Economic Perspectives on Watershed Level Assessment of Conservation Practices

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Background

- Evaluate management of phosphorous in farm runoff at watershed level
- NYC watershed
- Current approach:
  - Offering of infrastructure BMPs
  - Offering of change in practice BMPs

Areas of opportunity for improved assessment ~ Farm-level

Focus on whole farm

- Allow for interaction across conservation practices
- Allow for interaction across cons practices & production prog.

- Ensure that production program (inputs, outputs, environmental effort) is consistent with economic setting
  - Current input and output prices
  - Recent performance (past seasons)
- Ensure that farm performance allows for
  - Substantial heterogeneity across farms
  - Technical inefficiency

Areas of opportunity for improved assessment ~ Watershed level

- Evaluate current approaches to allocation of conservation practices to operators
  - Cost-share rates
  - Maintenance rental rates & incentives
  - Evaluate potential for coordinated placement of conservation practices
- Evaluate current approach of uniform payment rates for practices

Economics project approach

- Develop farm level model of environmental effects determined by
  - Producer choices of production programs
    (inputs, outputs, environmental effort)
  - Producer choices to implement and maintain EBAPs and BMPs
- Develop watershed level approach to “design” performance-based incentives to induce farms to contribute to improved watershed performance.

Motivation

Two levels of consideration

- Farm-level
- Watershed level

Farm-level

Salient features of farm-level ag-environmental interface

- Farm production occurs through a highly adaptive process of farm operator response to economic conditions
- Economic conditions vary substantially intra- & interseasonally
- Farm characteristics vary substantially across
  - Site specific land and climate characteristics
  - Farm locations within watershed
  - Environmental contributions of farm activities
- Environmental effects can be managed by changing economic decisions

Biophysical processes and farm production are joint

Farm production and envir/biophys processes are joint

$$g(y, e, x, z \mid \theta, \varphi) = 0 \quad \rightarrow \quad y, e$$

y	*private good outputs*	x	*private good inputs*
z	*env effort*	θ	*flows from farm assets (equip, bldg)*
e	*environmental impacts*		
φ	*environmental practices & infrastructure*		

Farm site variation affects environmental impacts

- Efficiency of cons practices varies across farms

- Management response to economic conditions affects efficacy of cons practices
  - Production program changes
  - Crop choice, animal enterprise decisions
  - Technical inefficiency

Economic decisions affect environmental impacts

Farm operators respond to their economic environment (incentives)

- Changing acreage allocation
- Changing inputs applied
- Changing practices

$P, R \rightarrow \quad max\ \pi = P'y - R'x \quad s.t.$

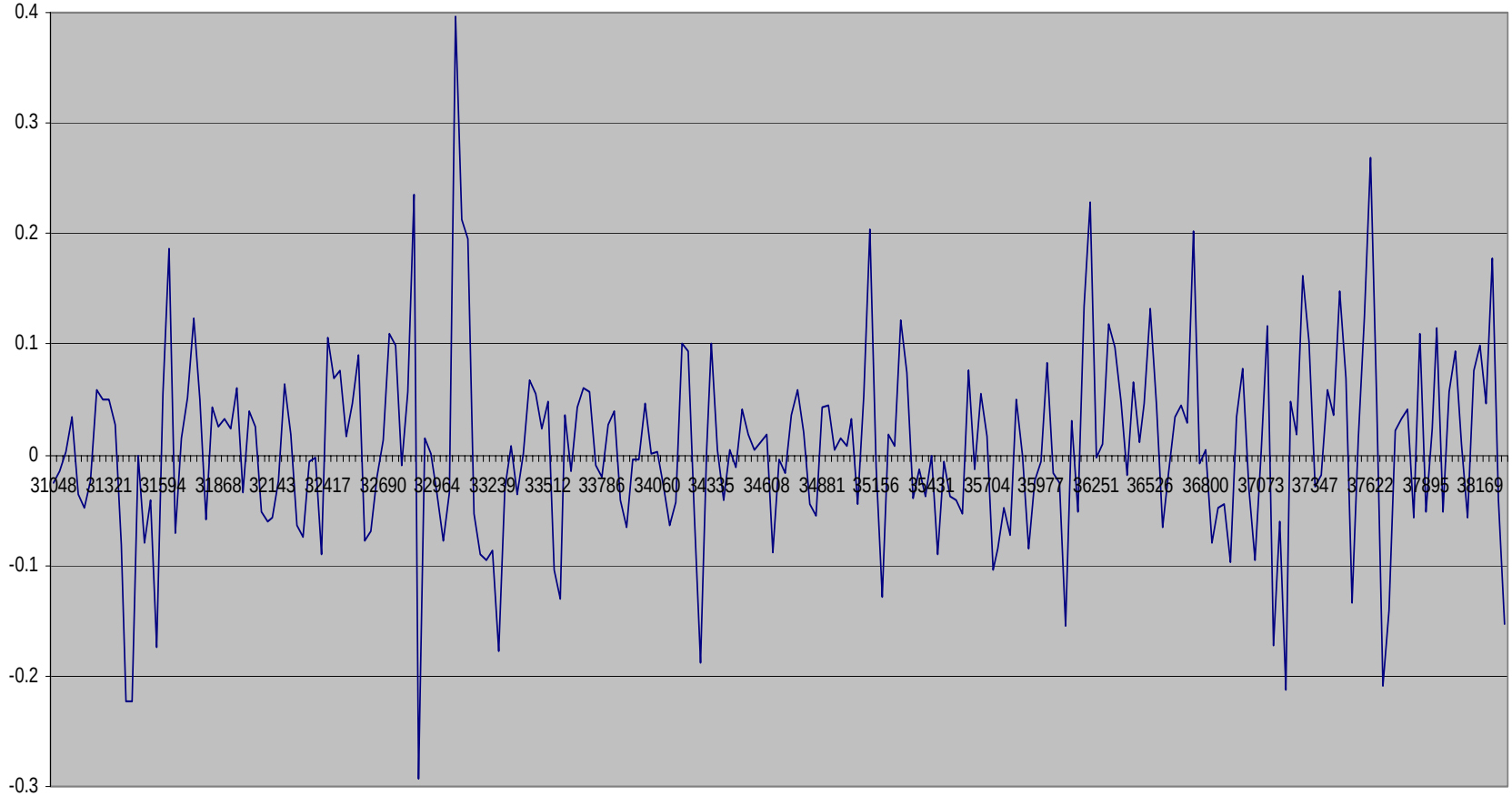
$g(y, e, x, z|\ \theta, \varphi) = 0$

$a'\imath \leq A \qquad \rightarrow y^*, x^*, z^*, e^*$

Economic conditions affect environmental performance

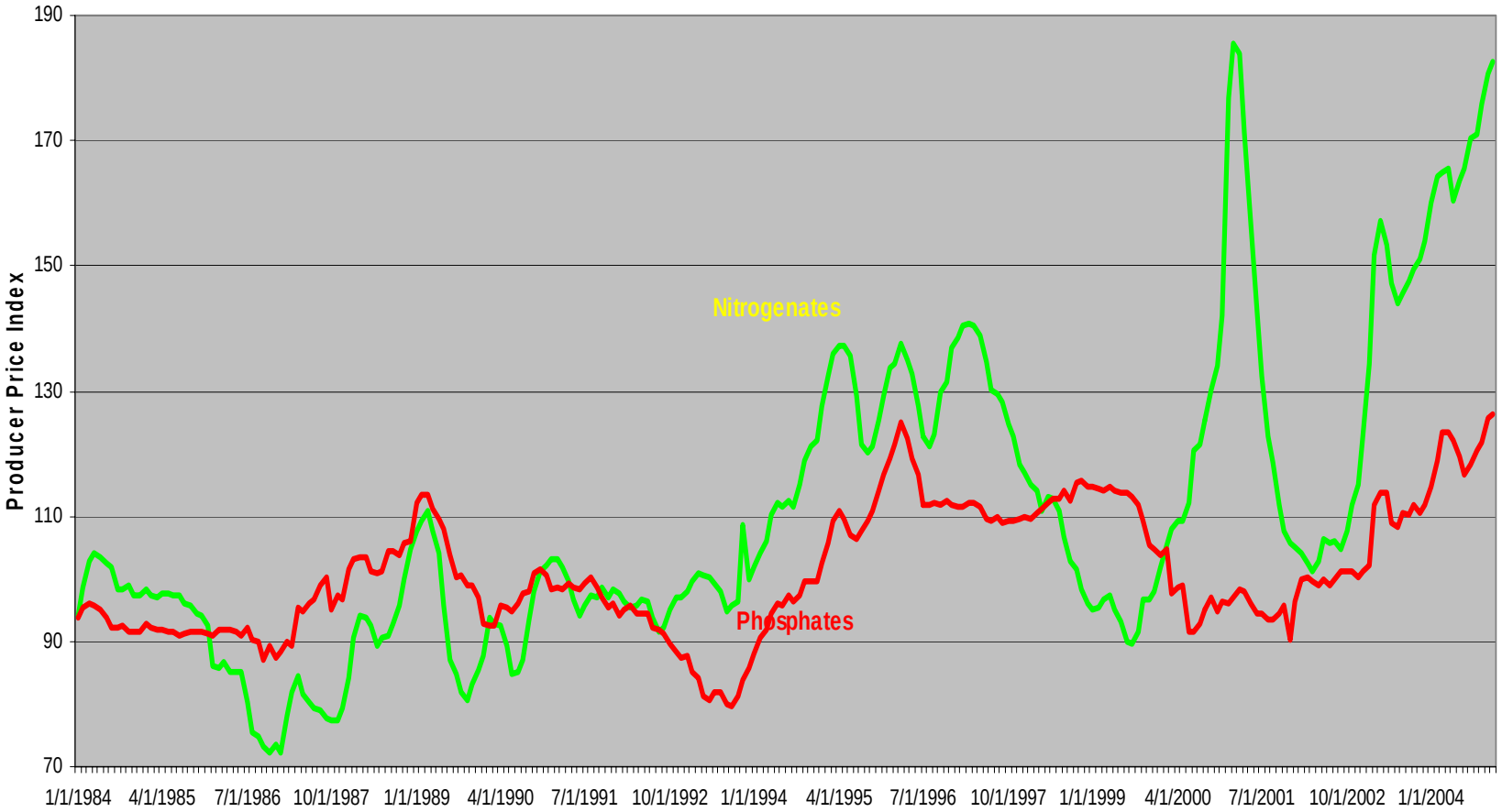
- Price changes are a fact of life
- Management response to them determines profitability
- Management response determines environmental impacts

% Change in Monthly No. 2 Diesel Prices
1985-2004



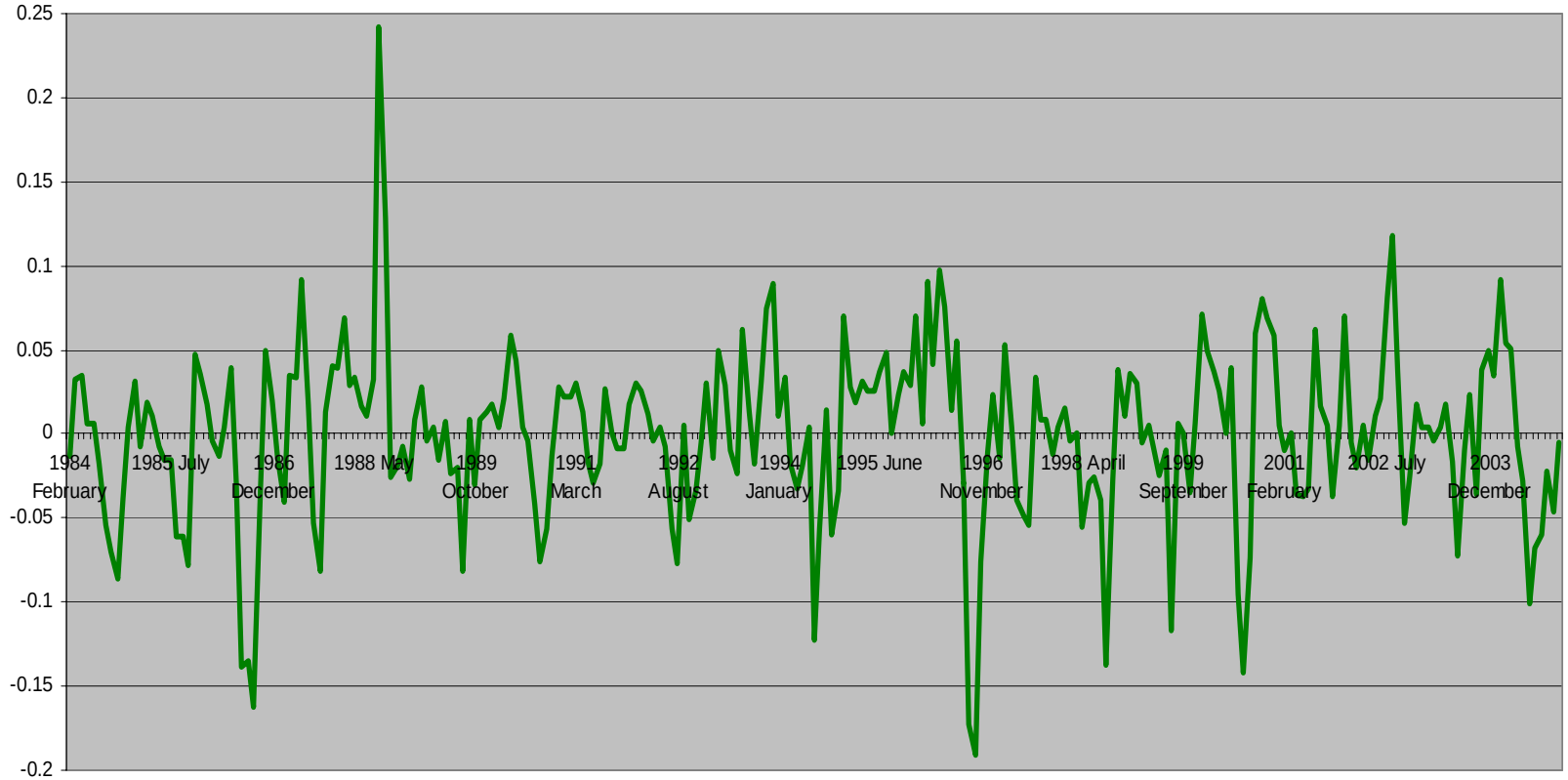
Source:http://data.bls.gov/cgi-bin/dsrv

Monthly Nitrogenate & Phosphate Prices
1984-2004



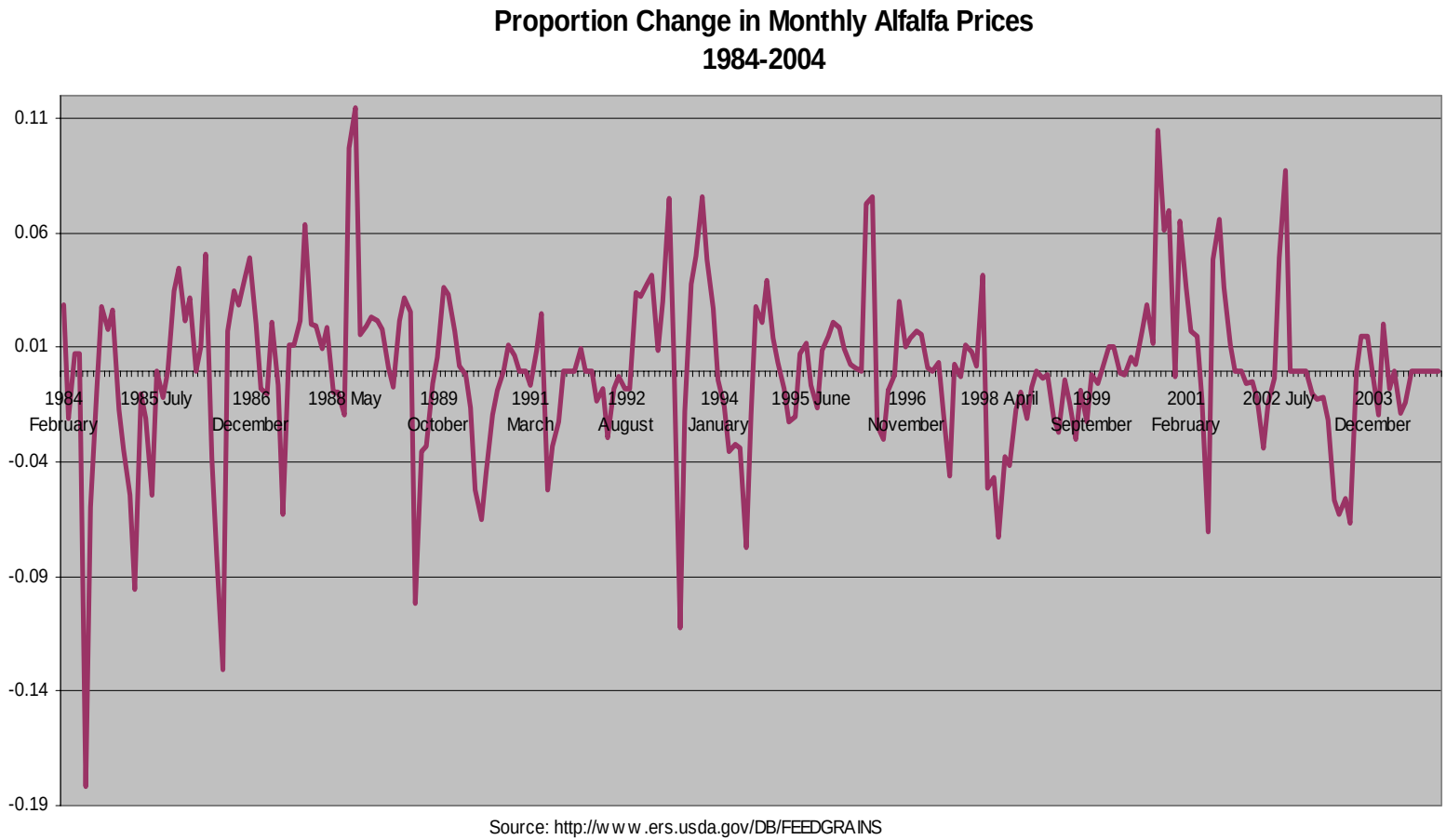
Source: http://data.bls.gov/cgi-bin/dsrv#list

Proportion Change in Monthly Corn Prices Received by Farmers 1984-2004



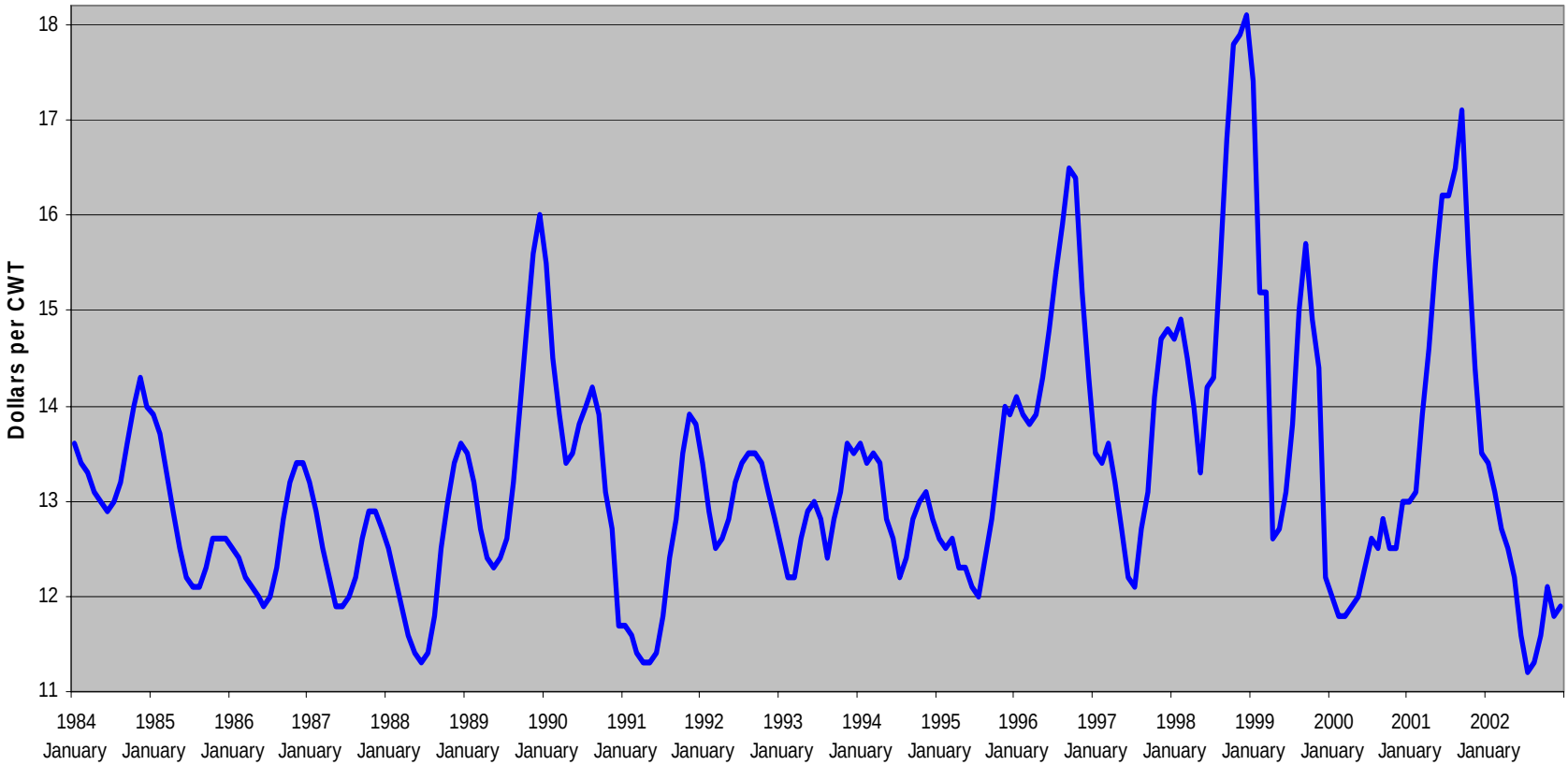
Source: http://www.ers.usda.gov/DB/FEEDGRAINS

Alfalfa prices vary substantially ~ regionally more so than nationally



Source: http://www.ers.usda.gov/DB/FEEDGRAINS

Monthly Milk Prices Received by Farmers
1984-2002



Source: NASS, "Agricultural Prices."

Farm characteristics variation ➔ variation in efficiency of cons practices

P, R ➔ $\max \pi_i = P'y_i - R'x_i \quad s.t.$

$$g(y_i, e_i, x_i, z_i \mid \theta_i, \varphi_i) = 0$$
$$a_i'\iota \leq A_i$$

➔ $y_i^*, x_i^*, z_i^*, e_i^*$

➔ $e_i^* = e(P, R \mid \theta_i, \varphi_i, A_i)$

Implications for farm-level

Environmental impacts can be managed through

- Infrastructure & practices (BMPs) φ_i
- Incentives that affect economic decisions
  - Environmental effort
  - Choice of inputs to apply, acreage, outputs
- Information that educates operators w.r. production process

Implications for approach:

Effects of policy approaches will be dependent on farm operator decisions and economic conditions

Efficacy of farm-level policy

$$e_i^* = e(P, R|\ \theta_i, \varphi_i, A_i)$$

1) Evaluation should consider policy approach to "picking" which farms will be treated with policy (how cons practices will be allocated to farms)

2) Evaluation should consider policy approach to setting farm incentives to implement and maintain cons practices

Watershed level assessment

Salient features of watershed problem

Policy affects private enterprises

- Heterogeneity across farms

  Implies uniform policy will be inefficient

  We want to "treat" only those farms that will be most efficient in attaining env goals

- Private interests
  - Farm manager is looking for profits and will adapt as economic environment changes
  - Policy must encourage operator to pursue policy goals

Salient features of watershed problem

- Asymmetry in information

  Farm manager will always have more information about potential to manage environmental effect than a regulator
- Heterogeneity across farms implies differential efforts will result
- Nature of incentives will affect extent to which enterprises contribute to policy objectives.

Implications for Approach

- Need to assess policy approach of uniform incentives

  Are current policy approaches striking a reasonable balance?

  Heterogeneity implies that fixes applied uniformly across problem setting will be inefficient

- Management and operator decisions will affect efficacy

  ➔ Do policy incentives induce decisions that are compatible with policy goals ?

- Do policy incentives make it rational for manager to participate?

Current knowledge

State-of-knowledge

- Production plans and implementation depend on
  - Expected and actual market conditions: prices, availability…
  - Available technology
  - Restricted resources: labor, machinery, infrastructure
  - Expected and actual climate

- Use of environmentally beneficial ag practices depends on
  - Same as above though over longer planning horizon
  - Managerial capacity to learn new practices
  - Managerial interest in environment?

- Technical efficiency of use inputs that affect environmental impacts
  - Nitrogen
  - Phosphorous
  - Potassium

Approach

Approach

- Build economic behavioral model for whole farm ➔ front-end for whole biophysical model
  - Link prices and farm characteristics to economic decisions
  - Forecast and track prices
- Build watershed level model capacity to design watershed incentives to encourage
  - Environmental action by producers who are most efficient in contributing to watershed goals
- Evaluate current policy approach vs. alternative incentive based approaches that focus on watershed performance

Illustration

Why economic behavioral modeling matters

- Incentives and other features of economic environment change substantially
- The key determinant of profitability is reaction to changes in economic environment, adjustment of production plans and practices.

- Production program changes
- Implementation of EBAPs and BMPs changes

Implications

- Estimation of environmental impacts must be conditioned on choices
  - Acreage
  - Inputs applied
  - Output levels
  - Production practices
- Choices used to estimate environmental effects must reflect current prices, farm characteristics

An illustration

Table 1. Changes in choice due to 2% increase in corn price

	Initial choice	Initial Corn Price	% chg Price	Elasticity	New Choice
	Townbrook Dat	($/ton DM)	($/ton DM)	% ch. in choice	% ch. in corn	sticity * % Chang
Inputs	**P-Farm**				
corn acreage	79.10000	108.86	2%	1.8	81.95
Pre N applied	40.15000	108.86	2%	1.5	41.35
Phosphate applie	19.63000	108.86	2%	1.5	20.22
Potash applied	40.15000	108.86	2%	1.5	41.35
Post Plant N	53.53000	108.86	2%	1.5	55.14
Reduced acreag	98.80000				95.95

Substantial changes in acreage can occur

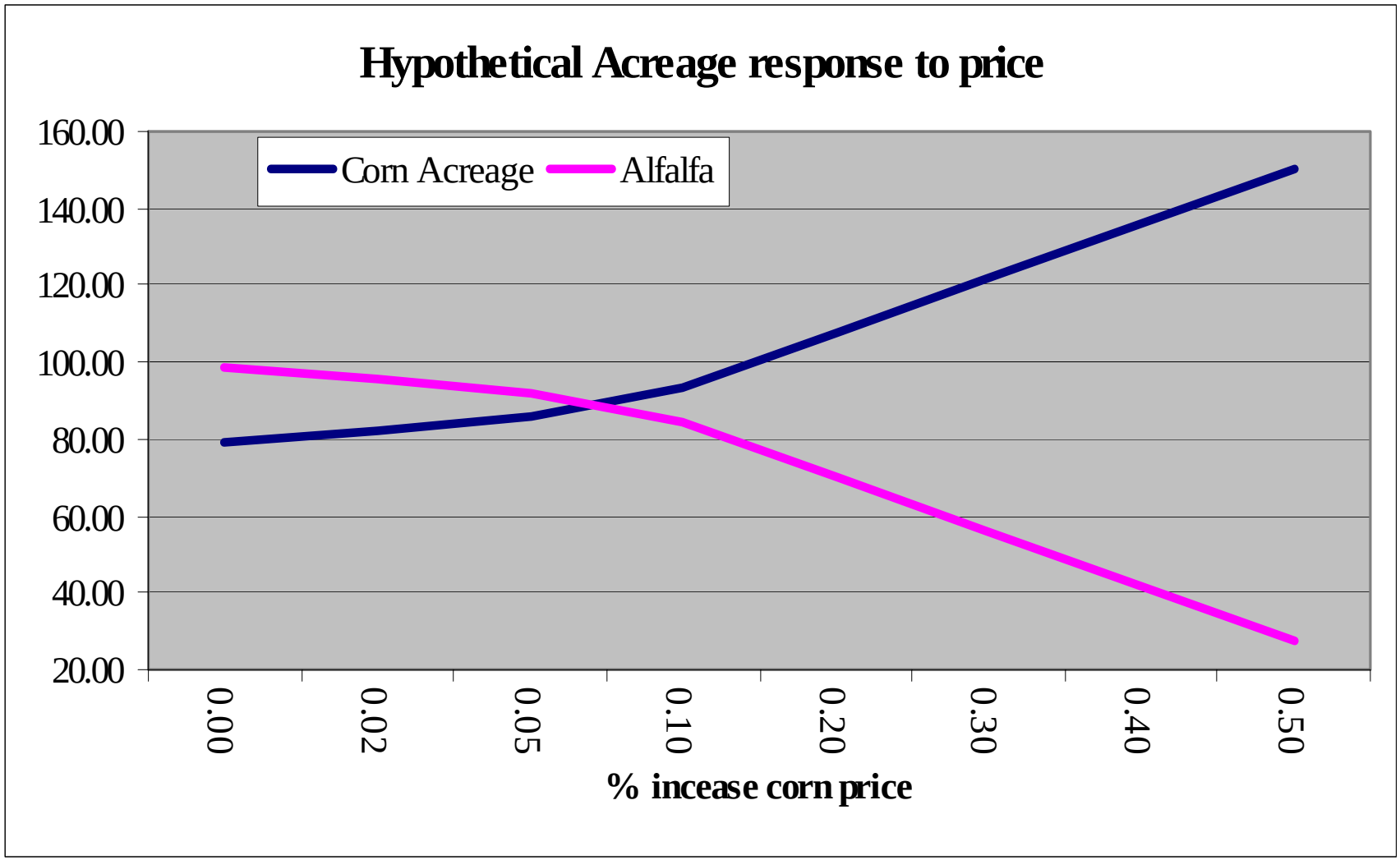


Chart 2. % Change N, P, & K Applied

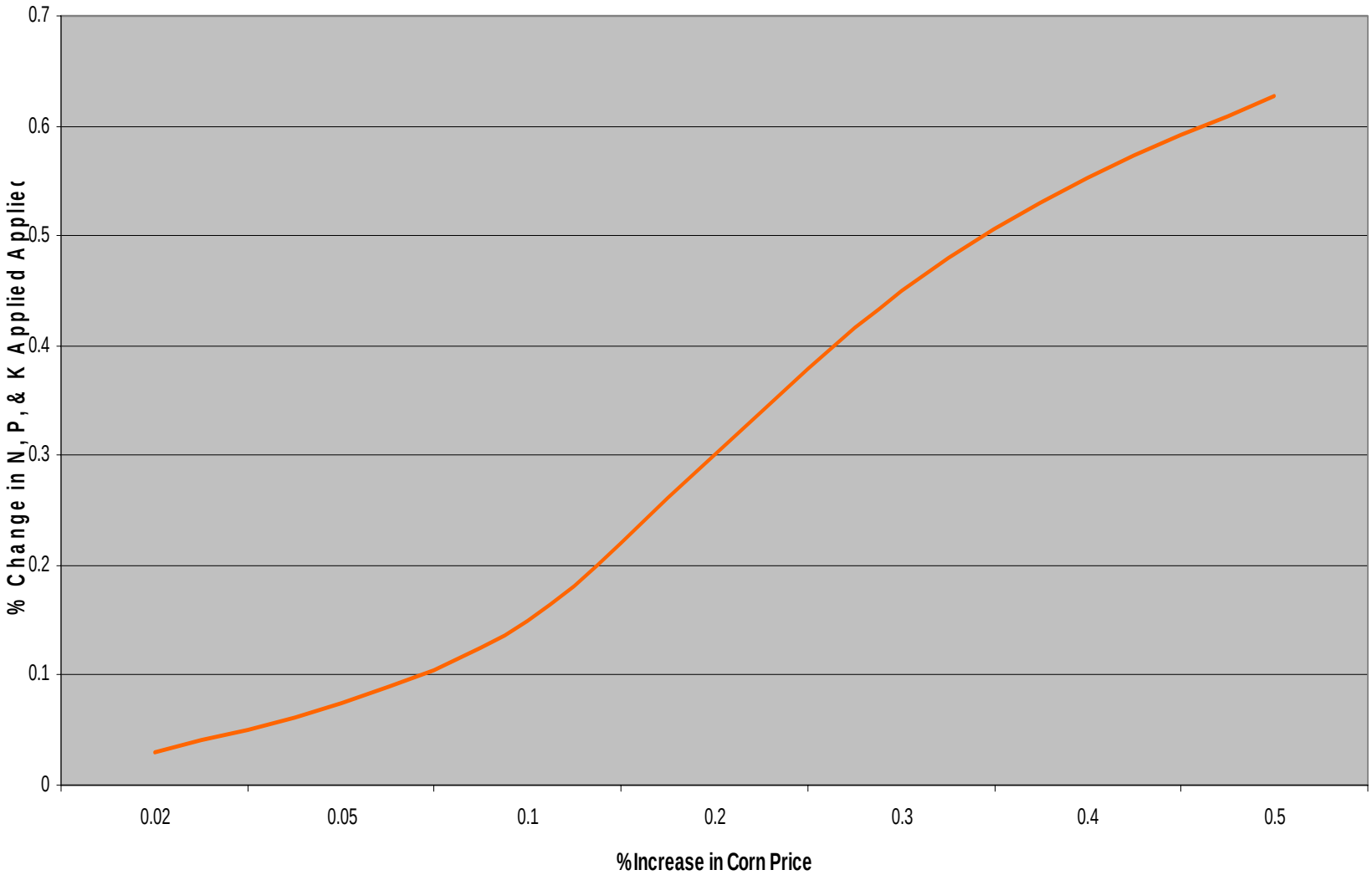
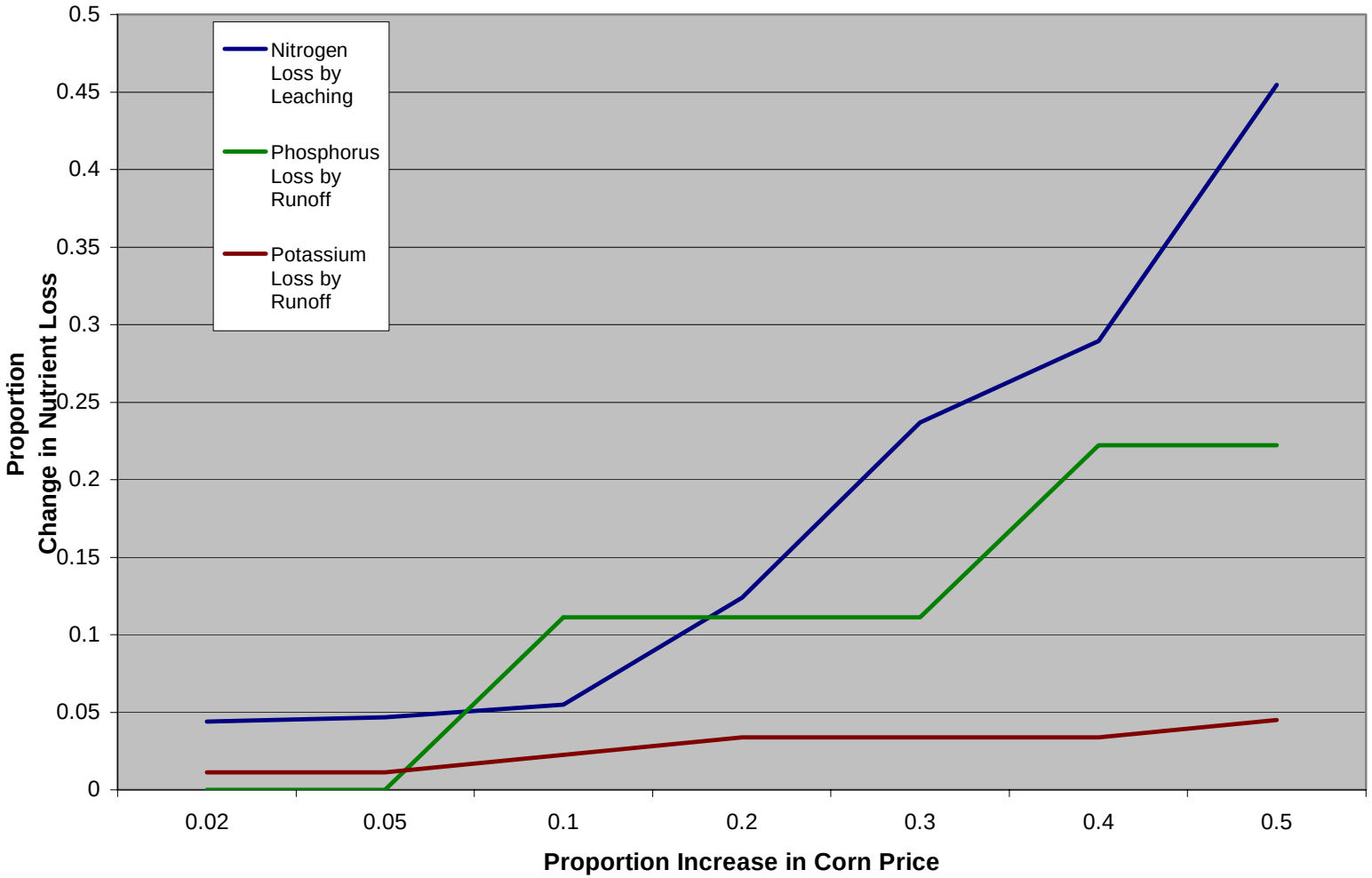


Chart 3. Proportion Change in Nutrient Loss Due to Proportion Change in Corn Price



Whole farm modeling

- Production program *(y,x,z)*
- Implementation of EBAPs and BMPs

Whole farm model - Alternatives

- Representative farm math programming model
  - Describe technology
    - Linear approximation (as in LP models)
    - Using nonparametric methods
  - Assume behavioral objectives
    - Profit max under certainty
    - Expected utility max under uncertain prices and climate
    - Multi-period
- Econometric
  - Cross-section or panel data
  - Subsamples to describe geophysical areas and farm types

Critique

- Mathematical programming models
  - Notoriously poor predictive performance
  - Tend to find specialization solutions
  - Require substantial simplification of processes
  - Allow for discrete choices
- Econometric models
  - Dependent on data quality
  - Require substantial simplification
  - Allow for discrete choices

Watershed level approach

- Expand farm modeling to incorporate choice of EBAPs and BMPs
- Allow for asymmetric information
- Recognize substantial heterogeneity implies efficacy of EBAPs and BMPs varies across farm settings and operators.
- Allow for moral hazard behavior by operators

- Recognize that implementation of EBAPs and BMPs involve private costs
- Efficacy of even mandated practices will depend on operator choices and behavior

Two levels of economics deserve further attention to support general application

@Farm level

- Economic conditions affect p-potential
- BMPs and other mandated tactics affect economic performance

@Watershed level

- Economic performance = Cost of BMP implementation + change in farm profits

How economic behavior affects environmental performance

1) Economic conditions affect p-potential

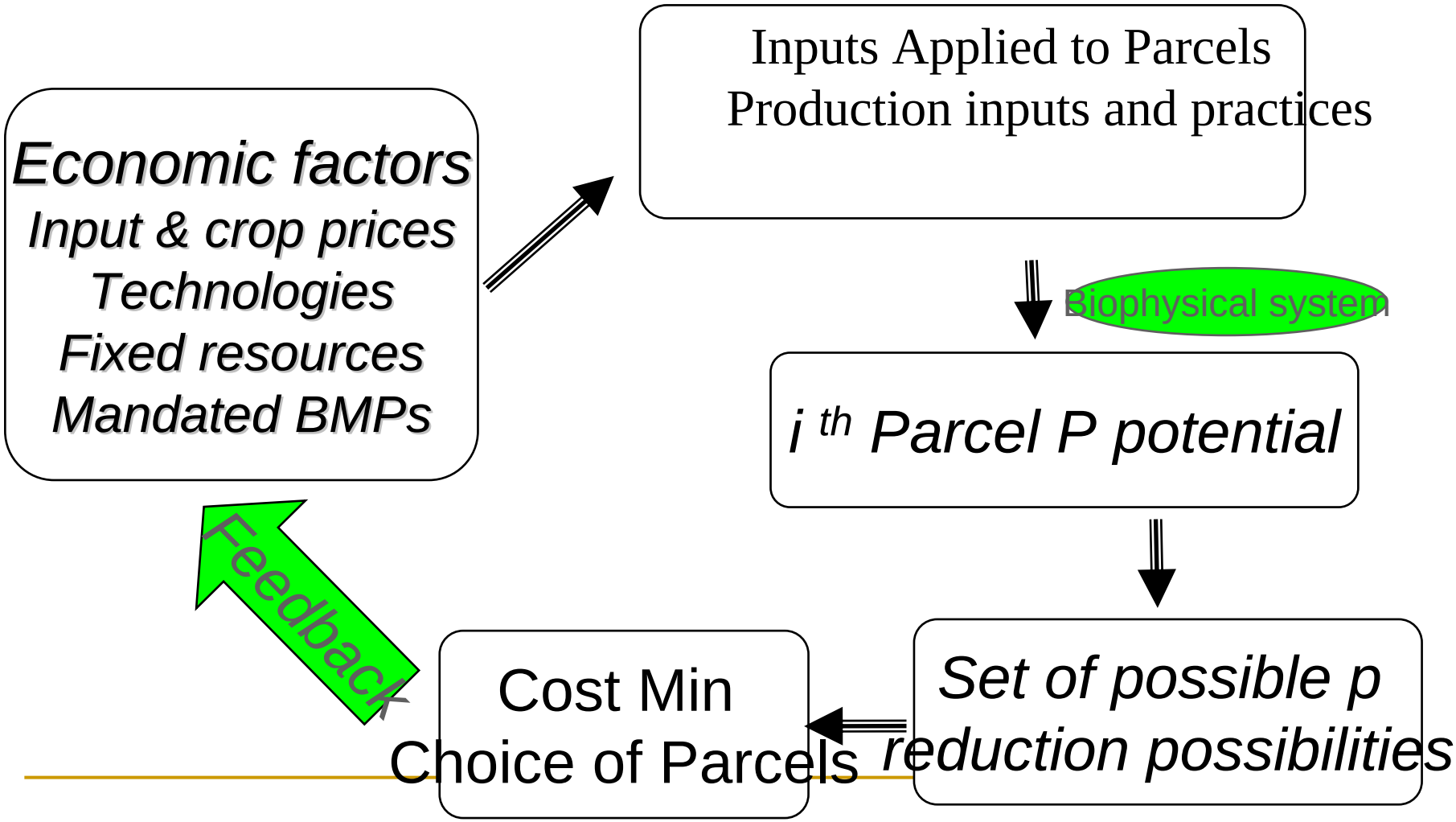
Farm-level operators change inputs, practices, and crop choice in response to economic factors

- Input and expected output prices
- Available or mandated technology: field practices and BMPs for environment

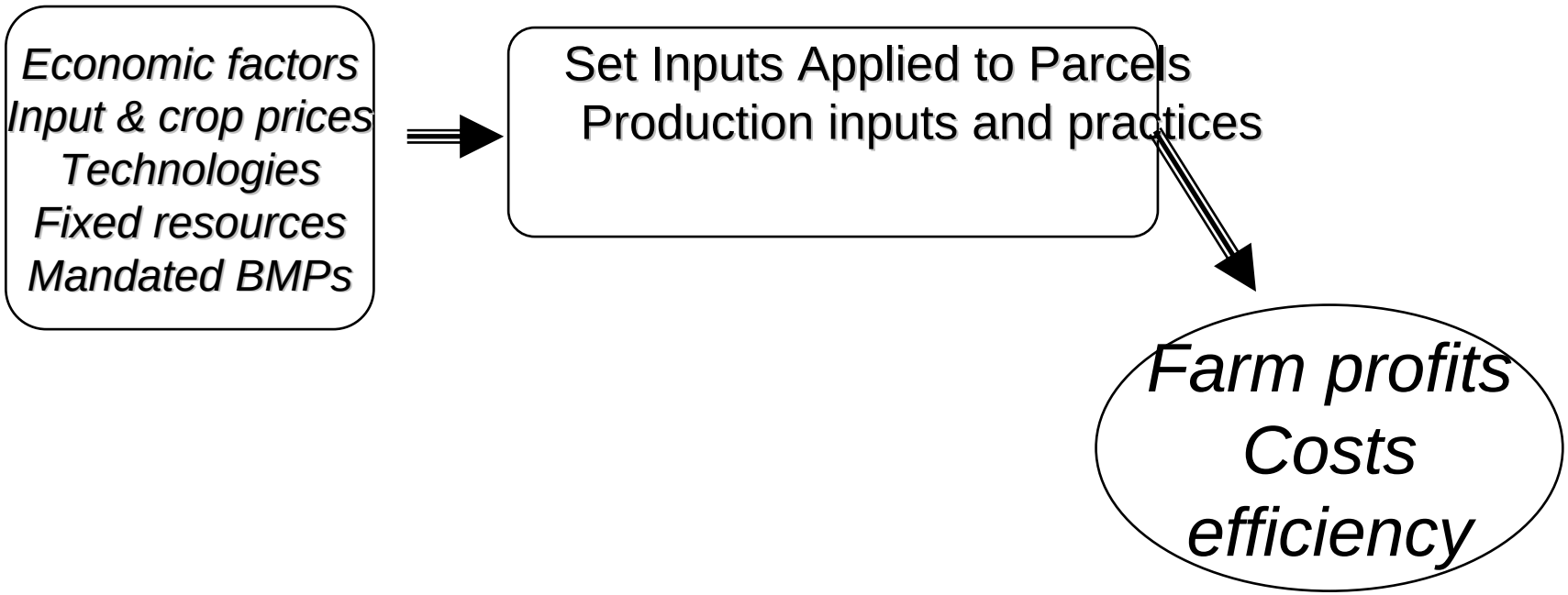
➔ Economic "feedback" occurs at field and farm level

➔ p - potential follows from biophysical characteristics of field + economic behavior

Economic Factors Affect Change in p potential



Mandated BMPs affect economic performance



How economics affects choice of environmental tactics

2) Watershed objectives can be extended to consider minimization of

Admin cost of implementing BMPs

+

Sum of change in farm level economic profits

Subject to the integrated biophysical & economic system

Economic System Affects Change in p potential