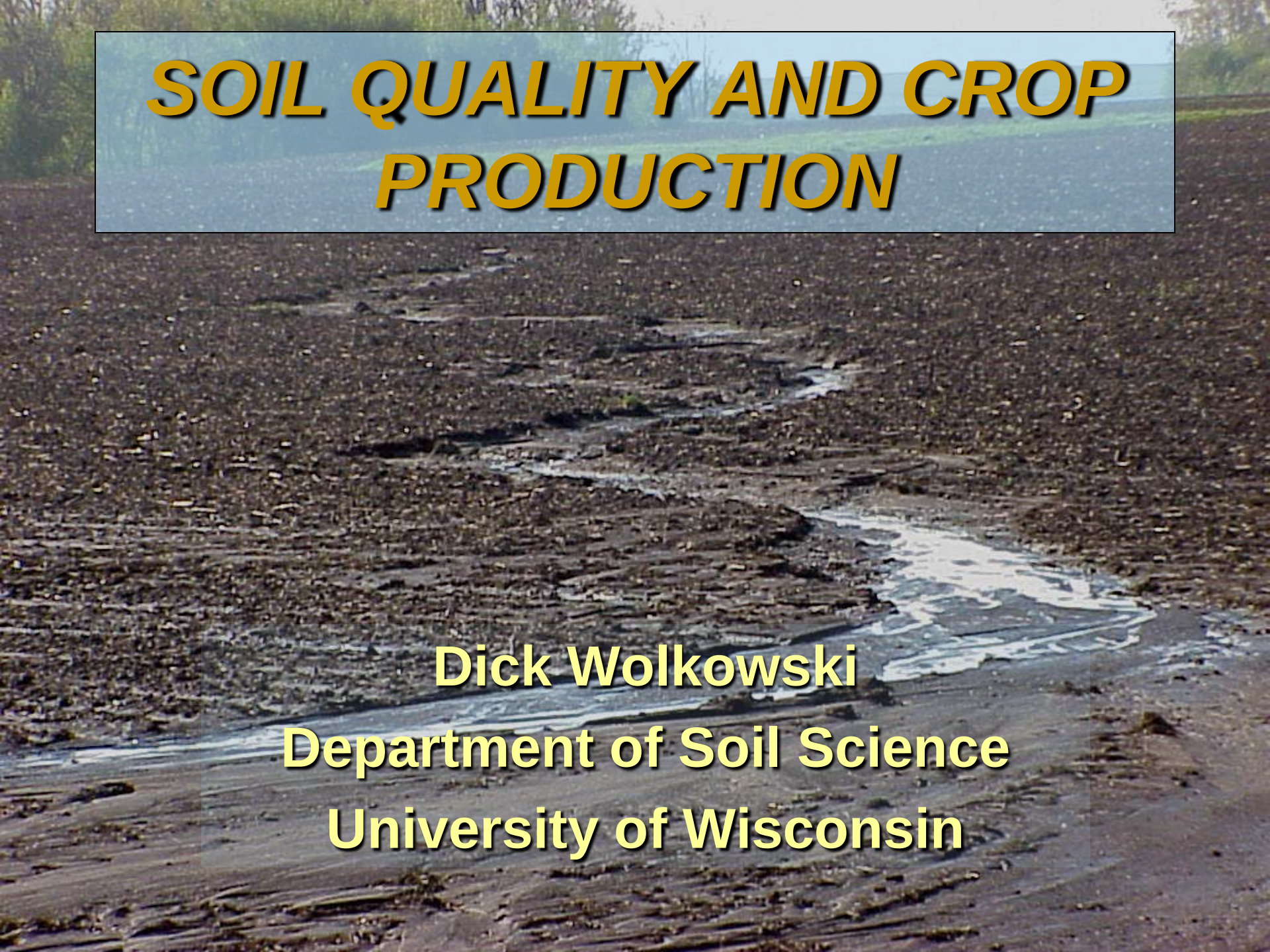
SOIL QUALITY AND CROP PRODUCTION



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WHAT IS SOIL QUALITY

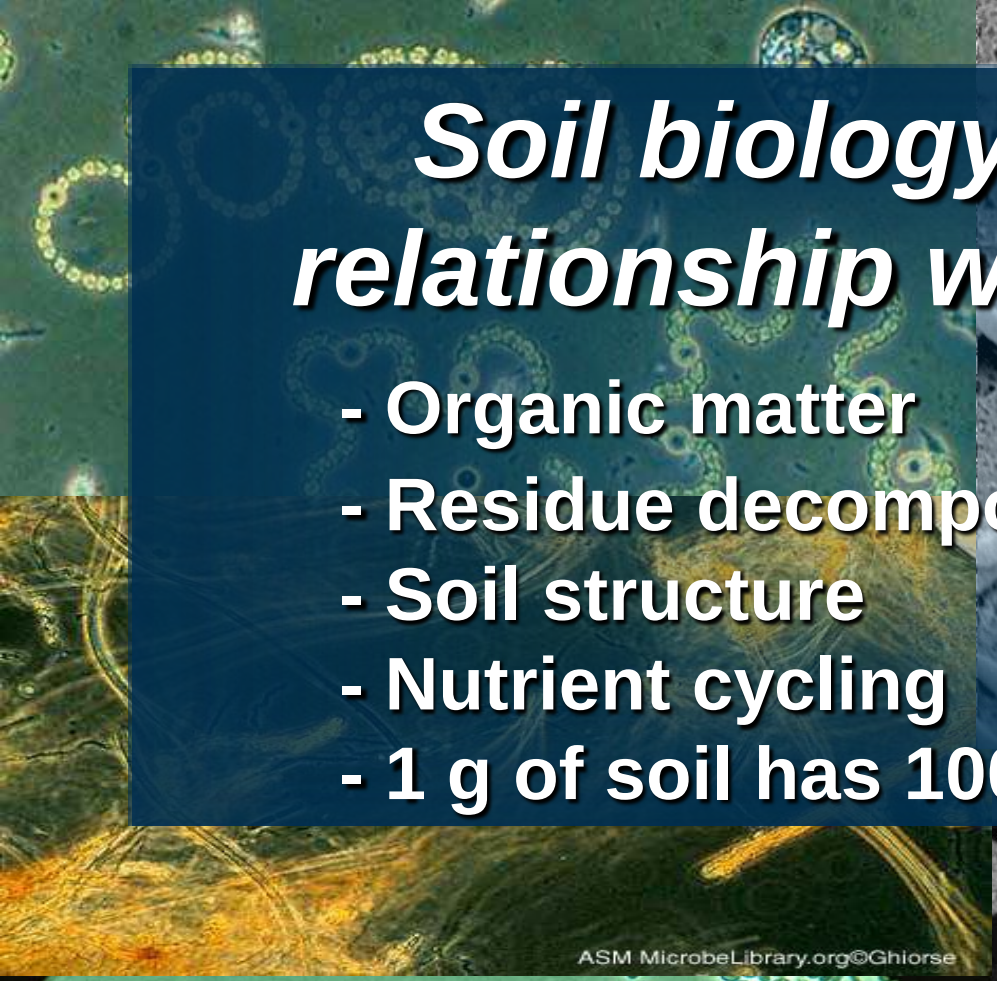
- **DEPENDS ON WHO YOU ARE:**
  - **Farmer: Highly productive, sustainable media for growing crops**
  - **Naturalist: Soil in ecological balance with the landscape and environment**
  - **Homeowner: Substance that offers building foundation, waste disposal, gardening opportunities**

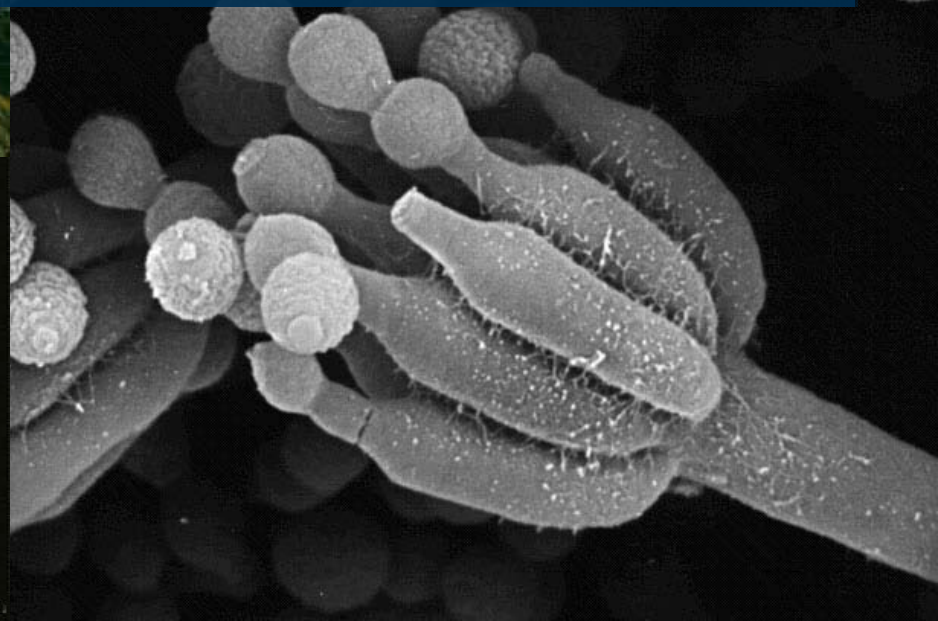
MANY FACTORS AFFECT SOIL QUALITY

- **Inherent properties**
  - Texture
  - Organic matter
  - Aggregation
  - Water holding capacity
  - Drainage
  - Bulk density
  - Topography
  - Climate
- **Management**
  - Tillage intensity
  - Compaction
  - Organic additions
  - Soil test and pH
  - “Artificial” drainage
  - Residue management
  - Microbial activity
  - Salts

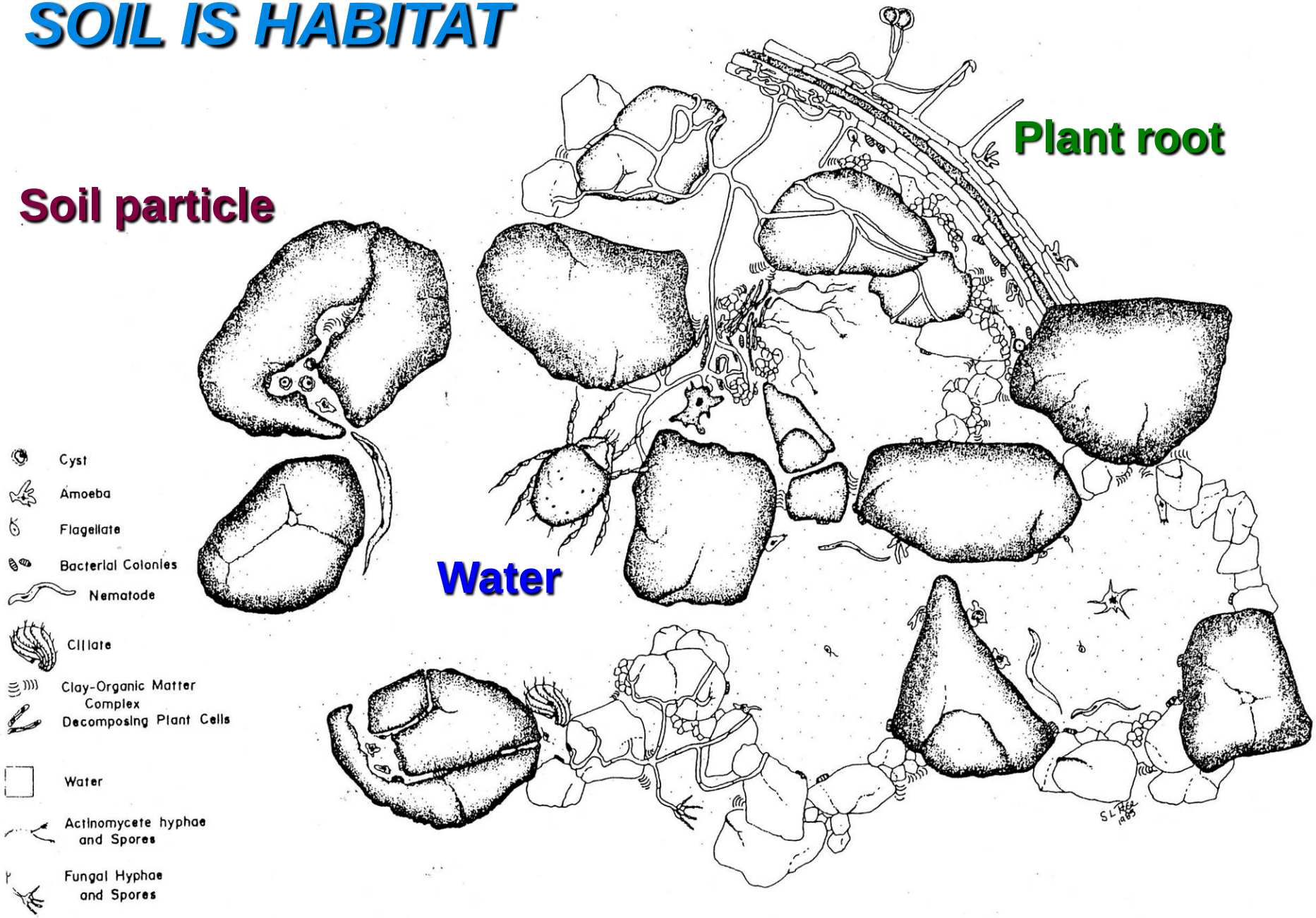
Soil biology: Important relationship with soil quality

- Organic matter
- Residue decomposition
- Soil structure
- Nutrient cycling
- 1 g of soil has 100,000,000 bacteria





SOIL IS HABITAT



AGGREGATE STABILITY IS A COMMON MEASURE OF SOIL QUALITY

- **INFLUENCED BY**
  - Organic matter and organisms
  - Texture
  - Rotation
  - Tillage
- **IMPORTANT FOR:**
  - Aeration
  - Water relations
  - Productivity (Tilth)

TILLAGE AFFECTS SOIL PROPERTIES RELATED TO SOIL QUALITY

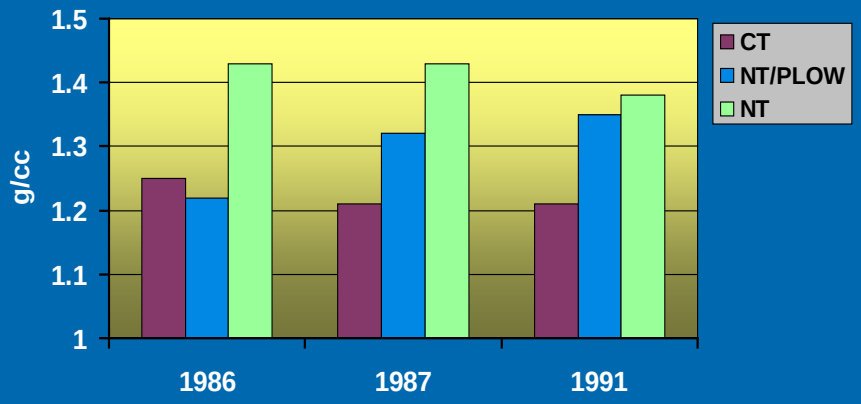
- Crop residue cover
- Soil test measurements
- Nutrient availability
- Structure and aggregate stability
- Water relationships
- Temperature
- Soil biology
- Compaction

SURFACE CROP RESIDUE INTERACTS WITH OTHER FACTORS

- Erosion
- Soil temperature
- Conserves moisture
- Soil physical properties
- Carbon and nutrient cycling

TILLAGE EFFECTS ON SOIL STRENGTH

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



Effect of periodic plowing On soil bulk density (0-3 in.) Pierce et al., 1994

COMPACTION AFFECTS SOIL QUALITY

Compaction affects the soil
- **structure**
- **porosity**
- **aeration**
- **strength**

Plant growth affected
- **root growth**
- **nutrient uptake**
- **water utilization**

SOIL FERTILITY LINKED TO ATTEMPTS TO IMPROVE SOIL QUALITY

N AVAILABILITY IS DECREASED IN REDUCED TILLAGE:

- **Lower and slower mineralization**
- **Greater immobilization**
- **Volatilization of ammonia from surface urea and urea-containing materials**
- **Potential for increased denitrification**
- **Higher supplemental N rate for >50% corn residue recommended (30 lb N/a)**

TEN FACTORS FARMERS CONSIDER IMPORTANT MEASURES OF SOIL QUALITY

1. Organic matter
2. Crop appearance
3. Earthworms
4. Erosion
5. Tillage ease
6. Drainage
7. Soil structure
8. Soil pH
9. Soil test P and K
10. Yield

ASSESSING SOIL QUALITY

- **OFTEN SUBJECTIVE:**
  - Soil Health?
  - Smell, feel, look, taste?
  - Soil Quality Index
- **MORE QUANTITATIVE**
  - Chemical
    - pH, O.M., nutrients
  - Physical
    - Structure, bulk density
  - Biological
    - Respiration, microbial biomass
  - Integrate factors into an index

Soil Quality Assessment Worksheet

Pennsylvania

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

A SOIL MANAGEMENT ASSESSMENT FRAMEWORK

(Andrews et al., 2004)

- **THREE STEP PROCESS**
  - Indicator selection
  - Indicator interpretation
  - Integrate into a SQ Index
- **SPECIFICATIONS**
  - Indicators must relate to soil function and be sensitive to management
  - Must be applicable over a range of soils and climate
  - Represent soil chemical, physical and biological properties
  - Can be applied to a number of land uses

Whistling Straits – 9th Green

INDICATOR SELECTION DEPENDS ON MANAGEMENT GOAL

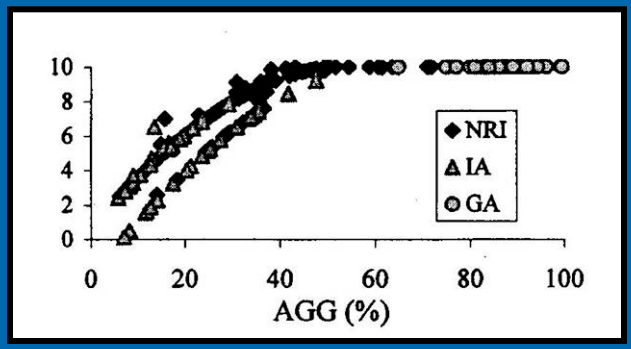
(Select four to eight)

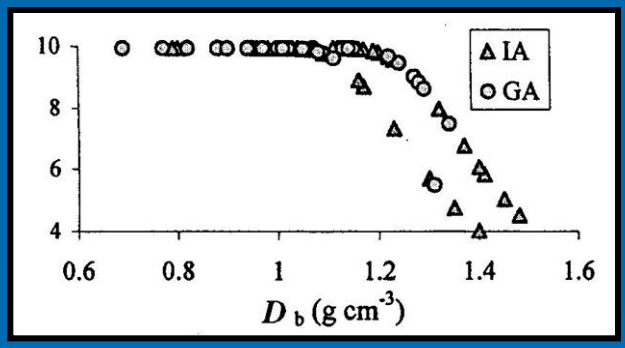
AGRICULTURAL MANAGEMENT GOAL		
Crop Production	**Waste Recycling**	**Environmental Protection**
Soil pH	Soil organic C	Slope
Crop residue	Drainage	Soil Test P
Tillage intensity	Microbial activity	Soil metal content
Soil test P and K	Texture	Texture
Water availability	Depth to restriction	Drainage
Bulk density	Aggregate stability	Landscape position

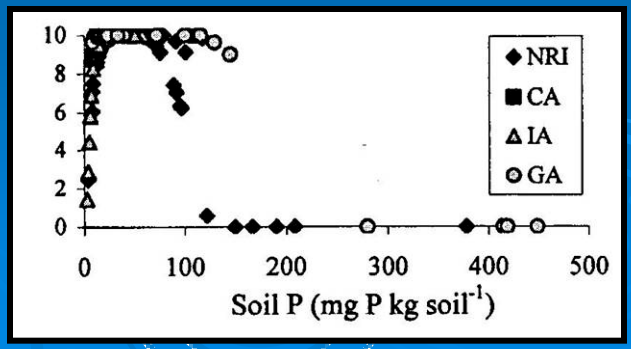
INDICATOR SCORING MODELS

- Indicator score from research based algorithms
- Relatively similar over soils and climates
- Soil Quality Index

$$SQI = \frac{\text{Sum Scores}}{n} \times 10$$

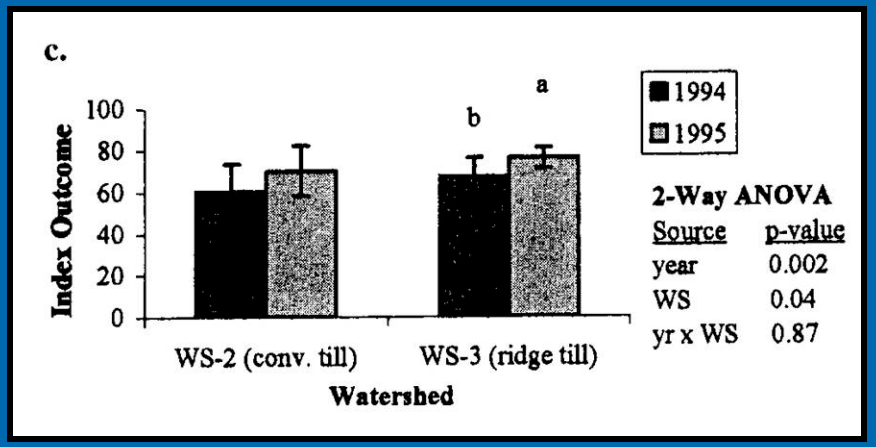






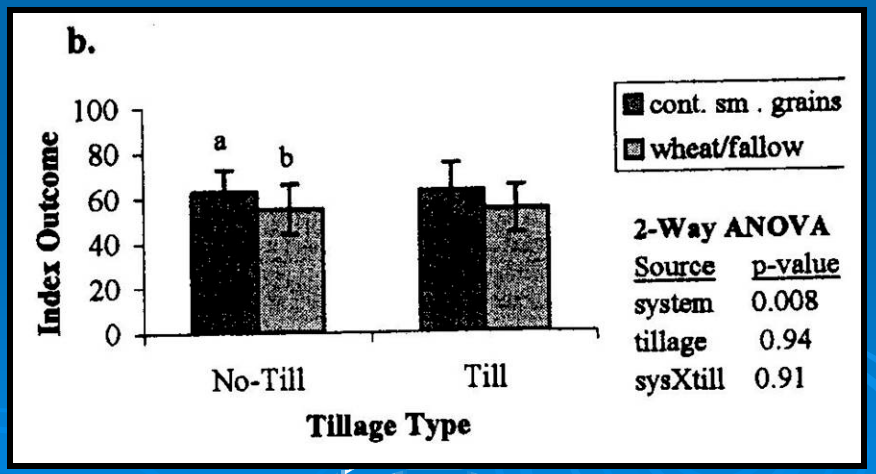
Andrews et al., 2004

EXAMPLE SOIL MANAGEMENT ASSESSMENT FOR SELECTED CASE STUDIES



Effect of tillage management in two Iowa watersheds

Effect of tillage management in SE USA



Andrews et al., 2004

SOIL QUALITY CONCEPTS ARE BEING INTEGRATED INTO CONSERVATION PLANNING BY NRCS

- **Soil Conditioning Index (SCI)**
  - Model that predicts the impact of adjusting rotation, tillage, and other management on soil organic matter
  - Assumes SOM is a major indicator of soil quality
  - Impacts erosion and is related to C sequestration
  - Calculated within RUSLE2
  - Scaled from -2 to +2
  - Goal is to plan to increase SCI

CONSERVATION PLANNING IS CHANGING

- Going are the days of measuring residue
- Soil Tillage Intensity Rating (STIR)
  - Reflects the impact of tillage type, operation speed, traffic management, depth, rotation, percent of surface disturbed
  - Calculated within RUSLE2
  - Lower STIR values = reduced soil erosion
  - Values range between 0 and 200
  - Typical no-till at 30 or less
  - Some “imbedded” credit for energy savings

CSP PROGRAM USES SCI AND STIR

Examples

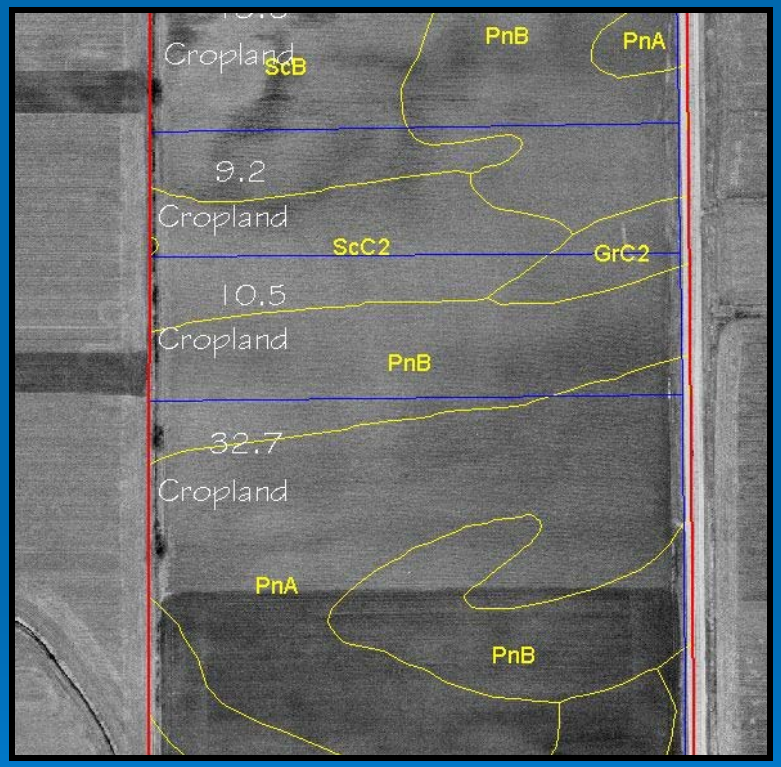
$1.16/a increase in cost-share for every 0.1 increase in the SCI in selected Wis. watersheds

- **2006 – Lake Dubay (NC Wis.)**
  Grant/Maquoketa (SW Wis.)
- **2005 – Duck Creek/Pensaukee (NE Wis.)**
  Crawfish (SE Wis.)
  Kishwaukee (Mostly in Illinois)
- **2004 – Lower Chippewa (WC Wis.)**

Other states

Up to $2.00/a in Colorado for low STIR values, double if using auto-steering

SOIL QUALITY PARAMETERS AND YIELD, GREEN LAKE COUNTY, WIS., 2005

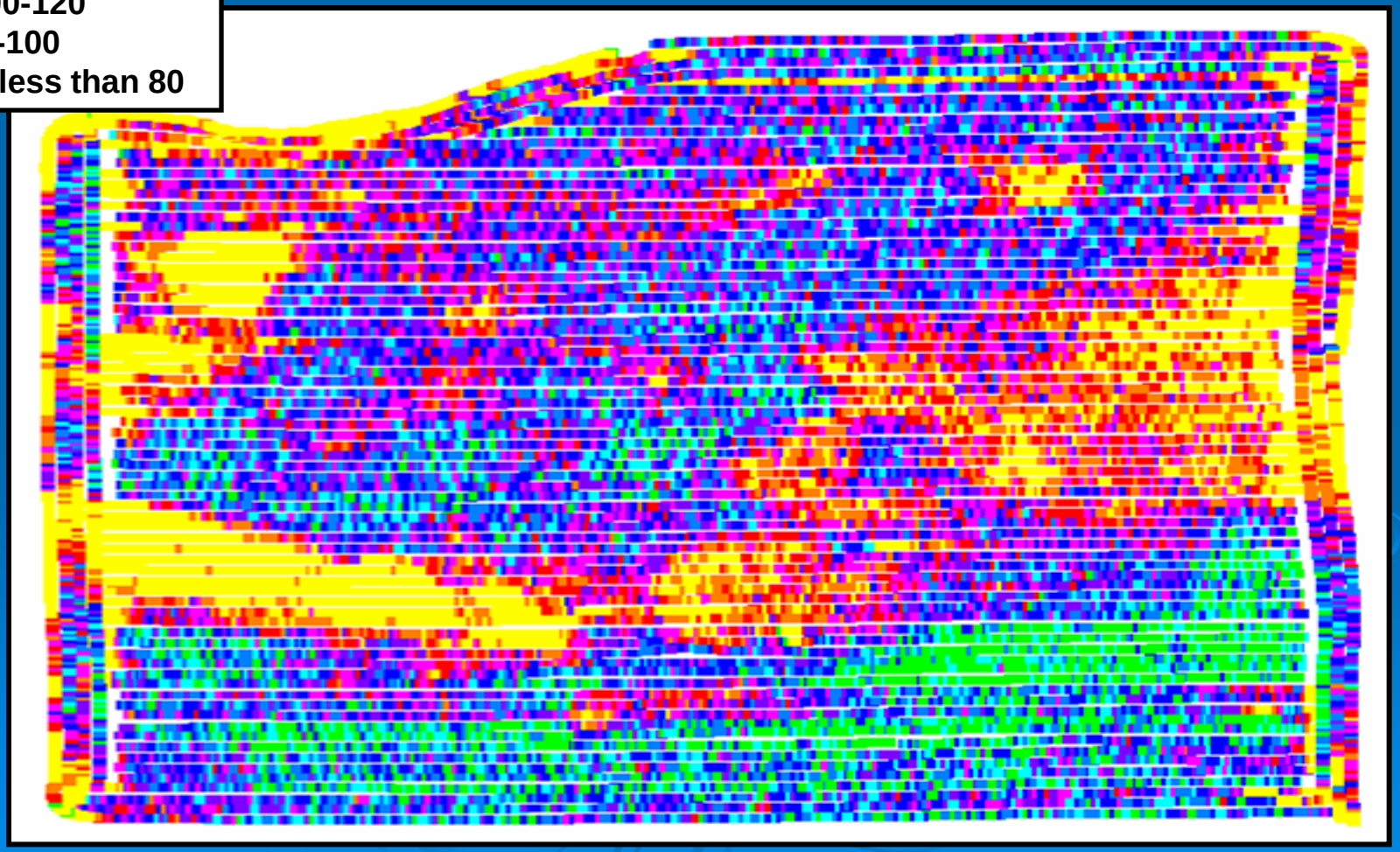


Soil map for field

Aerial view of field Sep. 2005

SOIL QUALITY PARAMETERS AND YIELD, GREEN LAKE COUNTY, WIS., 2005

Green = > 160
Light Blue = 150-160
Darker Blue = 120-140
Pink = 100-120
Red = 80-100
Yellow = less than 80



SUMMARY

- Soil quality is a reflection of inherent soil properties and management
- Agricultural practices such as tillage, vehicle traffic, manure application, crop rotation affect soil quality
- The assessment of soil quality can be subjective, but quantitative methods are available
- Future government programs recognize soil quality and will pay based on enhancement
- Improve traffic and tillage management and manage SOM to enhance soil quality