Residue and Nutrient Management Under Reduced Tillage Systems

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OUTLINE

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   B. Development of No-Tillage
2. Soil Property Changes Caused by No-Tillage
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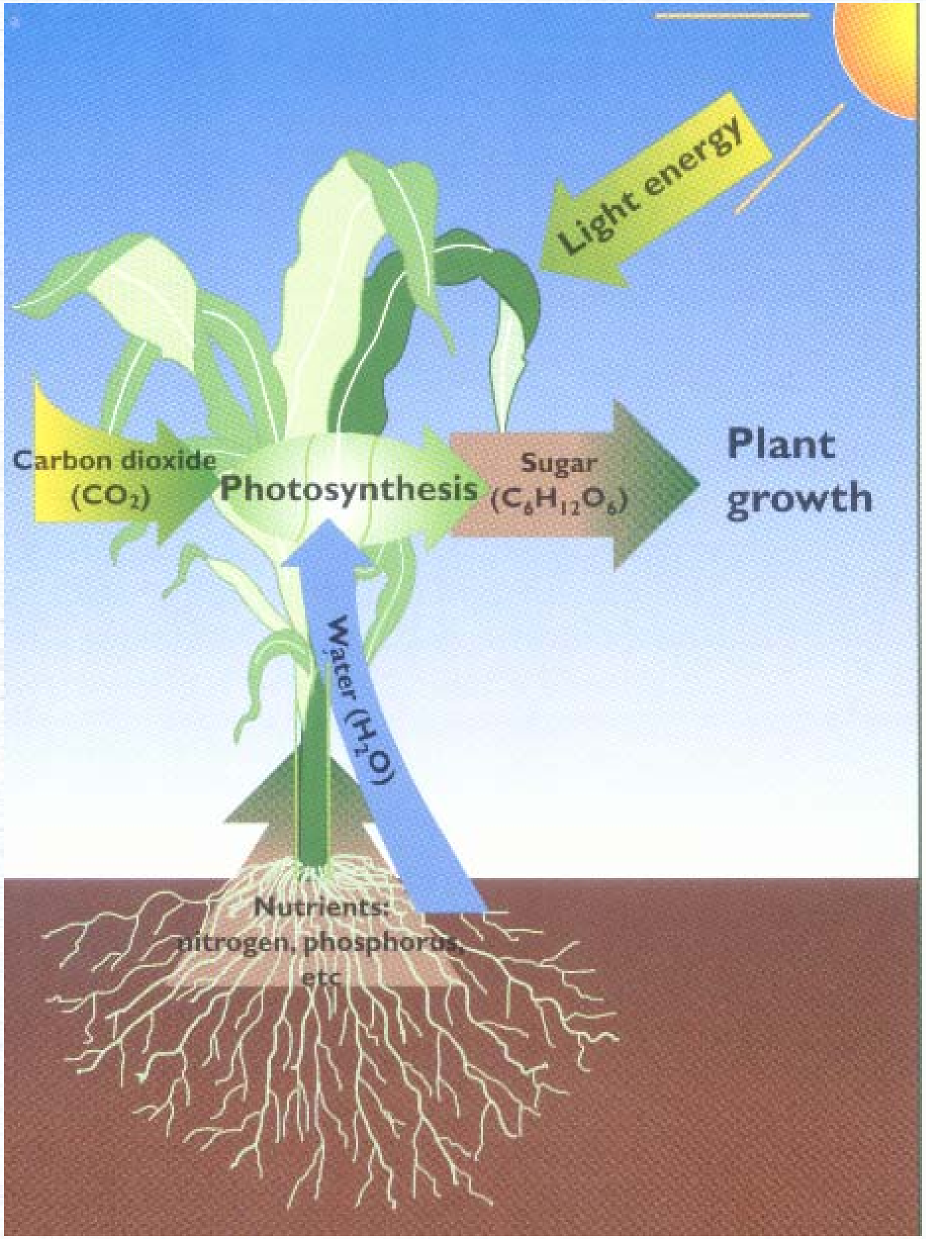
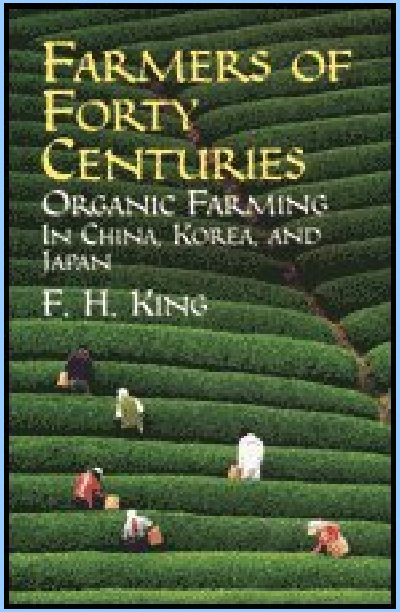


Cavigelli M.A., S.R. Deming, L.K. Probyn and R.R. Harwood (Eds.). 1998. Michigan Field Crop Ecology: Managing Biological Processes for Production and Environmental Quality. Extension Bulletin E-2646, Michigan State Universit Extension, East Lansing, MI. 92 pp.

Introduction
Historic Uses and Management of Residues

Historic Uses of Crop Residues

1. Animal feed
2. Animal bedding
3. Domestic fuel
4. Construction
5. Improving Soil Properties



Soil Benefits of Residues

1. Increased biological activity
2. Reduced release of carbon gases
3. Reduced soil erosion
4. Higher soil moisture
5. Moderates soil temperatures
6. Decreased soil compaction

Soil Problems Associated with Residues

1. Colder temperatures
2. Reduced seed germination
3. Increased levels of diseases
4. Increased levels of pests
5. Allelopathic activity
6. Poor performance of planting equipment

Burning of Residues in the Field

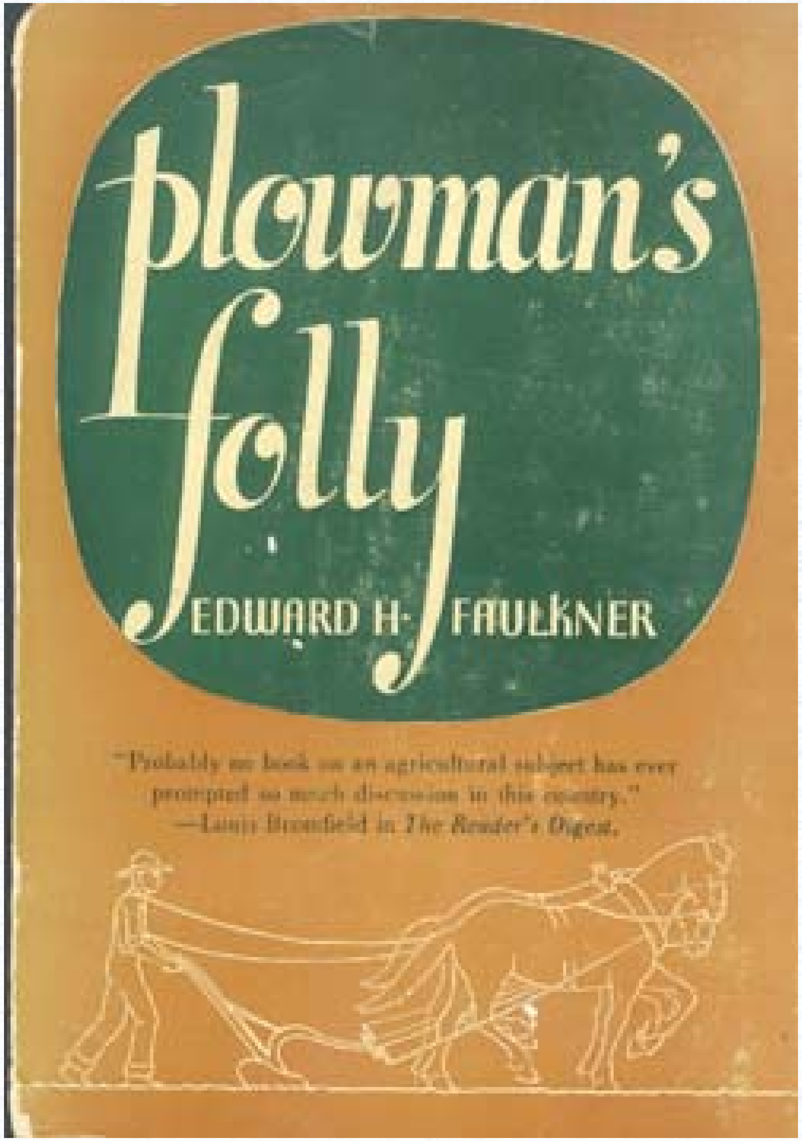
Burying Residues by Tillage

http://www.maes.msu.edu/ressta/saginawvalley/Pic_Tour/plowing.htm

Introduction
Development of No-Tillage

History of Tillage

Tillage has been considered synonymous with agriculture



"Briefly, this book sets out to show that the moldboard plow which is in use on farms throughout the civilized world, is the least satisfactory implement for the preparation of land for the production of crops……

The truth is that no one has ever advanced a scientific reason for plowing."

University of Oklahoma Press (1943)

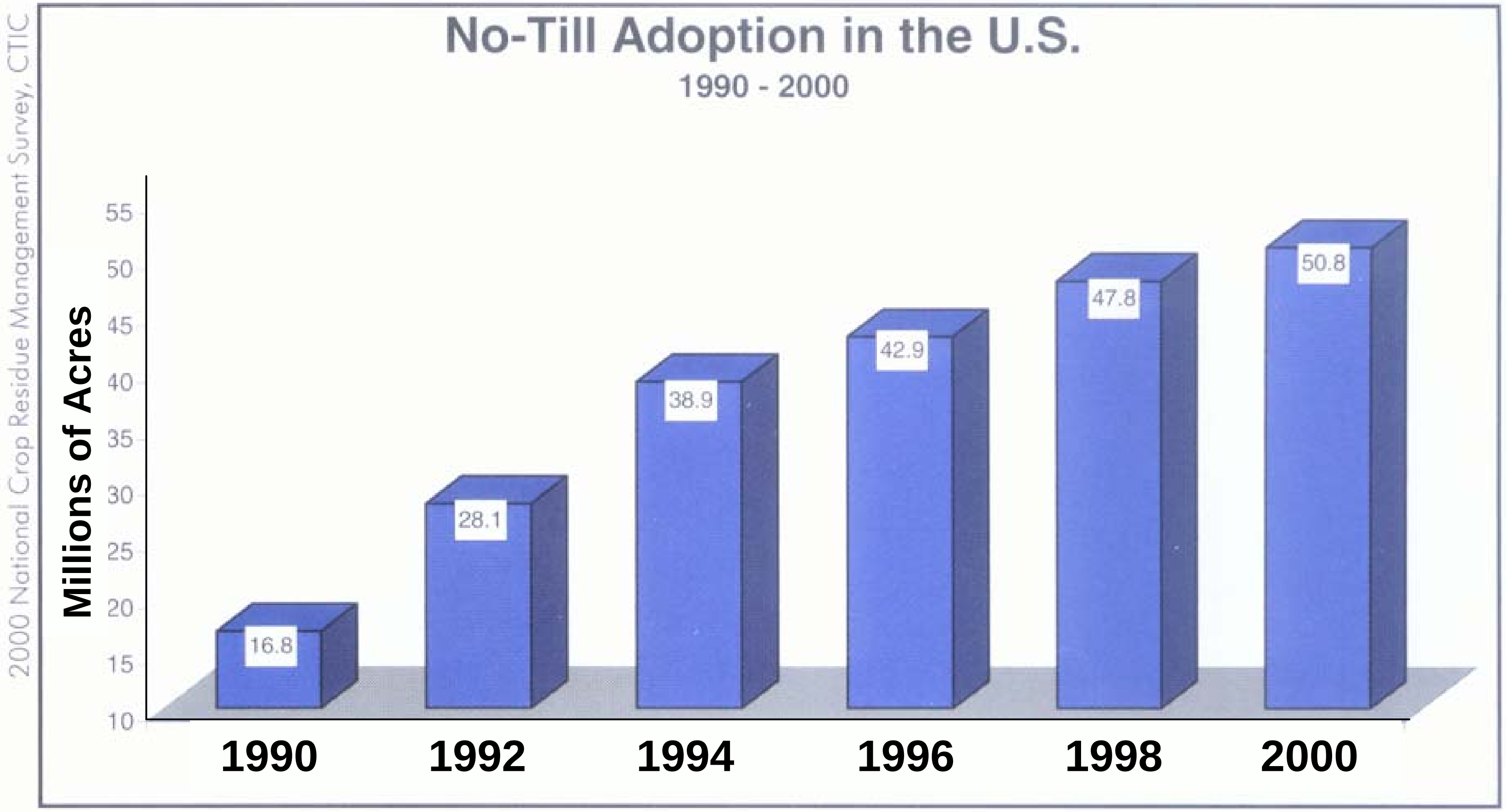
The Triplett - Van Doren Long Term Tillage Plots
Wooster, Ohio
1962 - 2002


TRIPLETT - VAN DOREN
NO-TILLAGE EXPERIMENTAL PLOTS

Agriculture without Tillage

Within a few years much of the cropland in the U.S. will be planted without a moldboard plow. In most conditions planting without tillage (but with herbicides) can save labor, energy, water and soil.

(Glover B. Triplett and David M. Van Doren, Jr. 1977. Scientific American, 236:2833)



More than 50 million acres were planted using no-tillage systems in 2000, up from less than 17 millions acres in 1990.

The numerous benefits of NT over CT should result in NT rapidly being implement in all of the major agricultural areas in the United States……..

but this has not occurred as foreseen in the early 1980s.

Martens, D.A. 2001 Nitrogen cycling under different soil management systems. Advances in Agronomy 70:143-192.

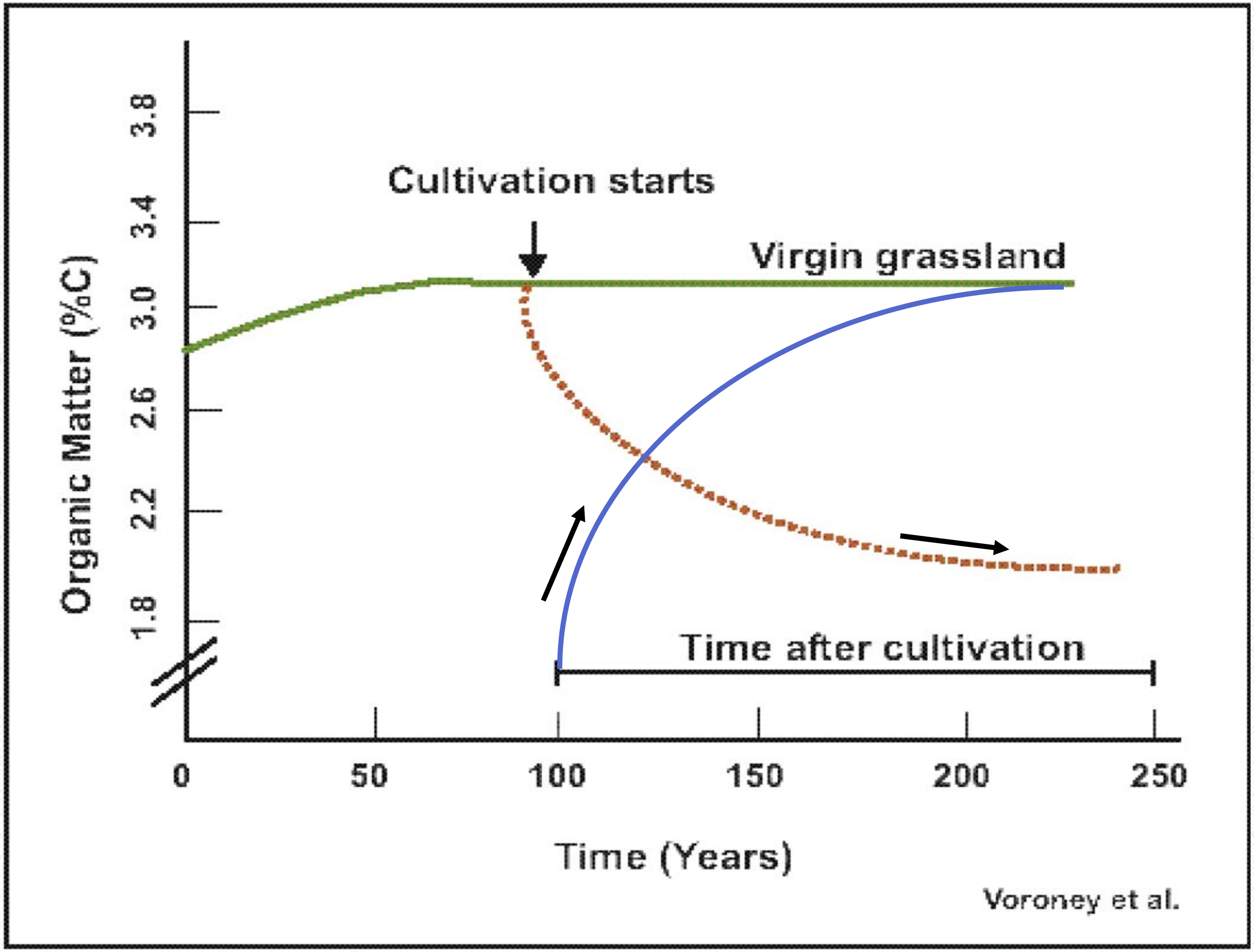
Objectives

1. To review nutrient management as affected by tillage and residues.
2. To identify the role of Dr. Martens in advances made in our under standing of the above.
3. To propose solutions and research needs.

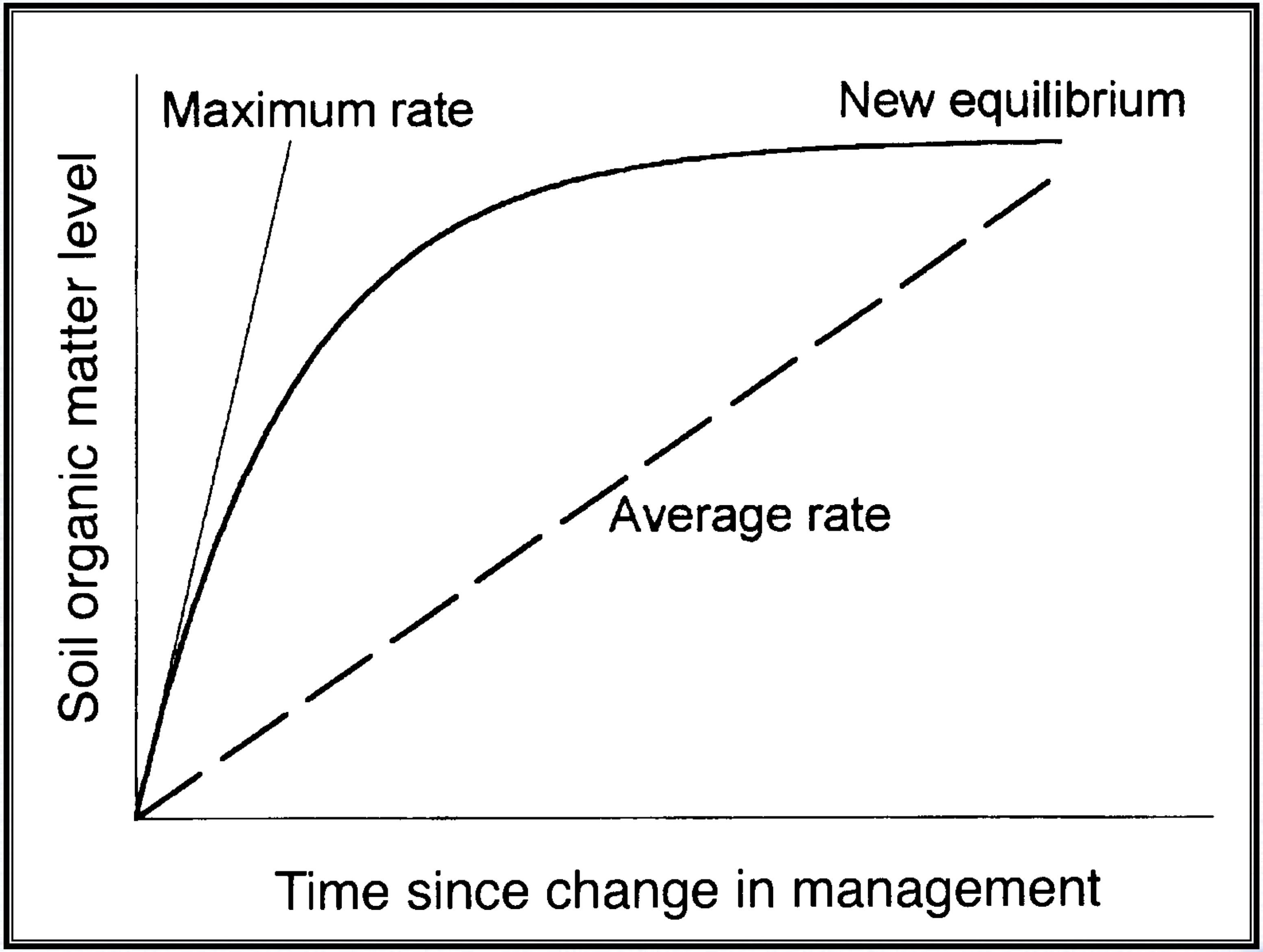
Soil Property Changes


Soybean after Corn


Cotton after Wheat



Cultivation starts
Virgin grassland
Organic Matter (%C)
3.8
3.4
3.0
2.6
2.2
1.8
Time after cultivation
0
50
100
150
200
250
Time (Years)
Voroney et al.



Maximum rate
New equilibrium
Soil organic matter level
Average rate
Time since change in management

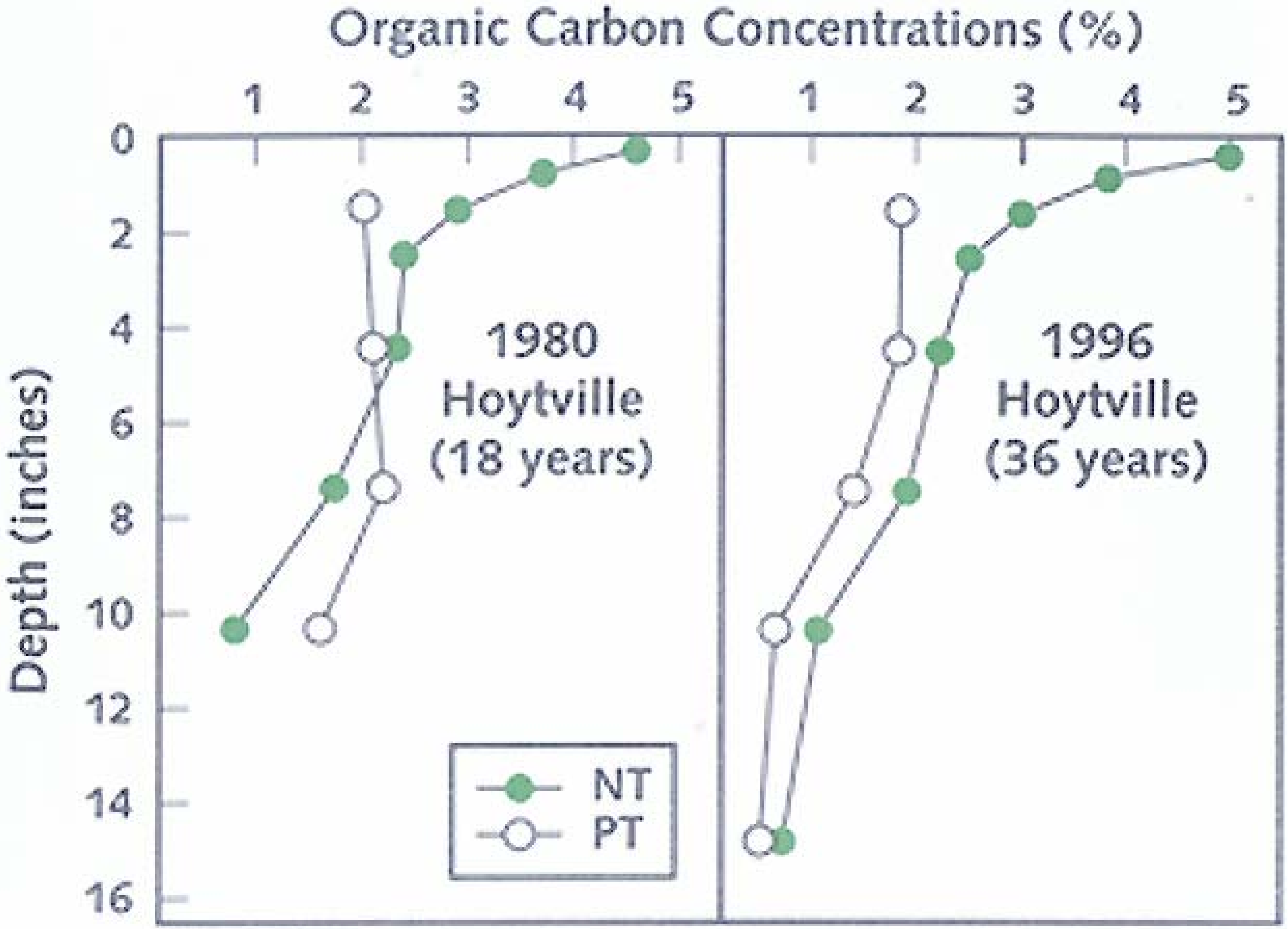
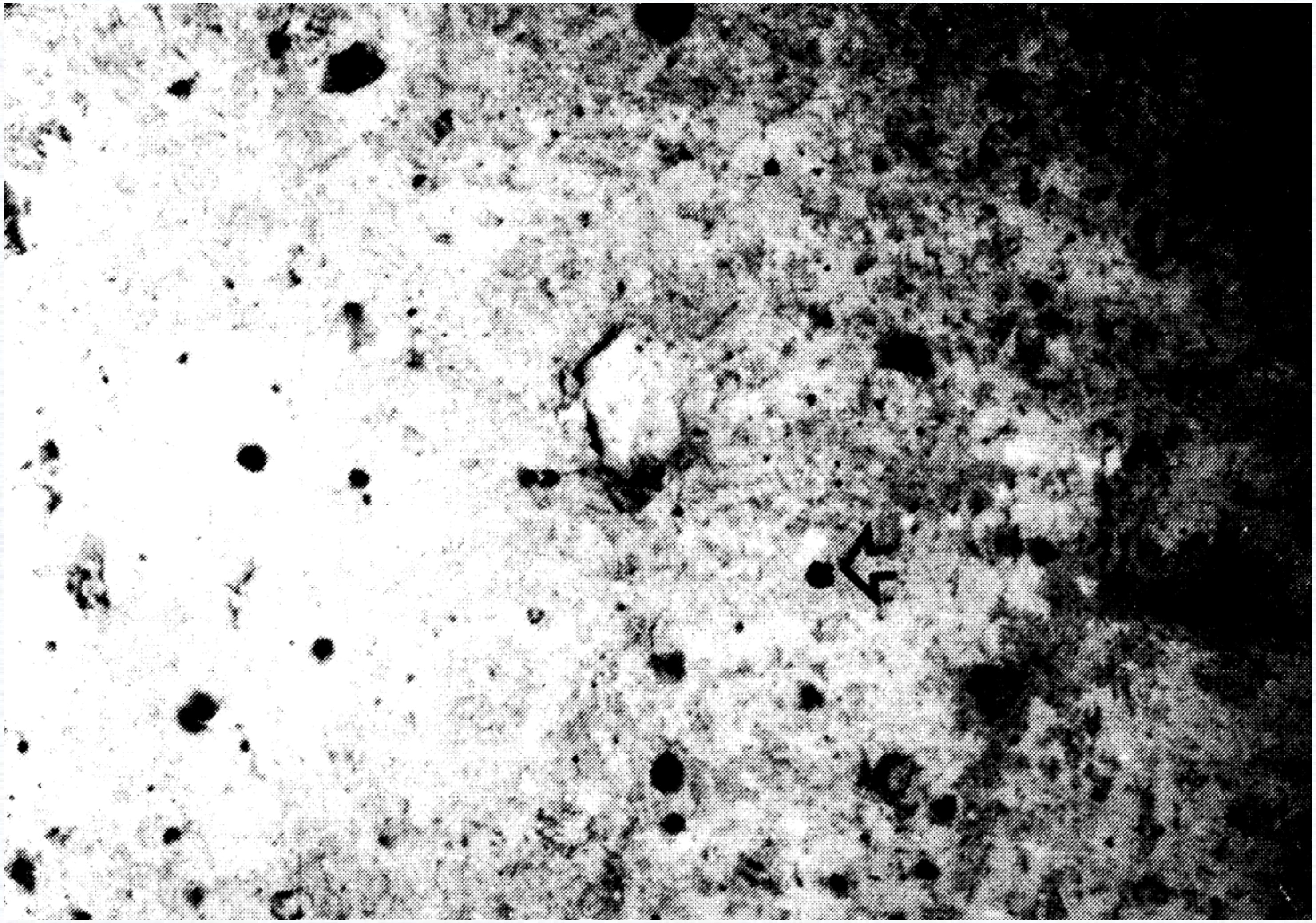

Organic Carbon Concentrations (%)
1
2
3
4
5
1
2
3
4
5
Depth (inches)
0
2
4
6
8
10
12
14
16
1980
Hoytville
(18 years)
1996
Hoytville
(36 years)
NT
PT

Table 4. Interaction of soil type and tillage on total and available P concentrations (from Dick and Daniel, 1987).

Soil	Tillage	Total P†	Available P‡
		mg kg^{-1}	
Typic Fragiudalf			
(Wooster soil)	Conventional	580	45
	No-till	609	160
Mollic Ochraqualf			
(Hoytville soil)	Conventional	867	38
	No-till	868	282

† Total P concentration in the 0 to 30 cm soil layer.

‡ Available P concentration in the 0 to 7.5 cm (conventional tillage) or the 0 to 1.25 cm (no-tillage) soil layers.



Development of Macropores in No-tillage Soils

Nutrient Cycling and Transport Interactions with Tillage

2006 Observation

Over the past 10 years, Lake Erie tributary loading data shows that dissolved reactive phosphorus, both in concentration and loading, is increasing dramatically in streams tributary to Lake Erie. Levels are almost back to what they were in the 1980's, and concentrations and loadings in ag watersheds go up during storm events - not at low flow.

Photographs from Martin Shipitalo, USDA, Coshocton.

Photographs from Martin Shipitalo and Jennifer Smeltzer
USDA, Coshocton.

"Numerous observations have suggested that there are significant differences between NT and CT soils with regards to soil N transformations and fate of fertilizer N."

Martens, D.A. 2001 Nitrogen cycling under different soil management systems. Advances in Agronomy 70:143-192.

Microbial Biomass

No-tillage yields a larger microbial biomass pool (but smaller size as a percent of total organic C) compared to more intensive tillage systems. Also, NT creates a more stable, less fluctuating microbial biomass.

Fungal populations are favored under NT due to extensive hyphal networks that can bridge between soil moisture, N and residue C.

Nitrogen Cycling

Tillage is one of the greatest contributors of N leaching to surface and ground water and the practice of row crop culture must be altered to maximize the use of residual and applied N.

Conservation tillage, especially NT, has the greatest potential to limit nutrient pollution to water supplies because NT has slower N mineralization and greater N retention due to more efficient N cycling when compared with tilled systems.

Nitrogen Cycling

Nitrification rates are slower in NT compared to tilled soil due to the low nitrate to ammonium ratio.

Immobilization is the competition between plants and microorganisms. Plants heavily assimilate nitrate and microbes assimilate ammonium.

Nitrogen Cycling

In long-term CT systems, C can become limiting, speeding the release of N and limiting N immobilization. Under NT, N become the limiting factor for nutrient cycling due to high rates of N immobilization.

No-tillage may increase the potential for denitrification compared to CT, but the actual amount of N lost is a small portion of the N balance. The low nitrate levels under NT limit the denitrification potential under NT.

Nitrogen Cycling

Low fertilizer N use has been frequently observed when ammonium based fertilizers, (such as urea, urea blends and ammonium sulfate), are directly applied to the surface of NT soils.

Surface residue accumulation under NT systems has been found to increase the activities of urease enzyme three- to four-fold when compared to CT systems.

Nitrogen Cycling

Overcoming reduced nutrient availability during early season crop growth is one of agriculture's greatest challenges for improving NT performance. The competition for applied and mineralized soil N between N immobilizers, nitrifiers, and plants is increased when crop residues are stratified on the soil surface with NT management.

Proposed Solutions and Research Needs

1. Development of better soil tests, especially for N, that are specific for no-tillage systems.
2. Use of zone tillage (for cold and clayey soils.
3. Use of cover crops.
4. Use of inhibitors (urease and nitrification inhibitors)
5. Application of soil amendments that help maintain good infiltration and aeration.
6. More focused efforts to match crop genetics with no-tillage systems.

7. Development of plants with residues that decompose at different rates in different climates.
8. Better understanding of how to manage the microbial biomass to utilize the nutrients stored in the SOM.
9. Develop new management strategies to reduce environmental problems associated with macropore flow and nutrient stratification.

Thank You!