Improving the Efficiency and Effectiveness of Agri-Environmental Policies

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Some Hydrological and Economic Facts

- Agricultural BMPs…
  - vary greatly in their effectiveness
  - and in their cost

= significant variation in field and farm scale cost-effectiveness (cost-efficiency)

Selected BMP Unit Costs

BMP	Unit	Cost/Unit
Ammonia Emissions Reduction –	$/AU/yr	$38.83
AWMS - Livestock	$/AU/yr	$194.22
AWMS - Poultry	$/AU/yr	$71.62
Dairy Precision Feeding	$/AU/yr	$0.00
Poultry Phytase	$/AU/yr	$0.00
Swine Phytase	$/AU/yr	$0.00
Barnyard Runoff	$/ac/yr	$508.80
Conservation Plan	$/ac/yr	$2.18
Conservation Tillage	$/ac/yr	$0.00
Continuous No-Till	$/ac/yr	$0.00
Cover Crops	$/ac/yr	$40.00
Cropland Irrigation Management	$/ac/yr	$0.00
Enhanced Nutrient Management	$/ac/yr	$9.10
Nutrient Management	$/ac/yr	$0.00
Prescribed Grazing	$/ac/yr	$16.00
Stream Access Control w/ Fencing	$/ac/yr	$5,840.30
Water Control Structures	$/ac/yr	$19.52

Source: (Abt Associates/USEPA 2012) with modifications

Selected BMP Efficiencies

More Cost – Effective (Bay-wide)	Nitrogen Reduction Efficiency (%)	Phosphorus Reduction Efficiency (%)	Sediment Reduction Efficiency (%)
Barnyard Runoff	20	20	40
Capture & Reuse	75	75	N/A
Conservation Plan	3 - 8	5 - 15	8 - 25
Conservation Tillage	1.8 - 3.9	3.7 - 7.5	9.9 - 20.3
Continuous No-Till	10 - 15	20 - 40	70
Cropland Irrigation Management	4	N/A	N/A
Dairy Precision Feeding	25	25	N/A
Enhanced Nutrient Management	7	N/A	N/A
Nutrient Management	4.5 - 9.9	8.2 - 20.9	N/A
Poultry Phytase	N/A	32%	N/A
Swine Phytase	N/A	17% - 35%	N/A
Water Control Structures	33	N/A	N/A

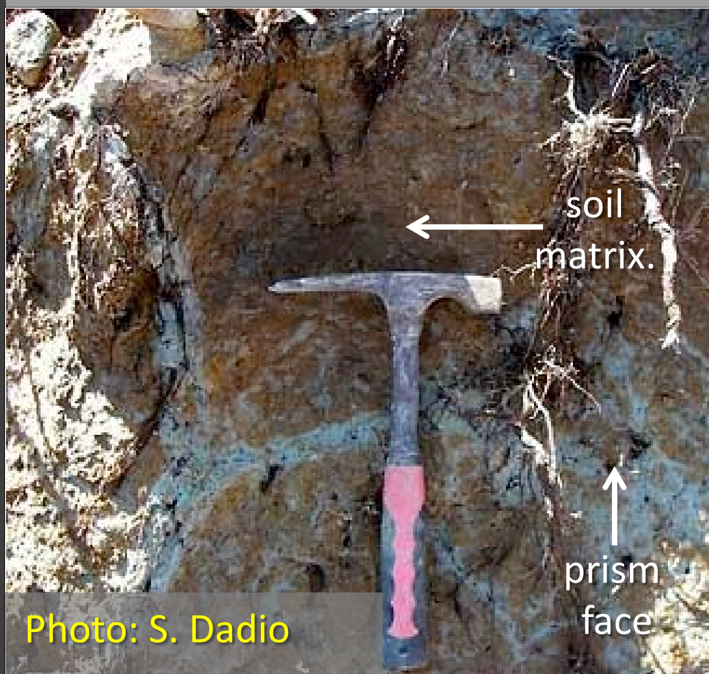
Less Cost – Effective (Bay-wide)	Nitrogen Reduction Efficiency (%)	Phosphorus Reduction Efficiency (%)	Sediment Reduction Efficiency (%)
Ammonia Emissions Reduction	60	N/A*	N/A
AWMS – Livestock	75	75	N/A
AWMS – Poultry	75	75	N/A
Cover Crop – Early Drilled Rye	34	0 - 15	0 - 20
Prescribed Grazing	9 - 11	24	30
Stream Access Control w/ Fencing	26.1 - 53.8	25.6 - 52.3	9.2 - 63.4

Some Hydrological and Economic Facts

- Agricultural lands within watersheds vary greatly in their intrinsic pollution potential
  - Most runoff is generated in small portions of watersheds that are susceptible to saturation
  - Determinants include soils, topography, upland watershed area, geology
  - Sources areas increase in size with the amount of rainfall

The fragipan and saturation excess runoff

Poorly-drained soil
fragipan



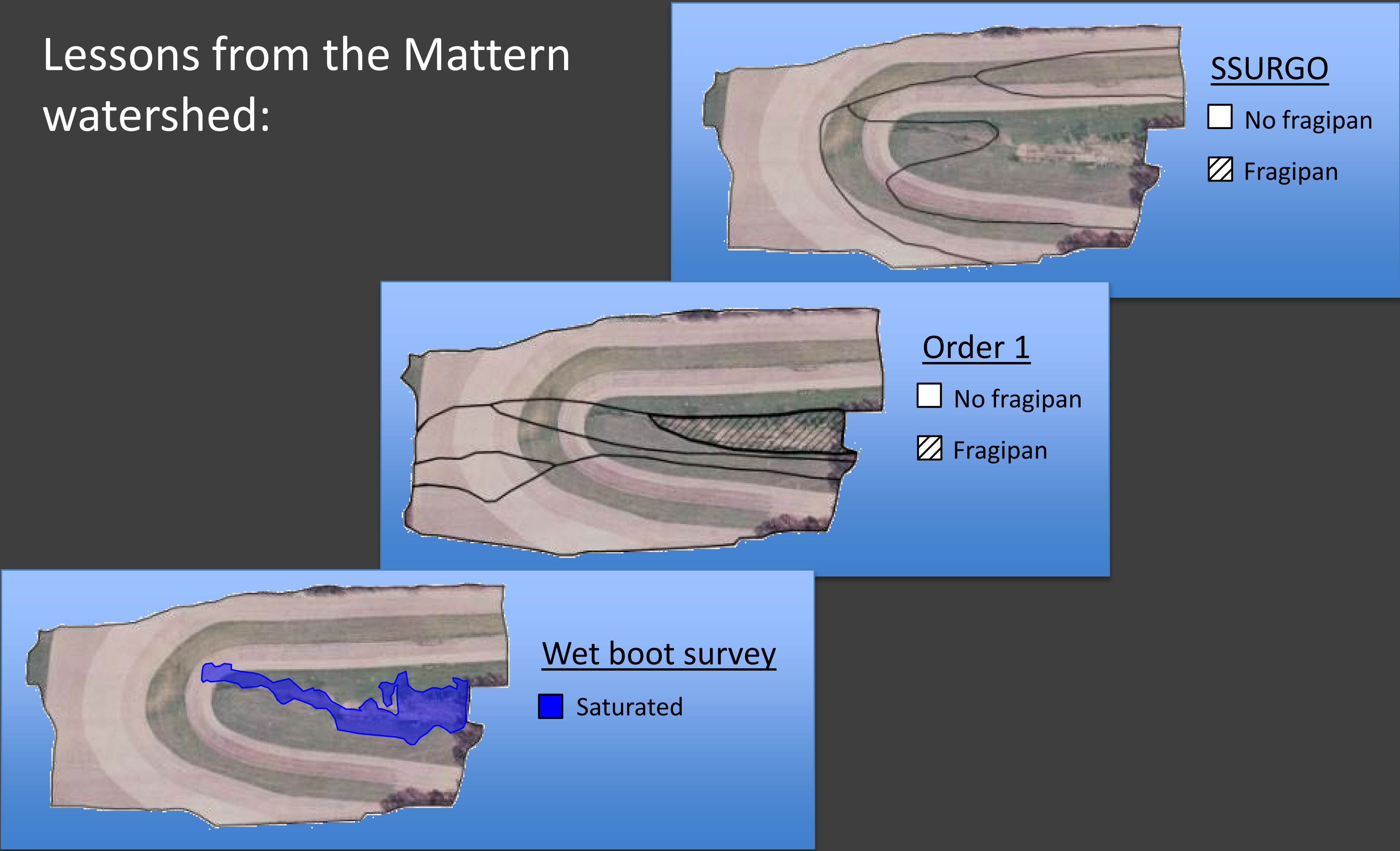
Relatively impermeable
(seasonal perched groundwater)

Well-drained soil
no fragipan

Large interstices allow for rapid
water infiltration

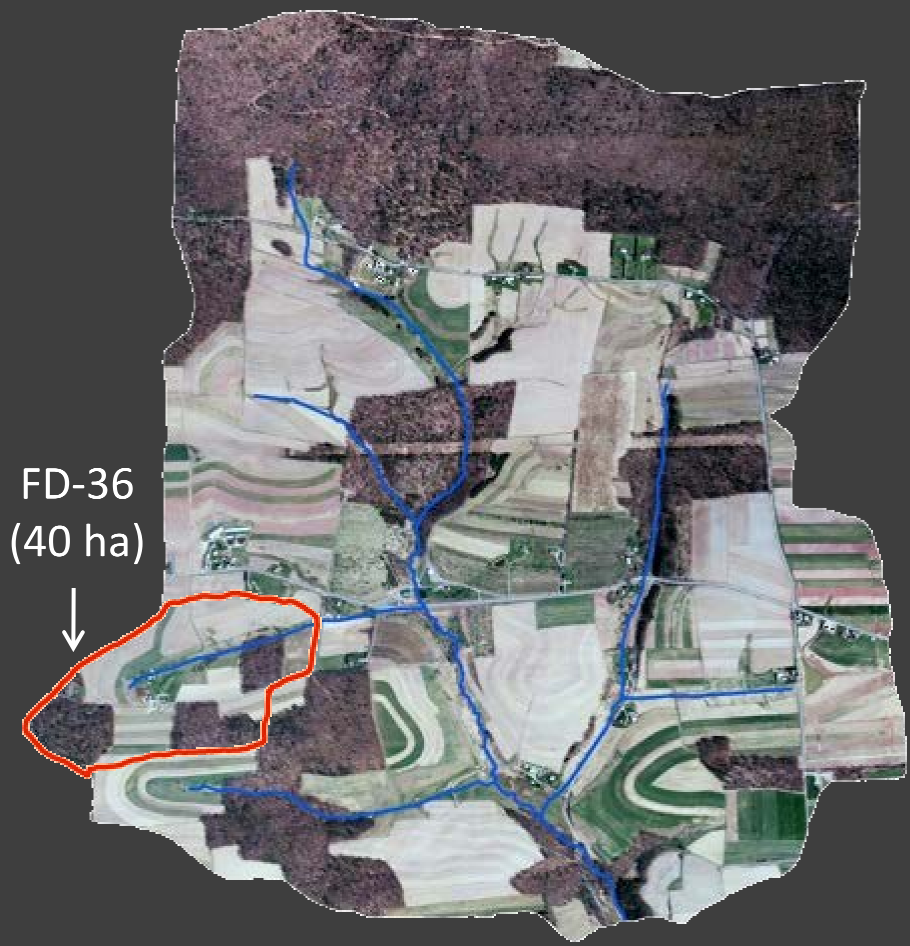
Need for improved mapping to identify "where" runoff is most likely to occur

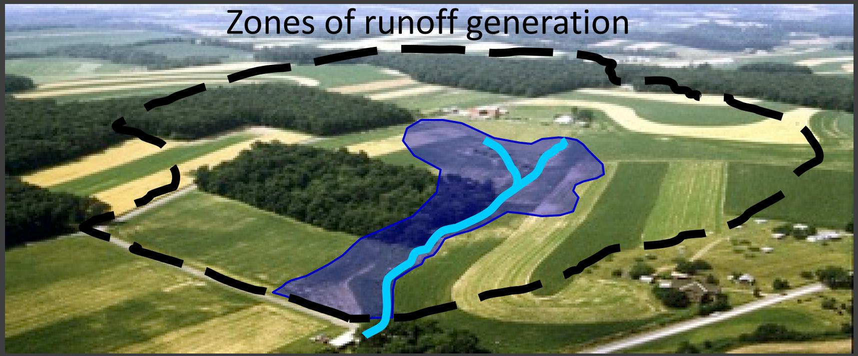
Lessons from the Mattern watershed:

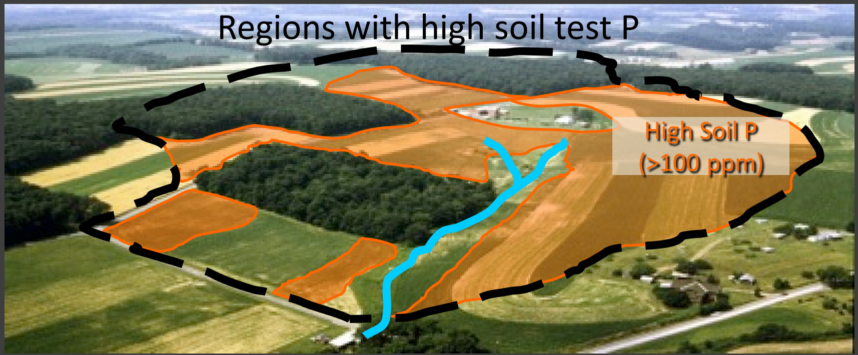


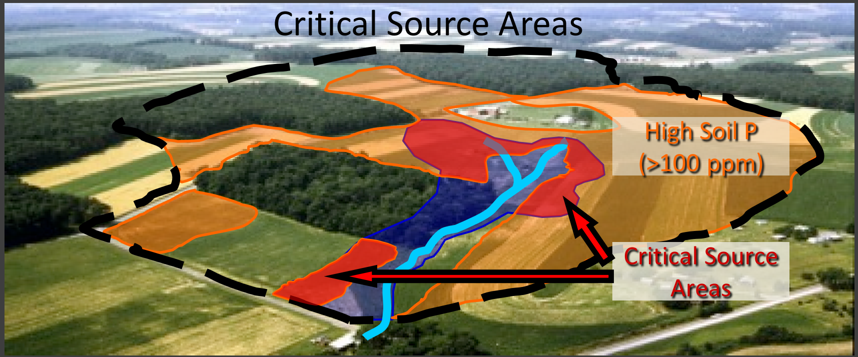
The FD-36 Watershed
Critical source area concept – P-Index

WE-38 watershed (7.3 km^2)







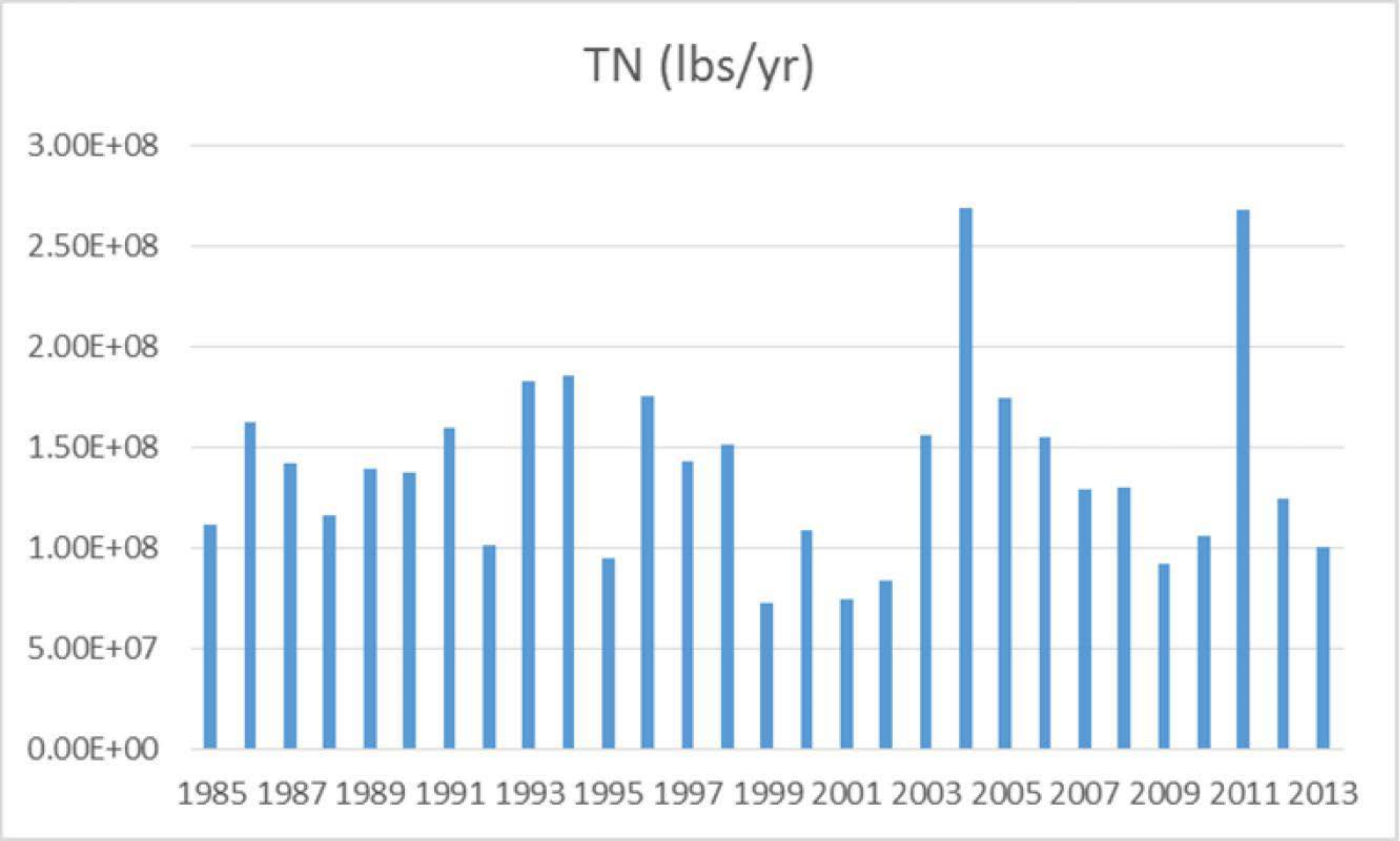


Courtesy Sharpley, USDA-ARS

Some Hydrological and Economic Facts

- Pollution discharges from agricultural catchments largely occur during high runoff events

Annual N Loads
Susquehanna @ Conewingo



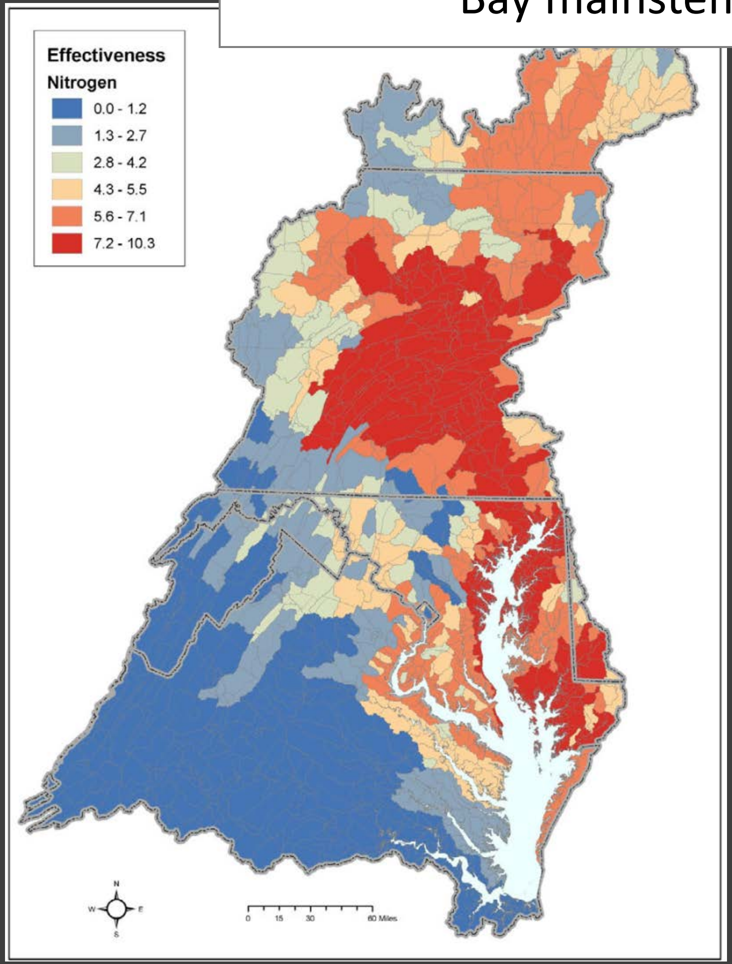
Some Hydrological and Economic Facts

- Watersheds can vary greatly in their intrinsic pollution potential

Watershed Reduction Requirements Based on Relative Effectiveness

- Basins ≥ 50% max Relative Effectiveness
- Reduce controllable N by max of 90%
- Basins with RE < 50% - sliding scale
- Reduce controllable N by max of 67%

Nitrogen runoff effect on Bay mainstem DO



Source: US EPA CBP 2010

Some implications…

- The costs of achieving water quality goals depend greatly on the BMP types and placement within and across watersheds
- Significant cost-savings can be achieved by efficient BMP selection and spatial targeting

What do we want from targeting?

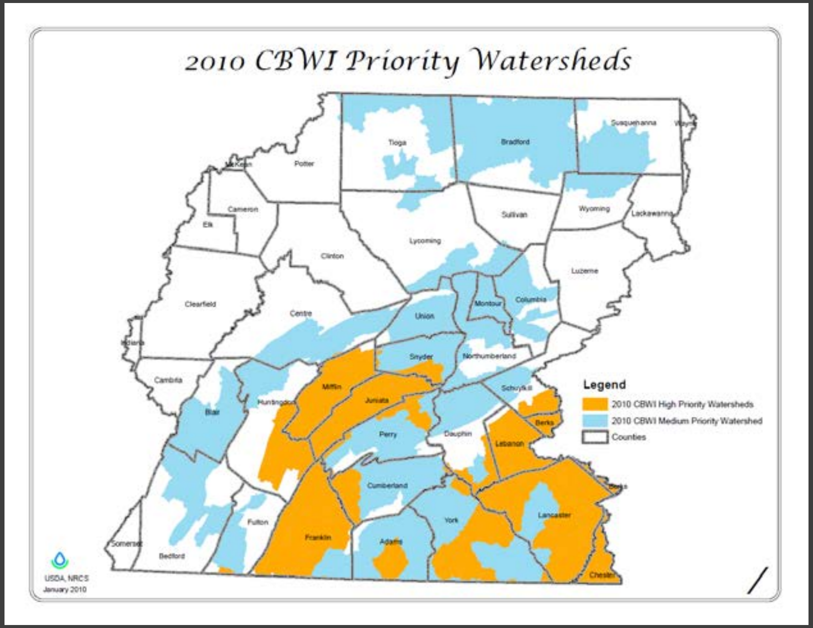
- For Chesapeake Bay TMDL:
  - Maximize progress toward load reductions given limited public resources for planning, enforcement, technical and financial assistance
  - Minimize cost to agriculture and municipal rate payers
- For other objectives:
  - Local water quality benefits
  - Ancillary ecosystem services

Guidelines for targeting to maximize benefits and minimize costs

- Select high impact projects
  - Emphasize pollution performance – not practices per se
  - Emphasize high impact watersheds
  - Emphasize high impact areas within watersheds (critical source zones)
- Select low cost provision
  - Emphasize implementation by low cost sources
  - Emphasize practices that are easier to monitor

Chesapeake Bay Watershed Initiative (CBWI)

- Priority funding for agricultural BMPs in Bay watershed (2008 Farm Bill)
- USDA NRCS established priority watersheds and priority practices for maximum nutrient and sediment pollution reductions
- Ranking criteria allowed NRCS to steer priority practices to priority watersheds
- NRCS continues to evaluate priority practices, watersheds and resource concerns in funding BMPs



WIP Costs vs "Cost Effective Portfolios(CEP)" For Chesapeake Bay TMDL (excluding land-retirement BMPs)

State	Annualized Cost		CEP Cost Saving
	WIP	CEP	
Delaware	$19.4m	$4m	80%
Maryland	$83m	$12.8m	85%
New York	$71.2m	$51.8m	27%
Pennsylvania	$378.3m	$241.3m	36% **
Virginia	$307.4m	NF (P)	NF (P)
West Virginia	$44m	$16.8m	62%
Total	$903m	$634.1	30%

**PA Phosphorous limit slightly exceeded

Source: Shortle et al. 2014. Costs of the Chesapeake Bay TMDL. Report to USDA OCE

Cost Effectiveness
Land Retirement vs. BMPs

Nitrogen	Average N MAC – Land Retirement	Average N MAC – All other BMPs
New York	$12.46	$52.11
Pennsylvania	$3.92	$14.04
Virginia	$10.32	$55.97
West Virginia	$13.83	$199.15

Phosphorus	Average P MAC – Land Retirement	Average P MAC – All other BMPs
New York	$170.61	$314.93
Pennsylvania	$134.12	$216.04
Virginia	$47.10	$260.91
West Virginia	$133.83	$754.14

Source: Shortle et al. 2014.

WIPs vs CEPs (including one land retirement BMP)

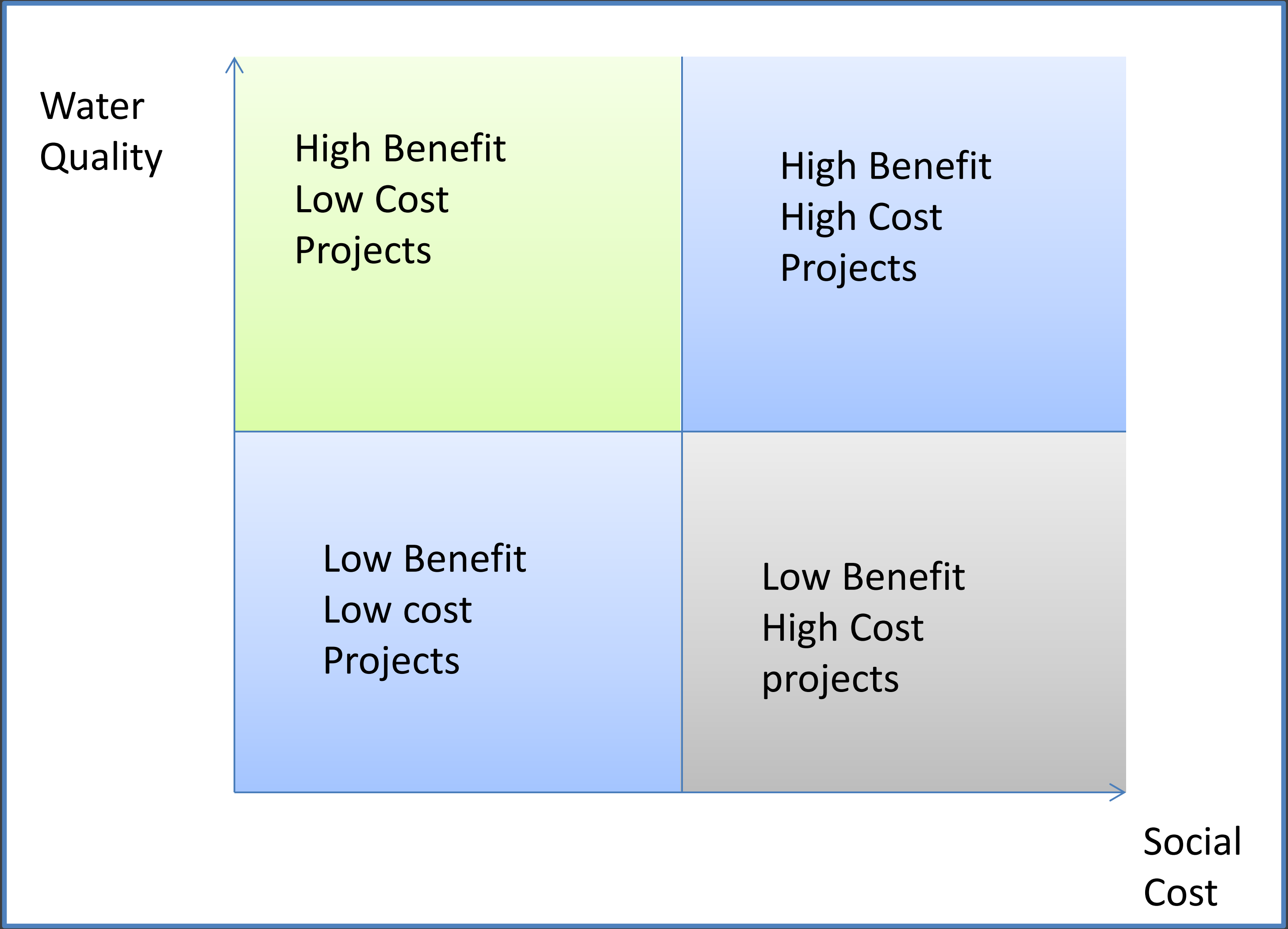
State	Annualized Cost		CEP Cost Saving
	WIP	CEP	
Delaware	$19.4m	$3.5m	82%
Maryland	$83m	$12.9m	84%
New York	$71.2m	$10.1m	86%
Pennsylvania	$378.3m	$101.6m	73%
Virginia	$307.4m	$223.6m	27%
West Virginia	$44m	$6m	86%
Total	$903m	$357.7	60%

Source: Shortle et al. 2014

Improving Cost-Effectiveness

- What should we put where?
  - Requires information, tools, and processes for ranking "projects"
- Policy
  - How do we actually get cost-effective practices in the right places?

What? Where?



Water Quality
High Benefit
Low Cost
Projects
High Benefit
High Cost
Projects
Low Benefit
Low cost
Projects
Low Benefit
High Cost
projects
Social Cost

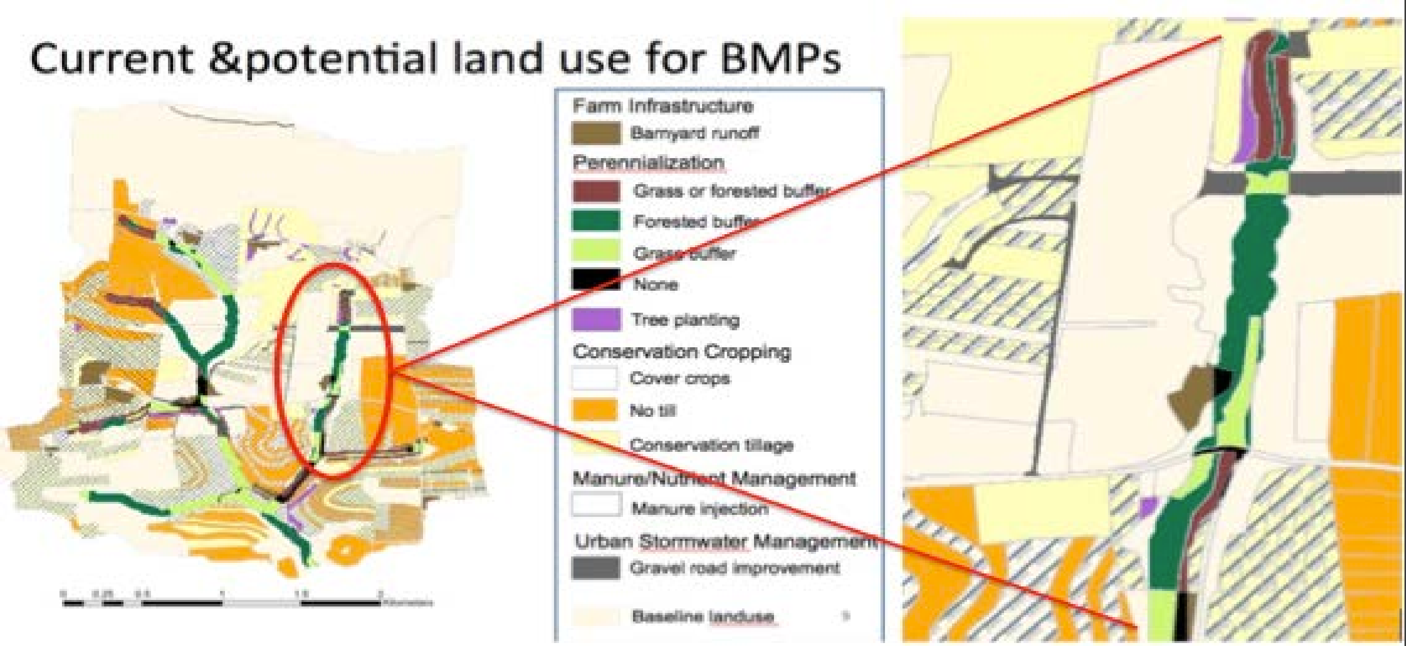
What &Where Assessment

- Tools to assess water quality outcomes
  - Alternative practices and places at multiple regional scales (field, farm, local water quality impairments to Bay TMDL)
- Tools to assess other outcomes
  - Ecosystem services
  - Economic costs
- Prioritization and optimization tools
  - What combinations of technologies, land uses, and places give the best ecological and economic outcomes?
- Current tools and data are
  - Imperfect
  - Getting better
  - Substantially Improvable
- Perfection is an enemy of the good - practical procedures need to be developed that are useful given reasonably available resources and analytical capacities

Center for Nutrient Pollution Solutions

- Old paradigm
  - BMP Fix
- Needed new paradigm
  - Tactics + Strategies
  - "Optimize" BMP types and locations
  - Address system level drivers
    - Mass imbalances
    - Agricultural structure
  - In harmony with multiple societal objectives for agriculture
- The CNS is developing tools, protocols, and processes to help answer what and where questions at small watershed scales utilizing a *shared discovery model*

Scenario of spatially explicit practices applied to a sample riparian corridor



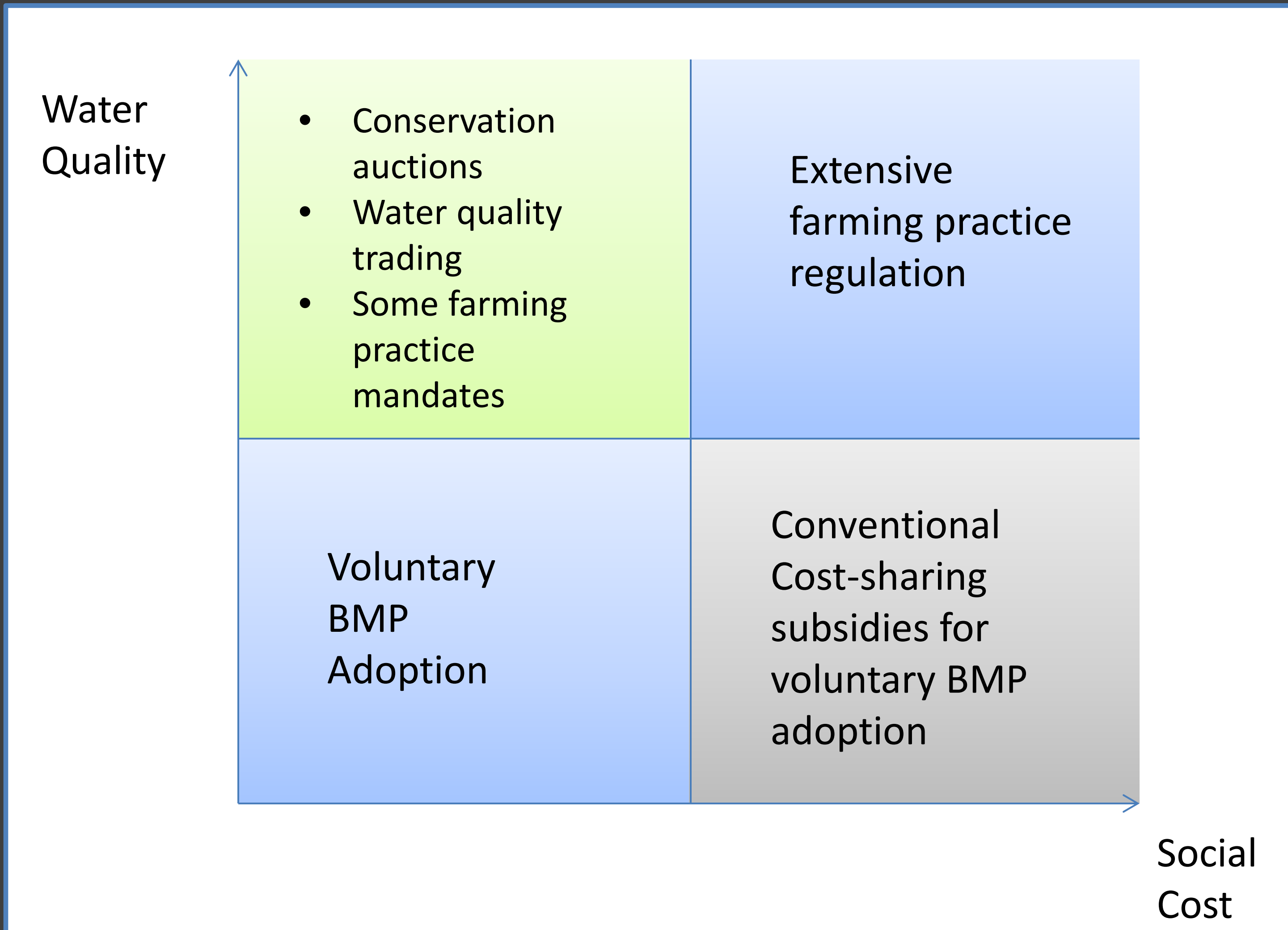
Portion of Mahantango watershed showing detailed field management and riparian corridors.

**CNS, Veith et al.

Policy Options

	Carrots (Payments/financial assistance that reduce the private costs of BMPs	Sticks (penalties, restrictions on eligibility for other benefits that increase the costs of non-adoption)	Mandates
Practice Based	Cost-Sharing (EQIP) Tax preferences	Cross-compliance Input taxes (e.g., fertilizer, phosphorous in feed)	CAFO permits Stream set backs Winter manure application bans Nutrient & manure management plans
Performance Based	Baseline-and-credit trading Conservation performance auctions	Pollution taxes Product taxes to fund conservation programs	
Mixed	Conversion of highly erosive lands to permanent vegetative cover based on “benefits index” (CRP)		

How do policies perform? (water quality benefit, social cost)



Private, Government, Social Costs

- Private costs
  - BMP out-of-pocket implementation and maintenance costs + opportunity costs
  - Less incentives (e.g., USDA EQIP, CREP; state incentives, NGO incentives)
  - Can be negative for some practices!
- Government costs
  - Planning and administration
  - Payments to farmers
- Social costs
  - Private costs + government costs – ancillary ecosystem service benefits
- Cost types and distribution vary by policy type and implementation

How do policies perform? (water quality benefit, govt cost)