Farmers as Producers of Clean Water: Providing Economic Incentives for Reducing Agricultural Non-Point Source Pollution

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Authors

- Alan Collins, Associate Professor, Agricultural and Resource Economics West Virginia University
- Peter Maille, PhD student in Natural Resource Economics

  West Virginia University

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Outline

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- Objectives
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  - Payment formula
  - Institutional framework
  - Simulation
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The Problem in General

1. **Current approaches to water quality are more expensive than they need to be**

   Non point source pollution problems have persisted despite billions of dollars spent on conservation cost-share programs by the federal government over the last 20 years (See US GAO, 1992 and US GAO, 2005). Cost-share programs are not least-cost strategies for pollution abatement.

2. **Water quality protection can raise equity concerns**

   Should rural areas with historically lower per capita incomes be expected to provide clean surface water supplies for higher income urban areas?

Unresolved Issues

3. **Who owns the property right to clean water?**

4. **Are farmers' land management goals properly aligned with water quality concerns of society?**

So we ask

Can economic incentives provided by performance-based payments motivate farmers to address water quality problems and make conservation efforts ultimately more successful for both farmers and society as a whole?

Objectives

For non-point source pollution at the watershed level:

1) **Derive and assess the incentives created by water quality and quantity based payment formula.**
2) **Assess changes in farmer attitudes and behavior towards water quality protection in response to a performance-based payment program.**
3) **Compare water quality changes under this program to water quality changes in other watersheds.**
4) **Compare cost effectiveness of this program to that of traditional cost-share programs.**

What is needed to accomplish these objectives?

- A theoretical model of farmer behavior
- A payment formula to create incentives for conservation
- An institutional framework from which to make payments and provide appropriate incentives
- Simulation of the payment formula for budgetary information

Preliminary Theoretical Model

$$\underset{K_{w,t}}{Max}\, EU = \int_0^{\infty} U(y \mid z) f(y) dy \quad \text{where:}$$

$$y = [AG((K_T - K_W - K_{OF}), e_{AG})] + [D \times (POR_i \times WQP(\sum_{i=1}^{n} K_w^{i \neq j} + K_j(E(\sum_{i=1}^{n} K_w^{i \neq j})), e_{WQP})] + [OFI(K_{OF})]$$

y is income

z is a vector of socio - demographic variables

AG is net returns to traditional agriculture

WQP is the water quality payment

D is a dummy variable that takes the value of 1 for participation and 0 otherwise

POR is the portion of the watershed payment allocated to landowner i

OFI is off - farm income

K_T is total productive resources defined as land, labor, and existing machinery

K_{AG} is productive resources devoted to traditional agriculture

K_W is productive resources devoted to water quality management

K_{OF} is productive resources devoted to off - farm income

e_{AG} is the outcome of $f(\bullet)$ for income from traditional agriculture

e_{WQP} is the outcome of $f(\bullet)$ for income from water quality

Requirements of a Payment Formula

- Provide an incentive to participate and pursue desired behaviors.
- Deal sensibly with environmental conditions.
- Transmit budget information to landowners and the Project Investigators.
- Be seen as fair and likely to enhance participant well-being.
- Simulate interest among participants in non-point pollution issues.

Payment Formula

Need a per-unit price

- Price was based on the lowest price that would induce BMP installation by farmers.

Need a unit quantity

- We choose volume as measured in acre-feet per month (1.23×10^6 liters).

Need to measure quality

- The quality measure needs to make payment an increasing function of improved water quality,
- Must deal with uncontrollable weather-related fluctuations in a fair and intuitive manner.

(Volume Water) x ($ per unit volume) x (quality-based adjustment)

Using the Payment Formula:

(Volume Water) x ($ per unit volume) x (quality-based adjustment)

we took these steps…

Step 1: Estimate prices for water

- Developed a GAMS program in which assumed net revenue maximizing farmers who faced a land tradeoff between agricultural production and higher watershed payments from water quality protection.
- Solved model for BMP-inducing prices as a function of rainfall and season.

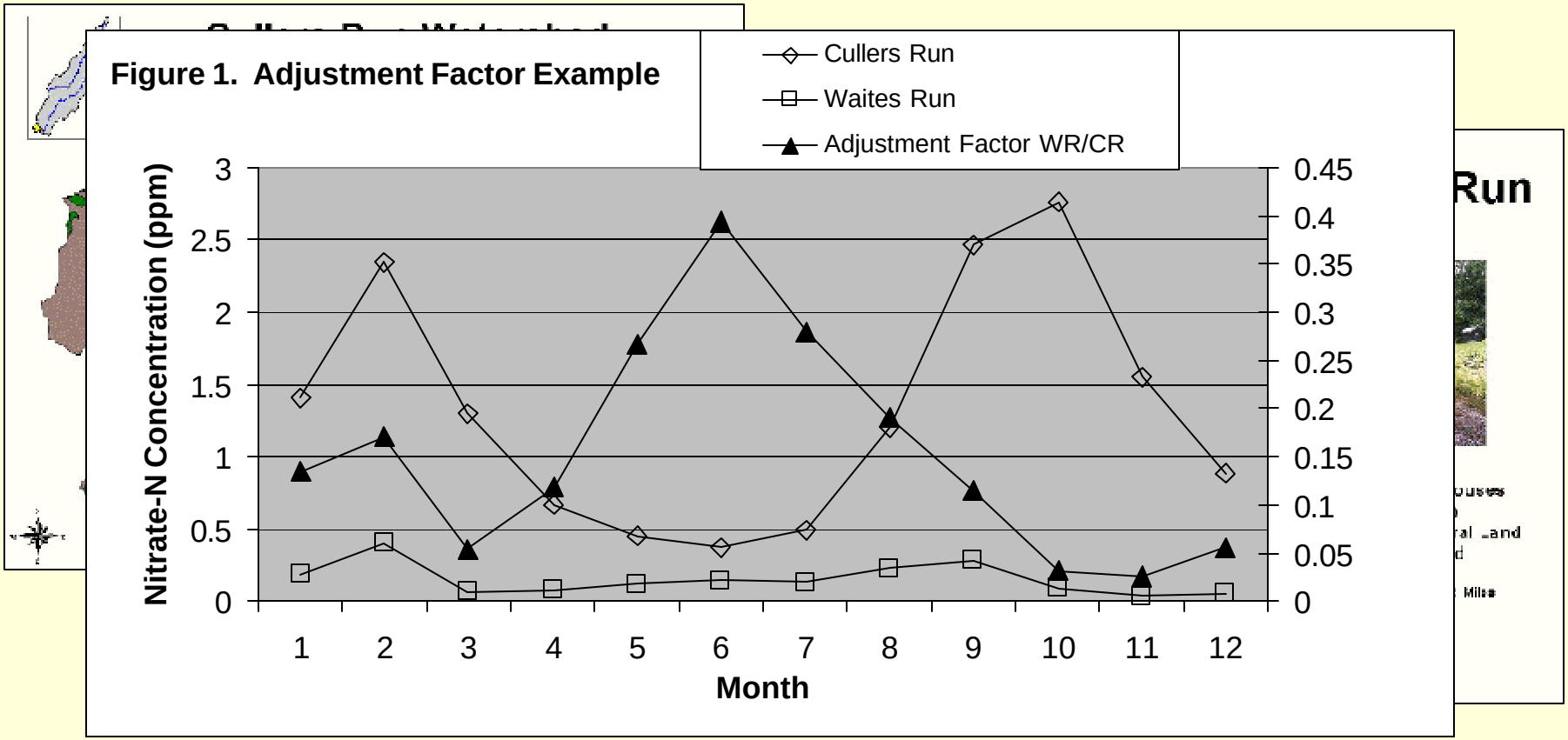
Step 2: Developed a quality adjustment

- Used an index watershed approach and Nitrate-N as a quality indicator.

Step 3: Test the payment formula

- Simulated monthly payments using field data and evaluated the results.

Quality Adjustment via an "Index Watershed" Approach



Our assumption is that using the index watershed approach provides the desired incentive in a way that is "fair."

Water Prices and Payments

We substituted the computed prices back into

(Volume Water) x ($ per unit volume) x (quality-based adjustment),

and used actual flow and nitrate-N concentration data from Waites Run and Cullers Run, to get…

Table 1. Price and Payment Summary Information					
Rainfall	**Price per Acre-Foot**		**Monthly Payments Growing Season**		**$ per kg. of N removed**
	Summer	**Winter**	**With BMPs**	**Without BMPs**	
Low	**$18**	**$8**	**$2,552**	**$678**	**$11**
Medium	**$8**	**$5**	**$2,584**	**$636**	**$9**
High	**$5**	**$5**	**$2,837**	**$638**	**$8**

Institutional Framework

- Determine who can participate within Cullers Run watershed.
- Payments will be made to participating farmers a monthly basis for the entire watershed measured by nitrate-N quality changes and quantity of water flowing from their watershed over two, one year periods.
- Farmer participants decide on sharing rules for watershed payments among themselves.
- Farmers select their own best management practices management to impact water quality.
- A unilateral contract defines roles and responsibilities, and lays out guidelines.
- The project provides facilitator and water quality experts.

Simulated Payment Levels

- Payments were estimated under current conditions, i.e. without best management practices
- Payments were estimated under implementation of best management practices on all agricultural land in Cullers Run watershed
- Best management practices are assumed to be 75% effective in removing nitrate-N.
- We simulated payments using rainfall amounts from 1998 to 2001. The average annual payment amount over 12 months without best management practices is $8,318. With best management practices, the average is $23,051.

Payment Simulations

The average annual payment amount over 12 months “without” best management practices is $8,318. “With” best management practices, the average is $23,051.

Rainfall Year	Annual Totals “without”	Annual Totals “with”
1998	$10,861	$29,966
1999	$10,208	$26,711
2000	$7,165	$21,350
2001	$5,041	$14,179

Current Progress

- Water quality data has been collected for the past four months.
- The local community and state agency personnel have been kept informed of the project.
- A list of agricultural landowners and renters in the watershed has been developed and invitations have been sent to attend an initial informational meeting (scheduled for February 5th).

Proposed Next Steps

Beginning in 2007 and continuing for 2 years:

Data Collection

- **Surveys and periodic farm visits** to document actions taken and attitudes
- **Weather/Water Quality Monitoring**
- **Payment Levels**

Data Analysis

- **Logit/Probit regression** of two-period panel data from household surveys, incorporating weather/payment/water quality monitoring information.
- **OLS regression** of water quality data.
- **Cost/Benefit Analysis** of conservation result.

Questions or comments?

Contact information:
alan.collins@mail.wvu.edu

304-293-4832 x4473

http://www.cacaponinstitute.org/wvunri.htm

"You have to know how to work the machine."

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