# Costs and Environmental Effects from Conservation Tillage Adoption in Iowa

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# Policy Background

- Conservation Security Act
  - What will it cost?
  - What benefits will it generate?
- Carbon Markets
  - What could agriculture supply?
  - What are the co-benefits?

# Major Model Components

- Economic Behavior: Adoption Model
- Environmental Consequences: Physical Process Models
- Simulation of Policy: Integration of Economics and Environment Measures

# Major Model Components: Economics

- What does it take for farmers to adopt conservation tillage practices?
  - Profit loss from switching
  - Reluctance (or premium) due to uncertainty

    risk aversion, value of information
- Estimate adoption based on observed behavior
  - The subsidy needed for adoption
  - Decompose subsidy into profit loss and premium

# Model of conservation tillage adoption

Traditional approach

$$\Pr[adopt] = \Pr[\pi_1 \geq \pi_0 + \sigma_\varepsilon \varepsilon] = \Pr[\pi_1 - \pi_0 \geq \sigma_\varepsilon \varepsilon]$$

$$= \Pr[\delta x \geq \sigma_\varepsilon \varepsilon]$$

$$= \Pr\left[\frac{\delta x}{\sigma_\varepsilon} \geq \varepsilon\right]$$

Our approach

$$\Pr[adopt] = \Pr[\pi_1 \geq \pi_0 + \sigma_\varepsilon \varepsilon] = \Pr[\pi_1 - \pi_0 \geq \sigma_\varepsilon \varepsilon]$$

$$= \Pr[\beta x - \pi_0 \geq \sigma_\varepsilon \varepsilon]$$

$$= \Pr\left[\frac{\beta x}{\sigma_\varepsilon} - \frac{\pi_0}{\sigma_\varepsilon} \geq \varepsilon\right]$$

# Model (continued)

$$\Pr[adopt] = \Pr[\pi_1 \geq \pi_0 + P + \sigma_\varepsilon \varepsilon]$$

$$= \Pr[\beta x \geq \pi_0 + \alpha\sigma_{profit} + \sigma_\varepsilon \varepsilon]$$

$$= \Pr\left[\frac{\beta x}{\sigma_\varepsilon} - \frac{\pi_0}{\sigma_\varepsilon} - \frac{\alpha\sigma_{profit}}{\sigma_\varepsilon} \geq \varepsilon\right]$$

# Data

- Random sub-sample (1,339 observations) of Iowa 1992 NRI data (soil and tillage) supplemented with Census of Ag. (farmer characteristics) and climate data of NCDA

- 63% of farmers already use conservation till without any subsidy

# Model Specification and Data (Continued)

$$\Pr(adopt) = \Pr\left[\frac{\beta x}{\sigma_\varepsilon} - \frac{\pi_0}{\sigma_\varepsilon} - \frac{\alpha\sigma_{profit}}{\sigma_\varepsilon} \geq \varepsilon\right]$$

- Expected profit of conservation tillage ( $x$ )
  - Depends on soil characteristics, climate, and farmer characteristics
- Expected profit of conventional tillage $(\pi_0)$
  - County level estimates for each crop based on budget estimates
- Adoption premium $(\sigma_{profit})$
  - Depends on historical (20 years) precipitation variability
  - Vary by crop, net returns, and farmer characteristics

## **Results** (standard errors in parenthesis)

- Net returns to conservation tillage

$$\pi_1 = \underset{(11)}{41} \cdot I_{corn} + \underset{(0.012)}{0.022} \cdot SLOPE + \underset{(0.31)}{0.63} \cdot PM + \underset{(29)}{73} \cdot AWC + \underset{(0.68)}{2.57} \cdot TMAX$$

$$- \underset{(0.72)}{2.48} \cdot TMIN + \underset{(69)}{76} \cdot PRECIP + \underset{(92)}{194} \cdot TENANT$$

- Premium (corn producers)

$$P_{corn} = \sigma_{precip} \{ \underset{(411)}{1400} - \underset{(0.11)}{2.79} \cdot \pi_0 - \underset{(47)}{103} \cdot OFFFARM$$

$$+ \underset{(274)}{607} \cdot TENANT - \underset{(1.8)}{5.1} \cdot AGE - \underset{(302)}{763} \cdot MALE \}$$

# Results

- Average required subsidy and decomposition for current non-adopters

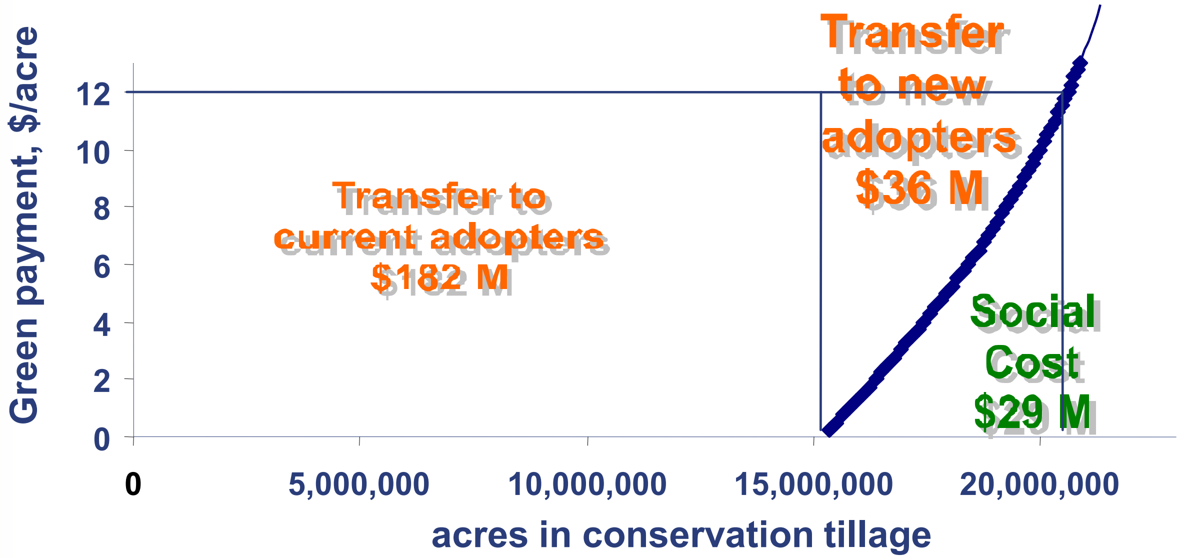
| Average/Current non-adopters | Corn ($/acre) | Soybean ($/acre) |
| --- | --- | --- |
| Profit loss | -10.6 | -34.8 |
| Premium | 13.1 | 38.4 |
| Subsidy | 2.5 | 3.6 |

# Conservation Tillage "Supply Curve"

Total Subsidy to Achieve 90% Adoption

= $247 M

= $29 M + $36 M + $182 M



## Model Components: Environmental Measures

- Environmental process models: EPIC CENTURY and SWAT (coming soon!)
  - Carbon sequestration
  - Nitrogen runoff
  - Soil erosion
  - Nitrogen leaching
  - Pesticides

## Model Components: Policy Simulations

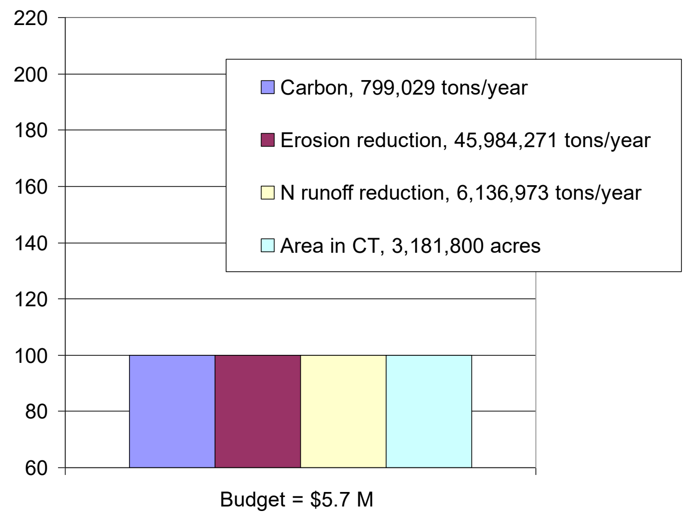
- Data: 13,000 NRI points located in Iowa
- Policies Considered:
  - Practice Based
  - Performance Based (Environmental Targeting)

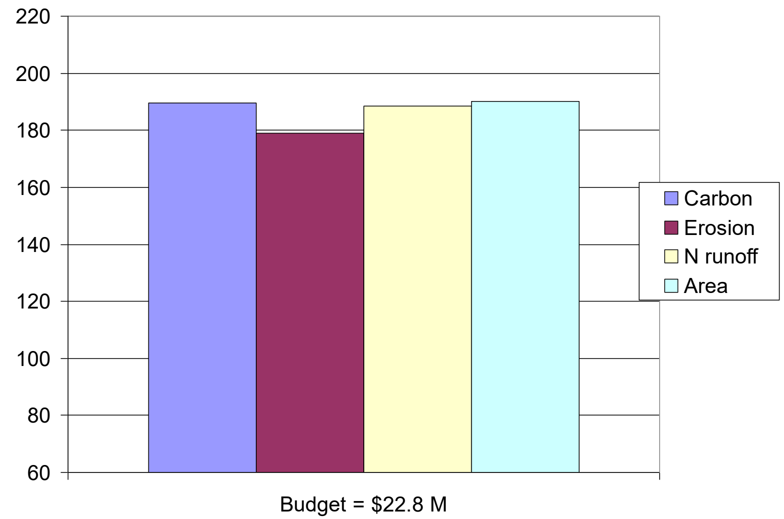
# Practice (Conservation Tillage) versus Performance (e.g. Carbon) targeting

- **Target conservation tillage:** rank producers by adoption subsidy ($/acre) from low to high, offer payments to those at the top of the list until the budget is exhausted
- **Target carbon:** rank producers by the cost to carbon production ratio ($/tons) from low to high, offer payments to those at the top of the list until the budget is exhausted

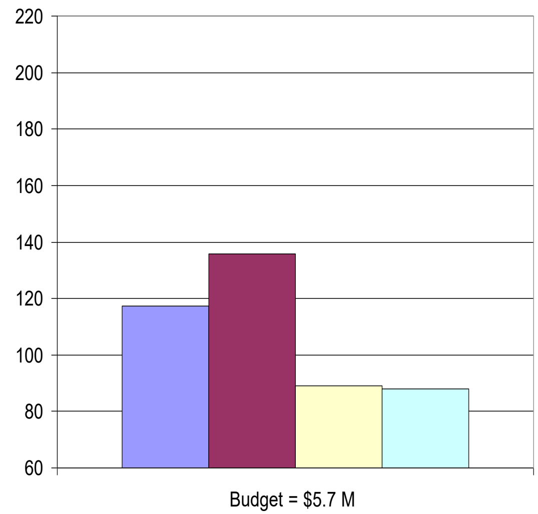
# Alternative targeting with alternative budgets

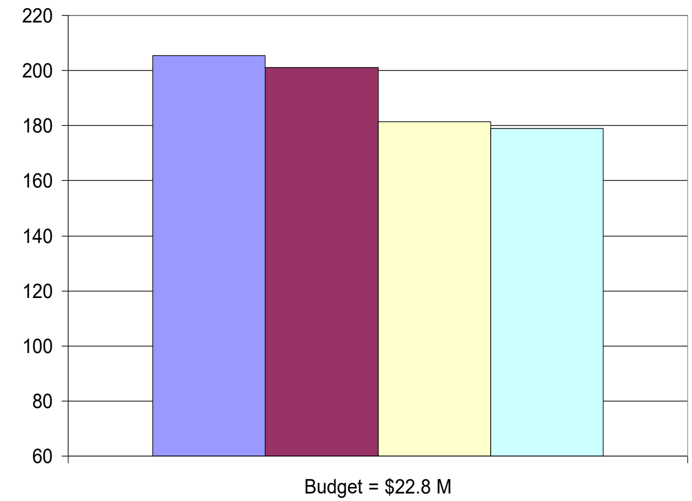
**target cons. tillage**



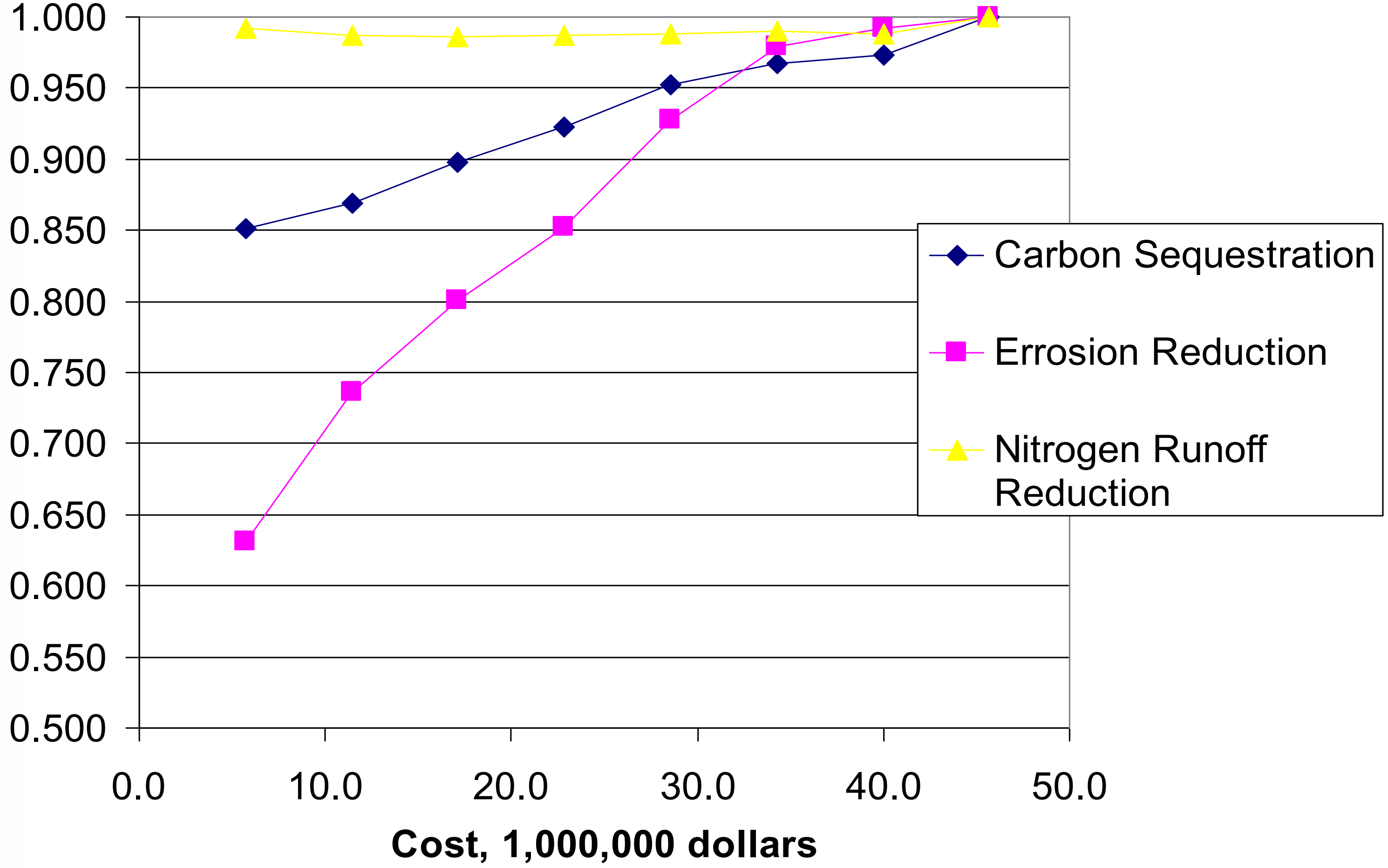




**target carbon**

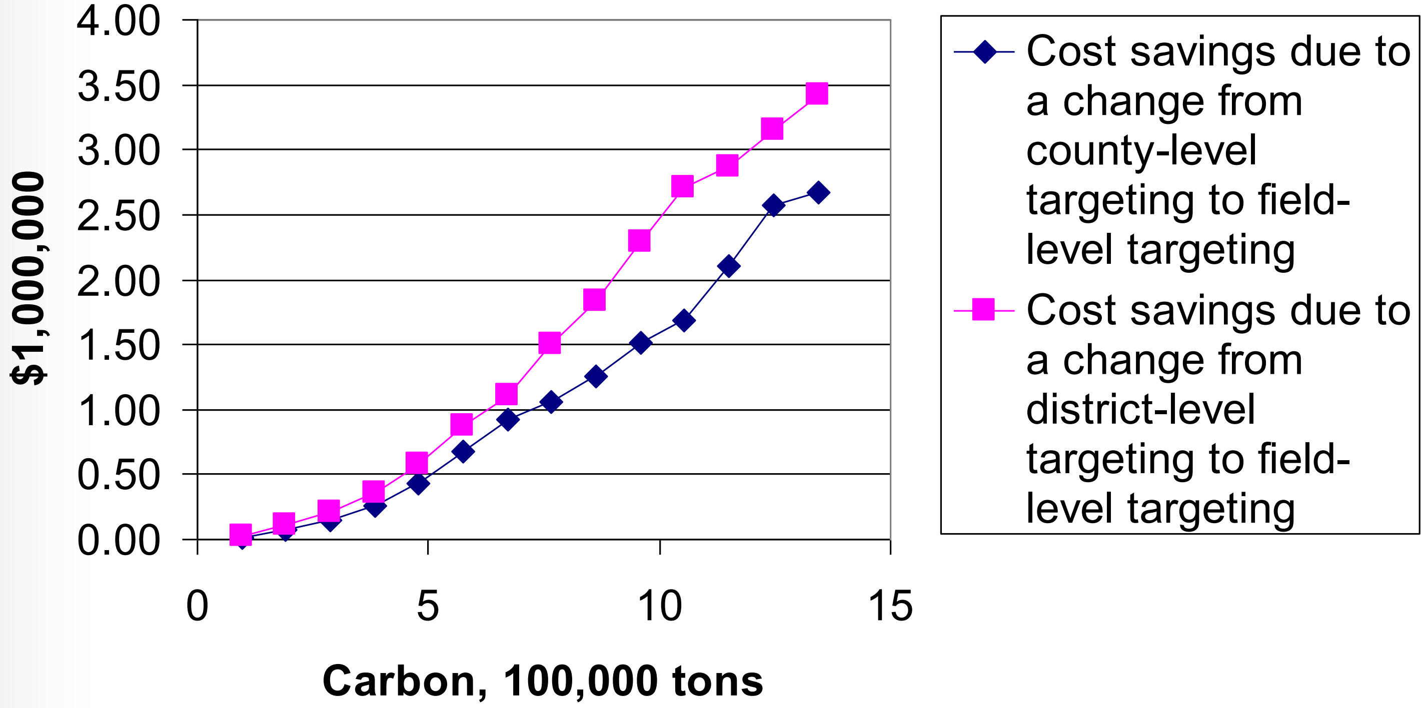


# Fraction of maximum possible benefits obtainable under conservation tillage targeting



# Gains from better carbon targeting technology



# What's Next?

1. Better environmental runs:

- EPIC on each point
- SWAT – instream water quality
- CENTURY

Cost assessment of water quality standards

# What's Next?

2. Apply model to CRP (NRI data again)

- Data on bids available (1993)
- Now, alternative is NOT stochastic
- Test for which effect dominates: risk aversion or real options

# What's Next?

3. Combined modeling

- 3 Choices: CRP, Conv till, Cons till
- Nested Logit Structure?

# What's Next?

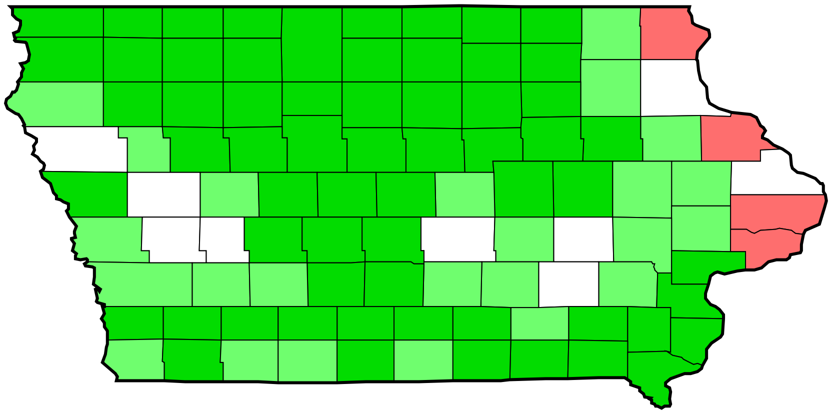
4. Policy Assessments

- 1992 limitation
- What is the affect of substitutability between programs?
- What prices would  provide the most environmental quality?

- Consider multiple land uses (multinomial logit)
  - CRP (NRI data)
  - Multiple tillage levels
  - Buffer strips, wildlife breaks, etc
- More complex modeling structures

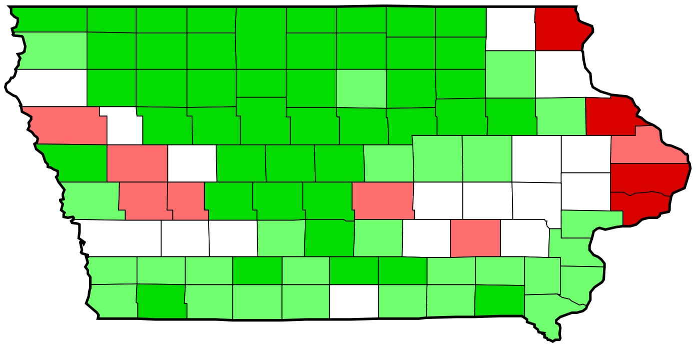
# How many conservation services can Iowa provide?

Green payments of $10.4/ac



# How many conservation services can Iowa provide?

Green payments of $3.25/ac



# How many conservation services can Iowa provide?

Currently

Soil loss due to erosion, tons/ac/year