The Complementarity and Substitutability of Environmental Attributes under Conservation Policy

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Conservation Security Program (CSP)

- Focused on land currently in production
- Tiered Payments to address a broad range of environmental issues
- "Good-Actor" payments for ex ante behavior (maintenance costs and bonus payments)
- Does not specify "cost-effective" provision of benefits
- Estimated budget = $200 million

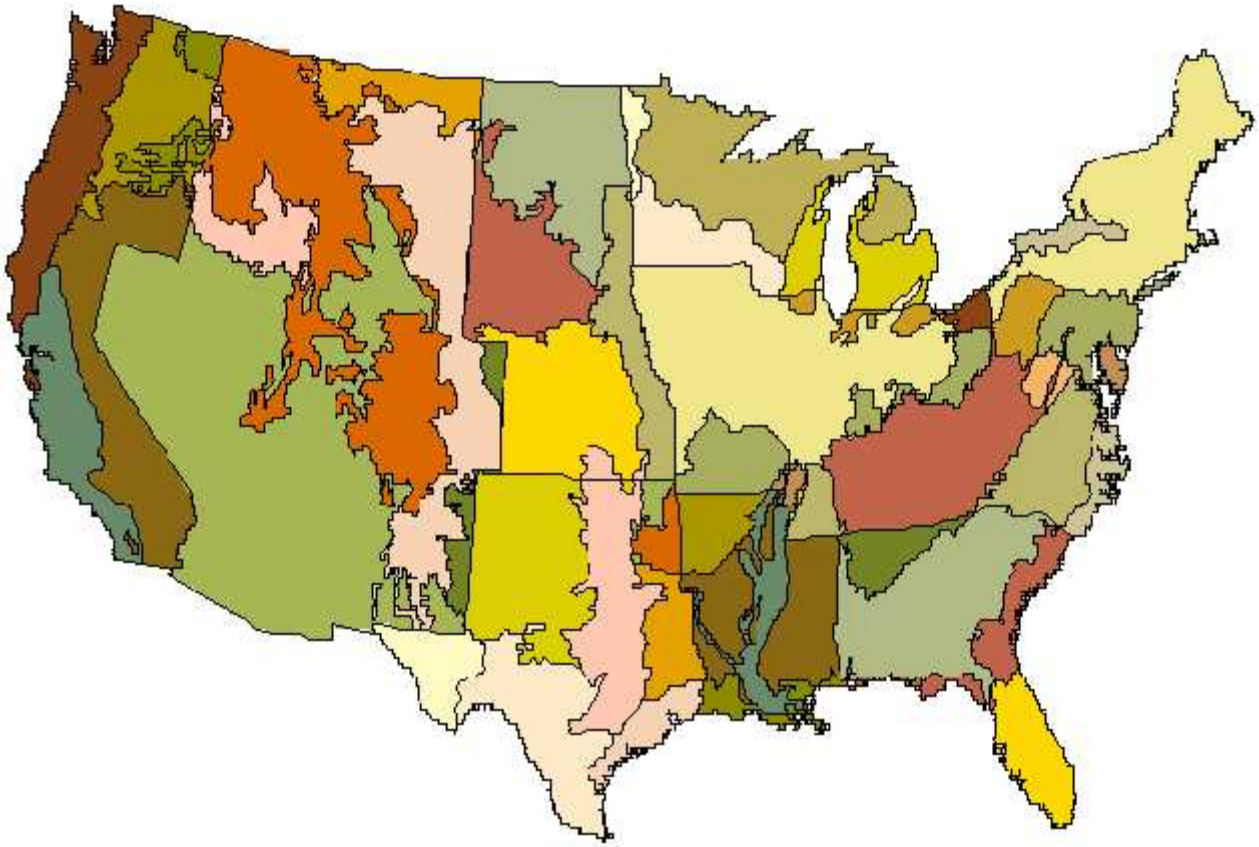
Objectives

- Evaluate Agri-Environmental Payments
  - practice-based payments
  - performance-based payments
  - marginal-cost payments
  - good-actor payments
- Illustrate environmental and budgetary tradeoffs

U.S. Regional Agricultural Sector Model

- A spatial equilibrium model including:
  - 5500+ cropping systems:
    - 10 major crops
    - tillage, rotations, fertilizer and pesticide regimes
  - 13 livestock systems
  - markets for 44 commodities
- Medium-run price and quantity shocks are endogenous
- Focus on the environmental performance of working lands

Regions



Relative Damage Estimates (RDEs)

$$RDE_{kji} = q_{kji} * t_{kj}$$

- RDE = mass arriving at respective medium
- q = edge-of-field emissions
- t = transport coefficient
- k = region
- j = externality
- i = production system

Relative Damage Indices

$$I_{kji} = \left(\frac{RDE_{kji} - \min(RDE_{j.})}{\max(RDE_{j.}) - \min(RDE_{j.})} \right)$$

- This index ranges between 0 and 1 for each pollutant and production system in each region.
- 0 indicates the least amount of pollutant emissions, 1 the greatest.

Base Level of Environment

(330+ million acres)

Externality	**Base (Million Units)**
Nitrogen to Estuaries	39 Lbs.
Nitrogen to Ground Water	1,706 Lbs.
Phosphorus to Surface Water	44 Lbs.
Soil Erosion to Surface Water	48 Tons
Wind Erosion	719 Tons
Loss in Soil Productivity	$372.35
Carbon Emissions	114 Tonnes
Pesticides to Surface Water	140,625 TPUs
Pesticide to Ground Water	36,322 TPUs
Total	519 Index Points

Aggregate Environmental Impact

$$I_{ki} = \sum_{j} w_{kj} I_{kji}$$

- **Aggregate impact on the environment for each practice is the weighted sum of individual indices, similar to the EBI.**
- **Where *w's* are socio-economic weights that describe preferences for mitigating the various pollutants**
- **Initially we let all w's = 1 to focus on the physical mass of all pollutants.**

Environmental Quality

$$E = \sum_k \sum_i xact_{ki} \times I_{ki}$$

$$dE = \sum_k \sum_i (xact^0_{ki} - xact'_{ki}) \times I_{ki}$$

Potential Policies

- Two types of policies will be examined:
  - Practice-based policies that couple good-actor payments to ex-post farming activities.
  - Performance-based policies that decouple good-actor payments from program payments.
- Evaluation will be based on three criteria:
  - Abatement costs.
  - Good-actor payments.
  - Total program costs.

Practice-based Payments

$$P \times (\bar{I} - I_{ki}) > 0$$

- Payments accrue to eligible farm practices defined by a hurdle rate
  - P is the payment rate
  - $\overline{I}$ is the hurdle rate
  - $(\overline{I}\text{-}I_{ki})$ is amount of benefits provided by ex-post production activities
- Producers will move to cleaner practices if the abatement cost is < program payment

Hurdle Rate

- Hurdle chosen: $\overline{I} = 1.535$
  - 168 million acres, or 50% are eligible ex-ante.
- Endogenous Good-Actor Payments
  - If you are already farming above the hurdle you are eligible to receive benefits without changing any practices.
  - If you are farming below the hurdle you can decide whether to switch or not based on expected payments
- Acreage constraint imposed.

Practice-based Optimization

$$J \equiv \max_{P} dE$$

Subject to:

$$B \geq \sum_{k} \sum_{i} P \times (\bar{I} - I'_{ki}), \forall\ I'_{ki} > \bar{I}$$

$$\sum_{\mathrm{i}} xact'_{ki} = \sum_{i} xact^{0}_{ki}, \forall\ k$$

Performance-Based

$$P \times \sum_{i} (xact_{ki}^{0} - xact_{ki}') \times I_{ki} + (good\text{-}actor\ payments)$$

- Payments are based on the net production of benefits
- Good-actor payments are not related to ex post production choices
- Producers will move to cleaner practices if the abatement cost is < program payment
- Acreage constraint imposed

Performance-based Optimization

$$J \equiv \max_{P} dE$$

Subject to:

$$B \geq \sum_{k} \left(\sum_{i} P \times \left(xact_{ki}^{0} - xact'_{ki} \right) \times I_{ki} \right) + \left(good\text{ - }actor\ payments \right)_{k}$$

$$\sum_{\mathrm{i}} xact'_{ki} = \sum_{i} xact_{ki}^{0}, \forall\ k$$

CSP Provisions

Similarities

- **Multiple pollutant**
- **Practice flexibility w/ ability to target eligibility**
- **Voluntary participation**
- **Acreage restriction**
- **Good-actor payments**

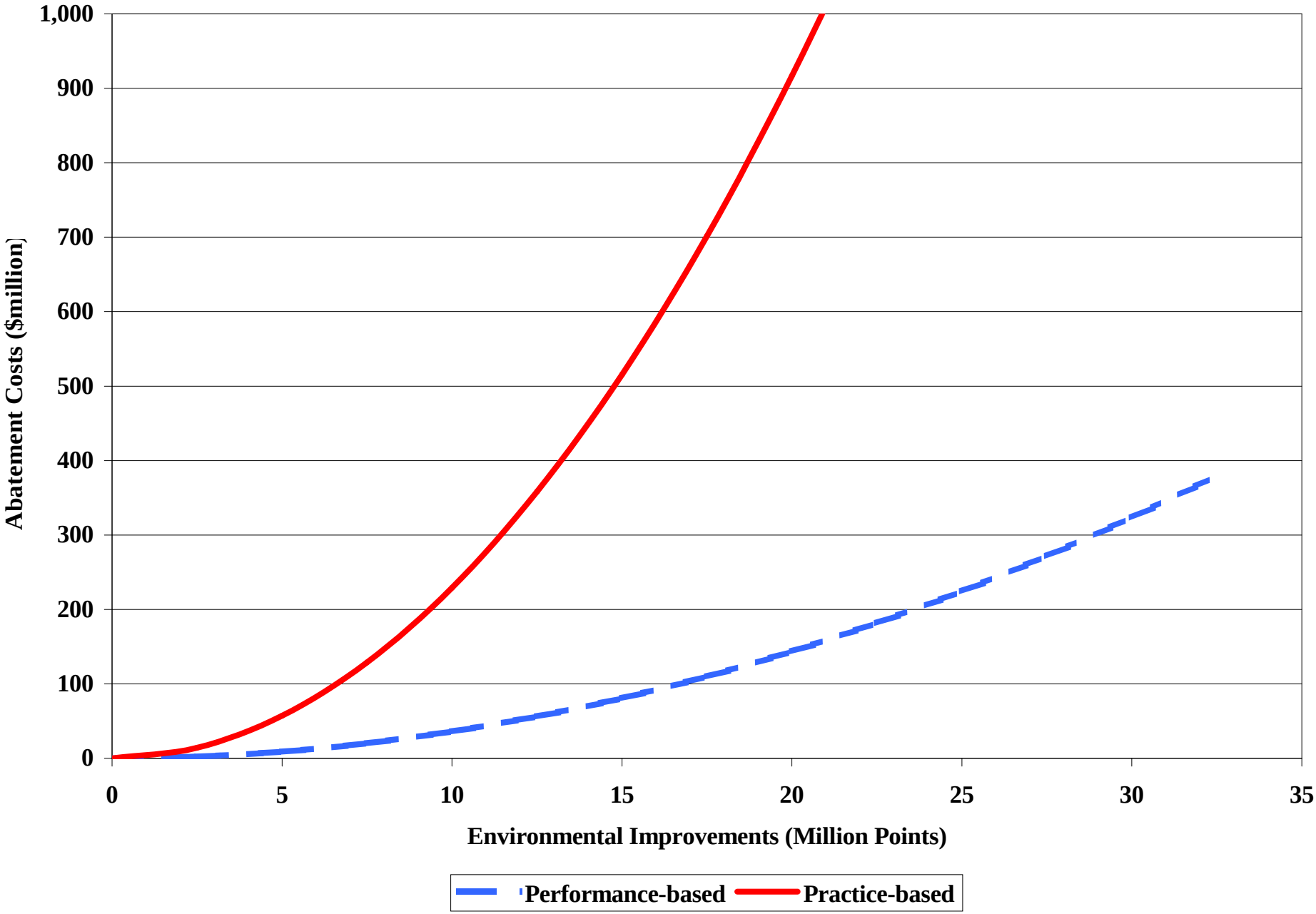
Differences

- **Not “cost plus” (% rental)**
- **Not tiered-payment base**
- **Not as many conservation practices (invasive species)**
- **Targeted delivery rates**

Estimated Costs

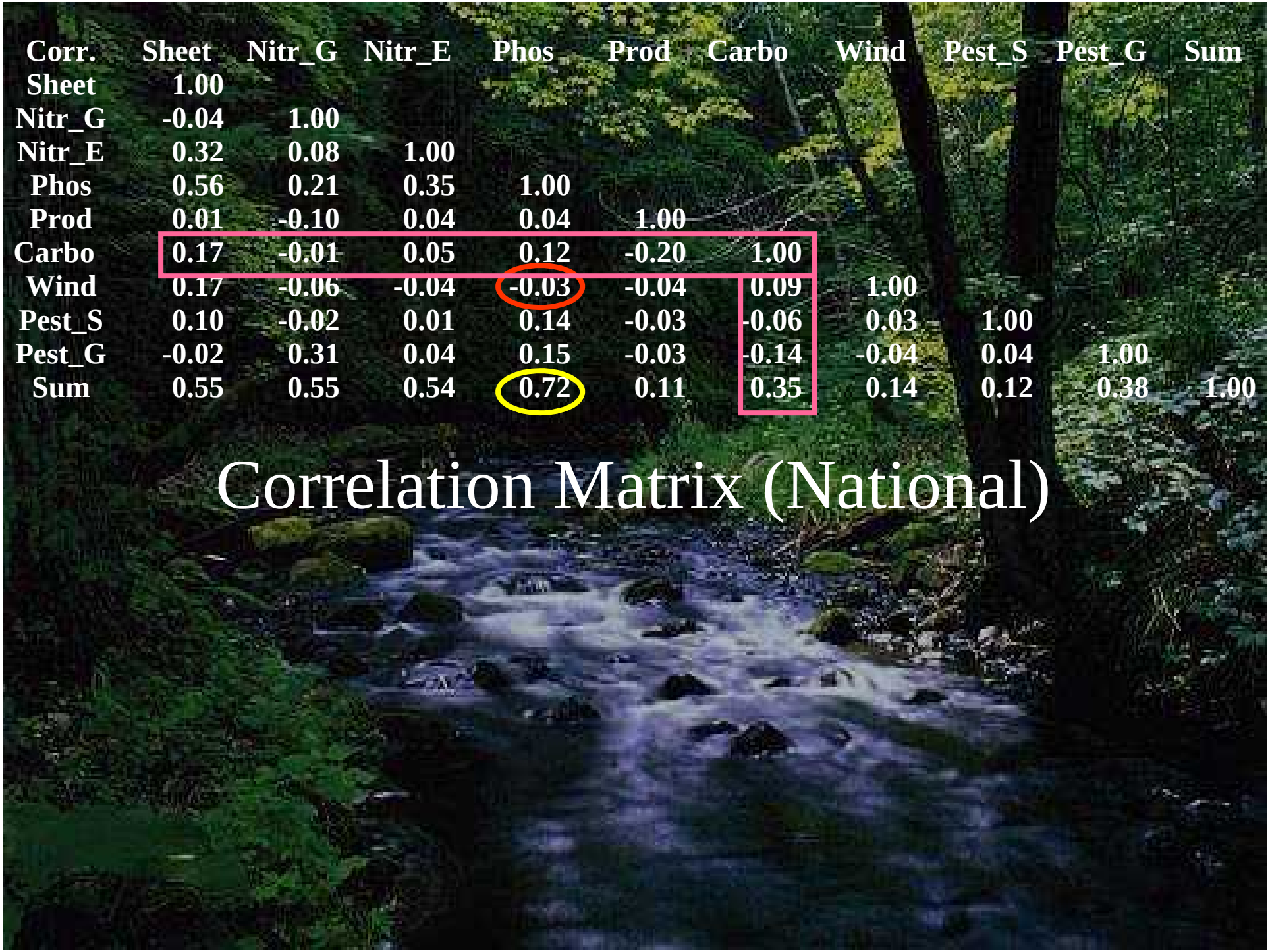
Environmental Goal Constant (A ~ 7 million benefits points)			
Policy	Abatement Costs	Good-actor Payments	Total Cost
Practice-based	$62.7 million	$332.7 million	$395 million
Performance-based	$10.8 million	$*GAP*	$10.8 million + $*GAP*
Budget Constant (B = $200 million) Good-Actor Payments Constant (GAP = $121 million)			
	Benefits Generated	Good-actor Payments	Budget
Practice-based	5.9 million	$121 million	$200 million
Performance-based	14.8 million	$121 million	$200 million

Aggregate Abatement Costs



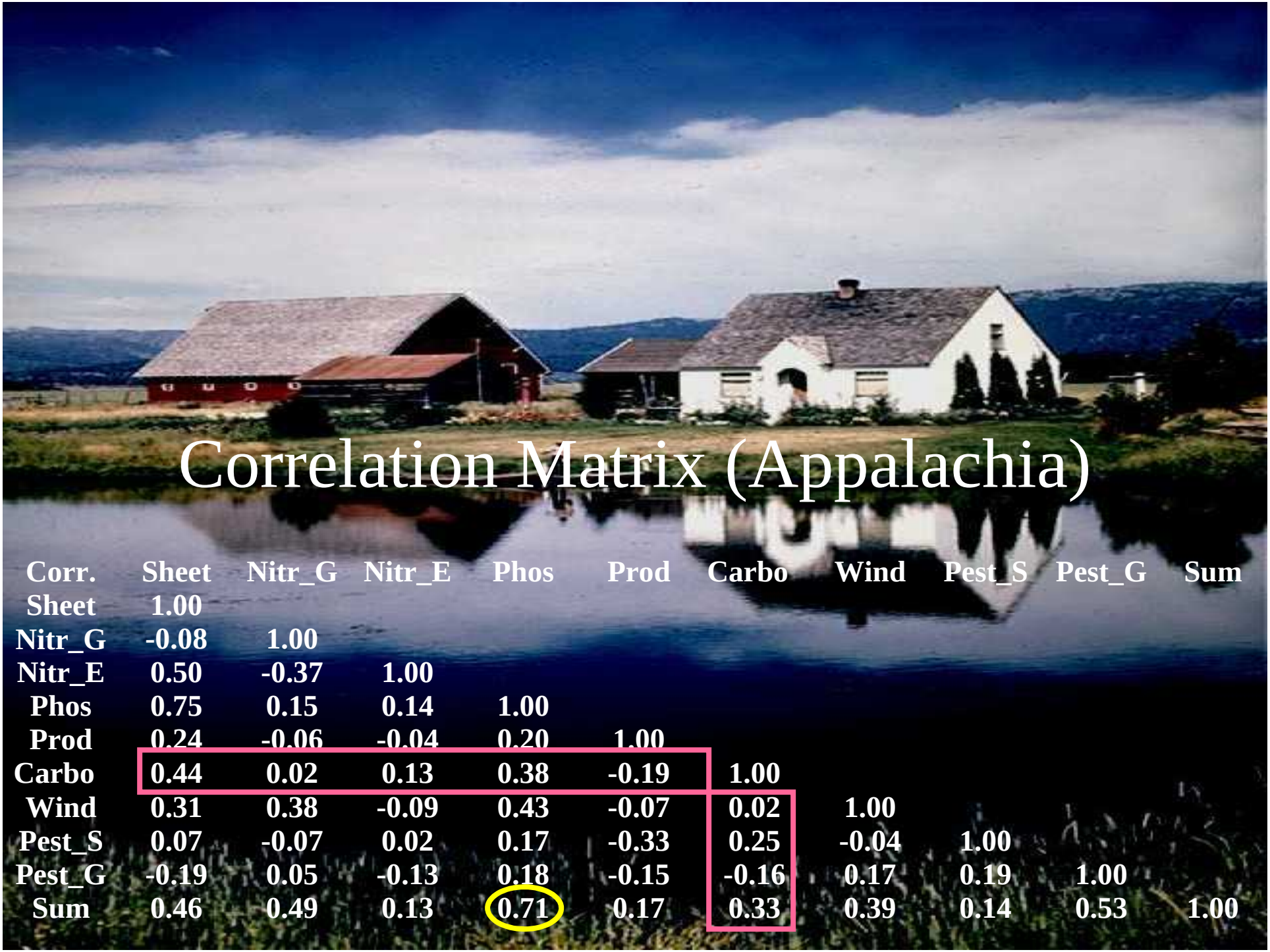
Abatement Differences
(7 million benefits points)

Externality	Practice-Based Abatement[b]		Performance-Based Abatement	
Nitrogen Estuary	1.79	4.59 %	1.73	4.44 %
Nitrogen Ground	18.46	1.08 %	31.73	1.86 %
Phosphorus	2.46	5.57 %	2.35	5.32 %
Sheet and Rill Erosion	2.43	5.09 %	2.19	4.59 %
Wind Erosion	57.13	7.96 %	9.74	1.36 %
Loss in Soil Productivity	274.80	73.80 %	156.10	41.92 %
Carbon Emissions	1.02	0.90 %	0.98	0.86 %
Pesticides Surface	296.85	0.21 %	559.87	0.40 %
Pesticide Ground	324.65	0.89 %	700.41	1.93 %



Corr.	Sheet	Nitr_G	Nitr_E	Phos	Prod	Carbo	Wind	Pest_S	Pest_G	Sum
Sheet	1.00									
Nitr_G	-0.04	1.00								
Nitr_E	0.32	0.08	1.00							
Phos	0.56	0.21	0.35	1.00						
Prod	0.01	-0.10	0.04	0.04	1.00					
Carbo	0.17	-0.01	0.05	0.12	-0.20	1.00				
Wind	0.17	-0.06	-0.04	-0.03	-0.04	0.09	1.00			
Pest_S	0.10	-0.02	0.01	0.14	-0.03	-0.06	0.03	1.00		
Pest_G	-0.02	0.31	0.04	0.15	-0.03	-0.14	-0.04	0.04	1.00	
Sum	0.55	0.55	0.54	0.72	0.11	0.35	0.14	0.12	0.38	1.00

Correlation Matrix (National)



Correlation Matrix (Appalachia)

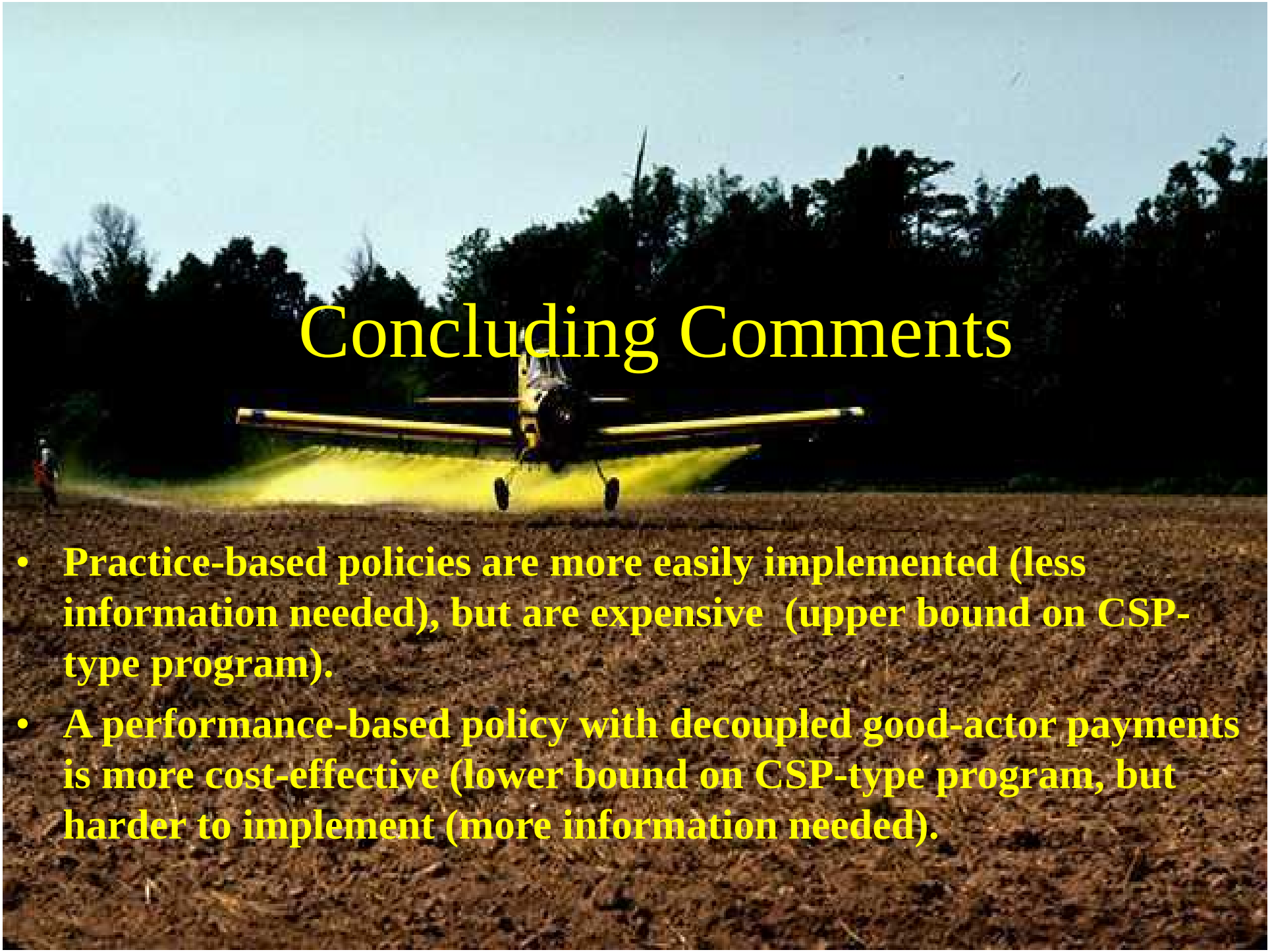
Corr.	Sheet	Nitr_G	Nitr_E	Phos	Prod	Carbo	Wind	Pest_S	Pest_G	Sum
Sheet	1.00									
Nitr_G	-0.08	1.00								
Nitr_E	0.50	-0.37	1.00							
Phos	0.75	0.15	0.14	1.00						
Prod	0.24	-0.06	-0.04	0.20	1.00					
Carbo	0.44	0.02	0.13	0.38	-0.19	1.00				
Wind	0.31	0.38	-0.09	0.43	-0.07	0.02	1.00			
Pest_S	0.07	-0.07	0.02	0.17	-0.33	0.25	-0.04	1.00		
Pest_G	-0.19	0.05	-0.13	0.18	-0.15	-0.16	0.17	0.19	1.00	
Sum	0.46	0.49	0.13	0.71	0.17	0.33	0.39	0.14	0.53	1.00

Corr.	Sheet	Nitr_G	Nitr_E	Phos	Prod	Carbo	Wind	Pest_S	Pest_G	Sum
Sheet	1.00									
Nitr_G	-0.10	1.00								
Nitr_E	0.28	0.01	1.00							
Phos	0.54	-0.23	-0.09	1.00						
Prod	0.04	0.08	0.01	0.19	1.00					
Carbo	0.25	-0.03	0.17	0.18	-0.26	1.00				
Wind	0.03	-0.11	-0.13	0.12	0.23	0.08	1.00			
Pest_S	0.22	-0.11	-0.08	0.36	0.20	-0.06	0.04	1.00		
Pest_G	0.12	0.10	0.15	-0.01	0.27	-0.16	-0.08	0.14	1.00	
Sum	0.75	0.09	0.59	0.59	0.21	0.48	0.04	0.22	0.25	1.00

Correlation Matrix (Corn Belt)

	Sheet	Nitr_g	Nitr_e	Phos	Prod_d	Carb_e	Wind	Pest_s	Pest_g
Nitr_g	-0.02	1							
	(0.40)								
Nitr_e	0.36	0.10	1						
	(0.00)	(0.00)							
Phos	0.58	0.19	0.35	1					
	(0.00)	(0.00)	(0.00)						
Prod_d	0.08	0.09	0.13	0.20	1				
	(0.01)	(0.00)	(0.00)	(0.00)					
Carb_e	0.14	0.02	0.03	0.08	0.06	1			
	(0.00)	(0.43)	(0.29)	(0.01)	(0.04)				
Wind	0.15	-0.06	-0.04	-0.04	-0.08	0.09	1		
	(0.00)	(0.04)	(0.17)	(0.21)	(0.01)	(0.00)			
Pest_s	0.09	-0.03	0.00	0.13	0.00	-0.15	0.02	1	
	(0.00)	(0.26)	(0.93)	(0.00)	(0.89)	(0.00)	(0.51)		
Pest_g	-0.01	0.30	0.05	0.15	0.02	-0.11	-0.04	0.01	1
	(0.78)	(0.00)	(0.10)	(0.00)	(0.56)	(0.00)	(0.22)	(0.76)	
Sum	0.54	0.60	0.55	0.70	0.26	0.36	0.10	0.12	0.38
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Correlation Matrix (National Current)



Concluding Comments

- **Practice-based policies are more easily implemented (less information needed), but are expensive (upper bound on CSP-type program).**
- **A performance-based policy with decoupled good-actor payments is more cost-effective (lower bound on CSP-type program, but harder to implement (more information needed).**

Concluding Comments

- **Under performance-based programs, nitrogen to ground water and pesticide discharges are reduced to a greater extent**
- **Under practice-based programs, increasing soil productivity and reducing wind erosion are encouraged**
- **Phosphorus abatement has the largest positive correlation nationally with environmental quality**
- **Policies aimed at increasing carbon sequestration may result in higher pesticide losses to ground and surface waters**
- **Regionally, the relationships between pollutants and aggregate environmental quality may differ**

Future Research Directions

- Conduct sensitivity analysis for weights and functional form for aggregate environmental quality
- Include additional practices: buffer strips and NMPs
- Investigate bidding down to marginal-cost payments