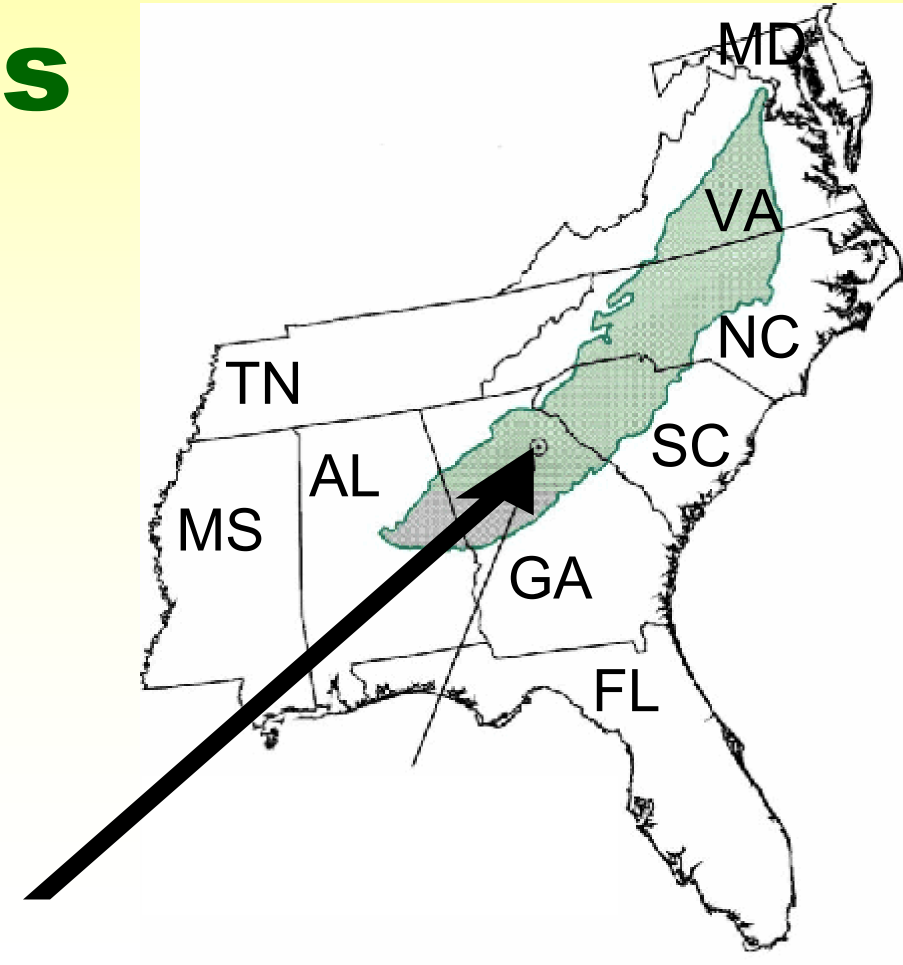
The Science of Integrated Crop – Livestock Systems

Alan J. Franzluebbers

Ecologist

USDA ARS

Watkinsville GA



Integrated Crop–Livestock Systems

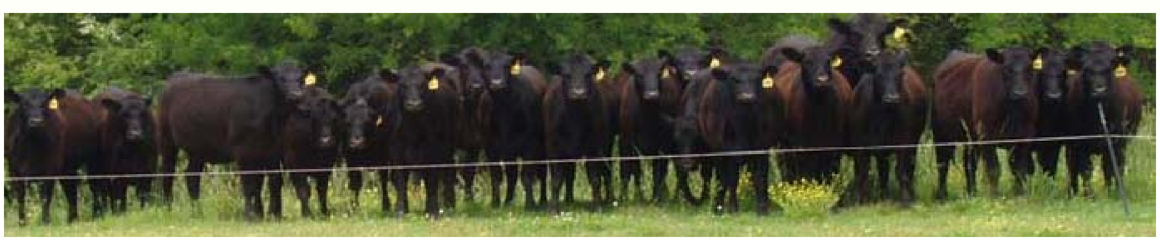
Why?

Production

- ✓ Farms operating on marginal profit
- ✓ Economic vulnerability with specialized production
- ✓ High cost of fuel and nutrients
- ✓ Pests become greater with monocultures
- ✓ Yield decline could be overcome with rotation

Environment

- ✓ Nutrient recycling could be improved in both systems
- ✓ Conservation of soil and water possible with sod-based management systems



Integrated Crop–Livestock Systems

Issues to be addressed

1. In an *integrated crop–livestock system*, there are many levels of subsystems that interact with each other. How do we study the science of integrated crop–livestock systems at multiple scales?

2. Are there any areas of research that can

   a. Improve our understanding of integrate crop–livestock systems?

   b. Increase the system's output while reducing input?

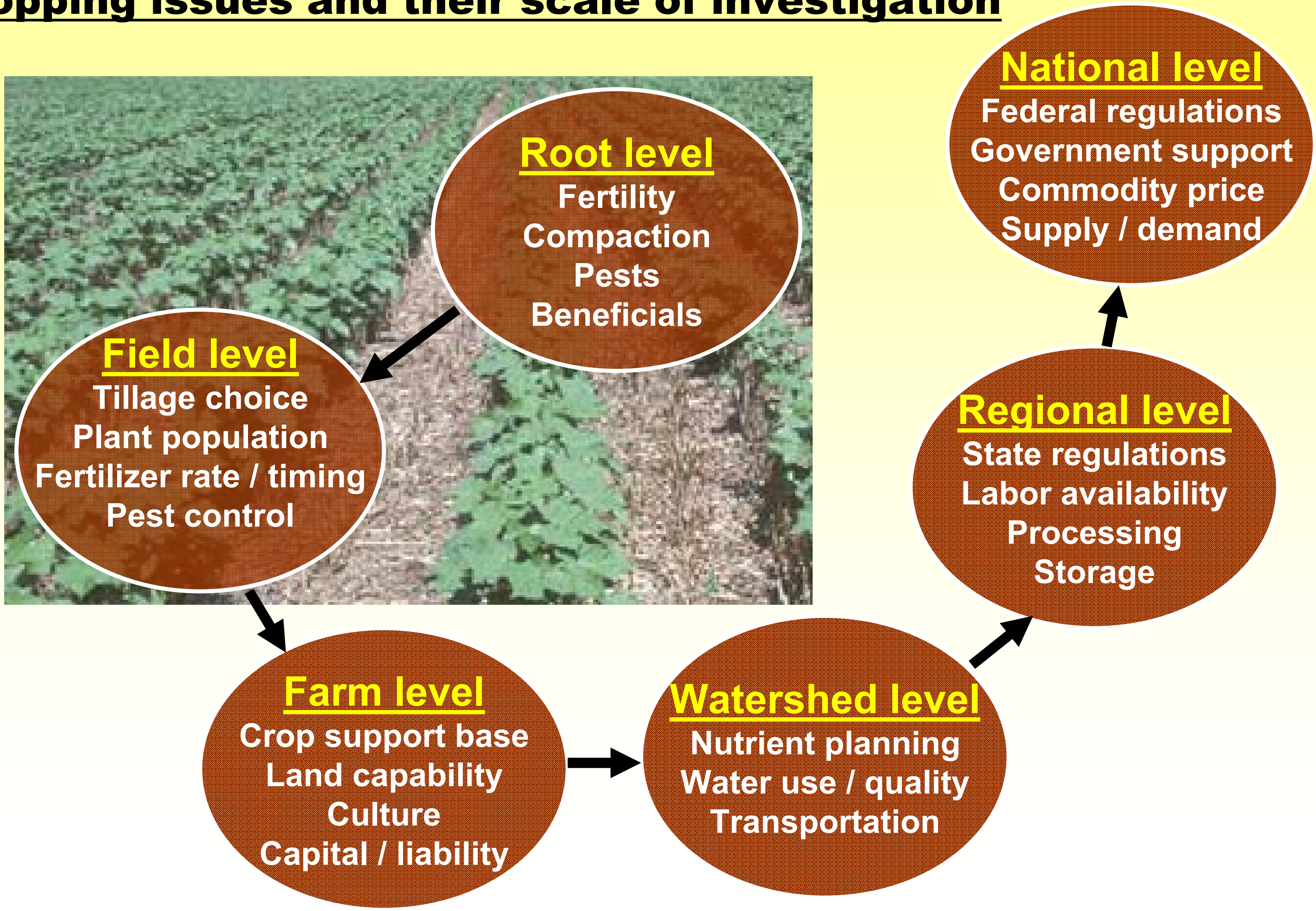
3. What do we know about managing cropping patterns, manure management, and grazing to optimize nutrient cycling within an integrated crop–livestock system?

4. What do we know about the benefits and trade-offs of a mixed livestock and crop system and how to optimize the system?

Integrated Crop–Livestock Systems

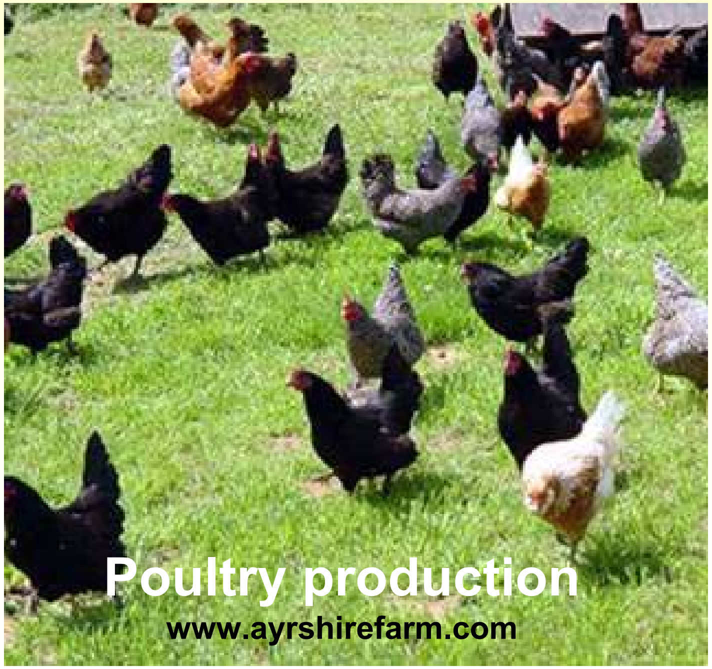
Integrated Crop–Livestock Systems

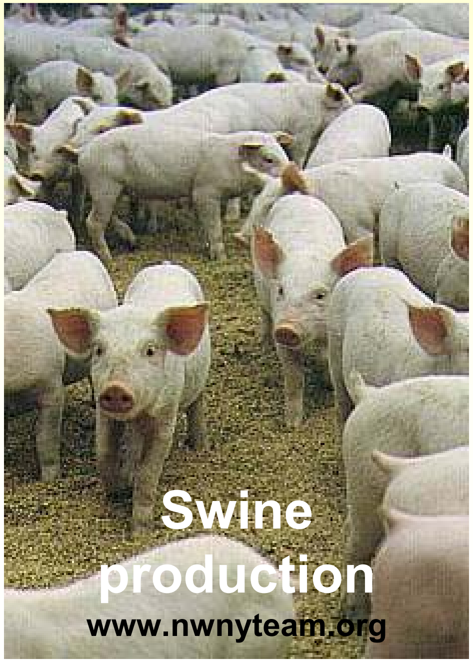
Cropping issues and their scale of investigation



Integrated Crop–Livestock Systems

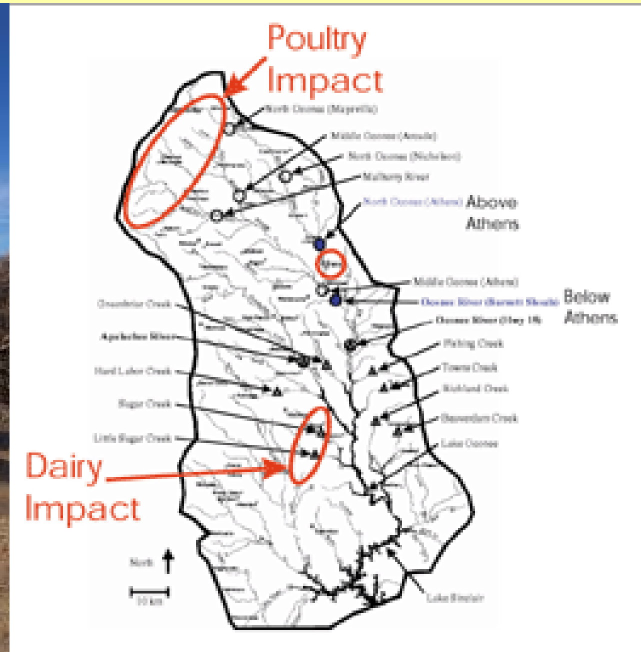
Livestock component

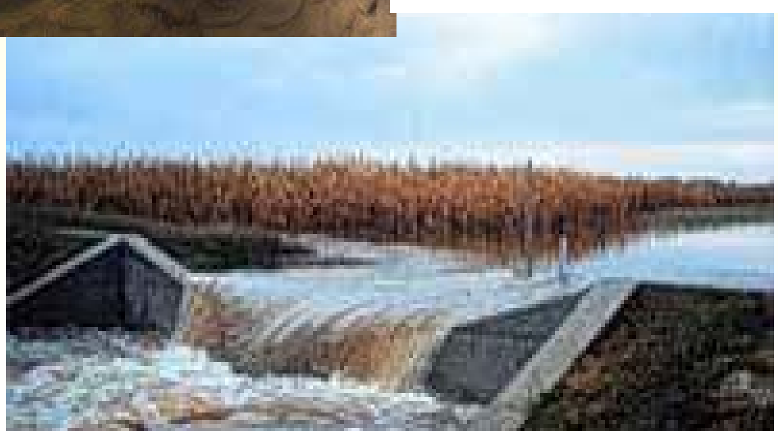




Integrated Crop–Livestock Systems

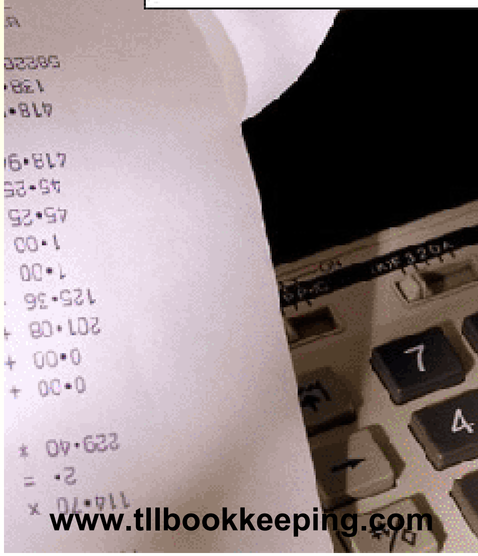
Environmental component

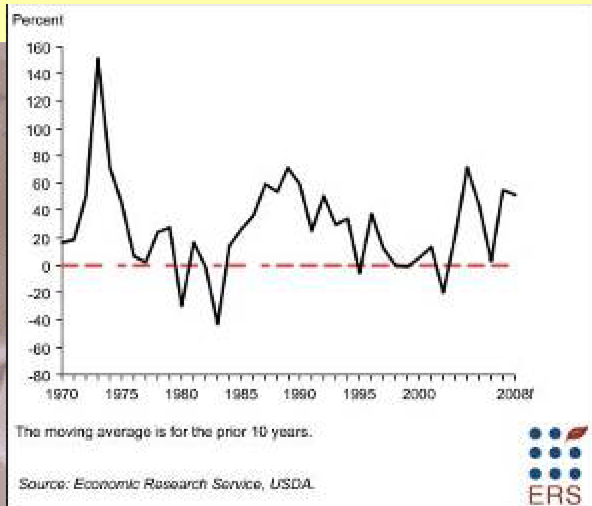




Integrated Crop–Livestock Systems

Socio-economic component





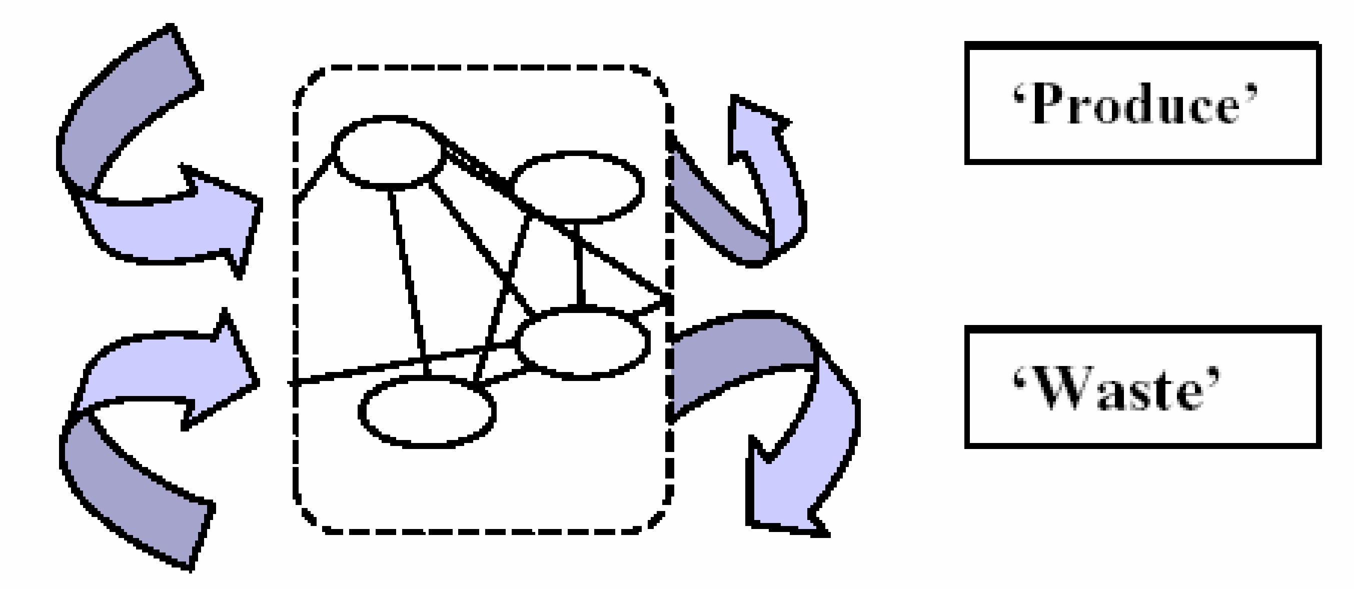
USDA ORGANIC

SARE AFSIC ATTRA

USDA Supported Programs for Sustainable Agriculture

Integrated Crop–Livestock Systems

How can research help?



…through analysis of systems; well-defined boundaries and goals, consisting of different parts that convert inputs into outputs and that work together towards a common goal

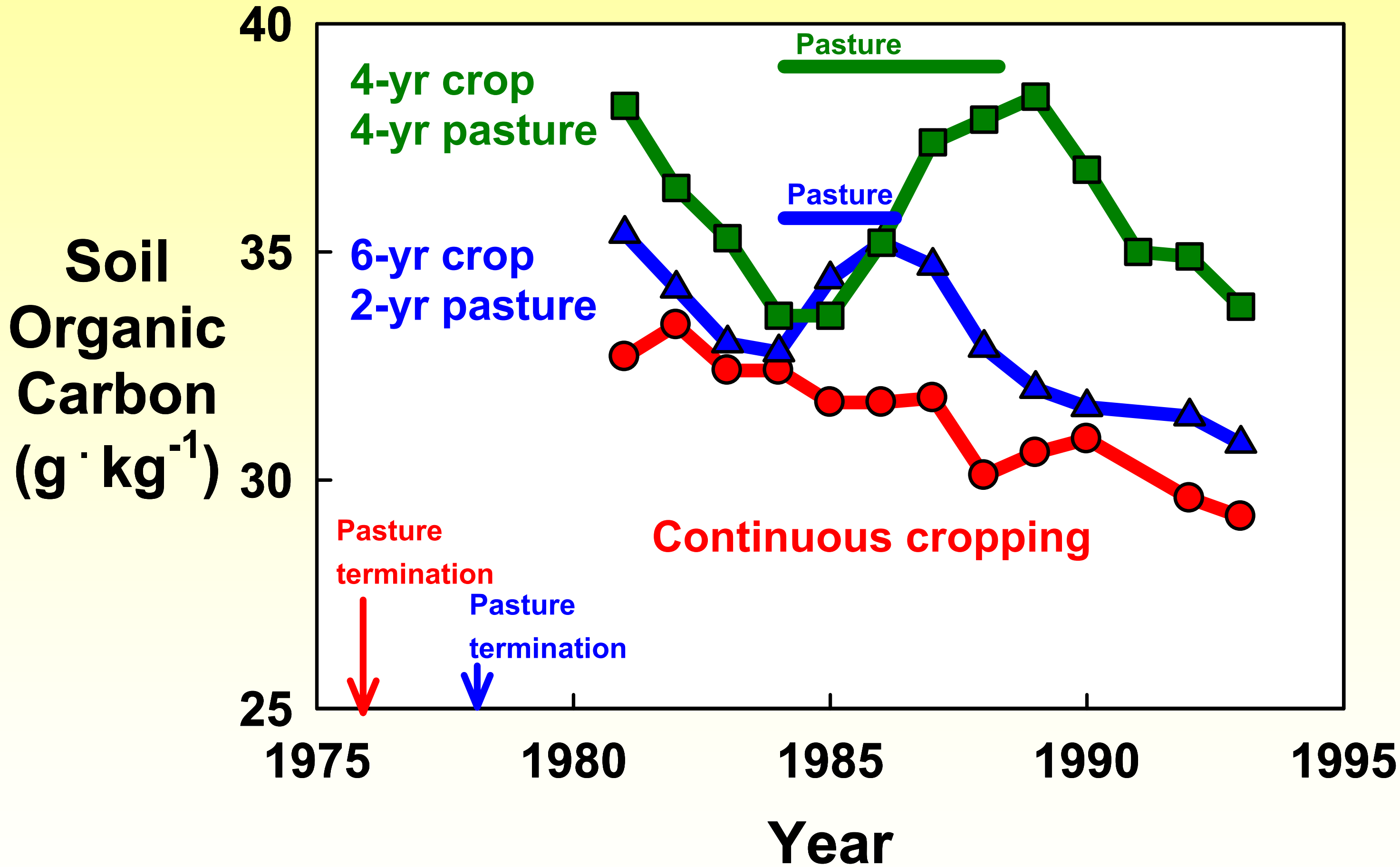
Both component- and system-level research needed

From van Keulen and Schiere (2004) Proc. 4th Int. Crop Sci. Congr.
www.cropscience.org.au/icsc2004/pdf/211_vankeulenh.pdf

Integrated Crop–Livestock Systems

How can research help?

Pasture-crop rotations



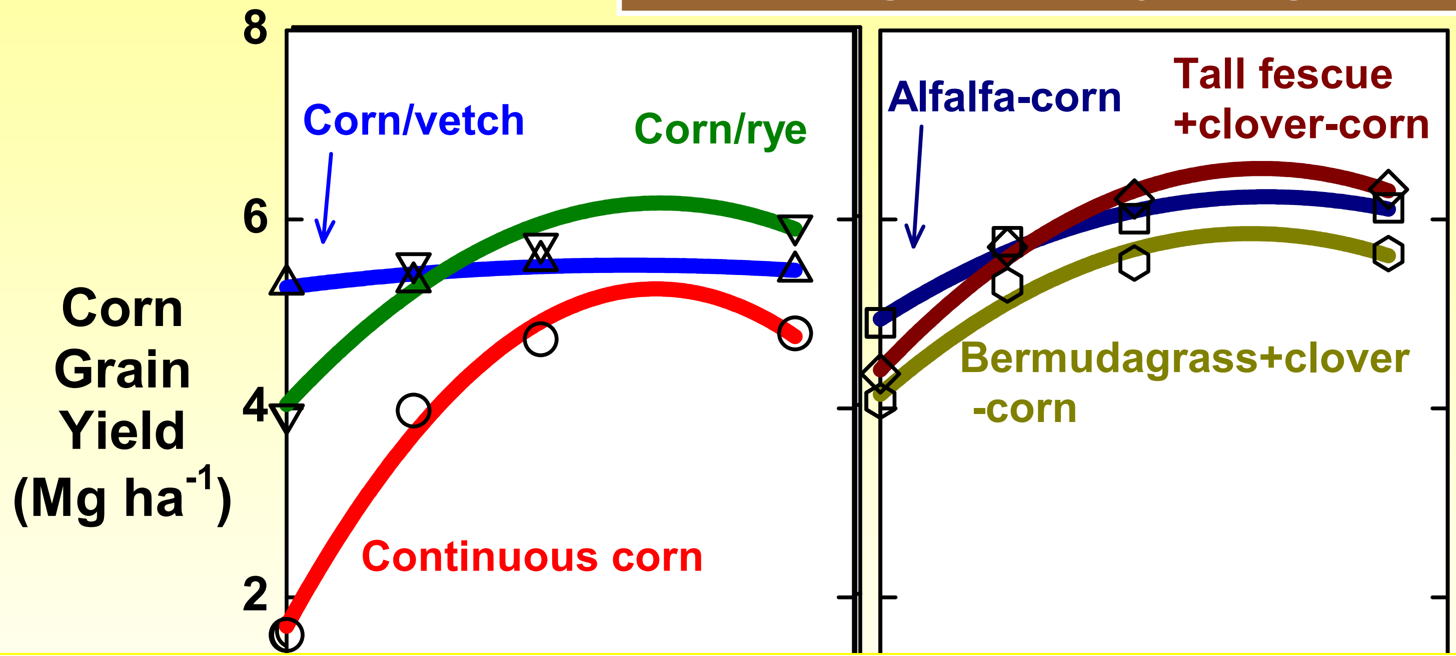
Sod-based crop rotations are needed to maintain fertility and soil quality

Data from Studdert et al. (1997) Soil Sci. Soc. Am. J. 61:1466-1472

Integrated Crop–Livestock Systems

How can research help?

Sod- and legume-based rotations are important for maintaining productivity through nutrient cycling



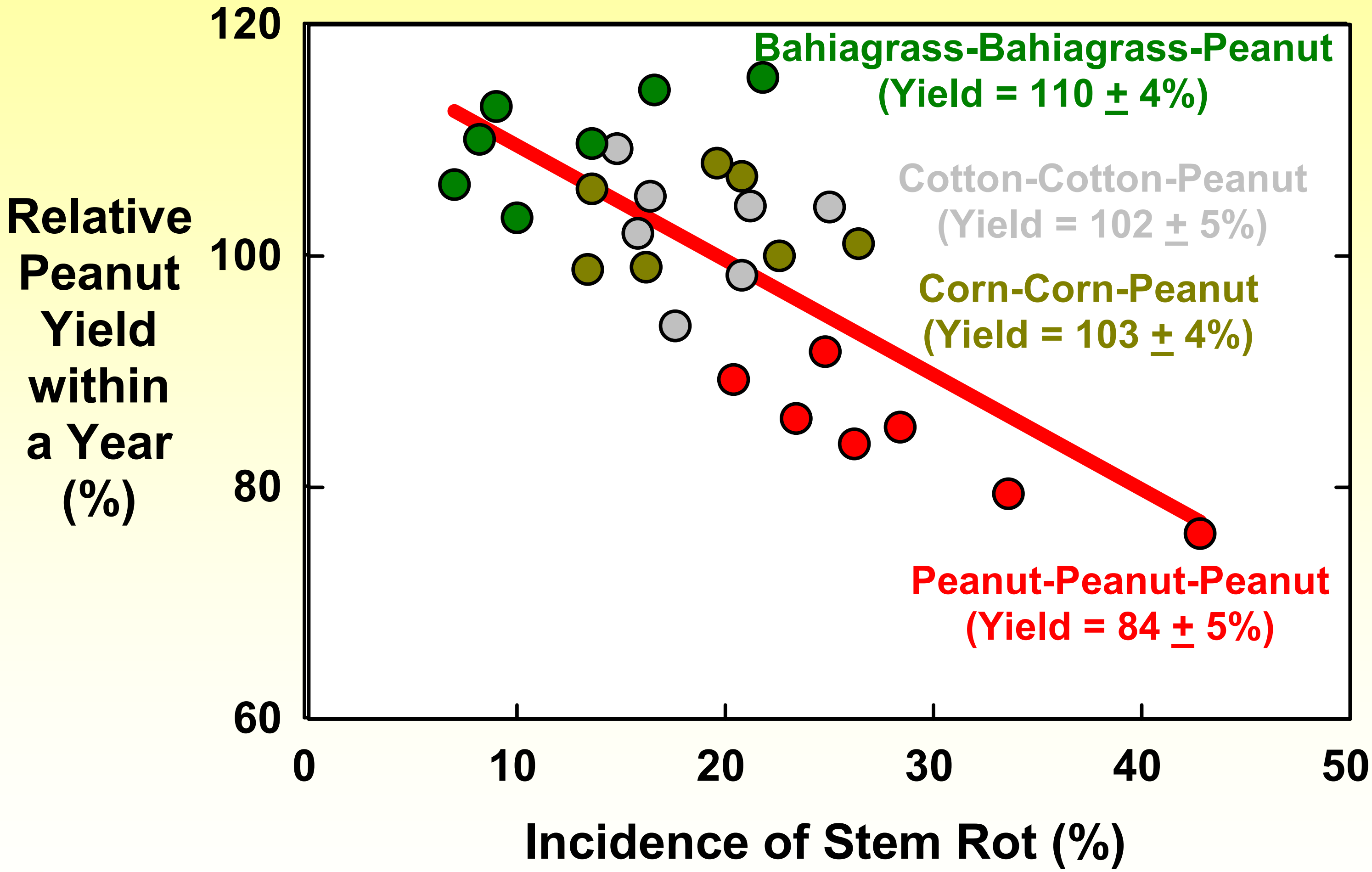
Compared with continuous corn	Rye	Vetch	Alfalfa	Bermuda	Fescue
Nitrogen savings (kg ha^{-1})	7	120	17	13	7
Rotation effect (% yield increase)	17	1	17	10	23

How might responses change if grazed by cattle?

Data from Adams et al. (1970) Agron. J. 62: 655-659

Integrated Crop–Livestock Systems

How can research help?



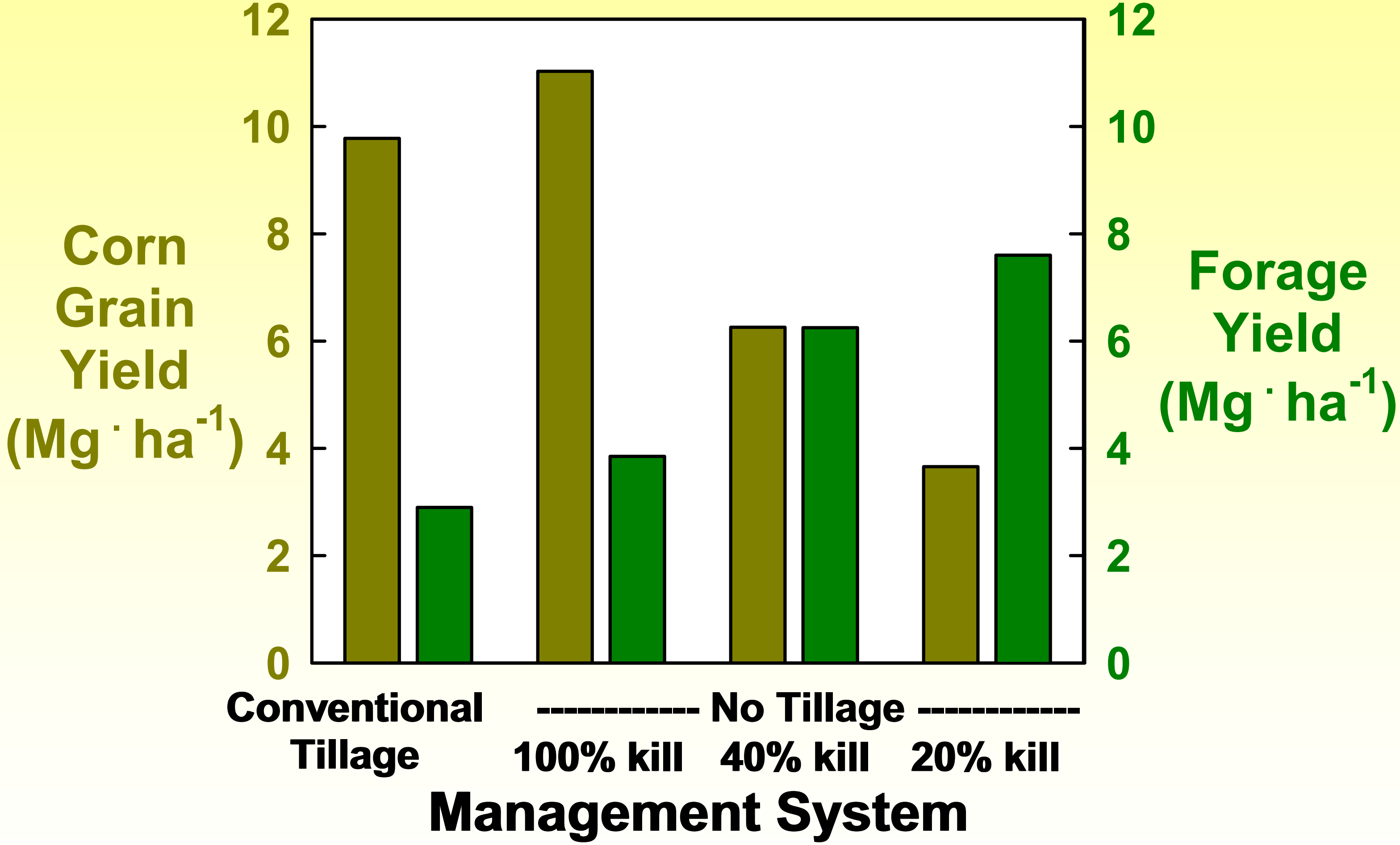
Crop-specific responses to rotations and integrated systems will be important

Data from Brenneman et al. (2003) Proc. Sod-Based Crop. Syst. Conf., Quincy FL, p. 59-65

Integrated Crop–Livestock Systems

How can research help?

Corn following sod



To meet changing farm needs, sod-grain intercropping can provide flexibility

Data from Wilkinson et al. (1987) Agron. J. 79:685-690

Integrated Crop–Livestock Systems

How can research help?

Standard cropping systems throughout southeastern USA without integration

Crop	Pairs of obs.	Conventional	No Till
		------------- Mg ha^{-1}	-------------
Corn grain	19	6.82	7.12
Corn silage	5	15.3	16.1
Cotton lint	18	1.04	1.06
Cotton seed	9	2.59	2.69
Peanut seed	6	3.37	3.43
Soybean seed	18	2.05	2.12
Wheat grain	9	3.00	3.11

Under a diversity of conditions, conservation tillage can produce successful crops

Reviewed in Franzluebbers (2005) Soil Till. Res. 83:120-147

Integrated Crop–Livestock Systems

How can research help?

Integrated crop-livestock system In Watkinsville GA

Cropping system	Years	Conventional	No Till	
		------------- Mg ha^{-1} -------------		
Sorghum (corn) / rye	2002-2005	3.20	3.39	+6%
Wheat / pearl millet	2002-2005	2.76	2.62	−5%
Rye / sorghum (corn)	2003-2005	6.03	7.02	+16%
Pearl millet / wheat	2002-2005	7.59	10.19	+34%

In an integrated crop-livestock system, conservation tillage can produce successful grain crops and even better cover crops!

Franzluebbers and Stuedemann (2007) Renew. Agric. Food Syst. 22:168-180

Integrated Crop–Livestock Systems

How can research help?

Integrated crop-livestock system In Watkinsville GA

Crop	Years	Ungrazed	Grazed	
		----------- Mg ha^{-1} -----------		
Sorghum grain	2002-2004	2.07	1.82	−12%
Corn grain	2005-2007	3.64	3.32	−9%
Wheat grain	2003-2008	2.96	3.09	+4%
		----- (head x day) ha^{-1} -----		
Cattle grazing days	2002-2005	none	352 ± 104	
		------------ kg ha^{-1} ------------		
Cattle gain	2002-2005	none	290 ± 142	

Crop yields may be somewhat negatively affected, but grazing cover crops can increase diversity and productivity of system

Franzluebbers and Stuedemann (2007) Renew. Agric. Food Syst. 22:168-180 + unpublished data

Integrated Crop–Livestock Systems

How can research help?

Integrated crop-livestock system
In Watkinsville GA

Item	Ungrazed cover		Grazed cover crop	
	Conv. Till	No Till	Conv. Till	No Till
	$ ha^{-1}			
Variable cost	258	267	253	263
Cover crop cost	91	91	91	91
Value of crop	275	307	290	266
Value of cattle gain	0	0	336	410
Net return	−74	−51	282	322

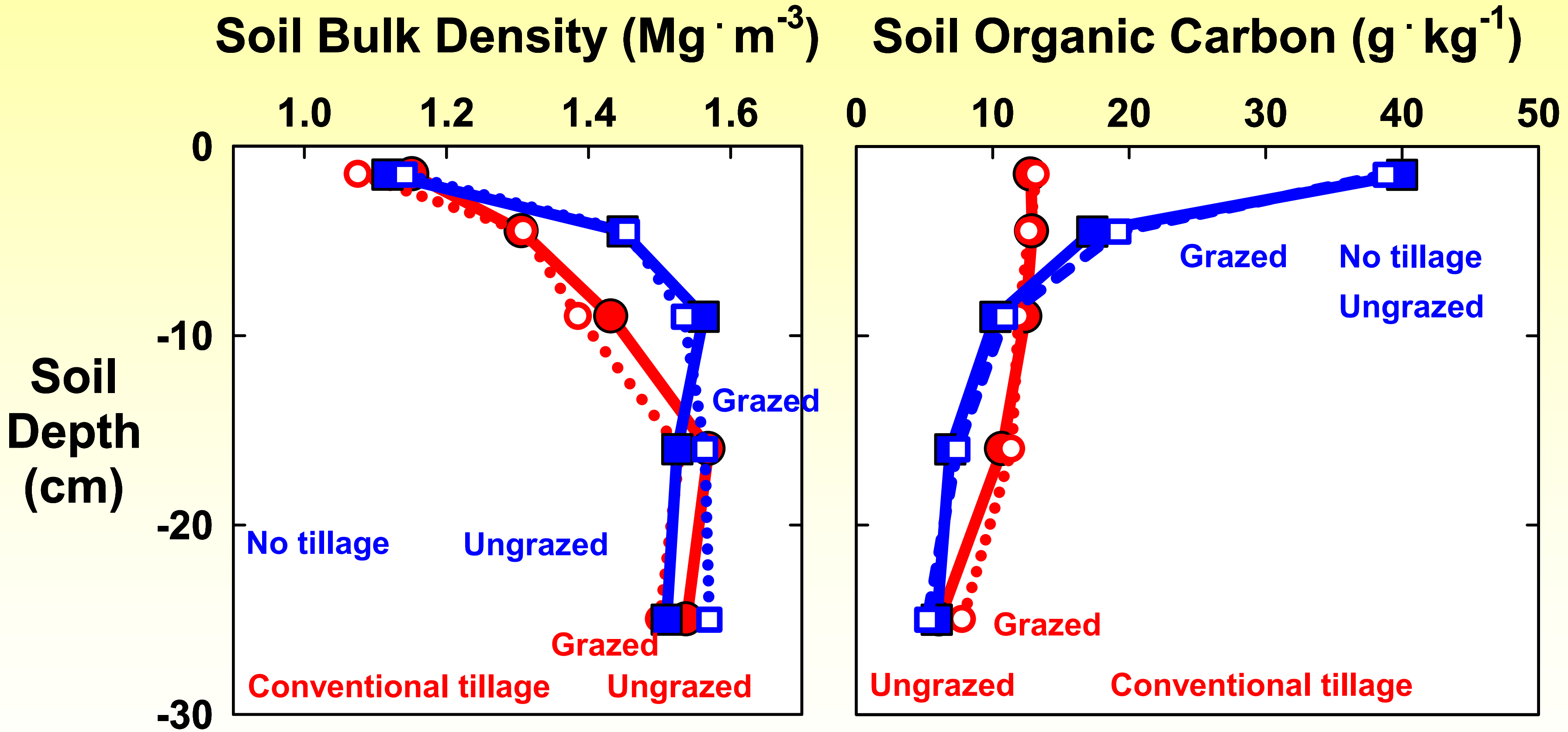
Diversity of crop and cattle system can improve economic bottom line, more so than tillage system

Franzluebbers and Stuedemann (2007) Renew. Agric. Food Syst. 22:168-180

Integrated Crop–Livestock Systems

How can research help?

Integrated crop-livestock system
In Watkinsville GA



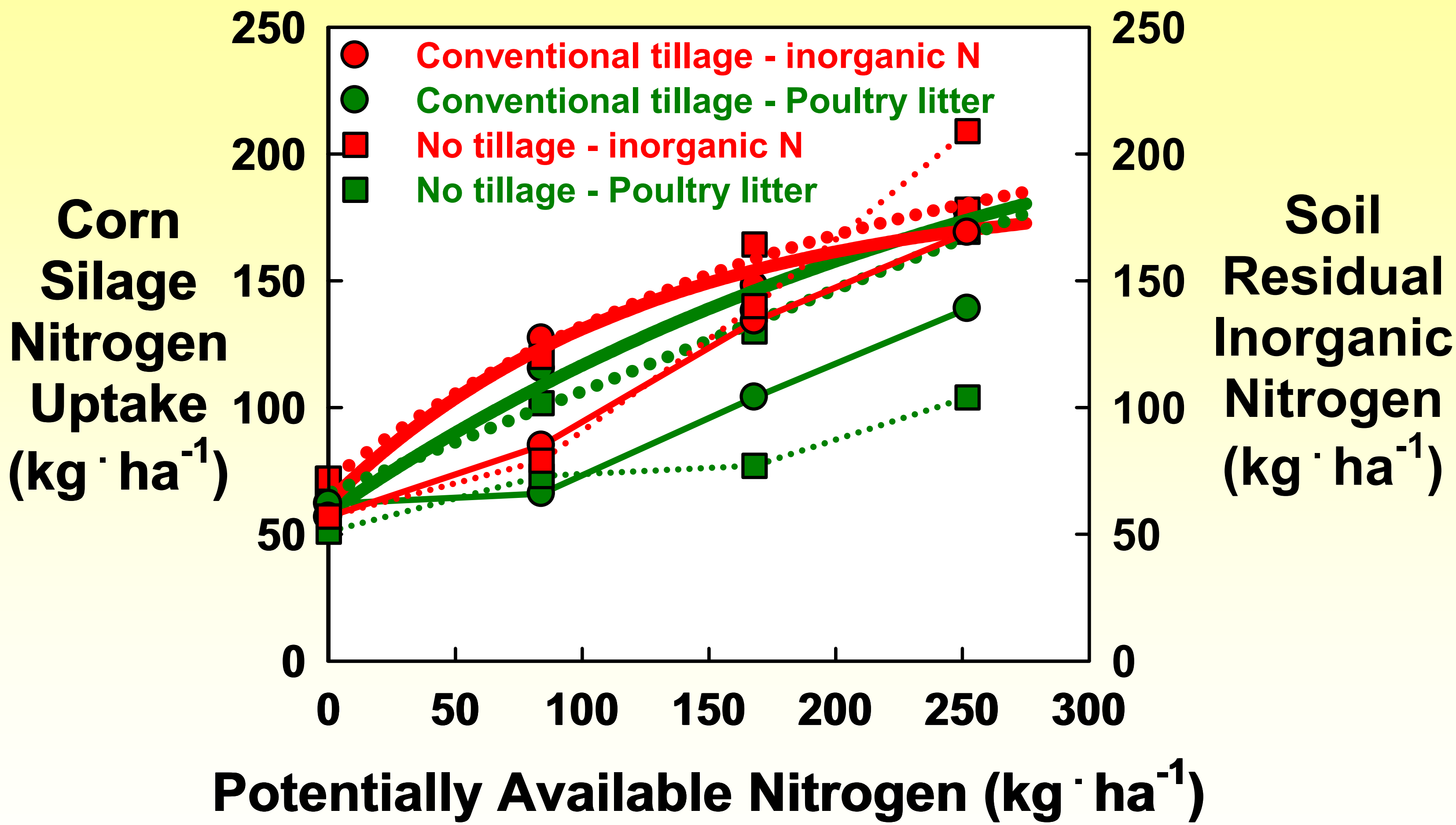
With short-term grazing of cover crops (48 ± 16 days),
compaction was not a problem and soil organic C was not affected.

Franzluebbers and Stuedemann (2008) Soil Sci. Soc. Am. J. 72:613-625

Integrated Crop–Livestock Systems

How can research help?

Mid-Atlantic Coastal Plain



Manure can be effectively applied to meet crop demand, and can limit leakage to the environment due to organic phase

Data from Sims (1987) Agron. J. 79:563-570

Integrated Crop–Livestock Systems

Benefits and trade-offs

Advantages	Disadvantages
Buffer against climate fluctuations	Risk of disease and crop damage
Diversified income sources	Continuous labor requirement
Source of security and savings	Requires investment
Investment option	Requires capital
Buffer against trade and price fluctuations	Requires multiple expertise; less economies of scale
Alternative use for low-quality roughages	Competition for crop residues with other uses

From van Keulen and Schiere (2004) Proc. 4th Int. Crop Sci. Congr.
www.cropscience.org.au/icsc2004/pdf/211_vankeulenh.pdf

Integrated Crop–Livestock Systems

Example systems research

Wisconsin Integrated Cropping Systems Trial

	Corn grain	Soy bean	Wheat grain	Alfalfa forage
	---------- Mg / ha ----------			
Cash grain systems				
1. Continuous corn, high fertilizer and pesticide input, chisel plow				
2. Corn-soybean, medium input, no tillage	8.7	3.4	3.2	
3. Corn-soybean-wheat/clover, organic, chisel plow				
Integrated crop-livestock systems				
4. Corn-alfalfa (3 yr), high fertilizer and pesticide input, chisel plow				
5. Corn-oat/alfalfa, low fertilizer + manure input, chisel plow	9.5			7.9
6. Mixed pasture, low fertilizer + manure input, no tillage				

Livestock production component should be included

Weeds reduced crop yield in organic systems by 26% in 1/3 of years (wet spring conditions), while in the remaining 2/3 of years organic production yielded the same as conventional production systems.

Data from Posner et al. (2008) Agron. J. 100:253-260

Integrated Crop–Livestock Systems

Example systems

Integrated Crop-Livestock with Zero Tillage in Brazil

Basic ICLZT systems in Brazil are comprised of:

1. **Winter stubble grazing on summer cropland**
2. **Summer crops with winter pastures (undersown or oversown)**
3. **Summer crop plus second crop plus stubble grazing in winter**
4. **Crop production for feed supplement (silage, sugarcane, elephant grass, hay, green forage), usually a minor area within another system**
5. **Some combination of these**

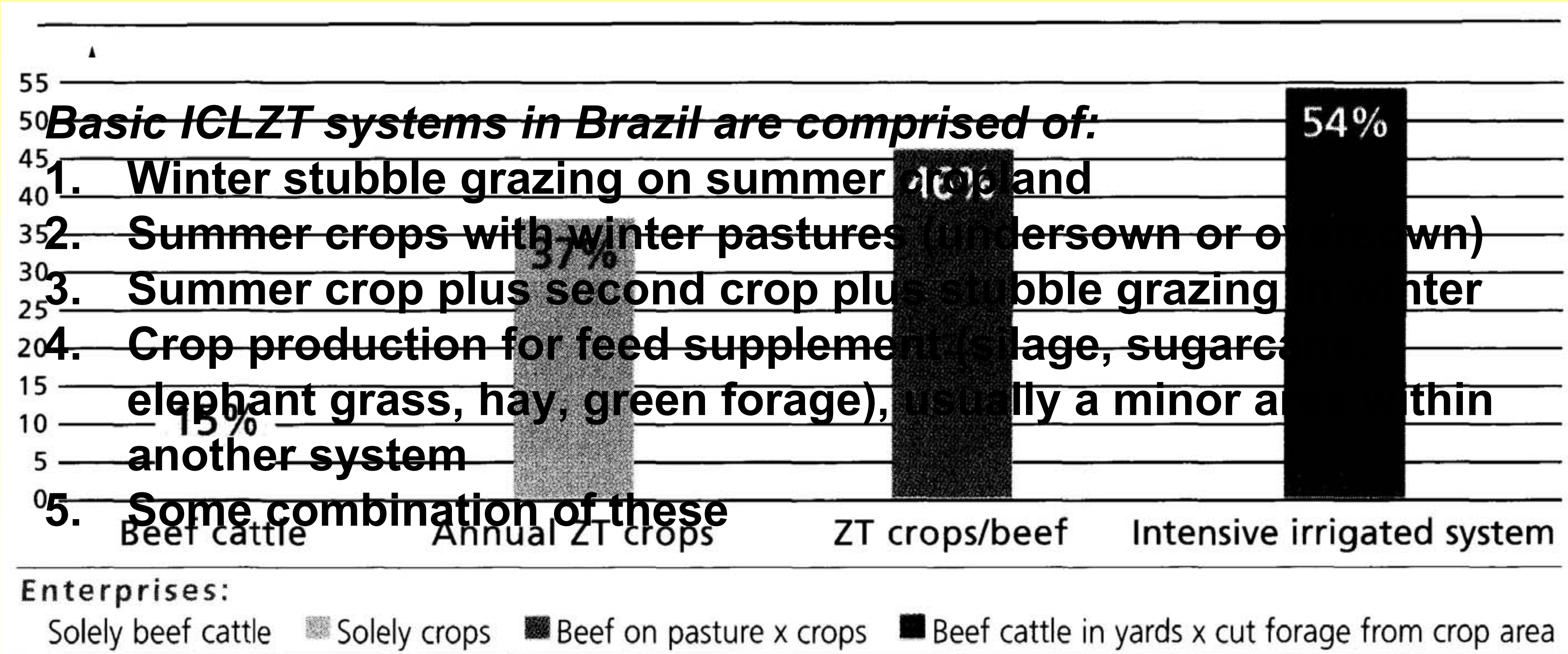


FIGURE 3: A comparison of gross margins at different levels of crop x livestock integration

Source: R. Merola, unpublished farm data.

Reviewed in Landers (2007) Integrated Crop Management, Vol. 5, FAO

Integrated Crop–Livestock Systems

Example systems

No-till drilling on upland sods in Mississippi

Benefits of no-tillage planting of crops into pasture

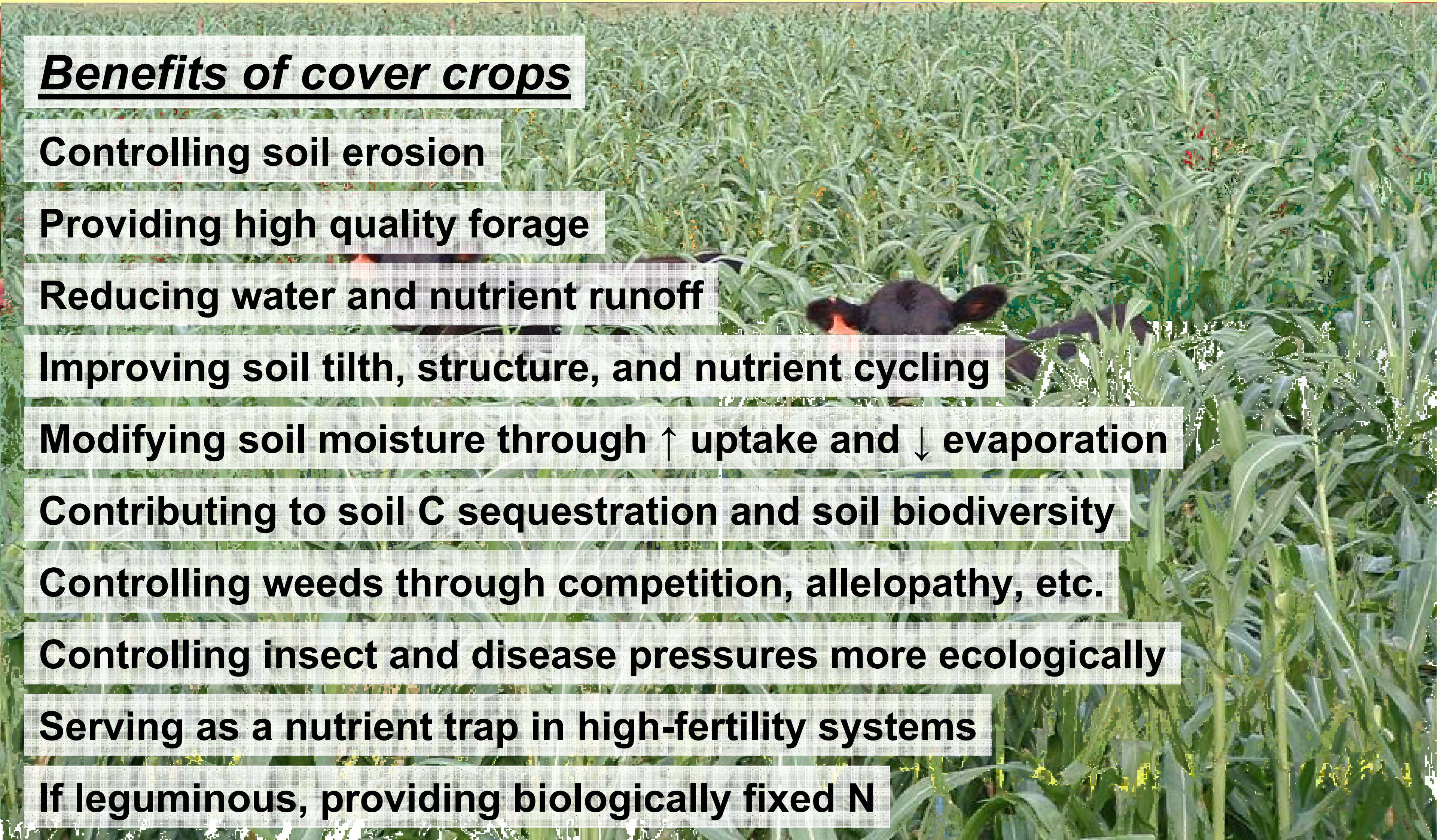
- Elimination of wild forms of E+ tall fescue
- Control of problem weeds in pastures
- Greater income from upland sites
- Greater labor efficiency

Information provided by Glover Triplett (personal communication)

Integrated Crop–Livestock Systems

Example systems

Short-term grazing of cover crops in Georgia



Benefits of cover crops

- Controlling soil erosion
- Providing high quality forage
- Reducing water and nutrient runoff
- Improving soil tilth, structure, and nutrient cycling
- Modifying soil moisture through ↑ uptake and ↓ evaporation
- Contributing to soil C sequestration and soil biodiversity
- Controlling weeds through competition, allelopathy, etc.
- Controlling insect and disease pressures more ecologically
- Serving as a nutrient trap in high-fertility systems
- If leguminous, providing biologically fixed N

Integrated Crop–Livestock Systems

Summary and outlook

Conservation of soil and water resources is a necessity in our world of ever-changing and competing human activities

Meeting the food and fiber demands of a growing world population will only become more difficult with competing energy and natural resource commitments

Integration of crops and livestock has great potential to improve resource efficiency of agricultural production around the world

Sod-based crop rotations effectively improve soil and water quality

Cover crops offer unique opportunities to integrate livestock grazing with cropping systems

Some cases of integration have been developed, but much more research is needed to optimize systems within unique local and regional conditions

Integrated Crop–Livestock Systems

Acknowledgements

Agricultural Research Service (ARS)
US-Department of Energy
Madison County Cattleman's Association
USDA-National Research Initiative – Soil Processes
Cotton Incorporated
Georgia Commodity Commission for Corn
The Organic Center
ARS GRACEnet team