

Moving towards sustainable land management in the Chesapeake Bay through novel engagement strategies

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Abstract

Each state and district within the Chesapeake Bay watershed has cooperated with the Chesapeake Bay Program (CBP) to develop local Watershed Implementation Plans (WIPs) that identify the type and quantity of best management practices (BMPs) that, if implemented, are estimated to meet 2025 Total Maximum Daily Load (TMDL) goals for Bay water quality. However, top-down management of large regions, such as the 167,000-km² Bay catchment, is often necessarily limited by the feasibility of providing implementation plans that are customized by watershed hydro-physiographic characteristics and socio-political considerations. The Bay simulation model divides the catchment into watersheds of approximately 350 km² each; these watersheds become the Bay model's smallest overland management unit. We used Bay WIP plans, local information, and a hydrologic model called TopoSWAT to model three of these smallest-unit watersheds in more local detail. Our smallest management unit became contiguous, similarly managed, cropland areas (i.e., one or several neighboring agricultural fields) and these management units were further divided by the topographic wetness index. Our watersheds represent three distinct hydrological and geochemical regions within the Chesapeake Bay catchment, namely Appalachian Valley and Ridge – karst, Appalachian Valley and Ridge – nonkarst, and Appalachian Piedmont. We modeled three scenarios for each watershed: baseline (pre-WIP), WIP implementation, and “smarter” WIP placement where we targeted BMP placements for cost-effectiveness. We then compared results among scenarios as well as across watersheds. We are interested to see how well the models agree at the watershed outlet, discover cost-effective BMP placements within each watershed that meet WIP goals, and compare our findings across the physiographic regions to determine how they can guide regional planning.

Case Study Watersheds

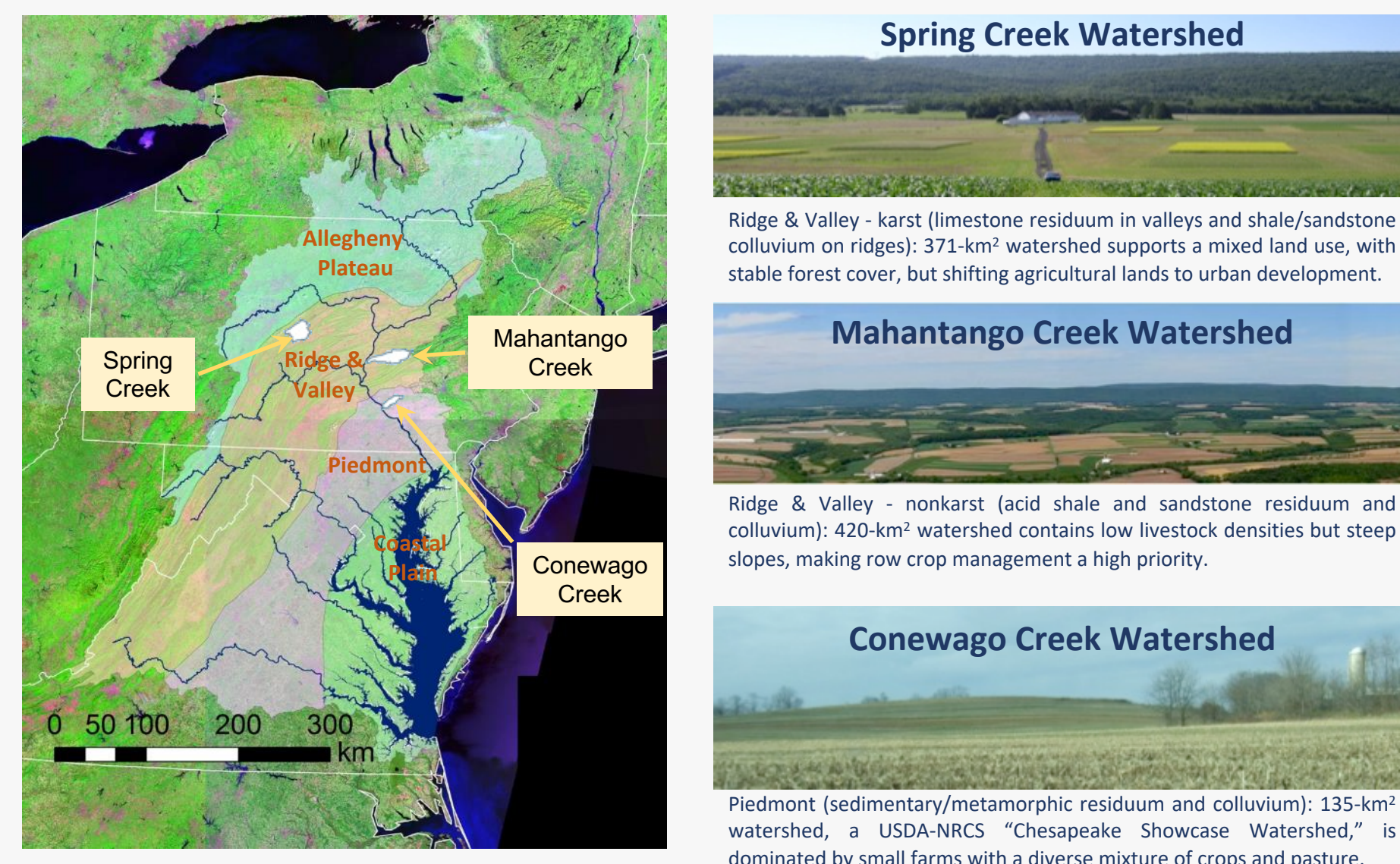


Figure 1. Chesapeake Bay and selected case study watersheds.

“Shared Discovery” Research Approach

Via community workshops, Penn State Center for Nutrient Solutions (CNS) actively engaged stakeholders to determine preferences for using limited resources to achieve water quality improvement goals. This information, in combination with state WIP goals, guided model scenario development and enabled locally-relevant land management recommendations.

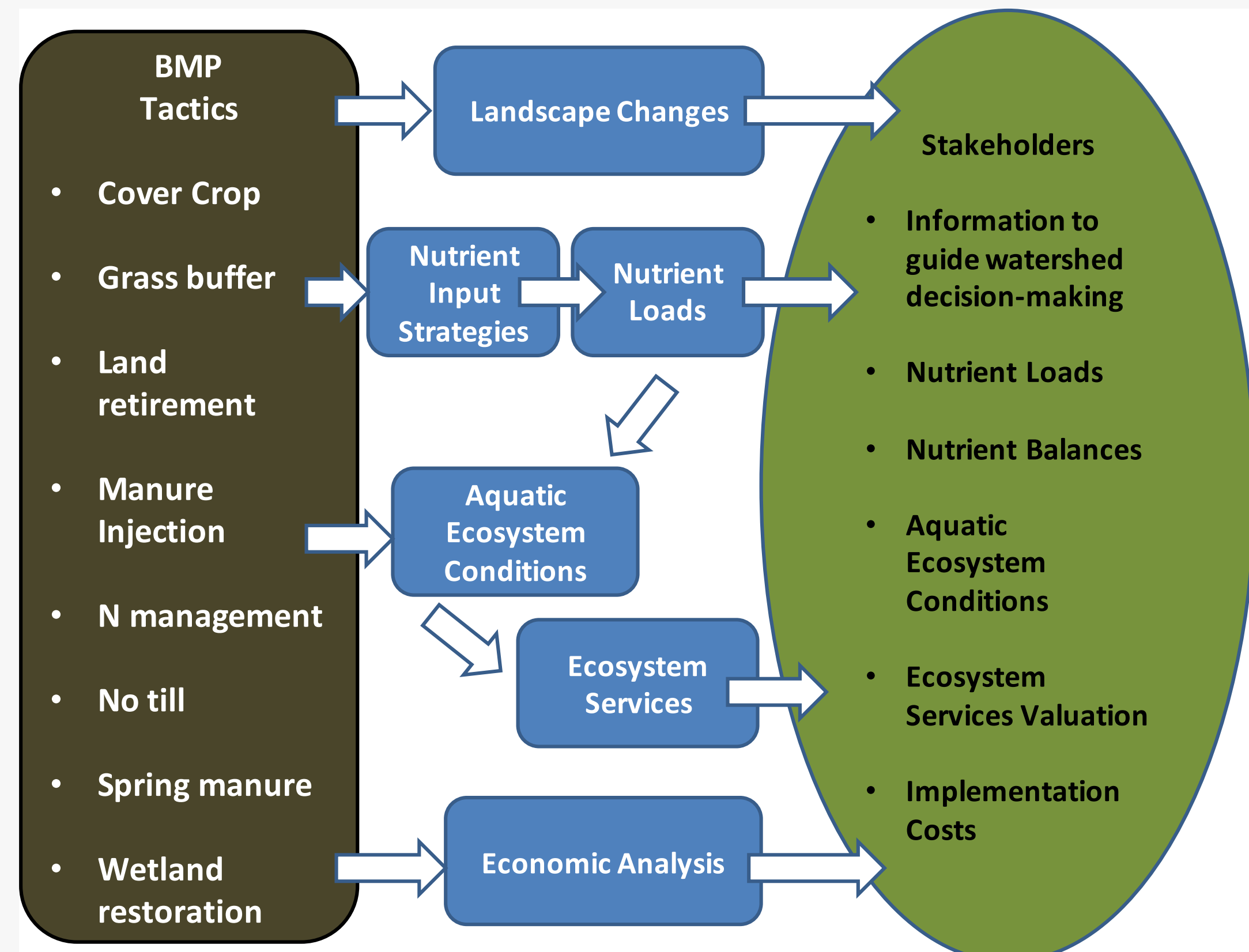


Figure 3. Schematic of overall research and engagement approach.

Scenario Modeling with Soil & Water Assessment Tool

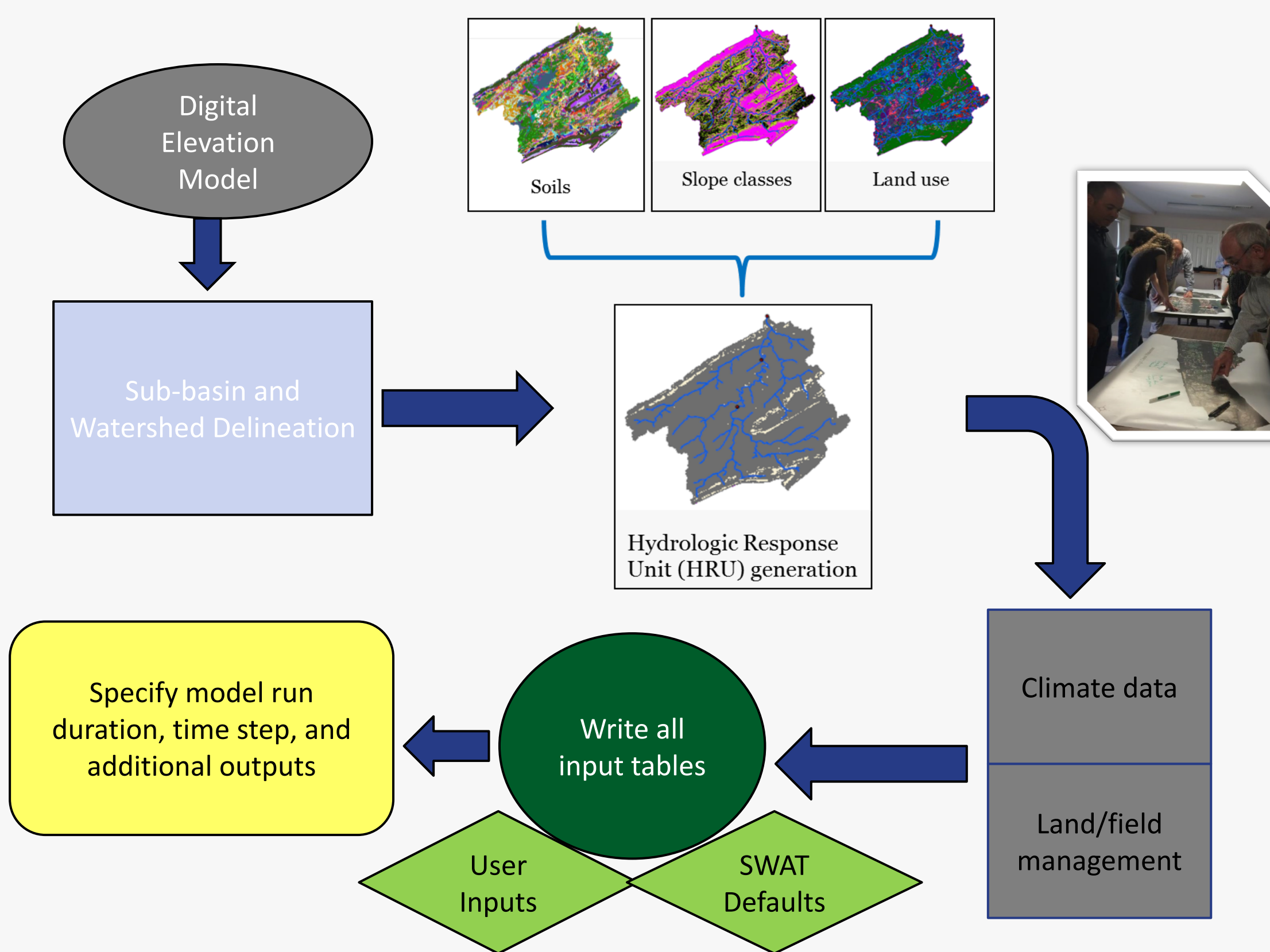


Figure 4. Schematic of SWAT model input and output.

2017 Oversight Status	Ongoing	Enhanced	Backstop
Delaware	Enhanced Oversight	Ongoing Oversight	Ongoing Oversight
District of Columbia	Not Applicable	Ongoing Oversight	Ongoing Oversight
Maryland	Ongoing Oversight	Enhanced Oversight	Ongoing Oversight
New York	Ongoing Oversight	Ongoing Oversight	Enhanced Oversight
Pennsylvania	Backstop Actions Level	Backstop Actions Level	Ongoing Oversight
Virginia	Ongoing Oversight	Ongoing Oversight	Ongoing Oversight
West Virginia	Ongoing Oversight	Ongoing Oversight	Ongoing Oversight

Figure 2. 2017 EPA oversight status for Bay states. Source: EPA, 2017

Scenario Development for Water Quality Modeling

- ❖ Scenario A: “baseline”
represent state of the watershed around 2012
- ❖ Scenario B: “WIP”
meet WIP-determined coverage area per BMP
- ❖ Scenario C: “Smarter” WIP
place WIP BMPs where most effective until goal is met; don't worry about matching WIP-estimated coverage area
- ❖ Scenario D: “Local Objectives”
incorporate additional issues raised by watershed stakeholders
- ❖ Scenario E: “Transformational Change”
best case scenarios; likely requiring paradigm shifts and policy changes

Highlighted Results

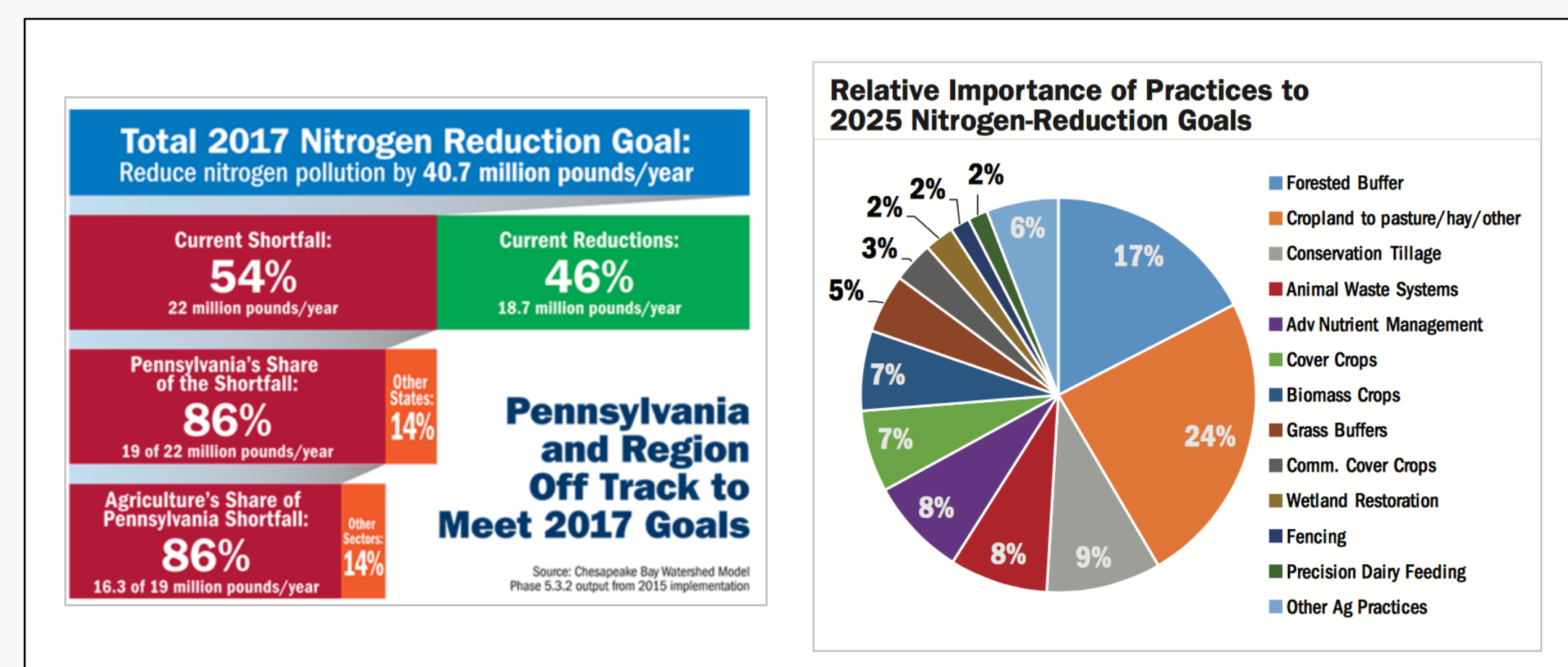


Figure 5. Pennsylvania BMP portfolio to meet nitrogen reduction goals. Source: Chesapeake Bay Watershed Model, 2015

Spatially targeting critical source areas uses suites of lower-cost, management-based BMPs

Spring Creek

BMP	WIP guide for watershed		WIP as simulated in SWAT		placement in SWAT	
	Target ha	USD/ha	Converted ha	Cost (USD)	Converted ha	Cost (USD)
cover crops	1520	\$ 55.00	1520	\$83,600	3692	\$203,066
conservation tillage	385	\$ 7.40	385	\$2,849		
enhanced N mang.		\$ 6.90			6154	\$42,459
no-till management	261	\$ 7.40	261	\$1,931	1296	\$9,590
land retirement	1473	\$299.40	1473	\$440,887		
manure injection	97	\$ 29.00	97	\$2,823	3692	\$107,071
trees outside buffer	24	\$195.00	24	\$4,746		
forest buffer	183	\$ 90.00	183	\$16,430		
grass buffer	134	\$ 63.00	134	\$8,434	160	\$10,080
Total	4077		4077	\$561,701	14994	\$372,266

Mahantango

BMP	WIP guide for watershed		WIP as simulated in SWAT		placement in SWAT	
	Target ha	USD/ha	Converted ha	Cost (USD)	Converted ha	Cost (USD)
cover crops	3981	\$ 55.00	4131	\$227,228	2453	\$134,940
conservation tillage	5340	\$ 7.40	5346	\$39,563		
enhanced N mang.		\$ 6.90			4907	\$33,858
no-till management	356	\$ 7.40	470	\$3,477	4416	\$32,680
land retirement	2509	\$299.40	2194	\$656,754		
manure injection	185	\$ 29.00	202	\$5,868	2944	\$85,380
trees outside buffer	356	\$195.00	385	\$75,168		
forest buffer	2509	\$ 90.00	23	\$2,044		
grass buffer	185	\$ 63.00	236	\$14,868	174	\$10,962
Total	15421		12988	\$1,024,969	14895	\$297,820

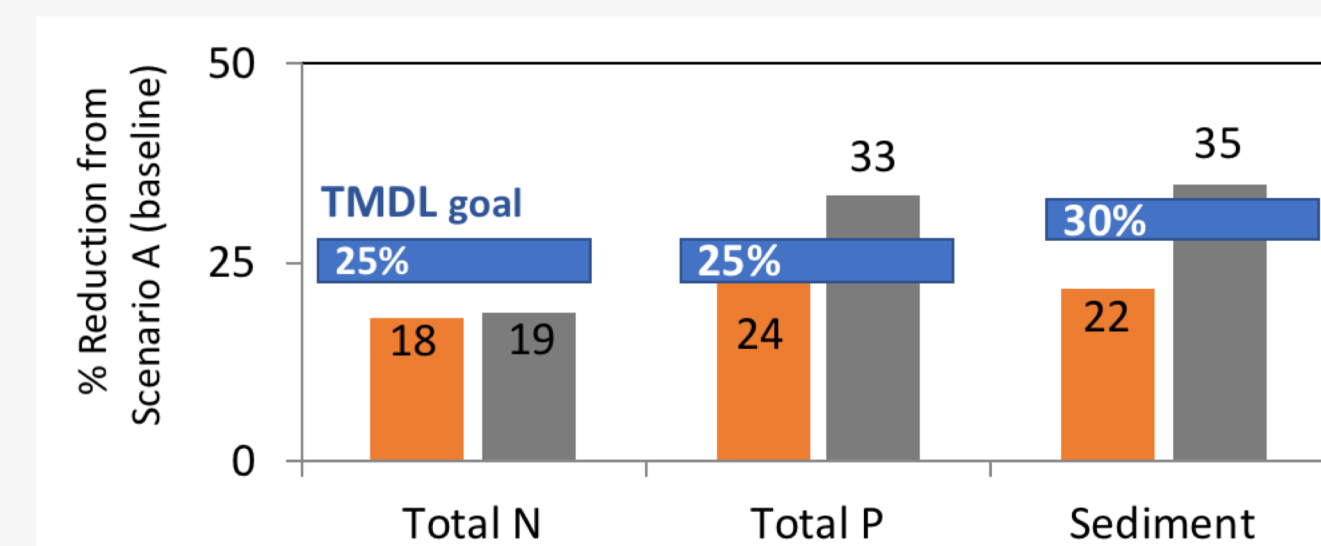
Conewago

BMP	WIP guide for watershed		WIP as simulated in SWAT		placement in SWAT	
	Target ha	USD/ha	Converted ha	Cost (USD)	Converted ha	Cost (USD)
cover crops	1301	\$ 55.00	1243	\$68,372	1629	\$89,607
conservation tillage	670	\$ 7.40	670	\$4,958		
enhanced N mang.		\$ 6.90		0	3394	\$23,420
no-till management	670	\$ 7.40	670	\$4,958	815	\$6,028
land retirement	399	\$299.40	771	\$230,837		
manure injection	97	\$ 29.00	84	\$2,436	2037	\$59,059
trees outside buffer	195	\$195.00	47	\$9,165		
forest buffer	87	\$ 90.00	45	\$4,050		
grass buffer	36	\$ 63.00	45	\$2,835	90	\$5,670
Total	3454		3575	\$327,611	7965	\$183,784

“Smart” placement of WIP management-based BMPs improves nutrient reductions, and costs less.

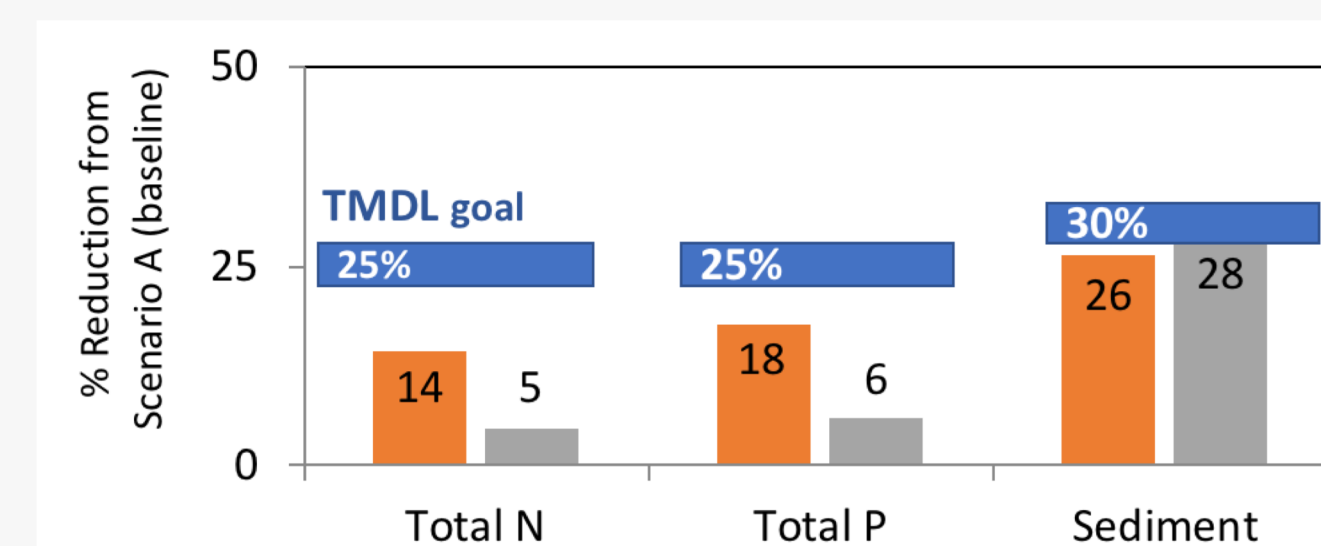
Spring Creek

BMP cost
\$15/ha: WIP
\$10/ha: “smart”



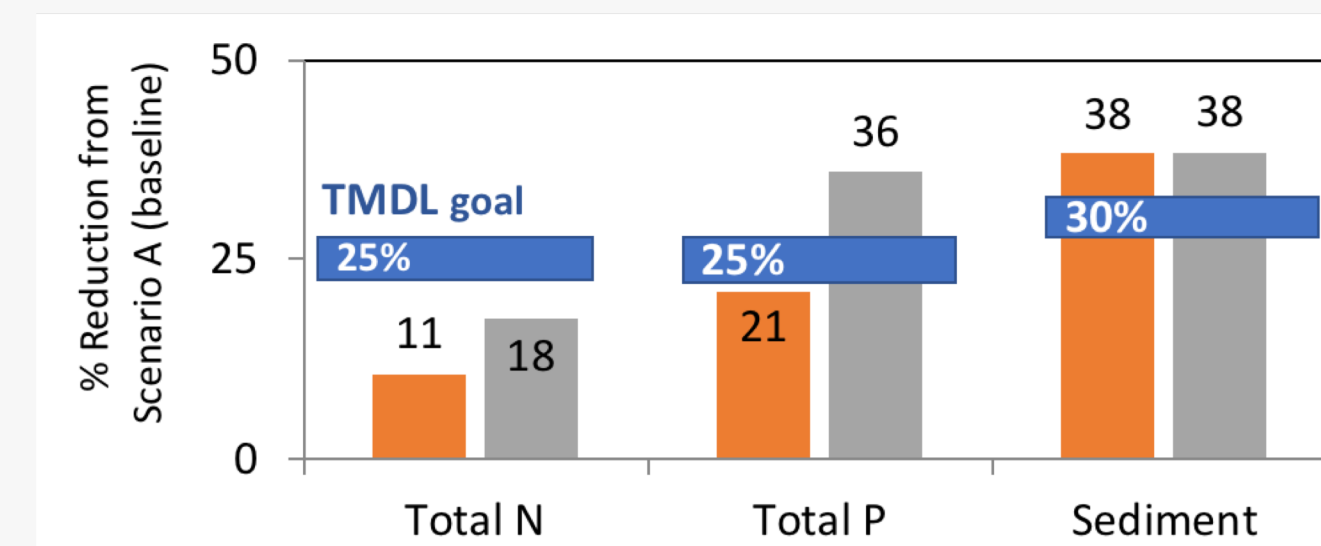
Mahantango

BMP cost
\$24/ha: WIP
\$7/ha: “smart”

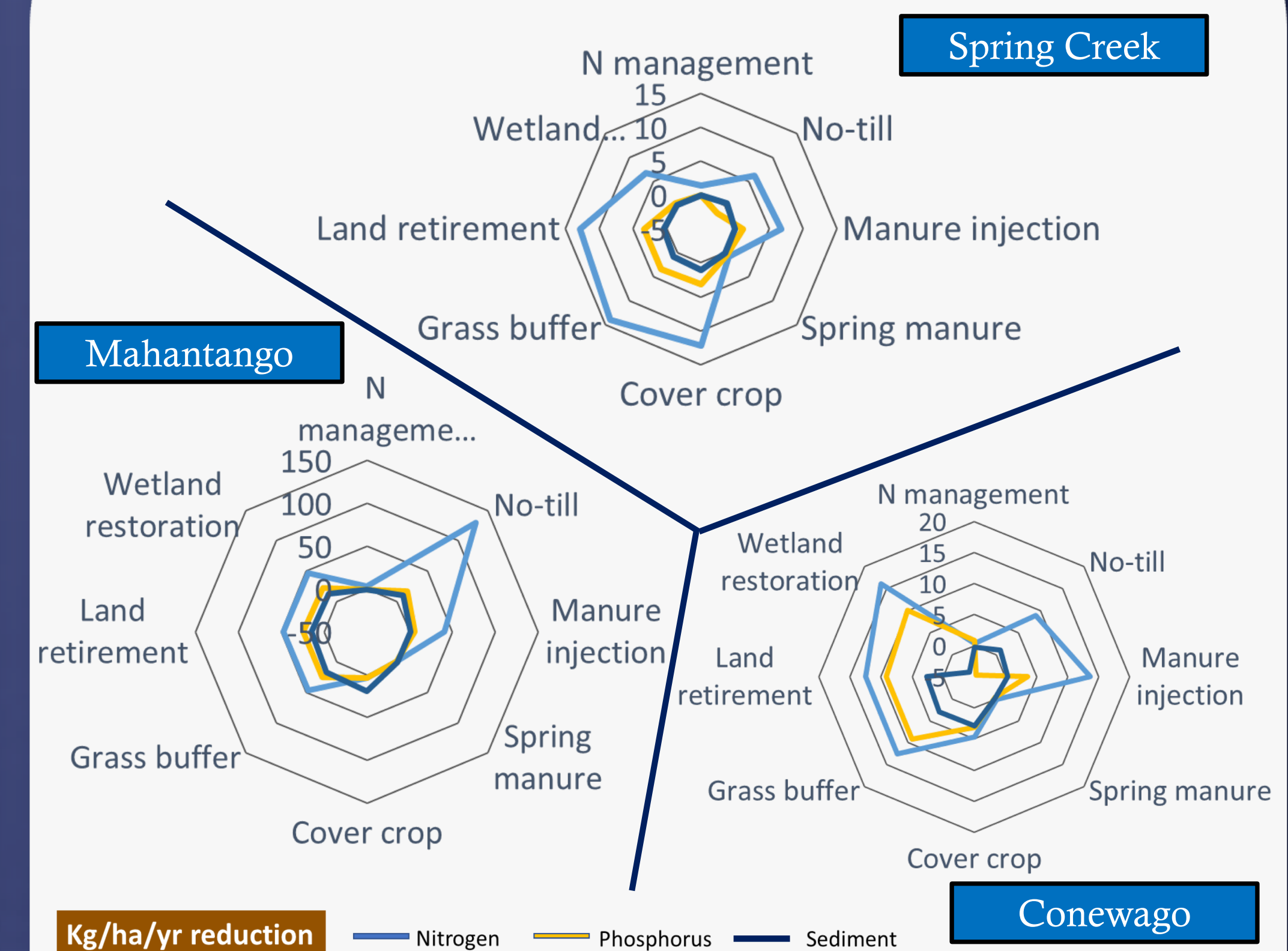


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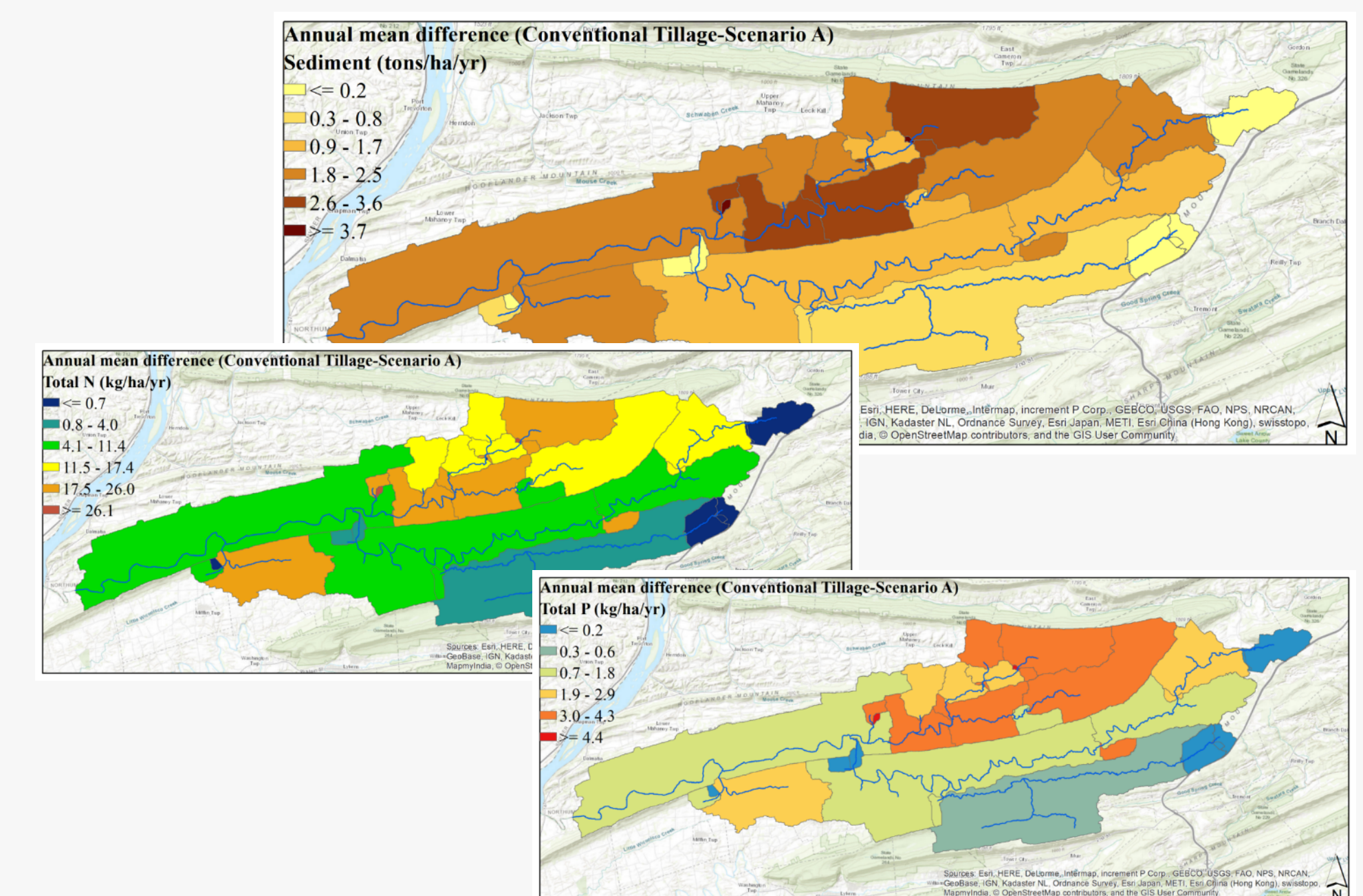
BMP cost
\$24/ha: WIP
\$14/ha: “smart”



Physiographic Regions Matter



Quantifying Current Impact Boosts Morale



Lessons Learned & Major Outcomes

- ❖ We can meet Bay's target load reduction at lowest cost by
 - ❖ No-till: reducing periods of soil disruption and bareness
 - ❖ Protecting stream edges
 - ❖ Making the most of manure and nutrients (incorporation and precision application)
- ❖ In-field management changes => low cost and big reward (improve soil health, reduce nutrient and erosion losses)
 - ❖ Manure timing and incorporation
 - ❖ Conservation tillage
 - ❖ Add cover crops and legumes to reduce N needs
- ❖ Space, place, and timing of stressors & management-related activities matter greatly
- ❖ Suites of management-based BMPs in critical areas leaves \$\$ for community improvements (e.g., streambeds, wetlands, rain gardens)

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