SOIL SMaRTS

Specific **M**anagement **a**nd **R**esources **T**rainings for **S**oil Health in Tennessee

TRAINING CURRICULUM

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Southern SARE Sustainable Agriculture Research & Education

UT Extension Institute of Agriculture The University of Tennessee

USDA United States Department of Agriculture

This curriculum was developed through a Southern SARE grant and collaboration between Tennessee State University, the USDA-NRCS, and the University of Tennessee. The objective of this curriculum is to provide training on soil health and sustainable management practices for soil health to extension agents and local officials so that they may disseminate this information to their stakeholders.

Soil Smarts Training Curriculum

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MODULE 3. SOIL HEALTH PRINCIPLES

Learning objectives:

Participants will be able to:

- define and describe soil health principles and their impact on soil health ecosystem functions
- identify key words within the soil health definition
- identify conservation practices and activities that address each soil health principle
- describe key soil health indicators

Materials:

- PowerPoint® slides "Module 3: Soil Health Principles"
- Lesson guide: Use the notes in this lesson guide to present information for each presentation slide.
- Questions found at the end of this lesson guide can be used to test participants' knowledge at the end of the presentation. This can be combined with clickers to improve audience engagement and create discussion.
- An evaluation of the presentation can be found in this lesson guide following the lesson questions.

Topics:

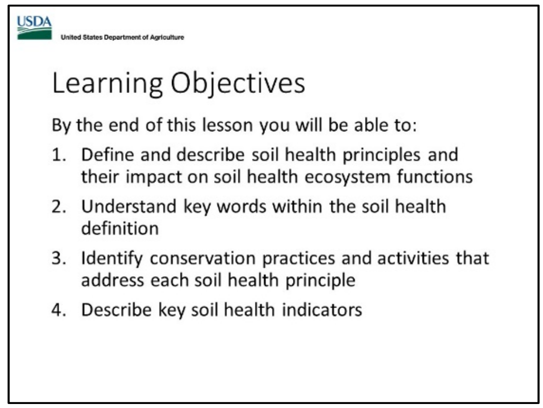
Soil degradation
Soil health principles
Agricultural disturbance
Cover crops
Crop rotation

<u>Slide 1</u>

This module covers soil health principles. When these principles are followed, we should be able to monitor key indicators (Module 4) to track our soil health regeneration.

Slide 1

<u>Slide 2</u>

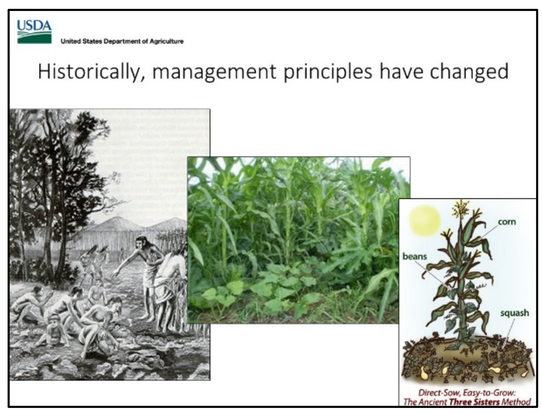


Slide 2

<u>Slide 3</u>

The Adena Indians (for example) used tools made of stone, animal bone, and tortoise shell to grow crops of squash, pumpkins, gourds, sunflowers and maize. The primary agricultural product of the Ohio Indians, shortly after the introduction of agriculture to Knox County, was maize.

We've all seen picture and renditions of "the 3 sisters".



Slide 3

Slide 4

As long as our tools involved wood and our horsepower was supplied by horses, or oxen, then we pretty much had to work with nature.

When the tools became steering wheels and push buttons and our power was supplied by hundreds of horses packed into a diesel engine, then our natural drive led us to management principles for controlling nature.

John Deere invented the steel plow in 1837 when the Middle-West was being settled. The soil was different than that of the East and wood plows kept breaking.

Slide 4

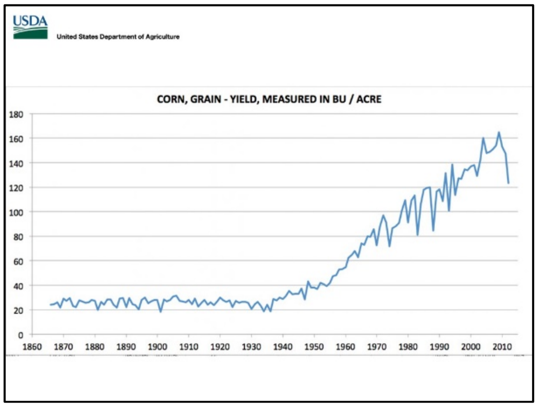
Slide 5

In no way is this a judgement against tradition or agriculture as a whole, but speaks to why change isn't easy for most of us. Some of the complacency among farmers (and some of our staff) for not changing management or looking harder into soil health systems, is that the deep prairie soils still reward them for the intensive tillage they have done or observed throughout their lifetime. We miss the realization that the Mediterranean and European style agriculture practices only arrived, in earnest, on this continent a couple of centuries ago.

Slide 5

Slide 6

The current agricultural intensification only took hold a few decades ago. So while our current methods seem to be working fine, that is largely due to the facts: that we haven't been at them here for very long and cheap energy inputs, mostly from finite resources, are still readily available. If we look at regions of the world where these farming methods have been in place for millennia or on poorer soils to begin with, then we see what a totally depleted resource brings (hunger, disease and war).



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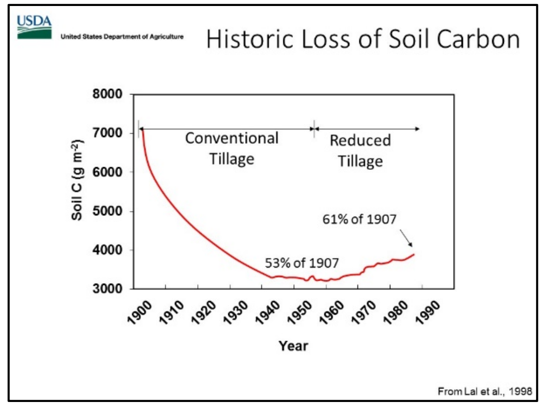
Slide 7

This graph shows simulated total soil carbon changes (0 - 20 cm depth) from 1907 to 1990 for the central U.S. corn belt and a portion of the Great Plains. This indicates that soil organic carbon levels dropped to 53% of precultivation levels in the 1960s and increased subsequently with the adoption of conservation tillage practices and the advent of higher yielding varieties which produce more crop residues (Lal et al., 1998). Not sure the increase has happened as predicted in this model.



Slide 7

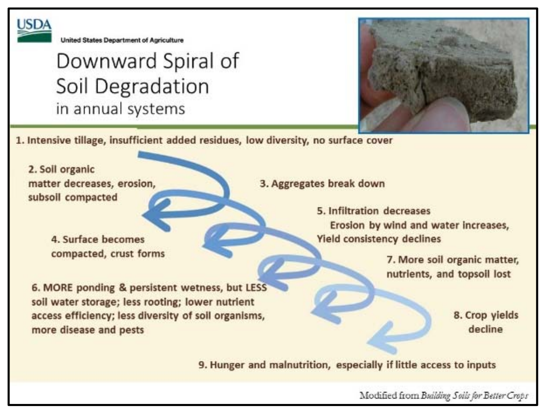
Relate this loss in carbon to the potential of soil to sequester carbon. The soil has the potential to put back or store all this lost carbon. The potential is about 40% of the pre-cultivation soil carbon.

In general, the C content of soil organic matter is about 58%. Soil organic matter is a key indicator of soil quality and is an integrated measure of change in soil function. Generally, increases in soil organic matter reflect increases in soil quality. Soil can function as a sink for atmospheric carbon, and therefore has the potential to decrease atmospheric carbon and aid in mitigating global climate change.

Slide 8

If current management principles include intensive tillage, insufficient addition of residues, low diversity, no surface cover….follow the graphics.

Over time, the way we manage our soil can, and has, led to degraded soil functions. (mention the functions that we discussed earlier).

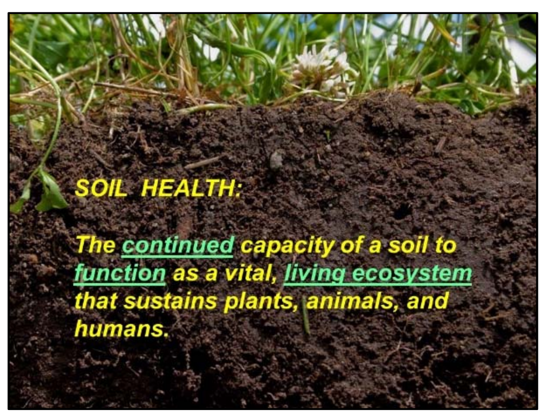


Slide 8

Slide 9

This definition which has been accepted by most stakeholders, focuses on the importance of soil function and the reality of soil as a living resource. When we speak of soil health, we are talking about improving the capacity of soil to function as a vital, living ecosystem that sustains plants, animals, and humans.

"Health" is usually used in the context of a living organism so managing soils for optimum health, in a way, ensures they are sustainable/alive for future generations.



Slide 9

Slide 10

Farmers like these all across the nation are now planning every operation and management decision around the guiding principles for soil health. They are leading many of the advancements in SH.

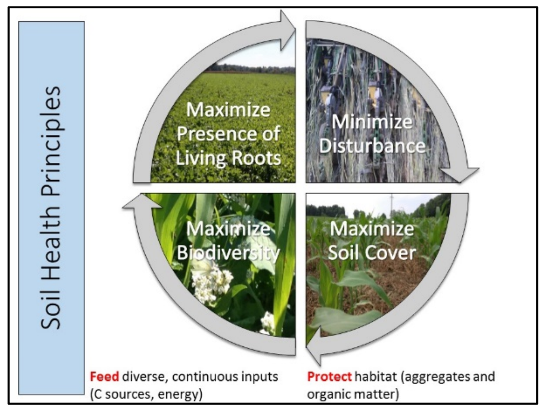
Slide 10

Slide 11

You were introduced earlier to the "principles" of soil health. To truly improve soil health, we must integrate 4 key management principles into every aspect of management decisions. So in this session we will dive deeper into why each principle is important and how each must be integrated into a system where it complements the rest.

By the end of this training, these principles should role off of your tongue when discussing soil health.

As part of the discussion we need to be pragmatic about these principles.



Slide 11

The principles tend to do one of two things, they either feed soil microbes by providing a continuous source of C or they protect the habitat

Slide 12

Most farmers who have studied yield maps have seen these principles at work. Ask- what happens to the yield map when you cross an old fence row, or maybe an old pasture that has been brought into production? … Most farmers in the room will start giving the thumbs up sign.

July 31, 2015 Aerial photo. In an extremely wet year why would this narrow part of the field look so much better?...Judging from this tract boundary line, there used to be a fence row there. The yield map would likely show an even greater advantage.

Slide 12

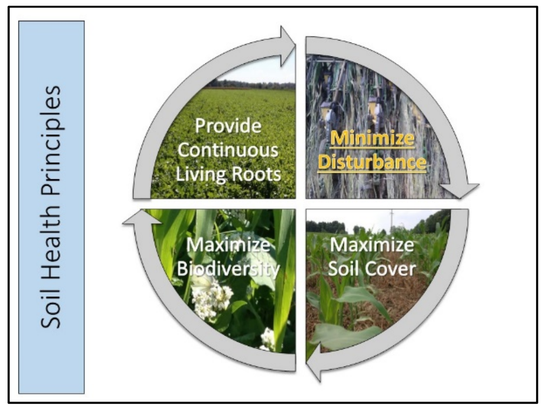
Slide 13

Those fence rows that are now in production had all of the principles in place for longer that the rest of the field. The purpose of this section is to see if we can integrate management that regenerates soil function like the fence row all across the field…farm…landscape.

Slide 13

Slide 14

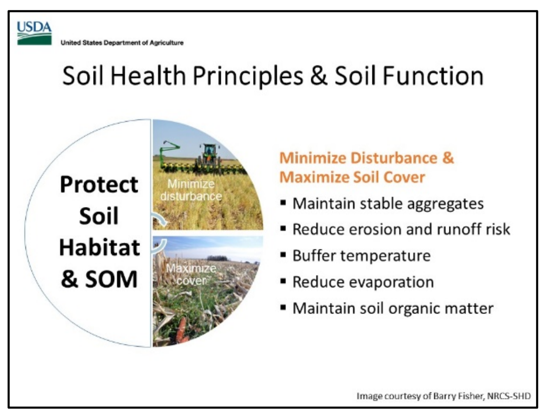
To start we will focus on the minimize disturbance portion of these principles and work our way clockwise around the circle.



Slide 14

Slide 15

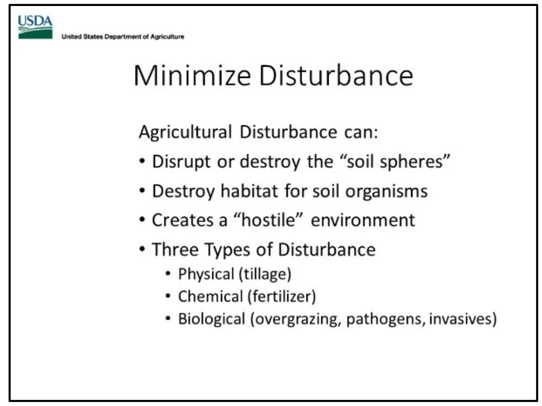
The first two principles focus on protection of the soil habitat: minimizing disturbance and maximizing soil cover maintains or increases stable soil aggregates and soil organic matter (SOM), and protects the fragile surface of the soil that is most susceptible to the degrading forces of wind and water. Covering the soil also buffers against extreme swings in temperature that stress plants and soil organisms, reduce evaporation rates, and increase water-use efficiency. SOM is highest at the soil surface and is critical for stabilizing soil aggregates. Maintaining SOM helps support additional soil functions including water infiltration and storage, nutrient-holding capacity and release, and habitat for soil biota.



Slide 15

Slide 16

Who can name some types of disturbance? The kinds of disturbances we've become accustomed to seeing in much of agriculture, and thought of as "normal", aren't really normal in nature and weren't occurring during the development of our great soils.



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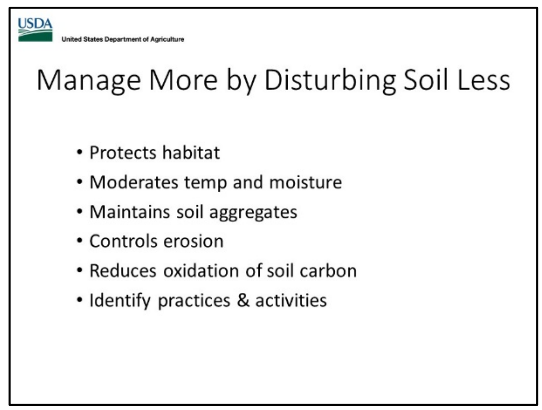
Slide 17

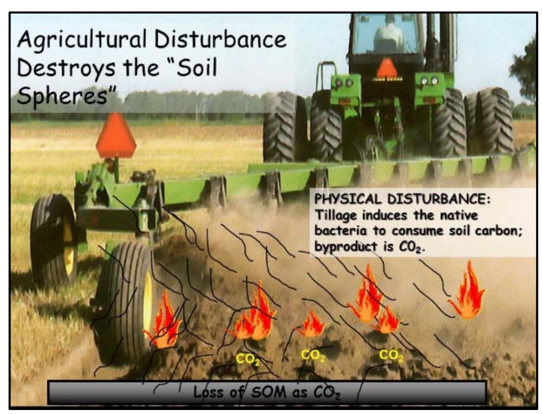
We truly need to minimize disturbance to the extent possible and practical to realize these benefits.



Slide 17

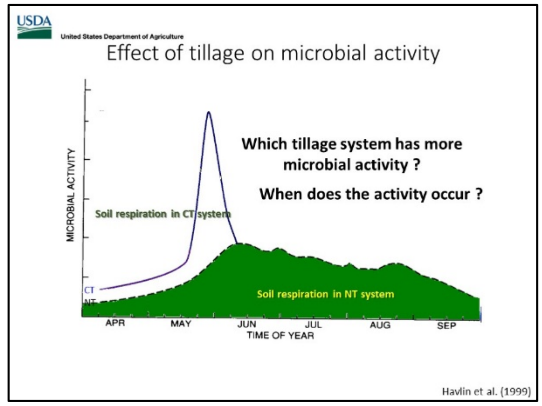
Slide 18

Tillage disrupts the pore space which impacts the water cycle. Physical disturbance causes native bacteria to consume soil carbon once the readily available food supply is exhausted. As the disturbance continues, the bacteria-driven soil can become adapted or "addicted" to the high disturbance environment.



Slide 18

Slide 19
To evaluate microbial activity, scientists often look to respiration or CO_2 production. Just like humans, microbes eat, drink and breathe. The more they eat, drink and breathe (or the more active they are, the more CO_2 they produce. The timing of this respiration is important- is it just lost or is it captured by the crop canopy and used for photosynthesis?



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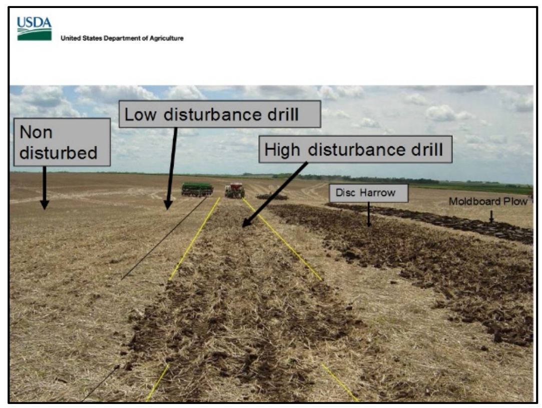
Slide 20
You can see the difference in disturbance made by different tillage techniques. The more soil exposed, the greater the chance for the decomposition of carbon and loss through erosion.



Slide 20

Slide 21
No-till can be an important step toward building a soil health management system. In this slide the roots are happy because there is organic matter present and good aggregation in the soil.

Slide 21

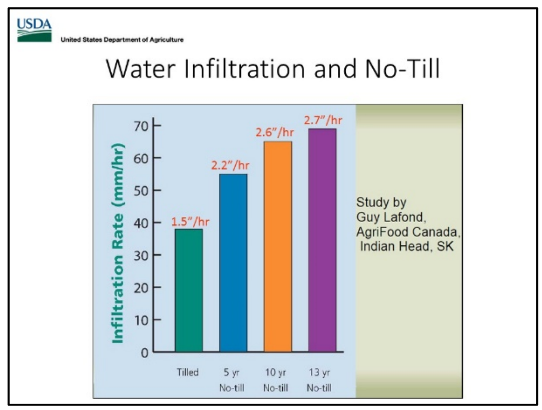
Slide 22

In this slide, however, even though no-till has been implemented, there are still issues with the soil. Eliminating disturbance alone will not always improve soil health. No-till can be an important step, however, not all no-till is created equal. There have been some studies that report no improvement in SOM, aggregate stability, or water infiltration. Few studies provide a detailed account or analysis of the no-till system. It would be a mistake to assume that the mere absence of tillage in a given year would achieve significant soil health benefits. The quality of the no-till system should be a part of any study. A "Quality No-till System" will integrate more than the single principles of reduced physical disturbance. It will be complemented by reductions in other types of disturbance and additional principles. We will cover more on practices and systems in a later session.

Slide 22

Slide 23

Many studies have concluded that No-till can improve aggregate stability and thus improve water infiltration.



Slide 23

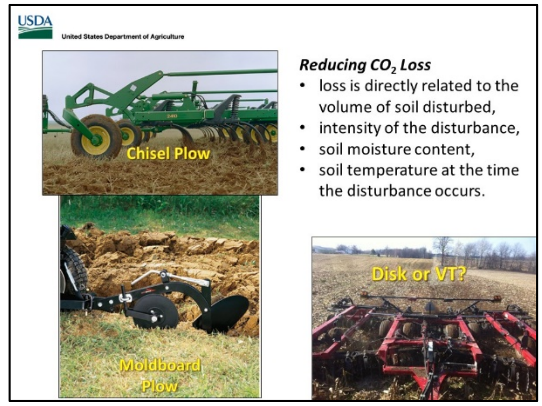
Slide 24

The traffic involved in tillage can also create compaction, particularly under wet conditions. The slide shows ponding in these compacted areas.

Slide 24

Slide 25

Shallow soil disturbance (1-3 inches) releases less CO_2 than deeper operations.
When deep soil disturbance is performed, such as by subsoiling or fertilizer injection, make sure the vertical slot created by these implements is closed at the surface.
Planting with a single disk opener no-till drill will release less CO_2 than planting with a wide-point hoe/chisel opener air seeder drill.
Soil disturbance that occurs when soil temperatures are below 50° F will release less CO_2 than operations done when the soil is warmer.
There are many brands and types of tillage tools and all have varying degrees of soil engagement and residue "management".



Slide 25

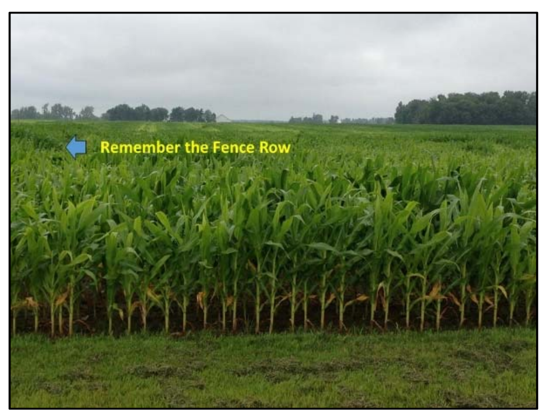
Slide 26

We can see that ponding and flooded crops were the norm for much of this region.

Slide 26

Slide 27

We can blame a lot on the weather, however, certain parts of the field revealed significant differences in soil health. The area to the left seems to be far more resilient to the extreme saturation. In fact it was an old fence row that had been brought into production a few years ago. This area, by coincidence, had the 4 principles in place until recently. Our goal is to replicate the fence row across the landscape.



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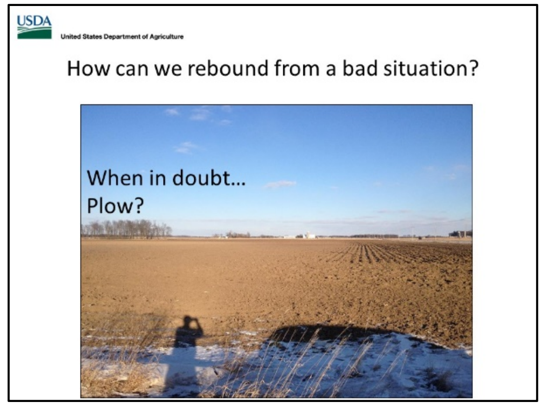
Unfortunately, once the crop was determined failed or immediately after the crop was harvested, most fields received "Iron" therapy. This was probably good therapy for the frustrated farmers, but had little to no effect on improving the soil.



Slide 28

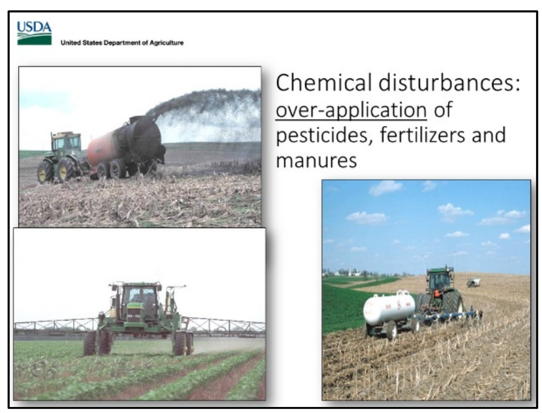
Slide 29

A few farmers took a different approach with a different mindset (when in doubt-plant).
Need to change our paradigm to look at soil health principles as the solution.

Slide 29

Slide 30

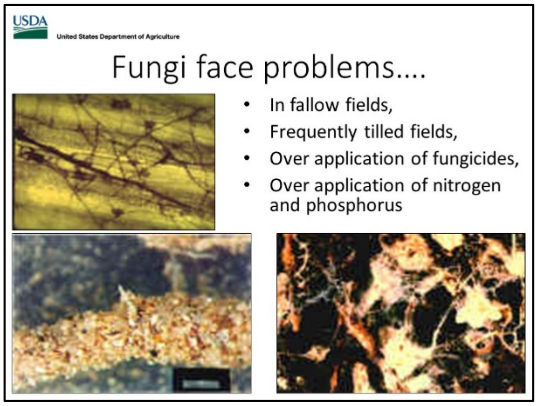
Other disturbances relate to chemicals where overapplication of pesticides, fertilizers, and manures can cause issues for the soil biology.



Slide 30

Slide 31

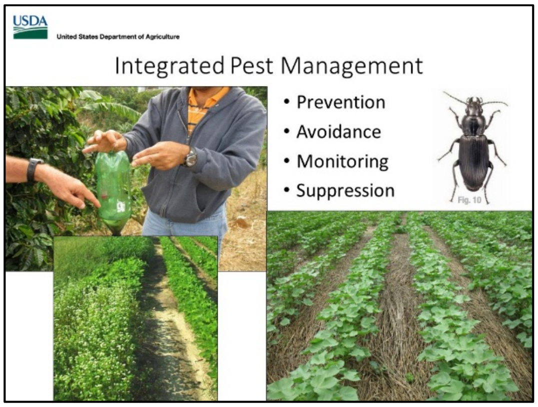
This can also be a biological disturbance.



Slide 31

Slide 32

Integrated pest management is similar to soil health management in that it focuses on sustainable management principles. IPM can aid in improving soil health by engaging in these sustainable practices and reducing pesticide use.



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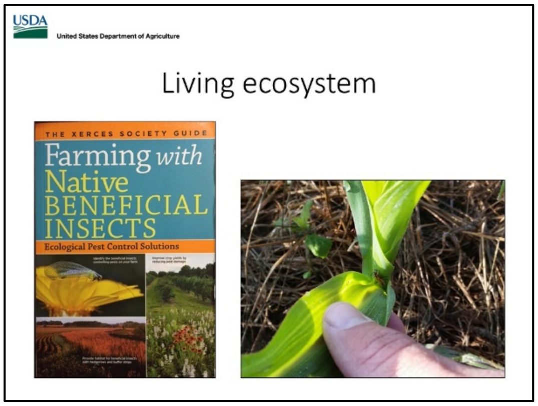
Slide 33

Remember, you are creating and managing a living ecosystem! Widespread use of pesticides may be wiping out organisms critical for soil health.



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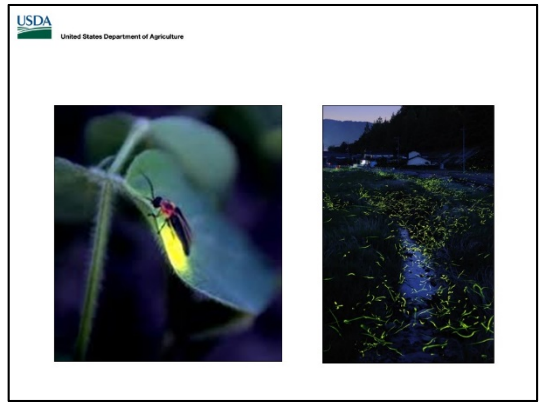
Slide 34

As an example, fireflies feed on egg masses of caterpillars, slugs, etc. many of the pests that we fight in agriculture.



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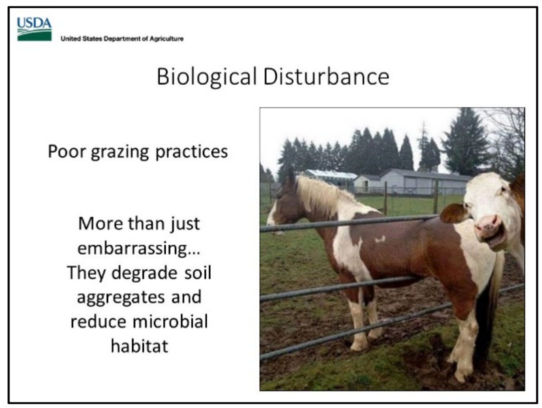
Slide 35

As we mentioned, biological disturbances can occur through the use of chemical applications but they can also be implemented through other management systems like grazing.

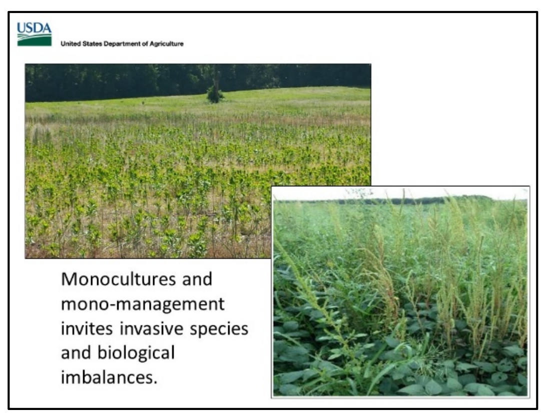


Slide 35

Slide 36

Ask the class to think of other biological disturbances.

Monoculture systems are a biological disturbance in that they don't provide a diversity of food and cover for soil microbial communities.



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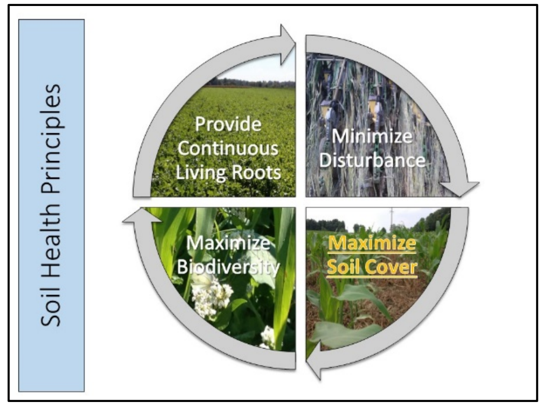
Slide 37

Now we will focus on management systems that maximize soil cover.



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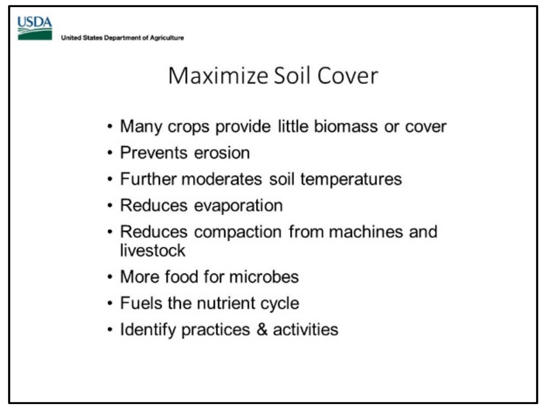


Slide 38

Slide 39

The more cover you can have over the soil, the better. Also, more species diversity in cover crops can enhance soil health properties. Cover crops can also provide additional cover for low biomass crops.

Slide 39

Slide 40

For many farmers, the concept that more is better is difficult. We here often-”my soil is too cold and wet” . Billions if not trillions of $ have been spent on equipment and technology to mechanically warm and dry the soil.

Slide 40

Slide 41

And yet, is tilled soil always warmer?...It depends on a number of factors including time of day, time of the season, moisture content, etc.

Slide 41

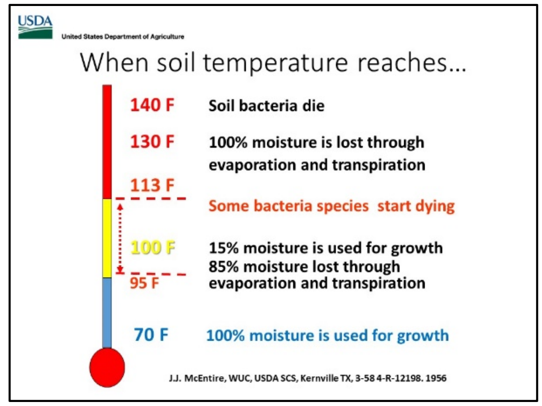
Slide 42

If you mechanically warm your soil in the spring are you giving up moisture, air, and habitat in the summer.

Slide 42

Slide 43

Soil temperatures are a way of determining the health of your cropland and pastures. By placing a temperature gauge on the surface can show you what kind of microclimate you have created. Soil temperatures can exceed ambient air temperatures by 10 to 20 degrees.



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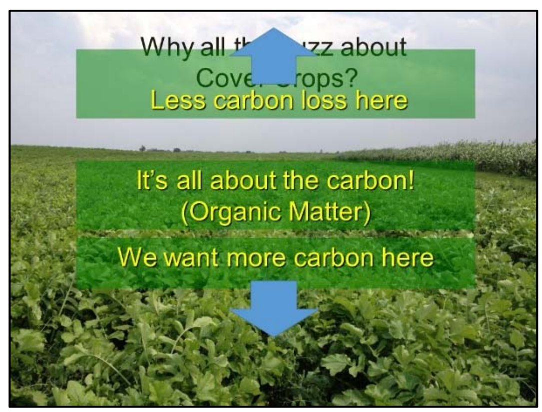
Plant use of moisture is directly linked to soil temperature. At 70 F soil temps 100% of the moisture is used for growth, none is loss. At 100 F you lose 85% of your moisture through evaporation-transpiration. At 113 F 100% of soil moisture is lost through evaporation-transportation, no plant growth is occurring. A plant's natural reaction to hot temperatures is to evaporate soil moisture through their system to cool itself. Protein cooks at 120 F. Thus the plant will avoid being cooked by using all the moisture you have caught in the soil for air conditioning. At 130 F, soil organisms start to die.

So it is important to manage for cool soil conditions. This is the biggest loser of soil moisture. Hot ground means you have created a drought even during moist years.

Slide 44

It's really all about the carbon cycle. We can build it so much faster in the soil if we grow more biomass and stop losing carbon to the atmosphere through tillage.



Slide 44

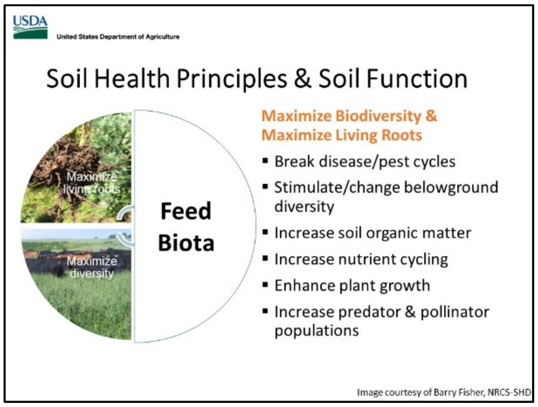
Slide 45

Now we will discuss some management practices that can help maximize biodiversity in the field which is our third soil health principle.

Slide 45

Slide 46

The second two principles focus on feeding the organisms inhabiting soil. Maximizing the diversity of food (energy and carbon inputs) and aboveground biodiversity through increased plant, animal, or soil amendments increases the diversity of soil animals, microorganisms, and activities. Diversity not only refers to food sources, but also aboveground diversification of plants and animals, as well as microbial diversification underground. Diversification stimulates a host of additional benefits including breaking disease cycles, providing habitat for pollinators, wildlife, and beneficial predators, and stimulating plant growth.



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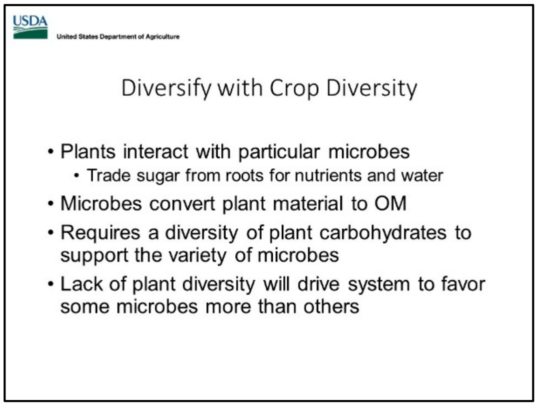
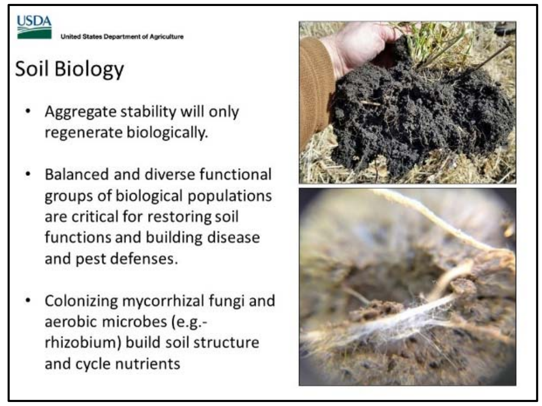
This slide focuses on how crop diversity can create diversity in soil biology.



Slide 47

Slide 48

Maximizing diversity is really all about habitat for soil organisms… build it and they will come….feeding the soil biology. As we discussed before, without habitat, beneficial soil biology, such as mycorrhizal fungi and rhizobia bacteria that build structure and tilth, may also be lost. Without a balance of these organisms, the soils lose key functions and are subject to compaction, crusting, and high bulk density.

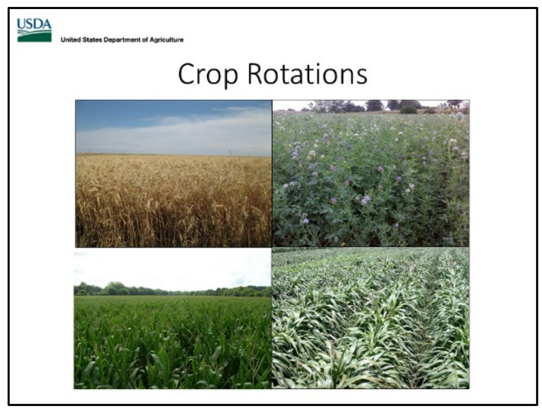


Slide 48

Observations in Tennessee…monoculture legumes will show poor to no defined aggregation. Speculation: Soil biology needs energy and will find and will digest it in and between aggregates causing them to collapse. No cover or plant growth will cause no aggregation or poor aggregation, platy structure. Aggregates require active carbon.

Slide 49

One of the most obvious ways to increase biodiversity is through crop rotations.



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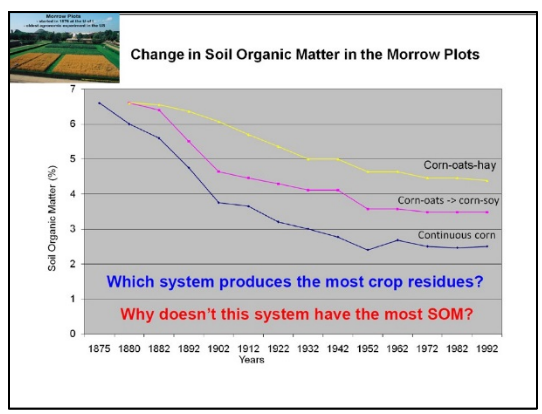
Slide 50

Morrow Plots at the University of Illinois is the oldest agronomic experiment in the US (started in 1876). They show a steady loss in soil organic matter but there is not as much loss in systems that have more diversity.



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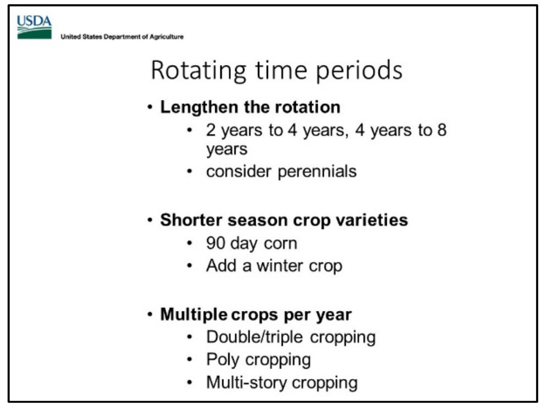
Slide 51

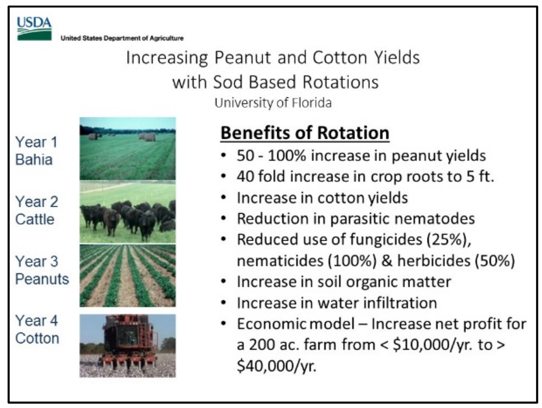
Rotation strategies for improving soil health



Slide 51

Slide 52

Example that uses crop rotation to increase peanut and cotton yields.



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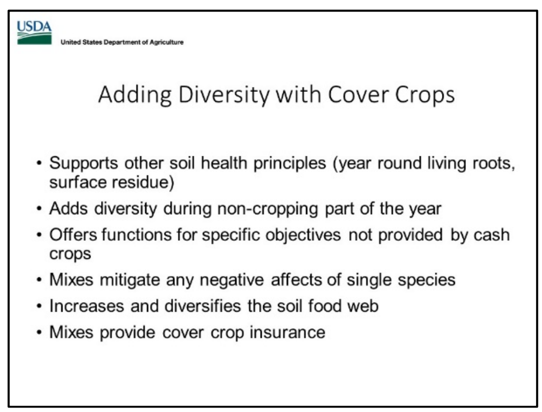
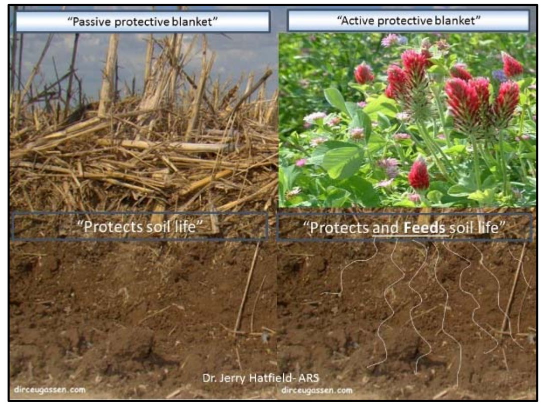
Examples of how cover crops can increase diversity



Slide 53

Slide 54

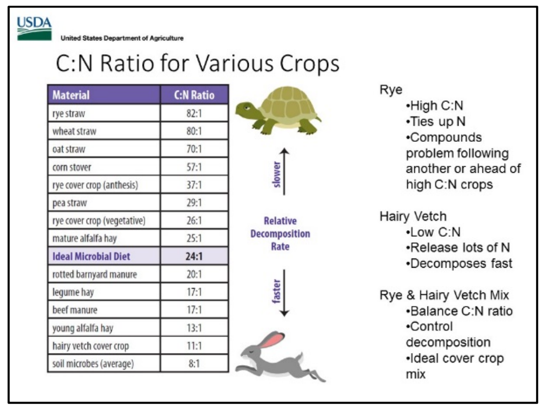
Cover is important as protection of soil life…a diverse and active cover not only protects but also feeds soil life. Like us, sooner or later they need to eat, and it can't always be shredded wheat.



Slide 54

Slide 55

Not all cover crops are created equal. We need to use covers that complement our crop rotation, provide desirable habitat and address resource concerns. Understanding differences in the Carbon:Nitrogen ratio between plants is critical for this selection.
Ask the class what drives C:N –is it the C or the N? Discuss that most plants contain 40-50% carbon so it is the N that is the driver (it is the limiting nutrient).
Ask the class how you can change the N in a plant. Vegetative vs mature, N fertilizer or N fixation by legumes.



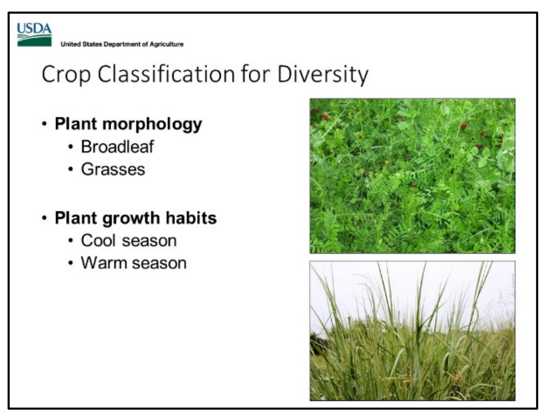
Material	C:N Ratio
rye straw	82:1
wheat straw	80:1
oat straw	70:1
corn stover	57:1
rye cover crop (anthesis)	37:1
pea straw	29:1
rye cover crop (vegetative)	26:1
mature alfalfa hay	25:1
Ideal Microbial Diet	**24:1**
rotted barnyard manure	20:1
legume hay	17:1
beef manure	17:1
young alfalfa hay	13:1
hairy vetch cover crop	11:1
soil microbes (average)	8:1

Slide 55

Ask class what effects a high or low C:N ratio cover crop may have on the next crop; nutrient cycles; residue decomposition.

Slide 56

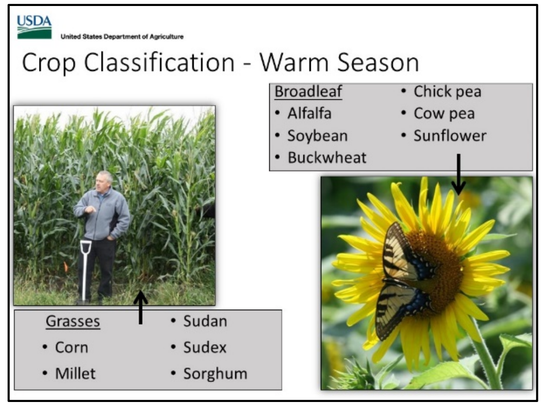
So if plant diversity is this important, maybe we should have a basic strategy that applies to most situations. For cropland, we try to at least get all crop types growing at some point in a rotation or together.
Why - ask the class for input. Basically, each crop type may provide a different function, food and outcome. We've known for years that certain crops of different crop types can be synergistic to each other (i.e. grasses and legumes). We know that different plants secrete different compounds that feed and attract different organisms.



Slide 56

Slide 57

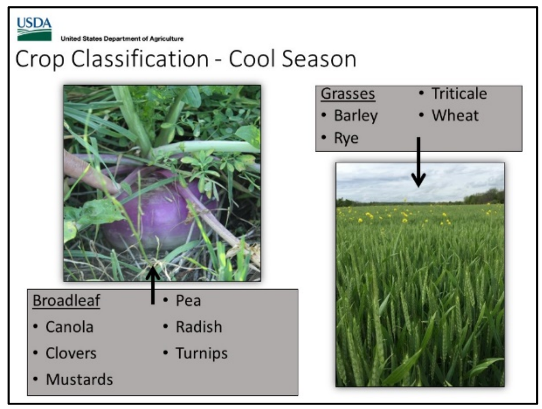
These are some examples of warm-season grasses and broadleaf crops.



Slide 57

Slide 58

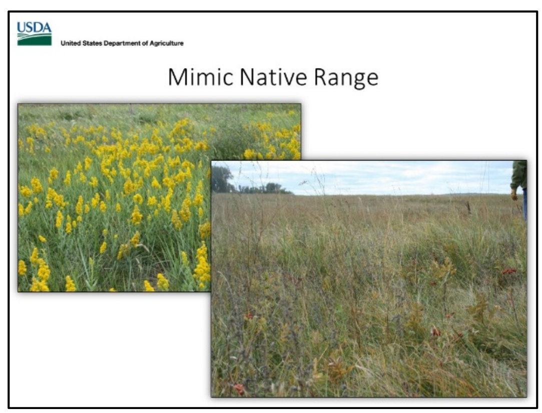
These are some examples of cool-season grasses and broadleaf crops.



Slide 58

Slide 59

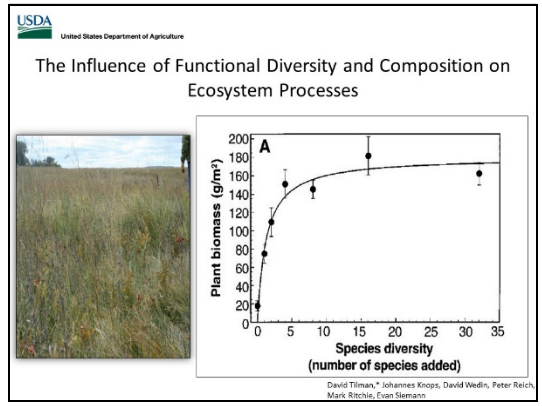
Mimicking native range can also mimic the positive soil health attributes found in these kinds of soils.



Slide 59

Slide 60

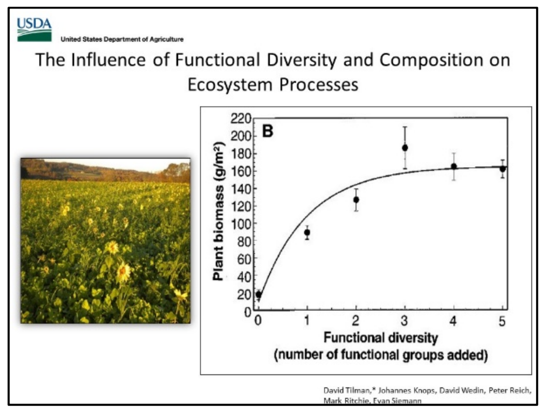
Aboveground biomass relates to site productivity. Therefore, up to a certain point, the greater the number of species present, the greater the productivity can be.



Slide 60

Slide 61

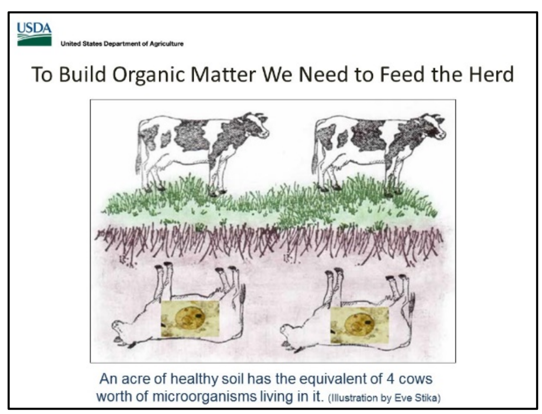
This is another way of showing the information, similar to the previous slide. In this case we are seeing that an increase in functional diversity (functional groups include legumes, cool-season grasses, warm-season grasses, woody plants, and forbs), up to a certain degree, also increases site productivity.



Slide 61

Slide 62

You can no more starve your way to a healthy heart than you can starve your way to a healthy soil. Continuous, diverse living cover is the best food source.



Slide 62

Slide 63

The bison roamed around eating the grass. Primarily it was warm season grass and forbs but there was a tremendous amount of diversity. There is still discussion about exactly how the bison grazed. There were a lot of factors that came into play (i.e. time of year, growing or dormant grasses, available water, what areas burned, what didn't burn). Some writings and accounts say they were in small groups grazing only in the burned areas for the entire year. These burned areas would have been grazed pretty hard while unburned areas were almost ungrazed and then the next year they moved to another burned area. There are also accounts of large herds numbering in the hundreds of thousands. As you can imagine when a large herd like this moved through an area everything probably got grazed and/or trampled pretty hard.   In either of these scenarios the grasslands were severely grazed and then rested for a long period of time, severely grazed and then rested. It was this type of management that developed some of the most fertile soils in the world. I think we can use different forms of this type of management to repair our eroded and worn out soils.

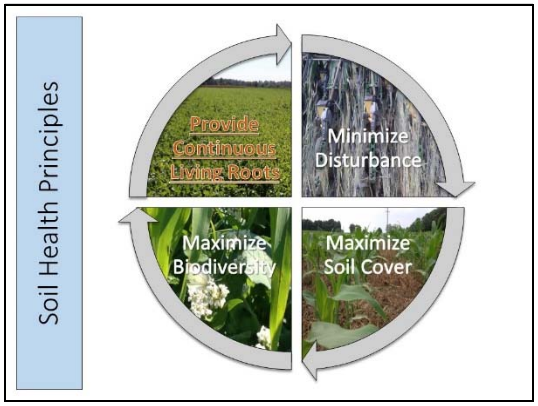
Slide 63

Slide 64

At first glance this may seem like too much disturbance, but in this system the rest period allows for rapid regeneration from the improved cycling of carbon and nutrients.

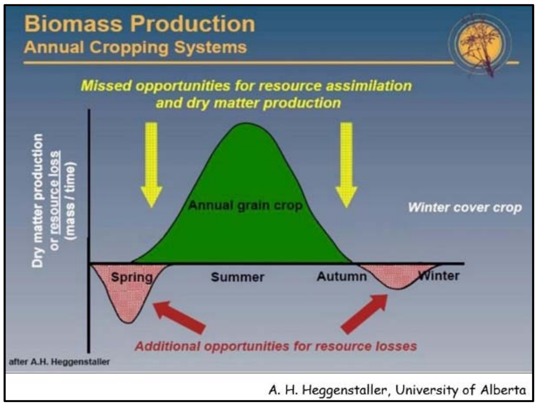
Slide 64

Slide 65
We'll now move on to our last soil health principle, Provide Continuous Living Roots.



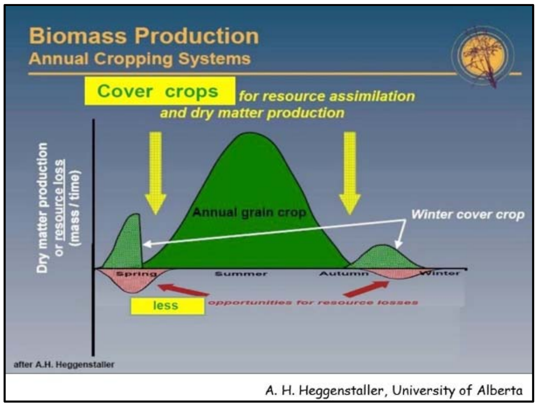
Slide 65

Slide 66
Without the winter cover crop, we can see the expected losses of resources in winter and spring when there is no crop being grown.



Slide 66

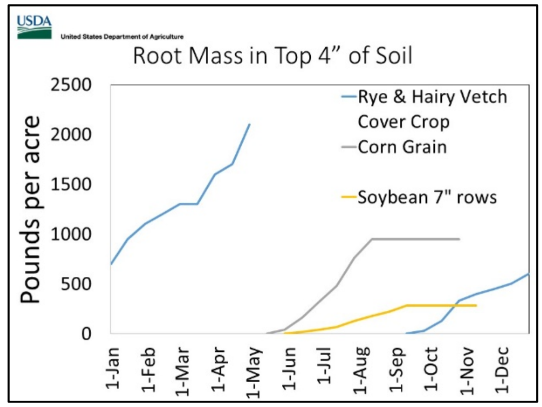
Slide 67
With cover crops, you can see the expected losses are smaller and dry matter production occurs. In some cases, sacrificing a whole crop system may be worth consideration to
maximize benefits to the soil ecosystem.



Slide 67

Slide 68

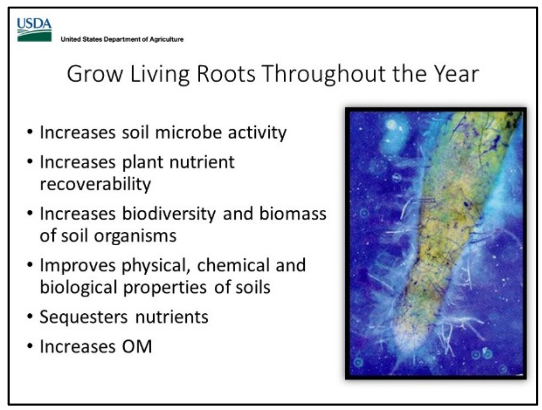
In a very short window, extensive root mass is possible. This adds to the soil carbon pool and greater production/maintenance of stable aggregates.
Corn produces approx. 950 lbs. of root mass in the top 4”
Soybeans/cotton produce approx. 400 lbs.
The cover crop produces over 2500 lbs. of root biomass planted in September and terminated in mid-April.



Slide 68

Slide 69

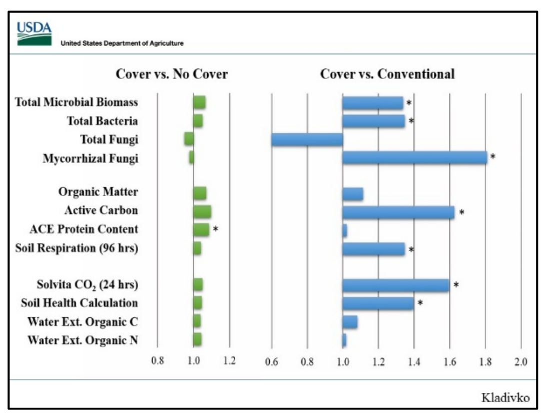
In addition to cover the root production can jumpstart soil biology and function.



Slide 69

Slide 70

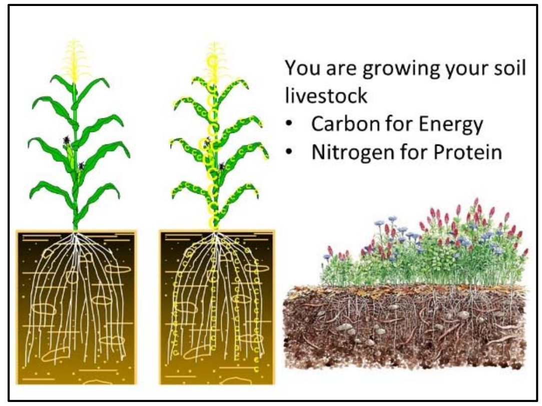
This slide shows response ratios of 12 soil health measures for 2016 sampling in NW Indiana. Values greater than 1 indicate a positive effect of the cover crop compared to either no cover (left) or the conventional neighbor (right) while values below 1 indicate a negative effect of cover crops relative to their comparison. Treatment pairs that were significantly different at 0.10 level are indicated by asterisks.



Slide 70

Slide 71

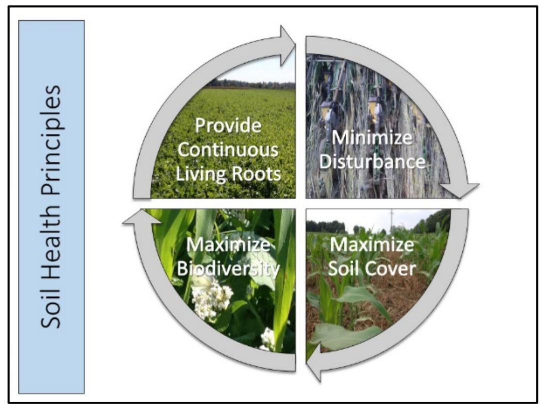
The growing roots also feed the biology (through dead root cells and root exudates) in the soil that is responsible for forming stable aggregates.



Slide 71

Slide 72

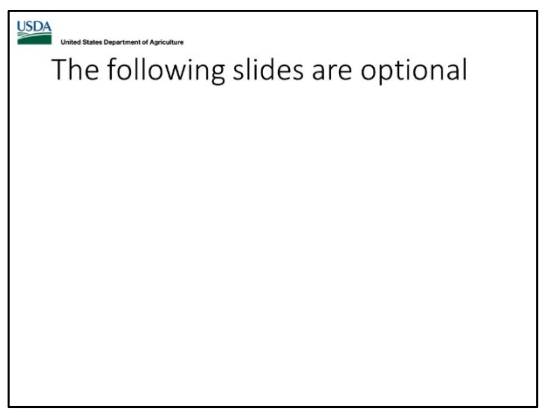
So, we've gone through the four soil health principles and discussed why they are important for soil health. Hopefully, once you leave this workshop, these principles will roll off of your tongue when discussing soil health. Next, we will identify the indicators in the field that will show us how well, or not so well, we are doing at adhering to these principles.



Slide 72

Slide 73

The following slides are optional and may be incorporated into specific sections of the presentation depending on the trainer and audience.



Slide 73

Slide 74

MP = moldboard plow

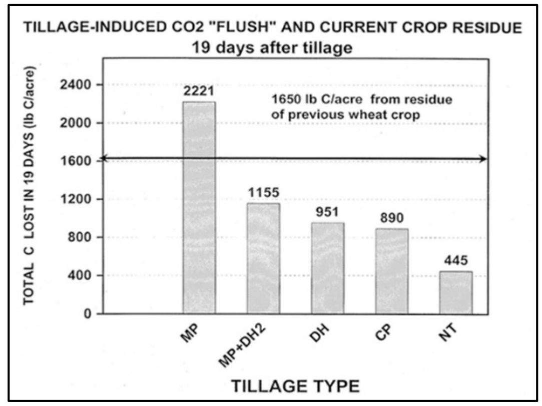
MP + DH2 = moldboard plow plus disk harrow twice

DH = disk harrow

CP = chisel plow

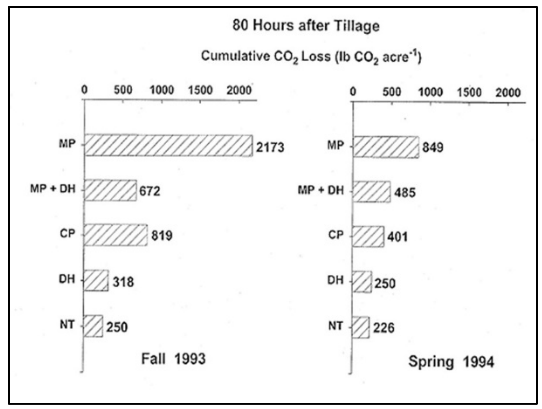
NT = no-till

How long we leave the soil open is a factor as well.



Slide 74

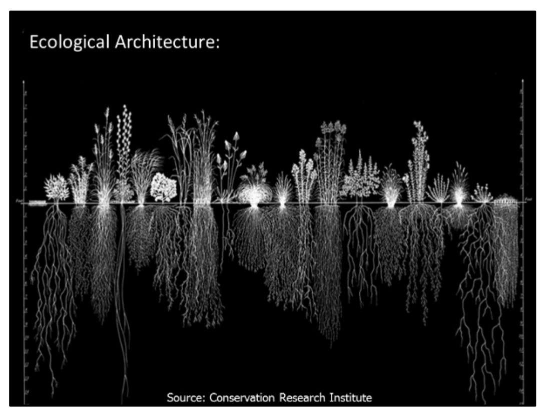
Slide 75



Slide 75

Slide 76

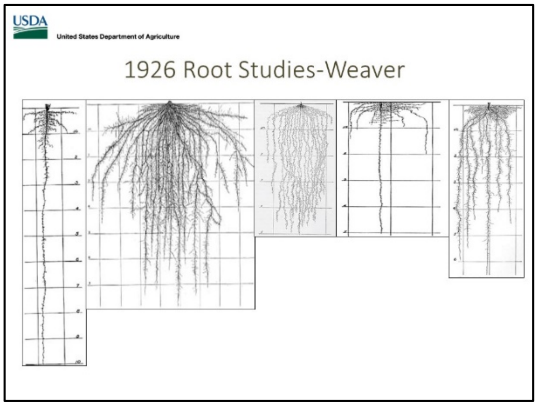
Plants have a diversity of rooting systems and rooting architecture.



Slide 76

Slide 77

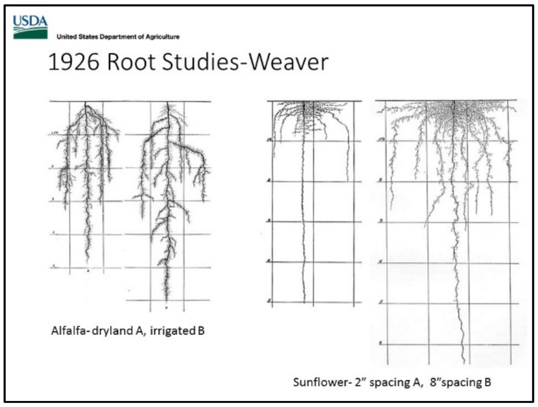
We've been studying diversity of plants for awhile.



Slide 77

Slide 78

Nature responds and adapts to environment



Slide 78

Slide 79

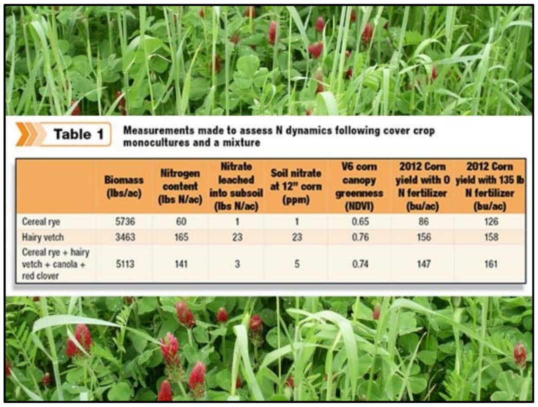


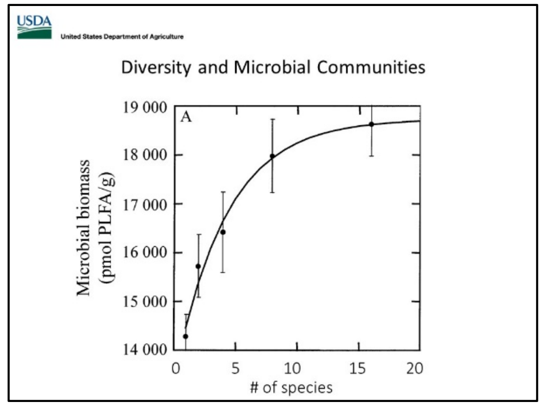
Table 1 Measurements made to assess N dynamics following cover crop monocultures and a mixture

	Biomass (lbs/ac)	Nitrogen content (lbs N/ac)	Nitrate leached into subsoil (lbs N/ac)	Soil nitrate at 12" corn (ppm)	V6 corn canopy greenness (NDVI)	2012 Corn yield with 0 N fertilizer (bu/ac)	2012 Corn yield with 135 lb N fertilizer (bu/ac)
Cereal rye	5736	60	1	1	0.65	86	126
Hairy vetch	3463	165	23	23	0.76	156	158
Cereal rye + hairy vetch + canola + red clover	5113	141	3	5	0.74	147	161

Slide 79

Slide 80

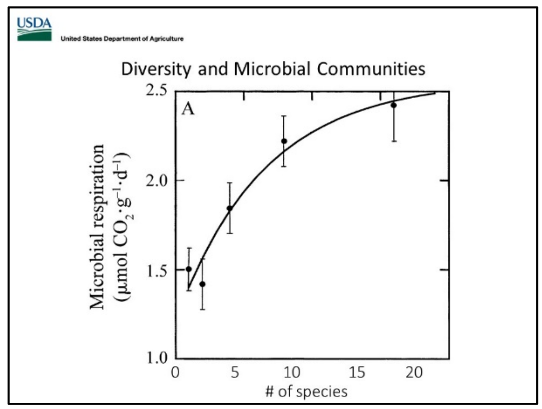
This slide indicates that as plant diversity increase so does the amount of microbial biomass in the soil as measured using the PLFA assessment.



Slide 80

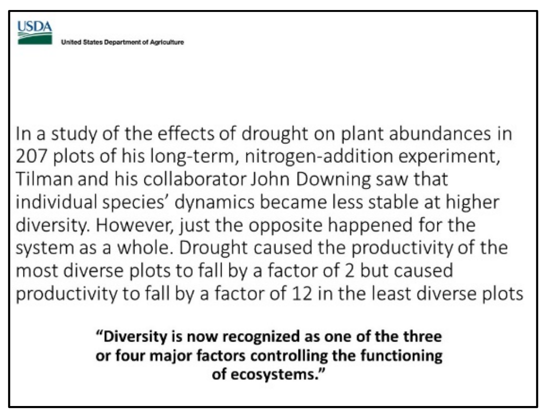
Slide 81

This slide look at the amount for microbial respiration, it increases as the number of plant species increases. Respiration is an indicator of activity, the more respiration the more biological activity taking place (e.g. increase nutrient cycling).



Slide 81

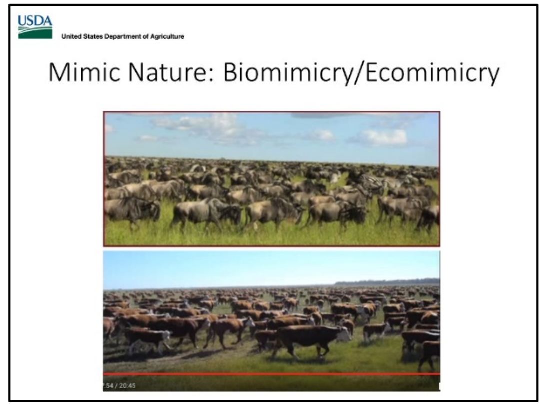
Slide 82



Slide 82

Slide 83

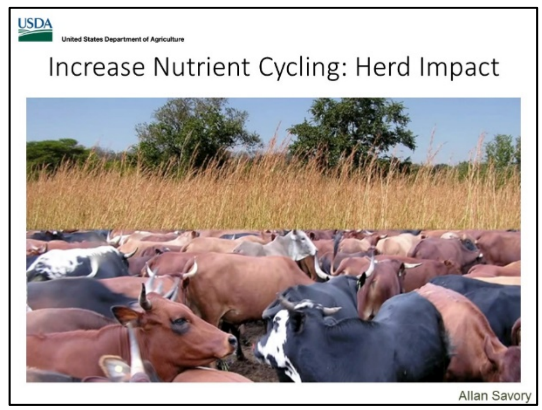
The great prairie soils of the world were developed with herd/livestock interaction. The animals moved in dense herds for protection from predators. They left behind dung and urine and kept moving. This will be discussed further in a later session.



Slide 83

Slide 84

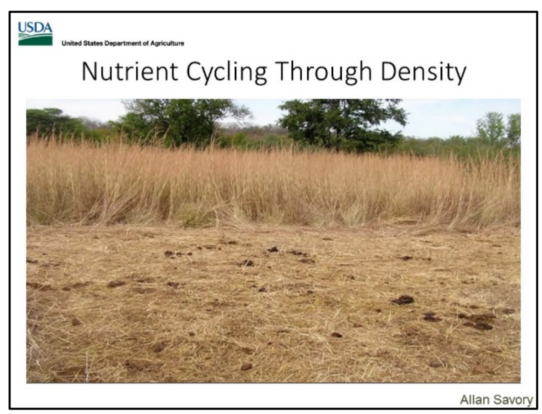
Depending on the agenda and location it may be good to show Allan Savory's Ted Talk video.



Slide 84

Slide 85

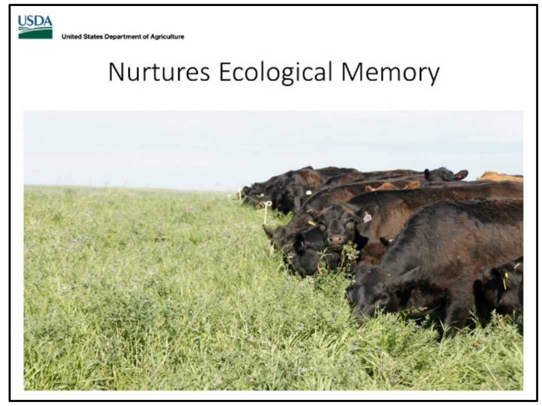
The animal rumen provides additional biodiversity with organisms designed to process the fiber.



Slide 85

Slide 86

It should be noted that management is key. Merely putting some livestock on the land doesn't assure success. We will discuss this in greater detail in later sessions.



Slide 86

Test their Knowledge - Questions for the audience

Soil health involves the __continued__ capacity of a soil to __function__ as a vital, __living ecosystem__ that sustains plants, animals, and humans.

The soil health principles are:

1. Minimize disturbance
2. Maximize soil cover
3. Maximize biodiversity
4. Maximize the presence of living roots

Q: Which soil health principles relate to protecting the habitat of soil organisms (aggregates and organic matter)?
A: Minimize disturbance and Maximize soil cover

Q: Which soil health principles relate to feeding diverse, continuous inputs to soil organisms (carbon sources and energy)?
A: Maximize biodiversity and Maximize the presence of living roots

The three types of agricultural disturbance include:

1. Physical (i.e. tillage)
2. Chemical (i.e. fertilizer)
3. Biological (i.e. overgrazing, pathogens, invasives)

Diversity in the soil ecosystem can be increased by using __crop rotations__ and __cover crops__.

Q: What does it mean that cover crops provide an "active protective blanket".
A: Cover crops not only protect the soil ecosystem (passive protective blanket) but they also provide food to this ecosystem.

Q: What is the concern with growing cover crops that together have either a high C/N ratio or a low C/N ratio?
A: Decomposition will be either too slow (high C/N ratio) or too fast (low C/N ratio). The ideal ratio is 24/1.

Up to a certain point, the greater the number of cover crop __species__ or __functional groups__, the greater the __site productivity__.

Q: What benefits to living roots provide?
A: They can (1) increase soil microbial activity, (2) increase plant nutrient recoverability, (3) increase biodiversity and biomass of soil organisms, (4) improve physical, chemical and biological properties of soils, (5) sequester nutrients, and (6) increase soil organic matter.

Soil Health Evaluation

Name of Activity: Soil health principles	Date of Activity:

A. Instruction	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1. The agent/specialist was well prepared.	①	②	③	④	⑤	⑥
2. The agent/specialist presented the subject matter clearly.	①	②	③	④	⑤	⑥

B. General Learning and Change	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1. I have a deeper understanding of the subject matter as a result of this session.	①	②	③	④	⑤	⑥
2. I have situations in which I can use what I have learned in this session.	①	②	③	④	⑤	⑥
3. I will change my practices based on what I learned from this session.	①	②	③	④	⑤	⑥

C. Specific Learning How much *did you / do you* know about these subjects?	*Before this program I knew...*					*Now I know....*				
	Very little	Little	Some	Much	Very Much	Very little	Little	Some	Much	Very Much
1. *Soil health principles*	①	②	③	④	⑤	①	②	③	④	⑤
2. Benefits that each soil health principle provides to the soil	①	②	③	④	⑤	①	②	③	④	⑤
3. Conservation practices related to each soil health principle	①	②	③	④	⑤	①	②	③	④	⑤
4. Cover crops	①	②	③	④	⑤	①	②	③	④	⑤

D. Specific Practices To what degree *did you / will you* do the following?	*Before this program I did...*					*In the future I will realistically do....*				
	Very little	Little	Some	Much	Very Much	Very little	Little	Some	Much	Very Much
1. *Measure different field indicators of soil health*	①	②	③	④	⑤	①	②	③	④	⑤
2. *Incorporate sustainable agricultural methods for soil health*	①	②	③	④	⑤	①	②	③	④	⑤
3. Seek additional NRCS information on financial and/or technical assistance for improving soil health	①	②	③	④	⑤	①	②	③	④	⑤

E. Satisfaction with Activity	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1. I would recommend this program to others.	①	②	③	④	⑤	⑥
2. As a result of this program, I am more likely to seek additional information from UT/TSU Extension.	①	②	③	④	⑤	⑥

F. Any suggested changes, additions, etc. to the curriculum?

Thank you for participating in this survey!