Managing Carbon in Wisconsin Soils

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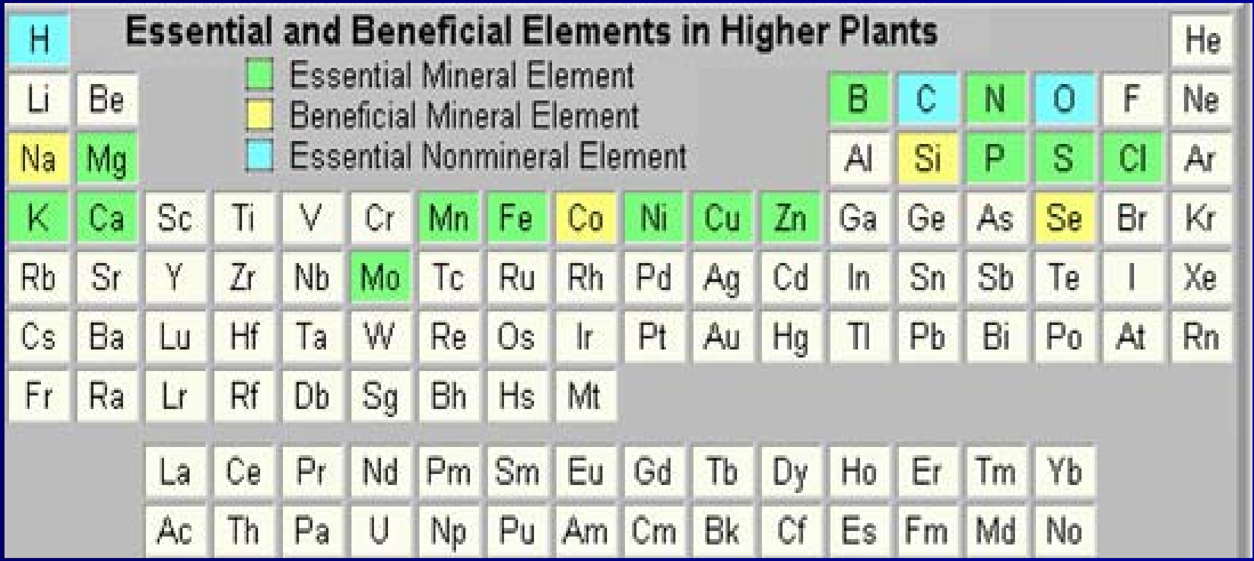
Carbon: The key element for life

- **Outline:**
  - The “ultimate” essential plant nutrient needed for life as we know it
  - Soil C and organic matter basics
  - Tillage impacts on soil organic matter
  - Potential impacts of biofuel production on soil C



Carbon: The key element for life

- Carbon:
  - Forms both the hardest and one of the softest minerals on earth
    - Diamond used as an abrasive
    - Graphite used as a lubricant
  - Fourth most abundant element in the universe (H, He, O)
  - Bonds to itself in a myriad of configurations to form over 10,000,000 different molecules
  - Cycled through variety of phases
    - Solid (cellulose)
    - Liquid (gasoline)
    - Gas (carbon dioxide)

Why worry about soil carbon: C is a major component of the soil organic matter

- Energy source for microorganisms
  - Nutrient cycling
  - Residue decomposition
- Improves aggregation
  - Aeration, drainage, erosion, tilth, etc.
- Storehouse for nutrients
  - Included in organic structure
  - Held on exchange sites
- C is sequestered in organic matter
- Interacts with environmental contaminants

What is soil organic matter

"The fraction of soil composed of anything that once lived"

- Consists of …..
  - Plant and animal remains in various stages of decomposition
  - Living soil organisms
  - Root and microbial exudates/waste products
- Not all the same
  - Labile (active)
  - Stabile (recalcitrant)
- Need continuous additions from crop residue, roots, and amendments

Labile or biologically active

- Living or microbial biomass
  - One gram of soil contains:
    - >100,000,000 bacterial cells
    - >16,000 species of bacteria
- Macro-organic matter
- Polysaccharide molecules
- Mostly involved in decomposition; energy and nutrient cycling

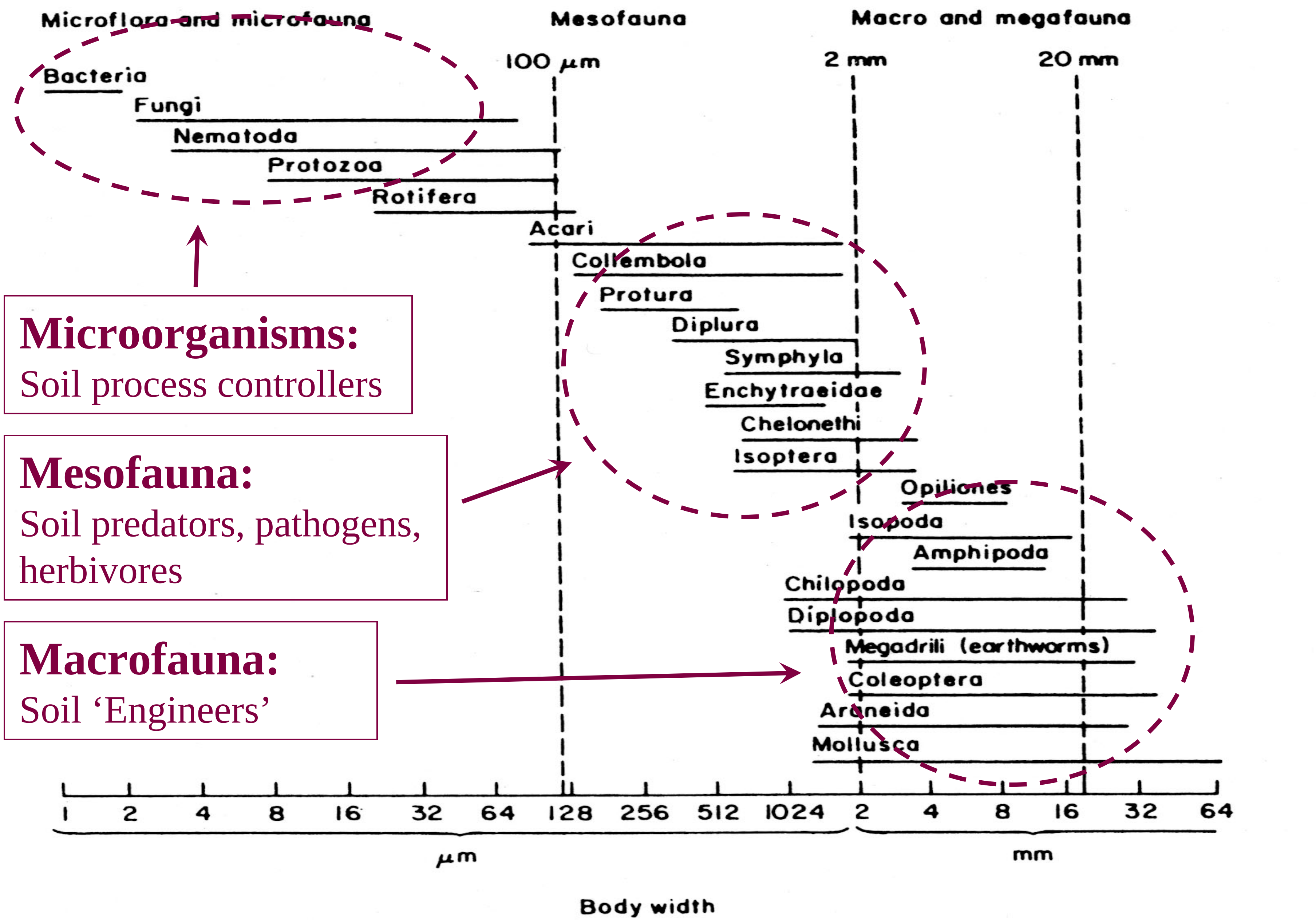


FIGURE 4.3 Size classification of organisms in decomposer food webs by body width (Swift *et al.*, 1979).

Stabile or recalcitrant organic matter

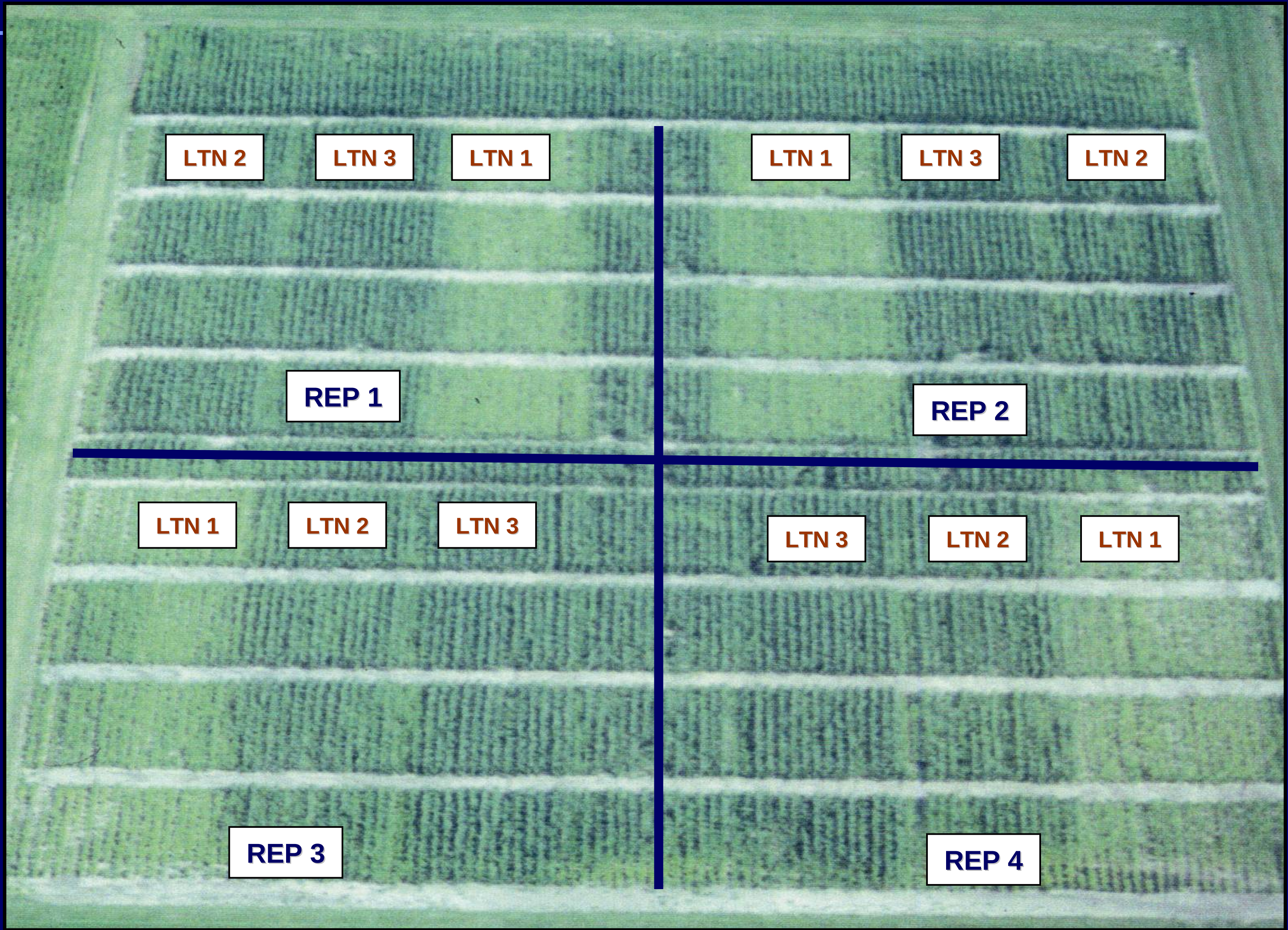
- Humus
  - Very well decomposed
  - Dark, porous and spongy
  - No definite chemical structure
  - Resistant to decay
- Age measured in decades/centuries
- Contributes to structural development, CEC, and affects compounds added to the soil
- Relatively constant content for a soil

Long-term studies assess N effect on soil organic matter management

(Vanotti et. al., 1997)

- Arlington
  - Established 1958
  - Continuous corn
  - History of residue burning
  - Three N rates
    - None
    - 50-75 %
    - 150 %
- Lancaster
  - Established 1967
  - Several rotations
  - Previous alfalfa history
  - Four N rates
    - 0 – 300 through '77
    - 0 – 200 since

Arlington Long-Term N Study



Effect of N fertilization on soil C accumulation, Arlington, 1958 - 1983

Treatment	Biomass		Total C (above ground)	Soil C
	------ t/a/yr ------		t/a	%
	Grain	Stover		
No N	1.7	2.6	30	2.0
50 – 75 %	3.0	3.4	41	2.2
150 %	3.1	3.6	42	2.2

Initial soil C = 1.9 %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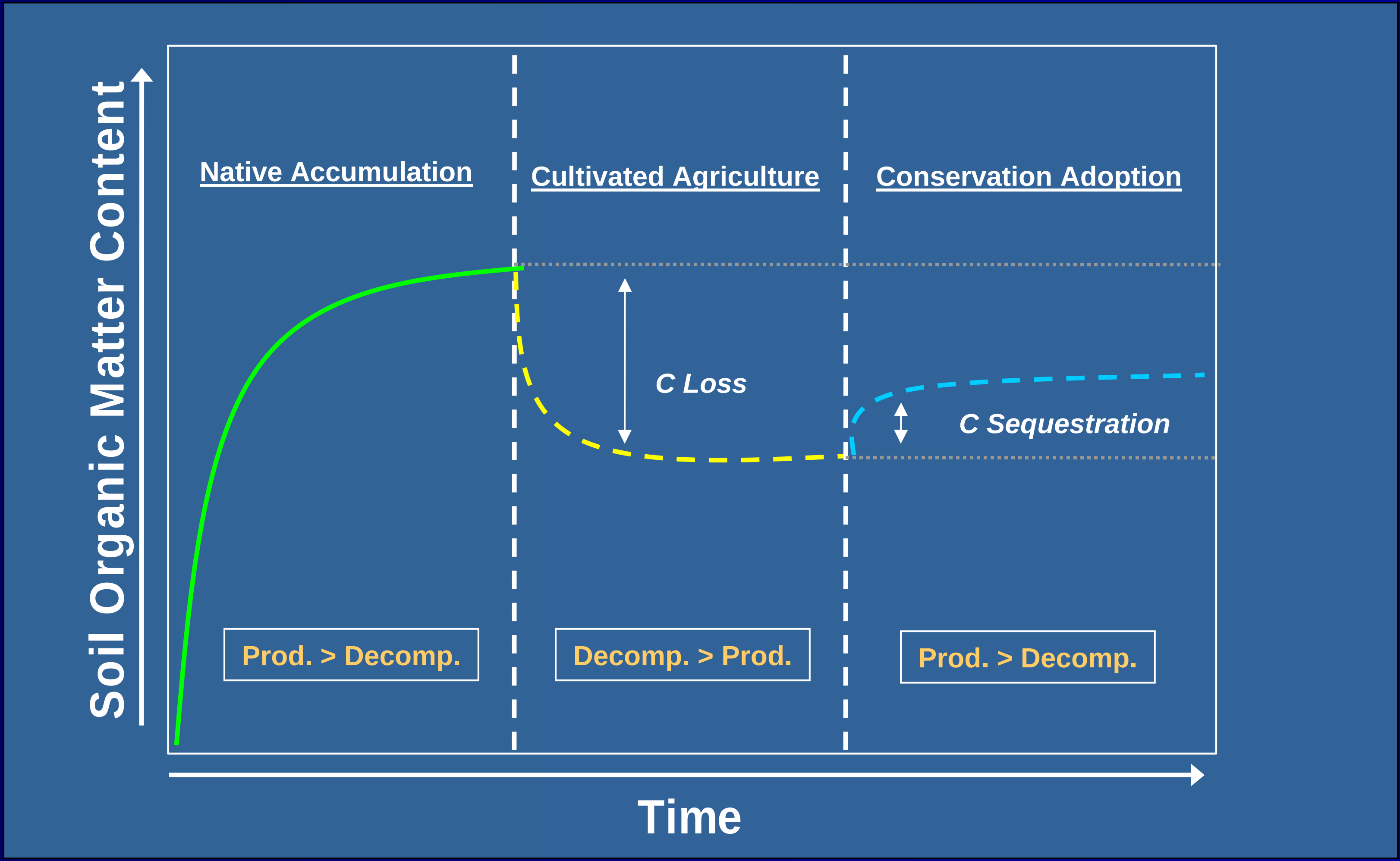
Effect of N fertilization on soil C accumulation, Lancaster, 1967 - 1989

Treatment	Biomass		Total C (above ground)	Soil C
lb N/a	------ t/a/yr ------		t/a	%
	Grain	Stover		
No N	1.5	2.4	25	1.4
50 or 75	2.7	3.3	34	1.2
100 or 150	3.1	3.5	37	1.4
200 or 300	3.3	3.7	38	1.3

Initial soil C = 1.6 %

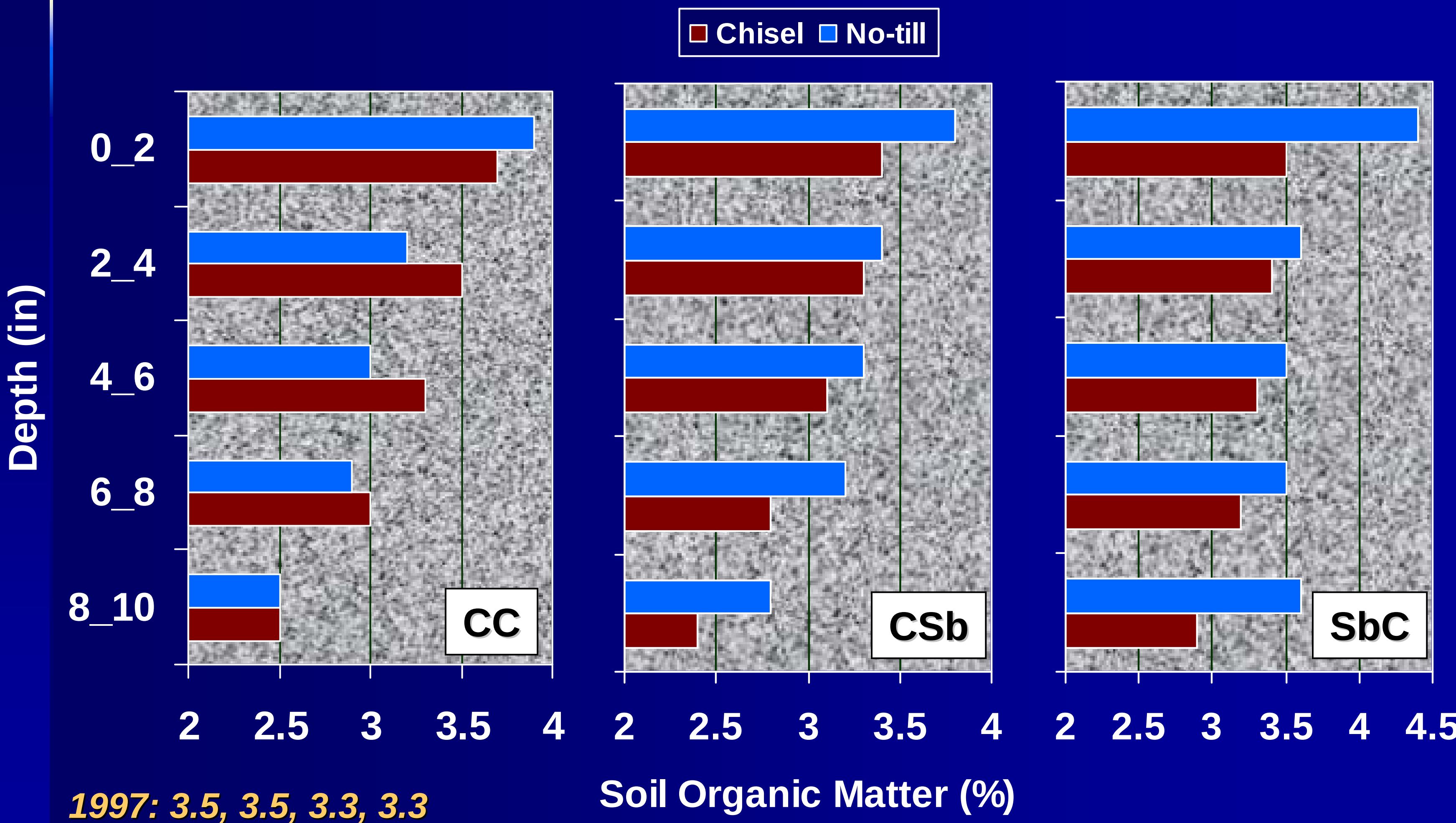
Tillage effect on soil organic matter

(adapted from Al-Kaisi and Licht, 2005)



Effect of 10 years of tillage and rotation on soil organic matter, Arlington, 2007

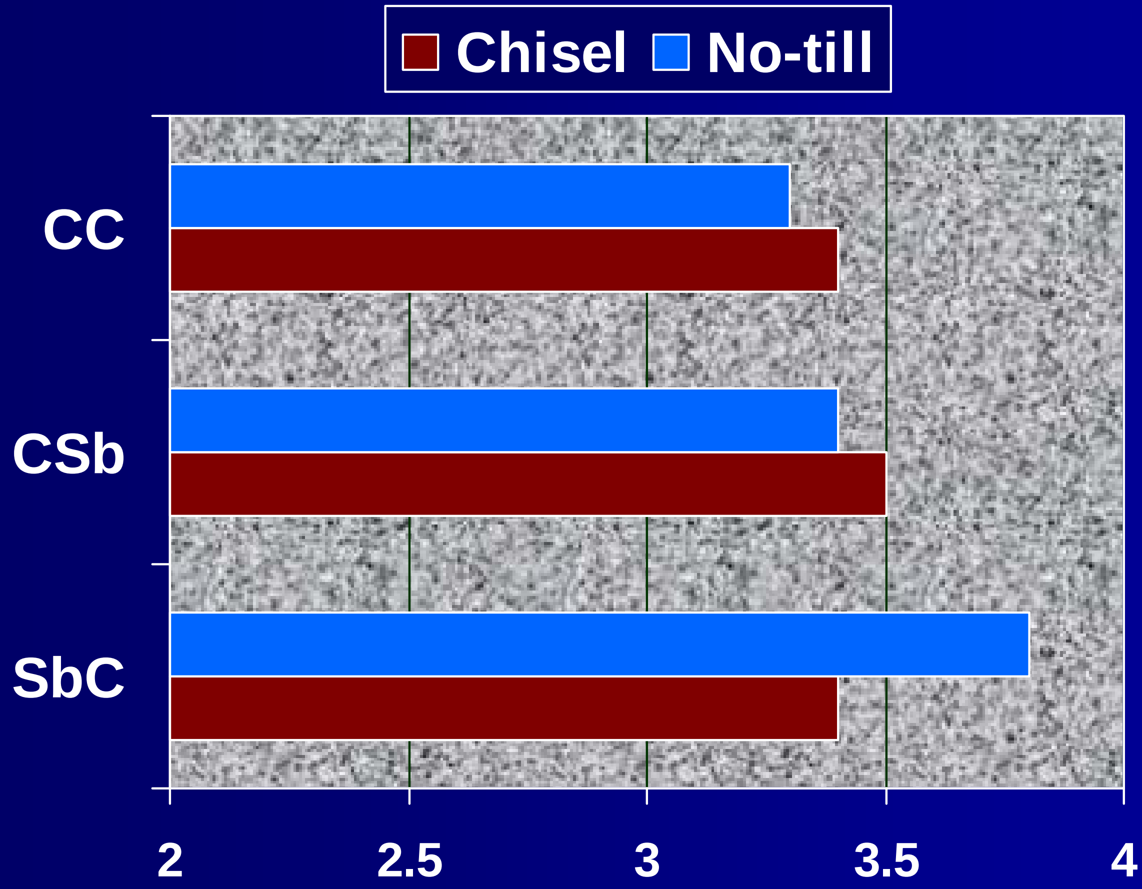
(Incremental sampling @ 2")



1997: 3.5, 3.5, 3.3, 3.3

Effect of 10 years of tillage and rotation on soil organic matter, Arlington, 2007

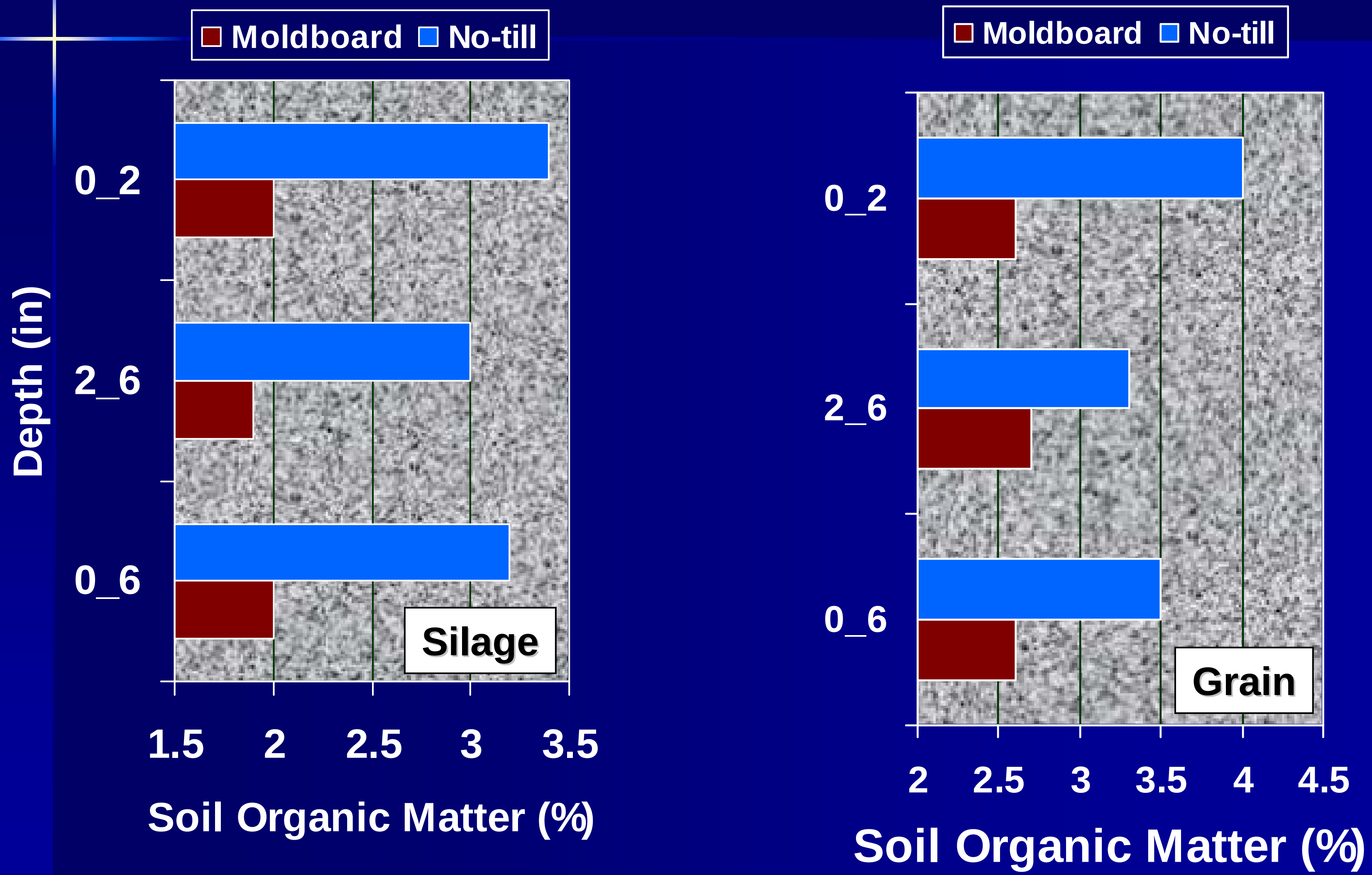
(Averaged over 0 – 8”)



Effect of tillage and corn management on soil C cycling (Hooker et. al. U-Conn.)

- Moldboard or No-till
- Harvested for silage or grain
- Field created from forested land in 1957 and in continuous corn with the tillage/harvest systems since 1972
- Until 1972 C inputs were as C3-C; whereas corn is a C4-C plant
- Utilize ^{13}C analysis to evaluate cycling

Effect of tillage and corn management on soil C amount over 28 years (Hooker et. al. U-Conn.)



Effect of tillage and corn management on soil C partitioning (Hooker et. al. U-Conn.)

Tillage	Corn Mgt.	C4-C	C3-C Half-life
		%	years
NT	Grain	42	19
NT	Silage	35	18
MB	Grain	32	15
MB	Silage	27	14

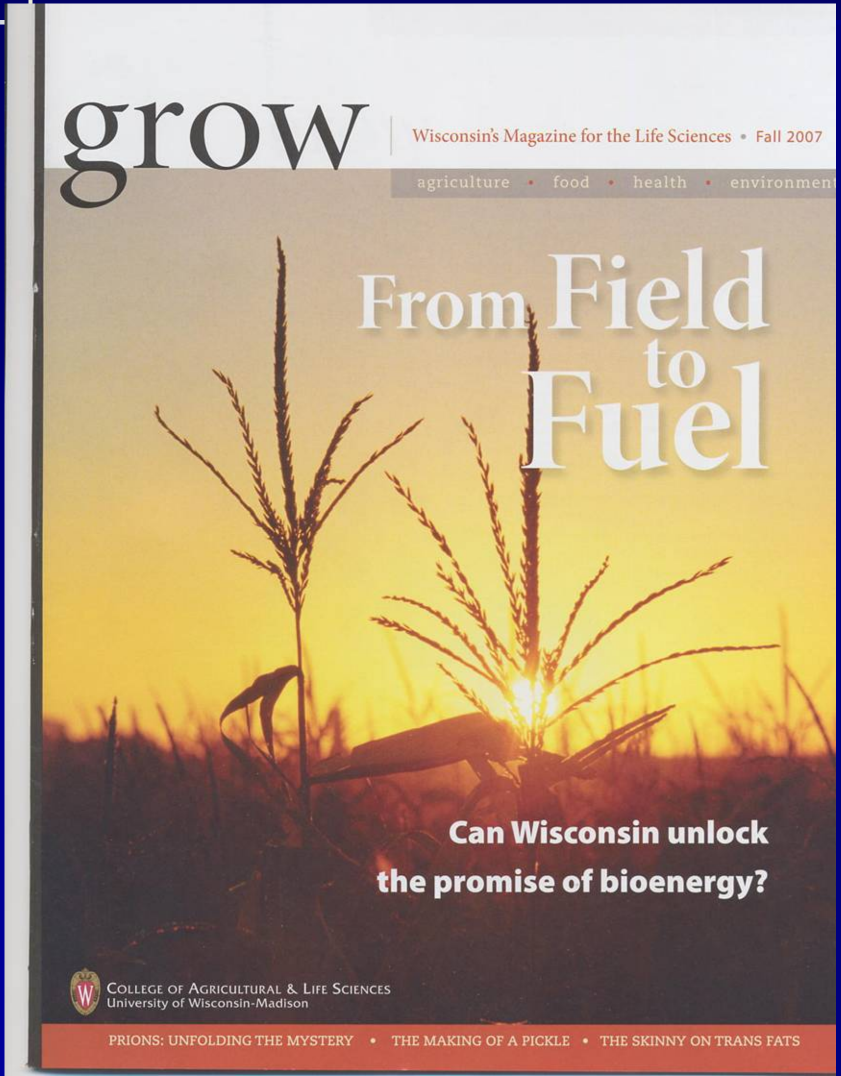
0 – 2 in.

Effect of tillage and corn management on soil C partitioning (Hooker et. al. U-Conn.)

Tillage	Corn Mgt.	C4-C	C3-C Half-life
		%	years
NT	Grain	17	57
NT	Silage	13	61
MB	Grain	24	32
MB	Silage	21	24

2 - 6 in.

Current challenges of bio-energy production on soil organic matter



- Corn ethanol is currently driving corn production
- Question of alternative methods
  - Cellulosic ethanol
  - Wind
  - Solar
- UW-CALS bio-energy initiative

Estimated ethanol from biomass

(Jeffries, USDA-FPL)

Biomass Source	Ethanol Produced
Agricultural Residues	20 - 25 B gal (conserv.) 36 - 45 B gal (optim.)
Energy Crops	33 - 61 B gal
MSW	5 - 10 B gal
Forestry/Mill Waste	0.5 - 1.0 B gal
Total (average)	66.5 – 107 B gal

Grain ethanol: ~ 13 B gal by 2009; 100 % grain use = 15% current fuel use

Concerns with using corn residues for bio-energy
(Blanco-Canqui and Lal, OSU)

- Long-term no-till: Removed 0, 25, 50, 75, and 100 % of stover after grain
- Three Ohio locations
- Removing > 50 % reduced soil C and grain yield by ~ 30 bu/a on one site
- Removing > 25 % reduced infiltration on two sites
- Removing > 50 % reduced PAW and earthworms on all sites.
- Recommend limiting stover removal to < 25 %

Many produces already chop stalks for bedding

Current practice leaves a considerable amount of stover (> 50 %?)

Removing stover also removes nutrients (Sawyer and Mallarino, ISU, 2007)

Elemental composition of corn stover and cobs

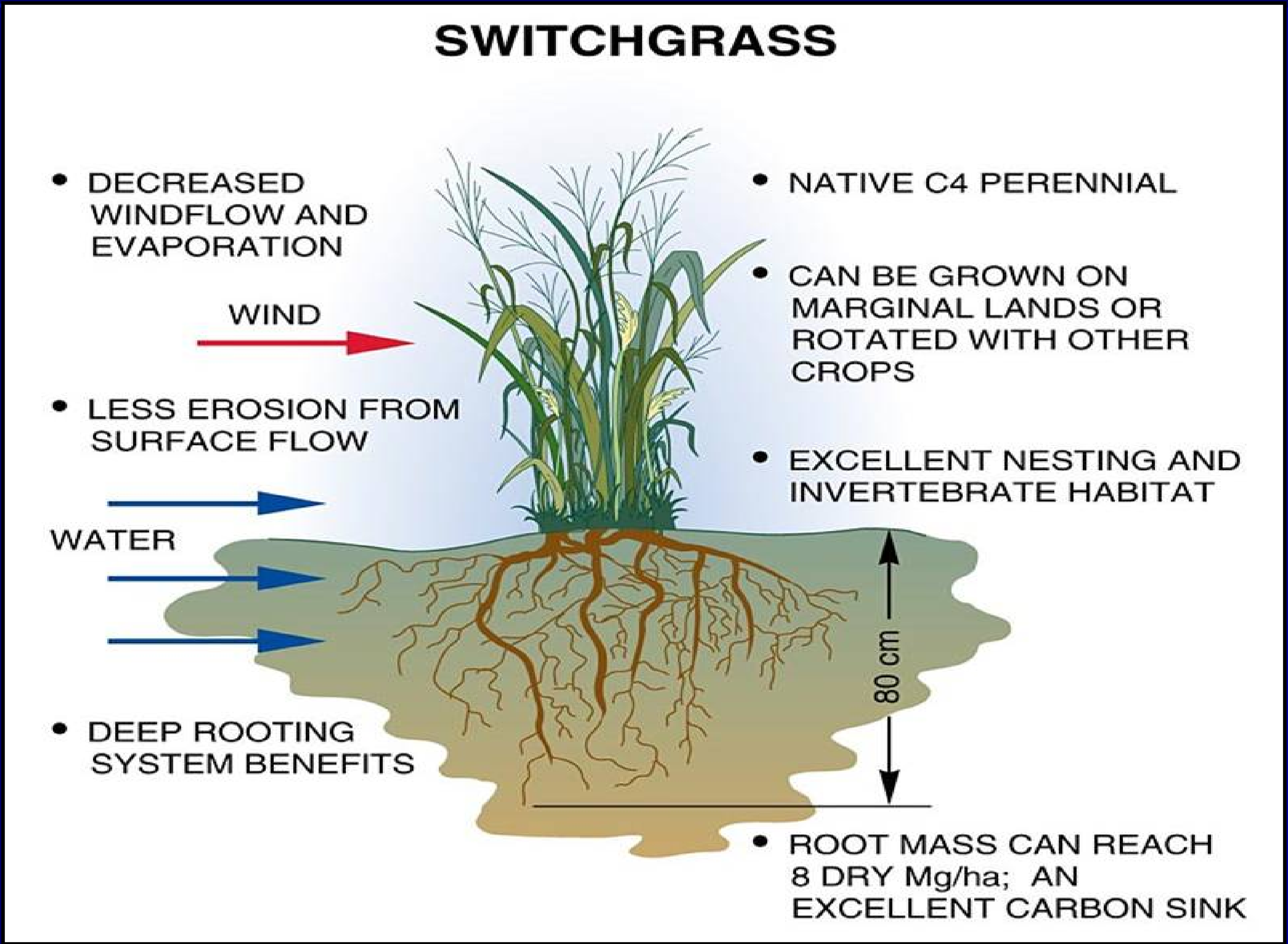
Crop component	N	P_2O_5	K_2O	Ca	Mg	S
	---------------- lb/ton DM ----------------					
Stover	20	4	35	11	8	3
Cobs	8	2	20	2	1	9

What is Switchgrass?

Warm season perennial grass (Panicum virgatum)

Source: http://www.iowaswitchgrass.com/benefits~onfarmbenefits.html

Karl Green, LaCrosse County CNRED Agent, 2007



Benefits of Switchgrass?

Karl Green, LaCrosse County CNRED Agent, 2007

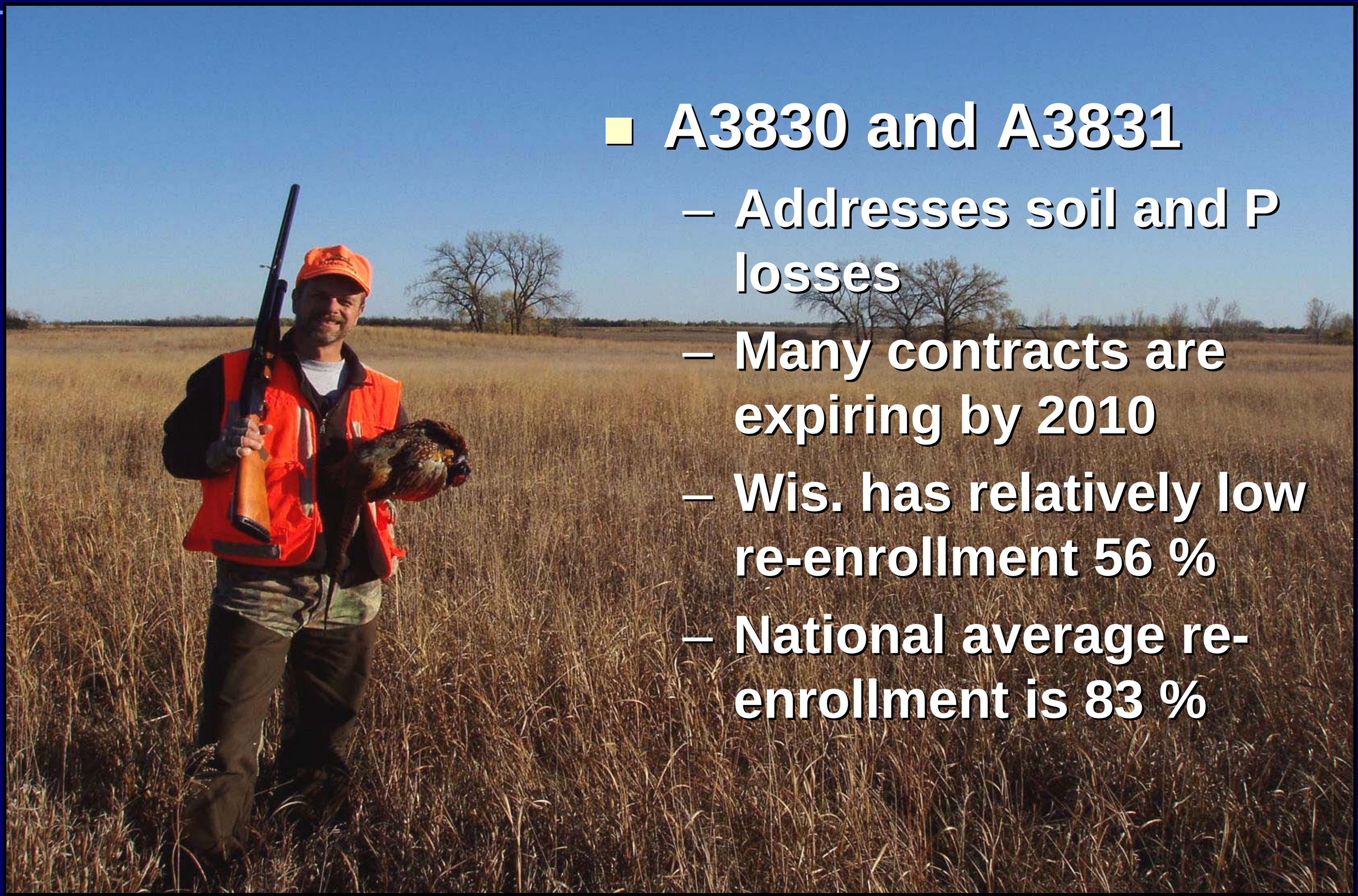
- **Dominant native species found on native North American plains/prairies of Canada & United States**
- **Attains reasonable yields w/o high rates of nitrogen fertilizer (low inputs)**
  - Cost component
  - Groundwater component
- **Longevity of Crop**
  - Approximately 10 years
- **Adapts to numerous soil/climatic conditions, therefore can be introduced onto marginal cropland**
  - Converting row crops to perennial grasses may increase soil stability
  - Carbon sequestration in root mass and stubble
- **Excellent burn qualities**
  - Can be co-fired w/ certain coal plants
  - *This creates an immediate end use (market) for crops, allowing establishment of crops as cellulosic technology develops*

Soil under switchgrass stores more C

Readily oxidizable C
H_2O_2 added

Arlington Research
K. Shinners, BSE

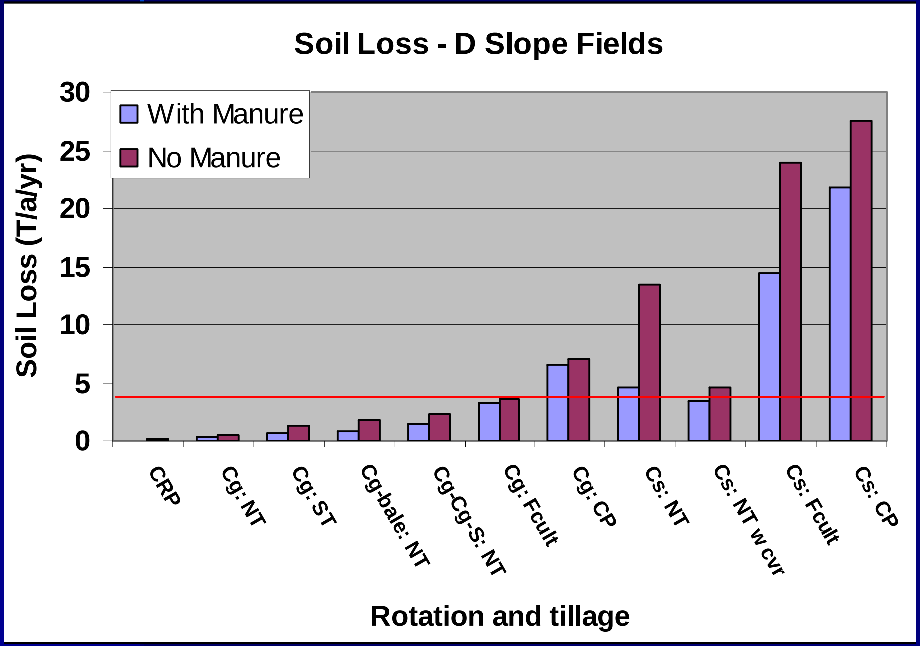
Potential soil (pheasant) loss from converting CRP to corn

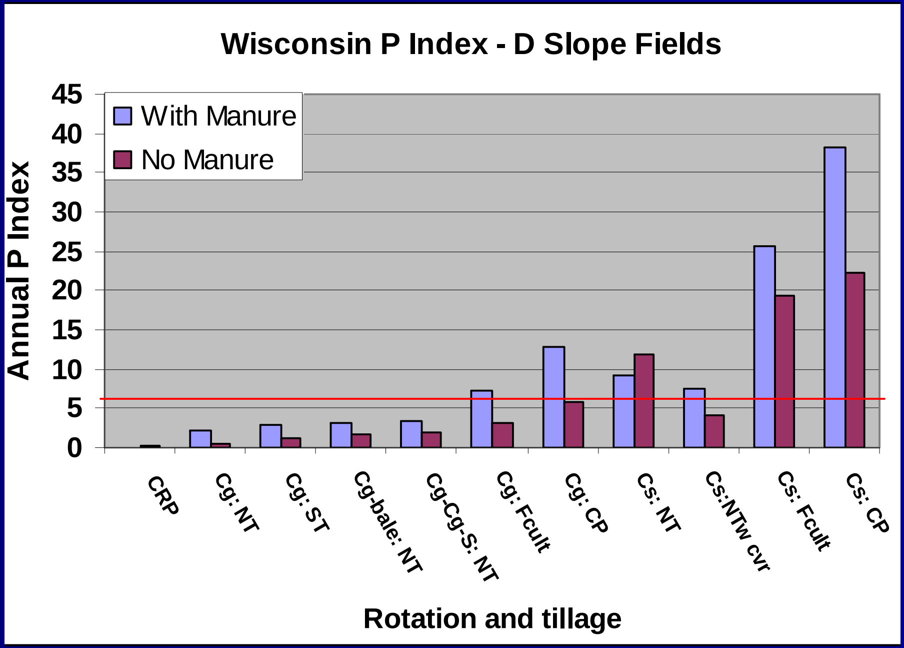


- A3830 and A3831
  - Addresses soil and P losses
  - Many contracts are expiring by 2010
  - Wis. has relatively low re-enrollment 56 %
  - National average re-enrollment is 83 %

Estimated soil and P loss from CRP conversion to corn

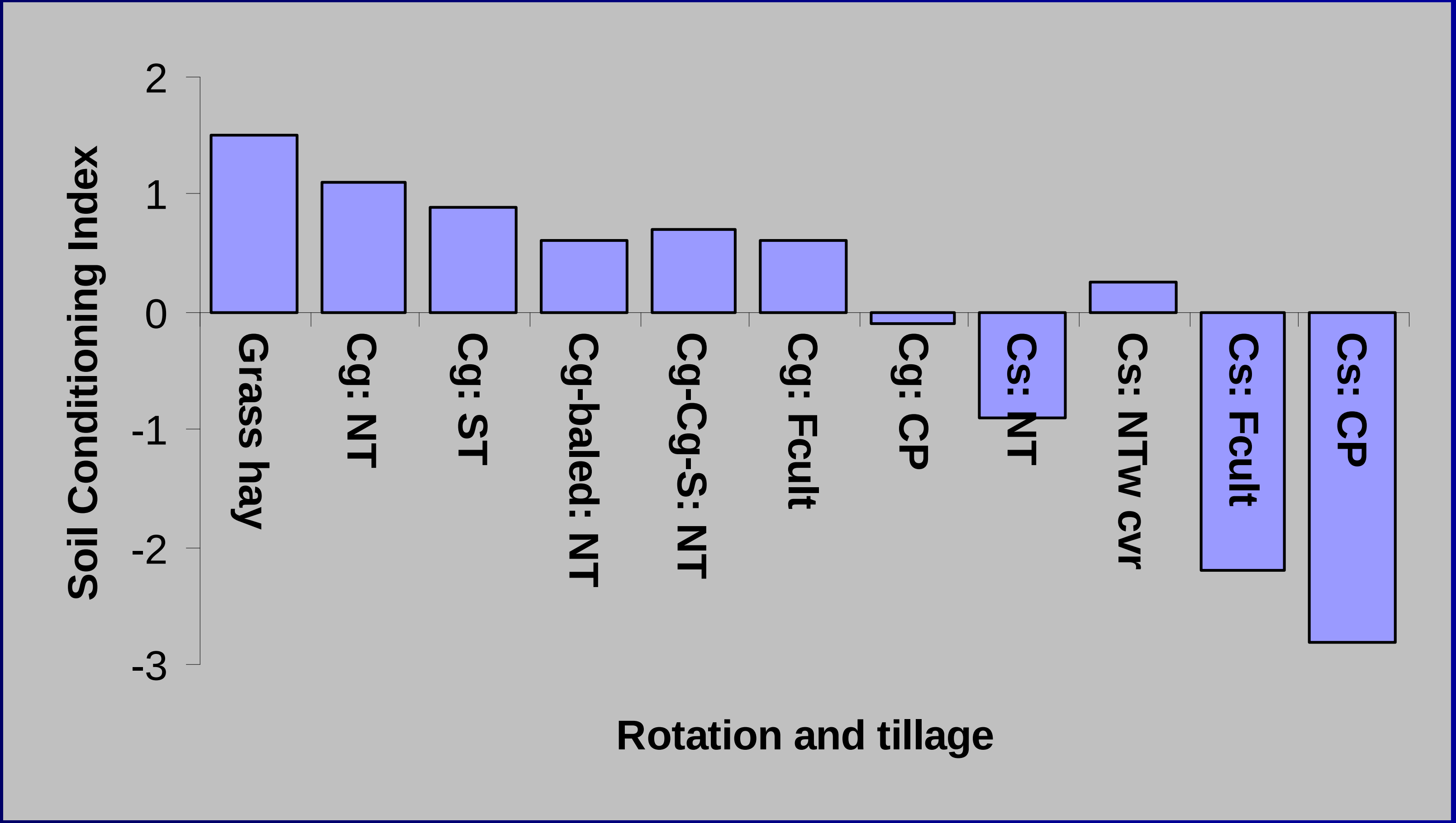
(Panuska et al., 2007)





Estimated Soil Conditioning Index for CRP conversion to corn

(Panuska et al., 2007)



Summary

- Soil organic matter is important
- Practices that maintain or build SOM should be encouraged
- Follow conservation plans and strive to reduce tillage intensity
- Return crop residues when possible
- Carefully consider impact of converting CRP
- Crop production for bio-energy may hurt or help soil quality