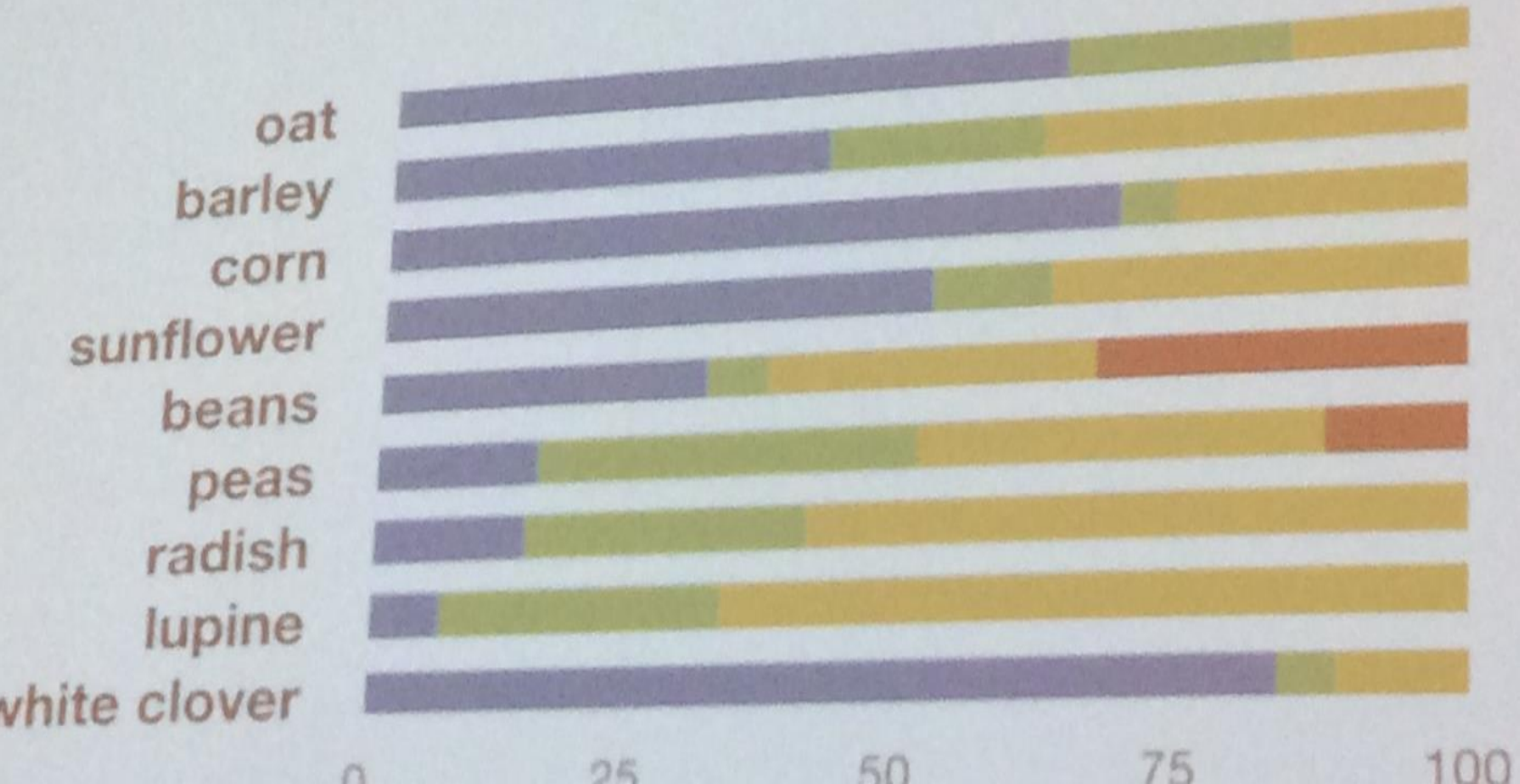
Capturing soil, sun, bio-mimicry AND carbon


Carbon above-ground

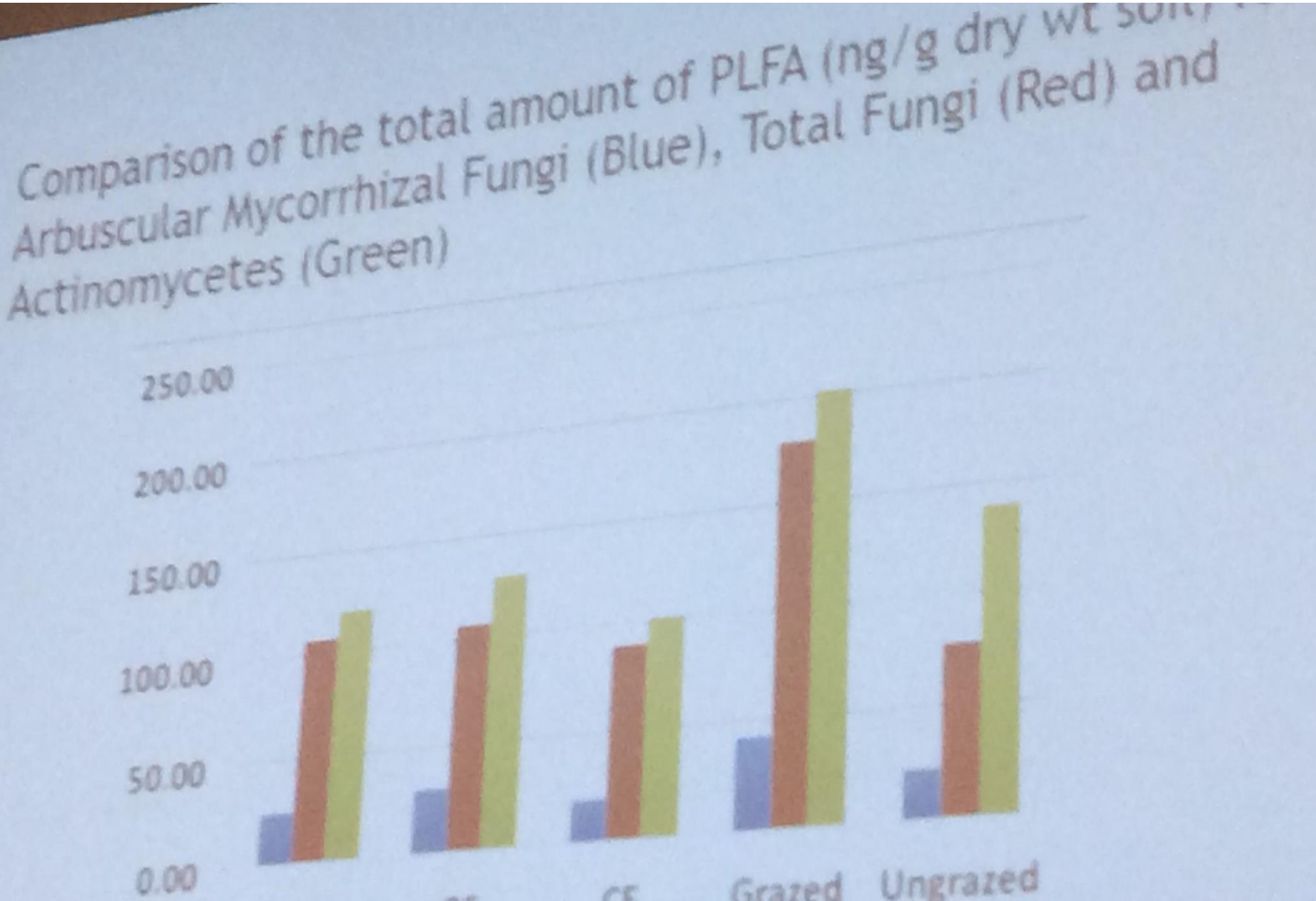

Carbon exudates
below-ground

No Till on the Plains, Jan. 25, 2016, Jill Clapperton

The percentage of N in the roots as nitrate (blue), amino acids (green), amides (yellow) and ureides (red). These compounds leak from the roots as exudates and are part of the plant's signature to create a unique rhizosphere.



No Till on the Plains, Jan. 25, 2016, Jill Clapperton



Summary on Rationale:

1.

2.

3.

Summary

- **Water infiltration**
- **Carbon: above and below ground—exudates**
- **Diversity: cover crops, cash crops, livestock**

Cover Crop Water Usage and Affect on Yield in No-Till Dryland Cropping Systems,

2007, NCR-SARE study by Keith Berns

- "Berns found CCs can *significantly boost corn yields in a non-irrigated setting. In one trial, they planted corn after a CC mix of grasses, legumes and brassicas, and saw a corn yield that was about 10 percent better than planting straight into wheat stubble…In their trials…(they) found that mixes were the best performers in part because they were the most frugal with water."
- Note, caveats: _____, _____, and _____.

Berns' study continued

- In addition, our discussions with Keith reveal no level of significance but anecdotally the soil tilth was improved,
- The soil armor was effective during the heat of the summer and wind erosion was reduced in the winter. Keith (also) suggested a purposeful matching of CC cocktails might be a key to the moisture question.
- (Second), the integration of cattle could foster the development of particular CCs such as the tillering of sorghum sudan even in droughty environments.

The Problem/Solution in our project

- The general consideration of CCs and their role in the systems approach to improving soil health is growing yet one, main question continually endures—what is the economic benefit and reliable data in using CC? We wanted to analyze how cattle impact CC benefits and crop yields while comparing grazed v. not-grazed plots in corn, soybean and wheat fields.

Objectives/Performance Targets and Results

- The weight gain of cattle in CC v. grazing in corn-, soybean- or wheat-stubble. Results—it was ~.80/lbs more/day in CC.

- The water usage and in turn crop yields did not provide reliable measurements because of excessive rain and the timing. Anecdotally, it appears that the cash crops that previously had CCs yielded %15 higher crops.

- Soil testing including water infiltration, soil density and soil organic matter levels were completed (refer to the Haney for the SOM). These were not significant but improved vs. the beginning of the project.

Objectives and Results continued

- The biomass testing of the CC resulted in in approximately 30% more mass for post-corn and soybeans; wheat was ~%40.
- The Haney Healthy Soil Test was completed; organic and inorganic levels for N-P-K and CC mixtures were gauged. Improvement was noted at Ackley's and McDonald's sites (to be discussed)
- The PLFA (phospholipid fatty acids) was completed for one site and improvement was strong (to be discussed).
- An informal economic analysis sheet was developed but it's reliability was not finalized because of the impact of weather and delayed plantings. Anecdotally, the role of livestock appears to positively impact the net return while not providing a # for the impact on soil health beyond the Haney.

General Impacts and Contributions/Outcomes

Two field days were held in 2015, respectively, in August and October. The rotations, grazing and cover crop sites were presented, analyzed and discussed. The first site in IA focused on rotational grazing, soil health, prevented planting options, drilling cover crops into post-wheat and discussed collaborative opportunities with the Practical Farmers of Iowa who also presented at the field day.

The second field day that was held at Palmyra and Douglas, NE on Oct. 6 was attended by over 67 producers and agricultural professionals. This day focused on: viewing cover crops and discussing advantages and disadvantages of species; viewing annual/perennial grasses and legumes and grazing paddocks; viewing a soil pit and discussing the soil biology of 3 years of cover crops; viewing and discussing the impact of compost; and discussing the impact of cover crops on weeds and stacked crop rotations.

General Impacts and Contributions/Outcomes continued

Each producer either drilled or interseeded cover crop cocktails into corn and/or soybeans. One continued and interesting aspect is the interplay with the wet year of over 45" of rain and how previous cover crop usage impacted grazing and the soil prior to planting over two springs (2014 and 2015). One site was not planted and three "windows" of grazing occurred because prevented planting was the complimentary option. This enhanced the ability to use "failed barley" and extend grazing possibilities.

The weather and impact on herbicides impacted cover crop and and spraying "windows" which in turn impacted which cover crops could be used. Specifically, herbicide residuality is much reduced. This helps brassicas but the weed pressure is too much and impacted fall options (i.e., drilling vs. interseeding).

General Impacts and Contributions/Outcomes continued

One interesting aspect is the interplay with the wet years and how previous cover crop usage impacted grazing and the soil prior to planting. It appears the cover crops enhanced the weight gain (not sure on the level of significance) and the soil tilth. The latter appeared to be positively impacted because the cover crops utilized moisture that was confounding the planting window.

General Impacts and Contributions/Outcomes continued

The price of cover crops has accelerated. When combined with the reduced price of commodities, it impacted the rotations of participants/producers. The typical rotation of soybean-corn was purposefully changed to include wheat in part because of this grant. However, the price of fertilizer, cover crop seeding "windows", and possible use of value added pulse crops (i.e., barley) impacted possible rotations and in turn which cover crops worked best (pre- and post- to cash crops).

General Impacts and Contributions/Outcomes continued

Last, the soil testing steps (Haney, PLFA and soil aggregates) influenced the fertilizer rates and cover crop mixtures. In addition, Paul Ackley was asked to participate in training by the Practical Farmers of IA and he set up training with his local, NRCS to discuss soil health including the testing.

cropwatch.unl.edu/2016/student-research-cover-crop-effects-soil-properties

What benefits can cover crops provide?

The USDA Sustainable Agriculture Research and Education program defines a cover crop as "a plant that is used primarily to slow erosion, improve soil health, enhance water availability, smother weeds, help control pests and diseases, increase biodiversity and bring a host of other benefits to your farm." Studies from all over the world show evidence that cover crops can be beneficial to an agronomic system. While they have been known to increase yield in some cases, more importantly they can also improve soil properties that, when combined, improve soil health.

“The Food and Agriculture Organization of the United Nations defines soil health: "the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal, and human health.”

www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/soil-biodiversity/the-nature-of-soil/what-is-a-healthy-soil/en/

cropwatch.unl.edu/2016/student-research-cover-crop-effects-soil-properties

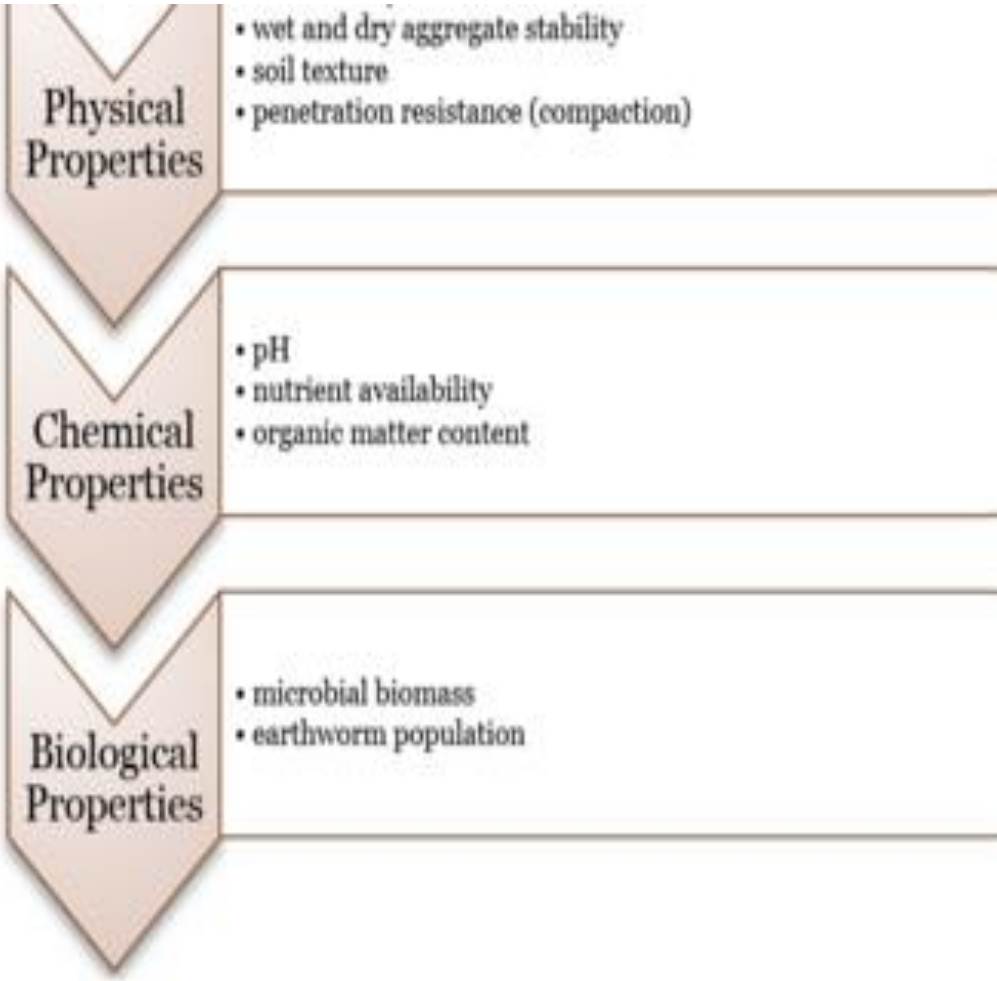


Figure 1. Once you know what's involved in determining soil health (1a, left), you can begin examining the properties that lie within each category (1b, right). The illustration shows

Haney - Soil Health Analysis

1:1 Soil pH	6.8
1:1 Soluble Salts, mmho/cm	0.43
Excess Lime Rating	1
Organic Matter, %LOI	4.7
Solvita CO2 Burst	
CO2-C, ppm C	162.5
Water Extract	
Total Nitrogen, ppm N	36.2
Organic Nitrogen, ppm N	30.6
Total Organic Carbon, ppm C	367
H3A Extract	
Nitrate, ppm NO3-N	3.7
Ammonium, ppm NH4-N	2.1
Inorganic Nitrogen, ppm N	5.8
Inorganic (FIA) Phosphorus, ppm P	24.3
Total (ICAP) Phosphorus, ppm P	38.1
Organic Phosphorus, ppm P	13.8
ICAP Potassium, ppm K	166
ICAP Calcium, ppm Ca	646
ICAP Aluminum, ppm Al	381
ICAP Iron, ppm Fe	204
Calculations	
Organic C:Organic N	12.0
Nitrogen mineralization, ppm N	23.8
Organic Nitrogen Release, ppm N	30.6
Organic Nitrogen Reserve, ppm N	0.0
Phosphorus mineralization, ppm P	13.8
Organic Phosphorus Reserve, ppm P	< 0.1
Phosphorus Saturation Al/ Fe, %	6.5
Phosphorus Saturation Ca, %	5.9
Soil Health	
Soil Health Calculation	20.31
Cover Crop Suggestion	10% Legume 90% Grass

WARD Laboratories, Inc.

Ag Testing - Consulting

Haney - Soil Health Analysis Contd.

Lab No. : 2740

Nutrient Quantity Available for Next Crop	
Nitrogen, lbs N/A	73.0
Phosphorus, lbs P2O5/A	97.3
Potassium, lbs K2O/A	199.7
Nutrient Value, $/A	184.49

Nitrogen Savings by using the Haney Test	
Traditional evaluation, lbs N/A	7.4
Haney Test N evaluation, lbs N/A	73.0
Nitrogen Difference, lbs N/A	65.6
N savings, $/A	41.96

PLFA Soil Microbial Community Analysis

Functional Group Biomass & Diversity

Total Living Microbial Biomass, Phospholipid Fatty Acid (PLFA) ng/g	2321.76
Functional Group Diversity Index	1.491

Total Biomass	Diversity	Rating
< 500	< 1.0	Very Poor
500+ - 1000	1.0+ - 1.1	Poor
1000+ - 1500	1.1+ - 1.2	Slightly Below Average
1500+ - 2500	1.2+ - 1.3	Average
2500+ - 3000	1.3+ - 1.4	Slightly Above Average
3000+ - 3500	1.4+ - 1.5	Good
3500+ - 4000	1.5+ - 1.6	Very Good
> 4000	> 1.6	Excellent

Functional Group	Biomass, PLFA ng/g	% of Total Biomass
Total Bacteria	1275.00	54.92
Gram (+)	854.49	36.80
Actinomycetes	235.43	10.14
Gram (-)	420.51	18.11
Rhizobia	16.04	0.69
Total Fungi	227.40	9.79
Arbuscular Mycorrhizal	73.52	3.17
Saprophytes	153.89	6.63
Protozoa	20.79	0.90
Undifferentiated	798.58	34.40

13 way CC mixture, aerially applied on Sept. 19, 2016 to soybeans

Fungi:Bacteria 0.1784

Bacteria tend to dominate in systems with fewer organic inputs or residues possibly leading to a lower C:N ratio. In addition, bacteria can be more prominent in the early spring or late fall as soil temperatures are usually cooler and vegetation is less active or absent. Dry conditions, slightly alkaline to alkaline pH values, or increased land disturbance through prolonged and extensive tillage, grazing, or compaction may also favor bacteria. While bacteria are important and needed in the soil ecosystem, fungi are desired and more often considered indicators of good soil health. Increased use of cover crops and/or other organic inputs and less soil disturbance should help the soil support more fungi. Adjustments to pH may also be recommended in some more extreme circumstances.

Scale	Rating
< 0.05	Very Poor
0.05+ - 0.1	Poor
0.1+ - 0.15	Slightly Below Average
0.15+ - 0.2	Average
0.2+ - 0.25	Slightly Above Average
0.25+ - 0.3	Good
0.3+ - 0.35	Very Good
> 0.35	Excellent

Predator:Prey **0.0163**

This ratio is also expressed as protozoa to bacteria. Protozoa feed on bacteria which helps release nutrients, especially nitrogen. A higher ratio indicates an active community where base level nutrients are sufficient to support higher trophic levels or predators. However, this ratio will always be a relatively low number because the prey will greatly outnumber the predators.

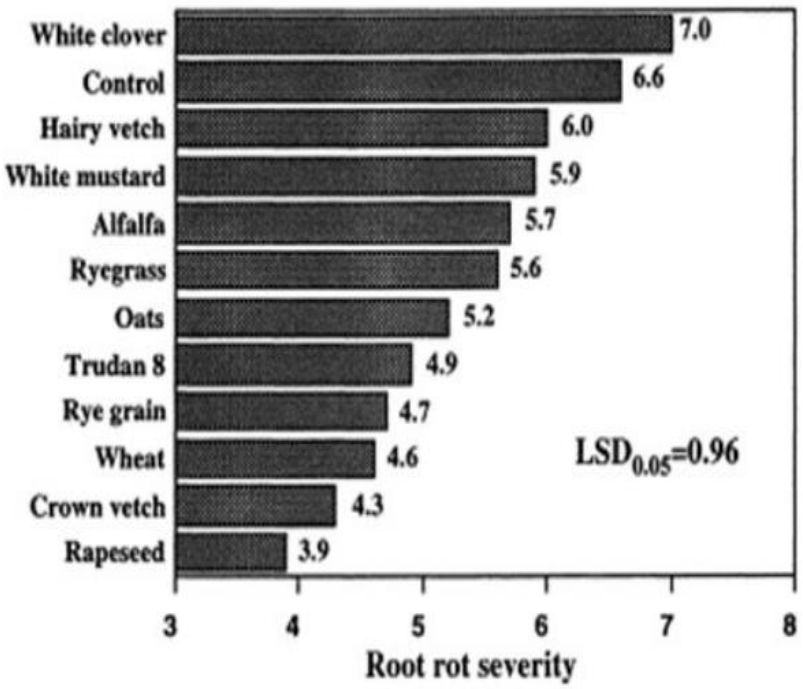
Scale	Rating
< 0.002	Very Poor
0.002+ - 0.005	Poor
0.005+ - 0.008	Slightly Below Average
0.008+ - 0.01	Average
0.01+ - 0.013	Slightly Above Average
0.013+ - 0.016	Good
0.016+ - 0.02	Very Good

Soil microbes – bacteria and fungi that live in the soil year round, can & should be active in the winter.

Weed Management and the Project

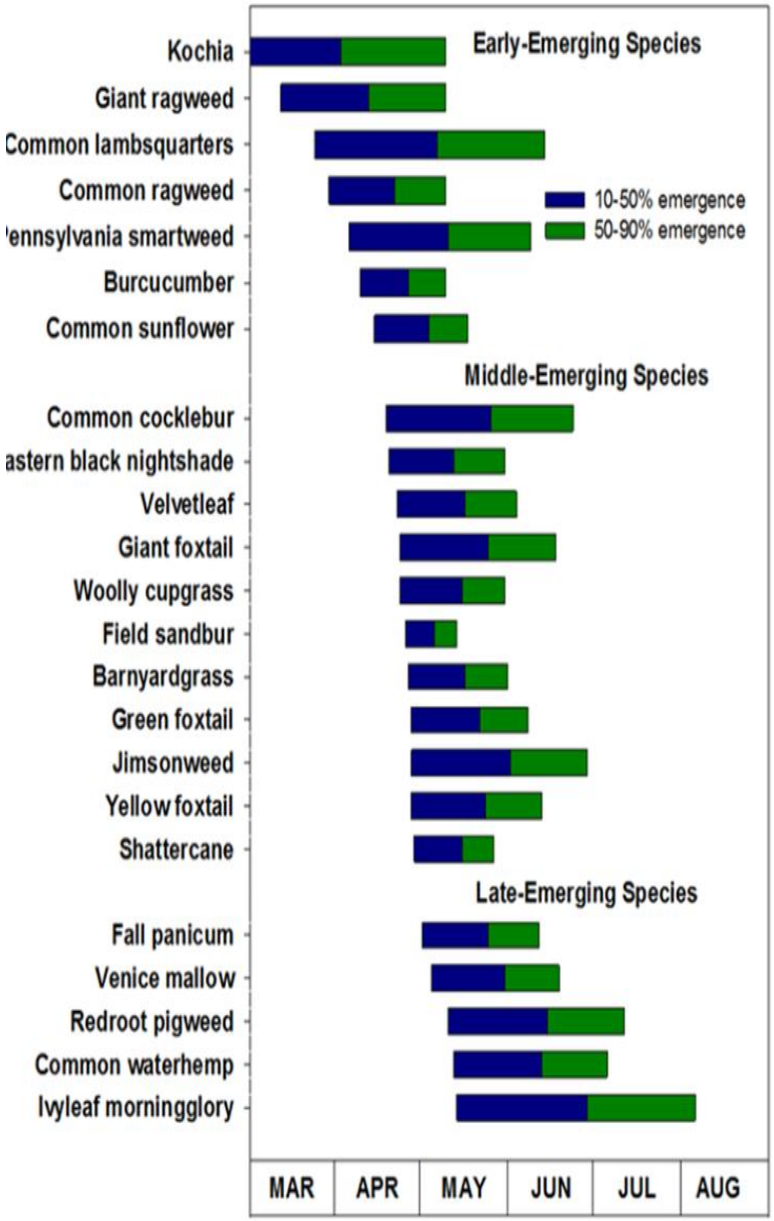
COVER CROPS

- Many examples of suppressive effects
- Potential mechanisms
  - Break disease cycles (*non-host crop*)
  - Allelopathy
  - Improve soil chemical & physical properties
  - ***Increase beneficial microbes***
- ***Challenge: suppressive activity could depend on the pest, plant species, and plant genotype***



The effects of various incorporated cover crops on root rot severity of snap bean (*P. vulgaris* L.) in a greenhouse test. Roots were rated on a scale of 1 (no root rot observed) to 9 (>80% of the roots infected). Numbers after the bar graph represent the actual values. Statistical differences compared by Fishers least significant difference test ($LSD_{0.05}$). (Abawi et al., 2001)

SUMMER ANNUAL WEED EMERGENCE SEQUENCE



Agronomy and Horticulture
WEED SCIENCE

Rodrigo Werle, Lowell D. Sandell, Douglas D. Buhler, Robert G. Hartzler, and John L. Lindquist (2014) Predicting Emergence of 23 Summer Annual Weed Species. Weed Science. 62:267-279.

Development of perennials after 2 years particularly clovers

Grazing and water-hemp

Pollinators

A habitat to make HAPPY pollinators

Youth, Pollinator Education, Leadership and NE SARE Field Day—Oct. 2016

Summary on the results of the Biology, Weeds, Pollinators, Livestock:

1.
2.
3.
4.

"I've got some bad news, Ole. Your farm is right on the state line, and we've determined that it's not in Minnesota. It's actually in Iowa."

Ole replied, " That's the best news I've had in a long time! I was just telling Lena that I don't think I can take another winter in Minnesota."

Future Steps

A—9 metrics and data-sets

B---6 immediate, management corrections

C—6 general, educational steps

A--My TOP NINE METRICS:

1—capture moisture at ALL times

2—intensity of production and ROI

3—INCREASING windows of seasons

4—build carbon AND MORE carbon through intentional CCs & rotations

Developing inorganic matter—
Candy Thomas, Oct. 2016

5—input tiers: i.e., reduce N, P, etc. but use 3 or more gauges (eliminate outliers) to be sure.

6—Look at herbicide MOA, residual and impact on CC needs. Do NOT underestimate. Compare 2012 vs 2015.

Broke the 11th Commandment—image courtesy of Darin Williams

Speciality is **BEYOND** non-GMO

7—value added rotations

--C-S-W vs S-Barley-non-GMO S. then C.

8—increase grazing windows

--csg then wsg while integrating legumes that work with herbicides

--integrate brassicas to break cycles

9—do NOT harm but increase AMF

Corn planted, 4.29.15; CC flown, 9.22.15

The brassicas are working during the winter. (1.24.16).

Clover and brassicas.
Maximize the seasons of soil intensity

B--The Big 6 Management Mistakes

1—Intentionality of CCs while balancing with diversity

--R-Up Alfalfa

--triticale vs. cereal rye vs elbon

--annual rye

--balansa clover (~525,000 seeds)

--camelina

2—INCREASING windows of seasons

--barley vs wheat

--corn: hi-moisture, GD, B-2-B

--soybeans: non-GMO vs. GMO; groupings

--artificial, CC interseedings (small seeds with field passes)

3--Use grazing and CC intensity to proactively attack Water Hemp, etc.

4—Utilize rotations that allow increased marketability AND stick to the marketing plan.

5--Balancing effective residuals with herbicide diversity, rotations and CC needs.

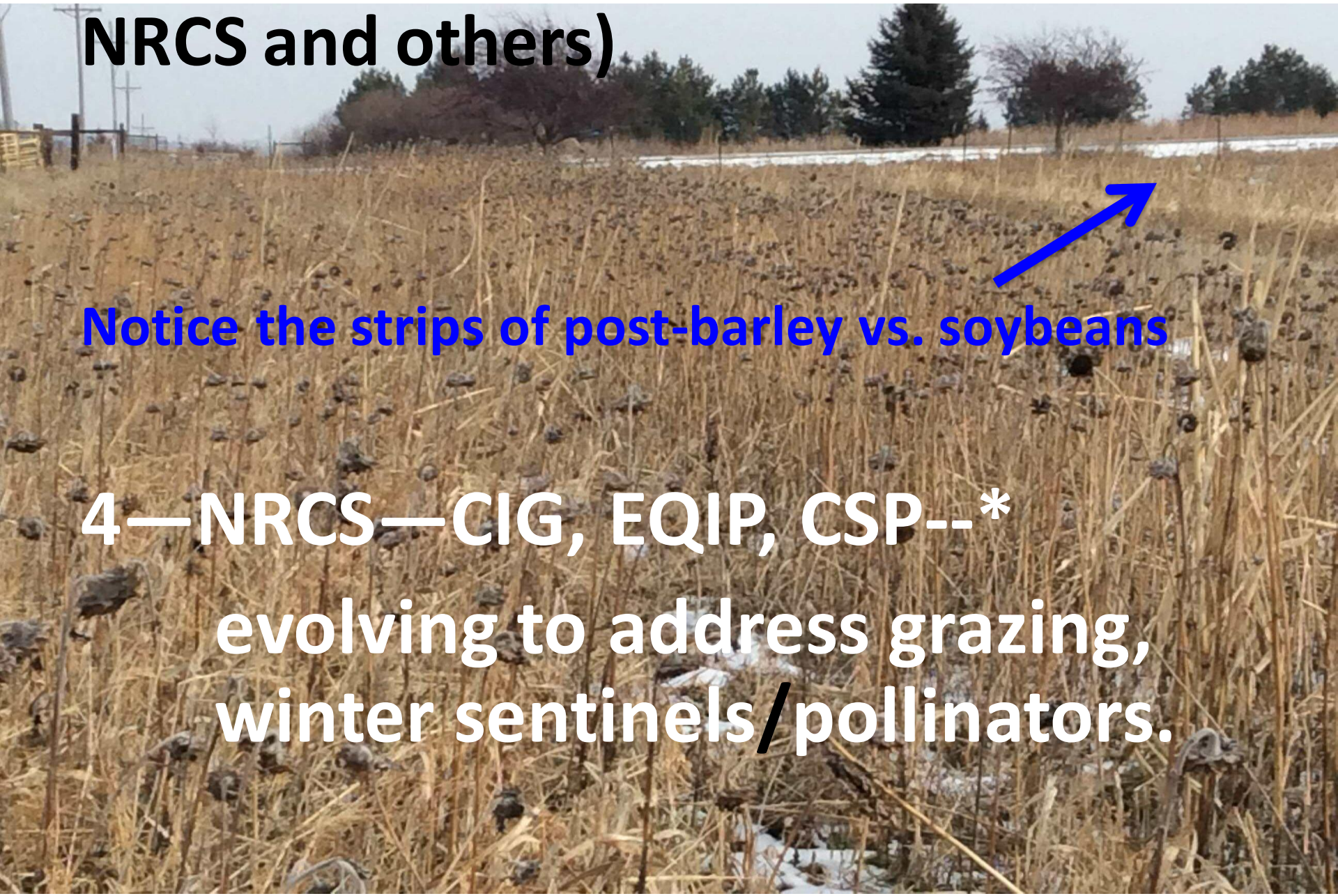
6—Document, document…pictures and records.

C—The big, 6 educational steps

1—Form a Peer Learning Group

2—Apply for grants and work with your local sources: SARE, Extension, Arrow, Stock, Green Cover…many others.

3—Beginning Farmer Support (FSA, NRCS and others)



4—NRCS—CIG, EQIP, CSP--*

evolving to address grazing, winter sentinels/pollinators.

5—Use the "snowball-effect" to form a team of quality coaches who read and attend conferences (NTOP)

6—It is a process and your family is key.

Suggestions in the grant-writing and monitoring process:

- Conceptualize and write from the “eye of the grant evaluator”
- “less is more”—examine my title and the confounding elements
- Plan backwards: objectives, measurability, responsibilities and the top-”take aways”
- Involve a lay-person who writes well but possibly knows very little about agriculture

Grant tips continued

- Determine sustainability and steps beyond the funding of the grant.
- Know that the “buck stops with you” and that you need contingencies if a partner changes their plans.
- Work closely with SARE and trusted resources. They want you to succeed and know that mistakes and issues will arise.
- Keep the “big-picture” in mind; it is hard-work but edifying.

Kudos and Thanks:

- NCR-SARE—especially Joan Benjamin; been overly patient and supportive
- NE-SARE—Gary Lesoing
- NRCS and UNL Extension
- NE Peer Learning Group
- KS Rural Conference
- NTOP, Arrow Seed, Green Cover Seed, Stock Seed and friends whom have helped me learn through trial and error.

- **Thank you for the opportunity and enjoy the Conference.**
- **mcdonald1.mike@gmail.com**
402.314.1571

My wife and NE farmgirl who supports, helps and loves unconditionally.

Smithsonian Museum of American Natural History, March, 2016