

Dyson  
Cornell  
SC Johnson College of Business

# Evaluating the Efficiency-Participation Tradeoff in Agricultural Conservation Programs

---

**Wendong Zhang**

Assistant Professor, Dyson School of Applied Economics and Management, Cornell University;  
Associate Professor, Economics and CARD, Iowa State University (On leave)

[wendongz@cornell.edu](mailto:wendongz@cornell.edu)

(607) 254-3231

OARES Seminar, October 26, 2022

**Coauthors: Greg Howard (ECU), Adriana Valcu-Lisman (USDA-ERS), and Phil Gassman (ISU)**

The authors gratefully acknowledge the funding support by Iowa Nutrient Research Center project 2017-07 GS-140136, USDA National Institute of Food and Agriculture Hatch Project IOW04099.

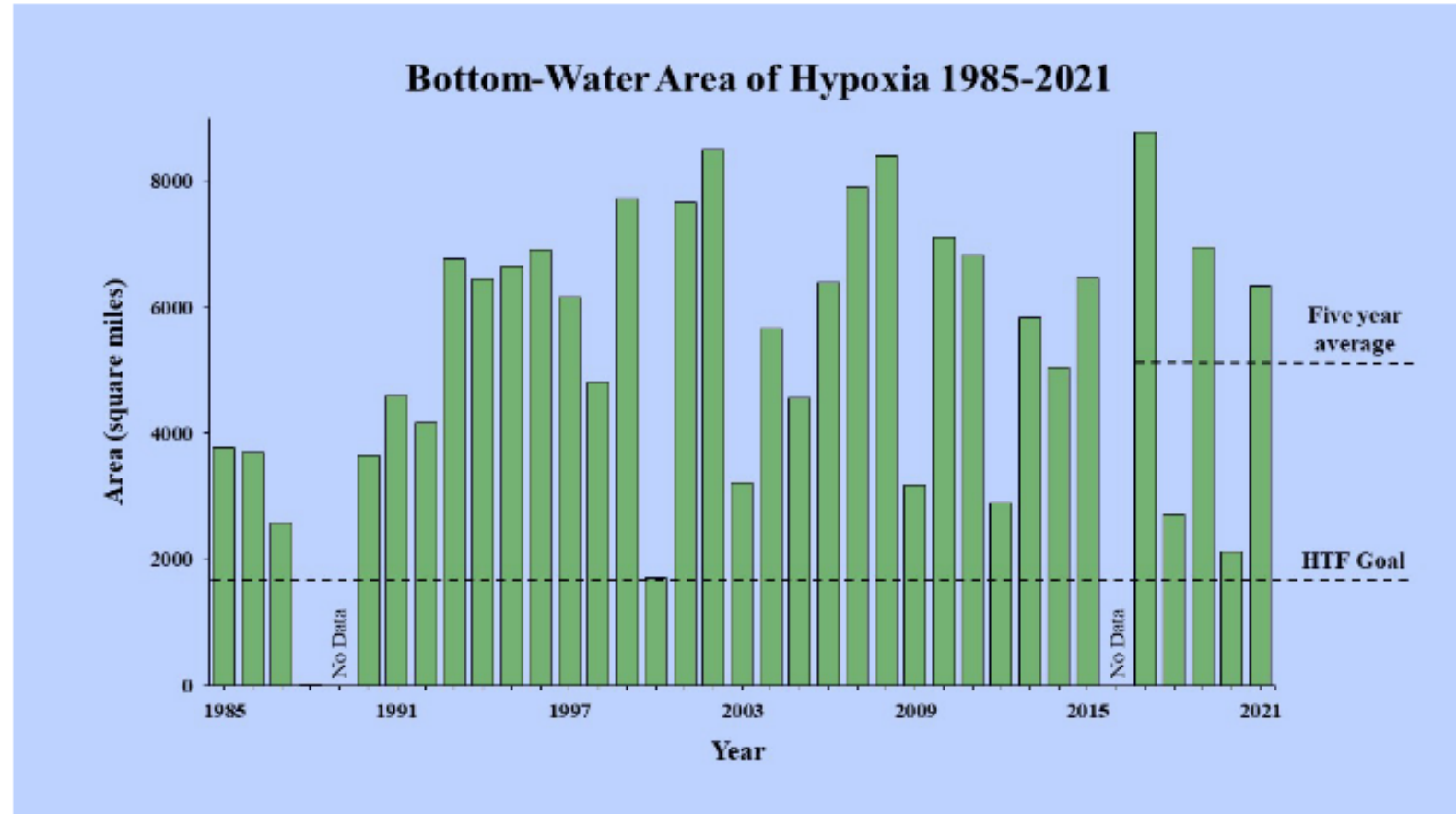
\*Author Valcu-Lisman was employed by ISU when this research was conducted. The findings and conclusions in this presentation are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy.

# Introduction: Ag Nutrient Runoff

N and P loadings in Mississippi River Basin have led to increasingly large hypoxic zones in Gulf of Mexico

Majority of loadings originate from upstream agricultural runoff

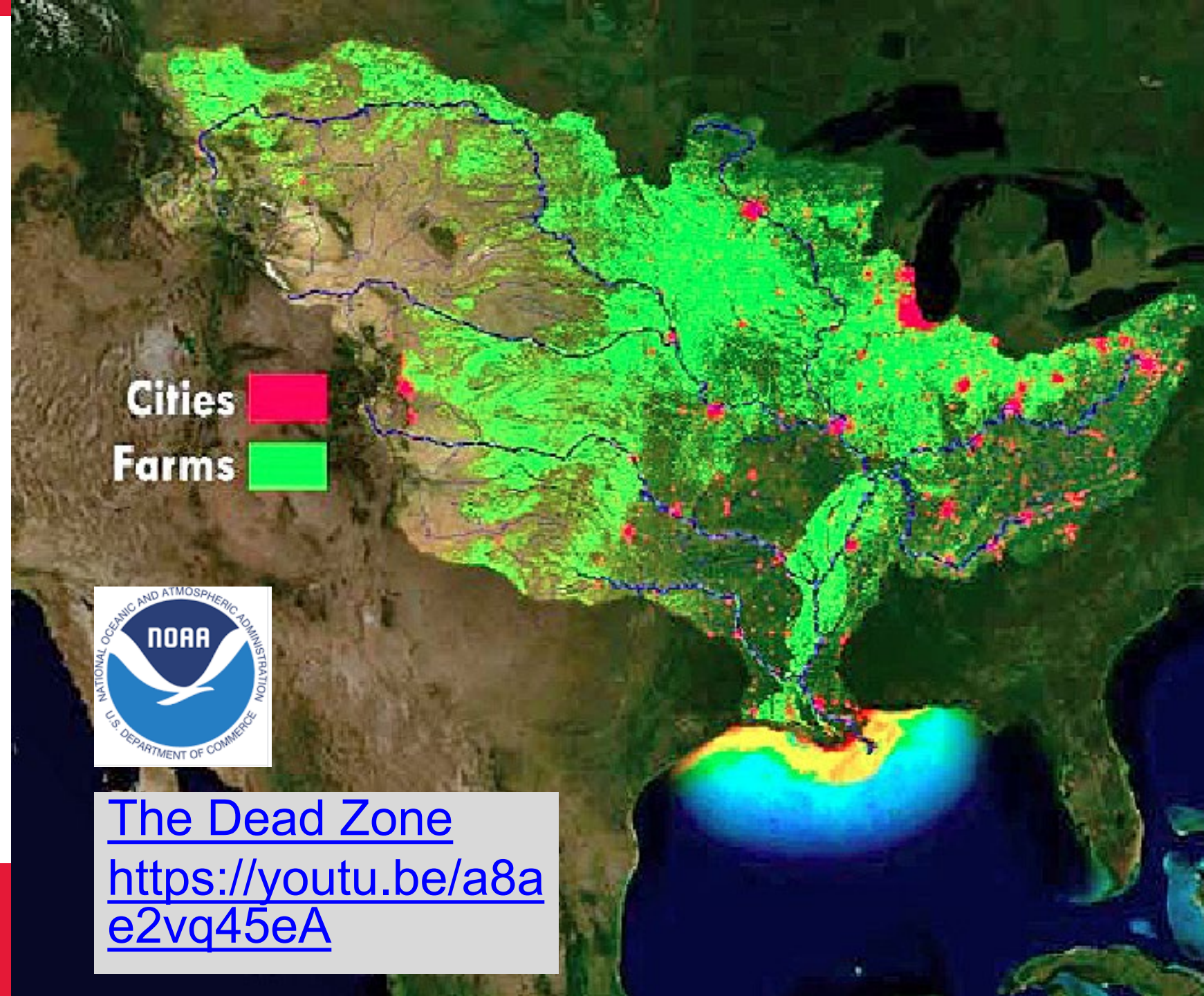
Many other upstream surface waters (rivers, lakes, etc.) also compromised



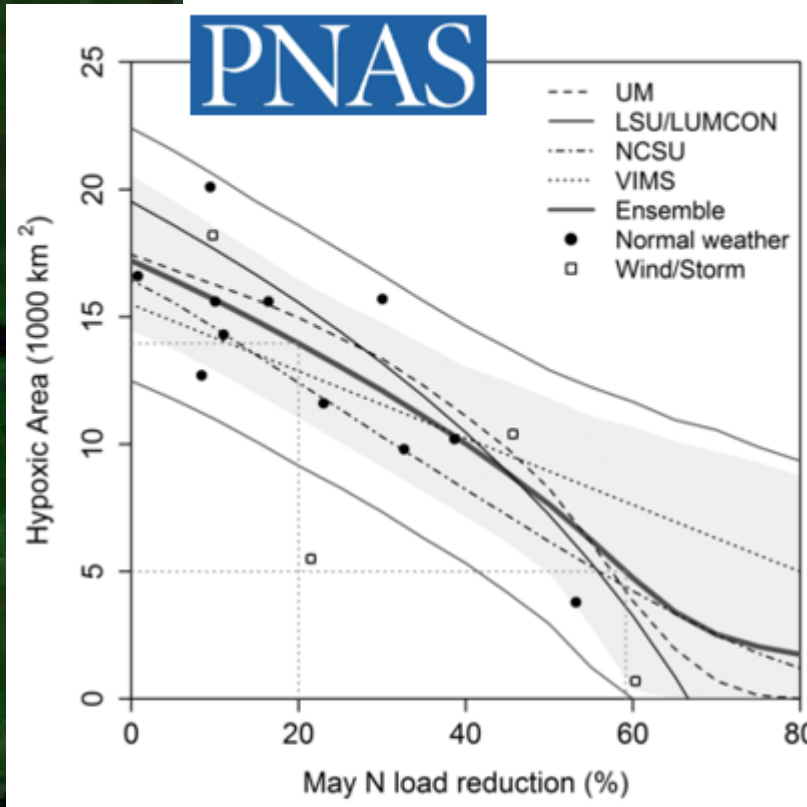
Long-term measured size of the hypoxic zone (green bars) measured during the ship surveys since 1985, including the target goal established by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force and the 5-year average measured size (black dashed lines). (LUMCON/NOAA)

<https://www.noaa.gov/news-release/larger-than-average-gulf-of-mexico-dead-zone-measured>





[The Dead Zone](https://youtu.be/a8ae2vq45eA)  
<https://youtu.be/a8ae2vq45eA>



**Ensemble modeling informs hypoxia management in the northern Gulf of Mexico**

● Donald Scavia, Isabella Bertani, Daniel R. Obenour, R. Eugene Turner, David R. Forrest, and Alexey Katin

PNAS first published July 31, 2017 <https://doi.org/10.1073/pnas.1705293114>



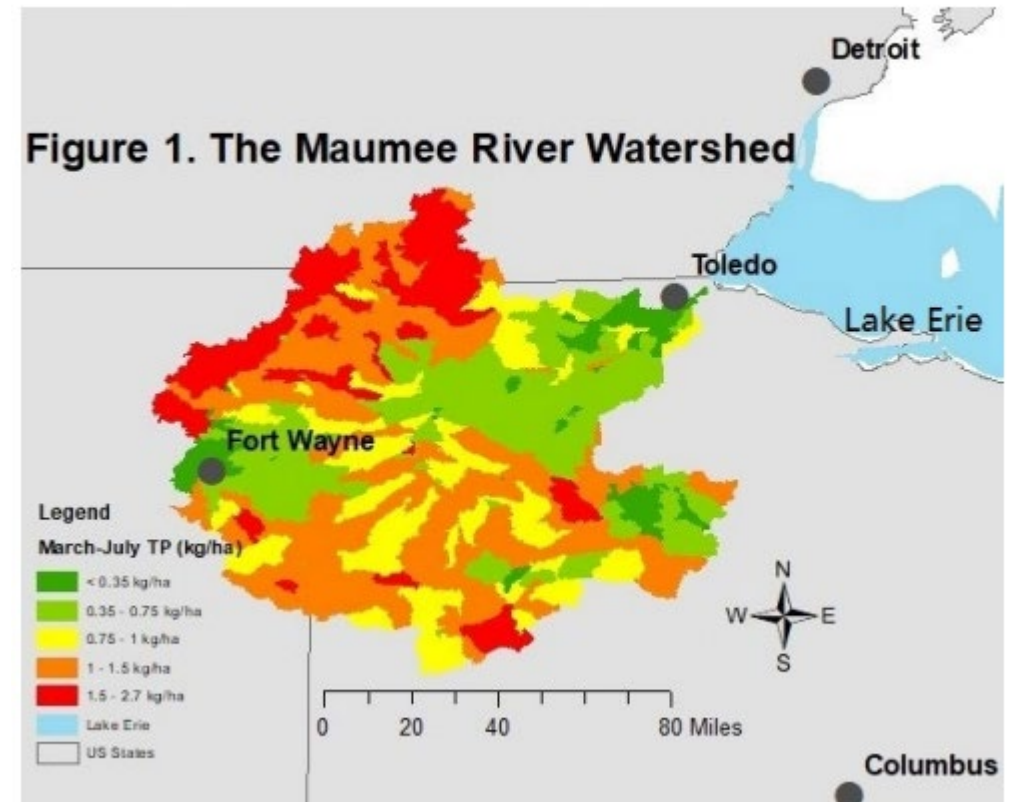
# Nutrient reduction target for Western Lake Erie Basin

2016 Great Lakes Water Quality Agreement  
Protocol, Annex 4 Spring (March-July) Targets

Baseline Load Year: 2008	Maumee Watershed	Western Lake Erie
Dissolved Reactive P (DRP)	186 MT	<b>40% less</b>
Total P (TP)	860 MT	<b>40% less</b>

## Maumee River Watershed

Figure 1. Map of the Maumee River watershed highlighting the per-acre phosphorus loading across subbasins.



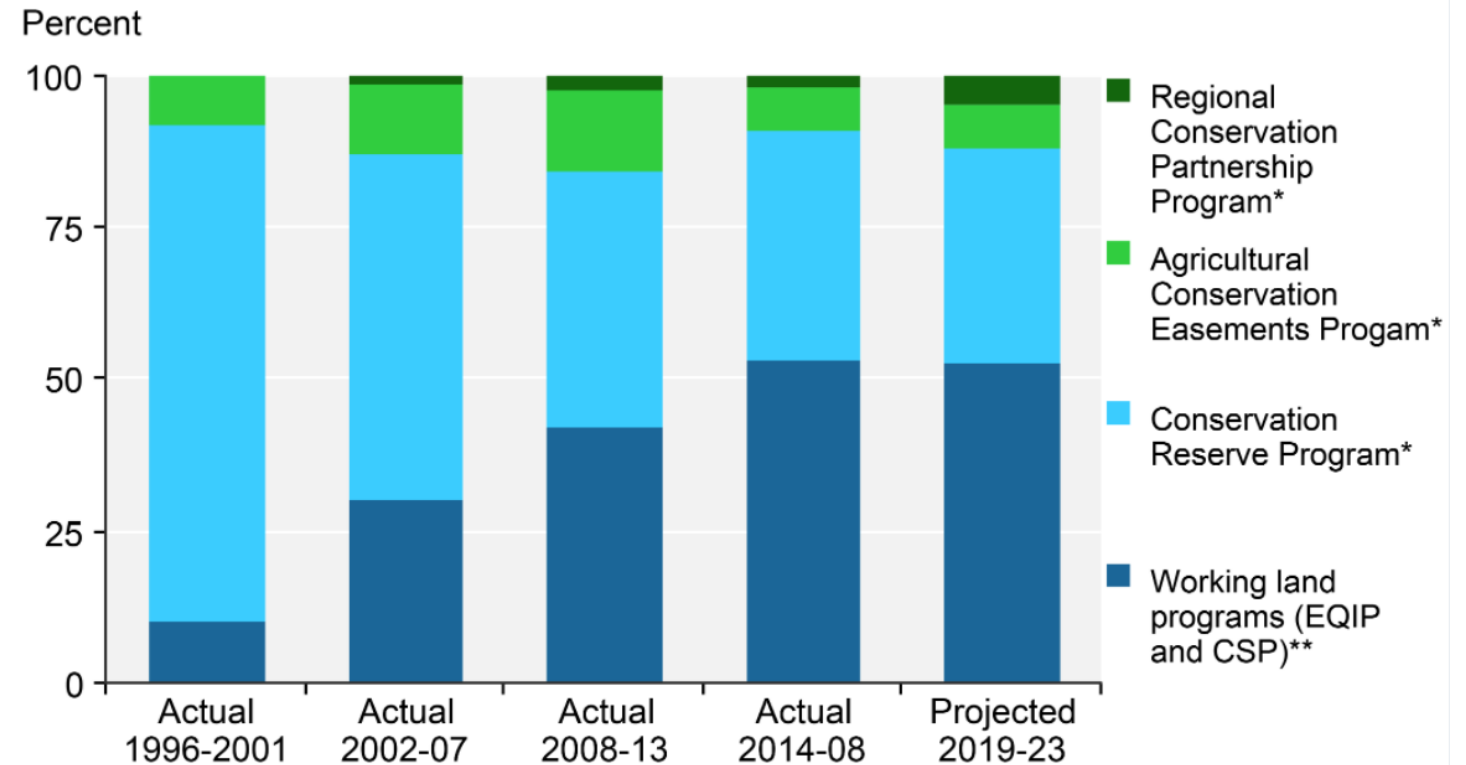


# Introduction: Voluntary Cost-Share Programs

USDA and state governments provide financial support annually for voluntary conservation incentive programs, now and in the future (Pavelis et al. 2011; 113th Congress 2014).

Certain characteristics of some conservation programs can hinder their ability to deliver water quality improvements at a low cost (Ferraro and Kiss 2002; Duke et al. 2013; Duke et al. 2014; Jack et al. 2008).

Share of conservation spending by major programs and predecessors in the 2018 and previous farm acts



\*Includes predecessor programs.

\*\*Includes the Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program (CSP), and predecessor programs (these are combined in the Congressional Budget Office estimates of spending under the 2018 Farm Act).

Sources: ERS analysis of Office of Budget and Policy Analysis data for 1996-2018 and Congressional Budget Office projections for 2019-23.

Source: USDA Economic Research Service

# A Side Note about Your Dissertation Research: Be Patient!

## Land Economics

[Home Page](#) | [Current Issue](#) | [Archive](#) | [Subscribe](#) | [Alerts](#) | [Activate/Manage Subscriptions](#)

Institution: IOWA STATE UNIV

This item requires a subscription to Land Economics.



Full Text (PDF)

Hongxing Liu, Wendong Zhang, Elena Irwin, Jeffrey Kast, Noel Aloysius, Jay Martin, and Margaret Kalcic

**Best Management Practices and Nutrient Reduction: An Integrated Economic-Hydrologic Model of the Western Lake Erie Basin**

*Land Economics* November 2020 96:510-530;



IOWA STATE UNIVERSITY  
College of Agriculture and Life Sciences  
Iowa Nutrient Research Center

Search

☰ Main Menu

Home » Projects » 2017

## Improving the Effectiveness of Conservation Programs through Innovative Reverse Auctions and Sensible Enrollment Restrictions

Date: Sep 2017

Investigators: Wendong Zhang, Gregory Howard

# Improving Cost Efficiency In Conservation Programs

Many conservation programs exist as defined cost shares

- Uniform payment levels

Economists (i.e., Hill et al. 2011, Palm-Forster et al. 2016b)

have pushed for innovations that can improve cost efficiency by either

- Boosting benefits (loadings reduced)
  - Enrollment restrictions, targeting high-potential-runoff fields, etc.
- Reducing costs
  - Price discrimination through reverse auctions or other devices

Some of these innovations have been implemented in select jurisdictions (e.g. ranking criteria for which contracts to accept); others less so

# Goal

Research plan: Compare enrollment and efficiency of different policy tools by simulating take-up of programs with different contract characteristics

- Individual farmer preference parameters → farmer-specific WTA for contract
- Extrapolate from sample to watershed
- Estimate N reductions using SWAT modelling

## Interested policy tools

- Reverse Auctions (RAs) vs. Cost Shares (CSs)
- Spatial targeting of high-projected benefit townships vs. no targeting
- Increased maximum allowable bids in Ras or higher CS payments



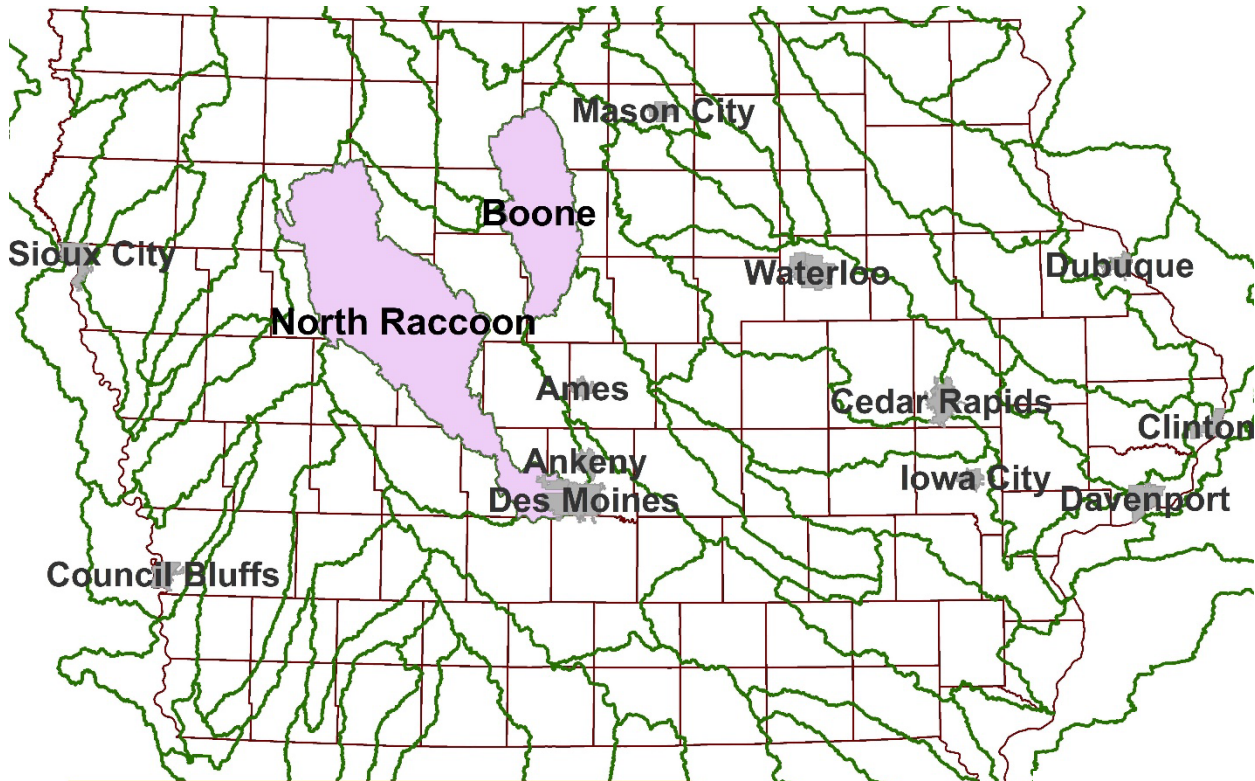
# Goal

Examine the impact of program characteristics on the scope of program adoption among farmers as well as program efficiency

## Interested policy tools

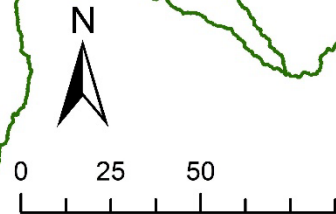
- Reverse Auctions (RAs) vs. Cost Shares (CSs) – **reduce avg. costs**
- Spatial targeting of high-projected benefit townships vs. no targeting – **increase avg. benefits**
- Increased maximum allowable bids in RAs or higher CS payments – **increase participation**

# Study Area: Boone and North Raccoon Watersheds in Iowa



## Legend

- Iowa\_Major\_Cities
- Boone\_North\_Raccoon\_Watersheds
- Iowa HUC-8 Watershed Boundaries
- Iowa County Map



Des Moines  
**Water Works**  
Water You Can Trust for Life

## Key achievement or drop in bucket? What \$282 million water quality bill means for Iowans

**Brianne Pfannenstiel** The Des Moines Register

Published 1:13 p.m. CT Jan. 27, 2018 | Updated 1:12 p.m. CT Jan. 28, 2018

# Data

Survey of Iowa Farmers following Dillman's Tailored Design framework (Dillman et al. 2014)

- Online + Two Rounds of Mail Surveys

Two waves of the survey: March 2019 and December 2019

- Each wave sent to different samples
- Second wave completed before COVID lockdowns

Wave 1: 1,800 recipients Mixed mode (online and mail) survey

Wave 2: 600 recipients mail only survey

# Data

Survey asked about farm characteristics, farmer demographics, and asks farmers to focus on a single field where runoff is the greatest concern in their operation

Choice experiment offering voluntary conservation contracts for the field in question

28.6% total response rate

Total of 430 with valid responses for the choice experiments and other necessary information



**Table 1. Demographics of Survey Samples**

	Full Sample		First Wave (2018)		Second Wave (2019)	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
<i>Age</i>	59.15 (413)	12.72	58.36 (283)	12.93	61.83 (130)	12.14
<i>Male</i>	0.96 (417)	0.19	0.95 (285)	0.22	0.98 (132)	0.12
<i>Owned Farm Size</i>	309.94 (407)	407.55	342.81 (273)	464.35	242.97 (134)	243.60
<i>Income &gt; \$250k</i>	0.51 (400)	0.50	0.51 (272)	0.50	0.50 (128)	0.50
<i>Experience</i>	34.33 (410)	14.65	33.35 (279)	15.26	36.42 (131)	13.09
<i>% Rent Farmland</i>	0.90 (389)	0.30	0.93 (259)	0.25	0.84 (130)	0.37
<i>Total Observations</i>	430		295		135	

Notes: *Owned Farm Size* refers to the acreage owned by the respondent and under production in the previous season. *Income > \$250k* is an indicator variable equal to 1 if reported farm income exceeds \$250,000. *Experience* is the number of years farming, and *Rent Farmland* is an indicator variable equal to 1 if the respondent indicated that they rent farmland.

# Choice Experiment: Treatment

## Random Assignment to either

### 1. Cost share contracts

#### Scenario 1

Please consider the terms of Programs A & B below for your field and answer the questions that follow as if a real conservation contract was being offered to you.

	Program A	Program B
<b>Length of Contract</b>	4 years (2021 - 2024)	4 years (2021 - 2024)
<b>No-Till or Strip-Till</b> (Leaving more than 90% residue)	Not Required	Must be used in 2021-24, <i>not</i> used in 2020
<b>Cover Crops</b> (Planting a crop after harvesting the main cash crop)	Must be used in 2021-24, <i>not</i> used in 2020	Not Required
<b>Split Nitrogen application</b> (Apply some N preplant/at-plant and the remainder sidedress)	Must be used in 2021-24, <i>not</i> used in 2020	Not Required
<b>Annual Cost Share Payment to You</b>	\$10/acre	\$100/acre

24. Which program do you prefer?

1 = Program A    2 = Program B    3 = Neither Program (If Neither, go to Page 7)

### 2. Reverse auction contracts with maximum cost share bids specified

#### Scenario 1

Please consider the terms of Programs A & B below for your field and answer the questions that follow as if a real conservation contract was being offered to you.

	Program A	Program B
<b>Length of Contract</b>	2 years (2021, 2022)	4 years (2021 - 2024)
<b>No-Till or Strip-Till</b> (Leaving more than 90% residue)	Not Required	Must be used in 2021-24, <i>not</i> used in 2020
<b>Cover Crops</b> (Planting a crop after harvesting the main cash crop)	Not Required	Must be used in 2021-24, <i>not</i> used in 2020
<b>Split Nitrogen application</b> (Apply some N preplant/at-plant and the remainder sidedress)	Must be used in 2021-22, <i>not</i> used in 2020	Must be used in 2021-24, <i>not</i> used in 2020
<b>Maximum Cost Share Payments You Could Request</b>	\$100/acre	\$130/acre

24. Which program do you prefer?

1 = Program A    2 = Program B    3 = Neither Program (If Neither, go to Page 7)

25. What is the **minimum** cost-share payment amount you would request for your preferred conservation program? (Remember, lower cost share requests are more likely to be accepted and approved.)

\$ \_\_\_\_\_ / acre

# Conservation Practices in Focus

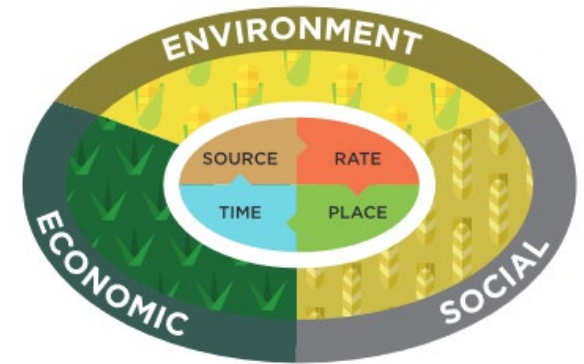


17



## No-Till/Strip-Till

LAND USES:  CCOP



split the application so that some is applied at planting and the rest is applied in the growing crop. Farmers can then adjust the rate and timing of the second application depending on the weather.

## Insure Your Nitrogen With PACE

Split Nitrogen Applications? There's Insurance for That

3/4/2022 | 5:00 AM CST



By Katie Micik Dehlinger, Farm Business Editor

<https://www.nrcs.usda.gov/wps/portal/nrcs/ia/newsroom/factsheets/>

Post Application Coverage Endorsement (PACE)



# Discrete Choice Model

## random parameters (mixed) logit

We utilize a random utility framework with unobserved preference heterogeneity in which the utility farmer  $i$  receives from choice  $j$ ,  $U_{ij}$ , is a function of a vector of choice attributes  $X_{ij}$ :

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta_i X_{ij} + \varepsilon_{ij}, \quad (1)$$

where  $V_{ij}$  is the systematic component of utility that is based on observable attributes of each alternative;  $\beta_i$  is a vector of farmer  $i$ 's latent preference parameters for the attributes of alternative  $j$ ;  $X_{ij}$  is a set of attributes and alternative-specific constants for alternative  $j$ ; and,  $\varepsilon_{ij}$  is a random error term with a type 1 extreme value distribution. We adopt a random parameters logit framework to model unobserved preference heterogeneity, in which each farmer's

We also allow for heterogeneity in preference for each attribute depending on the contract type (cost share or reverse auction):

$$V_{ij} = I(CS) * [\beta_{iC1}Length + \beta_{iC2}CoverCrop + \beta_{iC3}NoTill + \beta_{iC4}SplitN + \beta_{iC5}Payment + \beta_{iC6}SQ] + I(RA) * [\beta_{iR1}Length + \beta_{iR2}CoverCrop + \beta_{iR3}NoTill + \beta_{iR4}SplitN + \beta_{iR5}Payment + \beta_{iR6}SQ], \quad (4)$$



# Results: Mixed Logit

<i>Attribute</i>	<i>Contract Type</i>	<i>Mean</i>	<i>Std. Deviation</i>
<i>Contract Length</i>	Cost Share	-0.4072** (0.2051)	0.2211 (0.4228)
	Reverse Auction	-0.6137*** (0.1844)	0.2839 (0.2606)
<i>Cover Crops</i>	Cost Share	-1.3435*** (0.4615)	1.6714** (0.8191)
	Reverse Auction	-0.8930** (0.4044)	0.5619 (1.2905)
<i>No Till</i>	Cost Share	-1.7633*** (0.6329)	1.7230 (1.1258)
	Reverse Auction	-1.6698*** (0.6102)	2.1131*** (0.8088)
<i>Split Nitrogen</i>	Cost Share	-0.8247* (0.4573)	1.4282* (0.8348)
	Reverse Auction	-0.6561 (0.4071)	1.6560** (0.6847)
<i>Payment</i>	Cost Share	0.0321*** (0.0085)	0.0085 (0.0165)
	Reverse Auction	0.0172*** (0.0051)	0.0149 (0.0105)
<i>Status-Quo ASC</i>	Cost Share	-0.1595 (0.7246)	5.1210*** (1.1874)
	Reverse Auction	-0.5530 (0.6823)	2.6461*** (0.7612)
<i>Observations (Respondents)</i>			2,418 (430)

# Policy Simulation: Steps

1. For each scenario, we identify the percentage of our sample we project would enroll in the offered program (which occurs if their estimated WTA is below the offered cost share/maximum bid).
  - WTA estimation steps shown later
2. We also estimate average program cost per enrolled acre and average pounds of N reduced per enrolled acre. – N reduction estimated using the process-based hydrological model SWAT
3. We combine these to estimate the dollars spent per reduced pound of N and use an estimate of \$9.48 as the monetized benefit of a one-pound reduction in N (Ribaudó, Heimlich, and Peters 2005) to estimate a benefit-cost ratio for each program
4. Finally, we calculate the percentage of N loadings from the fields in our sample that is projected to be eliminated
5. Extrapolating to the whole watershed based on # farms/county using a small (\$600K) and large (\$3 million) budget [each sampled farmer represents 10.4 farmers]

## Policy simulation Step 0:

Determine scenarios to be simulated (15 Practice-Policy design combinations)

Scenarios: 3 × 5 design

Conservation contract offers for each examined BMP (Cover crops, No-till/split tillage, and split-N application) under 5 different policy environments:

- A. Baseline: Uniform cost share payments set at EQIP levels (\$50/acre for cover crops, \$10/acre for no-till/split tillage, \$10/acre for split-N application)
- B. Cost share payments set at EQIP levels, *spatially targeted* at fields that deliver above-median nutrient reductions using SWAT modeling
- C. Cost share payments equal to bids in a **reverse auction**, where maximum bid is set at EQIP levels
- D. Combination of B. and C.; reverse auction with spatial targeting
- E. Same as D., but with maximum bid set at 150% of EQIP level

## Policy simulation step 1.1:

### Generate farmer preference parameters using choice model

Mixed Logit estimates first two moments of a distribution of preferences for each attribute

- Normal for all (Payment fixed)

Generate preference parameter estimates for each respondent, conditioned on actual responses (1,000 Halton Draws; Stata using Hole's *mixlbeta* command (Hole 2007))

Our sample roughly is 10% of all farmers in our study watersheds



## Policy simulation step 1.2:

### Estimate farmer minimum WTA for specified contracts

Using individual-specific preference parameters, estimate minimum WTA for a specified conservation contract as

$$WTA_i = \frac{-(V_{1i} - V_{SQi})}{\beta_{payment}},$$

Where  $V_{1i}$  is the estimated utility of the offered contract,

$V_{SQi}$  is the estimated utility of the status-quo option, and

$\beta_{payment}$  is the preference parameter for contract payment

Then we identify the percentage of farmers in our watershed who would enroll in the offered program (which occurs if their estimated WTA is below the offered cost share/maximum bid).

More assumptions about bid choices needed for RA contracts

Treat bids as % of maximum allowed bid

Use bid distribution in data to assign bids to each farmer for RAs

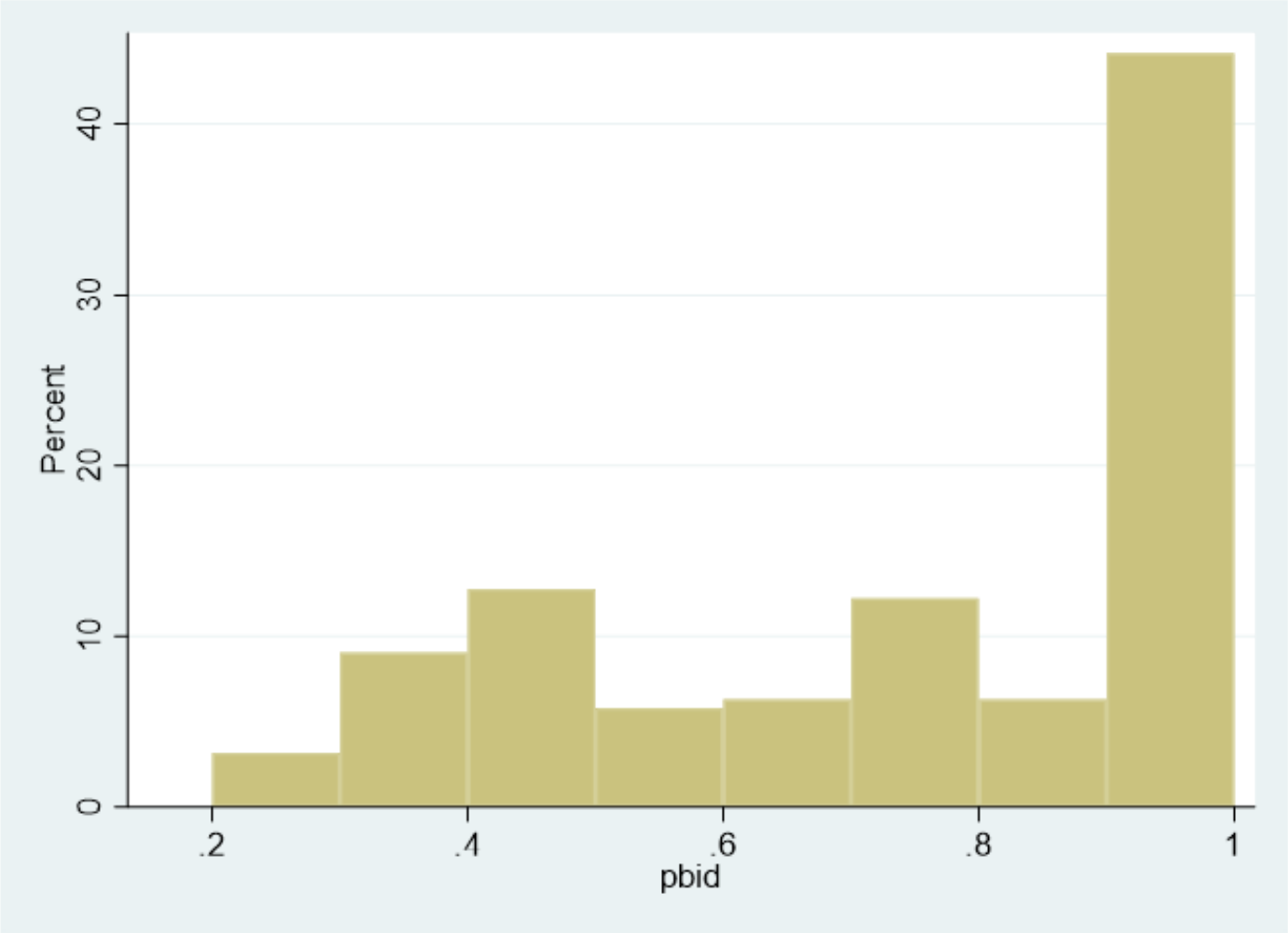


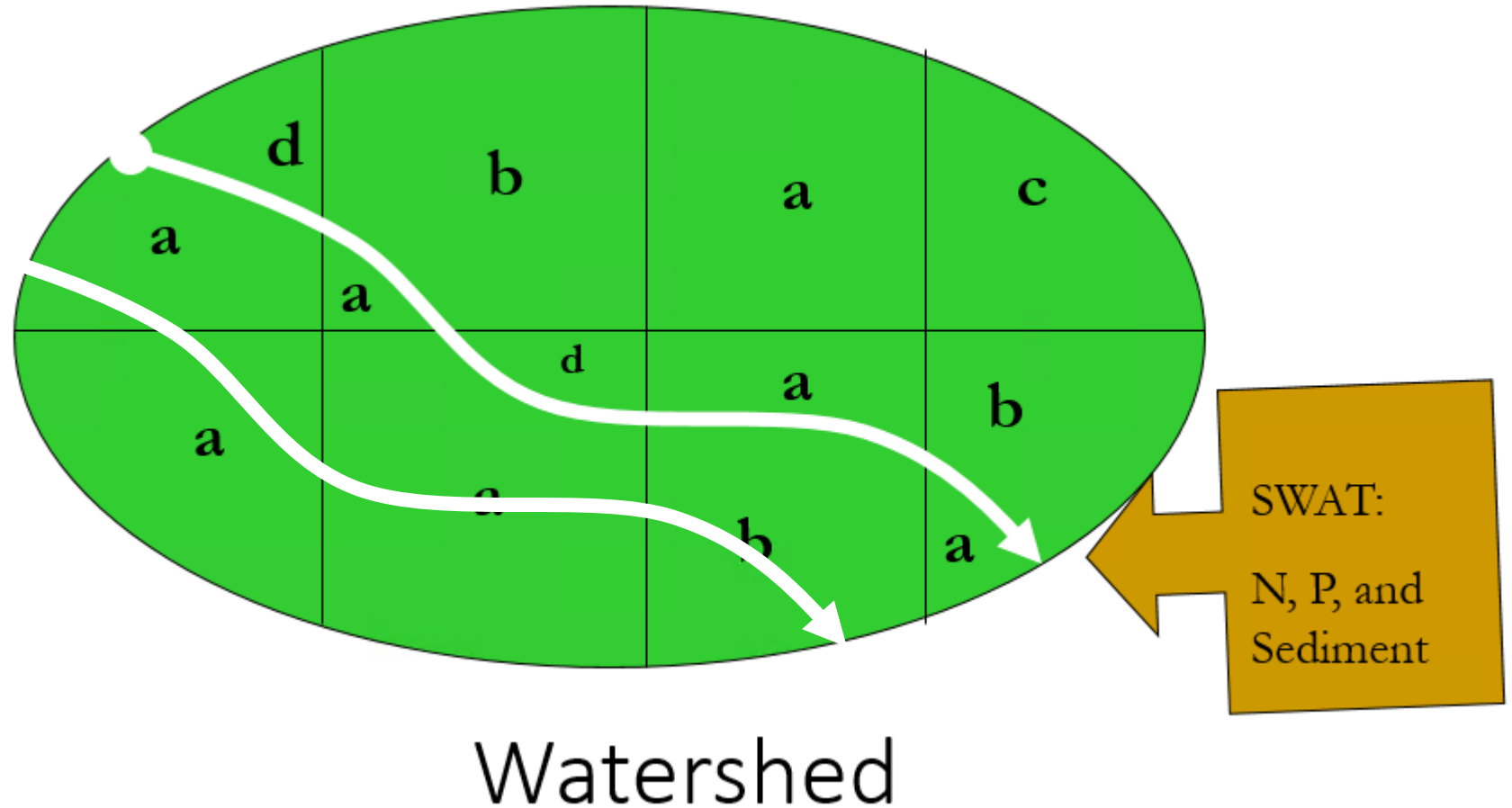
Figure 1: Distribution of bids as a proportion of maximum allowable bid

## Policy simulation step 2:

### Identify N reductions per acre from each practice using SWAT model

SWAT simulates water quality under any combination of landuse/abatement activities

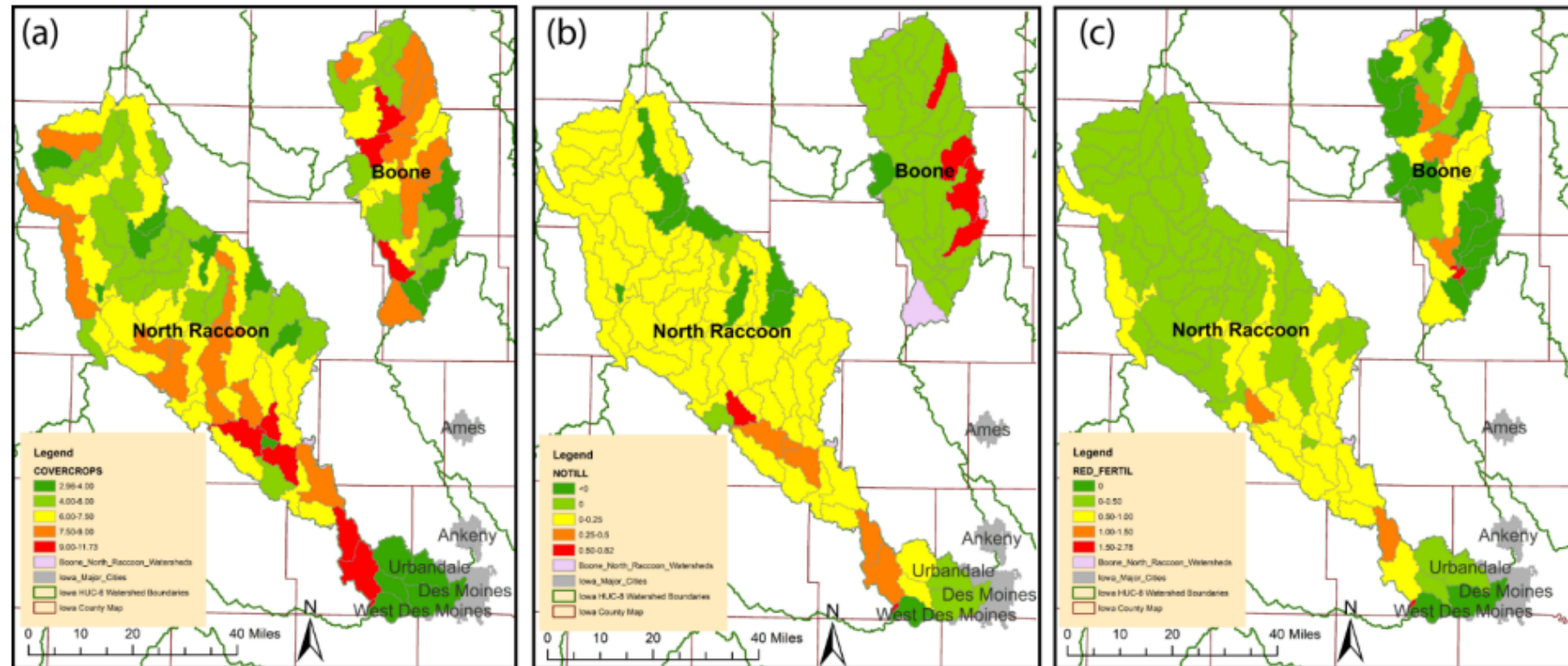
- Process-based Watershed-scale Ecohydrological simulation model developed by USDA - Agricultural Research Service
- Predicts ambient (instream) water quality associated with a spatially explicit set of land use/conservation practices



**Soil and Water Assessment Tool (SWAT)**

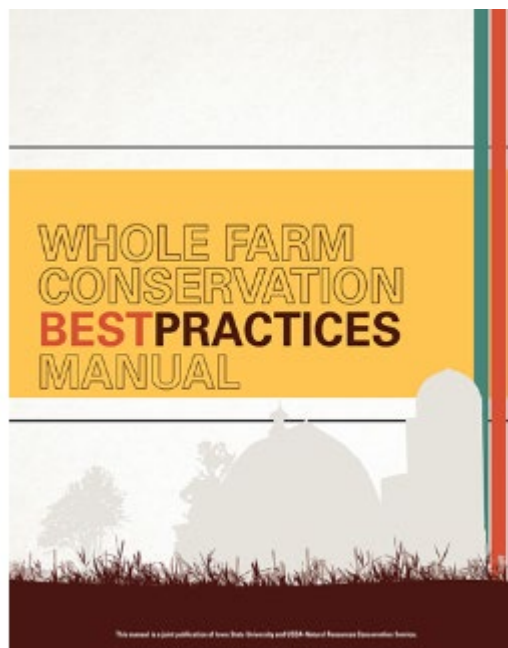
**Table 2. Nutrient Reduction Efficiency Coefficients (pounds of reduced nitrogen runoff per acre) for each Conservation Practice at the Subwatershed Level**

	No-till or Strip-till		Cover Crops		Reduced Fertilizer (Split Nitrogen)	
	Boone	Raccoon	Boone	Raccoon	Boone	Raccoon
<b>Mean</b>	0.08	0.08	6.60	6.11	0.45	0.48
<b>Standard deviation</b>	0.14	0.08	1.24	1.71	0.25	0.18



**Figure 4. Spatial distribution of nitrogen reduction coefficients (lbs. of N reduced per acre of conservation practice adopted): (a) cover crops; (b) no-till; and, (c) split nitrogen proxied by reduced fertilizer.**

Note: Based on Valcu-Lisman et al. (2017).



**— LEGEND —**




**Strong**



**Moderate**



**Weak**



**No Impact**

-  **Anecdotal Evidence**
-  **Multiple Studies**
-  **Scientific Consensus**

Practice	ABILITY TO ADDRESS RESOURCE CONCERN						
	Soil Health		Nutrient Loss Reduction			Habitat	
	Impact	Confidence	Nitrogen Impact	Phosphorus Impact	Confidence	Impact	Confidence
Cover Crops							
No-tillage							
Strip-tillage							
N Management							
P Management							
Diverse Rotations							
Wetlands							
Saturated Buffers	*						
Bioreactors	*					#	
Field Buffers	*						
Grassed Waterways	*						
Strategically Placed Perennials	*						
Prairie Strips	*						



Policy simulation whole-watershed budget size details:  
Two budget types for each simulated program (small & large)

### Small Budget

- Mirrors recent historic spending (2018-2020) by EQIP and CSP in target watersheds for specific practices
- Cover Crops: \$603,000
- No-till: \$84,000
- Split-N Application: \$84,000

## Policy simulation whole-watershed budget size details: Two budget types for each simulated program (small & large)

### Large Budget

- Imagines a concerted push to use available state and federal funds to increase adoption of target practice
- 2020 total EQIP and CSP incentive payments (all BMPs) in target watersheds, PLUS state funding
  - Recent IA legislation: \$154,000,000 for voluntary incentive payments over 12 years (\$13 million/year); 7% dedicated to target watersheds
- Cover Crops: \$3,145,000
- No-till : \$3,145,000
- Split-N Application : \$3,145,000

# The U.S. Department of Agriculture is investing up to **\$2.8 billion** in **70 selected** projects under the first funding pool of Partnerships for Climate-Smart Commodities.

CARD part of \$80 million USDA grant

September 23, 2022

AMES, Iowa — Keeping plants continuously growing on farmland through the winter protects and enriches soil, improves water quality and reduces greenhouse gas emissions. That's why Lisa Schulte Moore, a professor of [natural resource ecology and management](#) at Iowa State University, is working to make year-round covered ground a conventional practice.

"My vision is that when we drive around Iowa in December, we don't see a single bare field," she said.

While use of cover crops is growing, it's far from common. A new grant of up to \$80 million from the U.S. Department of Agriculture will fund a project meant to spur more farmers to plant cover crops and perennial prairie grass, through both direct payments and a demonstration of how harvested winter-hardy crops and grass can be processed into renewable natural gas.

"This is about creating economic incentives so farmers' hearts and minds can align. They want to keep their soil. They want to keep their nutrients in place. We know they value environmental quality. But it needs to make financial sense for them," said Schulte Moore, co-director of Iowa State's [Bioeconomy Institute](#) and a [2021 McArthur Fellow](#).

The five-year grant is among the \$2.8 billion in federal investments in 70 projects announced this month as part of the USDA's [Partnerships for Climate-Smart Commodities](#) program. The grant builds on the work of the [Consortium for Cultivating Human and Naturally reGenerative Enterprises](#) (C-CHANGE), founded in 2018 as an [ISU Presidential Interdisciplinary Research Initiative](#).

The initiative expanded in 2020 to a multi-institutional project led by Schulte Moore with a [five-year, \\$10 million grant](#) from the USDA's National Institute for Food and Agriculture.

Several CARD faculty members, including John Crespi, Dermot Hayes, Amani Elobeid, Alejandro Plastina, Wendong Zhang, and CARD Faculty Collaborator Jerome Dumortier will serve as principal investigators on the project.

Iowa State will receive roughly \$10 million from the new grant and is one of 14 partners involved in the project, which is called Horizon II and is led by [Roeslein Alternative Energy](#), a St. Louis-based company that is also an industry partner on C-CHANGE.

USDA  
U.S. DEPARTMENT OF AGRICULTURE

PARTNERSHIPS FOR  
**CLIMATE-SMART**  
COMMODITIES

## Policy simulation extrapolation details:

Generate rule for extrapolating farmer choice → watershed land use change

Estimate number of operators in the target watersheds

- 2017 Iowa Ag Census operators by county
- Weight by proportion of each county in watershed

Result: Each farmer in our sample represents 10.4 operators in target watersheds

**Table 5b. Full Watersheds Policy Simulation Results: Cover Crops Contracts, Large Budget**

Policy Scenarios	Total Budget Spent	Cost per Acre	Projected Farmers Enrolled	Acres Enrolled	Lbs. Reduced per Acre	Predicted N Reduction	Dollars per lb. Reduced	B/C Ratio
<b>1. Cost Share \$50</b>	\$3,076,350	\$50	634	61,527 acres	6.95 lbs.	427,987 lbs.	\$7.18	1.32
<b>2. Cost Share \$50, &gt;= Median reduction fields</b>	\$2,073,300	\$50	416	41,466 acres	7.38 lbs.	306,135 lbs.	\$6.77	1.40
<b>3. Reverse Auction \$50</b>	\$2,500,623	\$37.06	707	67,475 acres	6.39 lbs.	430,992 lbs.	\$5.80	2.60
<b>4. Reverse Auction \$50, Accepting &gt;= Median reduction fields</b>	\$1,305,736	\$38.43	364	33,977 acres	7.37 lbs.	250,309 lbs.	\$5.22	2.30
<b>5. Reverse Auction \$75, Accepting &gt;= Median reduction fields</b>	\$2,087,893	\$57.64	395	36,223 acres	7.34 lbs.	265,947 lbs.	\$7.85	1.23

Notes: Benefit-cost ratios assume a value of \$9.48 in benefits from a one-pound reduction of N (Ribaudo, Heimlich, and Peters 2005). According to SWAT modeling, the median field in our data set is projected to reduce N loadings by 6.5 lbs. per acre with the use of cover crops. Average N loading estimates from our SWAT modeling are 17.69 lbs. per acre for the two watersheds. The baseline N loading in the Boone and North Raccoon River watersheds are 12.42 and 27.24 million lbs., respectively (Gassman et al. 2017, Jones et al. 2017). Total budget allocated for each scenario is \$3,145,000.



**Table 5a. Full Watersheds Policy Simulation Results: Cover Crops Contracts, Small Budget**

<b>Policy Scenarios</b>	<b>Total Budget Spent</b>	<b>Cost per Acre</b>	<b>Projected Farmers Enrolled</b>	<b>Acres Enrolled</b>	<b>Lbs. Reduced per Acre</b>	<b>Predicted N Reduction</b>	<b>Dollars per lb. Reduced</b>	<b>B/C Ratio</b>
<b>1. Cost Share \$50</b>	\$593,300	\$50	104	11,866 acres	8.09 lbs.	95,973 lbs.	\$6.18	1.53
<b>2. Cost Share \$50, &gt;= Median reduction fields</b>	\$593,300	\$50	104	11,866 acres	8.09 lbs.	95,973 lbs.	\$6.18	1.53
<b>3. Reverse Auction \$50</b>	\$569,462	\$23.33	250	24,409 acres	6.71 lbs.	163,806 lbs.	\$3.48	2.73
<b>4. Reverse Auction \$50, Accepting &gt;= Median reduction fields</b>	\$599,813	\$30.50	208	19,666 acres	7.54 lbs.	148,272 lbs.	\$4.05	2.34
<b>5. Reverse Auction \$75, Accepting &gt;= Median reduction fields</b>	\$596,280	\$37.97	166	15,704 acres	7.44 lbs.	116,845 lbs.	\$5.10	1.86

Notes: Benefit-cost ratios assume a value of \$9.48 in benefits from a one-pound reduction of N (Ribaudo, Heimlich, and Peters 2005). According to SWAT modeling, the median field in our data set is projected to reduce N loadings by 6.5 lbs. per acre with the use of cover crops. Average N loading estimates from our SWAT modeling are 17.69 lbs. per acre for the two watersheds. The baseline N loading in the Boone and North Raccoon River watersheds are 12.42 and 27.24 million lbs, respectively (Gassman et al. 2017, Jones et al. 2017). Total budget allocated for each scenario is \$603,000

**Table 6a. Full Watersheds Policy Simulation Results: No-till/Strip-till Contracts, Small Budget**

<b>Policy Scenarios</b>	<b>Total Budget Spent</b>	<b>Cost per Acre</b>	<b>Projected Farmers Enrolled</b>	<b>Acres Enrolled</b>	<b>Lbs. Reduced per Acre</b>	<b>Predicted N Reduction</b>	<b>Dollars per lb. Reduced</b>	<b>B/C Ratio</b>
<b>1. Cost Share \$10</b>	\$74,460	\$10	73	7,446 acres	0.31 lbs.	2,332 lbs.	\$31.93	0.30
<b>2. Cost Share \$10, &gt;= Median reduction fields</b>	\$74,460	\$10	73	7,446 acres	0.31 lbs.	2,332 lbs.	\$31.93	0.30
<b>3. Reverse Auction \$10</b>	\$78,936	\$5.75	83	13,728 acres	0.28 lbs.	3,848 lbs.	\$20.51	0.46
<b>4. Reverse Auction \$10, Accepting &gt;= Median reduction fields</b>	\$78,936	\$5.75	83	13,728 acres	0.28 lbs.	3,848 lbs.	\$20.51	0.46
<b>5. Reverse Auction \$15, Accepting &gt;= Median reduction fields</b>	\$51,480	\$7.50	42	6,864 acres	0.31 lbs.	2,145 lbs.	\$23.99	0.40

Notes: Benefit-cost ratios assume a value of \$9.48 in benefits from a one-pound reduction of N (Ribaudo, Heimlich, and Peters 2005). According to SWAT modeling, the median field in our data set is projected to reduce N loadings by 6.5 lbs. per acre with the use of cover crops. Average N loading estimates from our SWAT modeling are 17.69 lbs. per acre for the two watersheds. The baseline N loading in the Boone and North Raccoon River watersheds are 12.42 and 27.24 million lbs, respectively (Gassman et al. 2017, Jones et al. 2017). Total budget allocated for each scenario is \$84,000.

**Table 7b. Full Watersheds Policy Simulation Results: Split N Application Contracts, Large Budget**

<b>Policy Scenarios</b>	<b>Total Budget Spent</b>	<b>Cost per Acre</b>	<b>Projected Farmers Enrolled</b>	<b>Acres Enrolled</b>	<b>Lbs. Reduced per Acre</b>	<b>Predicted N Reduction</b>	<b>Dollars per lb. Reduced</b>	<b>B/C Ratio</b>
<b>1. Cost Share \$10</b>	\$985,160	\$10	1,009	98,516 acres	0.46 lbs.	45,210 lbs.	\$21.79	0.44
<b>2. Cost Share \$10, &gt;= Median reduction fields</b>	\$482,660	\$10	499	48,266 acres	0.61 lbs.	29,521 lbs.	\$16.35	0.60
<b>3. Reverse Auction \$10</b>	\$323,028	\$7.18	510	44,990 acres	0.46 lbs.	20,818 lbs.	\$15.52	0.61
<b>4. Reverse Auction \$10, Accepting &gt;= Median reduction fields</b>	\$179,946	\$7.69	270	23,400 acres	0.61 lbs.	14,342 lbs.	\$12.55	0.76
<b>5. Reverse Auction \$15, Accepting &gt;= Median reduction fields</b>	\$303,882	\$11.54	292	26,333 acres	0.60 lbs.	15,872 lbs.	\$19.14	0.50

Notes: Benefit-cost ratios assume a value of \$9.48 in benefits from a one-pound reduction of N (Ribaudo, Heimlich, and Peters 2005). According to SWAT modeling, the median field in our data set is projected to reduce N loadings by 6.5 lbs. per acre with the use of cover crops. Average N loading estimates from our SWAT modeling are 17.69 lbs. per acre for the two watersheds. The baseline N loading in the Boone and North Raccoon River watersheds are 12.42 and 27.24 million lbs, respectively (Gassman et al. 2017, Jones et al. 2017). Total budget allocated for each scenario is \$3,145,000.

**Table 8: Benefit/Cost Ratios under different assumptions for benefits of per/lb. N reduction**

Policy	Cover Crops				No-till/Split-till			
	Social cost of N	\$9.48	\$2	\$5	\$20	\$9.48	\$2	\$5
1.	1.53	0.32	0.81	3.24	0.30	0.06	0.16	0.63
2.	1.53	0.32	0.81	3.24	0.30	0.06	0.16	0.63
3.	2.73	0.58	1.44	5.75	0.46	0.10	0.24	0.98
4.	2.34	0.49	1.24	4.94	0.46	0.10	0.24	0.98
5.	1.86	0.39	0.98	3.92	0.40	0.08	0.21	0.83

SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

## The social costs of nitrogen

Bonnie L. Keeler,<sup>1\*</sup> Jesse D. Gourevitch,<sup>1</sup> Stephen Polasky,<sup>1,2,3</sup> Forest Isbell,<sup>3</sup> Chris W. Tessum,<sup>4</sup> Jason D. Hill,<sup>5</sup> Julian D. Marshall<sup>4</sup>

# Main Findings about the program innovations

## Spatial Targeting

Lowers cost per lb. N reduced, but more pronounced with larger budgets

## Reverse Auctions

Can lower cost per lb. & improve cost-efficiency but could have lower watershed-level diminished N reductions

## Raising Bid Maxima

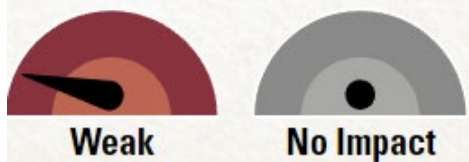
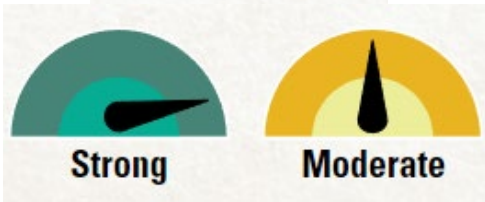
Appears to buy very little; counterproductive with limited budgets



# WHOLE FARM CONSERVATION BEST PRACTICES MANUAL



## — LEGEND —



- ✓ Anecdotal Evidence
- ✓✓ Multiple Studies
- ✓✓✓ Scientific Consensus

Practice	ABILITY TO ADDRESS RESOURCE CONCERN						
	Soil Health		Nutrient Loss Reduction			Habitat	
	Impact	Confidence	Nitrogen Impact	Phosphorus Impact	Confidence	Impact	Confidence
Cover Crops							
No-tillage							
Strip-tillage							
N Management							
P Management							
Diverse Rotations							
Wetlands							
Saturated Buffers							
Bioreactors							
Field Buffers							
Grassed Waterways							
Strategically Placed Perennials							
Prairie Strips							

# Conclusions

- We find that both spatial targeting of contracts and replacing uniform cost-share offers with reverse auctions leads to substantial increases in the cost-effectiveness of programs but also shrinks the total impact of the conservation program, reducing enrollment by 30%–70%.
- It is critical to examine how program design affects farmers' participation, especially in reverse auction contracts, to ensure program effectiveness.
- We find that benefit-cost ratios are consistently below 1 for no-till and split N application contracts and are consistently above 1 (1.15 to 1.82) for cover crop contracts, and no-till are particularly ineffective.
- Even with large budgets, the watershed level N reduction is merely 1%, far below the 45% policy goal – no silver bullets!!

# Thank you!

---

Wendong Zhang  
wendongz@cornell.edu

<https://wendongzhang.weebly.com/>



Dyson  
Cornell  
SC Johnson College of Business

# Work-in-progress: The Effects of Enrollment Restrictions & Additionality

Joint with Xiaolan Wan (ISU), Greg Howard (ECU)

---

## How to Grow and Sell Carbon Credits in US Agriculture

---

*Ag Decision Maker*  
extension.iastate.edu/agdm

File A1-76

While all programs require **additionality** to generate a credit, not all programs require that farmers change their production practices.

**Additionality** means that farmers must do something **different** to reduce carbon and increase ecosystem services. However, programs use a wide array of benchmarks to determine what is **different**. Some programs require a change of practices with respect to past practices on the same field, while some others require that practices in the field be different from common practices in the area (even

Prepared by Alejandro Plastina,  
extension economist, [plastina@iastate.edu](mailto:plastina@iastate.edu);  
Oranuch Wongpiyabovorn,  
graduate research assistant

[www.extension.iastate.edu/agdm](http://www.extension.iastate.edu/agdm)

<https://www.extension.iastate.edu/agdm/crops/pdf/a1-76.pdf>

# Example Scenario with Enrollment Restriction

## Section 3: Hypothetical Voluntary Conservation Program for Your Field

### *Conservation Program Overview.*

Consider a hypothetical situation where a government agency or conservation group is offering multiple *voluntary conservation contracts with different lengths starting the 2021 growing season* (from after harvest in the fall of 2020 until harvest in the fall of 2021). All contracts include the adoption of one or more management practices to reduce nutrient loss that **are not already in use or planned for use in the 2020 growing season**, as well as an annual per-acre cost-share payment to the farmer. The practices, as well as the per-acre cost share, apply to the acreage of the entire field.

These conservation programs are designed to encourage **additional, new** acres of three conservation practices: no-till or strip-till, cover crops, and split N application. As a result, not all acres are eligible for this program. For example, a field which currently uses cover crops is not eligible for conservation programs adding cover crops.



24. Still considering your field from the previous section, please indicate whether this field would be eligible for a voluntary conservation program based on the practices you will use in the 2020 season. Note that in this new conservation funding concept, **funding is only available to add additional, new conservation practices.**

*(Circle all that apply.)*

- 1 = I will not use no-till/strip-till, cover crops, or split-N-application on this field in 2020, so it is eligible for any conservation contracts presented in the next two scenarios.
- 2 = No-till/strip-till will be used on this field for the 2020 crop, so it is not eligible for contracts in 2021 **adding** no-till/strip-till.
- 3 = Cover crops will be planted on this field for the 2020 crop year (post-harvest 2019 until harvest 2020), so it is not eligible for contracts in 2021 **adding** cover crops.
- 4 = Split nitrogen application will be used on the field for the 2020 crop, so it is not eligible for contracts in 2021 **adding** the practice of split nitrogen application.

### Scenario 1

Please consider the terms of Programs A & B below for your field and answer the questions that follow as if a real conservation contract was being offered to you.

	Program A	Program B
<b>Length of Contract</b>	2 years (2021, 2022)	4 years (2021 - 2024)
<b>No-Till or Strip-Till</b> (Leaving more than 90% residue)	Not Required	Not Required
<b>Cover Crops</b> (Planting a crop after harvesting the main cash crop)	Must be used in 2021-22, <b>not</b> used in 2020	Not Required
<b>Split Nitrogen application</b> (Apply some N <u>preplant/at-plant</u> and the remainder <u>sidedress</u> )	Not Required	Must be used in 2021-24, <b>not</b> used in 2020
<b>Annual Cost Share Payment to You</b>	\$10/acre	\$70/acre

25. As mentioned earlier, the program is available for fields currently not using these practices. Based on the information above, is your field eligible for either Program A or Program B for the 2021 growing season?

- 1 = Yes, eligible for A and B
- 2 = Yes, but eligible for A only
- 3 = Yes, but eligible for B only
- 4 = Not eligible for either (If not eligible for either, go to Page 7)

26. If your field is eligible, which program do you prefer?

- 1 = Program A
- 2 = Program B
- 3 = Neither Program (If Neither, go to Page 7)

# Econometric Model

$$U_{ij} = (1 - R_i) \left\{ \sum_{k=1}^3 x_{kj} \beta_{kn,i} + SQ_j (\beta_{n,SQ} + G_i \gamma_{f,SQ}) \right\} \\ + R_i \left\{ \sum_{k=1}^3 x_{kj} \beta_{kr,i} + SQ_j (\beta_{r,SQ} + C_i \gamma_{c,SQ} + G_i \gamma_{f,SQ}) \right\} + l_j \beta_l + p_j \alpha + \epsilon_{ij} \quad (1)$$

where

- $x_{1j}$ ,  $x_{2j}$ , and  $x_{3j}$  denote contract  $j$ 's requirements for the three practices: cover crop, no-till, and split N application;  $l_j$  and  $p_j$  denote the mandatory years and annual cost-share payment.
- $SQ_j$  captures an alternative-specific constant for status-quo option.
- $R_i$  is an indicator for a farmer receiving the restricted enrollment choice questions;  $G_i$  is an indicator for a green farmer;  $C_i$  is an indicator for a farmer with only one contract eligible.

## Conditional Logit Regression Results

Variables	Explanation	Model 1
<i>length</i>	Contract length in years	-.227*** (0.054)
<i>payment</i>	Contract payment rates	.012*** (0.001)
<i>covercrops<sup>no</sup></i>	Subsidize cover crops without restrictions	-.555*** (0.162)
<i>covercrops<sup>res</sup></i>	Subsidize cover crops with restrictions	-.508** (0.213)
<i>notill<sup>no</sup></i>	Subsidize no-till without restrictions	-.734*** (0.169)
<i>notill<sup>res</sup></i>	Subsidize no-till with restrictions	-.556*** (0.206)
<i>splitN<sup>no</sup></i>	Subsidize split N without restrictions	-0.035 (0.171)
<i>splitN<sup>res</sup></i>	Subsidize split N with restrictions	-0.251 (0.214)
<i>ASC<sup>no</sup></i>	ASQ for status-quo option without restrictions	0.379 (0.268)
<i>ASC<sup>res</sup></i>	ASQ for status-quo option with restrictions	-0.371 (0.316)

Years	Practices	Payment	Brown Farmer			Green Farmer		
			No Res	Res	Difference	No Res	Res	Difference
2	CC	\$40	22.09%	39.15%	17.07%**	34.70%	54.67%	19.97%**
2	NT	\$10	14.10%	29.52%	15.42%**	23.53%	43.97%	20.45%**
2	SN	\$9	24.60%	36.62%	12.02%*	37.94%	51.98%	14.05%*
2	CC + NT	\$50	13.26%	30.00%	16.74%***	22.27%	44.55%	22.27%***
2	CC + SN	\$49	23.31%	37.16%	13.85%**	36.28%	52.56%	16.28%**
2	NT + SN	\$19	14.96%	27.79%	12.83%**	24.80%	41.90%	17.10%**
4	CC	\$40	15.19%	28.90%	13.71%**	25.13%	43.24%	18.11%**
4	NT	\$10	9.40%	20.92%	11.53%**	16.27%	33.15%	16.88%**
4	SN	\$9	17.08%	26.74%	9.66%	27.86%	40.61%	12.76%
4	CC + NT	\$50	8.81%	21.31%	12.5%**	15.33%	33.66%	18.33%**
4	CC + SN	\$49	16.10%	27.19%	11.09%**	26.45%	41.17%	14.72%**
4	NT + SN	\$19	10.00%	19.55%	9.55%**	17.24%	31.30%	14.06%**

\*\*\* Indicates significance at 1 percent.

\*\* Indicates significance at 5 percent.

\* Indicates significance at 10 percent.

Figure: The Estimated Adoption Rate for Brown Farmers and Green Farmers



# Thank you!

---

Wendong Zhang  
wendongz@cornell.edu

<https://wendongzhang.weebly.com/>



Dyson  
Cornell  
SC Johnson College of Business