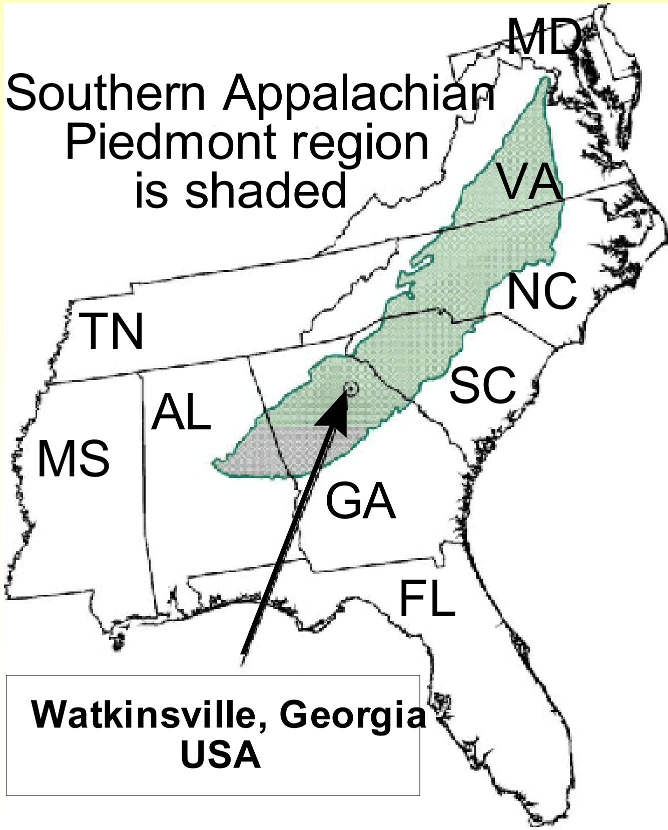
Depth Distribution of Soil Organic Matter and its Consequences on Soil Properties and Crop Productivity

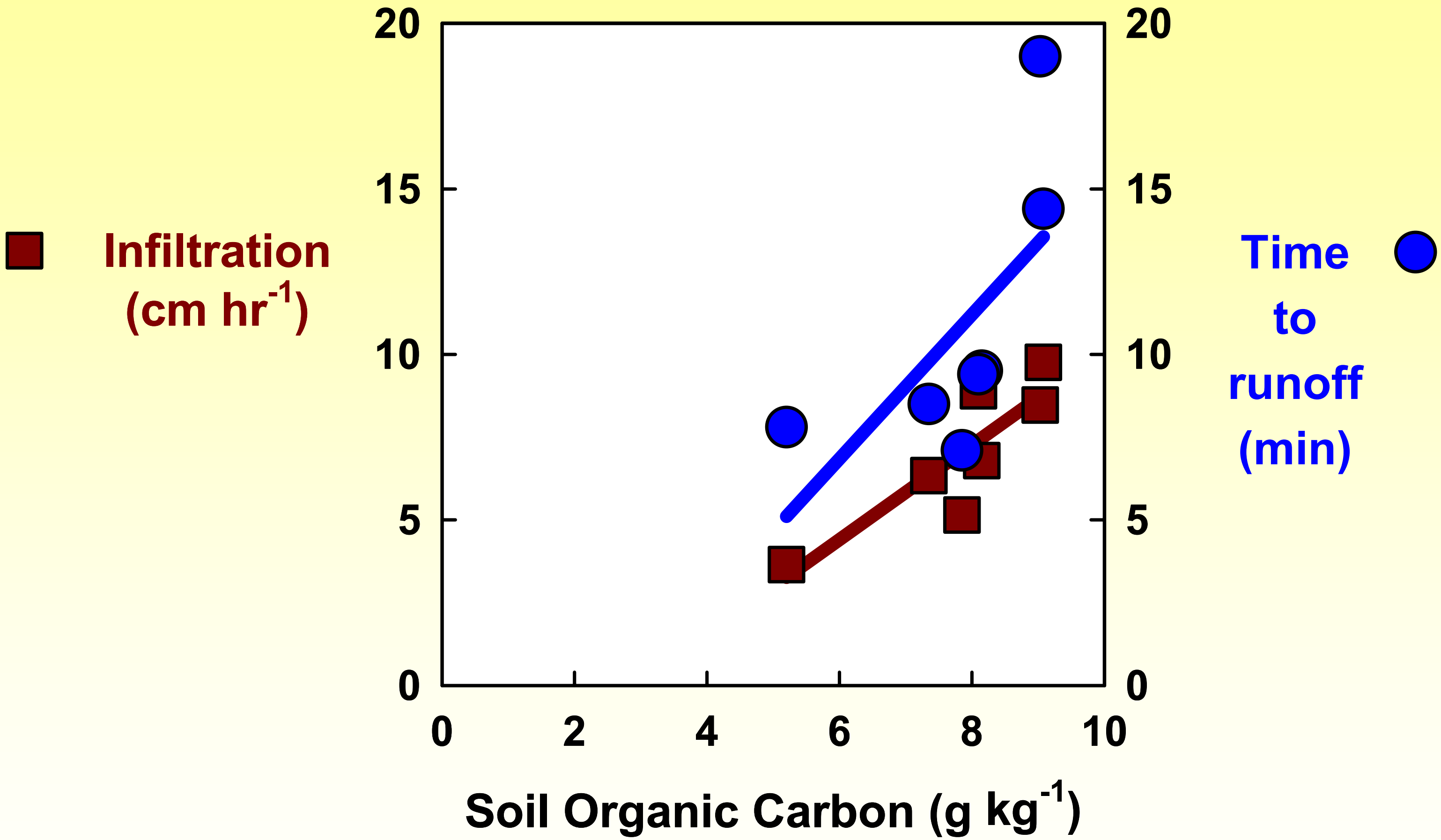
Alan J. Franzluebbers

Ecologist

Watkinsville GA



Soil Organic Matter



Premise

Quantity of soil organic matter affects ecosystem functions

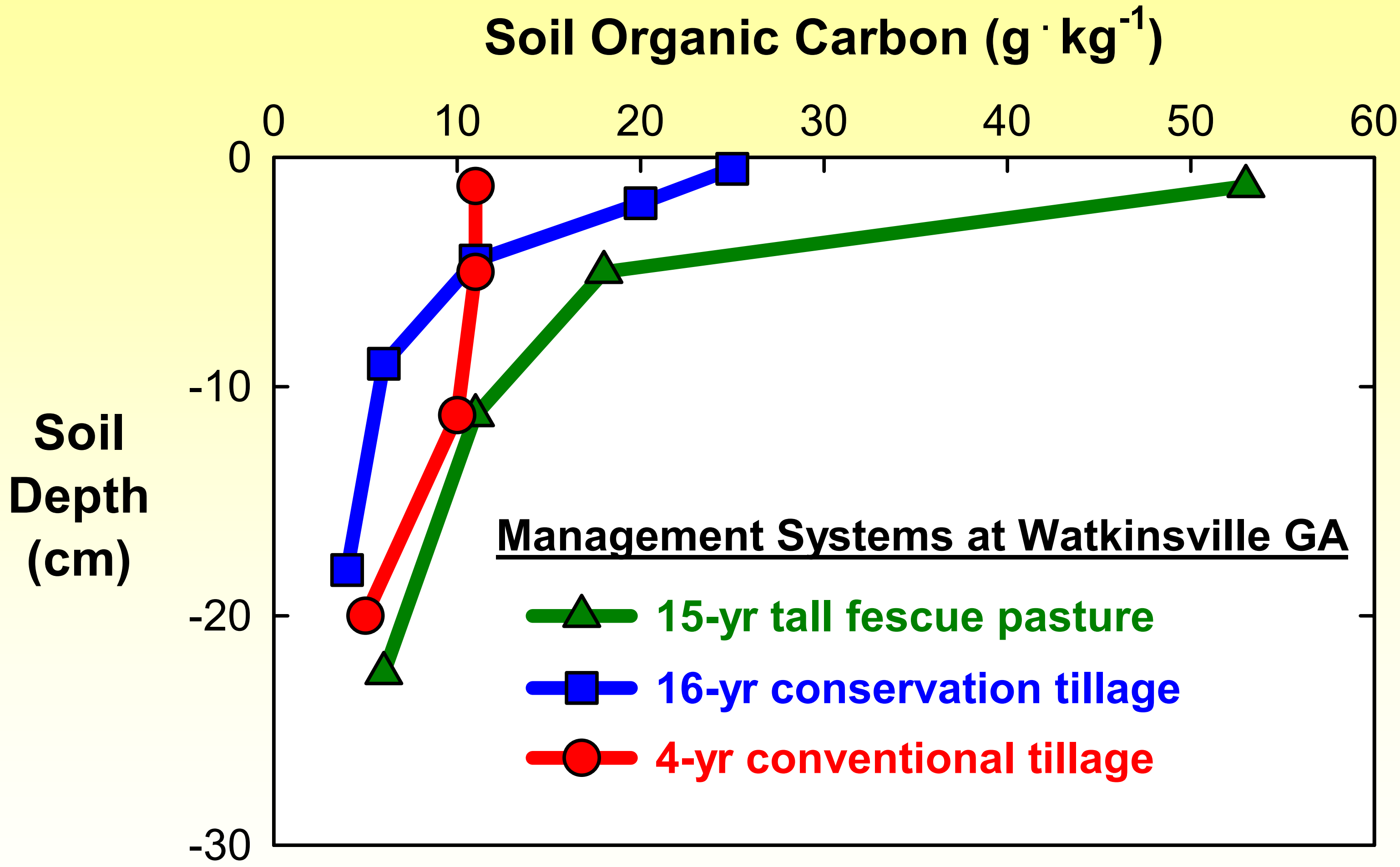
Carreker et al. (1977) *ARS-160*, US Govt Printing

Soil Management

Hypothesis

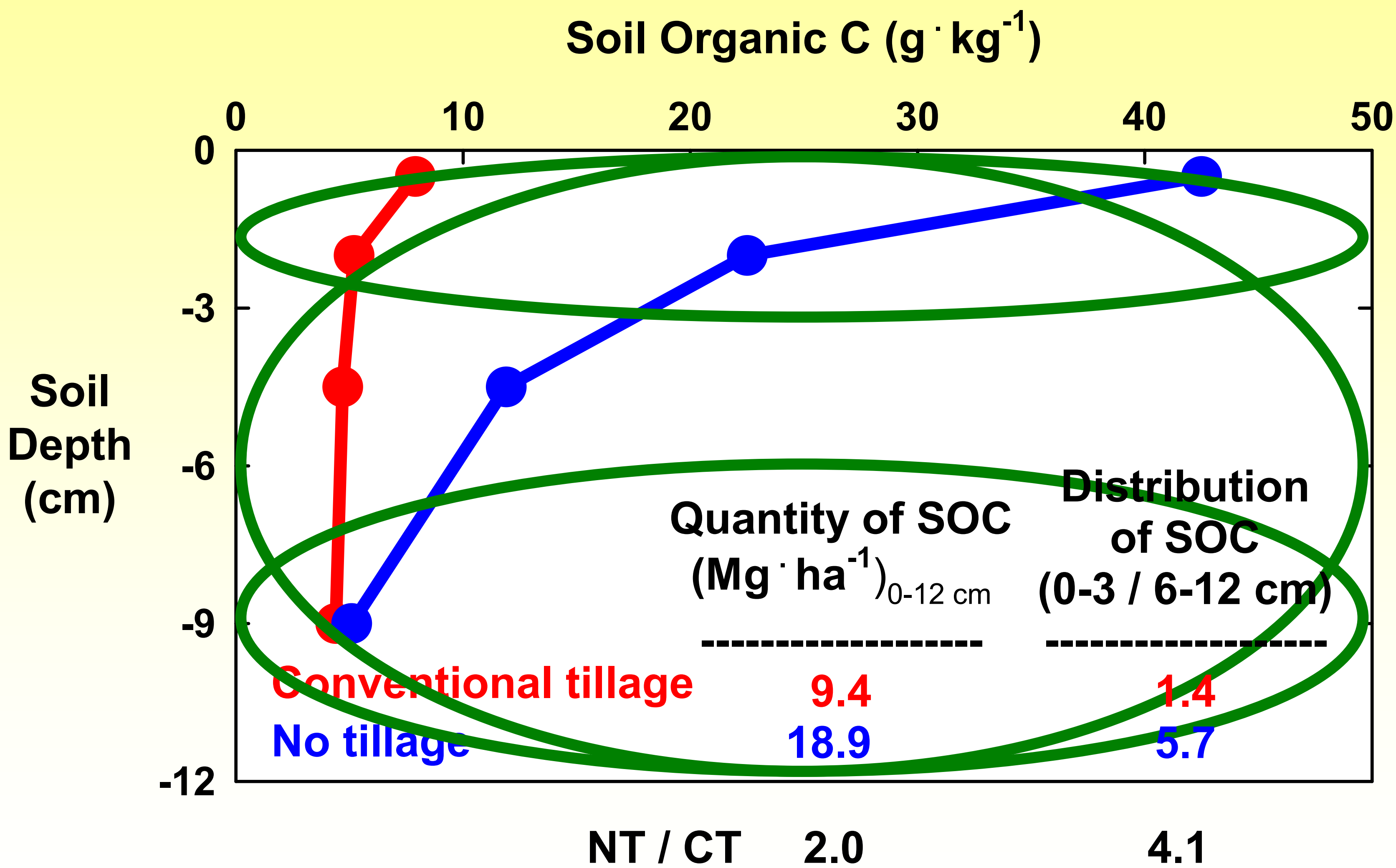
Surface soil condition dictates soil functional attributes
→ changes in crop productivity

Accumulation of Soil Organic Matter



In the warm-humid region of the southeastern USA, organic matter accumulates near the soil surface when undisturbed.

Quantity *vs* Distribution of Soil Organic Matter



Soil & Tillage Research 66 (2002) 197-205

Effect of Soil Organic Matter on Water Infiltration

Soil & Tillage Research 66 (2002) 197-205

Time (minutes) for 2.8 cm of water to infiltrate surface

	CT	NT
2x quantity Sieved	10.2	7.3
	$P = 0.10$	
4x distribution Intact	12.9	3.4
	$P < 0.01$	

Greater rate of infiltration due to stratified distribution of organic C, rather than quantity of organic C

Effect of Soil Organic Matter on Other Soil Properties

	Sieved (2X quantity)			Intact (4X distribution)	
	CT	NT		CT	NT
Bulk density (Mg m^{-3})	1.55	1.36		1.62	1.45
Stability of mean-weight diameter (g g^{-1})	0.75	0.86		0.78	0.88
Penetration resistance $(kPa)_{0\text{-}2.5\ cm}$	47	13	*	106	12
Water-filled pore space $(m^3\ m^{-3})_{0\text{-}3\ cm}$	0.12	0.17	*	0.15	0.22
N mineralization (kg ha^{-1} 12 wk^{-1})	12	13	*	13	29
P mineralization (kg ha^{-1} 12 wk^{-1})	0.4	0.6	*	0.6	1.0

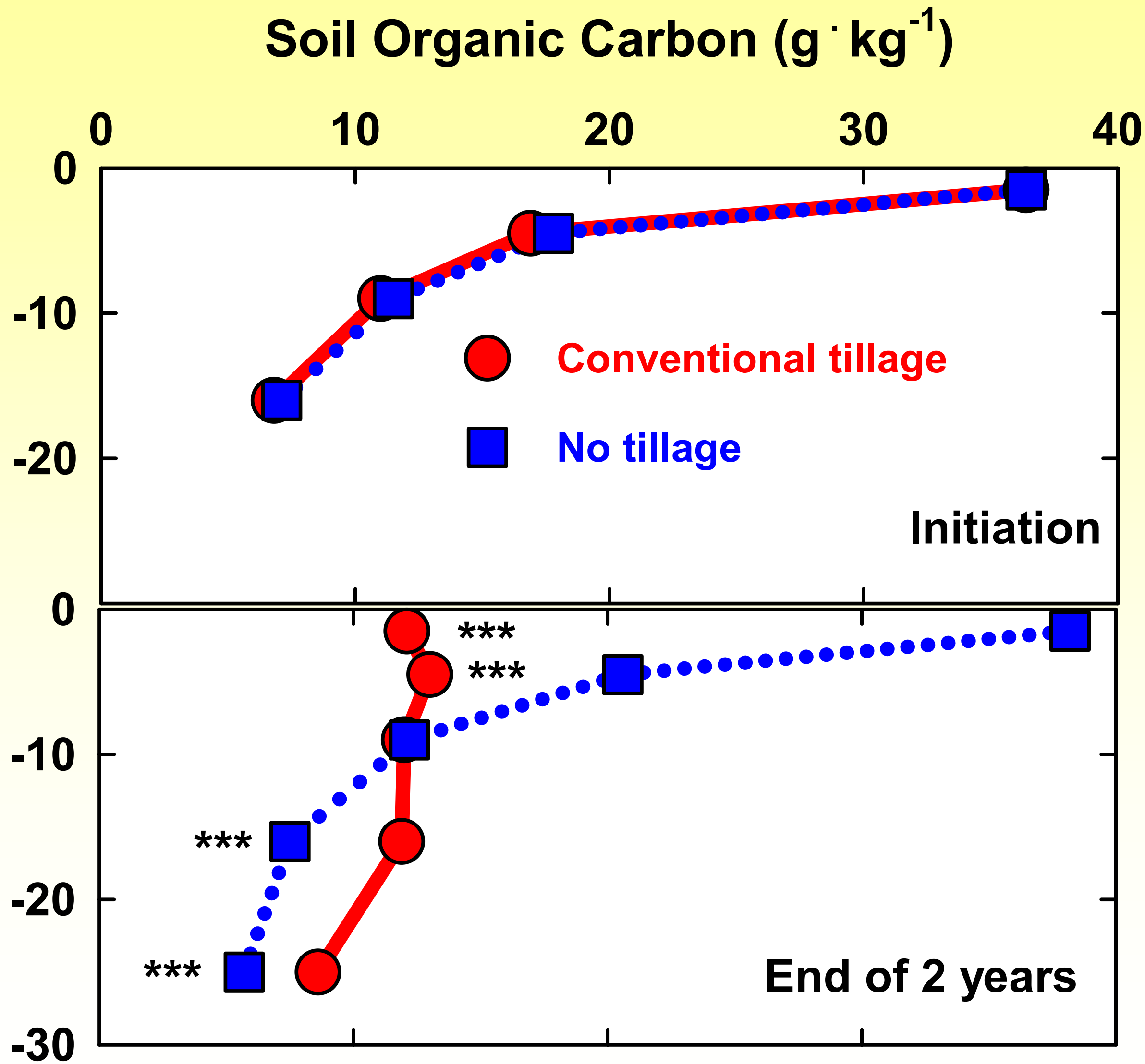
Distribution effect improved upon quantity effect

Soil & Tillage Research 66 (2002) 197-205 and unpublished data

...from a Current Field Study

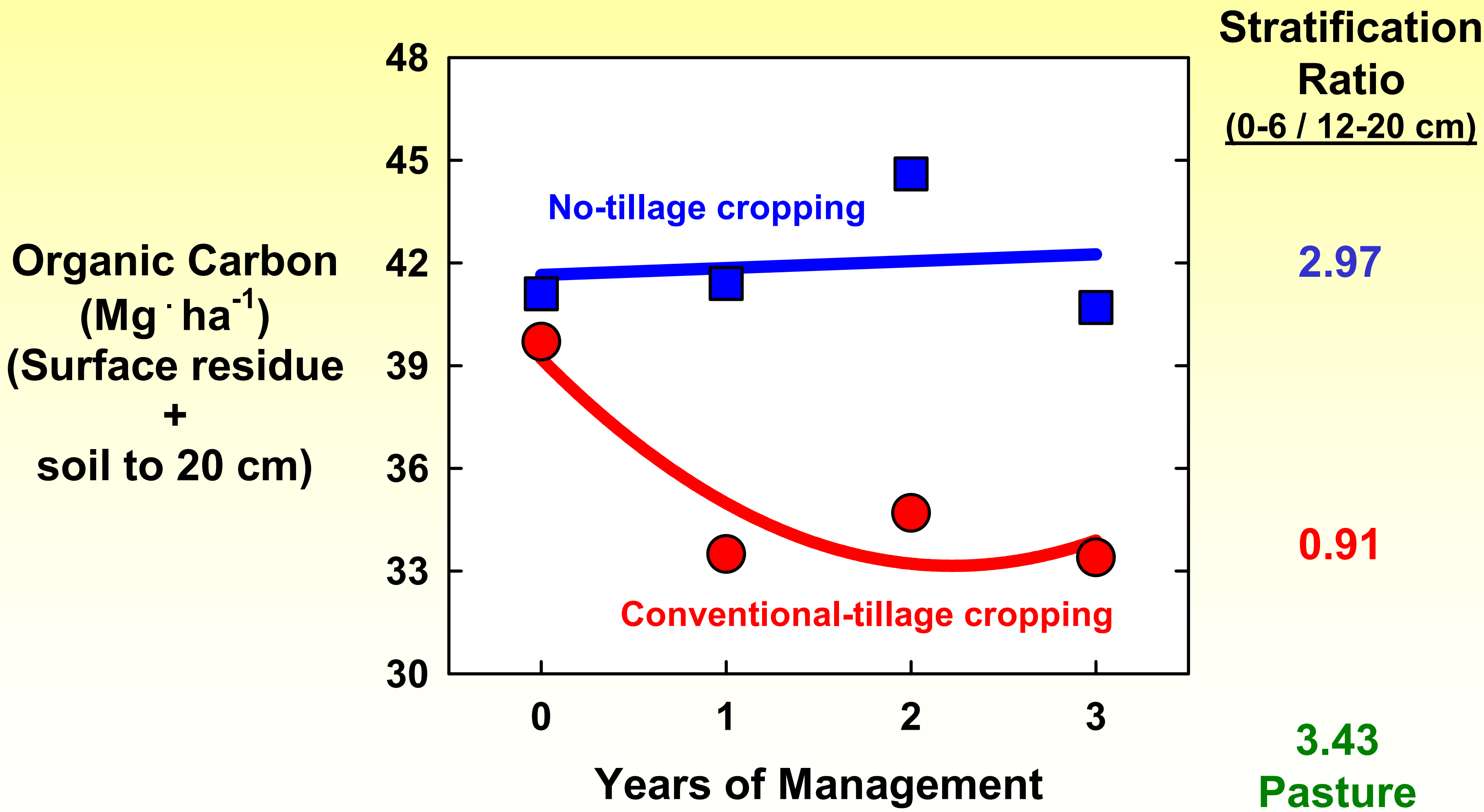
At initiation of this study, land was in long-term tall fescue pasture.

Land converted to cropping systems of wheat/pearl millet or sorghum/rye.



Advances in GeoEcology 38 (2006) 117-123

...from a Current Field Study



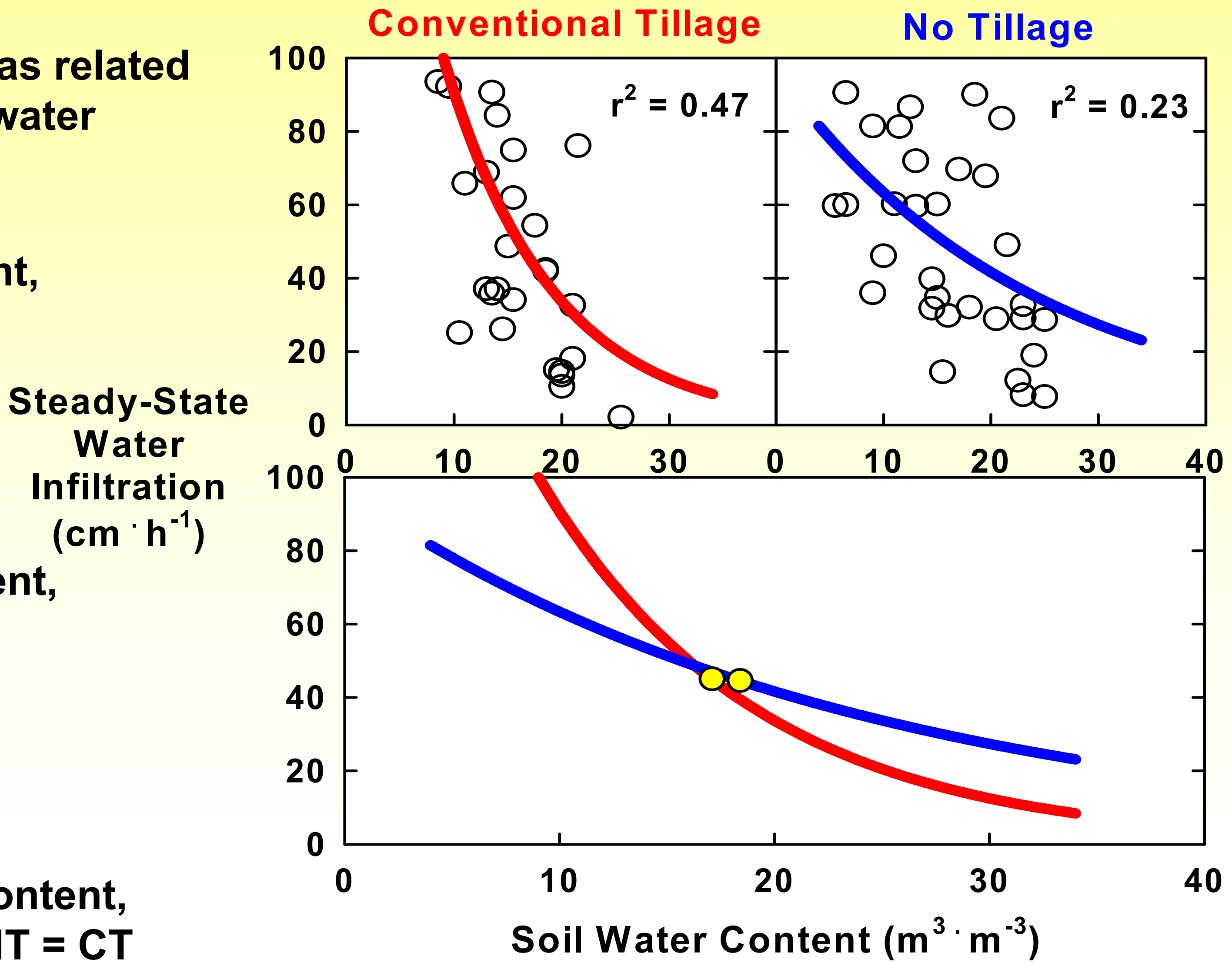
...from a Current Field Study: Ring Infiltration

Water infiltration was related to antecedent soil water content.

At low water content, infiltration was:
CT > NT
Likely due to large pores from tillage.

At high water content, infiltration was:
NT > CT
likely due to more connected pores.

At average water content, infiltration was: NT = CT



The Problem with an Unprotected Soil Surface

Runoff from Small Plots

Wisconsin	1.4 m^2 plots		Phosphorus Loss	
Tillage	Runoff	Soil Loss	Total	Bioavailable
	% applied	Mg ha^{-1}	kg ha^{-1} $event^{-1}$	
CT	45	4.2	1.3	0.2
NT	22	0.3	0.2	<0.1

Surface organic C was 33 Mg ha^{-1} under CT and 38 Mg ha^{-1} under NT.

Surface soil P was 39 mg kg^{-1} under CT and 62 mg kg^{-1} under NT.

Despite higher soil P under NT than under CT, runoff P loss was lower due to greater water infiltration and less soil loss.

Soil Science Society of America Journal 49 (1985) 1523-1527; Andraski et al.

Runoff from Large Plots

Virginia, 112 m^2 plots			Runoff Nutrients	
Tillage	Runoff	Soil Loss	Nitrogen	Phosphorus
	% applied	Mg ha^{-1}	kg ha^{-1}	
CT	53	3.6	10.3	4.1
NT	12	<0.1	0.5	0.3

Surface organic C was not reported, but expected to be greater under NT than under CT due to long-term management.

If so, then distribution of organic C was important in preventing soil erosion and water quality deterioration.

Final Report from Virginia Tech, Blacksburg VA, Ross et al. (2001)

Runoff from Water Catchments

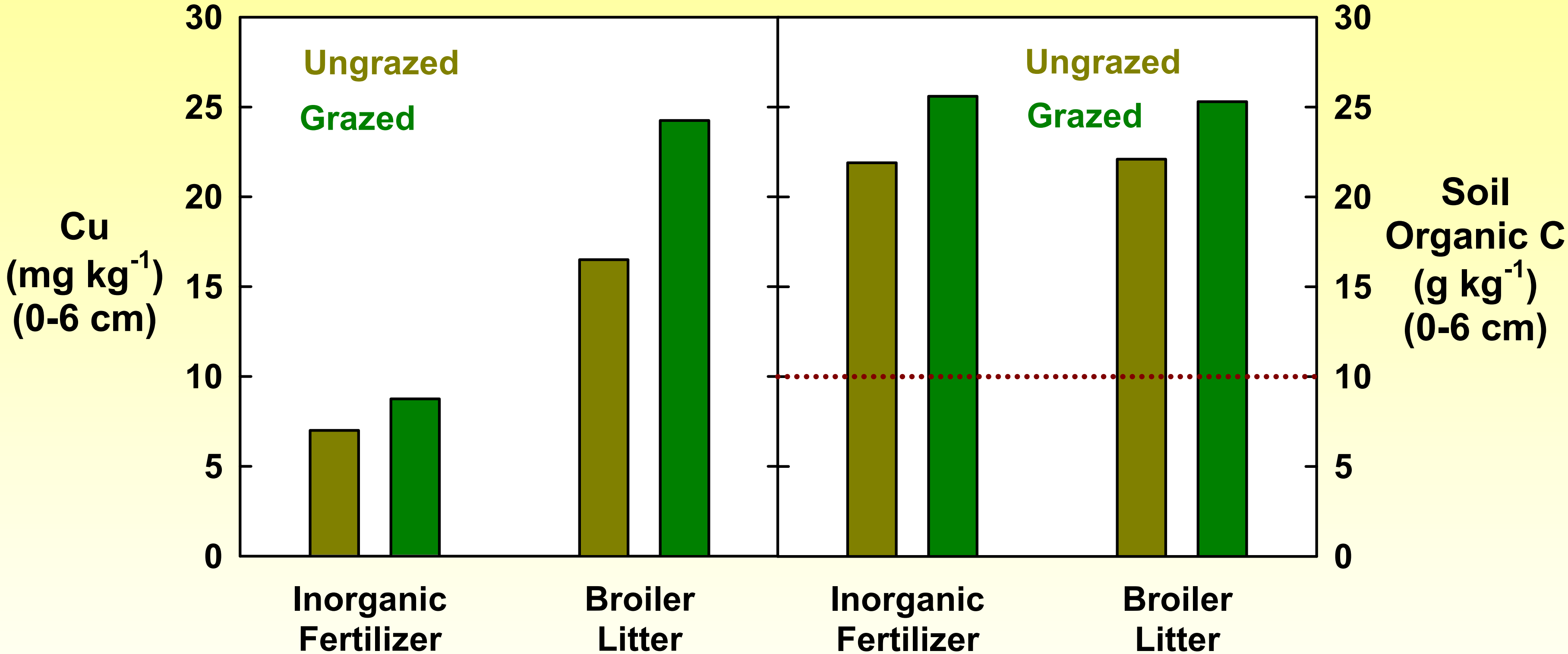
Oklahoma, 1.6-ha catchments, 5 years			Phosphorus Loss		
Tillage	Runoff	Soil Loss	Total	Particulate	Soluble
	% rainfall	Mg ha^{-1}	---------- kg ha^{-1} yr^{-1} ----------		
CT	19	7.2	4.2	3.8	0.4
NT	24	0.4	1.7	0.5	1.2
Native	18	<0.1	0.3	0.1	0.2

Surface organic C was not reported, but expected to be greater under NT (and native grass) than under CT due to long-term management.

Similar to other studies, distribution of organic C likely contributed to prevention of environmental degradation, but possibility for greater soluble P loss is of concern.

Journal of Environmental Quality 21 (1992) 30-35; Sharpley et al.

Environmental Buffering

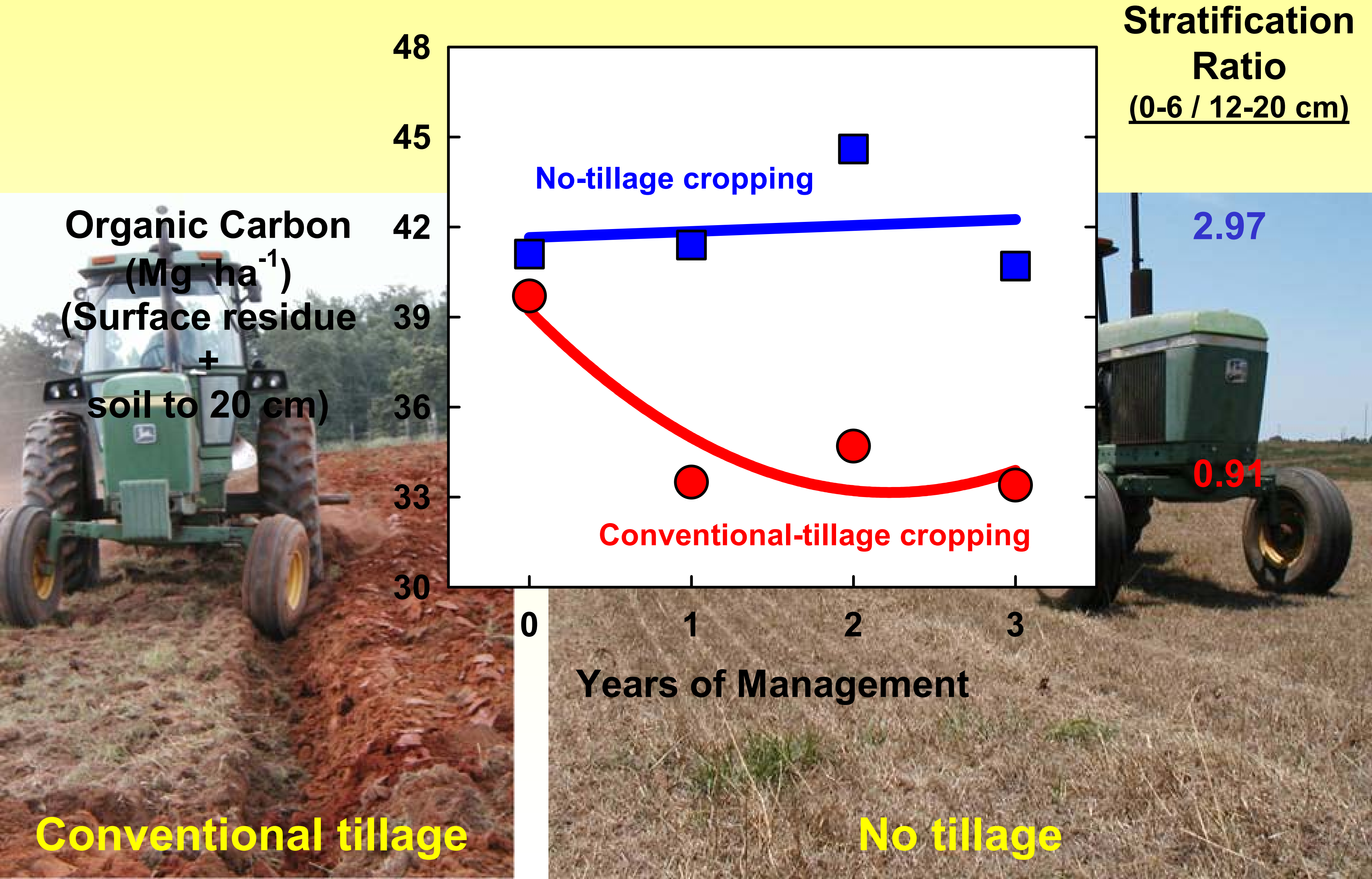


Accumulation of Cu occurred with broiler litter application, but surface accumulation of soil organic C would probably facilitate Cu sorption, which could prevent Cu runoff loss.

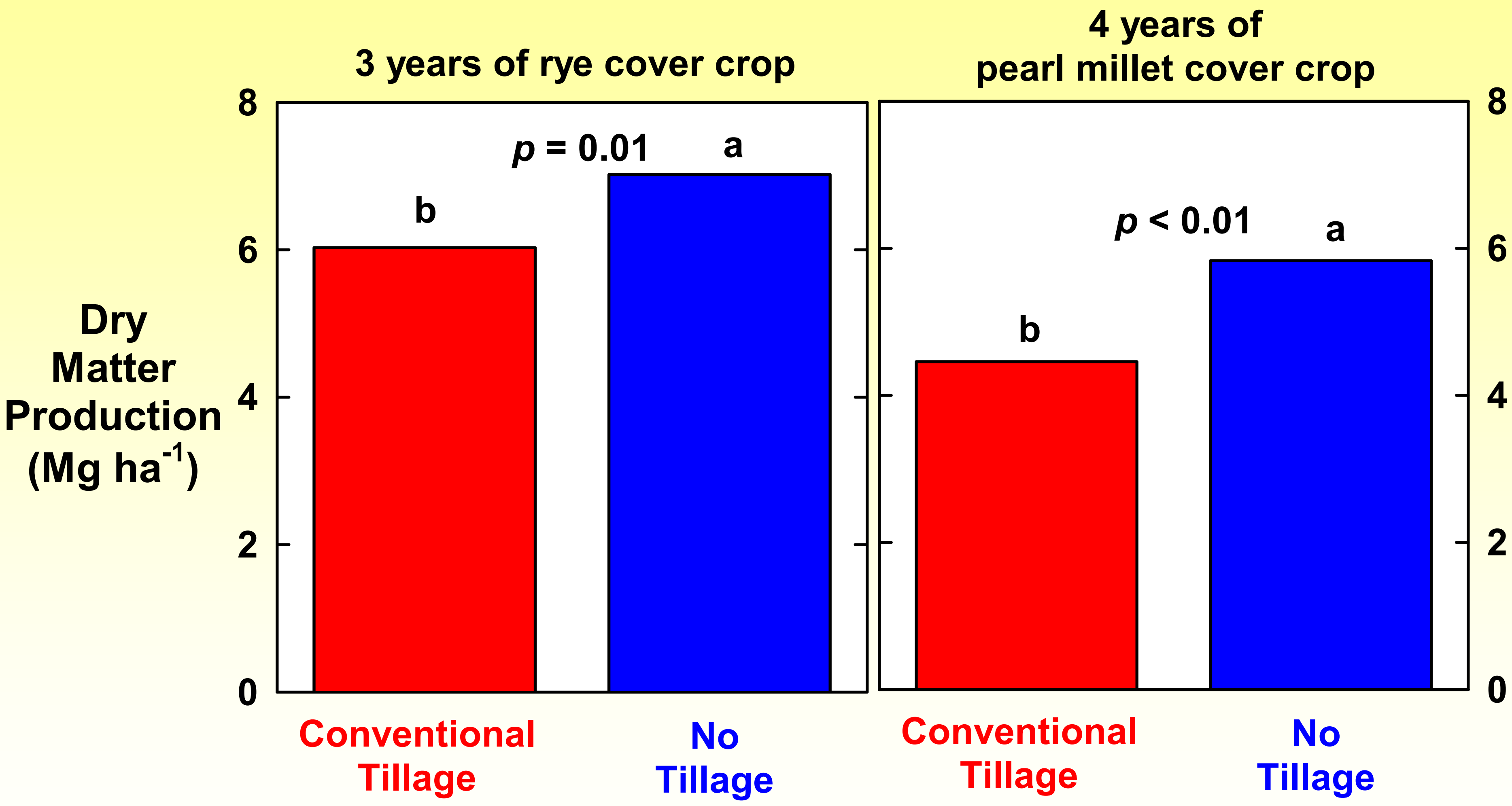
Need further testing.

Journal of Environmental Quality 33 (2004) 778-784

Nutrient Cycling and Productivity



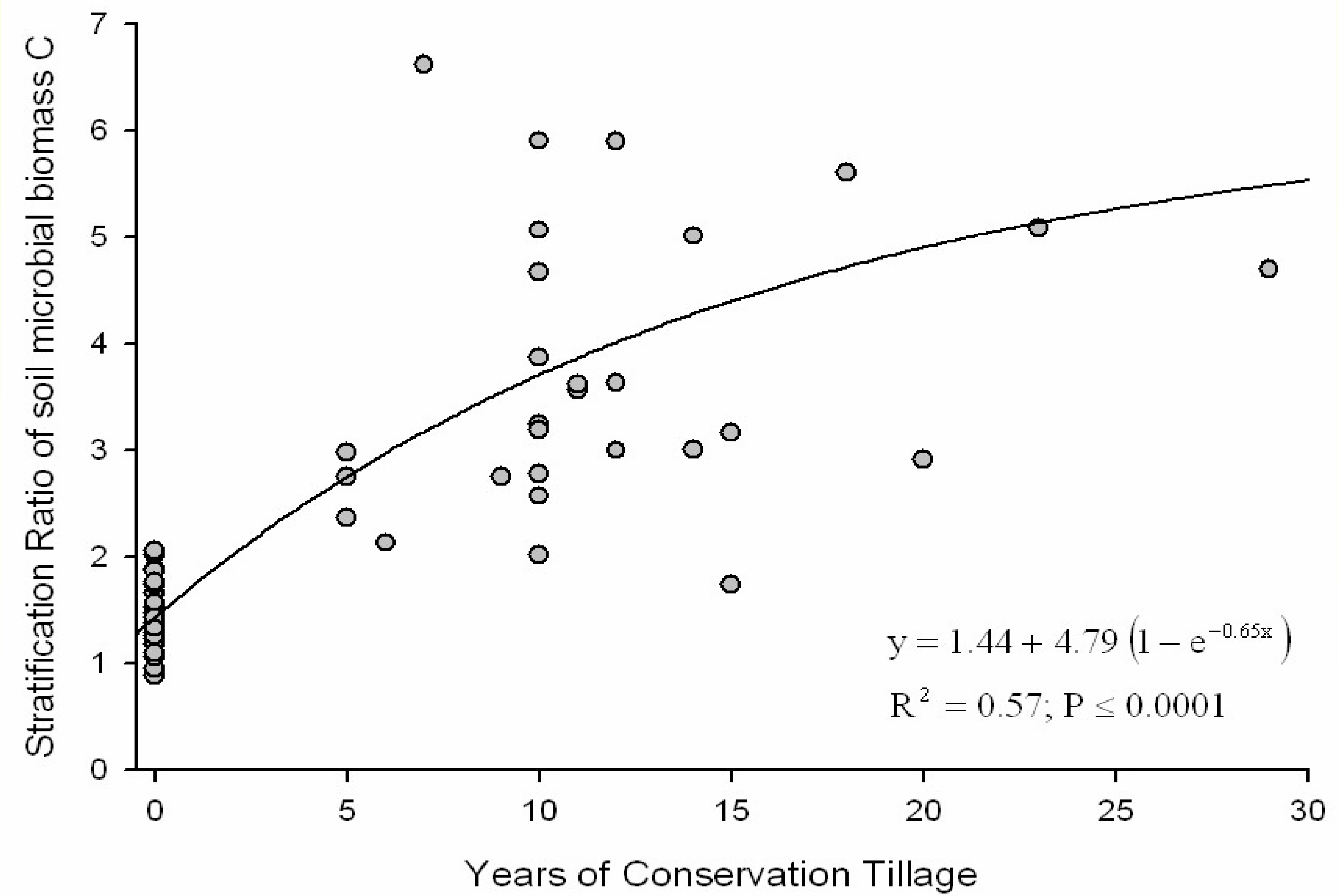
Nutrient Cycling and Productivity



Stratified soil led to improved nutrient release to plants

Renewable Agriculture and Food Systems (in review)

Stratification Ratio



Causarano HJ, 2006 PhD dissertation, Auburn Univ.

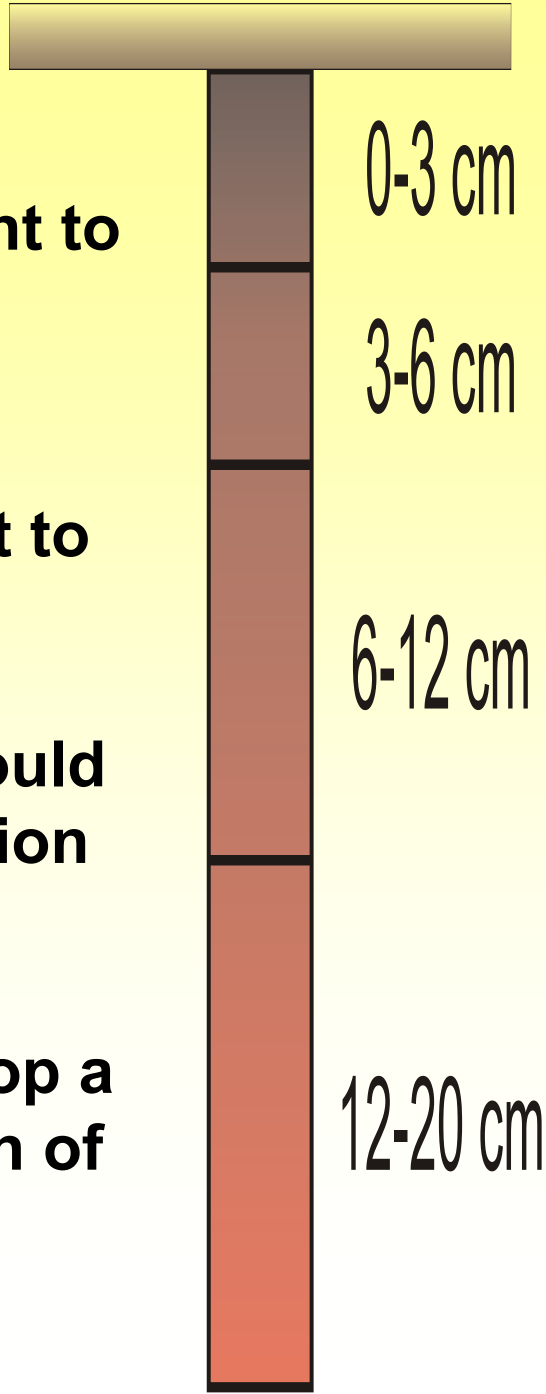
Conclusions

Quantity of soil organic matter is important to ecosystem functioning.

However, the distribution of soil organic matter appears to be even more important to ecosystem functioning.

Soil quality and ecosystem functioning could be assessed with calculation of stratification ratio.

More research will be conducted to develop a framework of how soil-profile stratification of organic matter might become even more revealing to ecosystem functions.



Acknowledgements

Soils and Soil Biology program of the USDA-NRI, Agr. No. 2001-35107-11126

Georgia Agricultural Commodity Commission for Corn