The case for diversity: extending the crop rotation

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COLLEGE OF AGRICULTURAL & LIFE SCIENCES University of Wisconsin-Madison

USDA United States Department of Agriculture National Institute of Food and Agriculture

“Extending the rotation”

What?: Diversifying management from year-to-year and place-to-place

Why?: Building and retaining resources

How?: Manipulating crop type, disturbance, nutrients, pests, harvest

Potential benefits:

- Farmer - income, soil building, nutrient conservation, pest suppression
- Society - communities, climate stabilizing, water quality & quantity, biodiversity

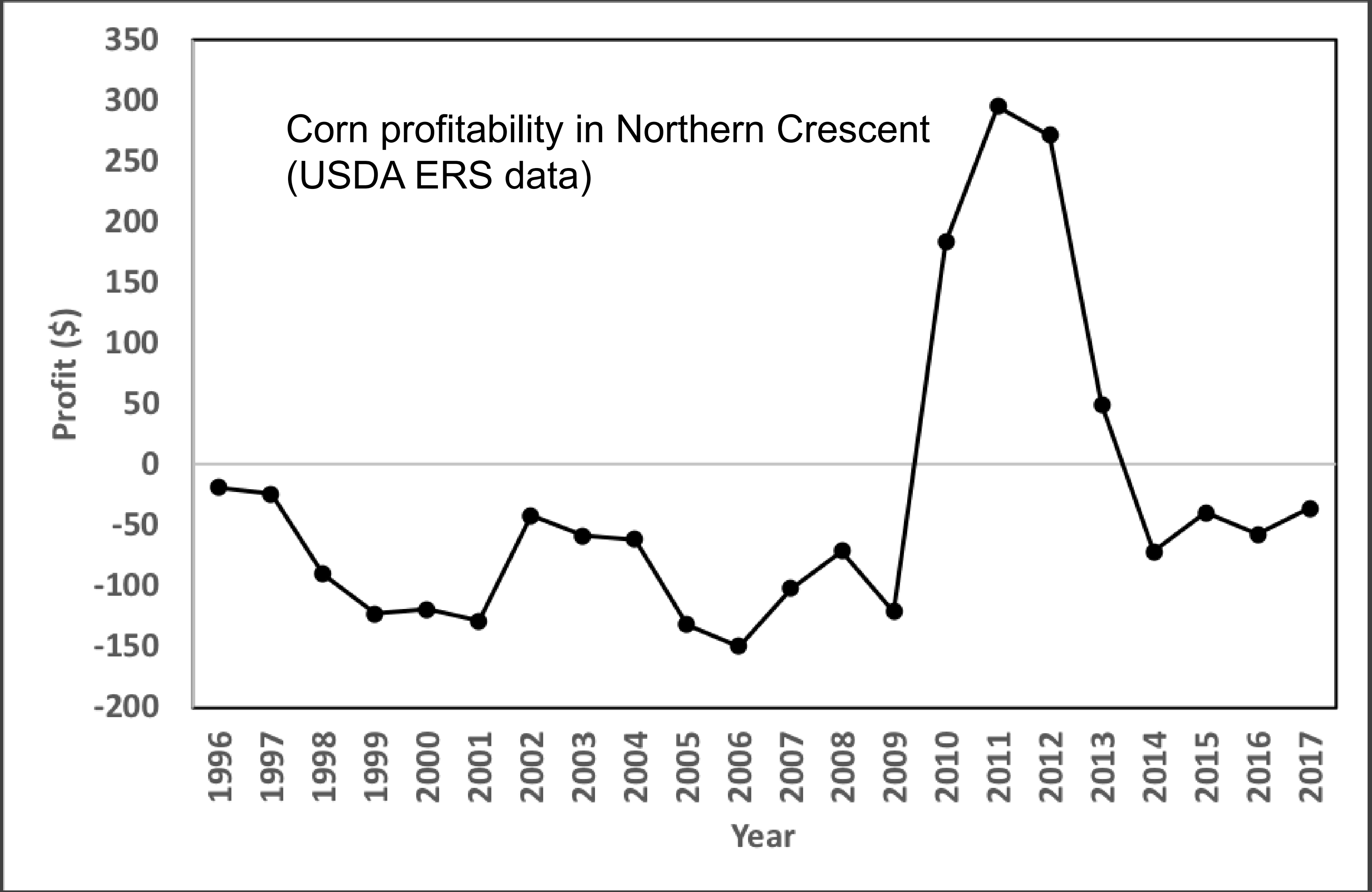
Potential costs:

- Farmer - seed, sowing, harvesting, reduced income
- Society - infrastructure re-building, compromised fisheries & recreation, etc.

Land management (relative intensity)

Cropping system				Soil disturbance	Nutrient inputs	Pest mgmt	Harvest mgmt
c	c	c	c	5-10	8-10	8-10	5-10
c	s	c	s	5-10	6-8	6-8	5-10
c	s/w	cl/o	c	5-10	5-7	5-7	4-8
c	a			3-6	2-4	4-7	3-7
c	o/a	a	c	4-7	2-4	4-7	4-8
pasture				0-2	0-3	0-3	0-10
prairie				0	0	0	0-10

Outcomes → profitability



Outcomes → economy

A. United States Economic Contributions

Results from IMPLAN models examining the contributions of grain and grain product exports confirm the importance of international markets to the U.S. national economy. In 2016, the U.S. exported $19.1 billion of grain and grain products to international destinations. **The direct economic contributions of these exports were nearly 56,000 jobs and $2.2 billion in GDP** that was created because of grain and grain product exports (Exhibit 5). From this analysis of the direct impacts, it becomes clear that grain and grain products exports are large contributors to the U.S. economy, even before the economic "ripple effects[2]" are accounted for. If U.S. grain and grain product exports were suddenly halted, the figures in Exhibit 5 indicate that over 56,000 jobs and $2.2 billion in GDP would be adversely impacted at the farm, ethanol production, and meat production levels before accounting for losses in linked industries.

In 2016, U.S. exports of grain and grain products totaled $19.1 billion and supported 56,000 jobs.

Exhibit 5: Direct Economic Contributions of U.S. Grain and Grain Product Exports

Commodity	Jobs	Labor Income ($ million)	GDP ($million)	Output ($million)
Malting Barley	82	$2	$3	$20
Other Barley	34	$1	$1	$8
Malt (Barley Equiv.)	486	$10	$16	$120
Corn	38,444	$765	$1,255	$9,491
Sorghum	5,008	$100	$163	$1,236
Ethanol	535	$52	$206	$1,693
Residual Milling Byproducts	610	$59	$235	$1,933
Meat*	10,747	$214	$351	$2,653
Total	55,947	$1,201	$2,230	$17,155

Source: USDA NASS, USDA ERS, IMPLAN, and Informa Agribusiness Consulting
Note*: Meat is in Corn Equivalent Value

The total economic contributions (direct, indirect, and induced contributions) created by the export of grain and grain products show the true importance of grain exports to the U.S. economy. By including the impacts to industries that are linked (either by

[2] The indirect and induced impacts.

indirect or induced spending) to grain exports **the 2016 U.S. grain export value of $19.1 billion is magnified to a figure of nearly $55 billion in economic output** (Exhibit 6). That is, the economic "ripple effects" of U.S. grain exports is 2.2 times as large as the value of grain exports. Another way to think of these effects is that for every $1 of grain and grain product exports, another $2.20 in economic output (industry sales) is indirectly supported across the United States.

For every $1 in grain and grain product exports an additional $2.20 is supported elsewhere in the U.S. economy.

Of course, the economic contributions of grain exports are not limited solely to economic output. As shown in Exhibit 6, **the total impact of grain and grain product exports indirectly supported nearly 274,000 jobs across the U.S. and $21 billion in GDP in 2016**. For every job directly created by the export of grain and grain products, an additional 3.9 jobs were indirectly supported in the U.S.

Outcomes → nutrient imbalance

photo by Pamela Smith)

Photo credit: National Weather Service.

Outcomes → nutrient imbalance

Outcomes → impaired water quality

Photo: Katie Rice

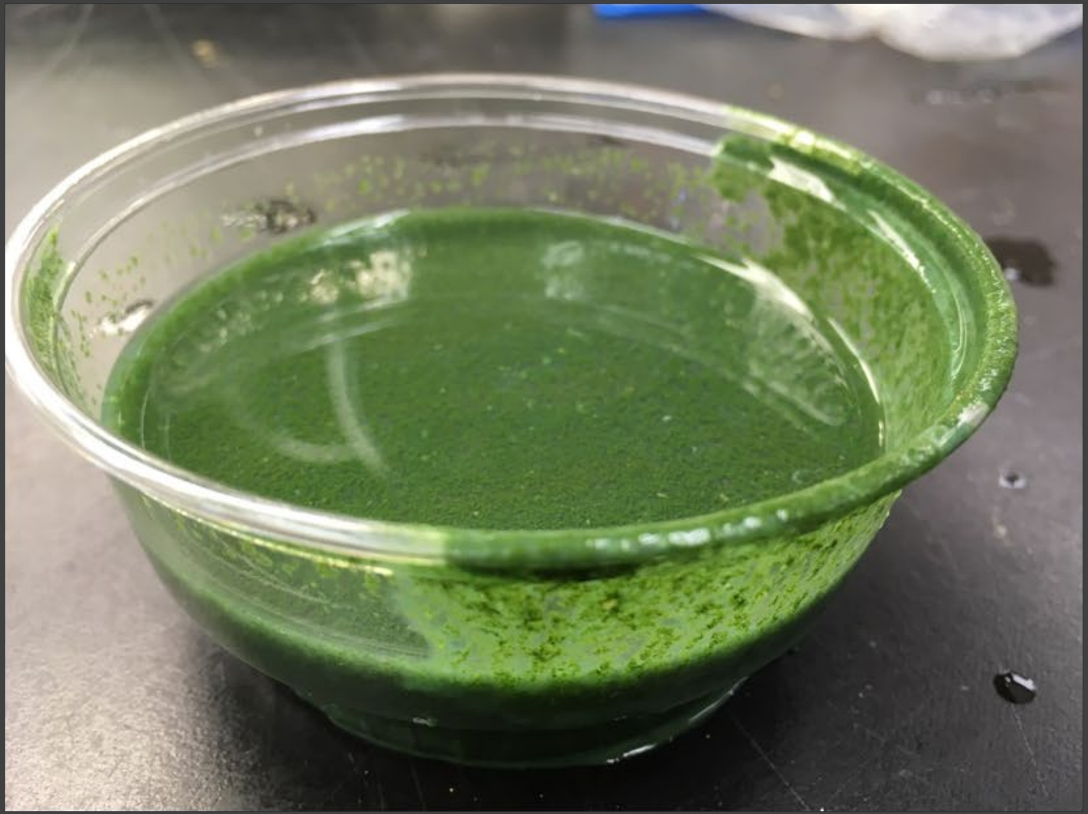


Photo: Emily Stanley

Outcomes → impaired water quality

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BREAKING TOPICAL FEATURED

DNA evidence traces drinking water hazards back to farms and manure

STEVEN VERBURG sverburg@madison.com 1 hr ago

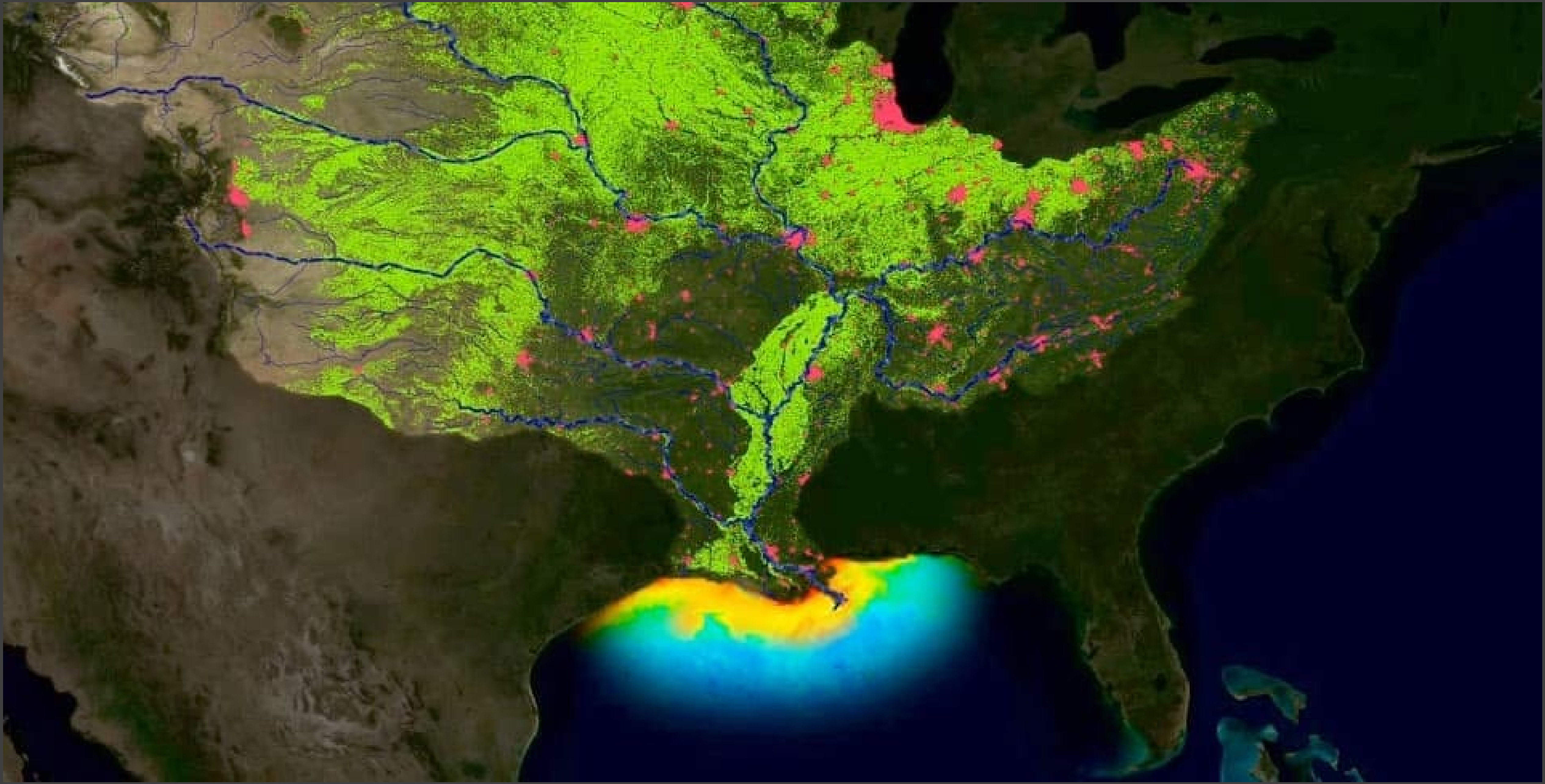
TRY 3 MONTHS FOR $3

Research Shows Tainted Wisconsin Water Tied to Animal Waste

Associated Press
March 12, 2019 10:48 AM

Print

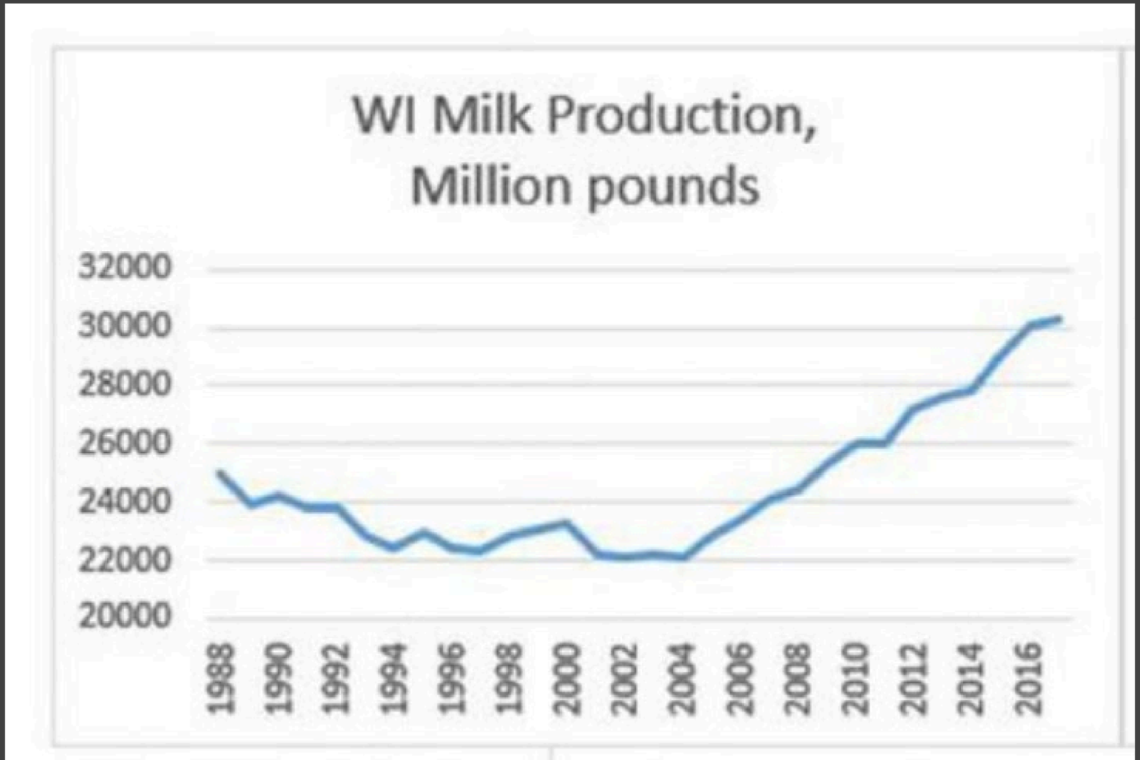
Outcomes → impaired water quality

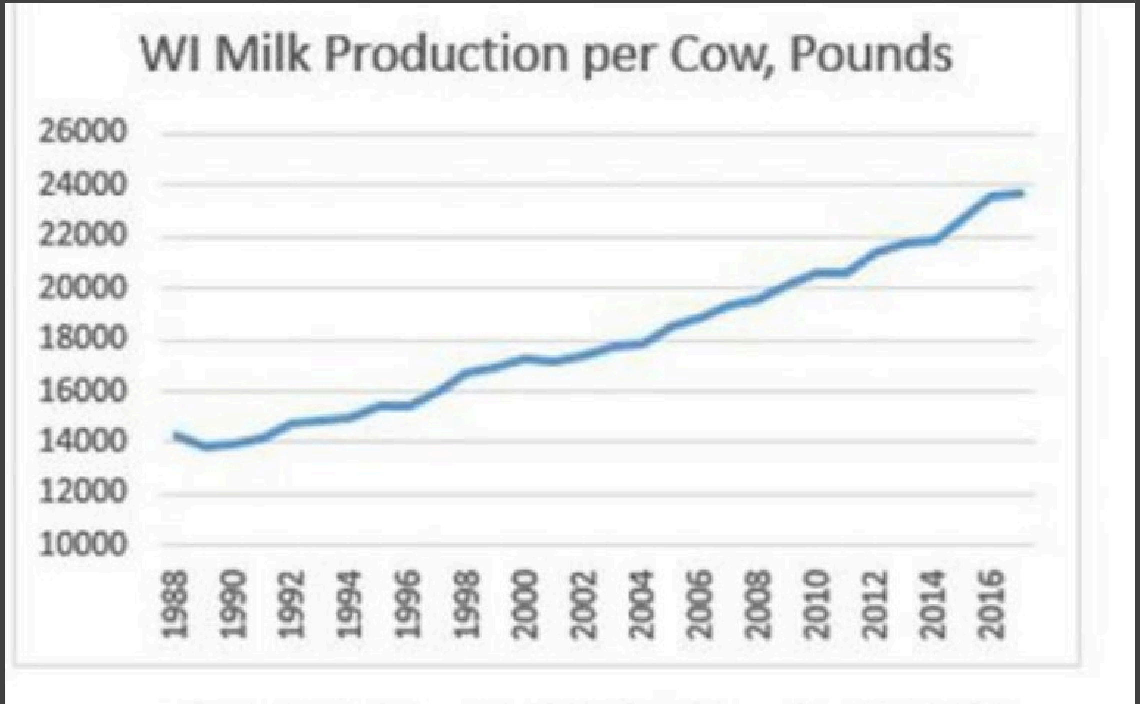


Outcomes → flooding

Outcomes → more yield

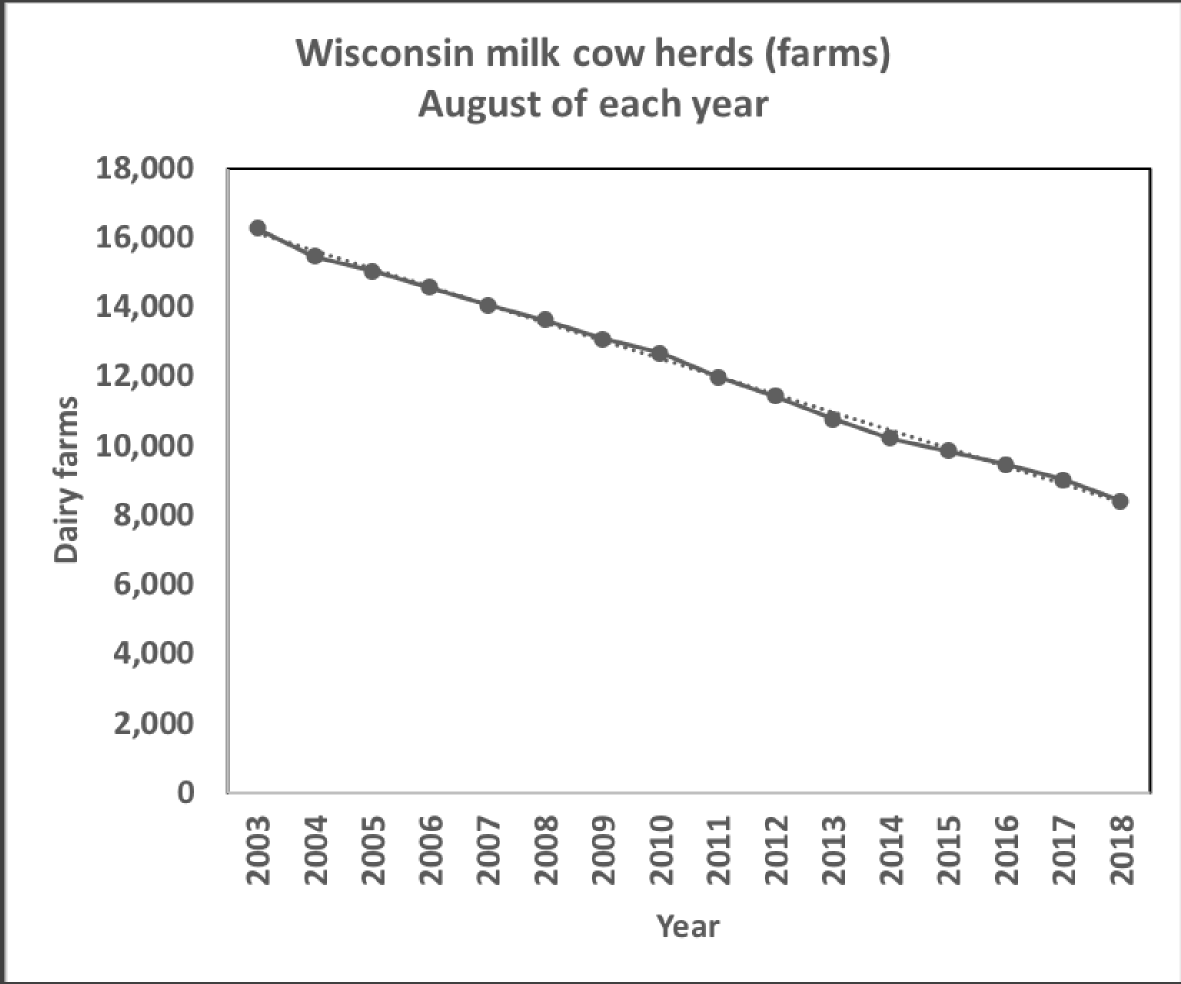
America's Dairyland





* Statistics from the USDA Wisconsin Field Office

Outcomes → fewer farms



Outcomes → consolidation

Credit: Mark Hoffman

Outcomes → abandonment

Credit: Alisa Chang

Outcomes → crisis

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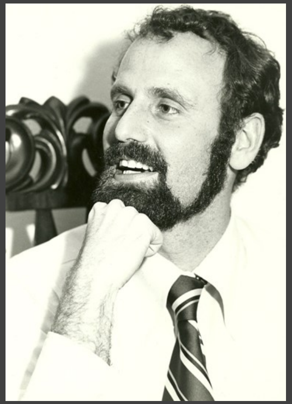
TOPICAL

Scott Walker says crisis team needed to help state's crippled dairy industry

ROB SCHULTZ rschultz@madison.com Jun 6, 2018

the Wisconsin Integrated Cropping Systems Trial (WICST)



Josh Posner

Janet Hedtcke

Gregg Sanford

WICST

Established in 1990

Two locations

- (ARL) Arlington, WI – 1990 to present
- (LAC) Elkhorn, WI – 1990 to 2002

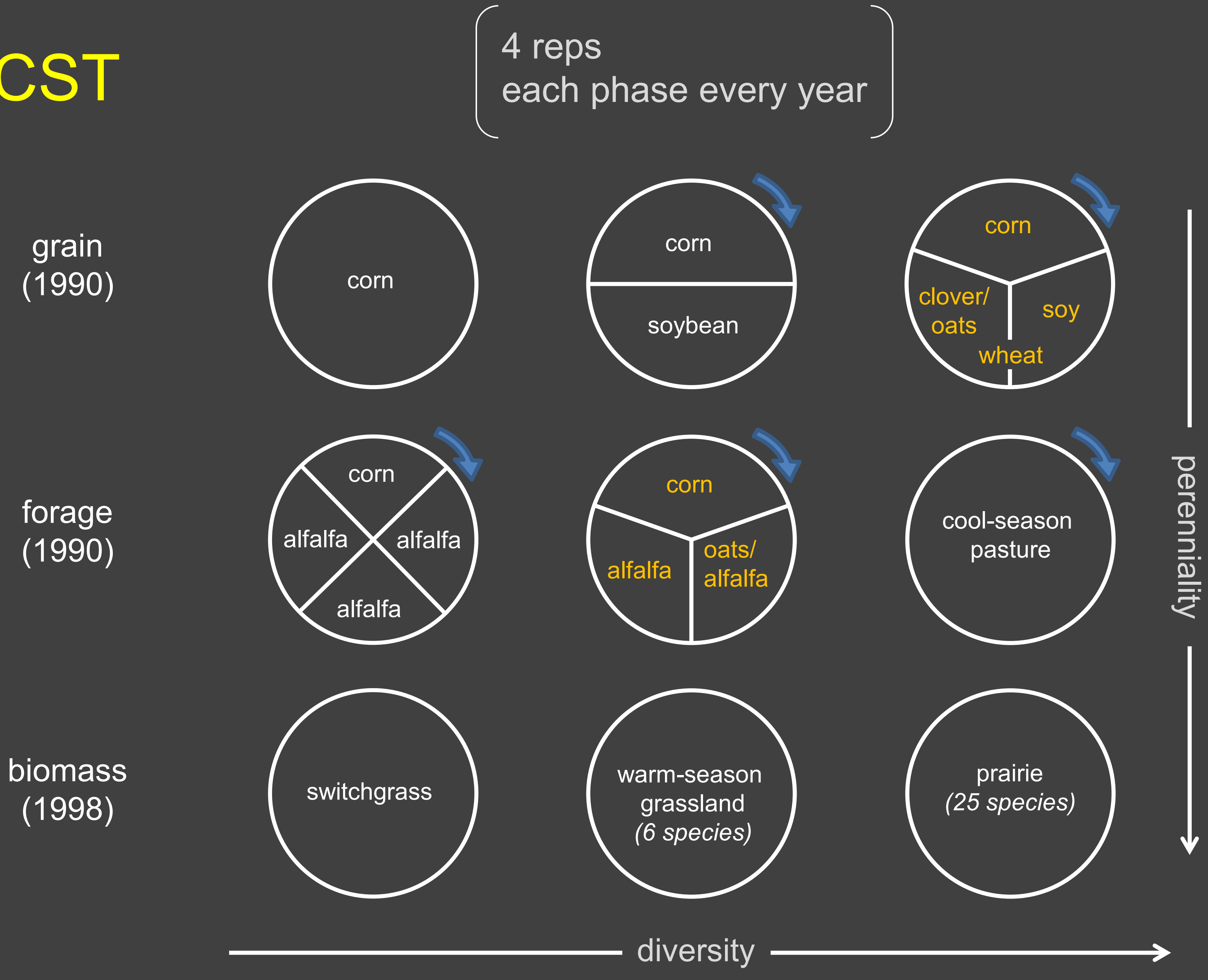
Large plots

- Plot size = 0.7 ac
- Field-scale equipment

Performance metrics:

- Productivity
- Profitability
- Environment

WICST


4 reps
each phase every year
grain (1990)
corn
corn
soybean
corn
clover/ oats
soy
wheat
forage (1990)
corn
alfalfa
alfalfa
alfalfa
corn
alfalfa
oats/ alfalfa
cool-season pasture
biomass (1998)
switchgrass
warm-season grassland (6 species)
prairie (25 species)
perenniality
diversity

WICST cropping system details (1993 to 2018)

Type	Label	System	Crop Phase	Average Yield[a] (Mg ha^{-1})	Average Dry Matter Yield (Mg ha^{-1})	Primary Tillage Equipment	Ave. annual N-P-K Inputs: First-year available[b] (kg ha^{-1})	Ave. annual N-P-K Inputs: Source[c]
Grain	c-c-c-c	continuous maize	corn	11.6	9.8	chisel plow	160-8-35	F
	c-s-c-s	maize-soybean	corn	12.0	10.1	no-till / strip-till	148-11-42	F
			soybean	3.7	3.3	no-till	1-2-22	
	c-s/w-cl/o-c	organic grain	corn	9.5	8.0	chisel plow	0-0-9 / 138-51-66[d]	F, CPM
			soybean → winter wheat	3.3	2.9	chisel plow	0-0-4 / 0-0-55	
			→ clover-oats[e]	4.1 (2.5)	3.6 (2.5)	chisel plow	0-0-0 / 55-19-63	
Forage	c-a-a-a	conventional forage	corn	13.0	11.0	chisel plow	88-31-160	F, M1
			alfalfa	5.8	5.8	chisel plow	100-29-155	
			alfalfa	11.4	11.4	none	0-1-96	
			alfalfa	10.1	10.1	none	0-0-108	
	c-o/a-a-c	organic forage	corn	10.6	9.0	chisel plow	71-20-121	F, M1
			oats → alfalfa	8.5	8.5	chisel plow	85-24-135	
			alfalfa	11.4	11.4	none	0-0-128	
	pasture	rotationally grazed pasture	cool-season grass & forbs[f]	0.84 kg hd^{-1} d^{-1}	--	none	69-13-103	M2

[a] Forage yields reported at 100% dry matter (DM), maize yields at 84.5% DM, soybean yields at 87% DM, and wheat yields at 86.5% DM. Both grain and straw yields (in parentheses) are reported for wheat. Yield for the rotationally grazed pasture is represented in average daily gain of dairy heifers (kg head^{-1} d^{-1}).

[b] First-year availability accounts for the nutrients released to a growing crop during the same year it is applied only. Manure and other organic forms of nutrients contain more total nutrients than are available to the crop in any given year. Legume N credits not included.

[c] F = fertilizer (conventional or organic according to system management); CPM = composted pelletized poultry manure; M1 = applied manure; M2 = manure deposited by grazing heifers.

[d] Between 1993 and 2007 all nutrients for CS3 provided by organically approved fertilizers (e.g. 0-0-50) or N fixed by the green manure crop. Beginning 2008 composted pelletized poultry manure added to the corn and wheat phases of the rotation to supply N, P, K, and micronutrients.

[e] Between 1993 and 2005 the cover crop was red clover (*Trifolium pratense* L.) frost-seeded or drilled into winter wheat in early spring; beginning 2006 this changed to a berseem clover (*Trifolium alexandrinum* L.)/oat (*Avena sativa* L.) mixture planted after wheat harvest.

[f] Timothy (*Phleum pratense* L.), smooth bromegrass (*Bromus inermis* L.), orchardgrass (*Dactylis glomerata* L.), red clover (*Trifolium pratense* L.). Red clover re-seeded every 2-3 years with NT drill.

WICST core data

Management
- agronomic calendars
- field notes/observation
- weather

Profitability
- input prices
- elevator prices
- hay auction prices

Productivity
- yields: grain, forage, pasture
- average daily gain (cattle)
- weed biomass (mid-season)

Environment
- spring & fall nitrates
- fall soil fertility
- soil organic carbon (SOC)
- soil archive

Mark Walsh


Jimmy Sustachek

WICST corn yields (1990-2002)

	Normal spring (May + June ~9” ppt)	
	ARL	LAC
Cropping system	bushel/acre	
c-s-c-s (conventional)	173	132
c-s/w-cl/o-c (organic)	167	124
organic : conventional	96%	94%

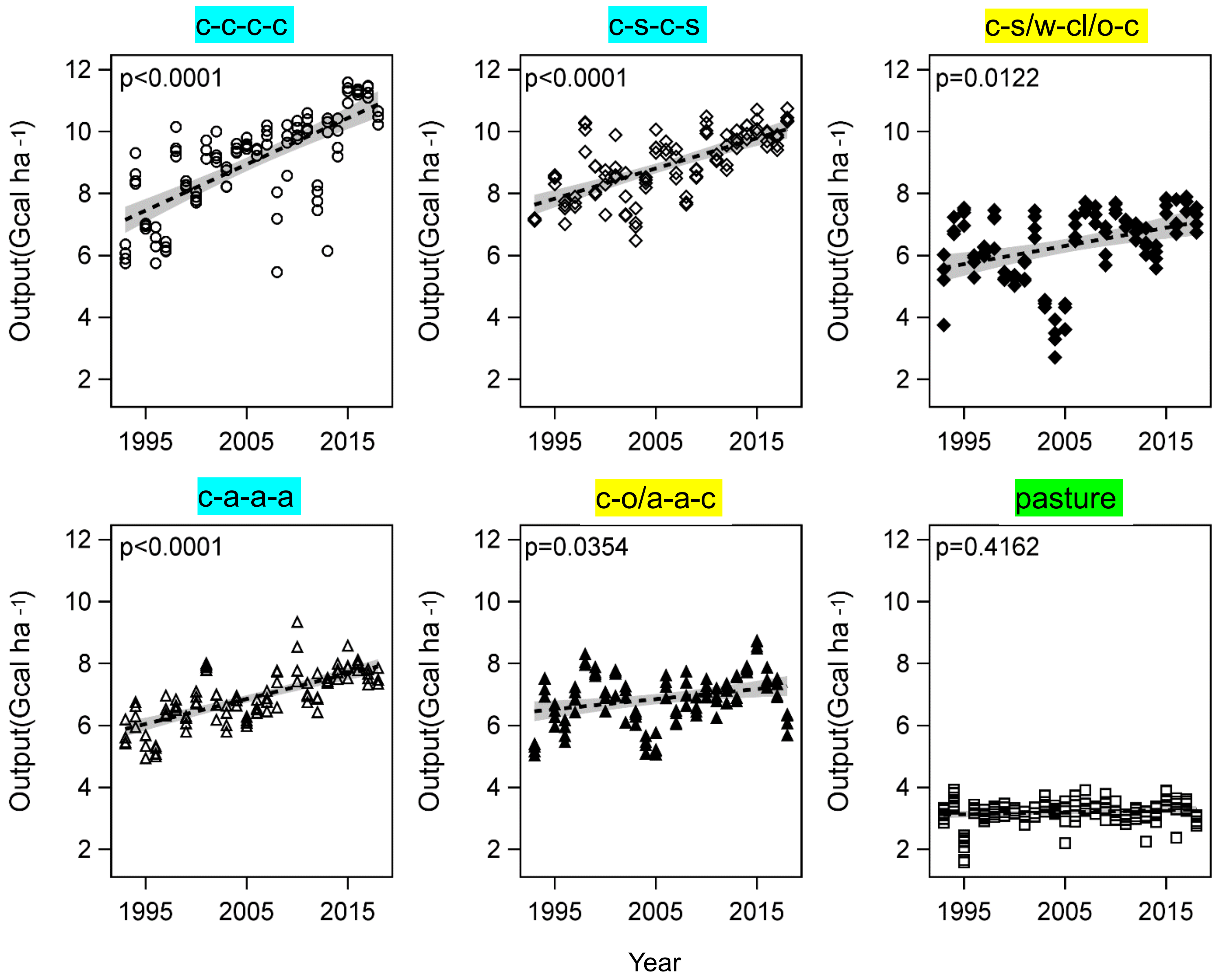
Posner et al. 2008

WICST soybean yields (1990-2002)

	Normal spring (May + June ~9" ppt)	
	ARL	LAC
Cropping system	bushel/acre	
c-s-c-s (conventional)	57	53
c-s/w-cl/o-c (organic)	54	49
organic : conventional	95%	92%

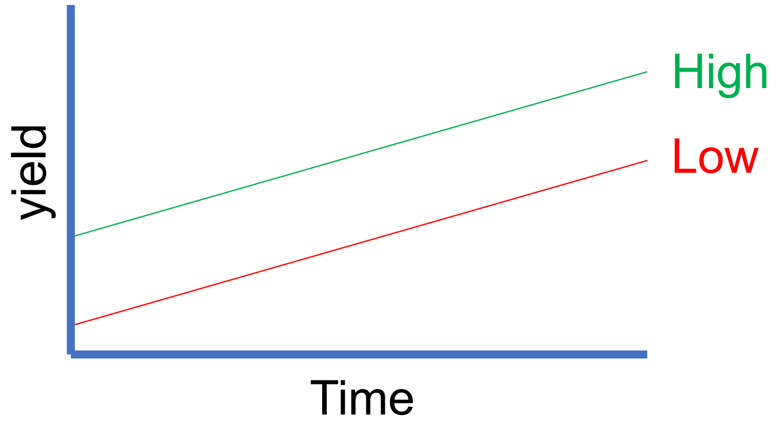
Posner et al. 2008

Energy yields over 26 years

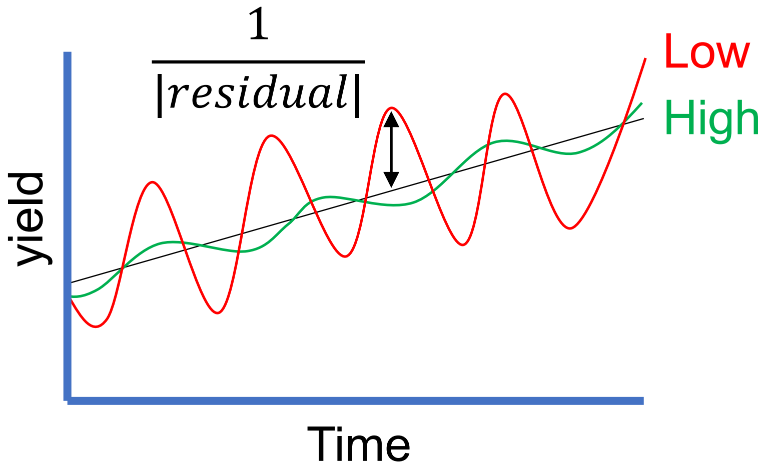


Long-term yields

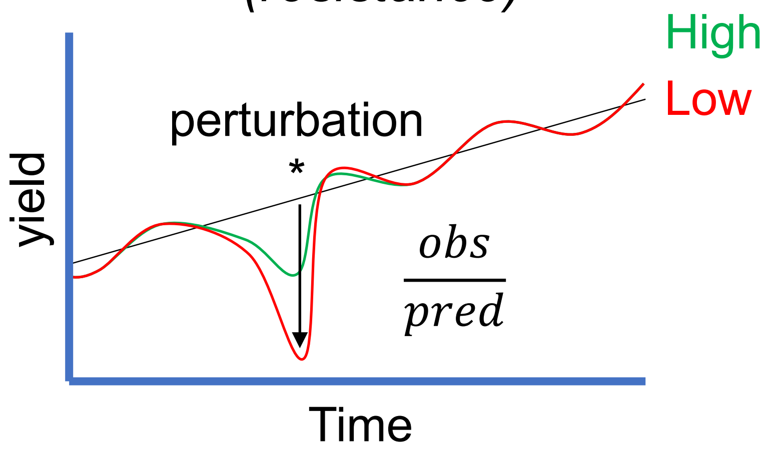
Productivity



Stability

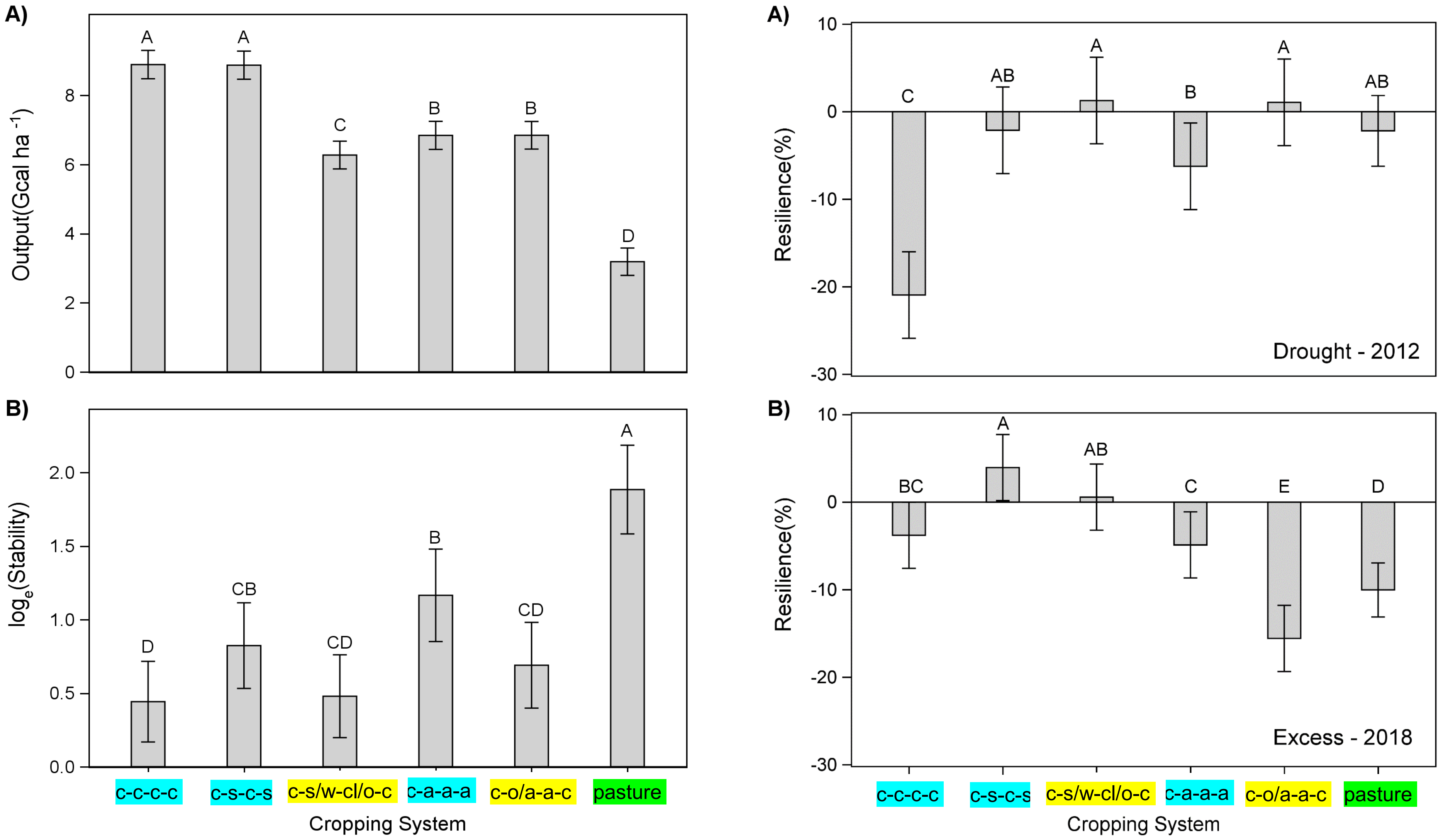


Robustness
(resistance)



Urruty et al. 2016

Yield stability and resilience over 26 years



Organic and Conventional Production Systems in the Wisconsin Integrated Cropping Systems Trial: II. Economic and Risk Analysis 1993–2006

Jean-Paul Chavas, Joshua L. Posner,* and Janet L. Hedtcke

Published in Agron. J. 101:288–295 (2009).
doi:10.2134/agronj2008.0055x

Table 3. Economic mean returns under alternative scenarios in the Year 2000.

				System	Arlington: No government payment or organic premium (Scenario 1)
					$ ha^{-1}
c	c	c	c	Continuous corn	365d†
c	s	c	s	No-till corn-soybean	465c
c	s/w	c	s/w	Organic grain corn-soybean-wheat	335d
c	a			Intensive alfalfa	535b
c	o/a	a	c	Organic forage	528bc
pasture				Rotational grazing	735a

† Within a scenario (column), numbers followed by a different letter are significantly different at the 0.05 level.

Scenario 1
Perennial forages, esp grassland > annual grains
Within grains, diversification didn't pay

Scenario 2
Grassland still best, but grains improved

Scenario 3
Organic grain w/ cover crops as good as grassland and forage, but no premium for organic grassland

J. Dairy Sci. 85:95–104
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Milk Production and Ec
Pasture Systems Using

S. L. White,* G. A. Benson,† S.
*Department of Animal Science,
†Department of Agricultural and Resourc
‡Department of Crop Science,
North Carolina State University, Raleigh

ABSTRA

This 4-yr study examined tot
of dairy cows in two feeding
and confinement. Spring and
used and each seasonal herd
and 36 cows in confinement
Jersey cows included over
Pasture-fed cows received
and baled haylage dependin
Confinement cows received

steins, $6.89 ...
for confinement Jersey
Jerseys; effects of breed
season, and interactio
such as labor for anim
management, and cow
cows. Higher fertility
partially offsets lowe
with Holsteins. Milk
for pasture-based sy
culling costs, and ot
pasture-based syste
finement systems.
(Key words: pastu
economics)

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Corresponding
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A Comparison of Profitability and Economic Efficiencies Between Management-Intensive Grazing and Conventionally Managed Dairies in Michigan

ABSTRACT

A retrospective cohort study was designed to
mine differences in profitability, asset efficien
erating efficiency, and labor efficiency between
gan dairy farms implementing management-int
grazing (MIG) and conventionally managed
farms. Financial information and labor use data
calendar year 1994 were collected with surve
personal interviews from 35 MIG dairies and 18 c
tionally managed dairies. Because the geograp
tribution of MIG and conventionally managed
in this study did not include Michigan's "dair

sion indicated that MIG dai
profit than conventionally ma
tured this profit by being mo
operating practices, and labo

(Key words: management-intensive grazing, n
income, operating efficiency, asset efficiency)

Abbreviation key: ATO = asset turnover, **MIG**
agement-intensive grazing, **NFI%** = net farm
percent, **aNFI** = accounting net farm income p
eNFI = economic net farm income per cow, **VFP**
of farm production per labor hour.

INTRODUCTION

Structural change has occurred within Mic
dairy industry. The number of operating dairy
has decreased (13) and herd size and milk proc

Received February 17, 1999.
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1999 J Dairy Sci 82:2412–2420

J. Dairy Sci. 96:1894–1904
http://dx.doi.org/10.3168/jds.2011-5234
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lk to and from twice a day.
its the maximum size of an
, especially in areas where

operations. Between
e number of dairy opera-
by 26%. That entire de-
th <500 cows; the num-
o 1,999 cows increased
nber of operations with
the US Department of
ce Management Survey
t significant economies
ossible to spread fixed
g equipment, and ma-
output, thus lowering
nald et al., 2007). De-
pidly as productivity,
prices. As a result,
ainstay of traditional
of the United States

-year farm records
ve grazing (MIG)
n confinement sys-
nore than offset the
xperiments (White
nd budgeting stud-
al., 1999; Gloy et
al., 2003; Kriegl, 2005; Taylor and
Foltz, 2006) have shown MIG operations to be at least
as profitable as traditional confinement operations—in

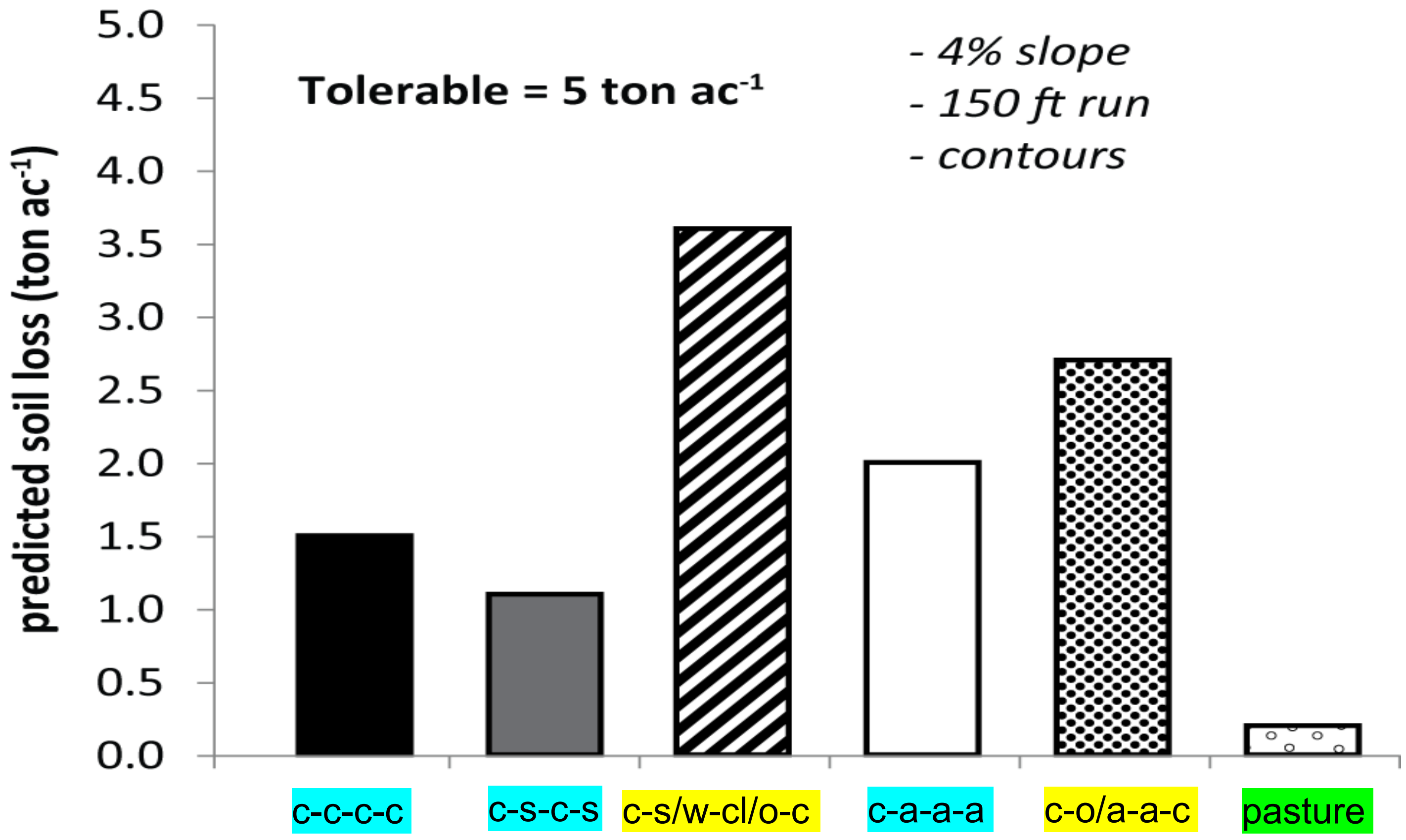
The Financial Performance of Wisconsin Grazing, Organic, and Confinement Dairy Farms from 1999 to 2014

Thomas S. Kriegl
University of Wisconsin Center for Dairy Profitability
University of Wisconsin-Extension
Madison, WI
See htpp://cdp.wisc.edu for more information
December 2015

Table 3: Sixteen-Year (1999-2014) Simple Average Cost of Production Per Cow for Wisconsin Organic, Grazing and Confinement Herds

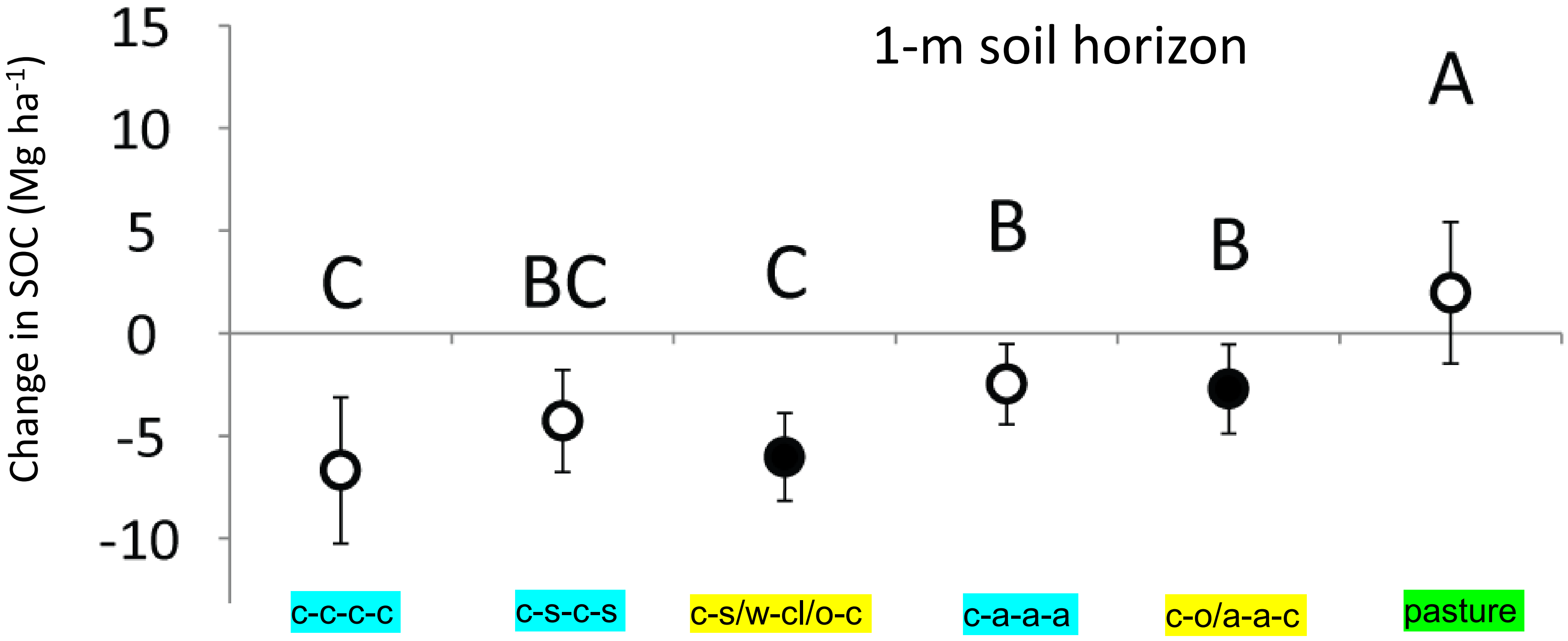
	Graziers*	Organic**	Confinement
Range of Observations per Year	7 to 43	6 to 17	304 to 721
Range of Average Herd Size per Year	60 to 90	48 to 80	110 to 204
Income	$3,323.51	$4,177.36	$4,557.13
Expenses			
Breeding Fees	$35.11	$43.43	$54.32
Car and Truck Expense	$24.52	$25.18	$16.37
Chemicals	$16.92	$3.58	$55.48
Custom Hire (Machine Work)	$117.44	$140.48	$145.32
Custom Heifer Raising	$5.35	$0.60	$13.55
Feed Purchase	$771.38	$602.79	$1,009.08
Fertilizer and Lime	$73.85	$119.06	$118.88
Freight and Trucking	$25.97	$43.87	$48.37
Gasoline, Fuel, and Oil	$87.06	$146.55	$128.78
Farm Insurance			
Marketing & Hedg			
Rent			
Repairs all			
Seeds and Plants Purchased			
Supplies Purchased	$138.30	$180.56	$111.66
Taxes	$47.72	$57.40	$38.48
Utilities	$77.86	$100.41	$89.33
Veterinary Fees and Medicine	$62.70	$53.60	$126.61
Other Farm Expenses	$85.24	$118.46	$281.01
Total Income - Total Cost	[illegible]	[illegible]	[illegible]
Net Farm Income from Operations (NFIFO)	**$780.14**	**$877.27**	**$457.57**
Gain (Loss) on Sale of All Farm Assets	$10.38	$22.66	$20.67
Net Farm Income (NFI)	$790.52	$899.93	$478.24

Soil loss (RUSLE2)



Hedtcke et al., unpublished

Soil carbon (1990-2010)



Sanford et al. 2012

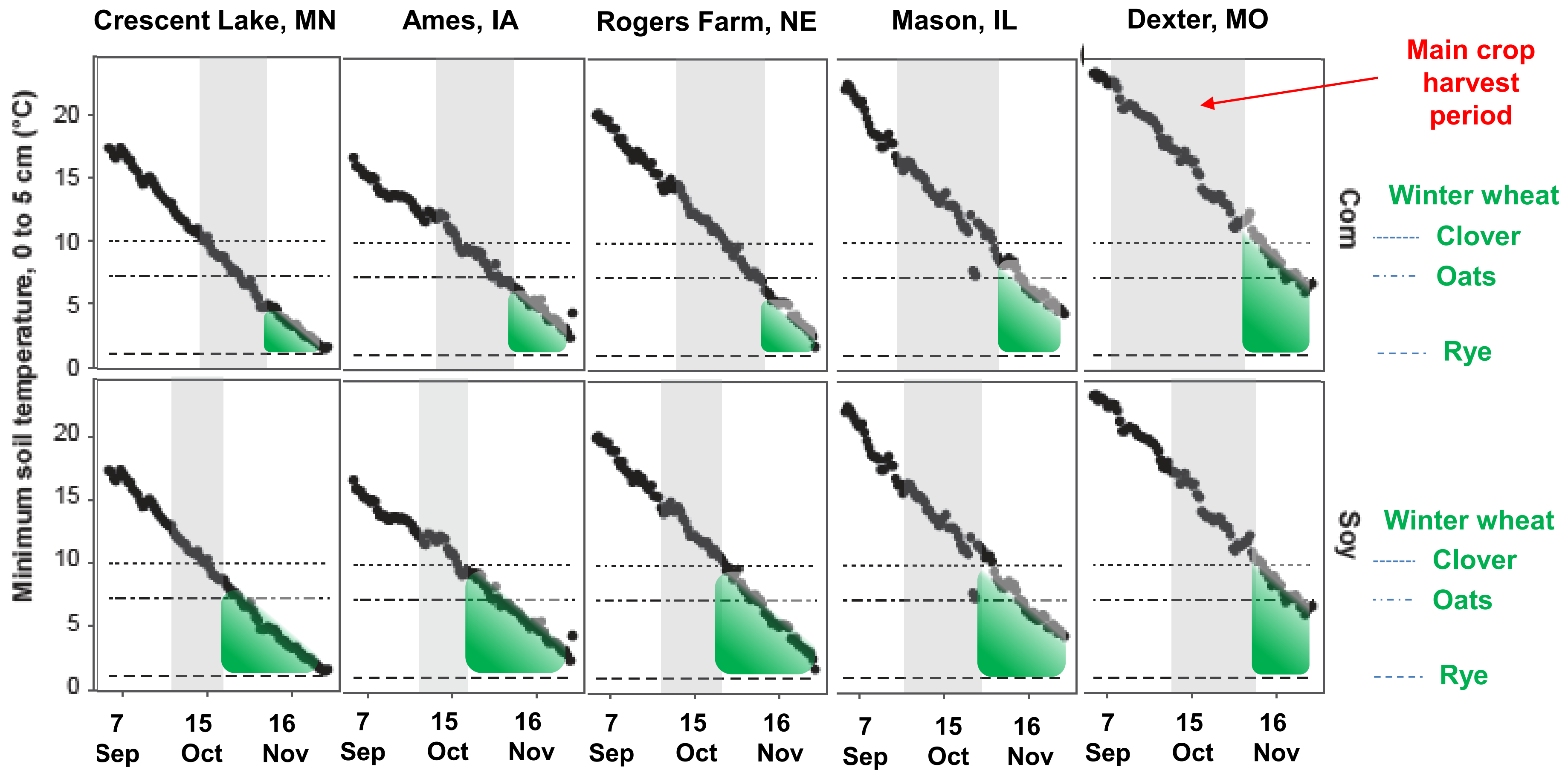
Young people are excited about grass-fed farming!

doi:10.2489/jswc.73.6.153A

FEATURE

What do we know about cover crop efficacy in the North Central United States?

Anna M. Cates, Gregg R. Sanford, Laura Ward Good, and Randall D. Jackson



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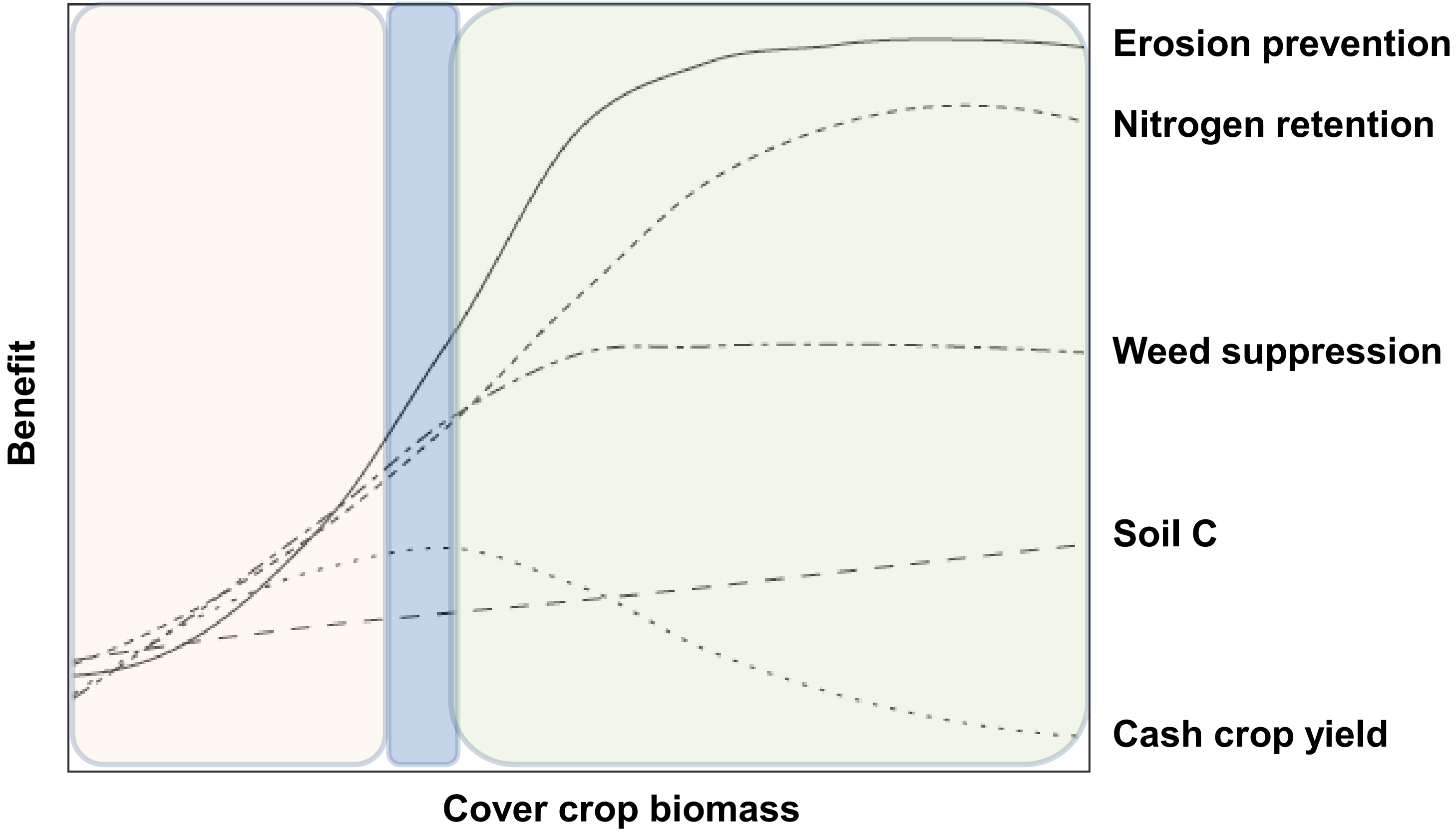


Cover Crop Effects on Net Ecosystem Carbon Balance in Grain and Silage Maize

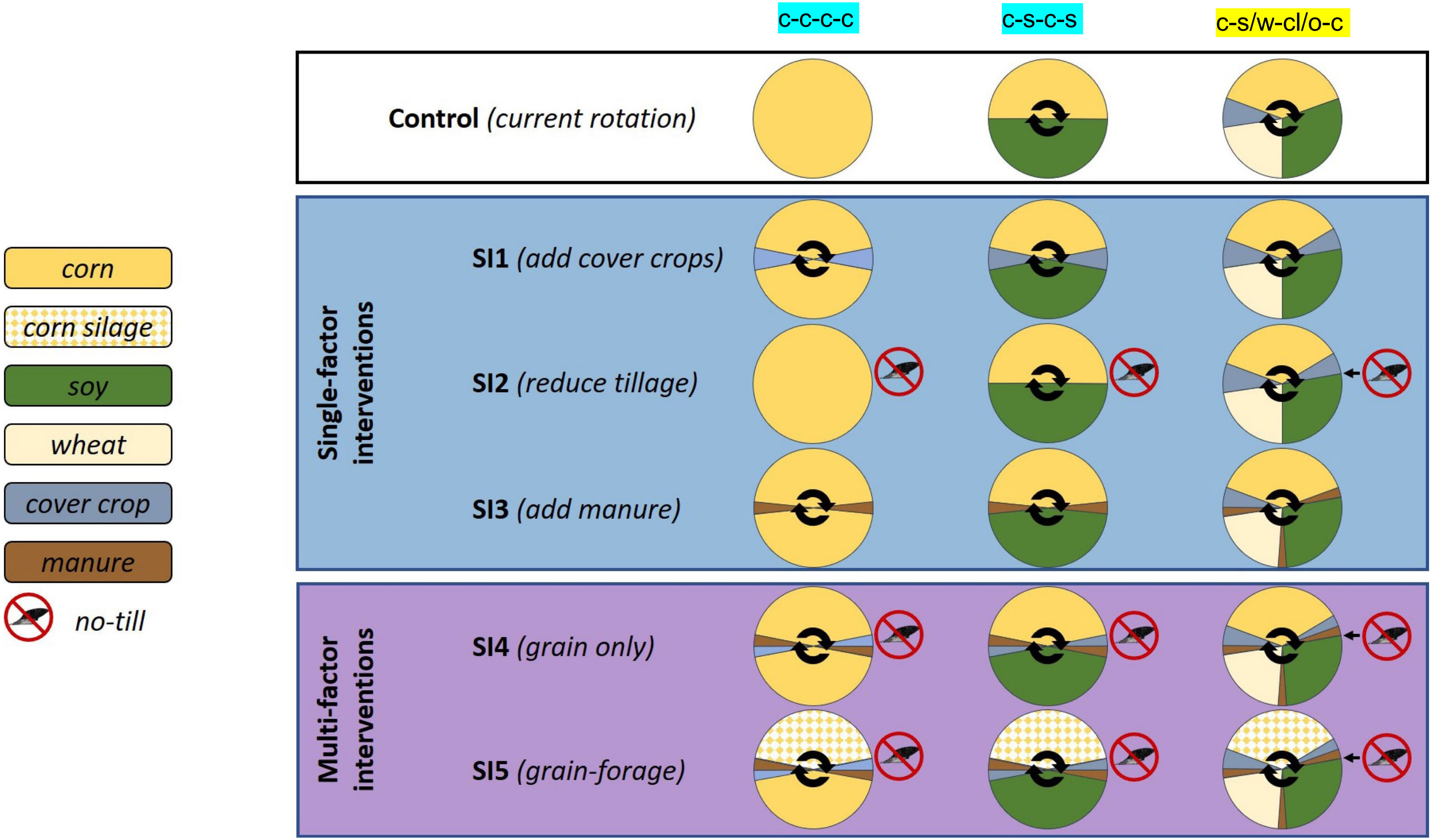
Anna M. Cates* and Randall D. Jackson

Published in Agron. J. 110:1–9 (2018)
doi:10.2134/agronj2018.01.0045

Table 3. Means (standard errors) for net ecosystem C balance (NECB) and various components: Aboveground net primary productivity (ANPP), belowground net primary productivity (BNPP) (includes both maize and cover crop biomass C), harvested biomass (Yield), and cumulative annual heterotrophic soil respiration (R_h). Lowercase letters indicate differences among cover treatments within a year and harvest treatment ($P < 0.05$).

Year	Grain maize					Silage maize				
cover	ANPP	BNPP	Yield	R_h	NECB	ANPP	BNPP	Yield	R_h	NECB
	g C m^{-2}									
2015										
Bluegrass	910 (107)b	288 (25)	–398 (40)	–1127 (79)	–327 (88)b	965 (99)b	293 (21)	–859 (110)a	–1112 (74)	–705 (86)
Rye	1029 (57)ab	274 (23)	–571 (18)	–894 (84)	–163 (120)ab	1393 (47)a	347 (5)	–1249 (47)b	–959 (47)	–468 (50)
No cover	1220 (126)a	317 (32)	–539 (9)	–1039 (57)	–41 (186)a	1367 (173)a	332 (31)	–1308 (173)b	–987 (43)	–596 (44)
2016										
Bluegrass	1104 (56)	271 (11)	–427 (9)	–671 (13)b	277 (79)a	712 (34)	202 (11)b	–663 (36)	–726 (108)	–476 (99)
Rye	1108 (84)	268 (15)	–448 (14)	–931 (148)a	3.5 (85)b	830 (66)	318 (27)a	–628 (73)	–946 (47)	–426 (61)
No cover	1194 (69)	280 (14)	–461 (2)	–768 (102)ab	245 (61)ab	858 (57)	214 (12)b	–800 (58)	–743 (102)	–470 (98)
2017										
Bluegrass	1065 (49)	335 (8)	–620 (45)	–612 (37)	167 (50)	916 (29	310 (14)	–831 (28)	–687 (53)	–290 (67)
Rye	1099 (76)	323 (26)	–649 (47)	–668 (29)	104 (45)	888 (40)	312 (19)	–750 (43)	–632 (21)	–181 (52)
No cover	1124 (23)	313 (23)	–667 (38)	–752 (43)	19 (45)	850 (40)	281 (22)	–777 (43)	–646 (35)	–292 (48)
Mean										
Bluegrass	1026 (80)b	298 (20)	–481 (56)	–803 (116)	39 (140)	864 (77)b	268 (26)b	–781 (75)a	–842 (117)	–490 (111)
Rye	1079 (69)ab	288 (23)	–556 (48)	–831 (107)	–18 (97)	1037 (127)a	326 (19)a	–876 (134)ab	–792 (91)	–358 (79)
No cover	1179 (88)a	303 (24)	–556 (45)	–853 (90)	74 (122)	1025 (150)a	275 (31)b	–962 (151)b	–846 (79)	–453 (85)

Ecological intensification at WICST



Summary → discussion

1. Extending rotations with cover crops can be tricky

   Establishment & efficacy is highly variable

2. Perennial grasslands check sustainability boxes

   Why don't we do more of it?

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