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Combining Supply and Demand Estimates for Ecosystem Services from Cropland

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Introduction

- Agricultural ecosystems are mainly managed to produce market goods, such as food, fiber and fuel. By the choice of production inputs and management practices, farmers can also supply important non-market *ecosystem services (ES)* that benefit the public (e.g., carbon sequestration and water quality).
- Payment-for-Ecosystem-Services (PES) programs can help to induce voluntary ES provision. Effective PES program design calls for a understanding of the underlying ES supply and demand.
- This study combines farmer supply of ecosystem services from low-input cropping systems with public demand for resulting environmental improvements by addressing:
  - **[Supply]** How much payment are farmers willing to accept to supply ES by adopting low-input land management practices?
  - **[Demand]** How much are residents willing to pay for better environmental quality?
  - **[Supply & Demand]** Does the willingness to pay match the required payment by service providers? Could one design a system of payment for ecosystem services from agriculture?
- Supply and demand relationships are estimated by contingent valuation. Individual values are aggregated for the State of Michigan by linking ecological processes to marginal benefit and cost functions.

Supply Analysis

- A mail survey was conducted in 2008 with 3000 randomly selected Michigan corn and soybean farmers (56% response).
- Each respondent was presented with four hypothetical cropping systems that provide sequentially increased levels of ecosystem services, management complexity, and payment.

Systems	A	B	C	D
Cover Crops	None	Any type over winter		
Rotation	Corn-Soybean		Corn-Soybean-Wheat	
Fertilization	Broadcast at full MSU rate; Split N based on PSNT			Band apply at reduced rate
Tillage	Chisel plow with cultivation as needed			
Soil Test	Pre-sidedress Nitrate Test (PSNT)			

- In each system, farmers were asked: "*how many acres of land would you enroll if a governmental or NGO program paid you $(X) per acre each year for 5 years ?*"
- A double hurdle econometric model is used to estimate farmers' enrollment decisions and to derive the state-level supply function.
- Results show that many farmers would adopt these ES-providing practices if paid. Their decisions depend on various farm and household characteristics, as well as the payment levels.

Demand Analysis

- A mail survey was conducted in 2009 with 6000 randomly selected Michigan residents (41% response rate).
- Each respondent was presented with three hypothetical government programs providing different levels of greenhouse gas (GHG) and eutrophic lake reductions for different income tax payment (illustrated below). Residents were asked whether to vote for each program given the payment.

	Now	Program is going to	After
Number of **Lakes** with excess nutrients	3,400	Reduce by **70 (2%)**	3,330
Greenhouse gas reduction needed to slow global warming	Need 30% reduction	Reduce by **0.6%**	Need 29.4% reduction
Your share of **costs** for the program	$ 0 per year in increased income tax	Increase by **$10**	$10 per year in increased income tax

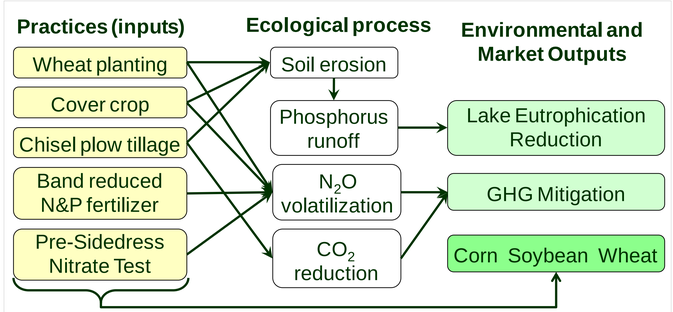
- Residents' willingness to pay is assumed to be a function of improvement in lakes, GHG, their quadratic terms, as well as other household characteristics. Random effect probit is used to estimate their willingness to pay and to derive the demand function.
- Results show that reducing global warming and eutrophic lake were of value to residents. The value of GHG mitigation depended on prior concern about global warming.

Aggregate Supply & Demand

1. Calculate real additional changes in farming practices

Insuring the additionality of ES supply is important to PES design. Real change for each practice is the acreage enrolled minus acreage where it was previously adopted.

2. Translate real changes in practices to quantitative improvements in clean lakes and reduced GHG emissions



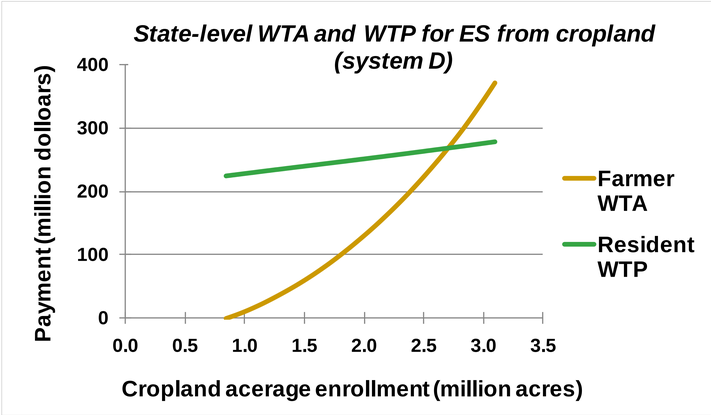
Aggregate Supply & Demand (cont.)

3. Match benefit and cost estimates for a feasible payment range to facilitate state-wide ES provision

As the per-acre payment to farmers gradually rises from $0 to $120, the increases in land enrollment and ecosystem service levels can be traced, and then used to derive the cost and benefit functions.

The cost function represents farmers' willingness to accept payment (WTA) for land enrolled in PES programs;

The benefit function represents residents' willingness to pay (WTP) for resulting environmental improvements from cropland stewardship.



4. Conclusion—benefit outweighs cost in a large payment range

For each cropping system, preliminary results reveal a wide potential payment range in which public benefit from ecosystem services exceeds farmers' cost to provide them from cropland. The payment ranges appear to cover payment levels offered in current farm PES programs. These findings suggest potential public support to transition U.S. farm programs from income support to a PES basis.

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