Trash, Residue or Nutrients in Limbo

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History

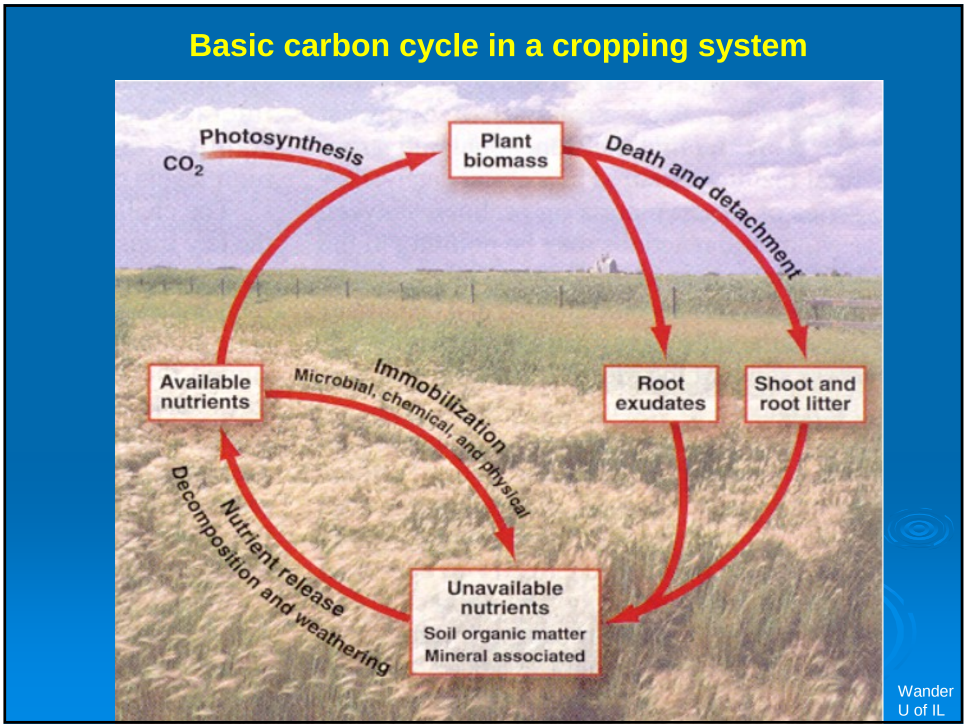
- Crop residue was considered trash
- Tillage must cover all residue
- New research in 70's showed benefits
- Reduced tillage adopted
- No-till increasing

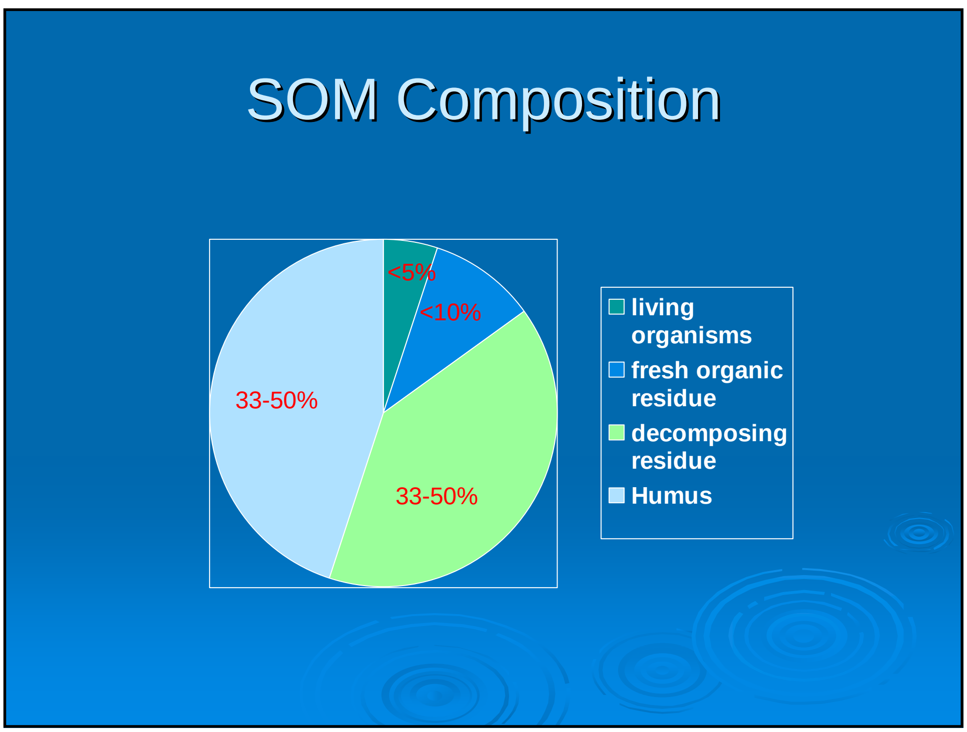
Soil Organic Matter

- Most Midwest soils 3% to 10% originally
- Major reductions with agriculture
- Many soils now 1% to 5%

Soil Composition

Organic Matter (<1% to 10%)
Air (25%)
Water (25%)
Mineral Matter (45%)


Basic carbon cycle in a cropping system
Photosynthesis
CO_2
Plant biomass
Death and detachment
Root exudates
Shoot and root litter
Available nutrients
Immobilization
Microbial, chemical, and physical
Nutrient release
Decomposition and weathering
Unavailable nutrients
Soil organic matter
Mineral associated
Wander
U of IL


SOM Composition
<5%
<10%
33-50%
33-50%
living organisms
fresh organic residue
decomposing residue
Humus

SOM Effects

- Stable aggregate structure
- Increased water infiltration/capacity
- Larger Nitrogen reserve
- Increased cation exchange capacity
- Increased availability of nutrients

Dynamic Pools & Fractions

- Living biomass
  - Mineralized C
  - Chloroform labile C
  - CFU, Direct counting
  - Root mass
- Residues
  - above ground residue, POM, MOM, LF
- Labile or 'active' SOM
  - Fulvic acid, carbohydrates, LF, Loose POM
- Physically protected, passive or 'slow' SOM
  - Occluded POM, Maccroaggregates, Humic acid
- Mineral associated, recalcitrant, or 'stable' SOM
  - Humic acid, Humin

Soil Bacteria

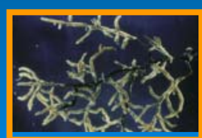
- Composed of 13 main groups
- Does decomposition of soft tissues
  - Sugars
  - Proteins
  - Pectins

Mutualists/Symbionts

Types
- Bacteria
- Fungi

Functions
- Enhance Plant Growth
  - Fix N_2
  - Mobilize P and H_2O
  - Immunization/ Resistance

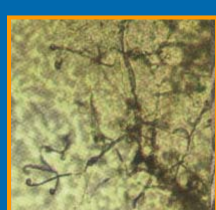
Soil Fungi



Decomposition of “intermediate tissues” (cellulose and hemicellulose)
Phosphorus movement

Byrd MSU

Soil Actinomycetes

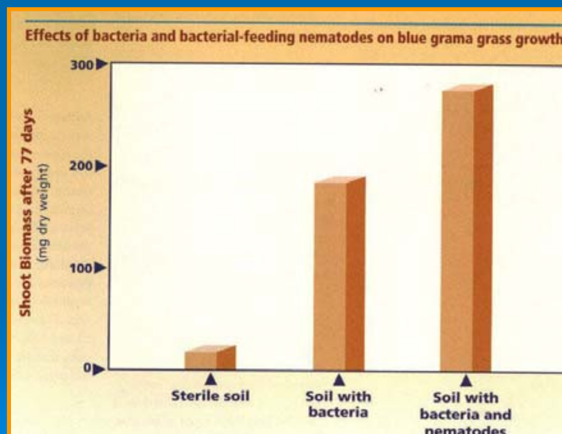


Actinomycetes (bacteria)

- -- Responsible for soil odor
- -- Decomposition of “tough tissues” (lignin).
- -- Antibiotic producers

Byrd MSU

Bacterial Feeding Nematodes Increase Productivity

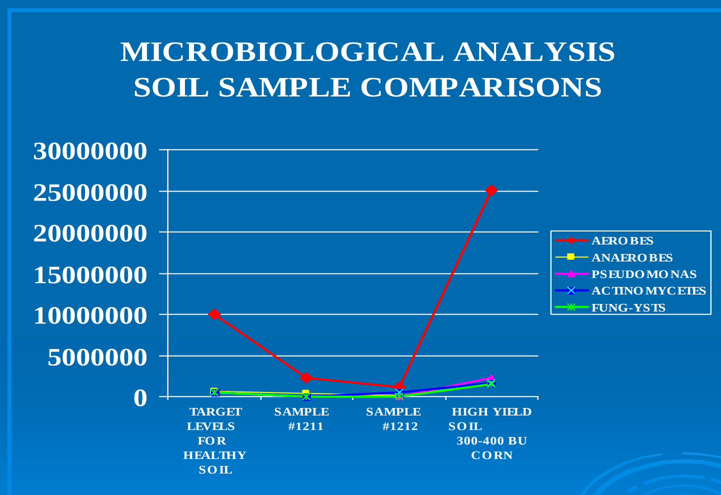


Ingham, R. *et al*. 1985. Ecological Monographs 55:199-140.

Fungivores Increase Nitrogen Mineralization

Treatment	Ammonium nitrate (ug NH_4^+-N) recovered*		
	7 days	14 days	21 days
Fungus	25.9	39.5	1.9
Fungus & nematode	26.1	50.5	19.9

Chen, J. and H. Ferris. 1997. Journal of Nematology 29:571.



Harwood
MSU

Active Fractions

- Biologically active
  - Plant available-N, N mineralization, Amino sugar N
  - Microbial respiration, biomass size, ratios
  - Particulate organic matter
  - Microbial activity, substrate decay potential
- Physically active
  - N Particulate organic matter
  - Aggregation
  - Residue
  - Carbohydrates, Amino sugar

Active SOM

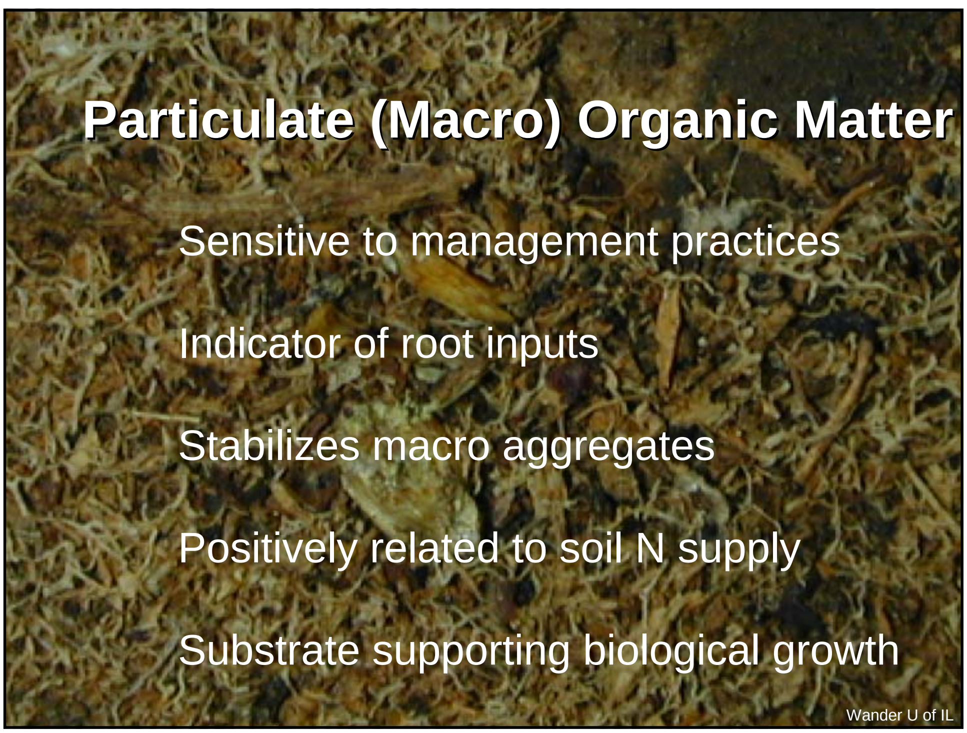
- POM
  - Management sensitive, needs roots
  - Reflects residue input
- Biological activity
  - Determines nutrient supply, availability
  - May suppress nutrient availability
- **Fungal and Bacteria populations**
  - **Affect soil aggregation**
  - **Plant available N**

Active Organic Matter

- Important to nutrient cycling
- Provides N, P and other nutrients
- Food for organisms that hold and release nutrients
- Decomposition depends on climate, tillage, organisms present, time
- May create temporary nutrient deficiencies
- Under constant change
- Can contribute to stabilized SOM if managed

Organic Matter

- Can supply up to: (3%som)
  - 25-100 # N/A
  - 6-8 # P/A
  - Provide pool of other nutients
- Chelates nutrients to prevent loss
- Improve soil structure
- Promote organisms that improve nutrient availability



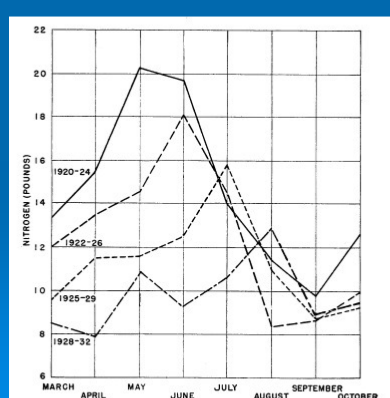
Residue to Nutrients

- “Soil Organic Matter may well be considered as fuel for bacerial fires in the soil which operates as a factory producing plant nutrients.”

Wm. A. Albrecht, U of Mo

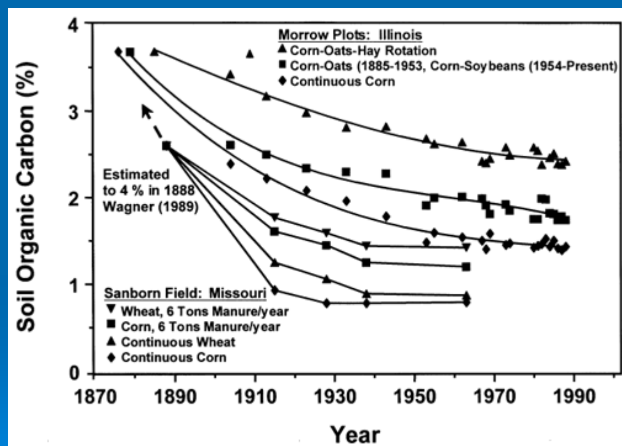
Tillage decreases SOM and nitrogen reserve

- We knew that years ago



Albrecht U of Mo

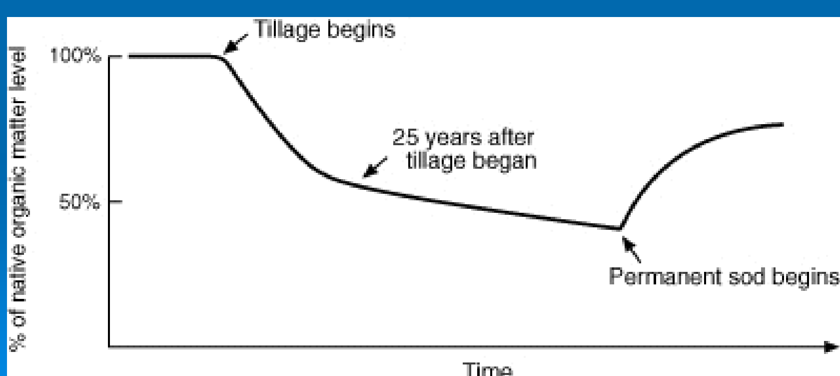
Soil carbon loss



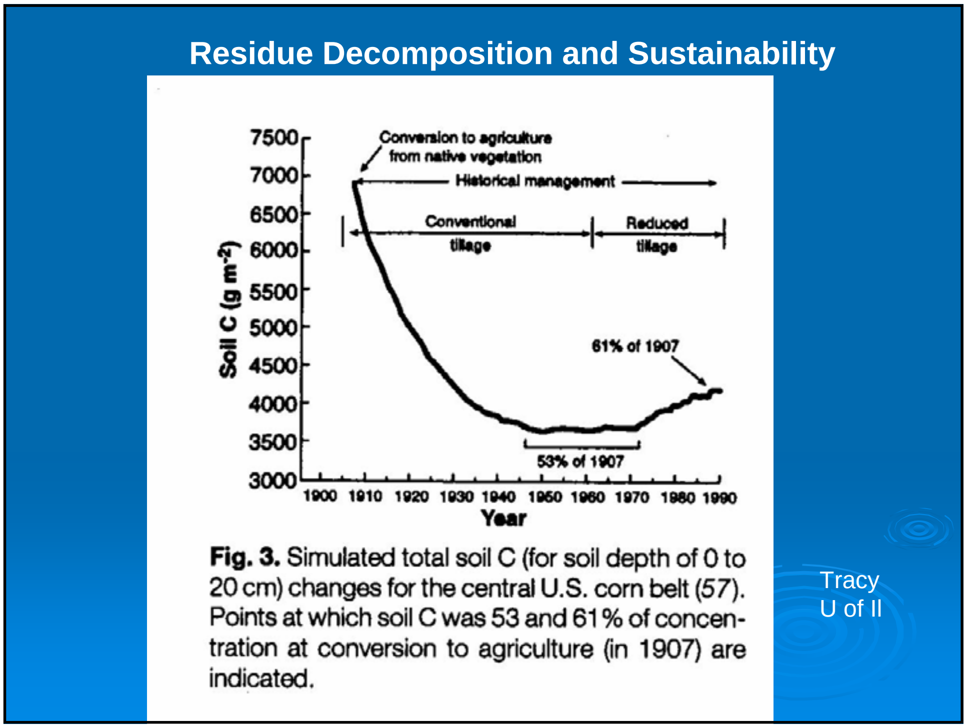
USDA-ARS IOWA

SOM loss

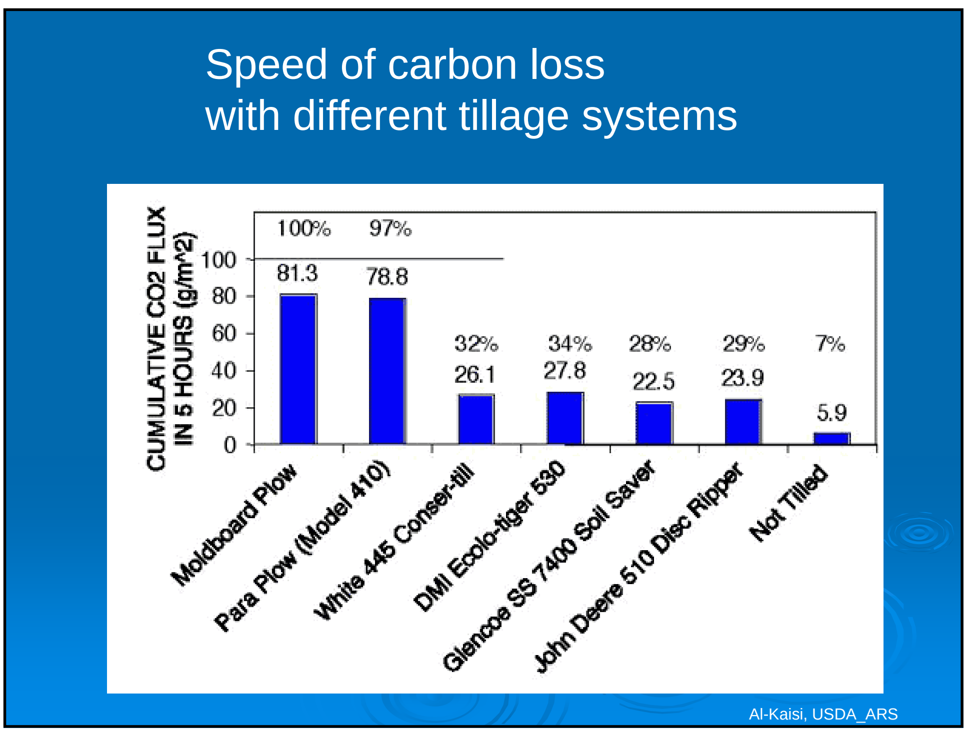
- Recent research



U of Mn



Residue Decomposition and Sustainability
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
Soil C (g m⁻²)
Conversion to agriculture from native vegetation
Historical management
Conventional tillage
Reduced tillage
61% of 1907
53% of 1907
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990
Year
Fig. 3. Simulated total soil C (for soil depth of 0 to 20 cm) changes for the central U.S. corn belt (57). Points at which soil C was 53 and 61% of concentration at conversion to agriculture (in 1907) are indicated.
Tracy
U of Il



Speed of carbon loss
with different tillage systems
CUMULATIVE CO2 FLUX IN 5 HOURS (g/m^2)
100
80
60
40
20
0
100%
97%
81.3
78.8
32%
26.1
34%
27.8
28%
22.5
29%
23.9
7%
5.9
Moldboard Plow
Para Plow (Model 410)
White 445 Conser-till
DMI Ecolo-tiger 530
Glencoe SS 7400 Soil Saver
John Deere 510 Disc Ripper
Not Tilled
Al-Kaisi, USDA_ARS

Residue Quality

Common index (C:N)

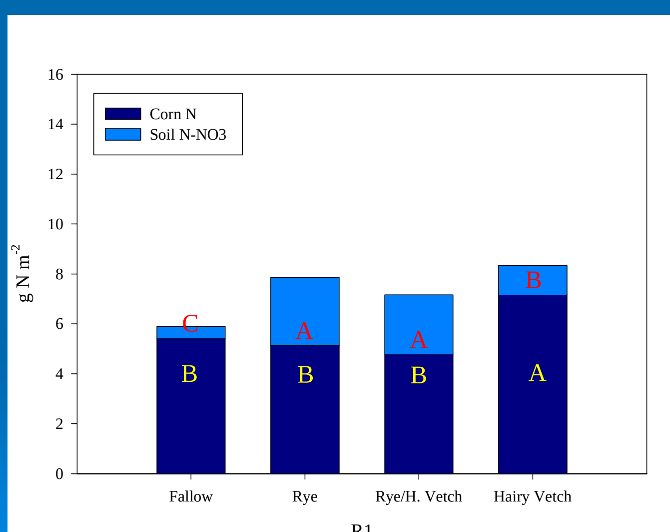
Residue < 20 C:N decompose fast >N levels

young legumes C:N 12:1

Green leaves C:N >30 decreases N available in soil

Soybeans	15-25:1
Corn	30:1
Corn stalks	60:1
Wheat straw	80:1

Soil N-NO_3^- content, corn N content at R1.



Wander, Bollero
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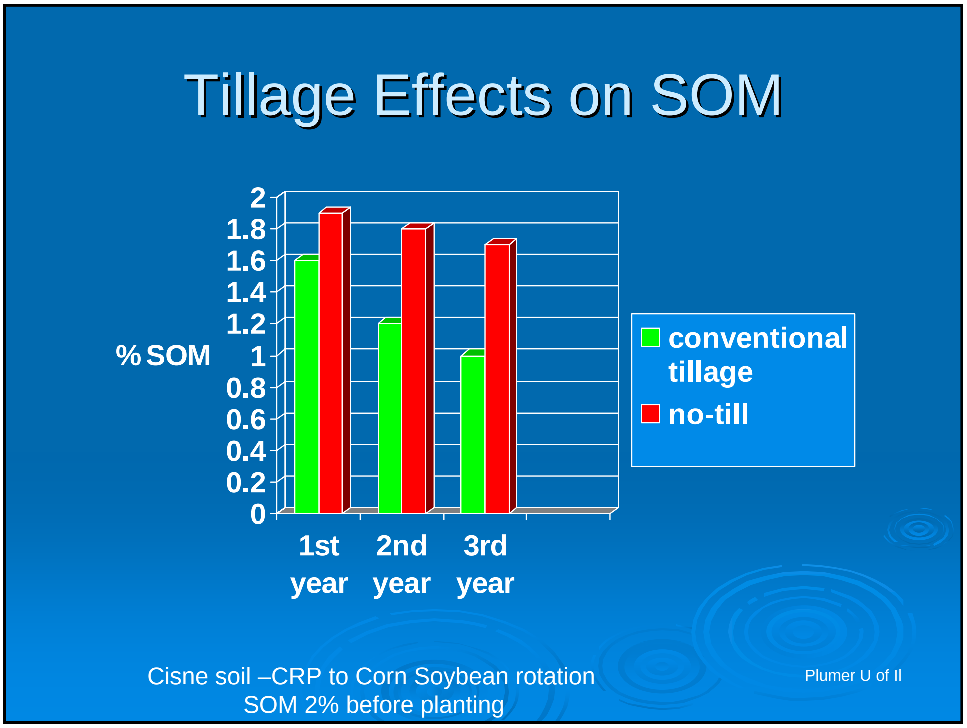
Tillage Effects on SOM
% SOM
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1st year
2nd year
3rd year
conventional tillage
no-till
Cisne soil –CRP to Corn Soybean rotation
SOM 2% before planting
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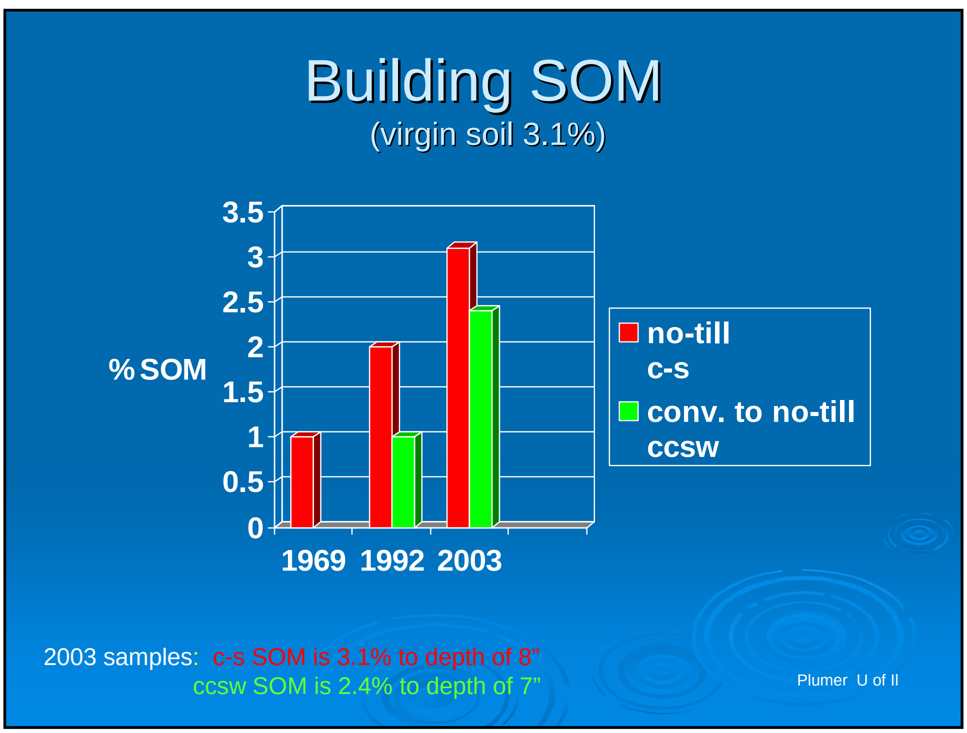
Building SOM
(virgin soil 3.1%)
% SOM
3.5
3
2.5
2
1.5
1
0.5
0
1969
1992
2003
no-till c-s
conv. to no-till ccsw
2003 samples: c-s SOM is 3.1% to depth of 8"
ccsw SOM is 2.4% to depth of 7"
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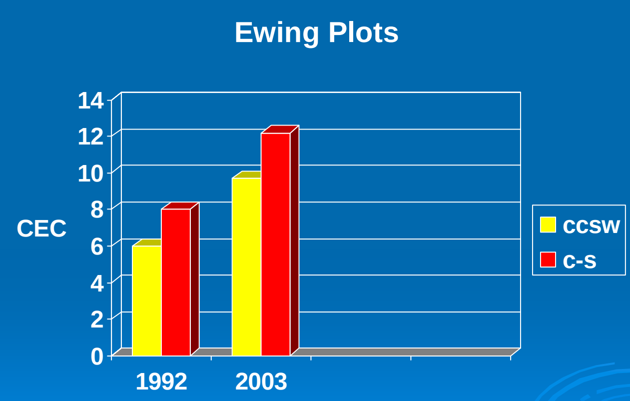
SOM changes CEC



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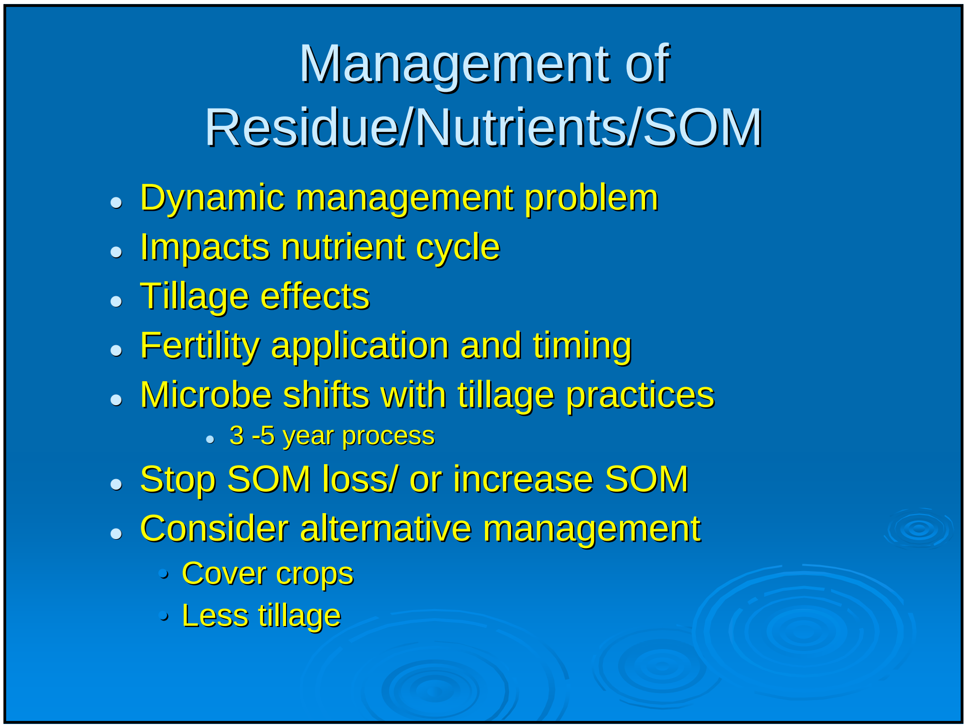
Issues of SOM Loss

- Artificial support of soil productivity
- Eventually reduces soil productivity
- Decreases soil structure, water infiltration
- Soil becomes more erodible
- Nutrients more prone to loss


Management of Residue/Nutrients/SOM
• Dynamic management problem
• Impacts nutrient cycle
• Tillage effects
• Fertility application and timing
• Microbe shifts with tillage practices
• 3 -5 year process
• Stop SOM loss/ or increase SOM
• Consider alternative management
• Cover crops
• Less tillage