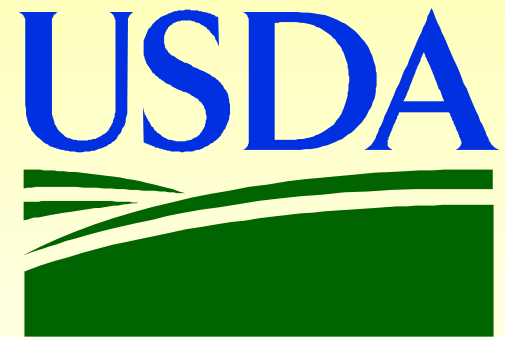


Crop Residues: A Resource for Whom?

Alan J. Franzluebbers

Ecologist

Watkinsville GA




Jane M.F. Johnson

Soil Scientist

Morris MN

Crop Residues

- 
- ✓ **A renewable, natural resource product that has a long history of utilization in agriculture and society**
 - ✓ **Valued in different ways, depending upon user's perspective**
 - **Sometimes as a waste, but mostly as a resource**
 - ✓ **How we use it on a large scale could have major implications for agricultural sustainability**

Competing Uses for Crop Residues

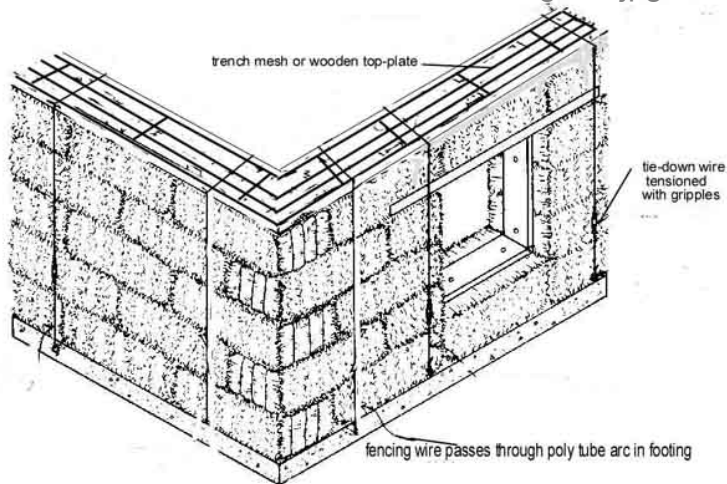
Construction

<http://www.gutenberg.org/files/12849/12849-h/img/pl41.jpg>



<http://followhim.typepad.com/follow/images/dscf0203.jpg>

<http://foodforest.com.au/strawbaleWallDiagram.jpg>



<http://www.singletonbrothers.co.uk/images/thatchers-devon.jpg>

Competing Uses for Crop Residues

Arts and crafts



<http://www.strawartmuseum.org/Gleaners.jpg>



http://www.strawartmuseum.org/coiled/1997_133.jpg



http://www.strawartmuseum.org/coiled/1995_111c.jpg



http://www.cowboyhatinfo.org/images/straw_hat_weaving.jpg



<http://www.strawcraftsmen.co.uk/images/rwmaiden.jpg>

Competing Uses for Crop Residues

Heating and cooking



<http://solarcooking.org/images/scr/nov02/photob.JPG>



<http://www.berkeley.edu/news/media/releases/2001/08/images/githeri.jpg>



http://www.unfpa.org/swp/2001/images/ch04_a.jpg



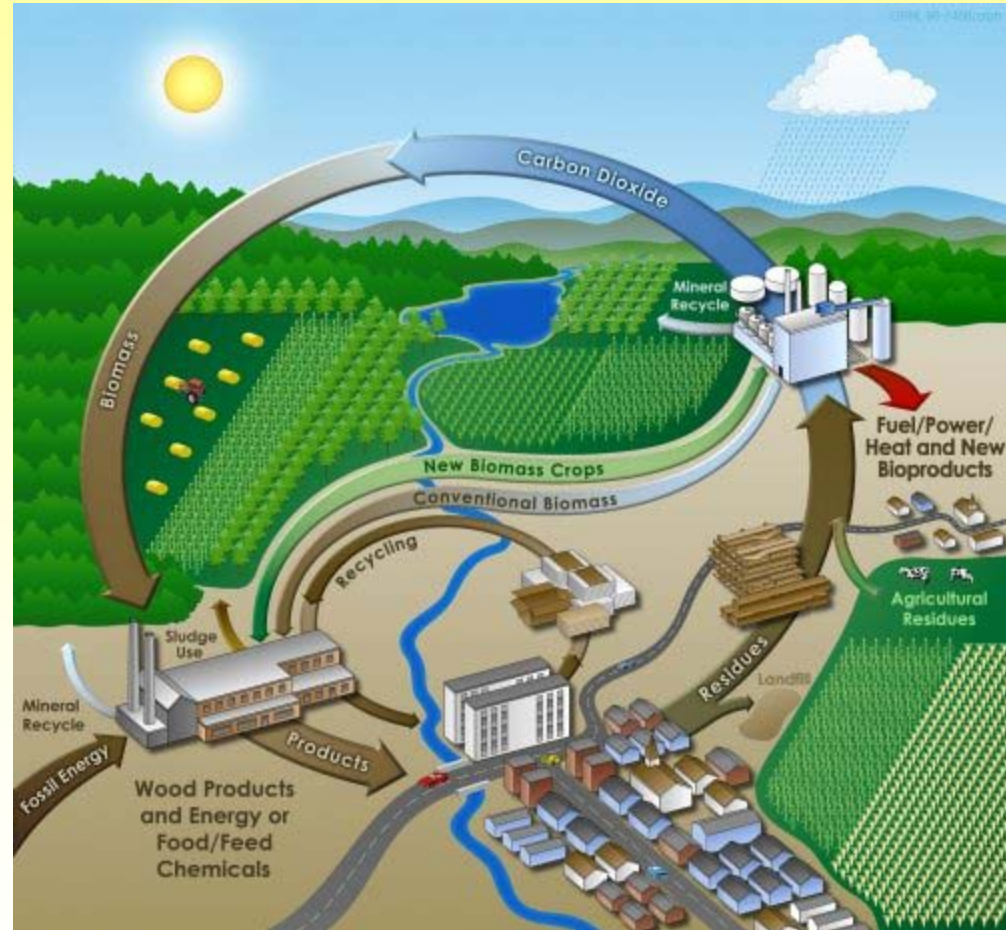
http://impact.wsu.edu/newsletter_blog/images/nov05/Fruit_Grower_truck_1.jpg

Competing Uses for Crop Residues

Industrialized biofuel production



<http://www.nrel.gov/data/pix/Jpegs/10429.jpg>



<http://www.repp.org/bioenergy/bioenergy-cycle-med2.jpg>



http://thefraserdomain.typepad.com/energy/images/2007/06/21/verenum_cellulosic_ethanol_facil_2.jpg

Competing Uses for Crop Residues



<http://www.fao.org/docrep/x5672e/x5672e0z.gif>

Bedding for animals



<http://www.benicia.k12.ca.us/henderson/Image57.jpg>

<http://www.danagri-3s.com/images/equipment/straw01.gif>



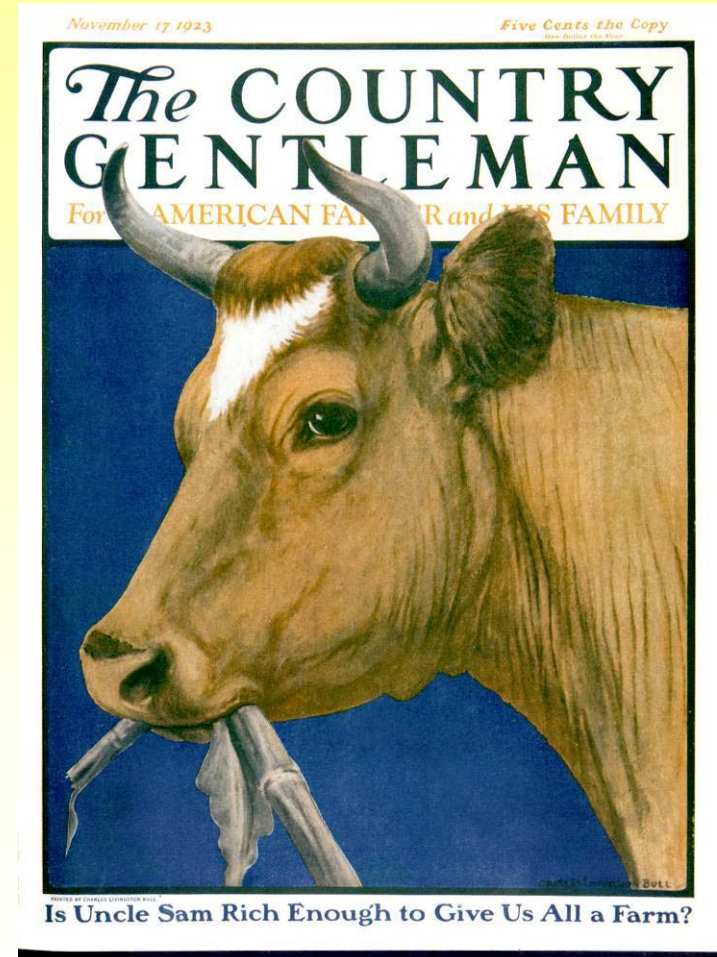
Competing Uses for Crop Residues

Animal feed

http://www.precisiontillage.com/assets/uploads/cows_grazing.jpg



http://ohioline.osu.edu/anr-fact/images/0010_1.jpg



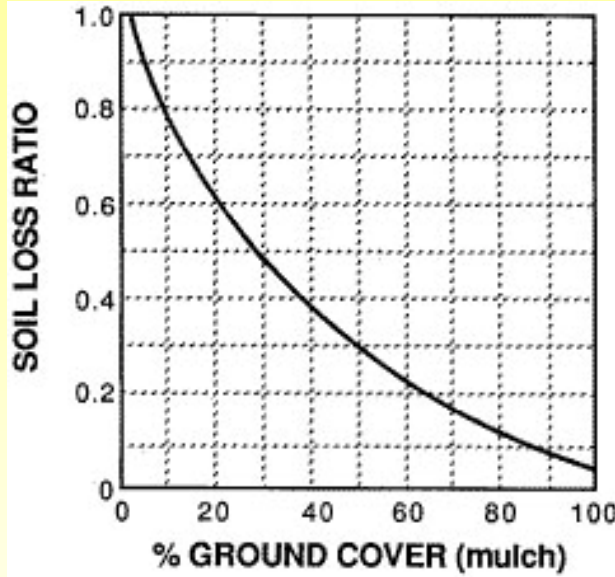
<http://www.curtispublishing.com/images/NonRockwell/19231117.jpg>

Competing Uses for Crop Residues

Soil protection and nourishment



<http://cropwatch.unl.edu/photos/cwphoto/residue.JPG>



<http://extension.missouri.edu/explore/images/g01650art01.jpg>



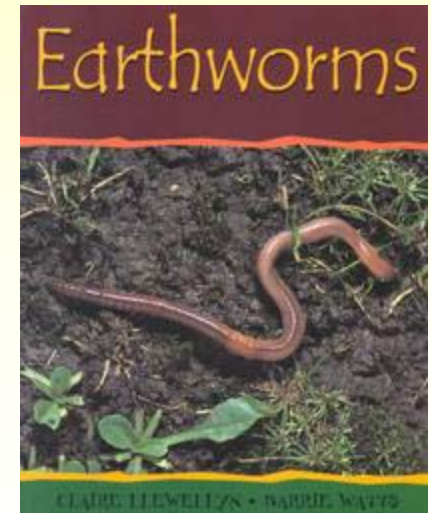
http://www.eurogeosurveys.org/_STUDIOEMMA_WWW/uploads/Image/wind%20erosion_BGR.jpg



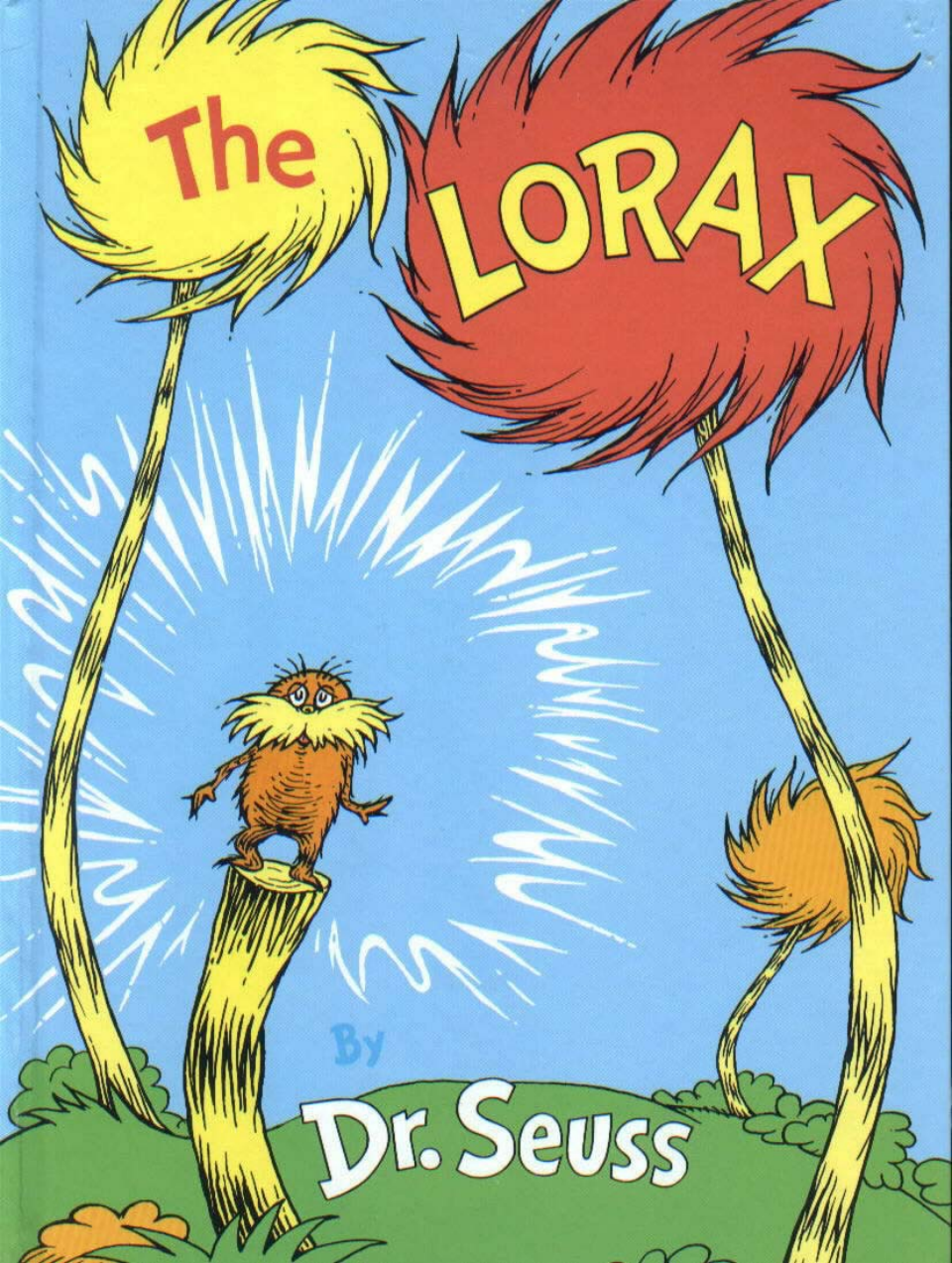
<http://www.extension.umn.edu/cropnews/images/2002/02MNCN32-1.jpg>



<http://elkhorn.unl.edu/public/live/g1537/build/graphics/g1537-3.jpg>



http://dl.nlb.gov.sg/ask/Kelvin_Earthworms%20by%20Claire%20Lewellyn.jpg

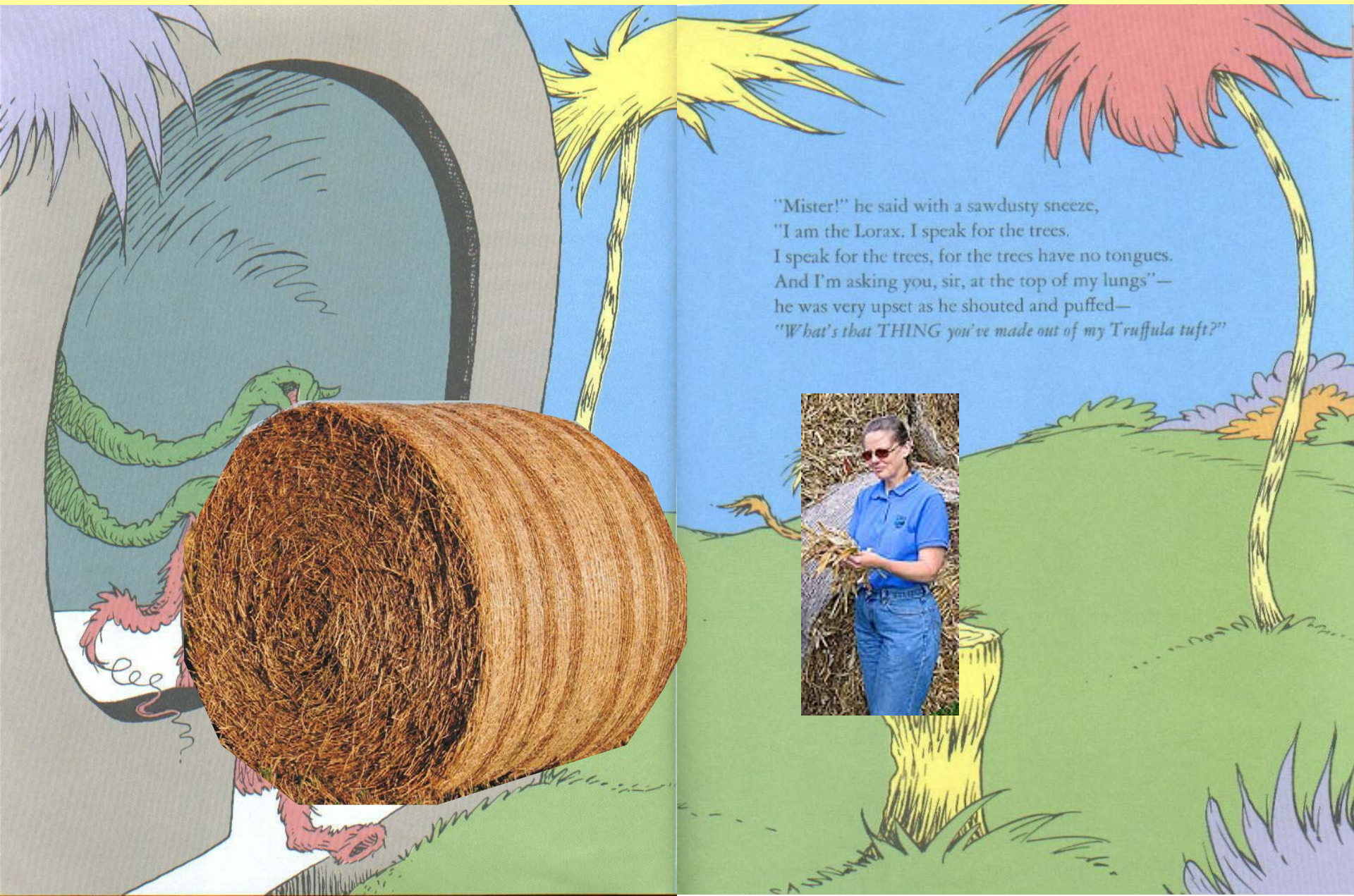


...simple similarities



© 1971 by Dr. Seuss Enterprises, L.P.
Random House, Inc., New York

“Mister!” he said with a sawdusty sneeze, “I am the Lorax. I speak for the **SOIL**, for the **SOIL** has no tongue. And I’m asking you, sir, at the top of my lungs” – he was very upset as he shouted and puffed –
“*What’s that THING you’ve made out my **surface cover**?*”

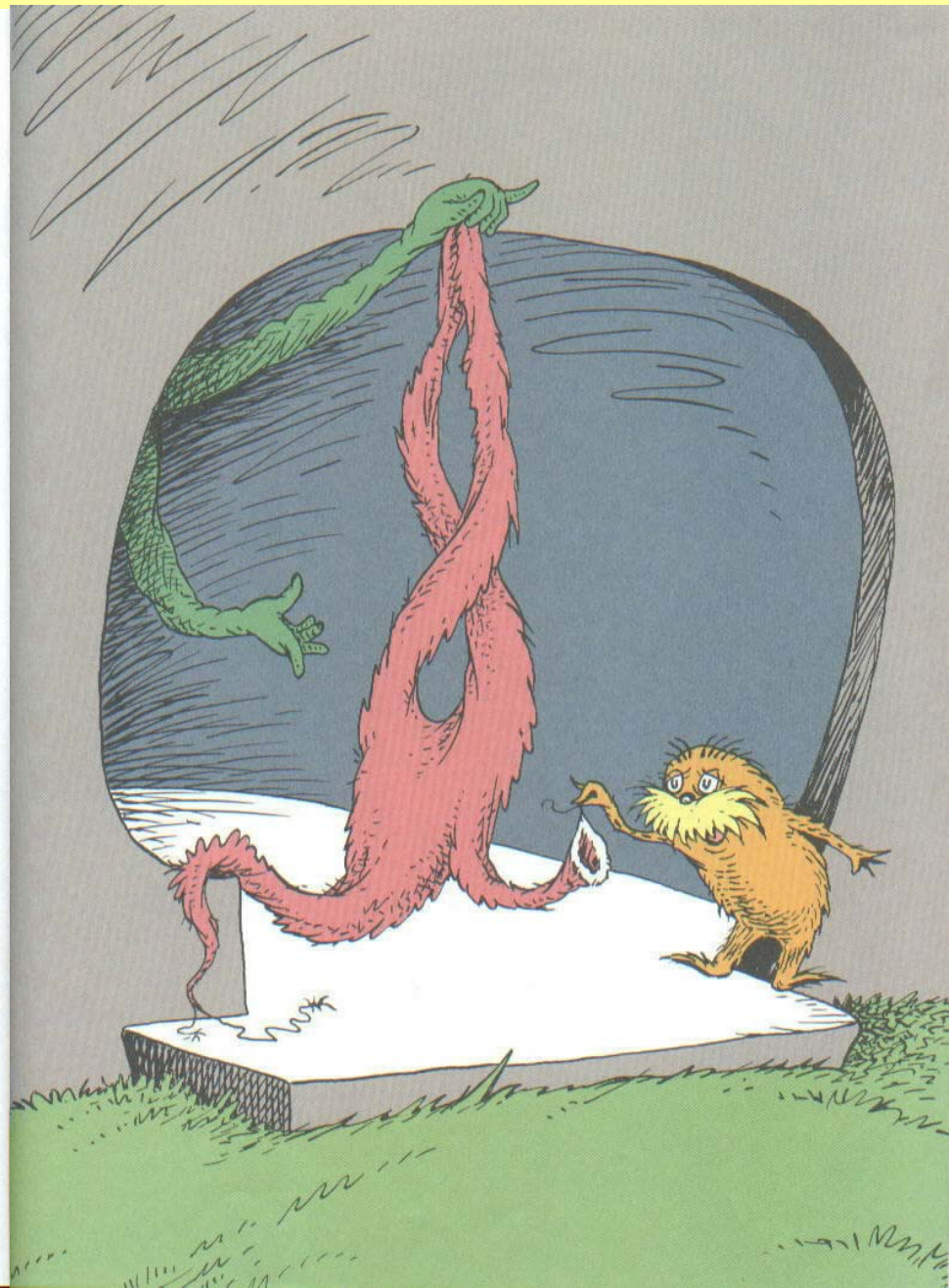


“Mister!” he said with a sawdusty sneeze,
“I am the Lorax. I speak for the trees.
I speak for the trees, for the trees have no tongues.
And I’m asking you, sir, at the top of my lungs” –
he was very upset as he shouted and puffed –
“*What’s that THING you’ve made out of my Truffula tuft?*”



"Look, Lorax," I said. "There's no cause for alarm.
I chopped just one tree. I am doing no harm.
I'm being quite useful. This thing is a Thneed.
A Thneed's a Fine-Something-That-All-People-Need!
It's a shirt. It's a sock. It's a glove. It's a hat.
But it has *other* uses. Yes, far beyond that.
You can use it for carpets. For pillows! For sheets!
Or curtains! Or covers for bicycle seats!"

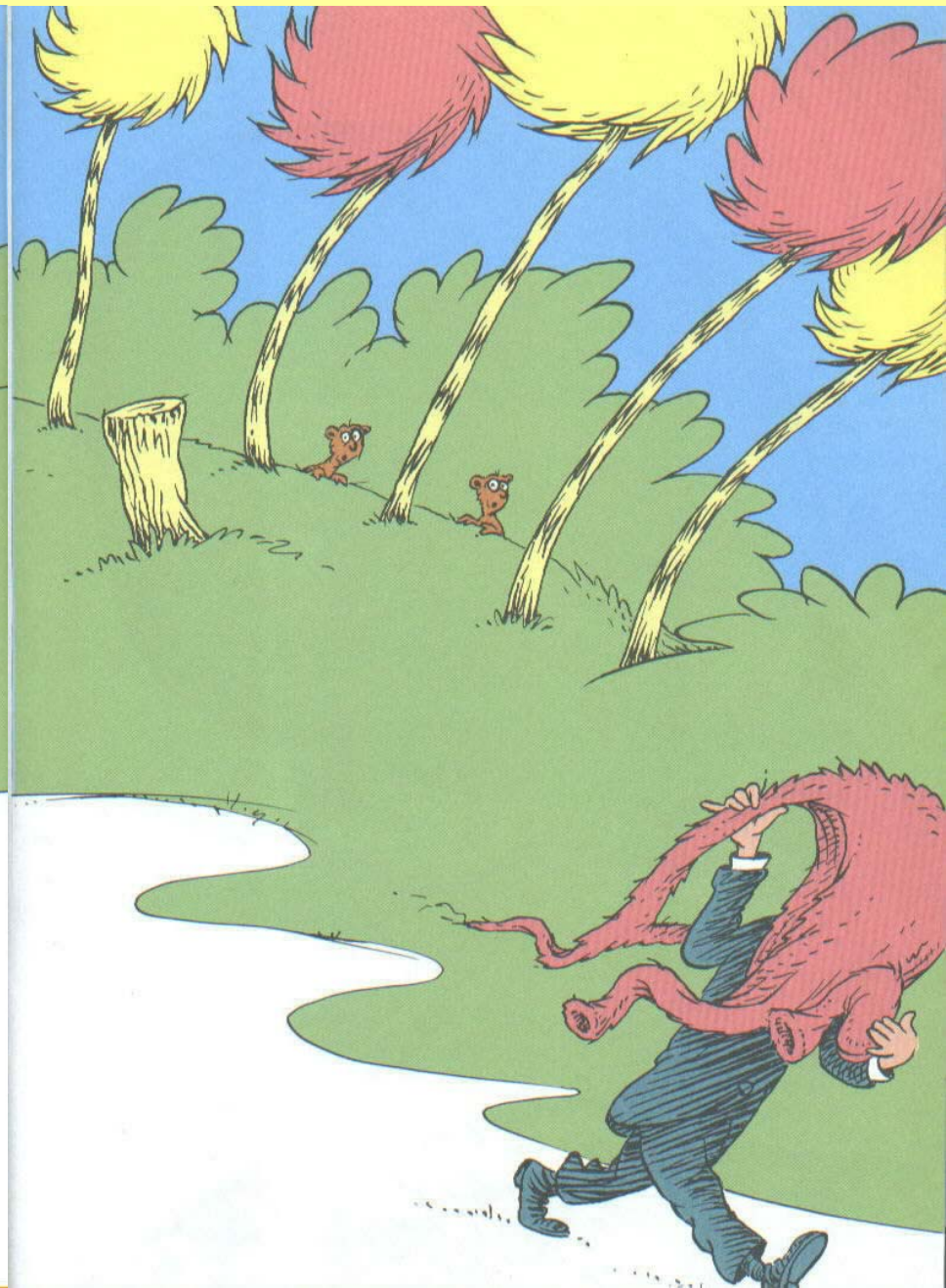
The Lorax said,
"Sir! You are crazy with greed.
There is no one on earth
who would buy that fool Thneed!"





But the very next minute I proved he was wrong.
For, just at that minute, a chap came along,
and he thought that the Thneed I had knitted was great.
He happily bought it for three ninety-eight.

I laughed at the Lorax, "You poor stupid guy!
You never can tell what some people will buy."



...and the story continued until all the trees had been cut down

- ✓ Taken to an extreme, almost all natural resource extractions can have negative consequences on the environment.
- ✓ Crop residue harvest for biofuel production may not be as simple as this story, but keeping simple principles in mind will help prevent environmental disasters that may be lurking in the future.

An extremely real example...

- ✓ The continual harvest of crop residues in the semi-arid region of West Africa has led to a spiral of land degradation, in which nutrients are not returned to the soil and rainfall is in short supply.
- ✓ However, when rain does fall, much of the soil washes away.

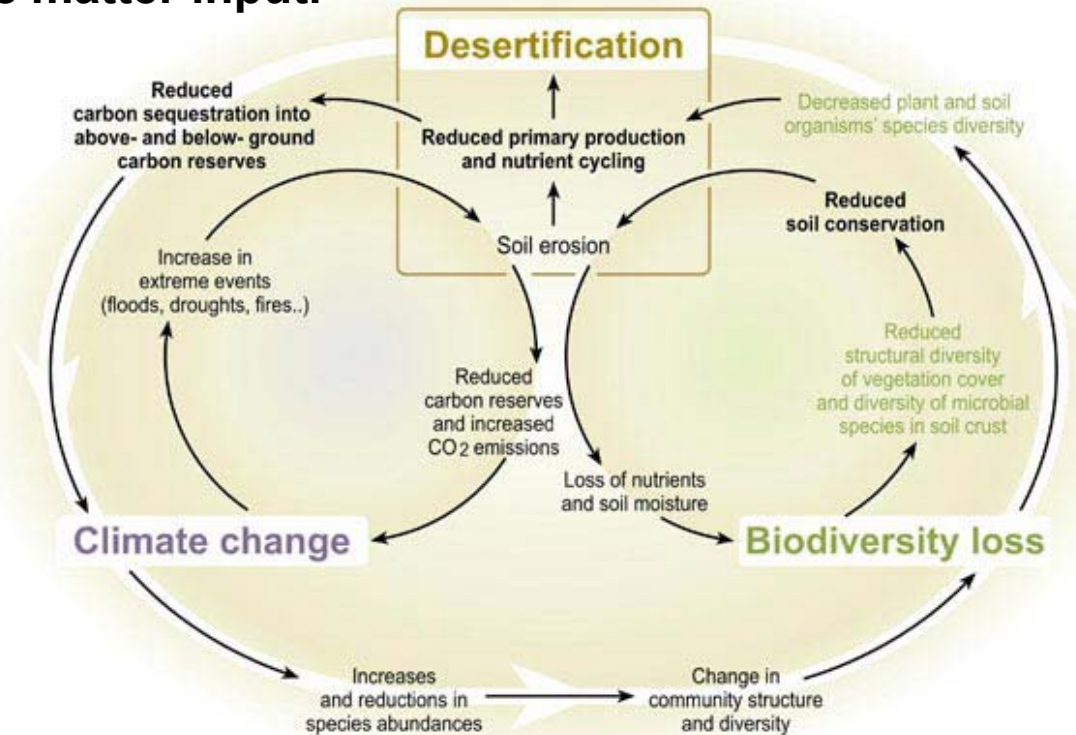


- ✓ Consequently, soil has little life, because there is little organic matter input.

http://www.cgiar.org/images/des_fact1.gif



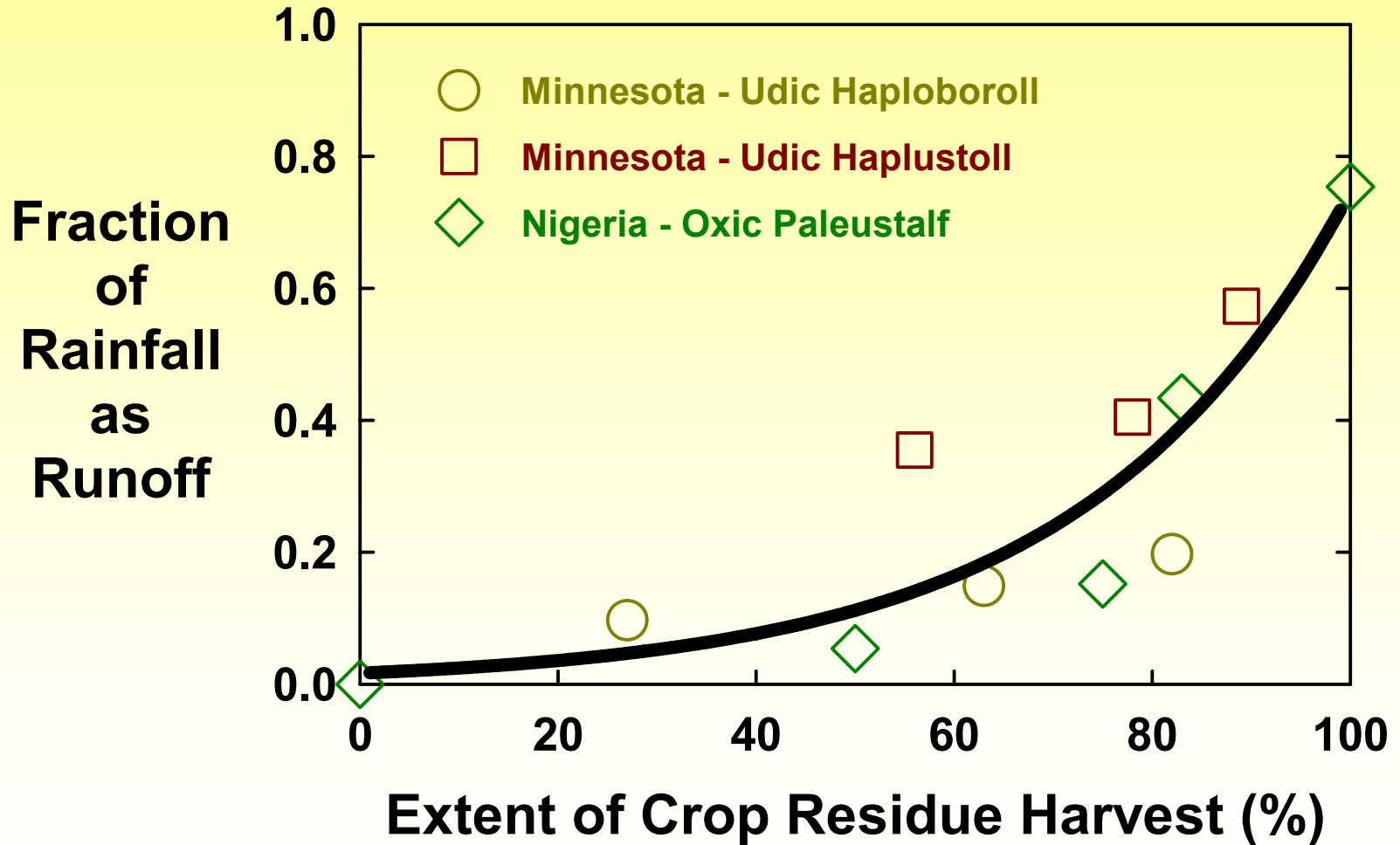
<http://www.wmo.ch/pages/mediacentre/news/archive/images/desert.jpg>



in green: major components of biodiversity involved in the linkages
bolded: major services impacted by biodiversity losses

Source: Millennium Ecosystem Assessment

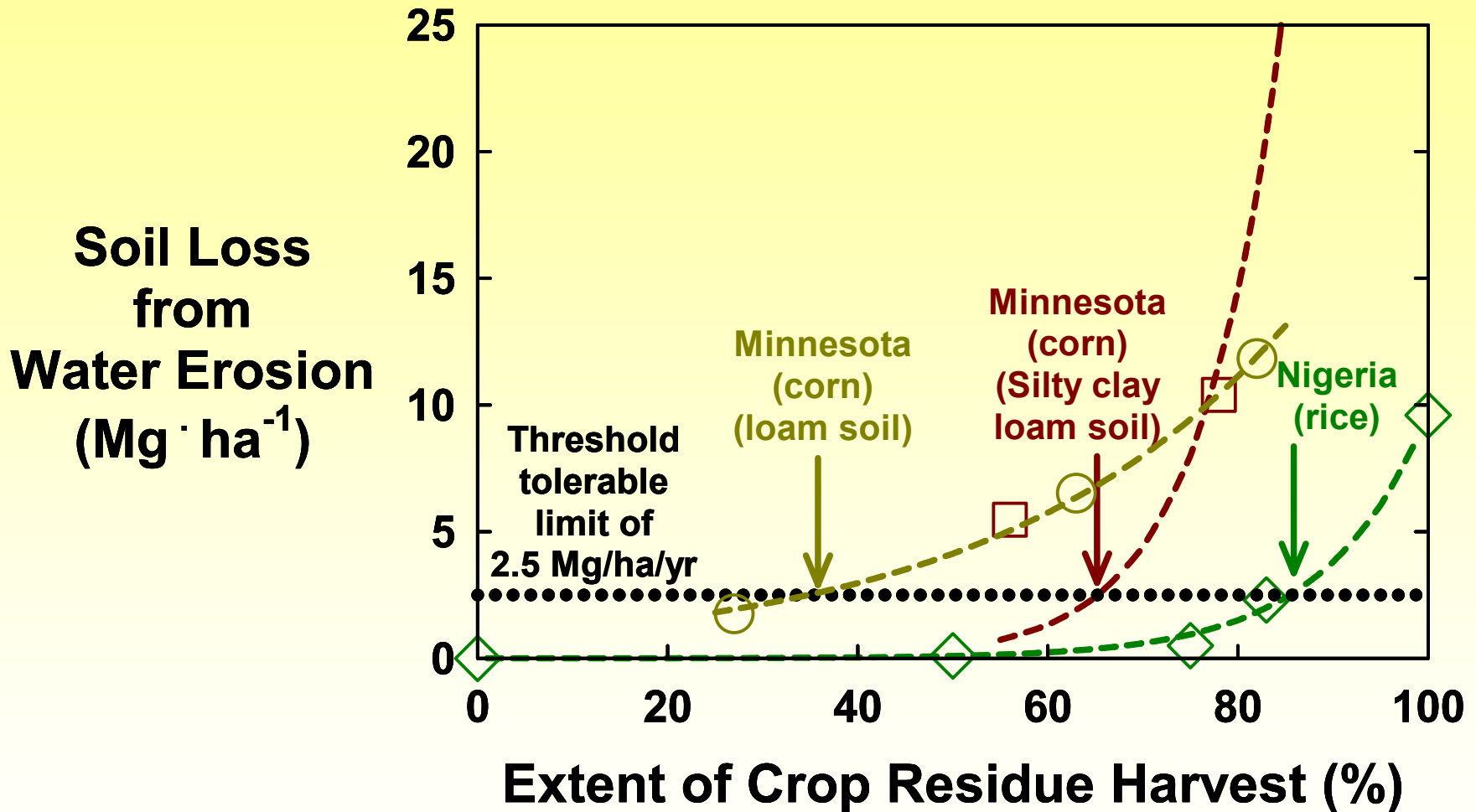
Water Runoff Response to Residue Harvest



Data from Erenstein (2002) Soil Tillage Res. 67:115-133

Data from Lindstrom (1986) Agric. Ecosyst. Environ. 16:103-112

Soil Erosion Response to Crop Residue Harvest

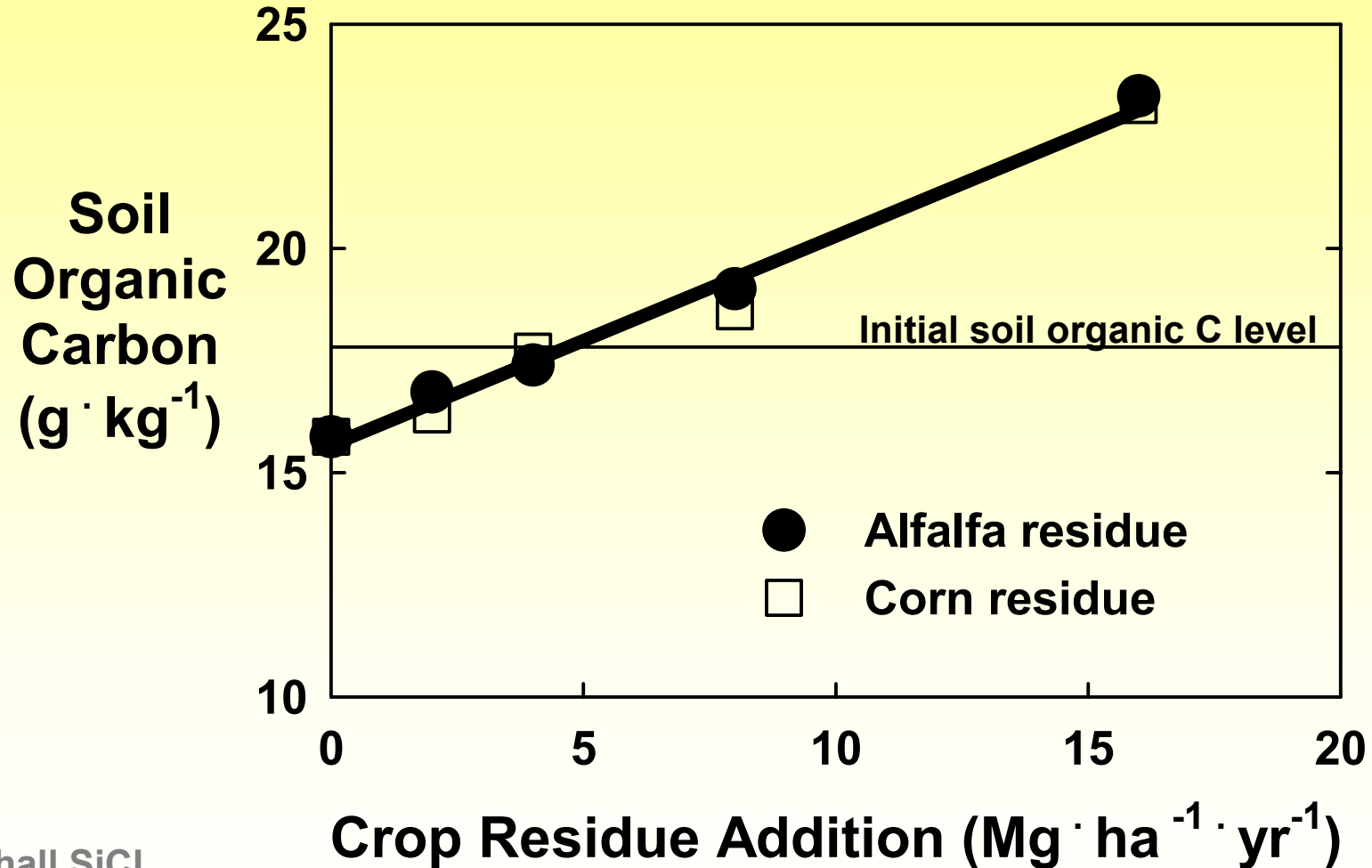


Data from Erenstein (2002) Soil Tillage Res. 67:115-133

Data from Lindstrom (1986) Agric. Ecosyst. Environ. 16:103-112

Soil Carbon Response to Crop Residue Input

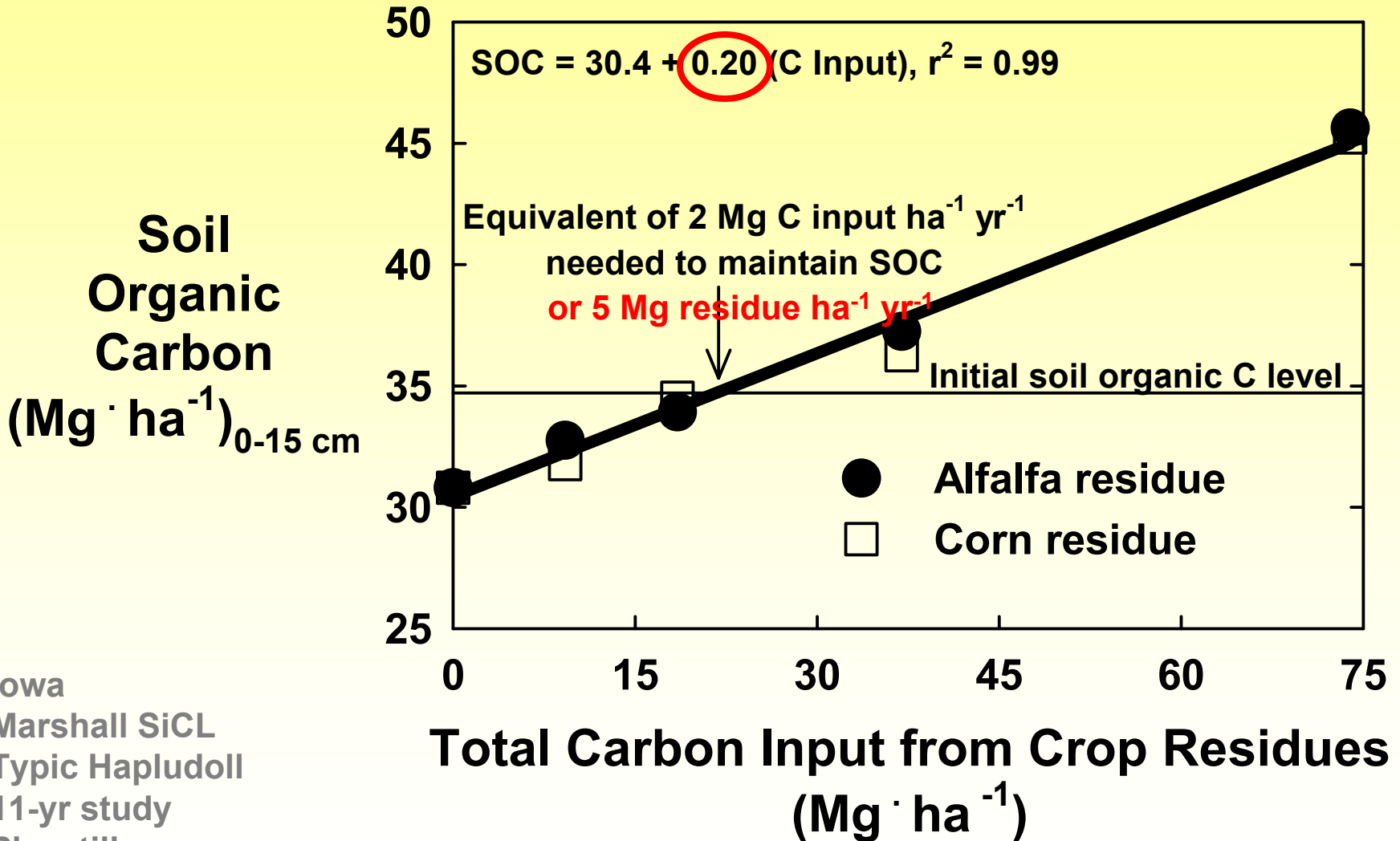
Some widely cited responses from the literature...



Iowa
Marshall SiCL
Typic Hapludoll
11-yr study
Plow tillage

Data from Larson et al. (1972) Agron. J. 64:204-208

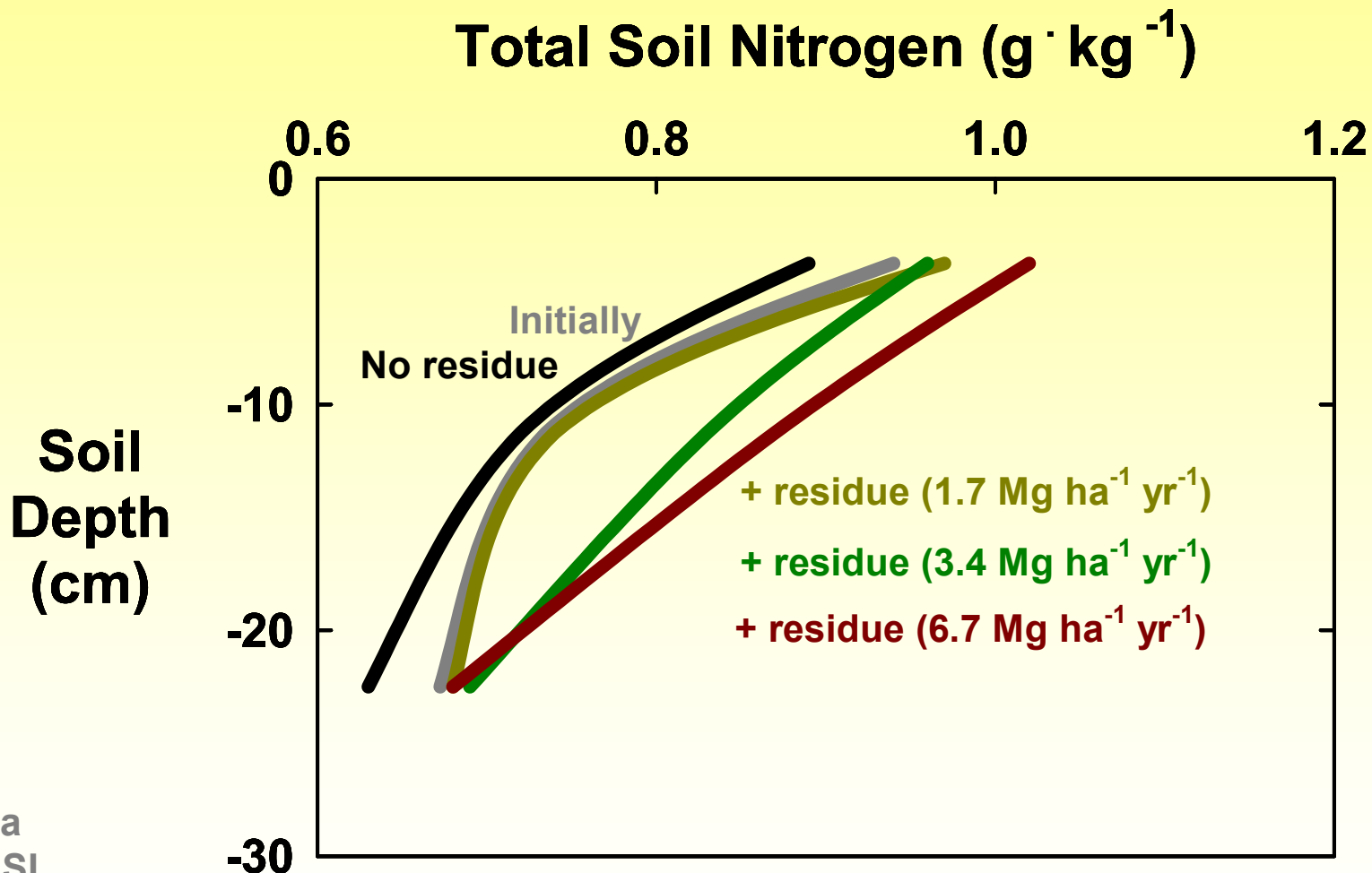
Soil Carbon Response to Crop Residue Input



Iowa
Marshall SiCL
Typic Hapludoll
11-yr study
Plow tillage
Assuming bulk density of 1.3 Mg/m³
Assuming 42% C in residue

Data from Larson et al. (1972) Agron. J. 64:204-208

Soil Nitrogen Response to Crop Residue Input



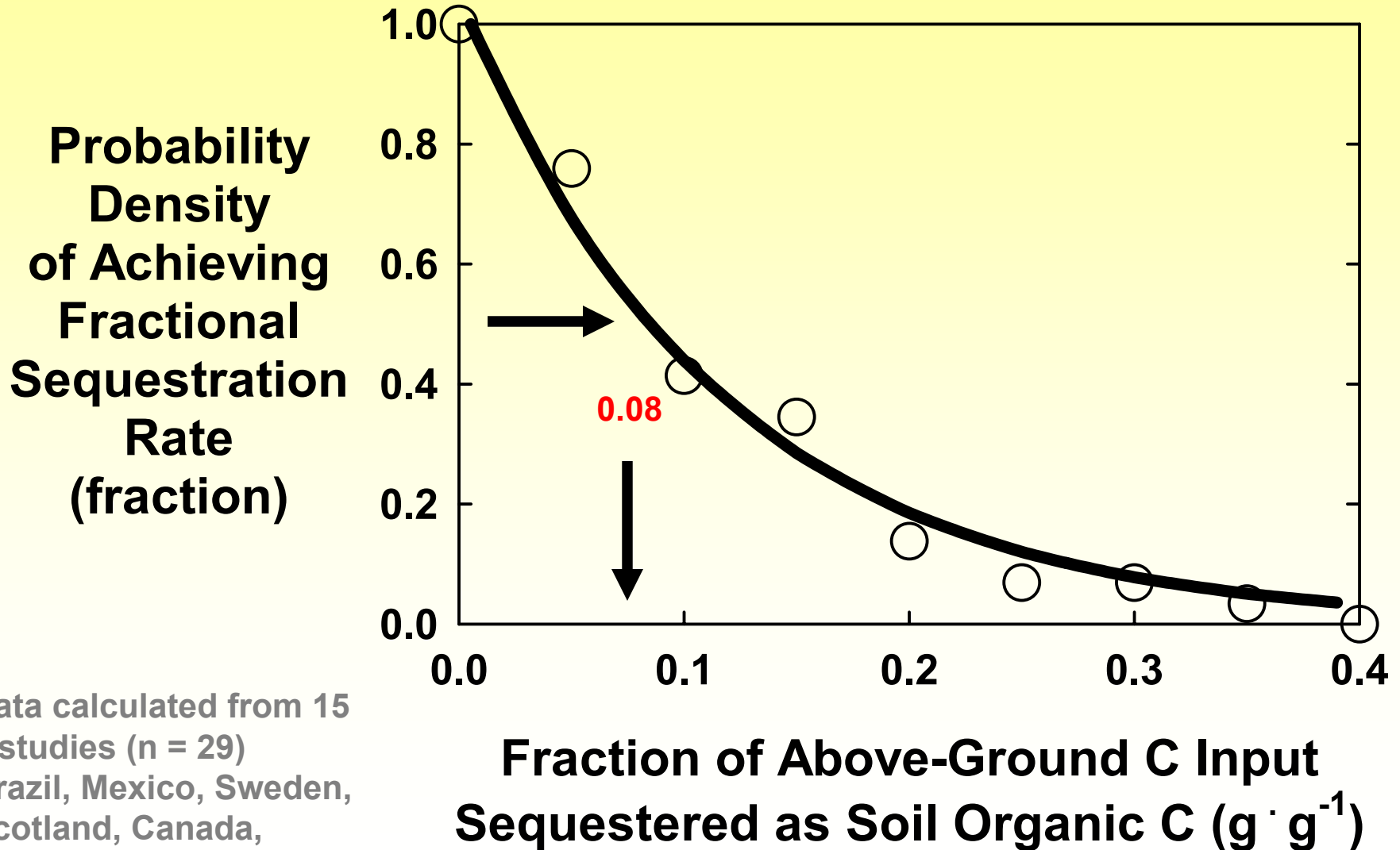
Montana
Dooley SL
Typic Argiboroll
8-yr study
Wheat-fallow
V-blade tillage

Harvesting residue reduced soil N by 4 kg/ha/yr
Additional residue increased soil N 9-19 kg/ha/yr

Data from Black (1973) Soil Sci. Soc. Am. Proc. 37:943-946

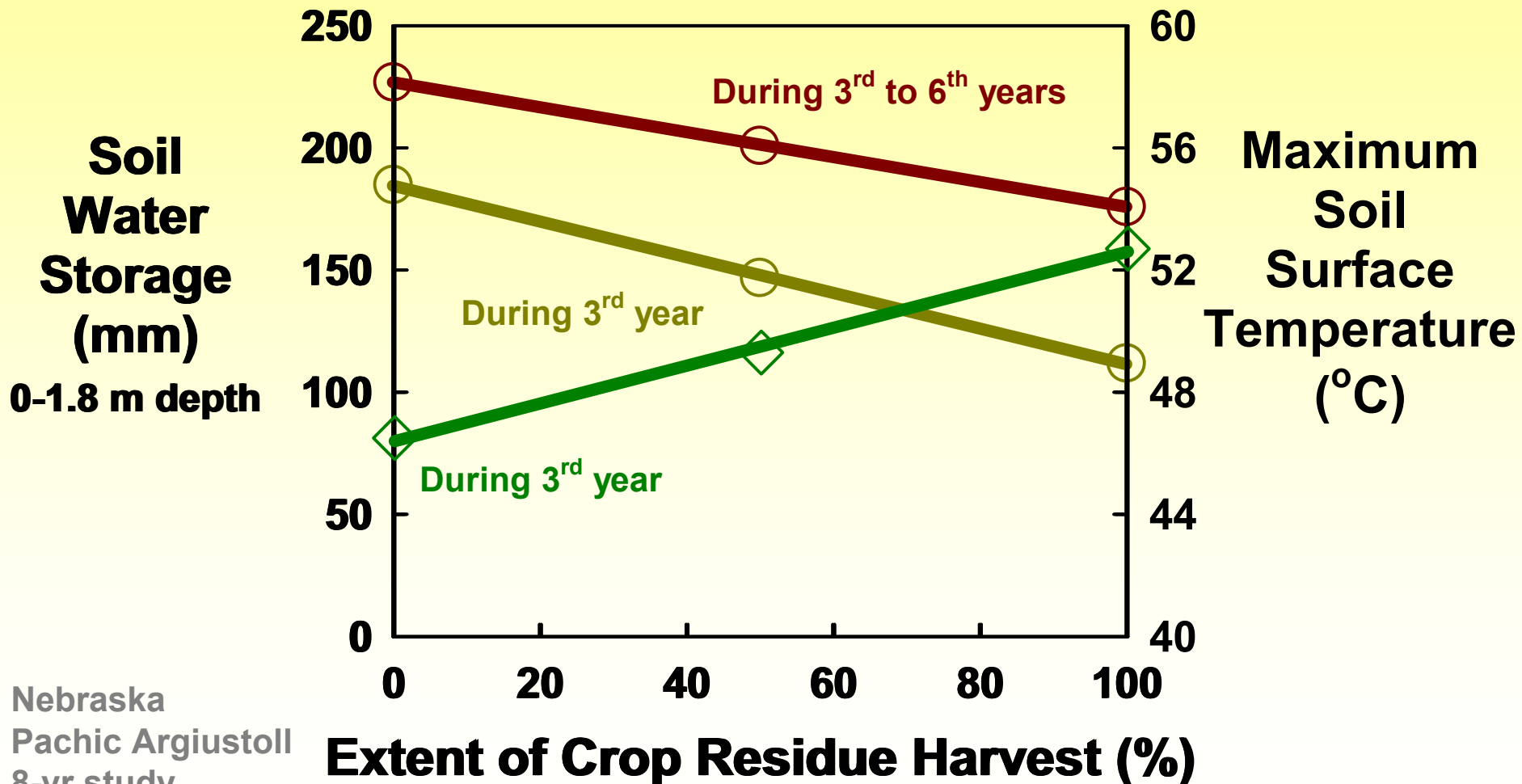
Soil Carbon Response to Crop Residue Input

...in reality there are a diversity of responses



Data calculated from 15 studies (n = 29)
Brazil, Mexico, Sweden, Scotland, Canada, MT, OH, KY, IN, IA, CT

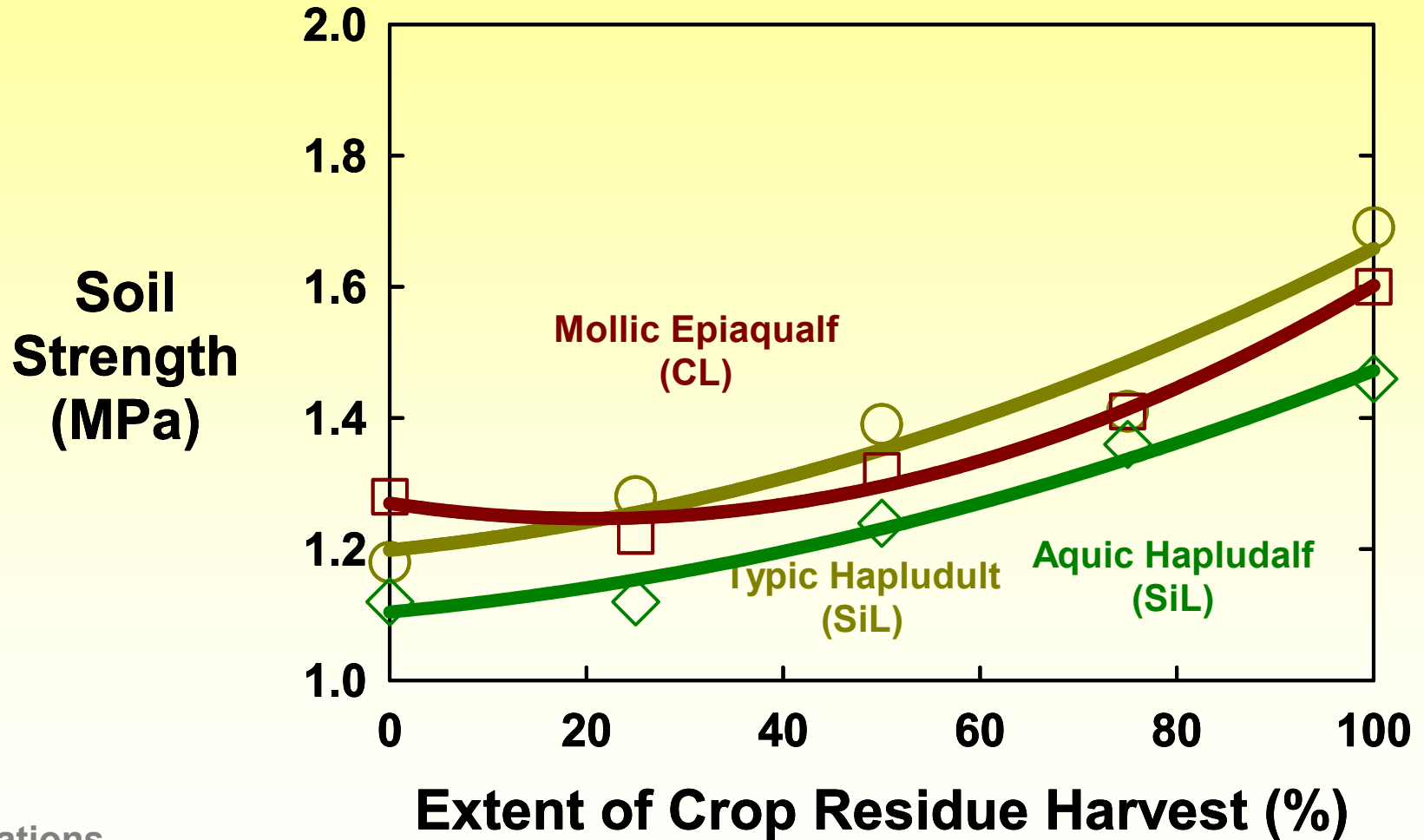
Soil Temperature and Water Responses to Crop Residue Harvest



Nebraska
Pachic Argiustoll
8-yr study
Corn
No tillage

Data from Doran et al. (1984) Soil Sci. Soc. Am. J. 48:640-645
and Wilhelm et al. (1986) Agron. J. 78:184-189

Soil Strength Response to Crop Residue Harvest



Ohio
3 locations
1-yr study
Corn
No tillage

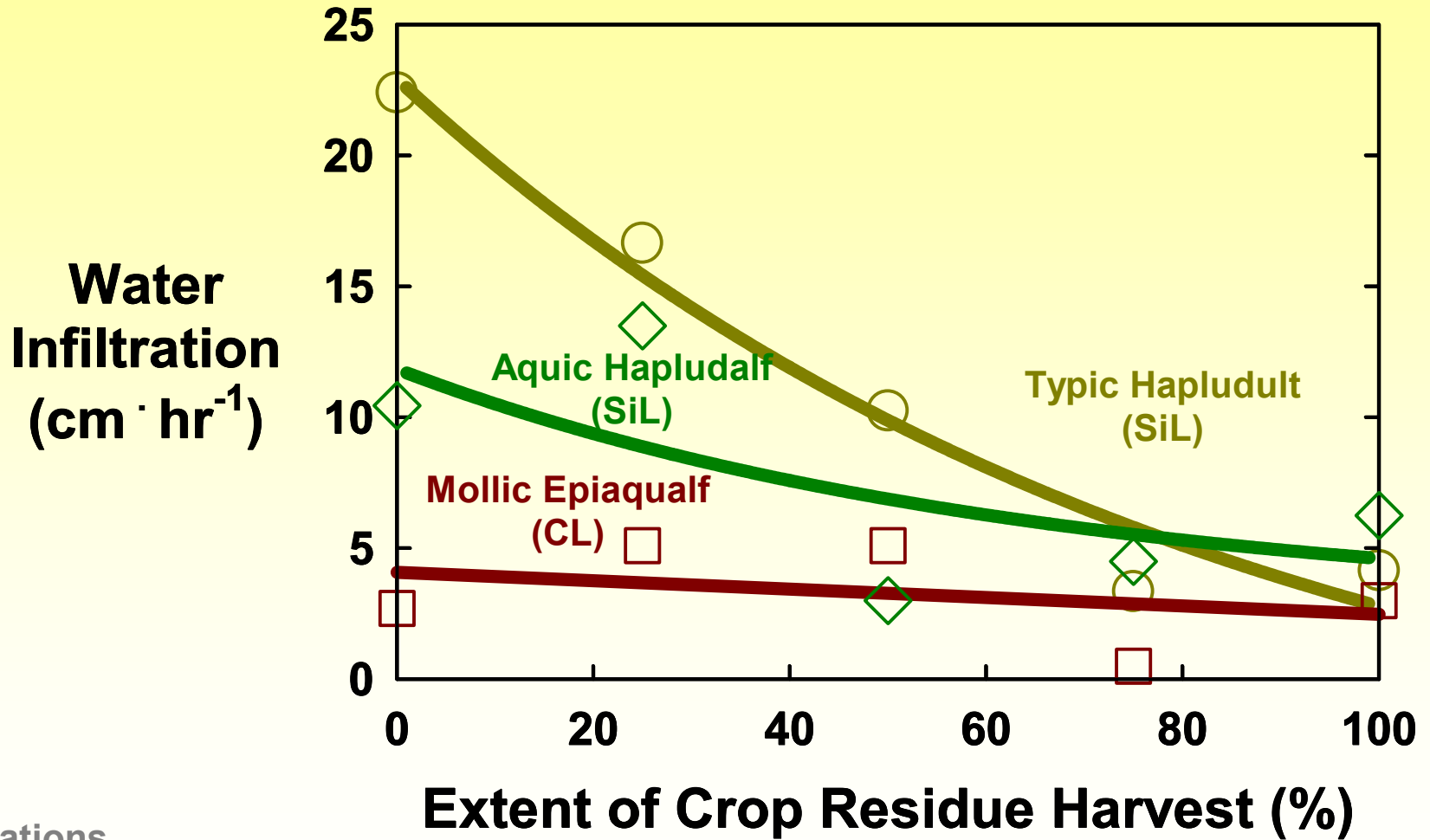
Data from Blanco-Canqui et al. (2007) Soil Tillage Res. 92:144-155

Soil Aggregation Response to Crop Residue Harvest

Wind-Erodible Aggregates (<1 mm, %)

Soil	Years	Tillage	Straw removed	Straw retained	Source
Sandy Clay Loam Mollic Cryoboralf	4	Tilled No till	50 40	47 34	Malhi et al. (2006) Soil Tillage Res. 90:171-183
Sandy Loam Typic Cryoboralf	5	Tilled No till	43 33	43 30	
Clay Loam Mollic Cryoboralf	5	Tilled No till	27 17	28 15	Malhi & Kutcher (2007) Soil Tillage Res. 94:353-361
Loam Udic Boroll	6	Tilled No till	39 23	33 18	
Loam Mollic Cryoboralf	6	Tilled No till	46 35	42 28	Singh & Malhi (2006) Soil Tillage Res. 85:143-153
Sandy Clay Loam Mollic Cryoboralf	8	Tilled No till	17 21	11 13	
Clay Loam Udic Boroll	9	Tilled	73	52	Singh et al. (1994) Soil Tillage Res. 32:117-133
Mean			36	30	P < 0.01

Water Infiltration Response to Crop Residue Harvest



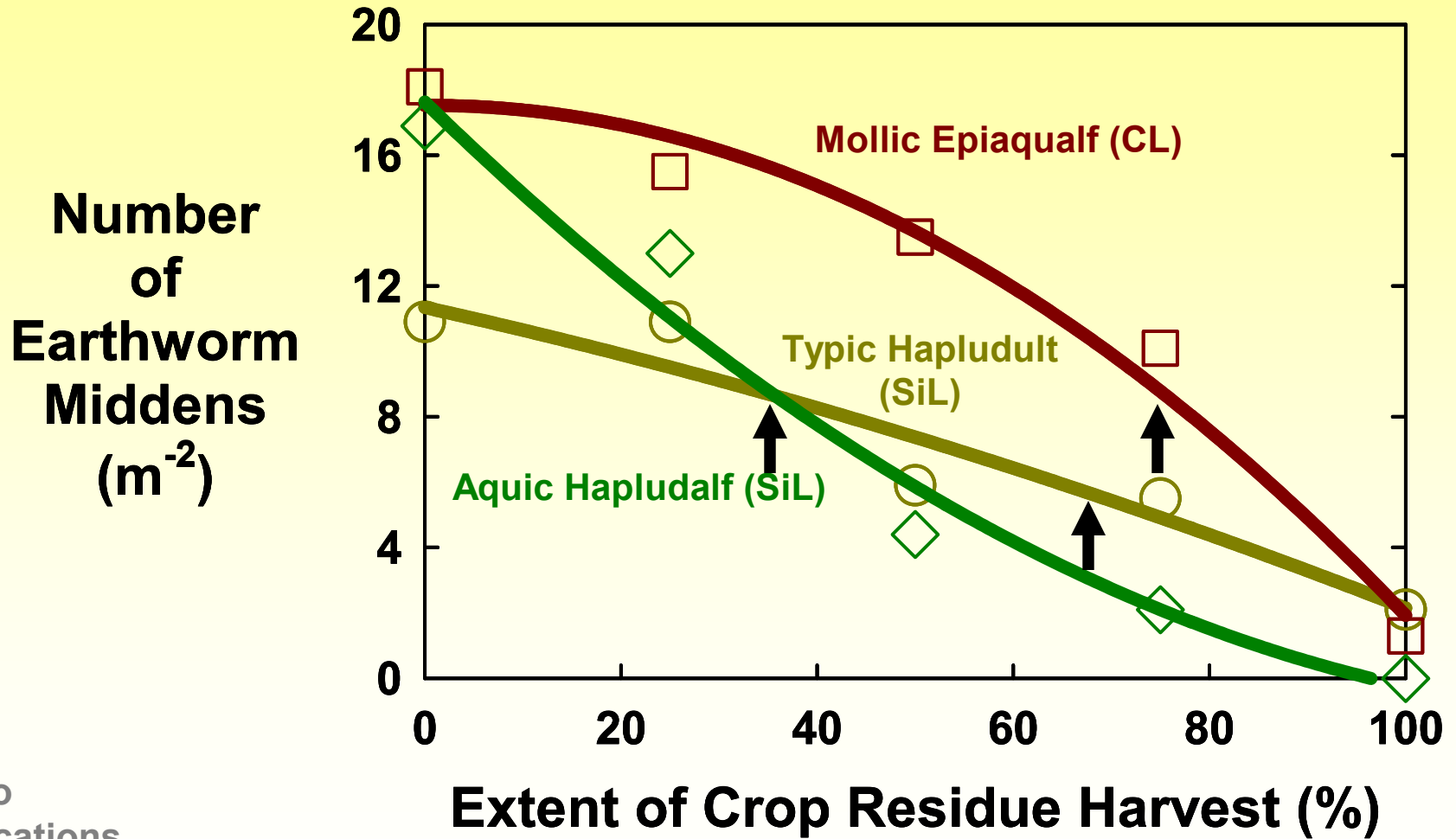
Ohio
3 locations
2.5-yr study
Corn
No tillage

Data from Blanco-Canqui & Lal (2007) Geoderma 141:355-362

Soil Biological Response to Crop Residue Harvest

Location	Response	Soil	Residue removed	Residue retained	Source
Finland	Earthworms (no. m ⁻²)	Silty clay	1.2	2.0	Nuutinen (1992) Soil Tillage Res. 23:221-239
		Silty clay loam	1.7	1.7	
		Sandy loam	0.7	0.8	
New Zealand		?	243	323	Fraser & Piercy (1998) Applied Soil Ecol. 9:369-373
Wisconsin	Microbial C (mg kg ⁻¹)	Silt loam	53	78	Karlen et al. (1994) Soil Tillage Res. 31:149-167
		Silt loam	330	696	
Denmark		Loamy sand	151	184	Debosz et al. (1999) Applied Soil Ecol. 13:209-218
Mexico		Sandy clay	324	364	Limon-Ortega et al. (2002) Soil Tillage Res. 63:123-132
New Zealand	Fungi (km g ⁻¹)	Silt loam	3.0	4.0	Cookson et al. (1998) Applied Soil Ecol. 7:179-188

Soil Biological Response to Crop Residue Harvest



Ohio
3 locations
1-yr study
Corn
No tillage

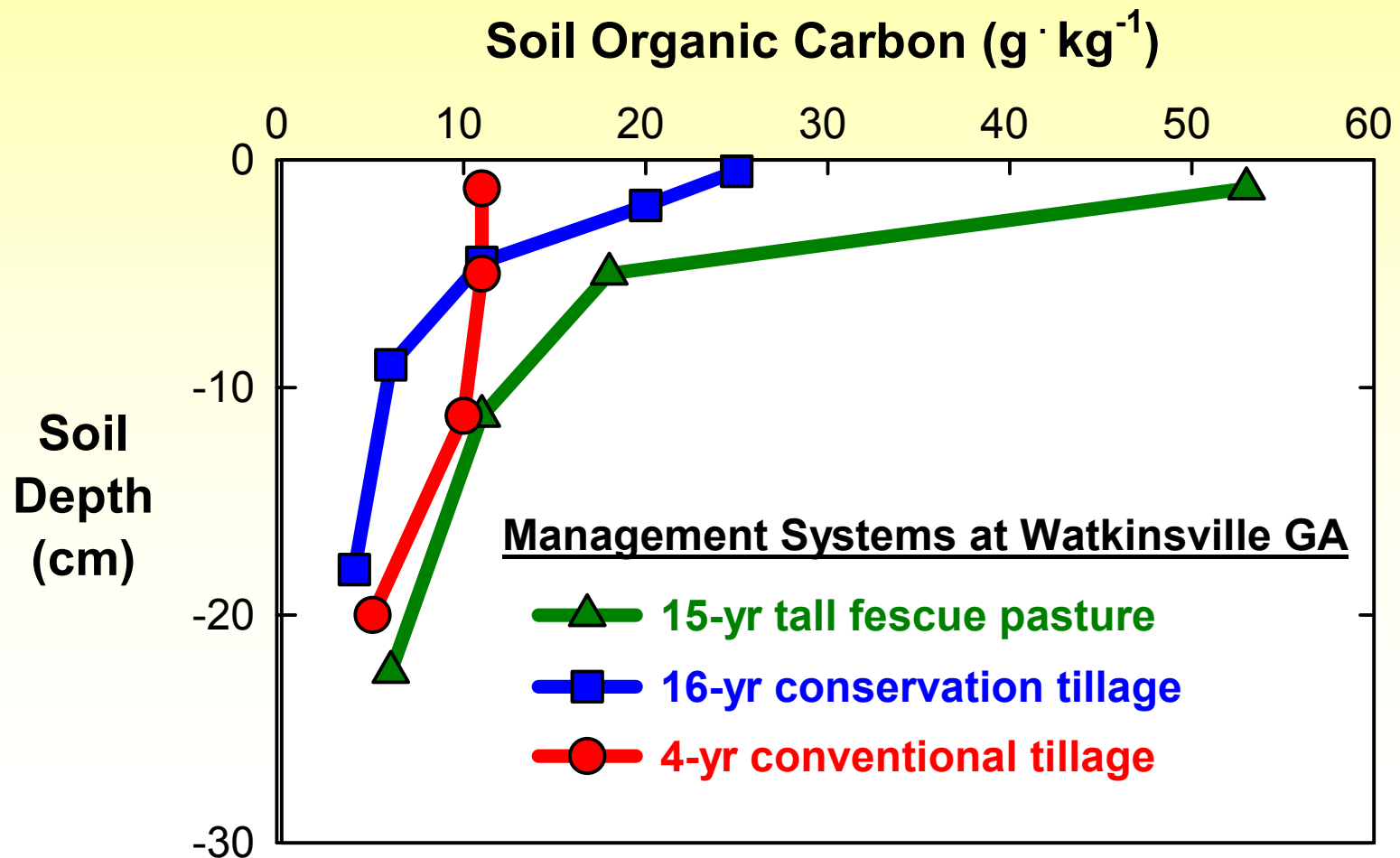
Data from Blanco-Canqui et al. (2007) Soil Tillage Res. 92:144-155

Summary of Soil Responses to Crop Residue Harvest

- ✓ Reduced water infiltration, especially with >50% removal
- ✓ Increased soil erosion, most likely with >50% removal
- ✓ Reduced soil organic C and N storage (dependent upon soils, climate, etc.)
 - Soil organic matter is a key component that controls many other soil properties
- ✓ Reduced water storage and increased surface soil temperature
- ✓ Increased soil strength
- ✓ Reduced soil aggregation
- ✓ Reduced soil biological activity

Management Alternatives to Promote Soil and Water Quality if Harvesting Crop Residues

- ✓ Sod-based crop rotations



Management Alternatives to Promote Soil and Water Quality if Harvesting Crop Residues

- ✓ Animal manure collection and distribution onto soil

Percentage of C in manure that is retained as soil organic C

Temperate or frigid regions ($23 \pm 15\%$)

Thermic regions ($7 \pm 5\%$)

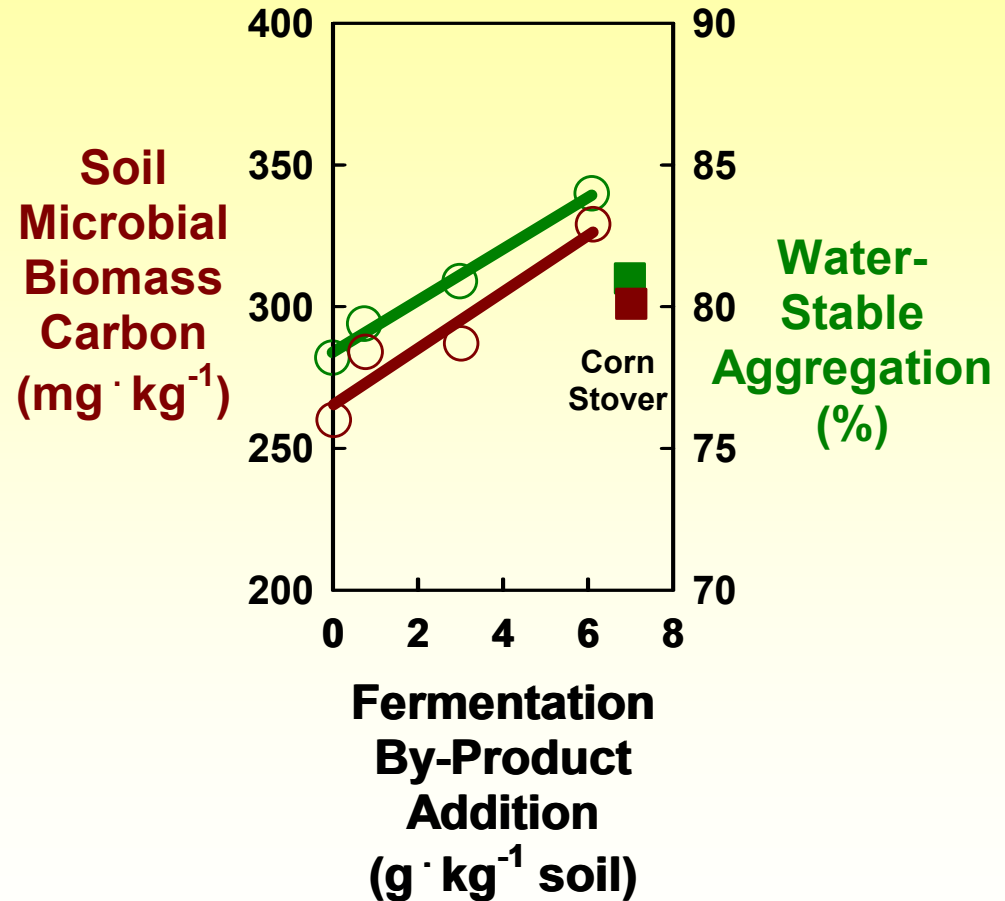
Moist regions ($8 \pm 4\%$)

Dry regions ($11 \pm 14\%$)

Management Alternatives to Promote Soil and Water Quality if Harvesting Crop Residues

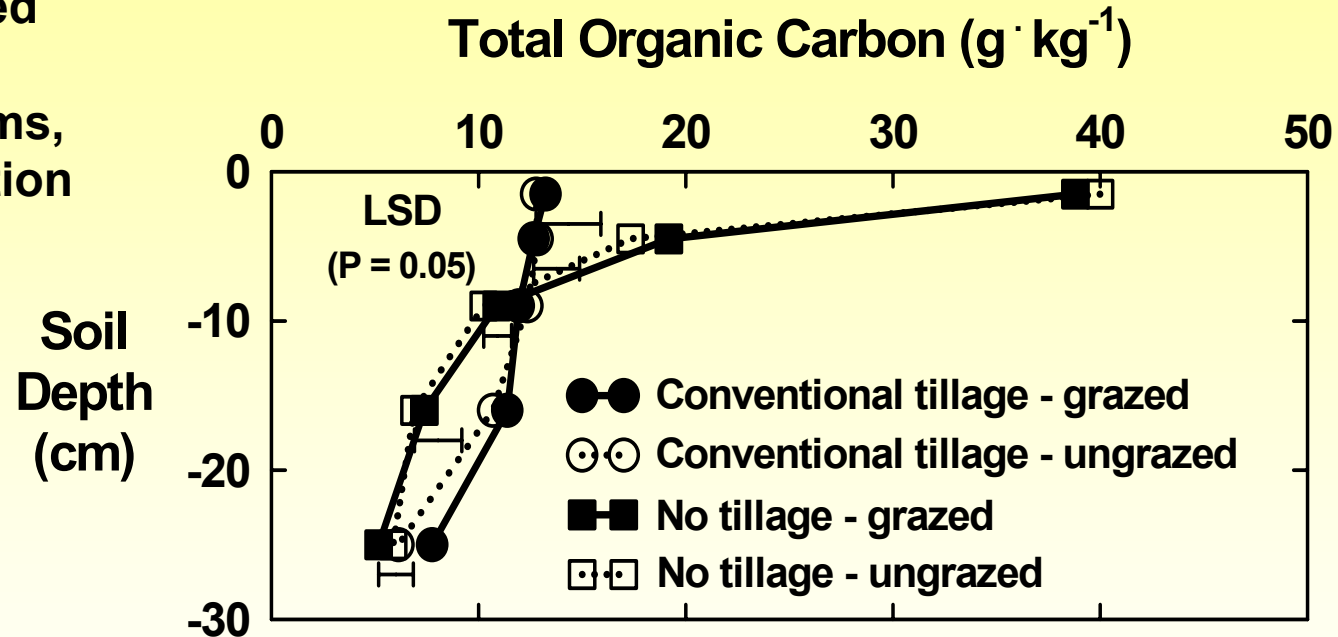
- ✓ Utilization of biofuel and industrial by-products as soil amendment

Property	% Composition	
	Corn Stover	Ethanol By-Product
Lignin	20	62
Cellulose	36	13
Hemicellulose	23	3
Carbon	47	49
C-to-N ratio	67	24



Management Alternatives to Promote Soil and Water Quality if Harvesting Crop Residues

- ✓ Regionally adapted conservation agriculture systems, including integration of crops and livestock



Data from Franzluebbbers and Stuedemann (2007) Soil Sci. Soc. Am. J. (in press)

Management Alternatives to Promote Soil and Water Quality if Harvesting Crop Residues

- ✓ Geospatially distributed perennial and annual cropping



Conclusions

- ✓ There is an extremely urgent need to carefully assess the potential impacts of crop residue harvest for biofuels on soil, water, and air quality.
- ✓ A diversity of environmental re depending upon the climatic ar for large-scale harvest of crop
- ✓ If crop residues must be harvested for biofuel production, then innovative management practices need to be implemented to maintain and improve soil quality for sustained agricultural production in the future.

