

ARE TILLAGE AND SOIL QUALITY MUTUALLY EXCLUSIVE



**Dick Wolkowski
Department of Soil Science
University of Wisconsin**

WHAT IS SOIL QUALITY

➤ **DEPENDS ON WHO YOU ARE:**

- **Farmer:** Highly productive, sustainable soil having certain properties
- **Naturalist:** Soil in harmony with the landscape and environment
- **Consumer:** Source for plentiful and inexpensive food



ASSESSING SOIL QUALITY

➤ OFTEN SUBJECTIVE:

- Smell, feel, look, taste?
- Soil Quality Index

➤ MORE QUANTITATIVE

- Chemical
 - pH, O.M., nutrients
- Physical
 - Structure, bulk density
- Biological
 - Respiration, microbial biomass



Field ID _____

Date _____

→ See instructions on other side of this sheet.

Indicator	Descriptions			√ Rating			Comments
	Good (8-10)	Medium (4-7)	Poor (1-3)	Good	Med	Poor	
Soil Tilth ⌚, >	Mellow; Pliable; Crumbly; Clods easily broken apart by tillage	Firm; Some large clods; Clods can be broken apart by tillage	Hard dense chunks; Tight; No structure; Difficult to break apart by tillage				
Compaction ⌚, >	Little resistance to penetration by soil probe, shovel, wire flag, tillage implement, etc.; No hard pan	Some resistance to penetration by soil probe, shovel, wire flag, tillage implement, etc.	High resistance to penetration by soil probe, shovel, wire flag, tillage implement, etc.; Hard pan present				
Water Infiltration and Drainage ●	Soil drains well after rain; Little or no ponding or runoff following rain; Can get into the field soon after a rain	Water drains slowly with some ponding	Water ponds or runs off following most rains; Long wait to get on the field following rain; soil surface crusted				
Erosion ⌚, ●	No gullies or visual evidence of erosion; any runoff that occurs is generally clear; Deep topsoil	Some visual signs of erosion; Cloudy runoff	Obvious signs of erosion; Muddy runoff; Shallow topsoil; Subsoil showing at the surface				
Surface Cover ⌚	Soil surface covered year round; Little bare soil; Dense sod or other vegetation; Heavy, well distributed residue present	Some residue or vegetation present but soil surface not completely covered. Bare soil during part of the year	Little or no soil cover; Bare soil for much of the year				
Soil Life ☼	Signs of earthworms and other soil life common. (worms, worm casts, worm holes, etc)	Occasional signs of earthworms and other soil life. (worms, worm casts, worm holes, etc)	No visible signs of earthworms and other soil life. (worms, worm casts, worm holes, etc)				
Soil Organic Matter >	Dark color; visible organic material; Earthy smell; high organic matter soil test	Medium organic matter soil test	Light color; No visible organic material in soil; No smell; Low organic matter soil test				
Plant Growth ☼	Healthy uniform plant growth; Consistent good yields; Crops resist stress, such as drought	Plant health varies; Inconsistent yields; Crops somewhat resistant to stress	Spotty, uneven crops; Plants unhealthy; Consistently poor yield; Crops susceptible to stress				
Plant Roots ☼	Robust, large, deep, well dispersed root system; No obvious restriction to root growth; Many fine roots	Roots present in profile; Some misshapen roots; Some restriction to root growth	Few or no roots present; Roots short, coarse, not uniformly distributed; Roots growing sideways; Obvious restrictions				
Other							

Best Assessed: ⌚ = Anytime; > = with adequate moisture; ● = after rain; ☼ = during growing season

TILLAGE IS A KEY PART OF CROP PRODUCTION

- **THE PHYSICAL
MANIPULATION OF
THE SOIL FOR THE
PURPOSES OF:**
- **Management of previous
crop residues**
 - **Control of competing
vegetation**
 - **Incorporation of
amendments**
 - **Preparation of a seedbed**



TILLAGE AFFECTS SOIL PROPERTIES RELATED TO SOIL QUALITY

- **Crop residue cover**
- **Soil test measurements**
- **Nutrient availability**
- **Structure and aggregate stability**
- **Water relationships**
- **Temperature**
- **Soil biology**
- **Compaction and Strength**

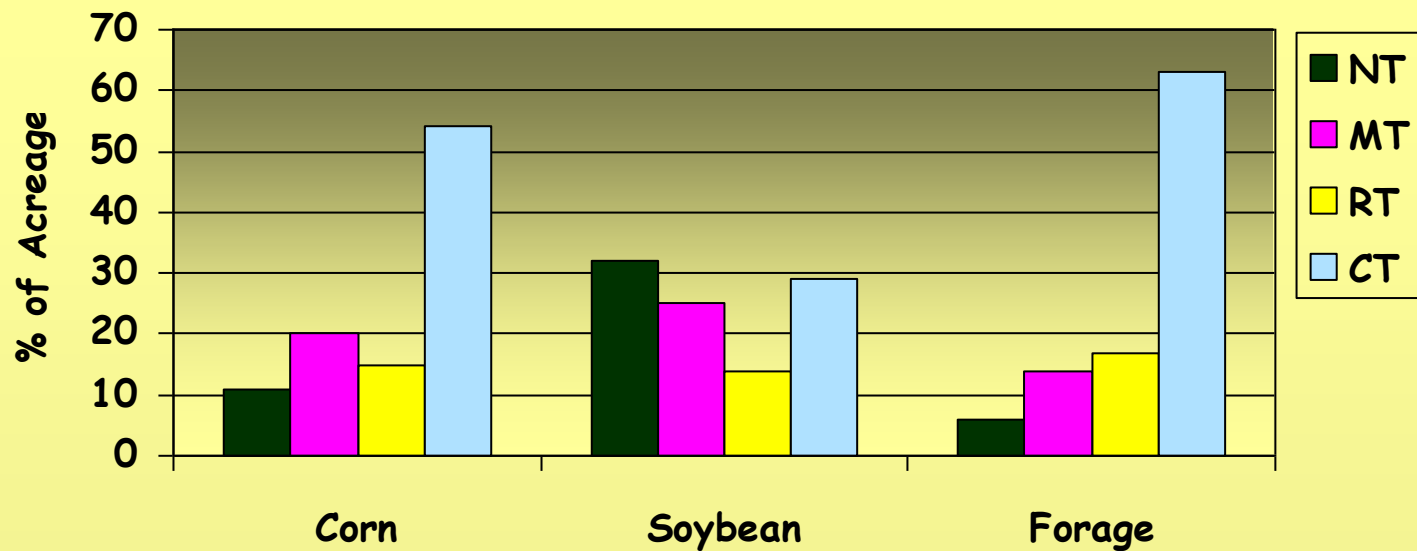


SURFACE CROP RESIDUE INTERACTS WITH OTHER FACTORS

- **Impact on erosion**
- **Cooler soils**
- **Conserves moisture**
- **Affects soil physical properties**
- **Affects carbon and nutrient cycling**



TILLAGE INTENSITY IN WISCONSIN VARIES BY CROP



CTIC, 2002

TILLAGE EFFECT
EROSION ON CLEAN-TILLED
GROUND, DANE CO., WIS.



CROP MANAGEMENT EFFECT
EROSION ON CORN SILAGE
GROUND SHAWANO CO., WIS.



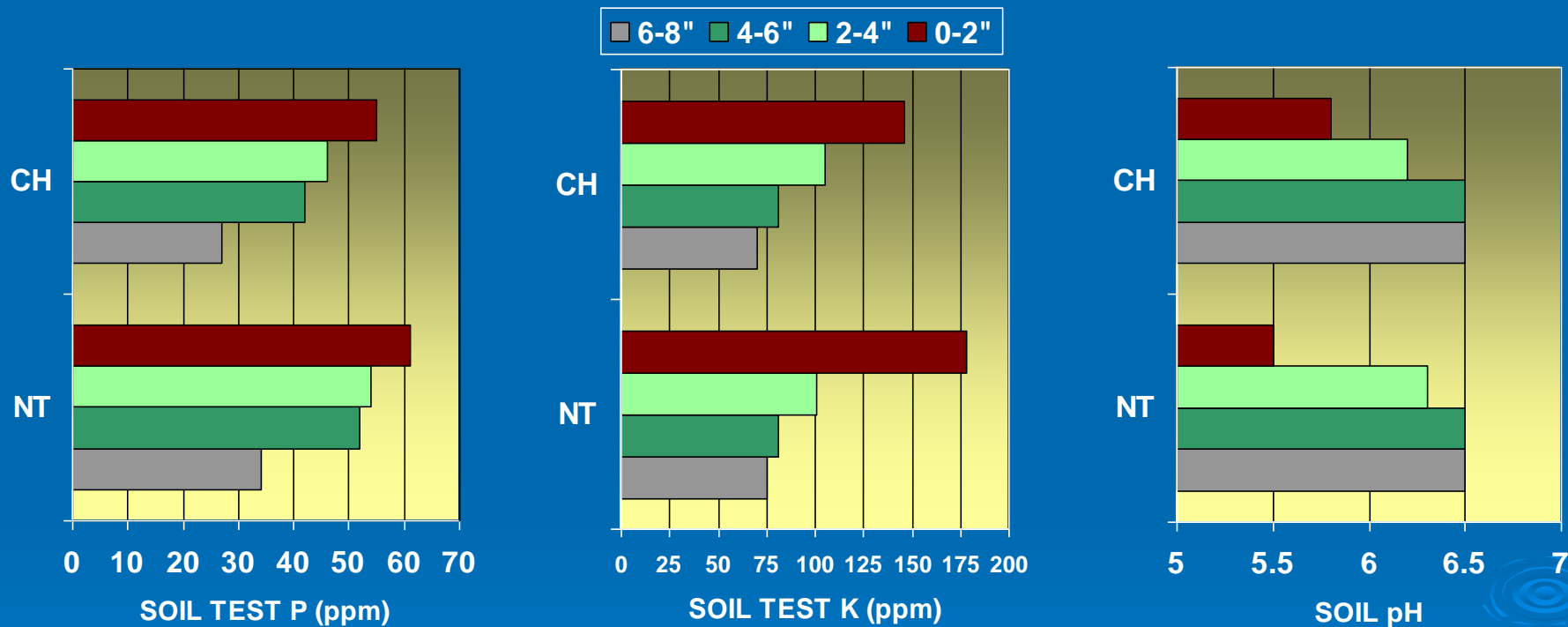
TILLAGE EFFECT ON SOIL TEST

ISSUES

- **Nutrient stratification**
 - Surface applied nutrients
 - Crop residues
 - Vertical and horizontal
- **Fertilizer placement considerations**
- **How to collect a representative sample**



SOIL TEST STRATIFICATION FOLLOWING FIVE YEARS OF TILLAGE MANAGEMENT, ARLINGTON, WIS.



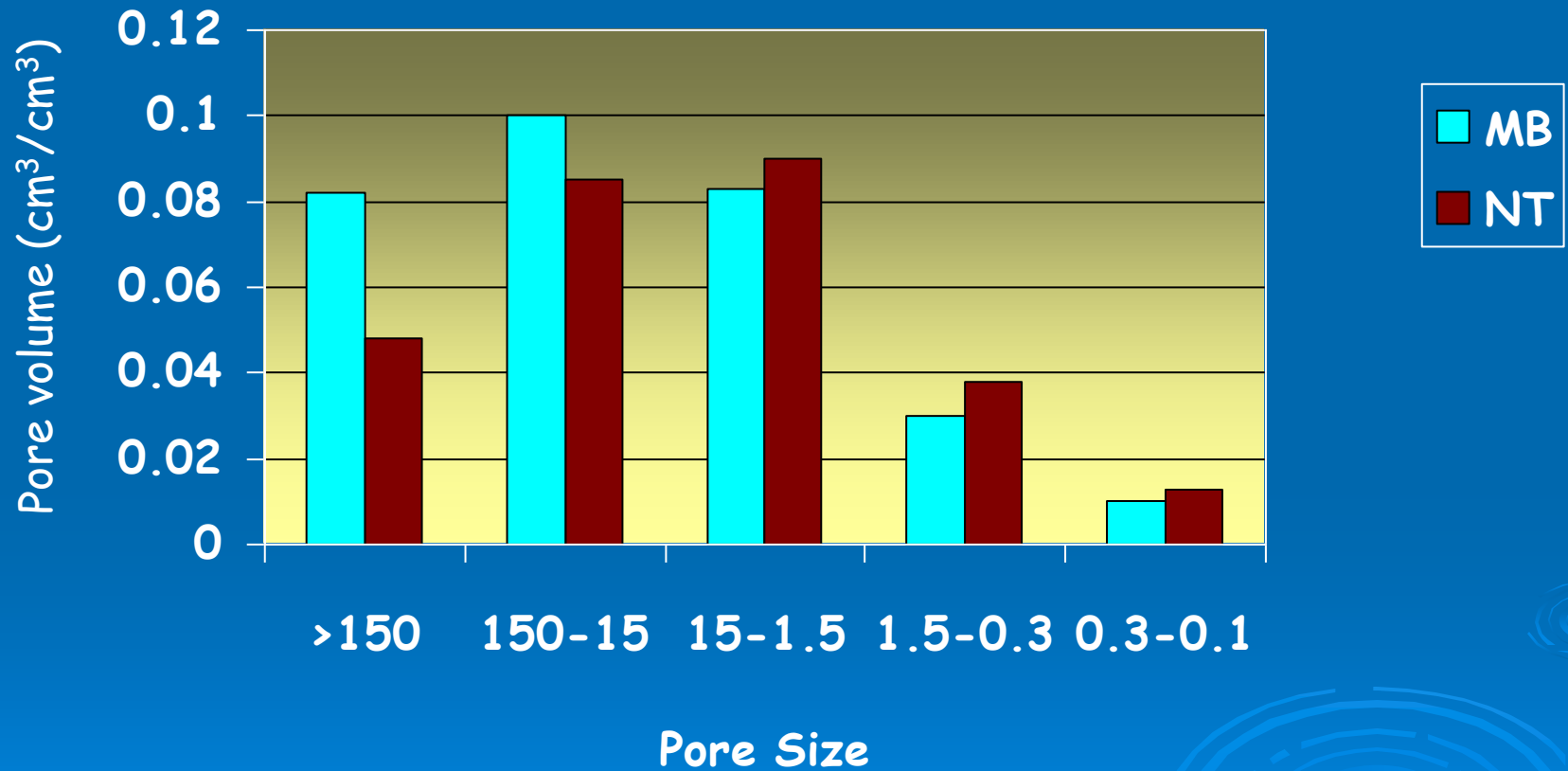
Wolkowski, 2003 (Corn/soybean rotation)

***TILLAGE HAS A PROFOUND
EFFECT ON THE SOIL PHYSICAL
CONDITION***



***TEN BOTTOM MOLDBOARD PLOW
SET AT 11", WOOD CO., WIS.***

EFFECTS OF LONG-TERM TILLAGE ON THE PLOW LAYER PORE SIZE DISTRIBUTION



Hill et al., 1985

AGGREGATE STABILITY

➤ INFLUENCED BY

- **Organic matter and organisms**
- **Texture**
- **Rotation**
- **Tillage**

➤ IMPORTANT FOR:

- **Aeration**
- **Water relations**
- **Productivity (Tilth)**



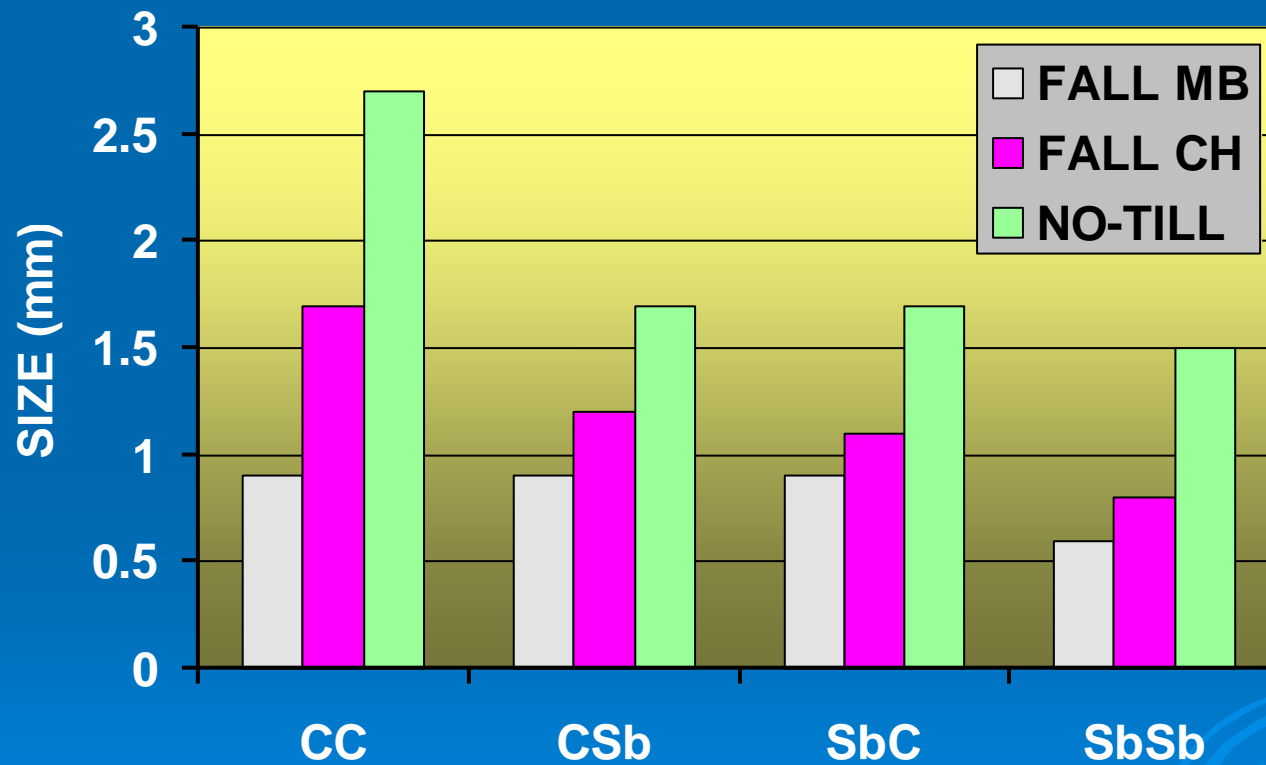
“HEALTHY” CORN ROOT MASS

TILLAGE EFFECTS ON SOIL (0-2 IN.) PROPERTIES AT LANCASTER, WIS.

TILLAGE	STAB. AGGR.	TOTAL C	EARTH WORMS
	%	g/kg	No./m²
No-till	46	24	78
Chisel	34	16	52
Plow	36	11	53

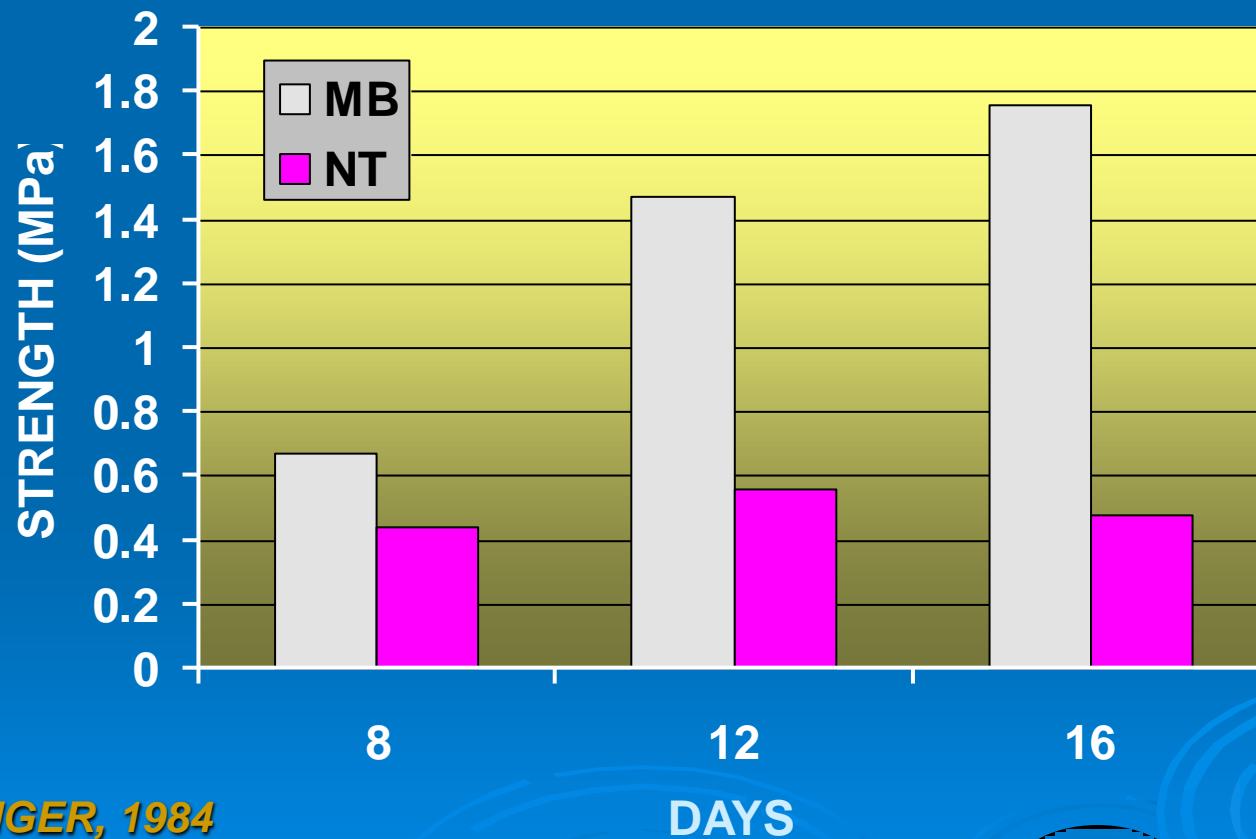
Karlen et al., 1994

WATER-STABLE AGGREGATE SIZE IN THE 0-3 IN. DEPTH AS AFFECTED BY ROTATION AND TILLAGE



Kladivko et al, 1986

EFFECT OF TILLAGE ON CRUST STRENGTH AFTER A HEAVY RAINFALL



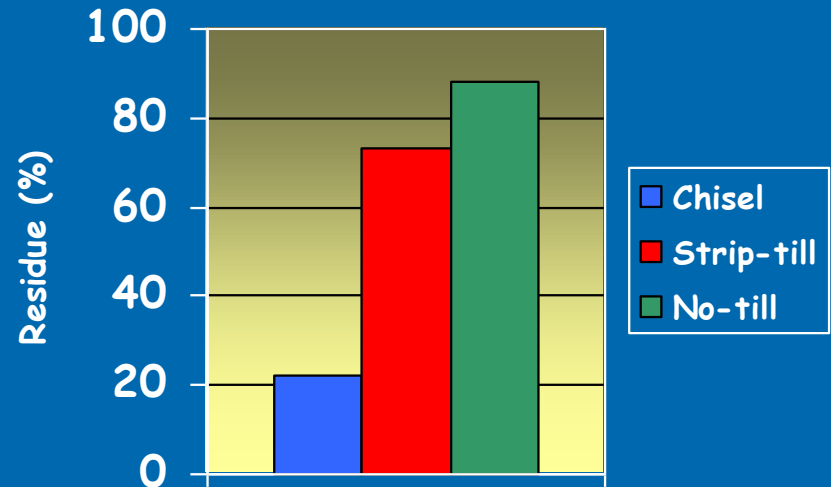
UNGER, 1984

TILLAGE EFFECTS ON SOIL TEMPERATURE

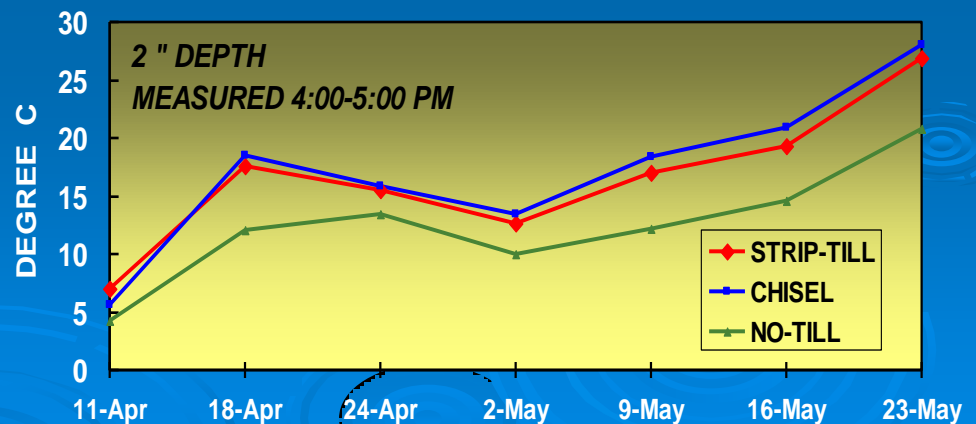
- **Cooler temperatures associated with high residue**
- **Residue buffers temperature change**
- **Emergence and early growth affected**
- **Corn on corn no-till systems have been shown to be 5-10% less productive in Wisconsin**

SOIL TEMPERATURE AFFECTED BY TILLAGE AND CROP RESIDUE

*Effect on crop
residue, Arlington,
1994*



*Effect on in-row soil
temperature,
Arlington, 1994*



Wolkowski, 2000

***STRIP TILLAGE OFFERS
AN ALTERNATIVE TO
FULL-WIDTH TILLAGE***



EFFECT OF TILLAGE ON THE EARLY GROWTH OF CORN, ARLINGTON, WIS.

TILLAGE	EMERGENCE	V6	V12	SILKING
	plt/ft	----- g/plt -----		%
Strip-till	1.6	1.1	28	62
Chisel	1.8	1.1	29	80
No-till	0.7	0.7	18	36

Wolkowski, 2000

TILLAGE AFFECTS BIOLOGICAL ACTIVITY

➤ Cooler and wetter no-till soils

- **Slower residue decomposition**
- **Nutrient immobilization**
- **Greater denitrification potential**

➤ Surface organic material promotes localized biological activity



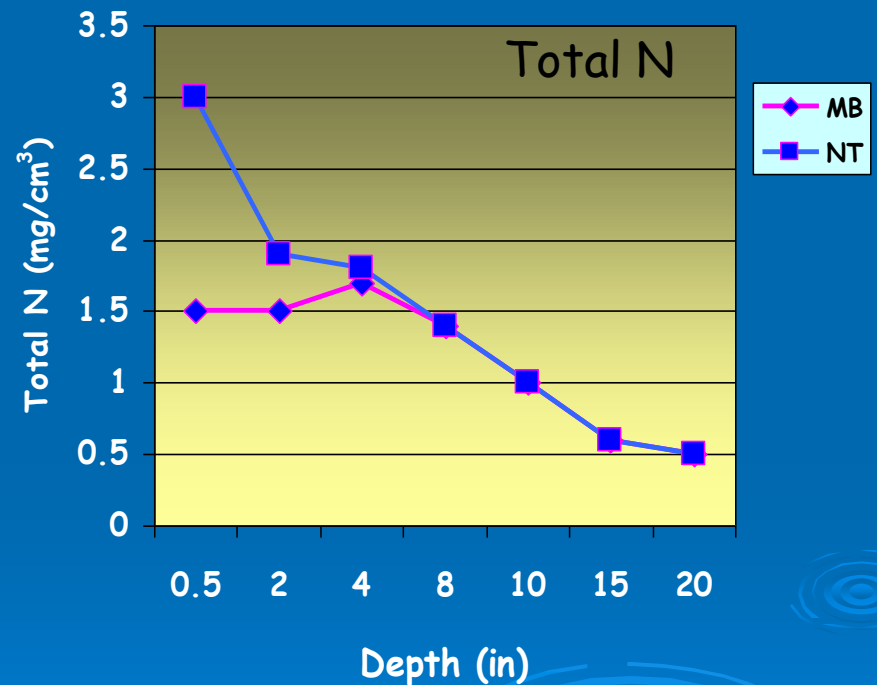
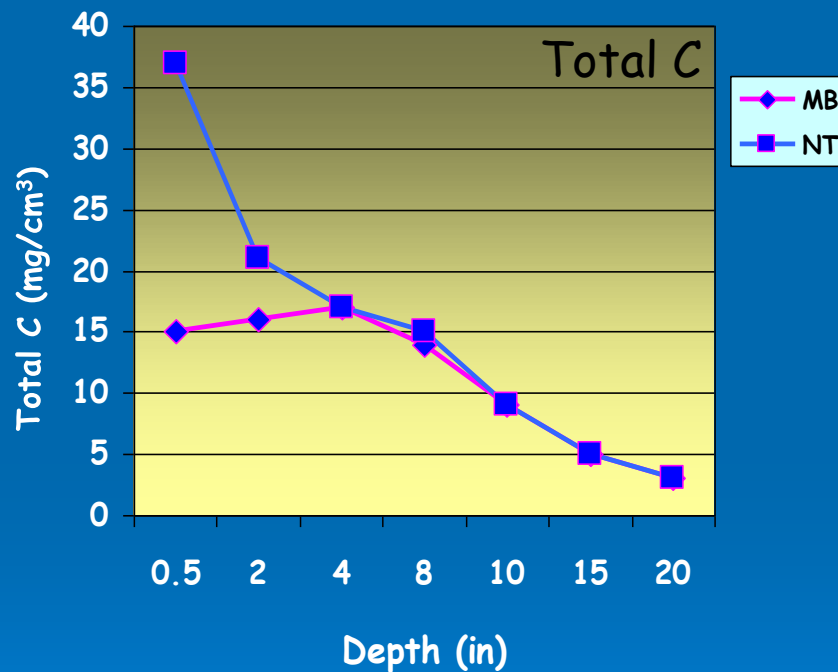
EARTHWORM ACTIVITY GREATER UNDER REDUCED TILLAGE



Midden

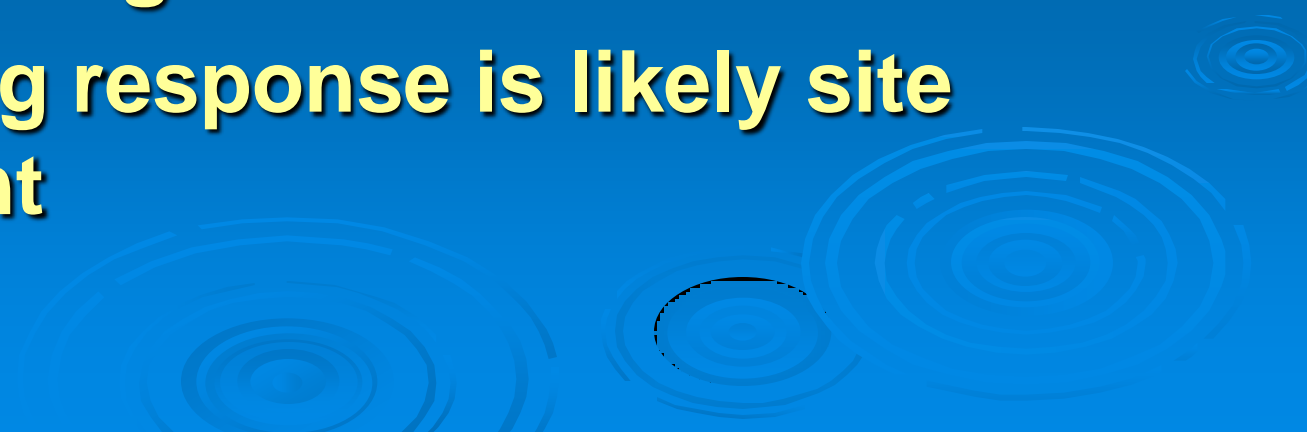


SOIL C AND N DISTRIBUTION AFTER 12 YEARS OF CONTINUOUS CORN



Karlen et al., 1994

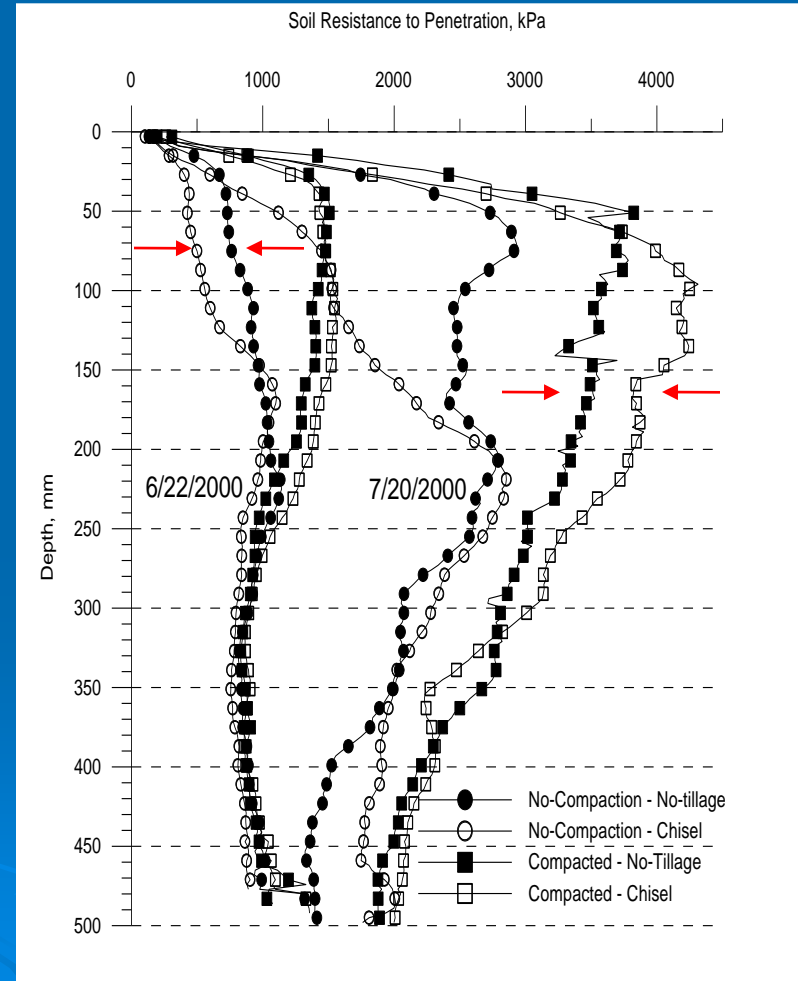
TILLAGE EFFECTS ON SOIL STRENGTH

- **Reduced tillage soils have higher surface bulk density and penetration resistance**
 - **Short-term response to occasional tillage**
 - **Traffic management critical**
 - **Subsoiling response is likely site dependent**
- 

TILLAGE INFLUENCES RESISTANCE TO PENETRATION

- Greater penetration resistance in no-till in top 6" compared to chisel when not compacted
- Compacted chiseled soil has greater resistance than no-till
- Greater penetration resistance when soil is dry
- Compaction effects more distinct in dryer soil dry (36 % vs. 27 %)

Arlington, Plano silt loam





Would these guys be smiling if they really knew how much pressure this grain cart put on the ground ($800 \text{ bu} \times 56 \text{ lb} = 44,800 \text{ lb}$)



Compaction affects the soil

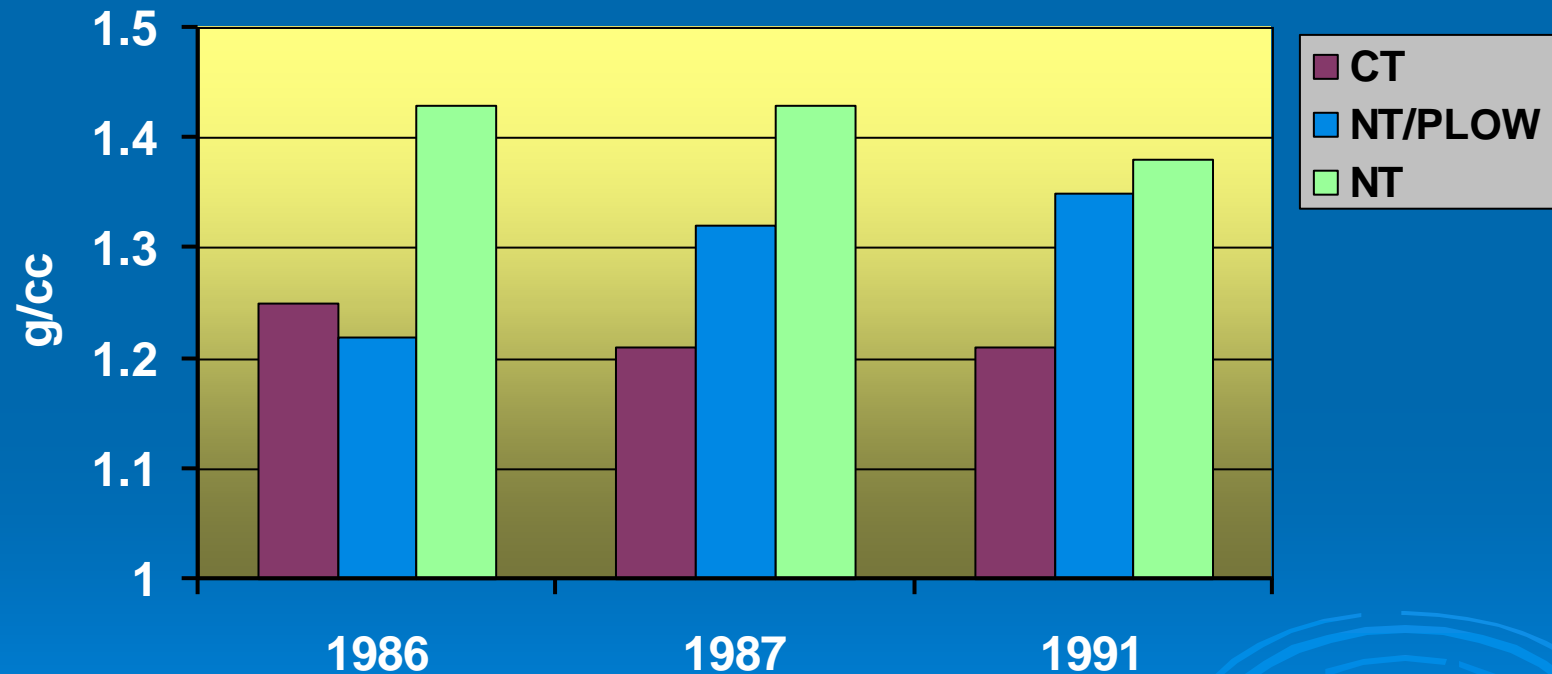
- structure
- porosity
- aeration
- strength

Plant growth affected

- root growth
- nutrient uptake
- water utilization

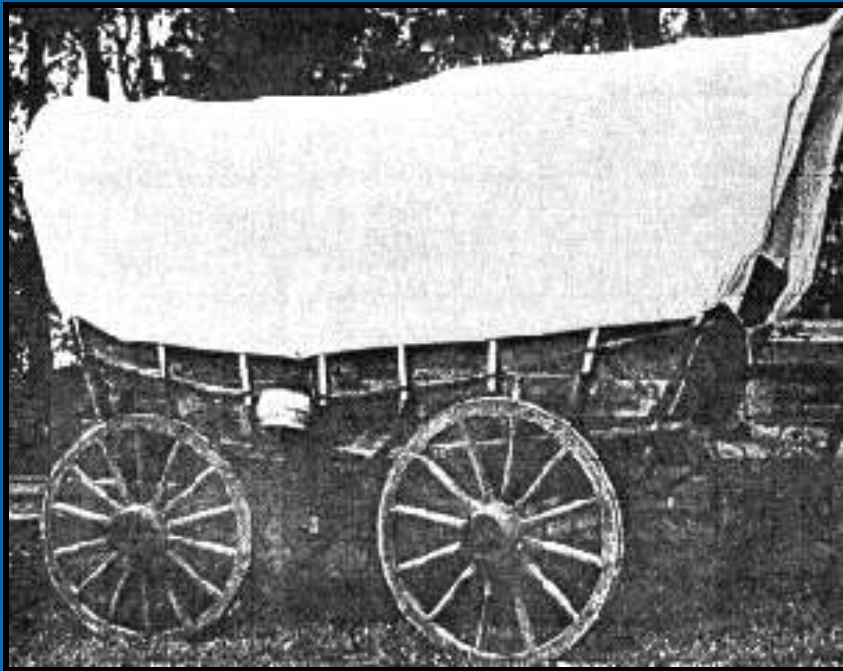


EFFECT OF PERIODIC PLOWING ON SOIL BULK DENSITY (0-3 in.)

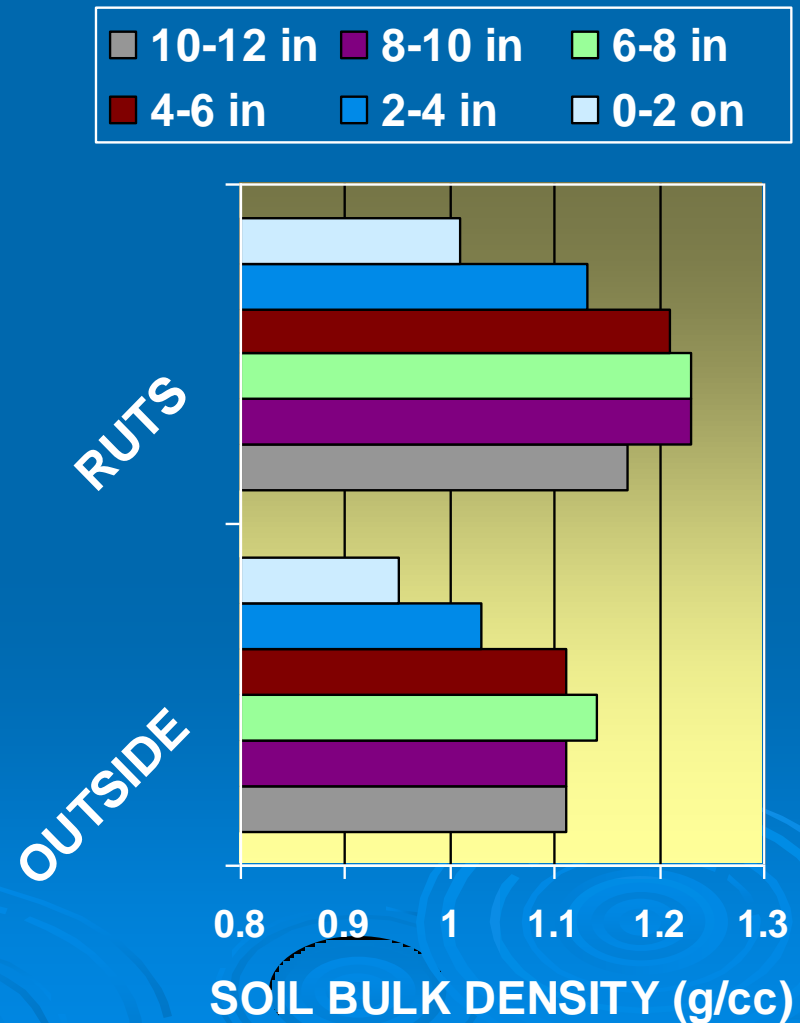


Pierce et al., 1994

PERSISTENCE OF COMPACTION ALONG THE WADSWORTH TRAIL, MINNESOTA



Sharratt et al., 1998



SUMMARY

- **Tillage management can greatly modify soil properties related to soil quality and crop growth**
- **Tillage intensity will impact residue management and soil consolidation**
- **Many physical, chemical, and biological properties are affected**
- **High residue systems need “tweaking” in Wisconsin**
- **Better traffic and tillage management will enhance soil quality and maintain productivity**