Payback Potential for Enhancing Soil Health- The Journey

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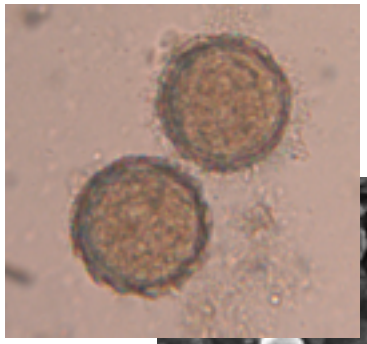
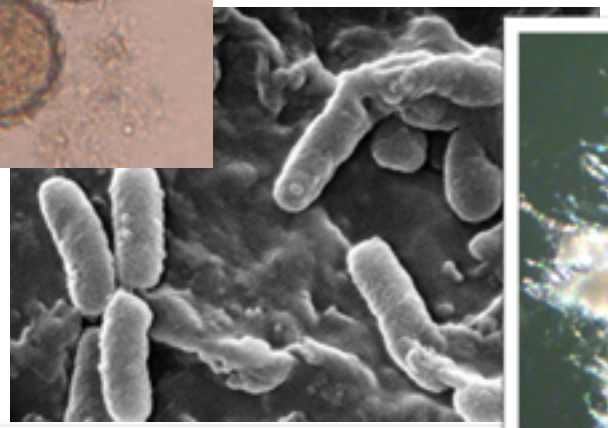
Ag Conservation Solutions

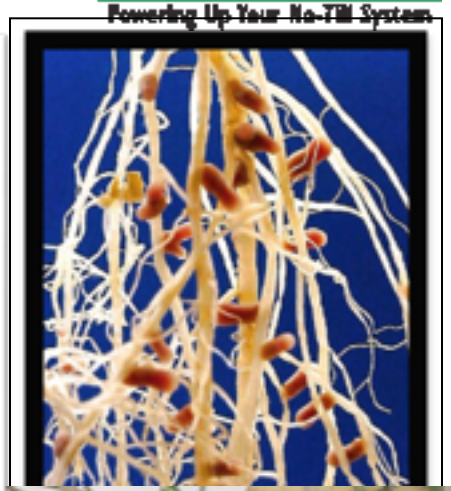
January 9, 2013

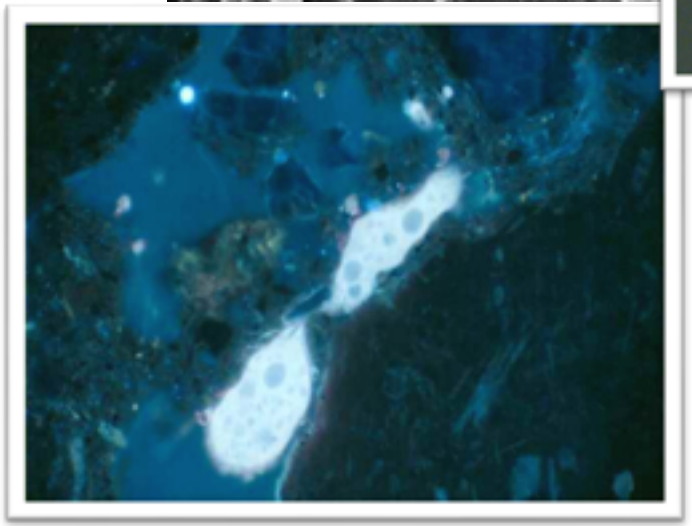
Signs of a Great Soil

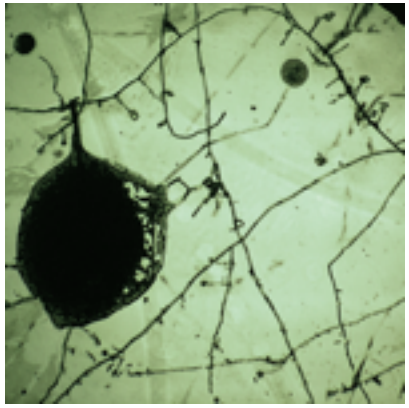
Microbes, etc











MICROBES in the Body

- They're Invisible
- They're Everywhere
- And they RULE!
- Microbes in your body can weigh as much or more than your brain
- Outnumber your own cells 10:1

Human Gut Bacteria

-Help digest food

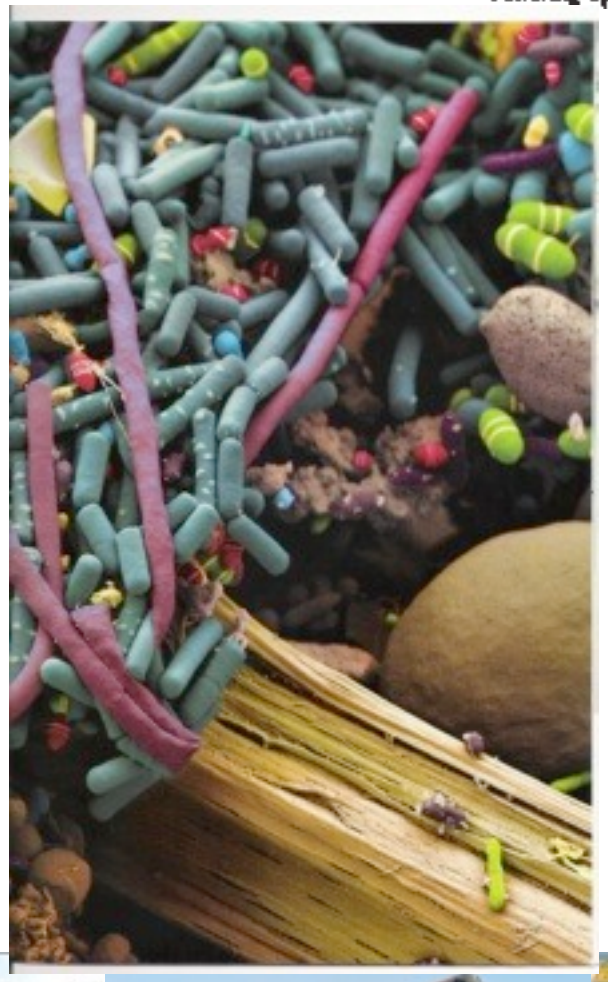
-Absorb nutrients

-Protect intestinal walls

-Help regulate weight

-Wards off autoimmune diseases

-most are either beneficial or unobtrusive freeloaders



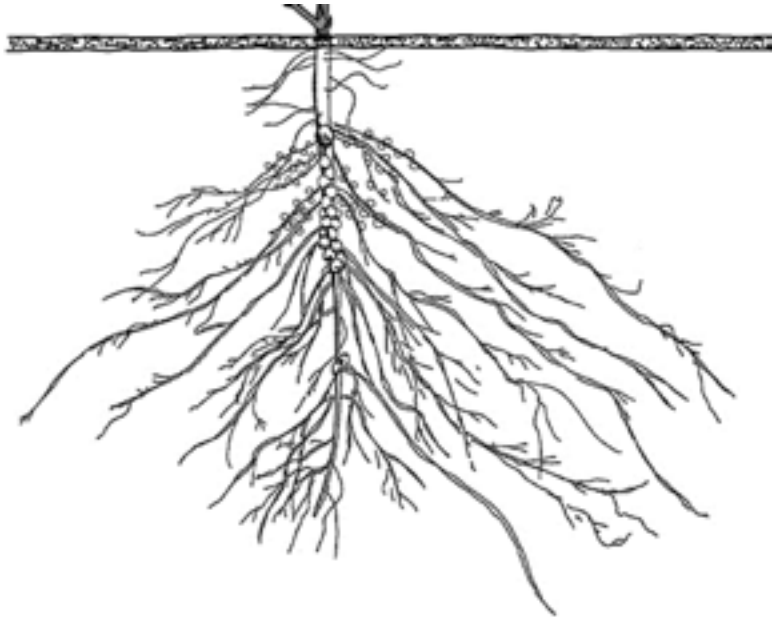
Microbes/Antibiotics

- Diarrhea from antibiotics – due to gut microbiota being disturbed
- Scientists are seeing the microbiota not as a collections of species but as a dynamic environment

Types of microbes in the soil

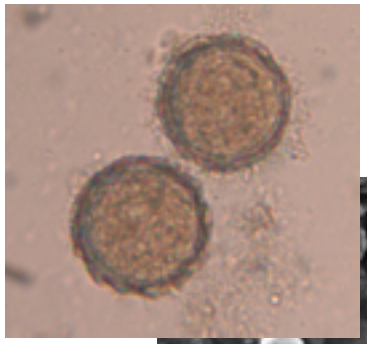
- Bacteria
- Algae
- Fungi
- Mycorrhizae
- Nematodes
- Macroarthropods
- Microarthropds
- Earthworms
- Protoza

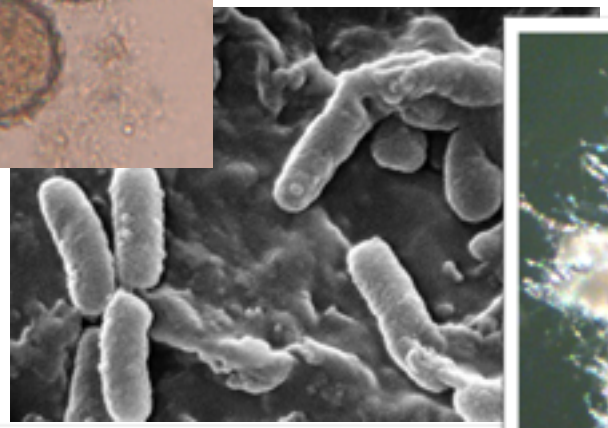
Plant Roots

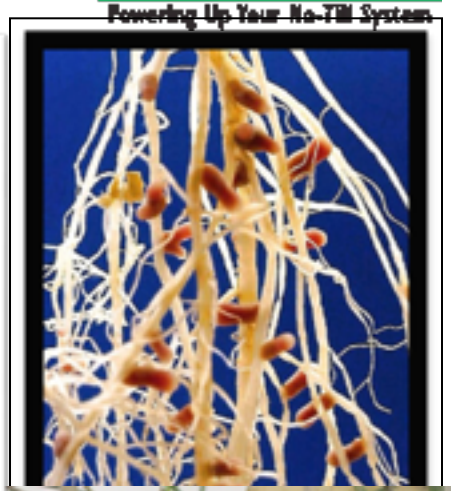


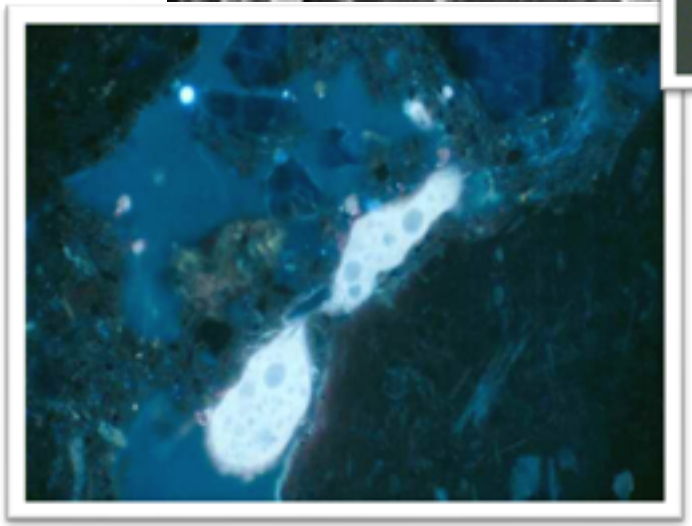
- Roots leak sugars to Mycorrhizae Fungi-
- Fungi bring additional water and nutrients for the plant

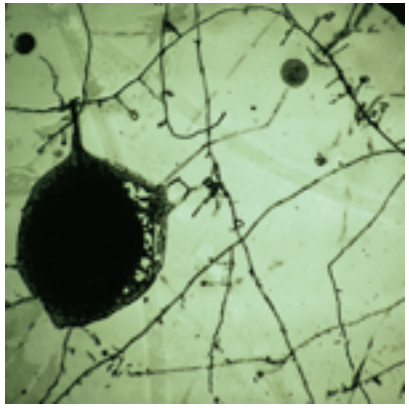
Soil Critters







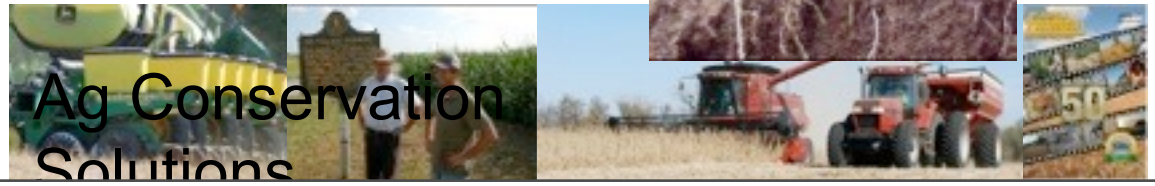




Carbon to Nitrogen ratio of Microbes

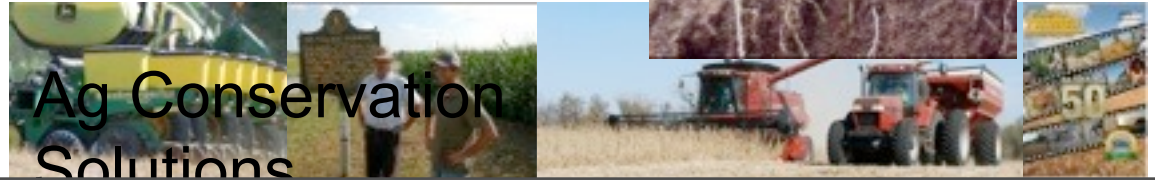
- Bacteria: 5:1 (20% Nitrogen)
- Fungus: 10:1 (10%Nitrogen)
- More nitrogen less carbon in Bacteria than in Fungus
- Reproduction Phase
- Bacteria: 30 minutes Fungus: ??
- Protozoa: 6 hours Nematodes: 2 years
- Where are the microbes located? 1,000 to 2,000 times more located next to the roots.

Soil Biology



Soil Biology

- ✓ **Mychorrhize fungi increase**
  - ✓ **Act as an extension of plant roots – improving nutrient and moisture uptake**



Soil Biology

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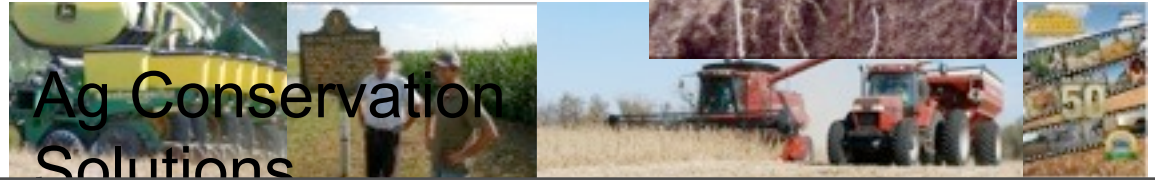

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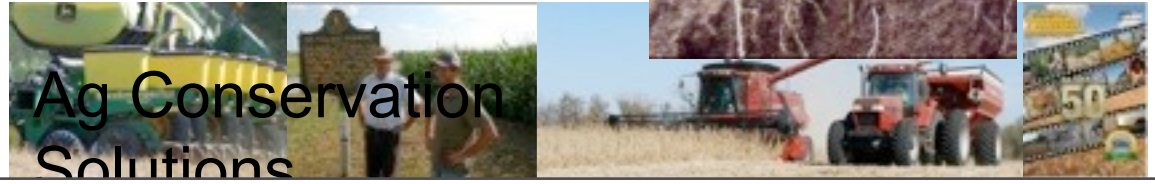
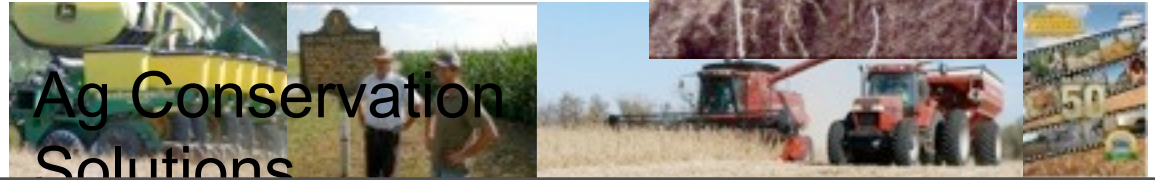


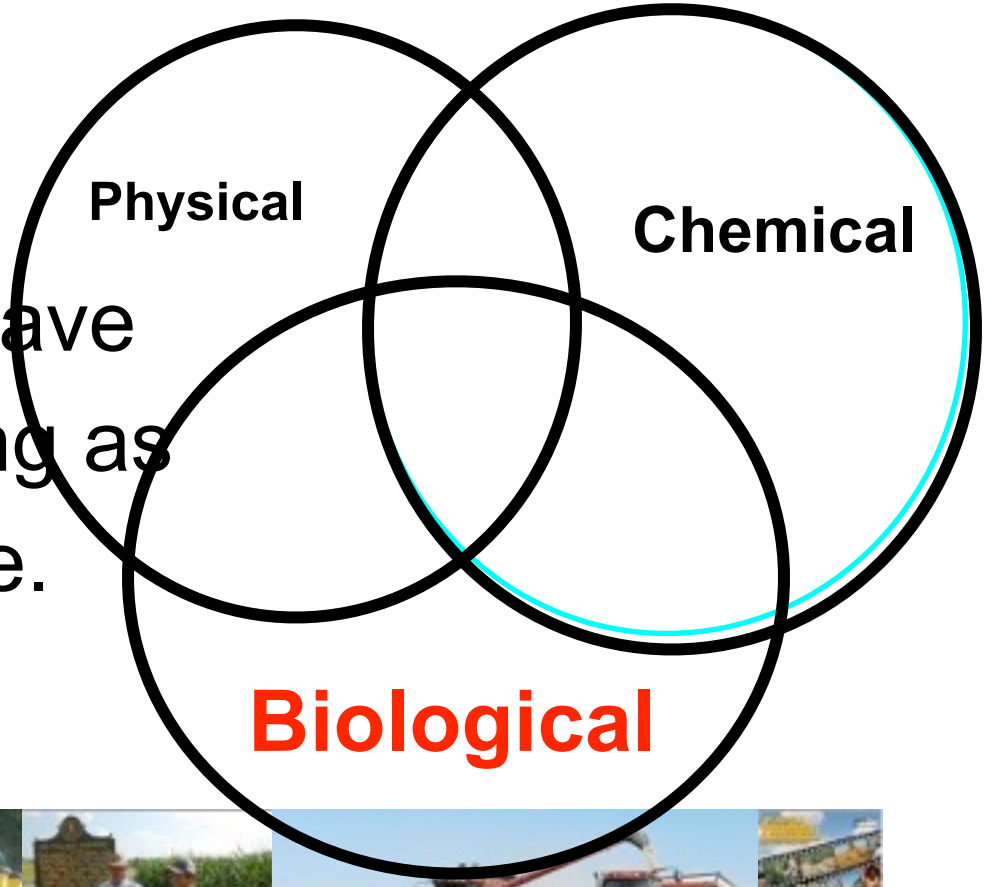
Soil Biology

- ✓ **Mychorrhize fungi increase**
  - ✓ **Act as an extension of plant roots – improving nutrient and moisture uptake**
- ✓ **May take several years for a population shift**
- ✓ **Fungi produce glomulin (like super glue)**
  - ✓ **Improves soil aggregation**



Soil Properties

- Physical
- Chemical
- **Biological**
- Soil is meant to have something growing as much as possible.



Improved Soil Health Systems

- **<u>Dynamic system</u>** – it changes over time
  - Primarily due to changes in **soil biology**.

So How Do We Get More Active Soil Biology?

- We manage it.
- We increase the numbers and diversity of the microbes.
- Let's use a scale of 1-100 regarding biological activity.

Poor Soil Structure

Biological rating - 10

Improved Soil Health Basics

Sustainable and Profitable Agriculture

1. **Minimal soil disturbance**

Improved Soil Health Basics

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2. **Permanent soil cover**

Improved Soil Health Basics

Sustainable and Profitable Agriculture

1. Minimal soil disturbance
2. Permanent soil cover
3. **Diverse crop rotation r cover crops**

Four Phases of Soil Health Improvement

- **Phase 1 – Initialization**

  -Soil structure starts to improve and microbial activity increases

  -Additional N may be required

Biological rating - 30

Four Phases of Soil Improvement

Phase 1 – Initialization

- **Phase 2 – Transition**

  -OM accumulates

  -Soil aggregation and soil microbial activity elevates

  - P accumulation, N immobilization and

Four Phases of Soil Improvement

Phase 1 – Stabilization

Phase 2 – Transition

Phase 3 – Consolidation

-Carbon accumulates and additional water is available in the soil

– N mineralization and immobilization

– >CEC and nutrient cycling

Four Phases of Soil Improvement

Phase 1 – Initialization

Phase 2 – Transition

Phase 3 – Consolidation

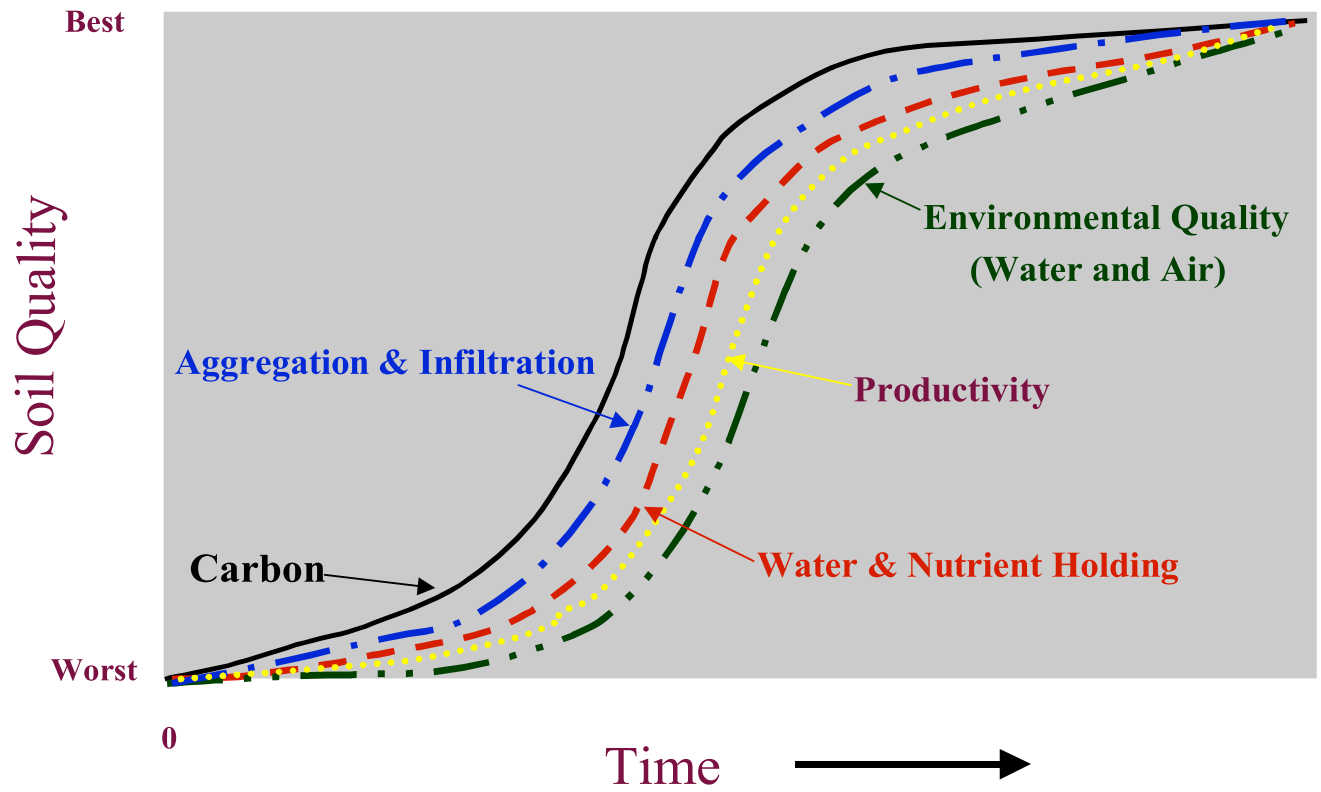
- **Phase 4 –Maintenance**

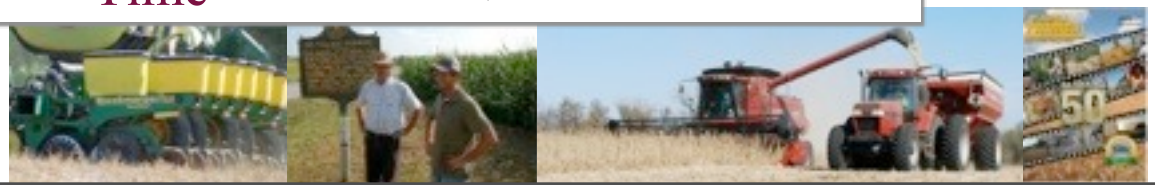
-Continuous flow of N and C

– Greater availability of water

– High nutrient cycling with increases in N

Clean Water and Air depend on Healthy Soil

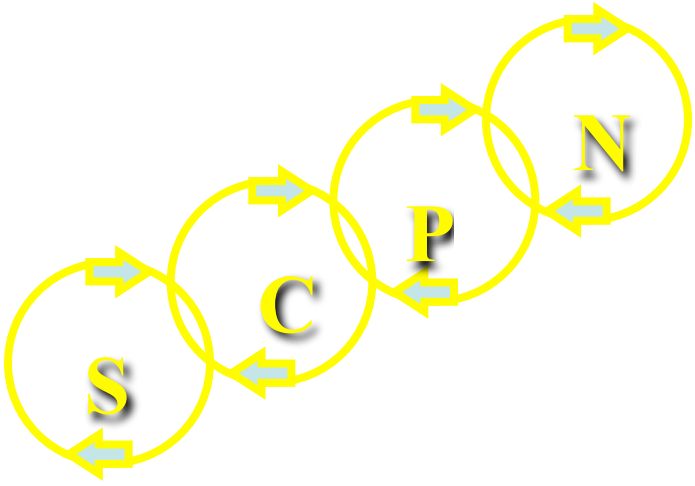




Roots are chiefly responsible for <u>increasing soil carbon</u>

Crop	Estimated Root Residue (lbs/ac)
• Native Prairie	15,000 - 30,000
• Annual ryegrass	2,600 - 4,500
• Cereal rye	1,500 - 2,600
• Red Clover	2,200 - 2,600
• Oats	1,300 - 1,800
• Corn	3,000 - 4,000

Nutrient Management



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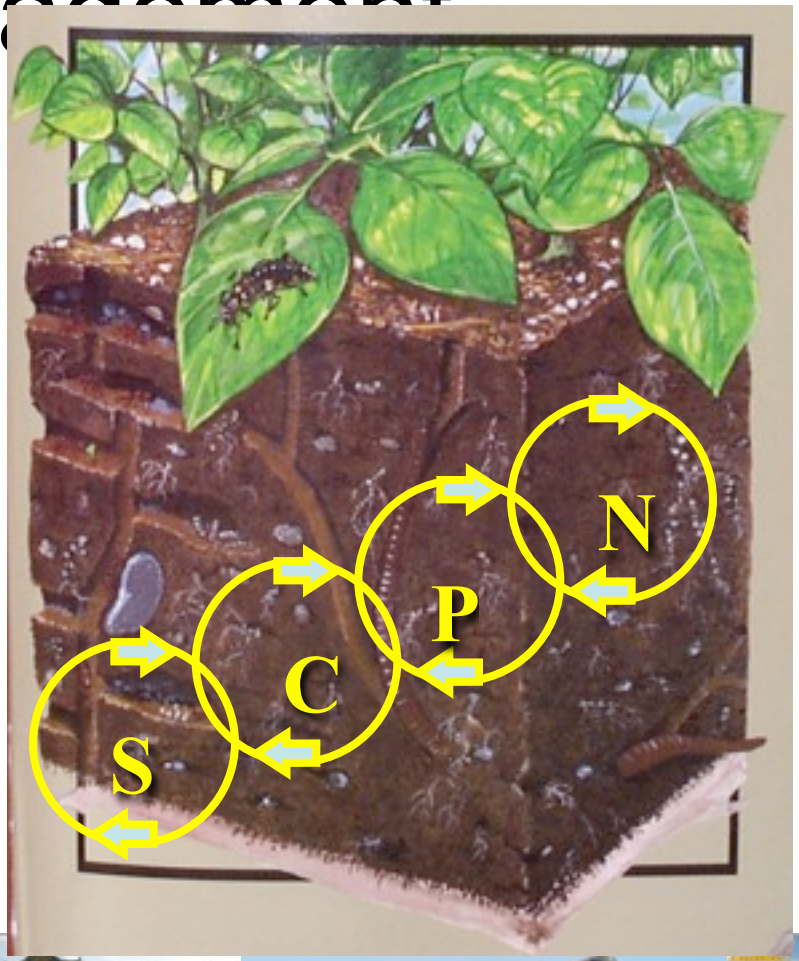
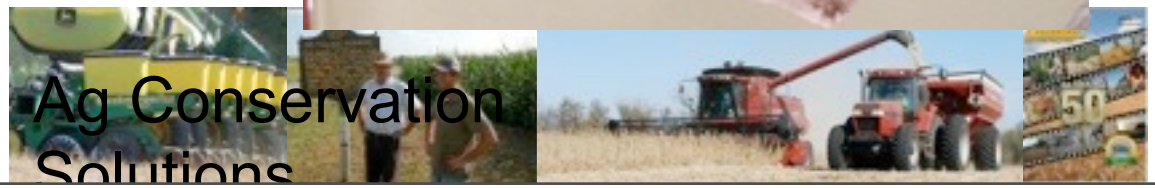
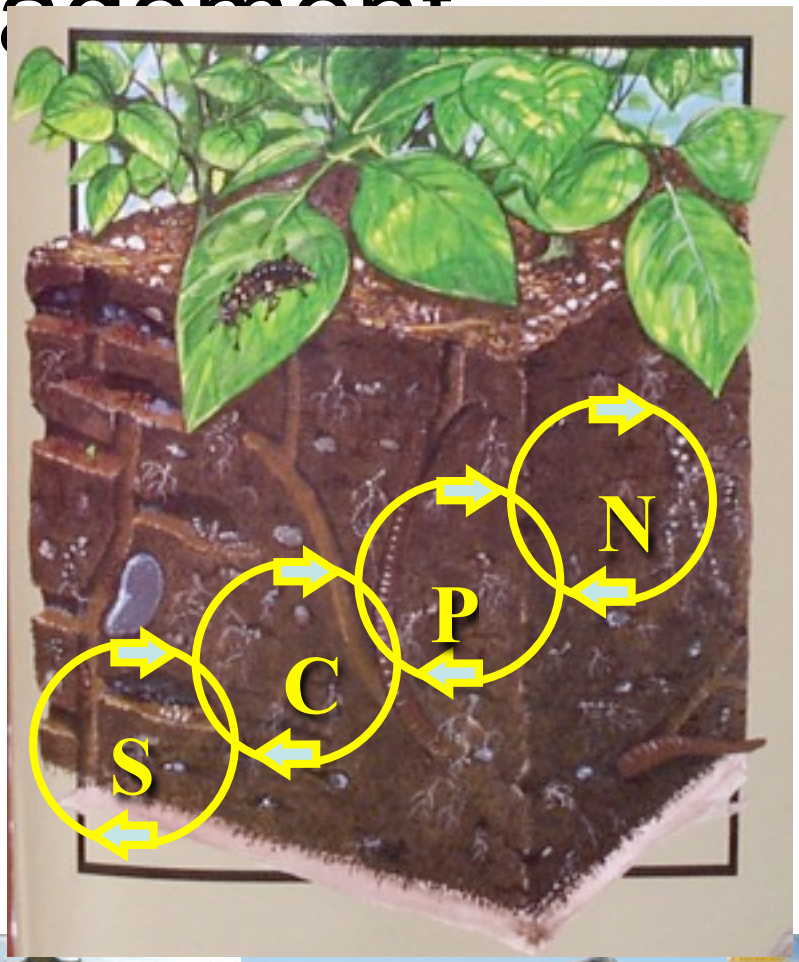
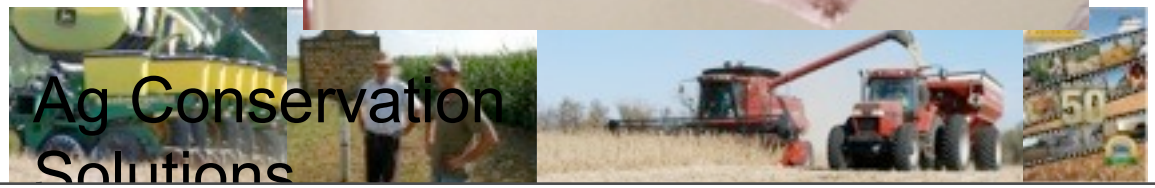




Nutrient Management

- ✓ C:N ratio is critical





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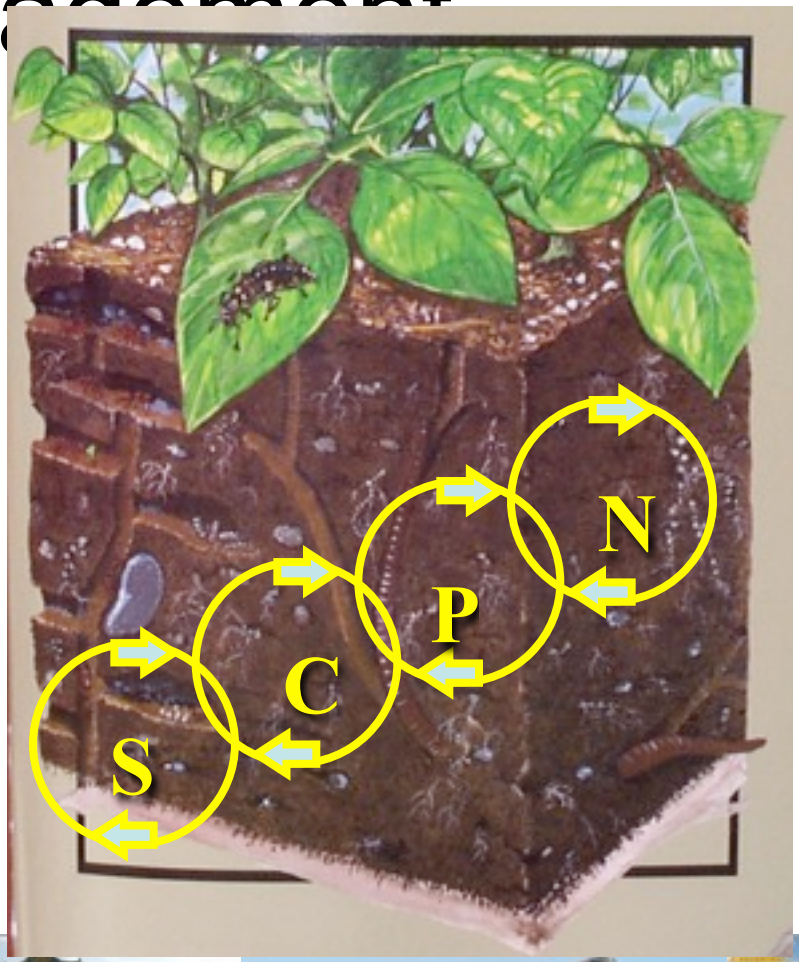
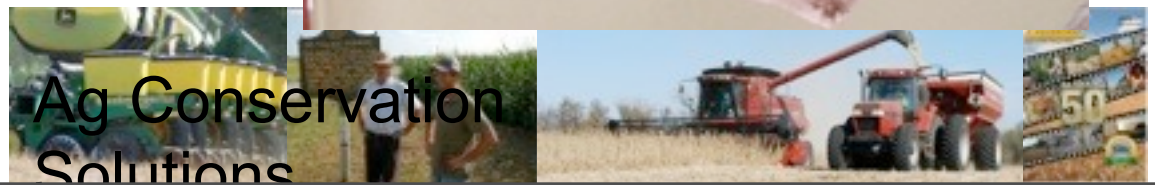
- ✓ One tillage pass may release 40 lb/ac of N





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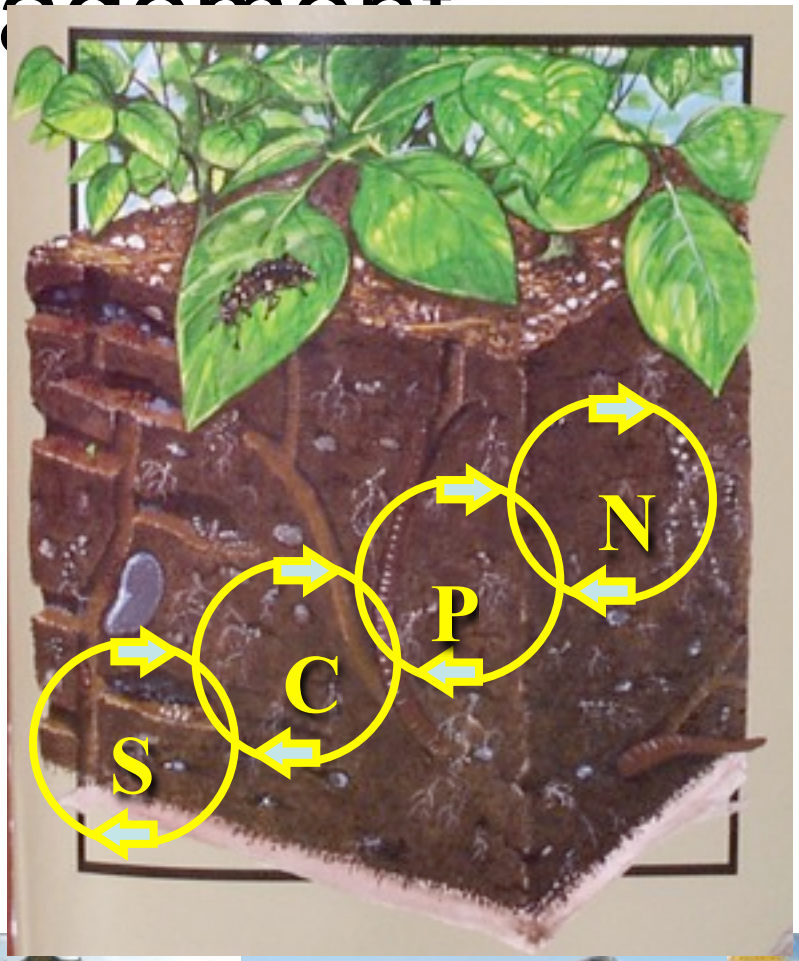

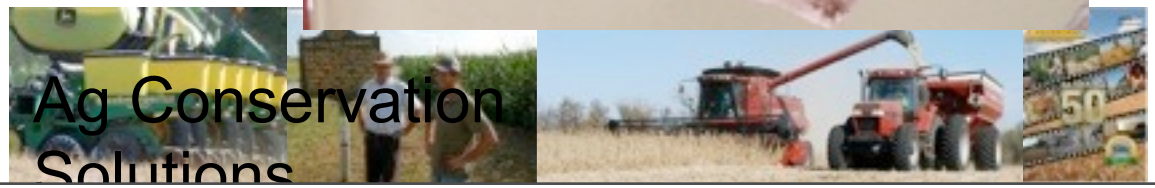

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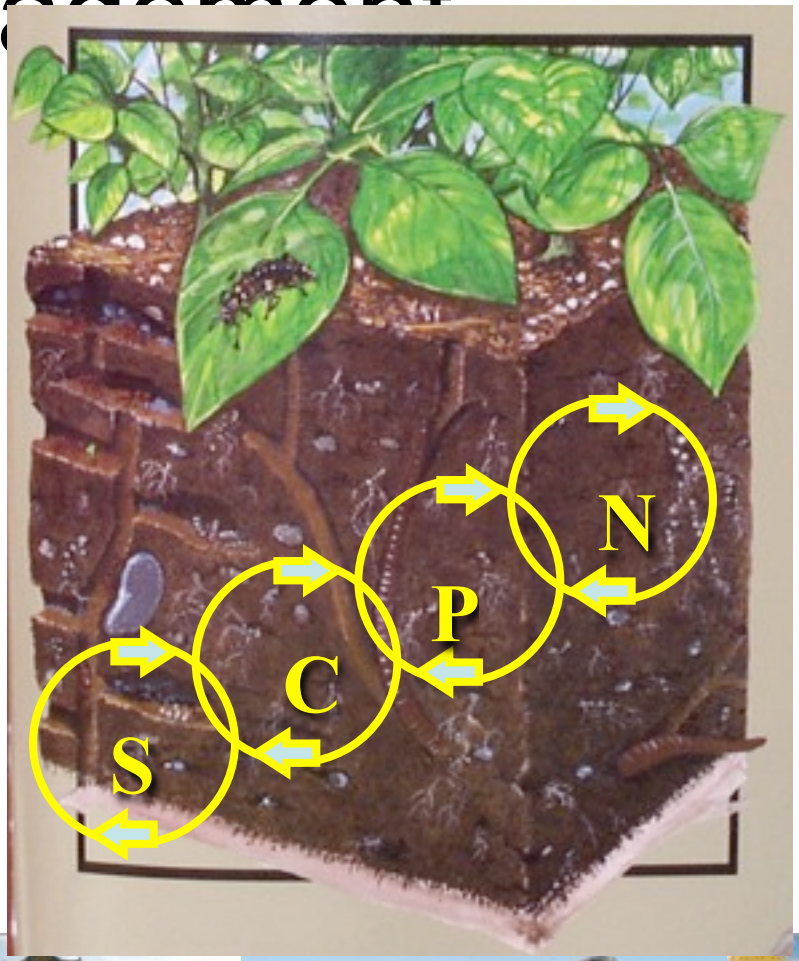

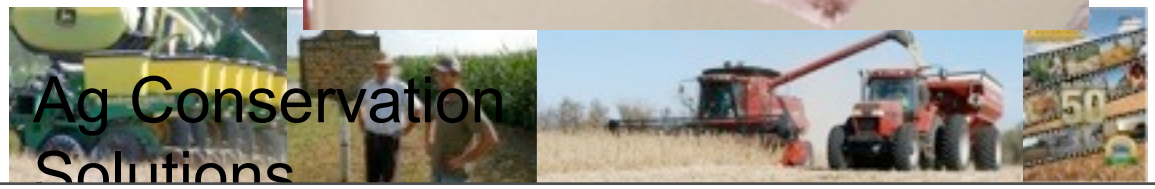

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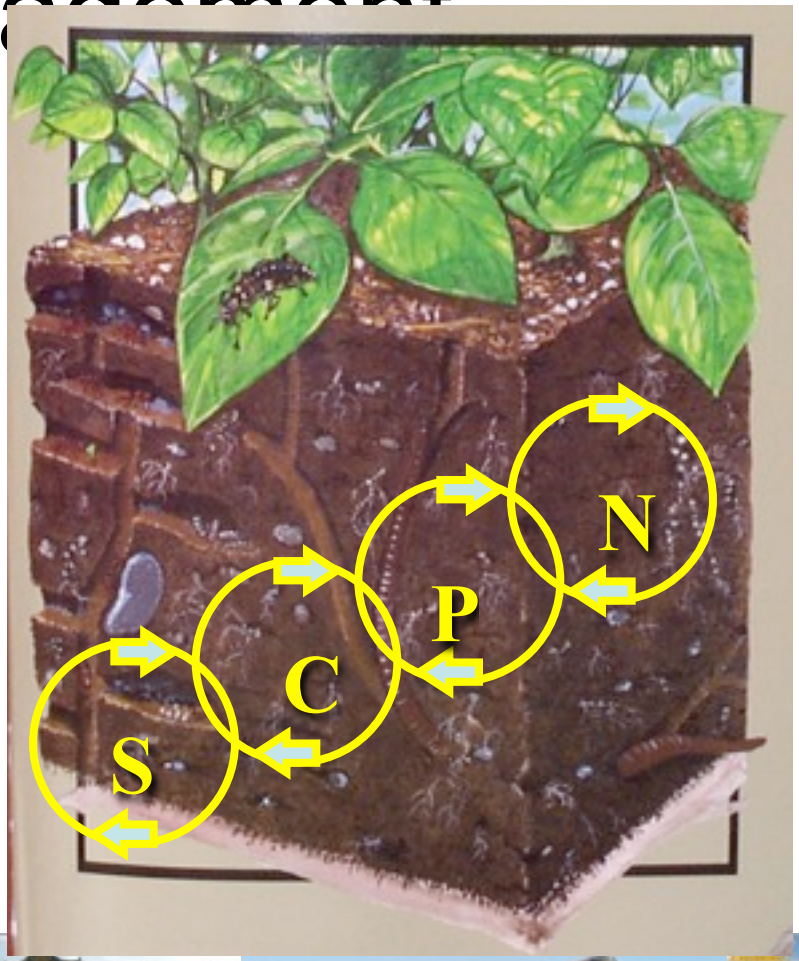

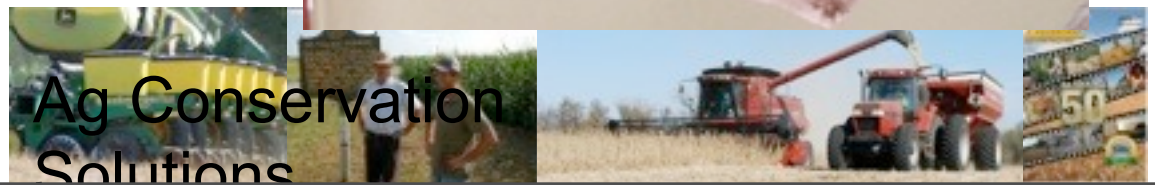

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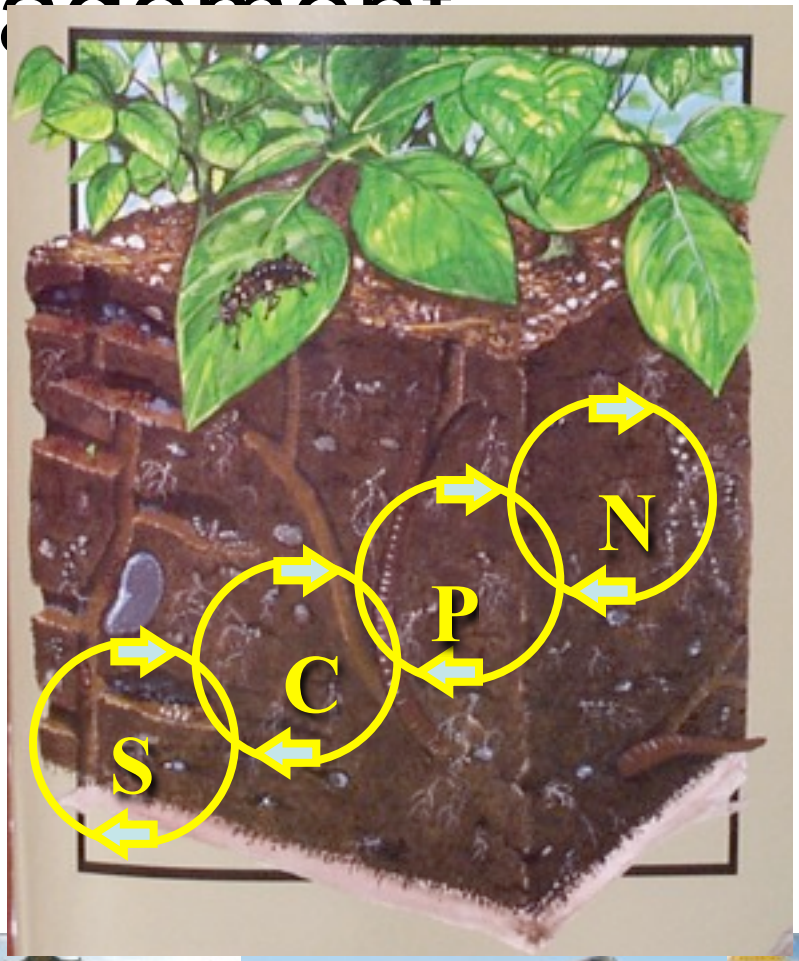
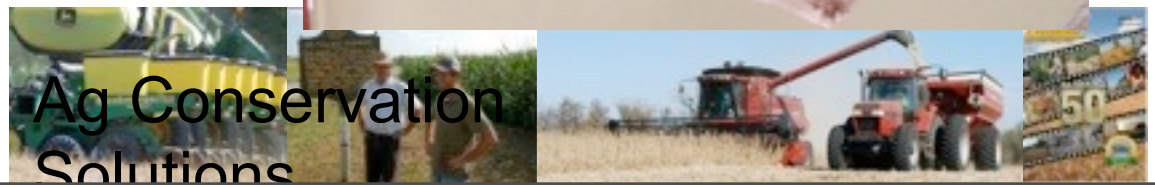
- ✓ Early years of no-till may need slightly more N to compensate for no tillage
- ✓ Sulfur addition
- ✓ Microbes may cause corn N shortage early in growing season





1% Organic Matter Contains

- 1,100 pounds of Nitrogen
- 116 ponds of Phosphate
- 105 pounds of Potash
- 145 pounds of Sulfur
- 6 tons of Carbon

4% Organic Matter

- 4,400 pounds of Nitrogen
- 464 ponds of Phosphate
- 420 pounds of Potash
- 580 pounds of Sulfur
- 24 tons of Carbon or 48,000 pounds

But How Much N is Available form Organic Matter?

- Typically about 2%
  - 1% OM – 1,110 lbs/ac or 22 lbs/ac
  - 4% OM – 4,400 lbs/ac or 88 lbs/ac
  - * The 2% is traditional text book under conventional tillage. The more active organic portion may be closer to 3% or 132 lbs/ac.

C:N Management

Early kill date most effective

- High nutrient content/ quickly decomposes
- Releases nutrients captured/ stored

Later kill date

- More cellulose produced
- Nutrient tie up/uses available Nitrogen

Common C:N Ratios of Cover Crops

Organic Material	C:N Ratio
Young rye plants	14:1
Rye at flowering	36:1
Rye stems (mature)	72:1
Annual Ryegrass	20:1
Hairy vetch	11:1
Crimson clover	15:1
Corn stalks	60:1

Nitrogen in Tops vs Roots

Crop	Tops	Roots	
		% N	%
N			
• Soybeans	93	7	
• Vetch	89	11	
• Cowpeas	84	16	
• Red Clover	68	32	

Average biomass yields and nitrogen yields of several legumes.

Cover Crop	Biomass tons/acre	Nitrogen* lbs/acre
Sweet Clover	1.75	120
Berseem Clover	1.10	70
Crimson Clover	1.40	100
Hairy Vetch	1.75	110

Biomass yield and nutrient accruement by selected cover

Crop	Biomass	N	K	P
Hairy Vetch	3,260	141	133	18
Crimson Clover	4,243	115	143	16
Rye	5,608	89	108	17
Austrian Winter Peas	4,114	144	159	19

Average biomass yields and

	Biomass tons/ac	N lbs/ac
• Annual ryegrass	1-3	40-100
• Cereal rye	2-4	30-100
• Crimson Clover	1.40	80-130
• Forage radish	1.50	70-120
• Hairy Vetch	1.75	80-160

- Ranges from 12 to 200 lbs/ac with 40-70%

Recycling of nutrients by

Nutrient	Concentration%	Content lbs/ac
• Nitrogen	1.89	250
• Potassium	3.27	230
• Sulfur	0.81	60

C:N Ratio Management

- Immobilization - Early spring N is tied up by microbes breaking down residue;
- Mineralization – Early summer microbes die and nitrogen is released

C:N Management

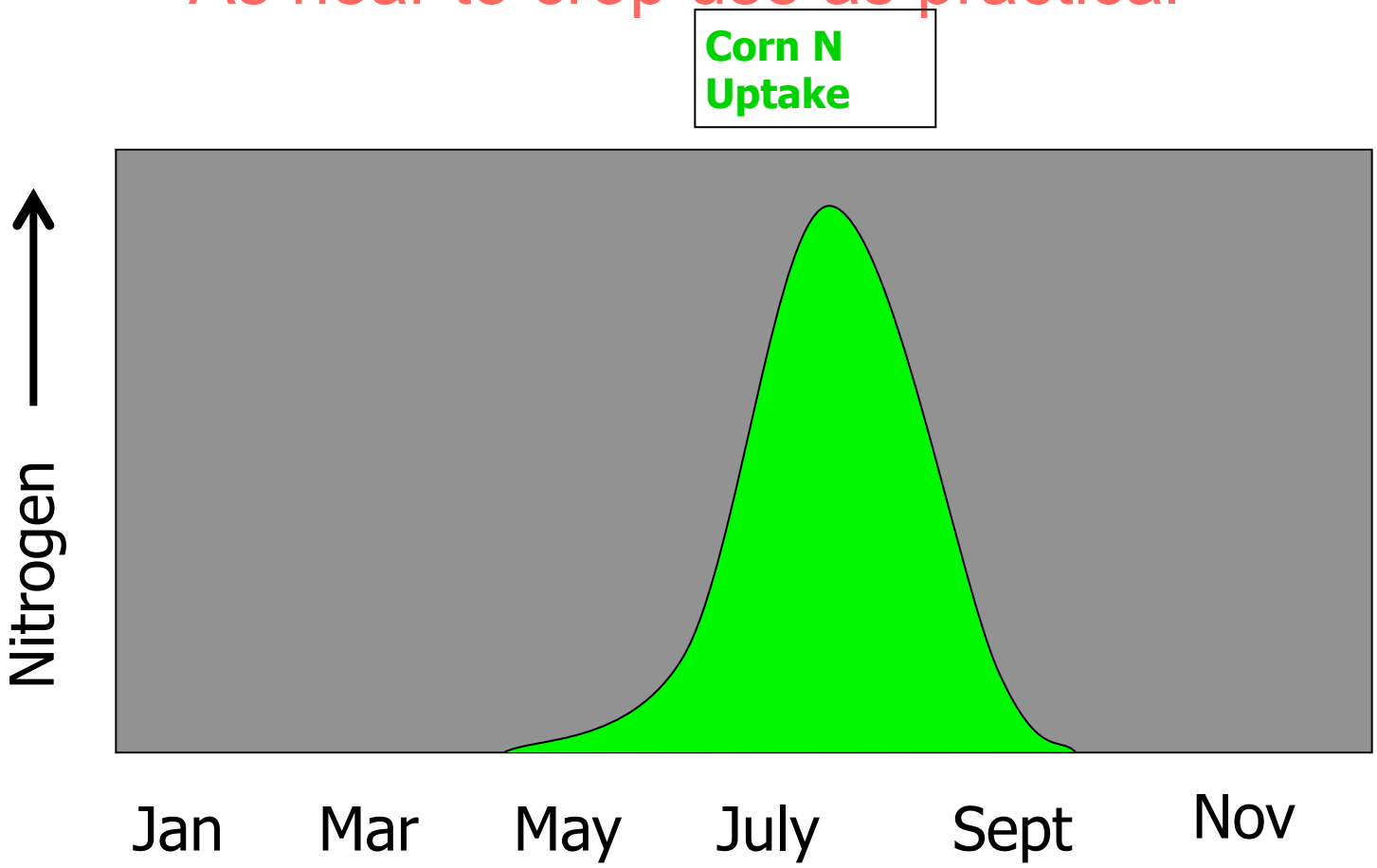
- Early Spring

C:N ratio < 30:1 – Nitrogen may be available to corn plant by July

C:N ration > 30:1 – Nitrogen will not be available until sometime after August

Timing of N Application

As near to crop use as practical



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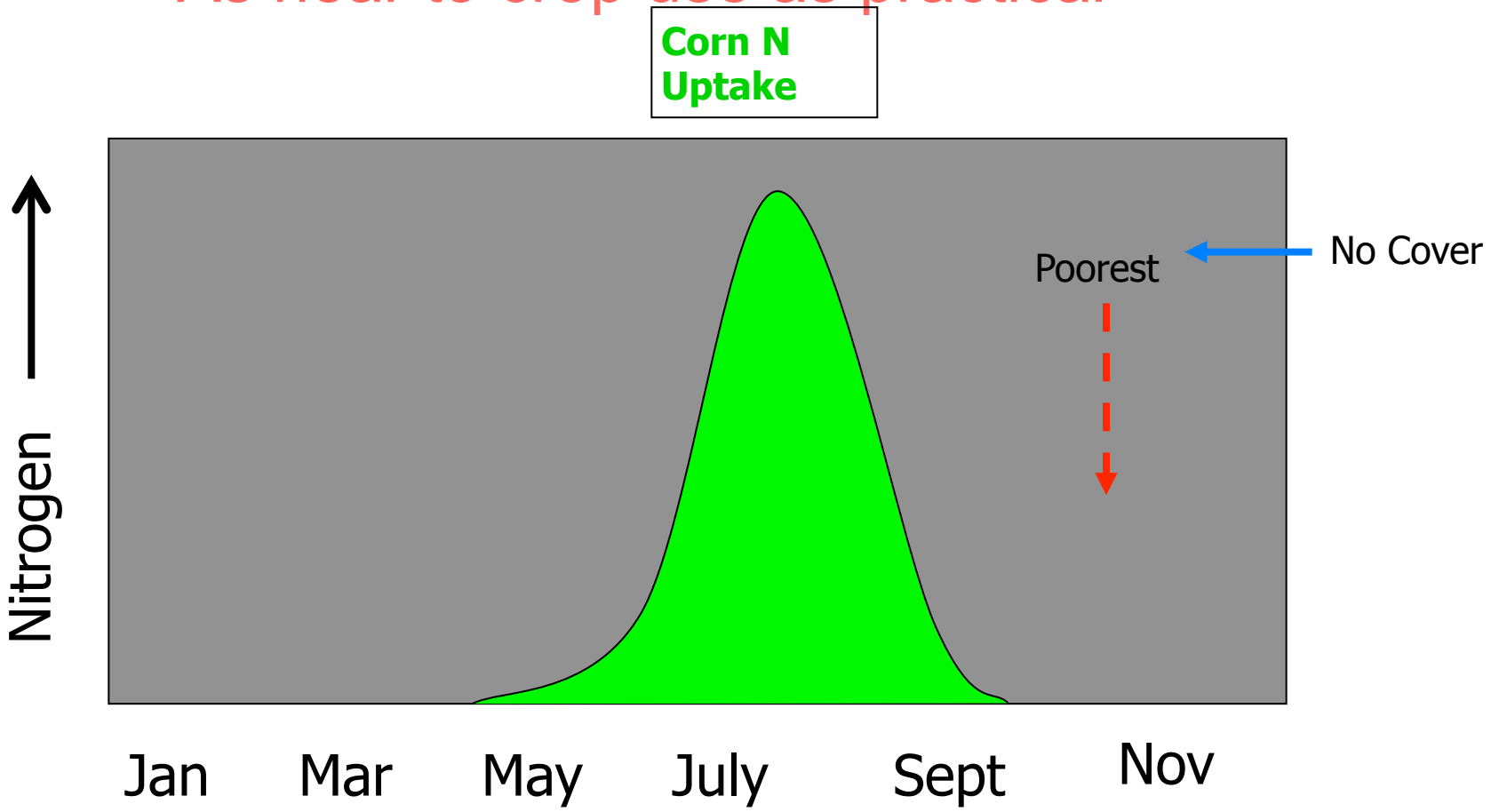

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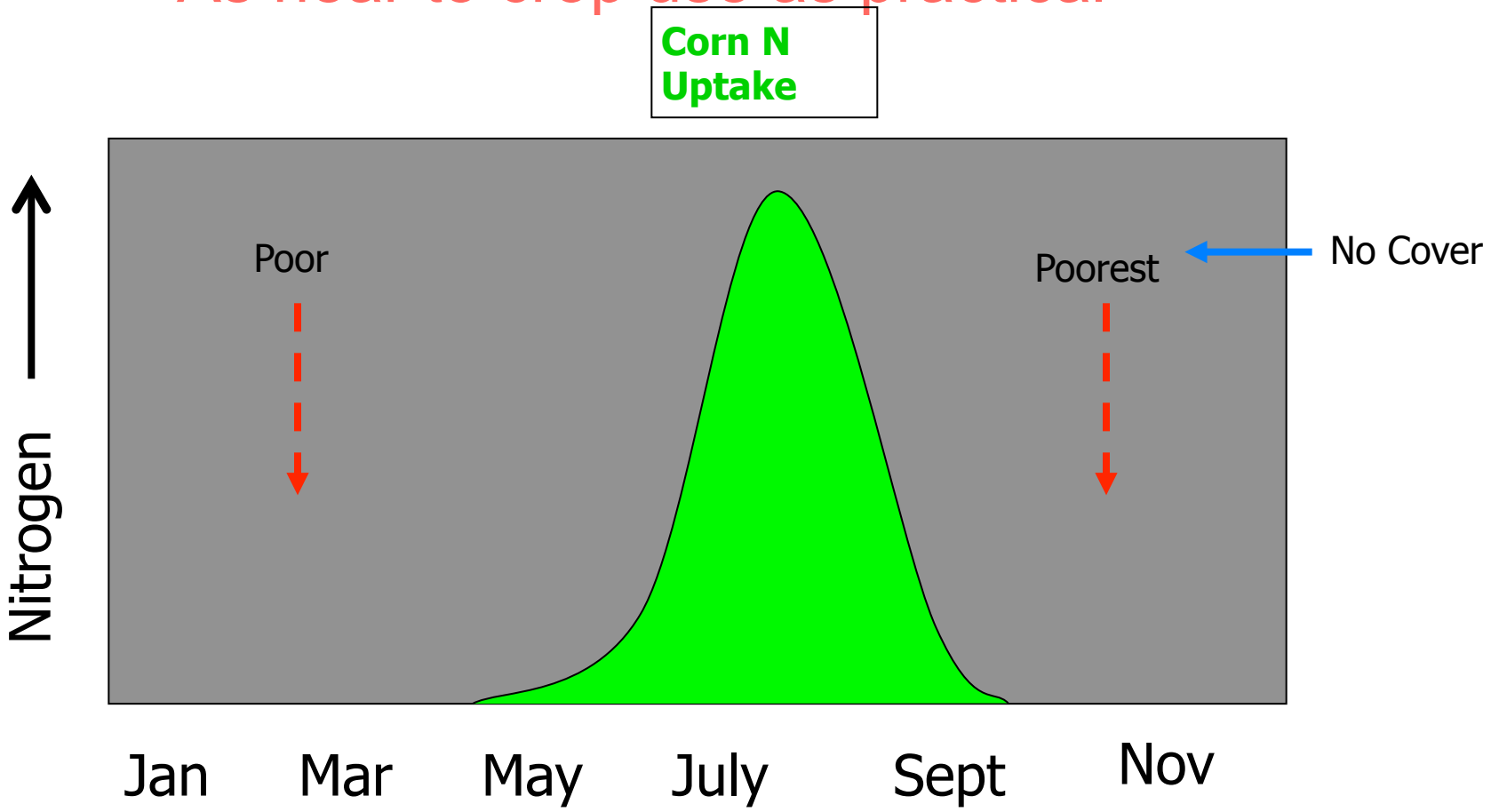

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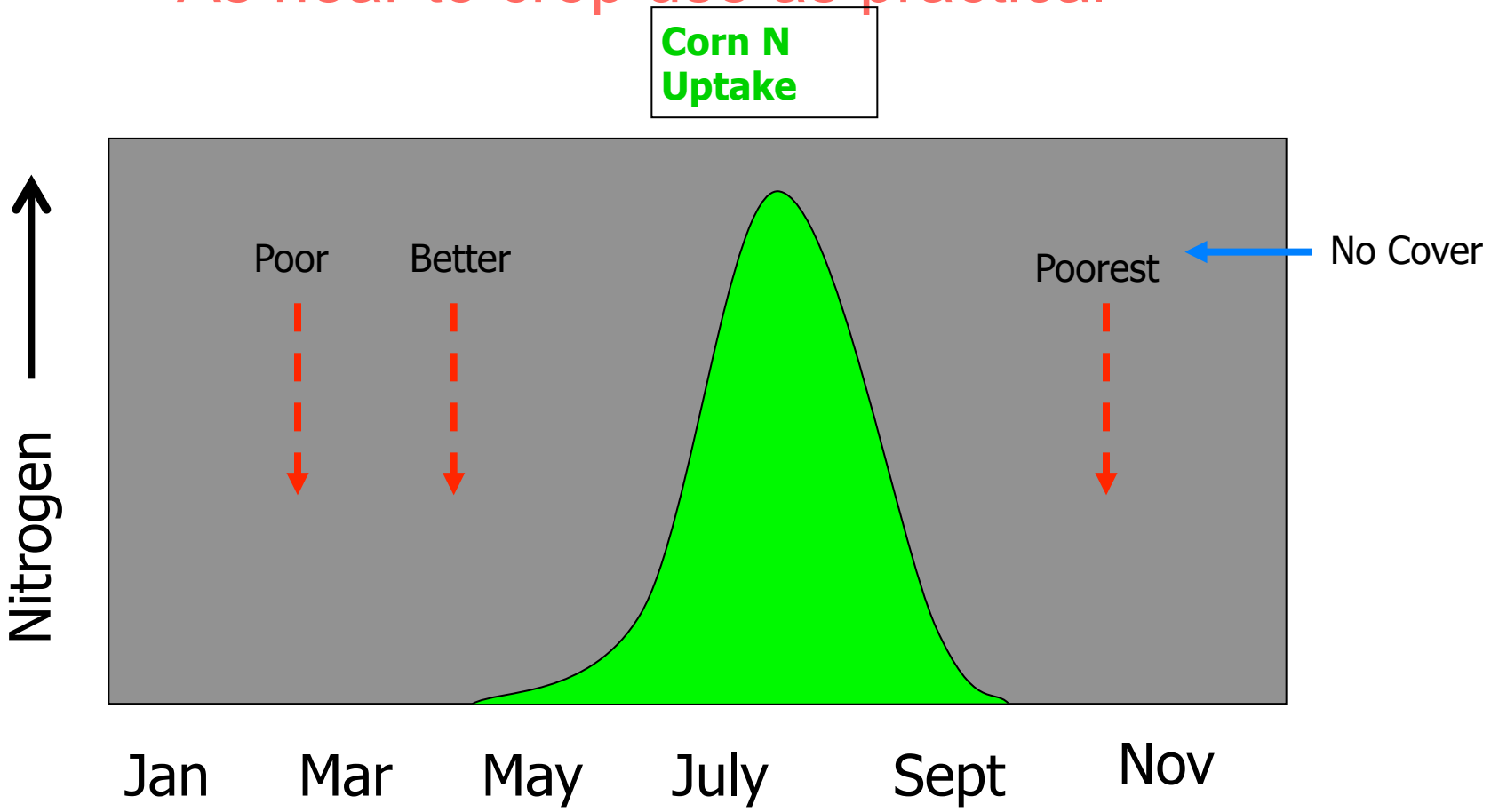

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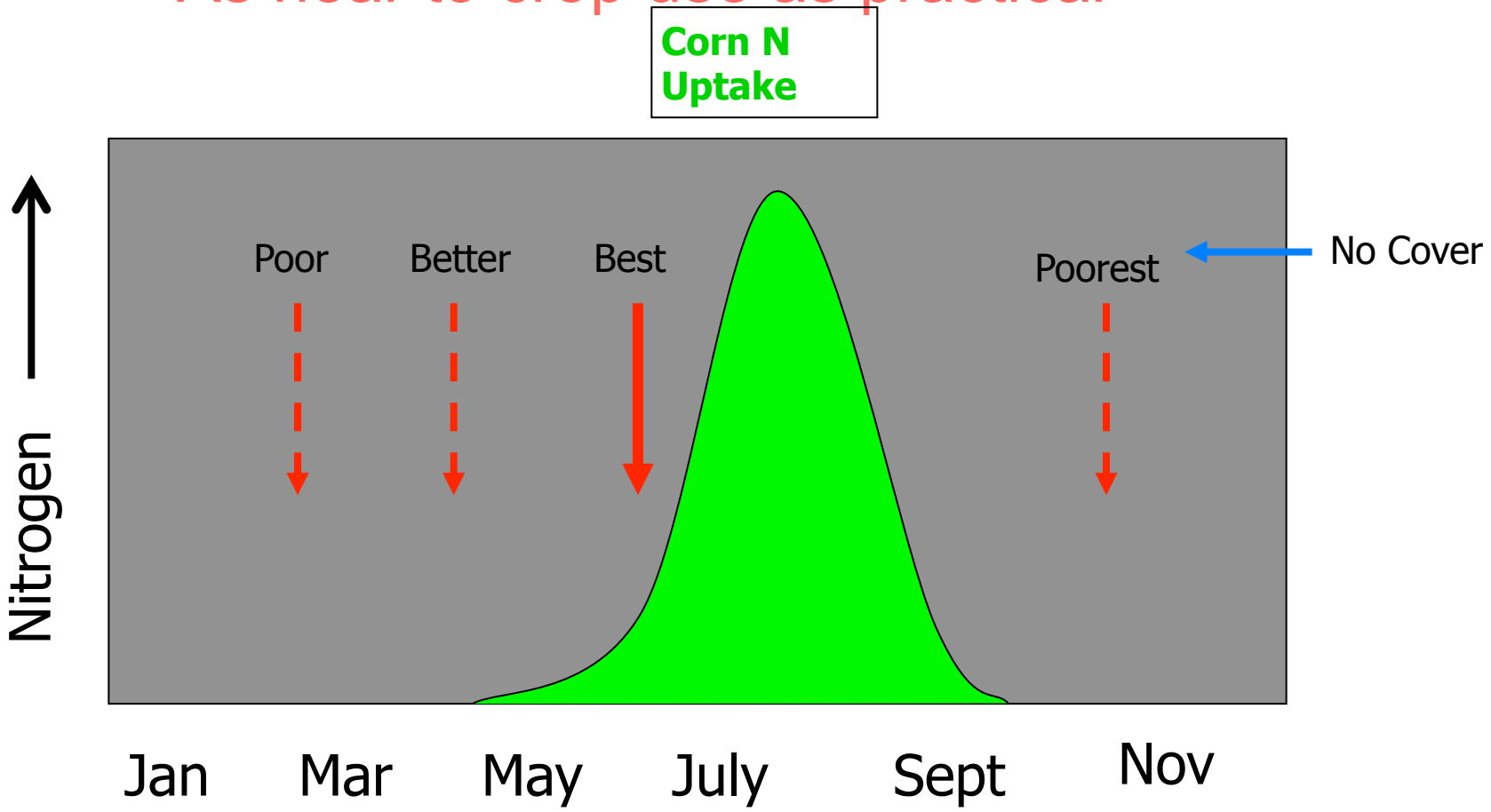

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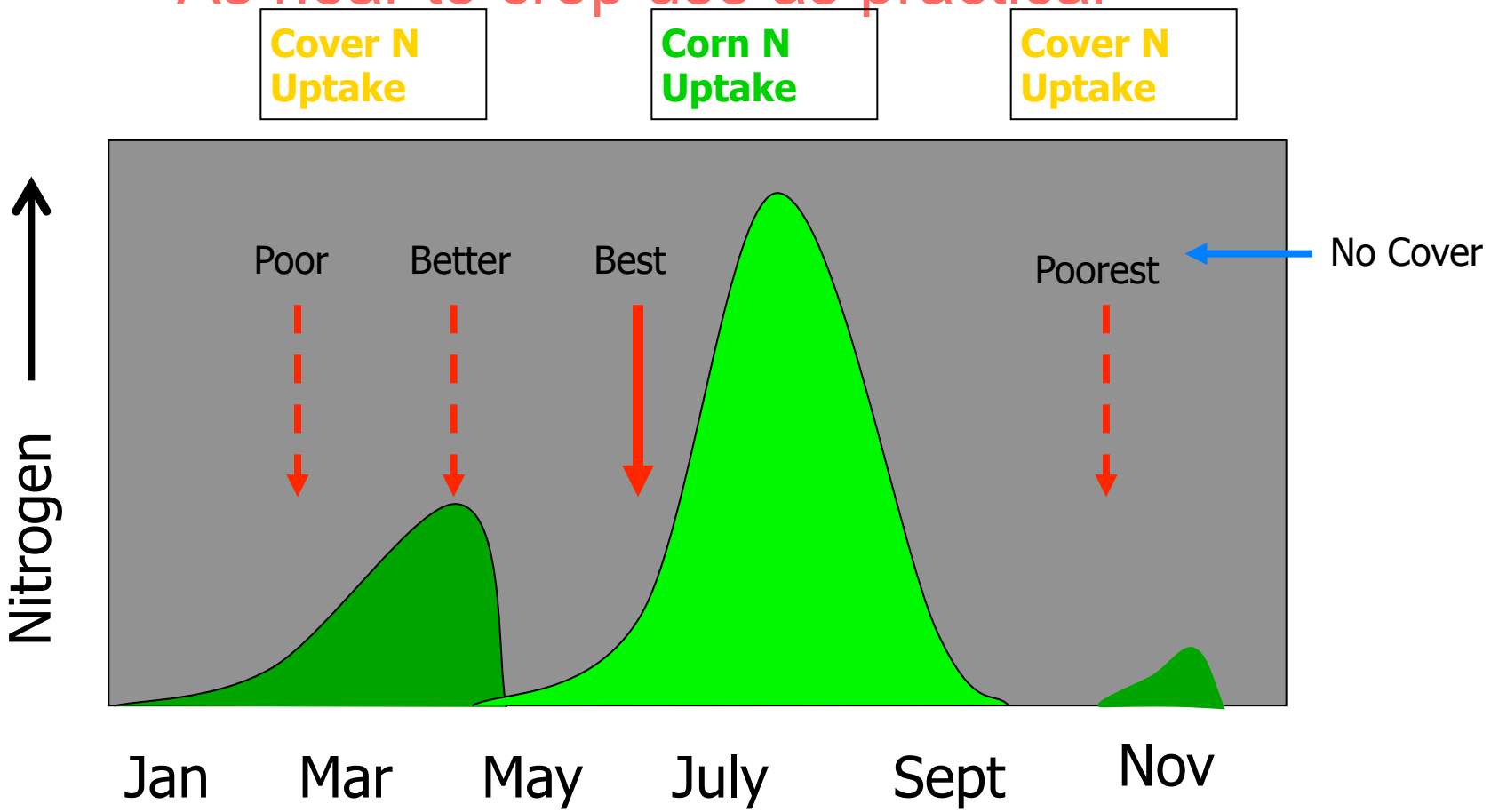

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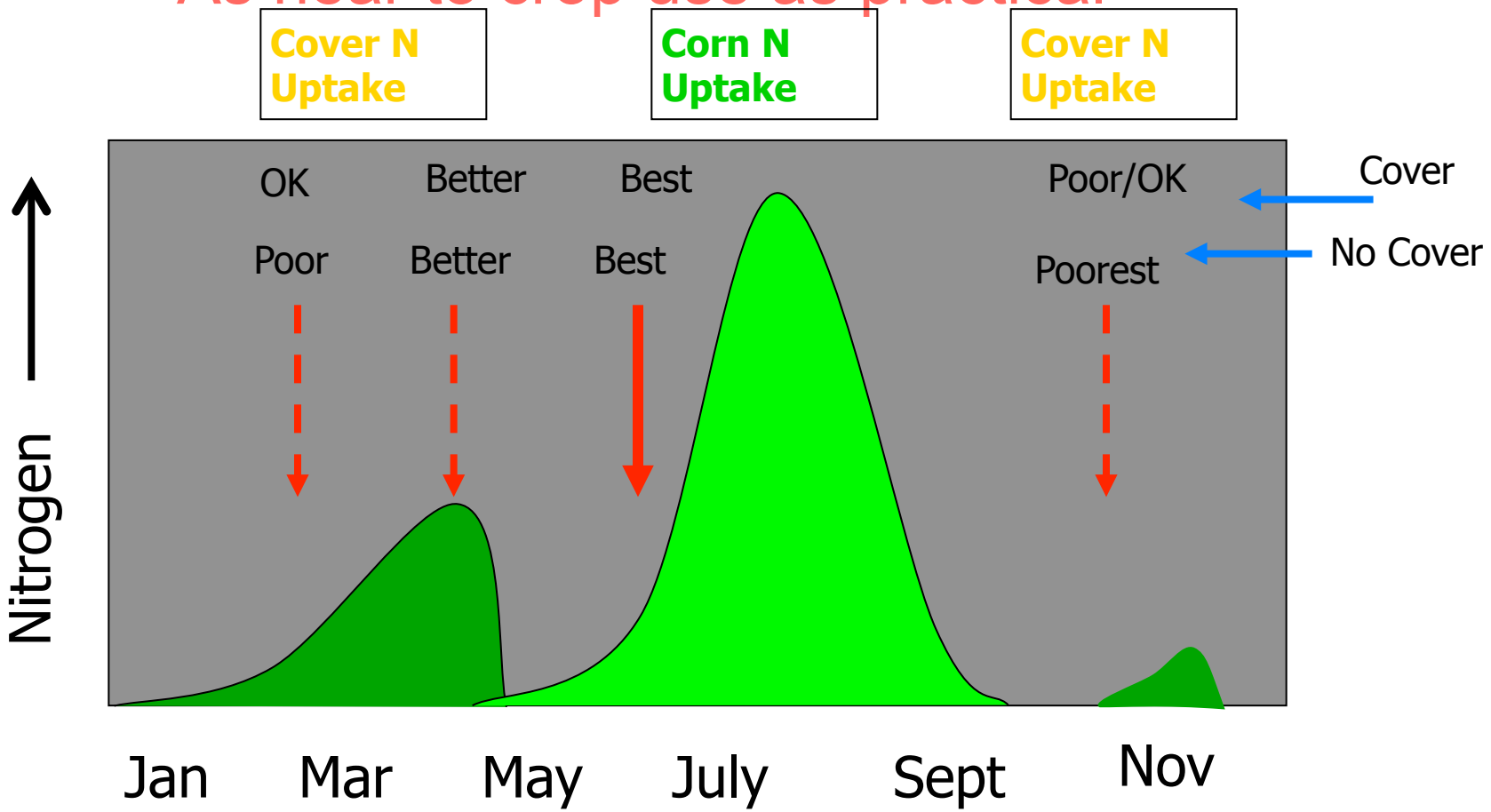


Cameron Mills example

- North Central Indiana – Logansport area
- Continuous no-till for 12 years and cover crops for 5 years

Cameron Mills – 2012

165 bu/ac with 170 lbs/ac of 28% sidedressed

- No cover crop N test
  - 0-12” – 60 lbs/ac
  - 12-24”- 56 lbs/ac
- Total **116 lbs/ac**

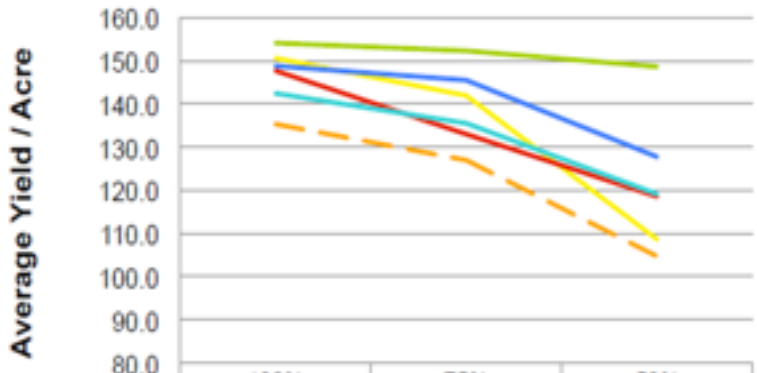
- Annual ryegrass flown on
  - 0-12” - 8 lbs/ac
  - 12-24”- 4 lbs/ac
- **Total 12 lbs/ac**
- Annual ryegrass biomass

  1350 lbs top & 1350 in roots (est)

  78 lbs/ac N & 100 lbs/ac K

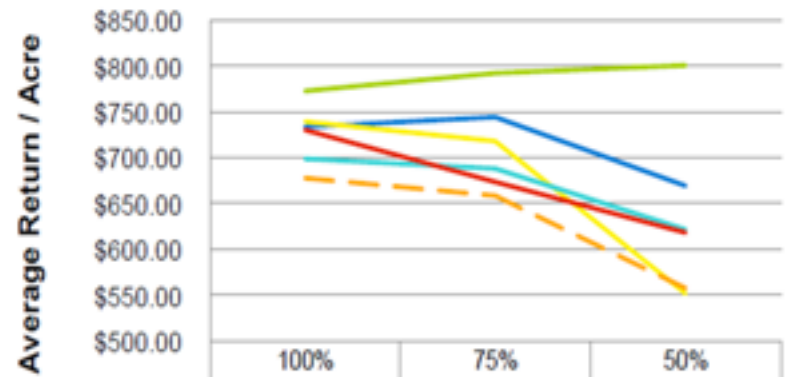
Beck's Central Illinois CC plots

2012 Corn After Cover Crop: Yield/A



	100% Nitrogen	75% Nitrogen	50% Nitrogen
RyeGrass	154.1	152.3	148.6
Corn Mix	150.6	141.9	108.6
SB Mix	148.8	145.5	127.7
Radish	147.7	133.0	118.5
Clover	142.4	135.5	119.1
No Cover Crop	135.3	126.9	104.7

2012 Corn After Cover Crop: Return/A



	100% Nitrogen	75% Nitrogen	50% Nitrogen
RyeGrass	$772.59	$792.12	$800.44
SB Mix	$733.32	$744.00	$669.13
Corn Mix	$739.14	$717.96	$551.64
Clover	$698.56	$688.00	$621.39
Radish	$730.03	$673.45	$618.05
No Cover Crop	$677.67	$658.26	$557.43

Economics

- Cover crop
  - Seed - $15 to $27/ac
  - Seeding -$12 to $18/ac - Total $27 to $45

  VS

  -Tillage cost of $12-$30/ac

Does It PAY??

- CNT and cover crops – 0.2%/yr increase in organic matter;
- 5 years – 1% increase;
- 10 years – 2% increase
- Following changes may occur:

  -N mineralization rate

  -Moisture holding capacity

Does It Pay??

- Better yields, especially in years with extreme weather events and on soils with low organic matter
- Less fertilizer inputs
- Less ponding,
- Less loss of nutrients & improved cycling

Summary

- Understand dynamics of C:N ratio
- Field history will greatly influence N scavenging
- Growth of cover crop may vary widely and will affect results
- Dynamic system – understand it takes time to get your soil biology cranking!

Ultimate Sustainable System

- Continuous no-till - row crops
- Cover crops –keep something growing
- Grazing cattle – cheapest way to harvest forage and to add fertilizer
  - Manure application – alternative to grazing cattle

- Dan Towery

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