Adaptive Management in the Chesapeake Bay Program

Feedbacks between monitoring, modeling, and implementation

STAC Quarterly Meeting
March 9, 2022

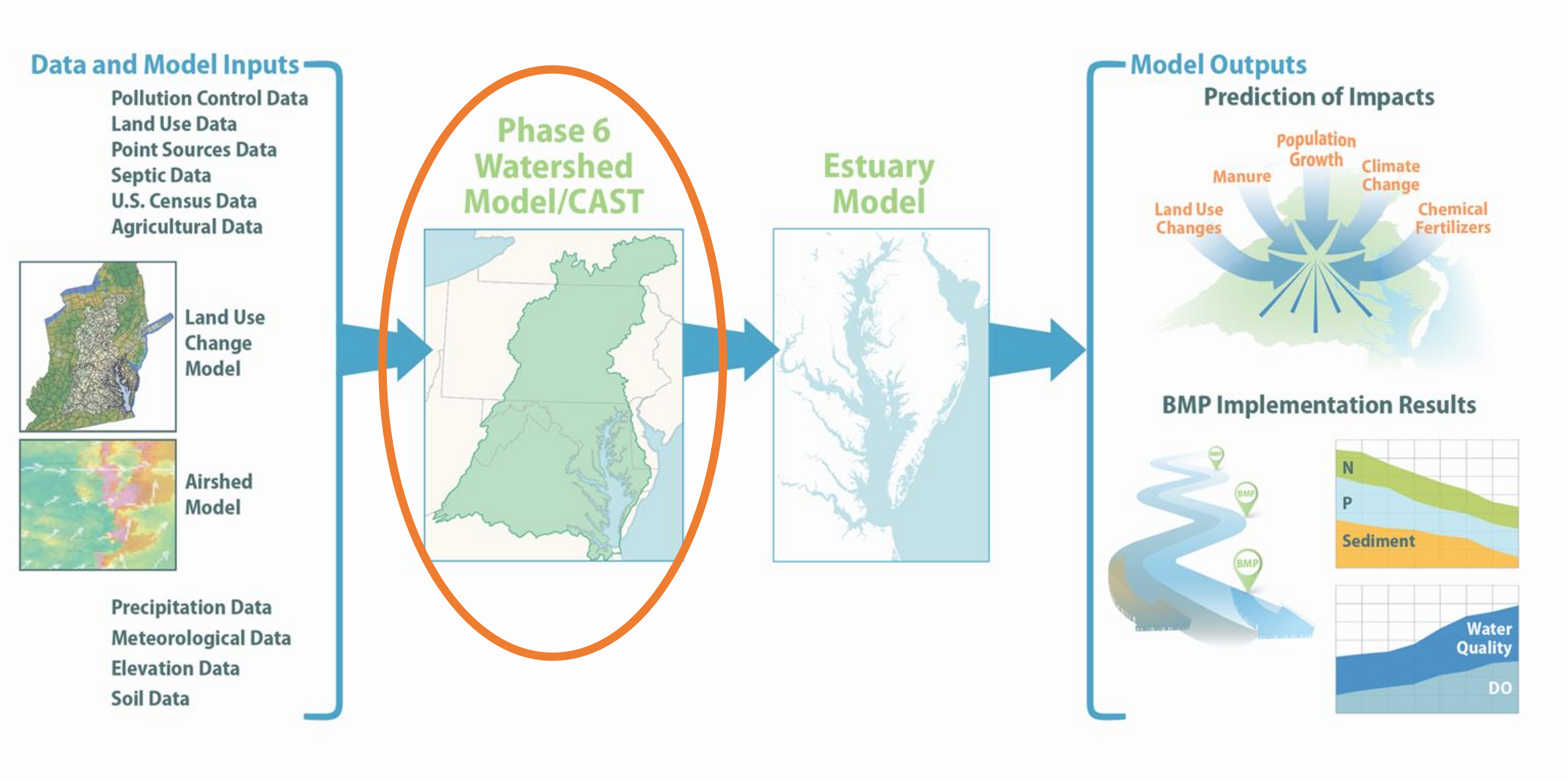
Jeni Keisman, USGS

With thanks to Olivia Devereux, Gary Shenk, and James Martin for materials

How can monitoring, modeling and implementation inform each other?

1. The CBP Modeling Framework and CAST
2. Monitoring Data for Model Evaluation
3. Translating to Management Action

CBP TMDL Modeling Framework



Courtesy Chesapeake Bay Program

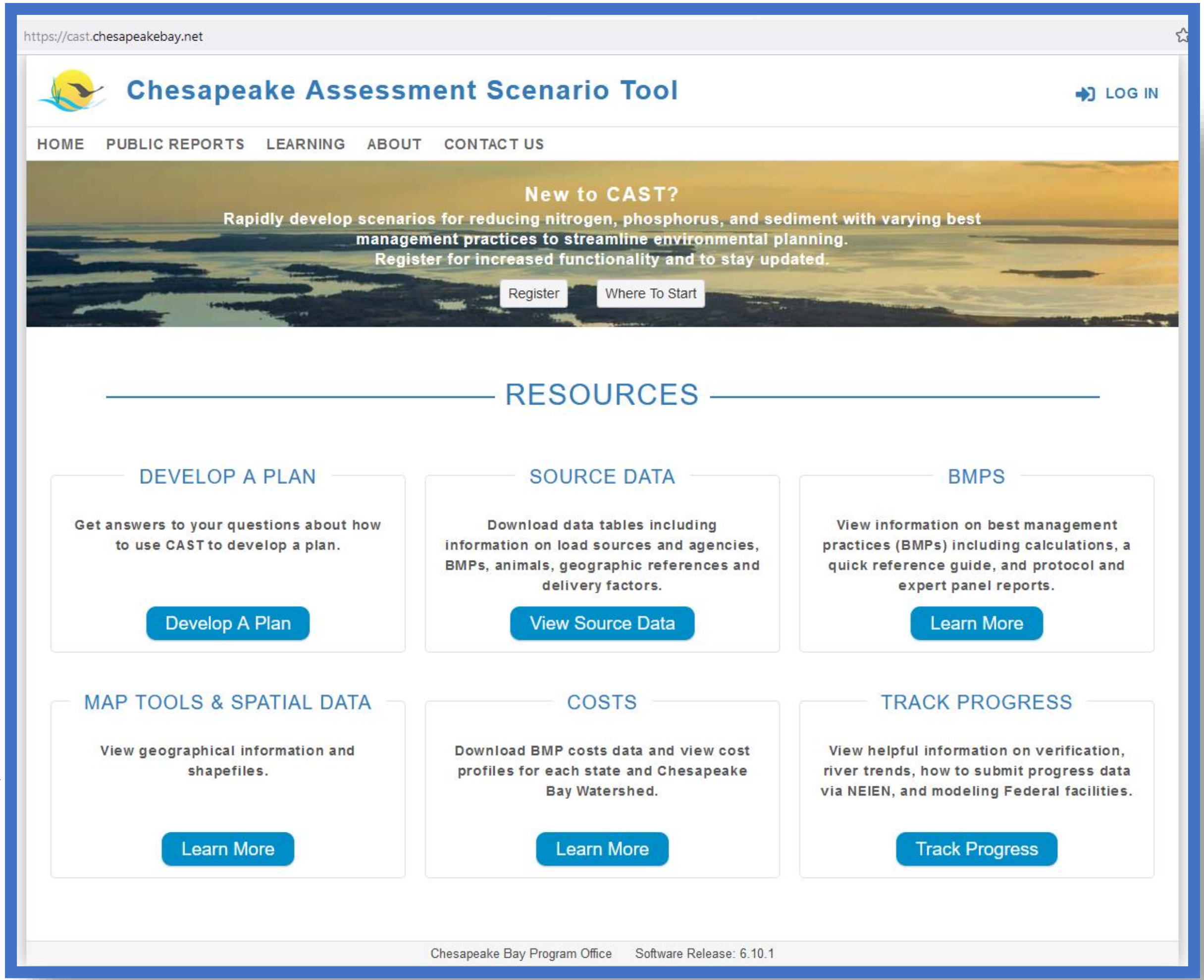
CAST is used to assess impacts of BMPs on Load Reductions

Dynamic Watershed Model

- Hydrology is time variable
- Calibration determines river delivery factors
- Feeds the Estuarine Model

Data Analyses used in CAST

- Online, publicly accessible
- Hydrology is the 10-year average
- Uses the data from the calibration
- Predict nitrogen, phosphorus, and sediment loads based on changes to inputs
- Includes the official management scenarios



CAST incorporates data from the time-variable, Dynamic Watershed Model

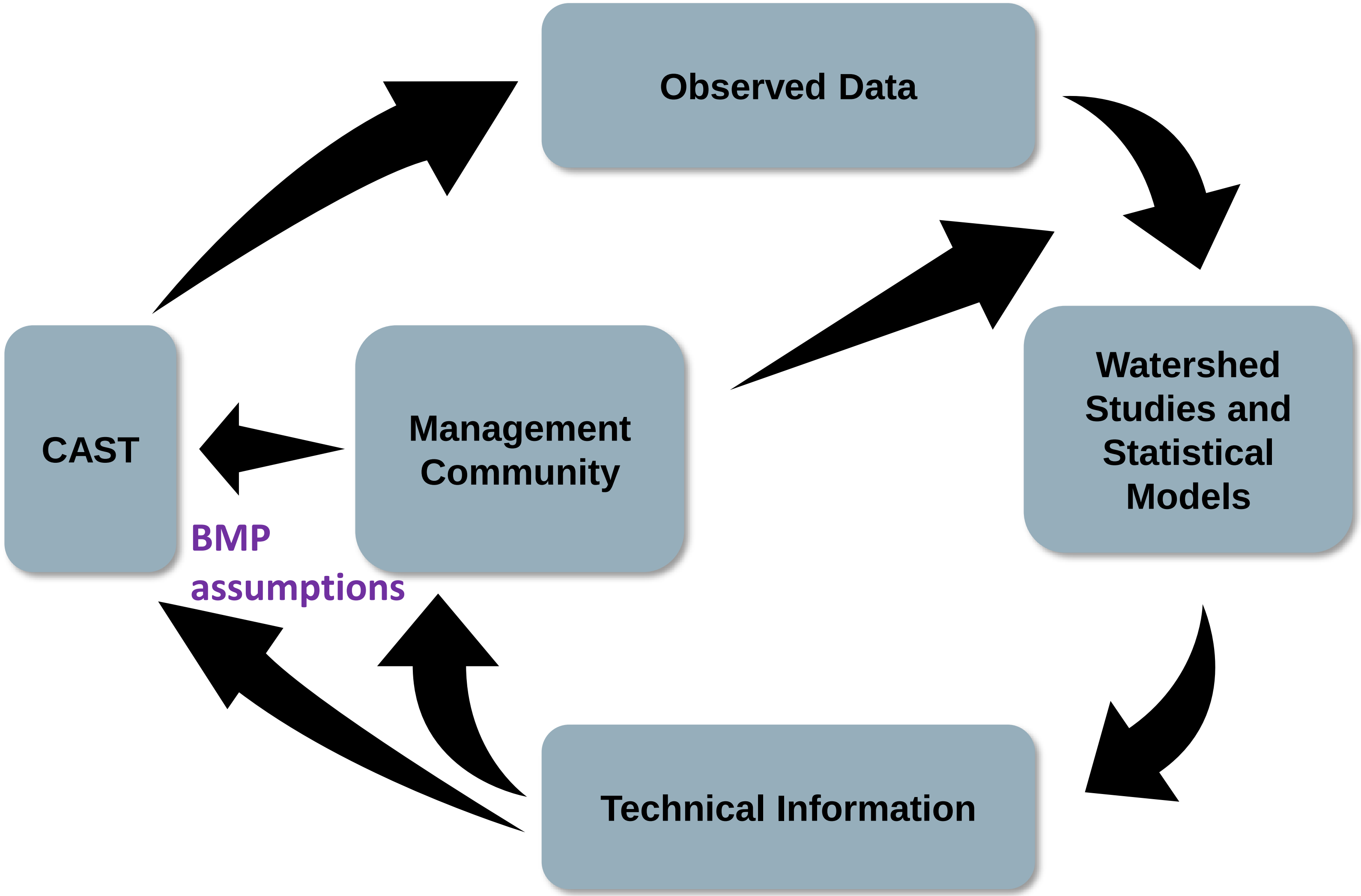
Courtesy CBP/Olivia Devereux

The Chesapeake Bay watershed model (CAST) is a comprehensive synthesis of knowledge that can help direct management

- **Observed data, Watershed studies and statistical models** provide **technical information** that is used to improve **CAST**.

- The **management community** uses **CAST** to develop management strategies.

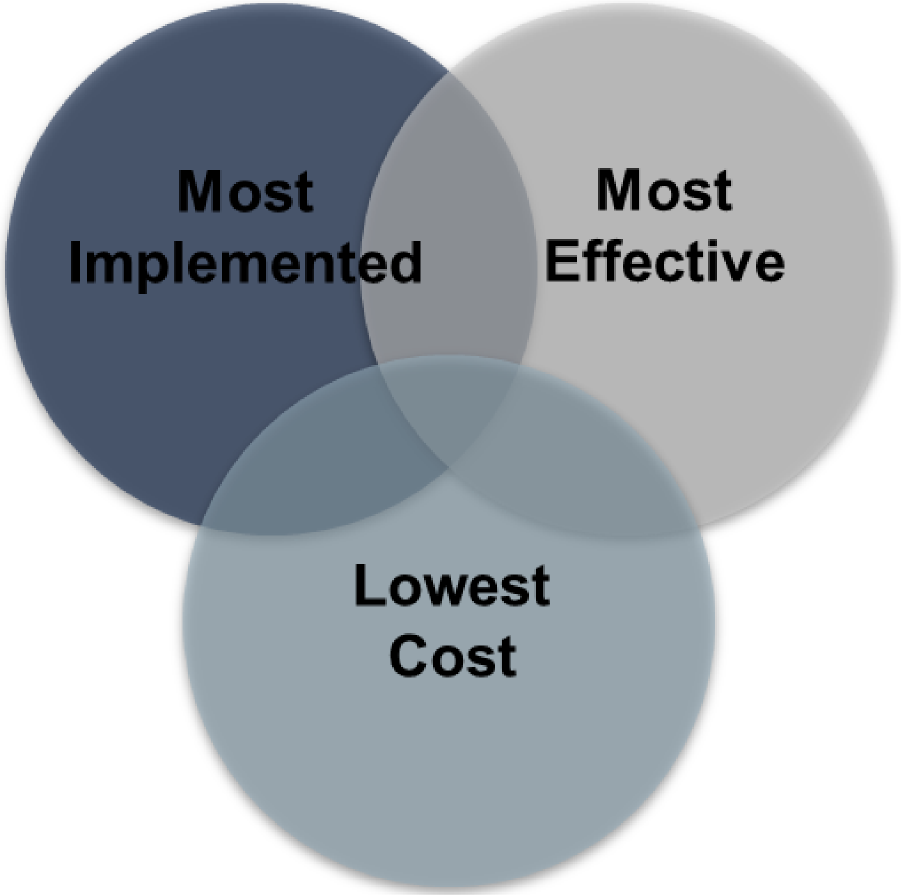
- **CAST** predictions and performance are assessed against **observed data**.



Courtesy CBP/Olivia Devereux

CAST is used to assess impacts of BMP implementation on Watershed Loads

- CAST provides estimates of BMP costs and expected nutrient/sediment reductions, customized by geography.
- High loading areas can be targeted for BMPs
- Managers can prioritize BMPs that offer the largest nutrient and sediment reductions at the lowest cost.



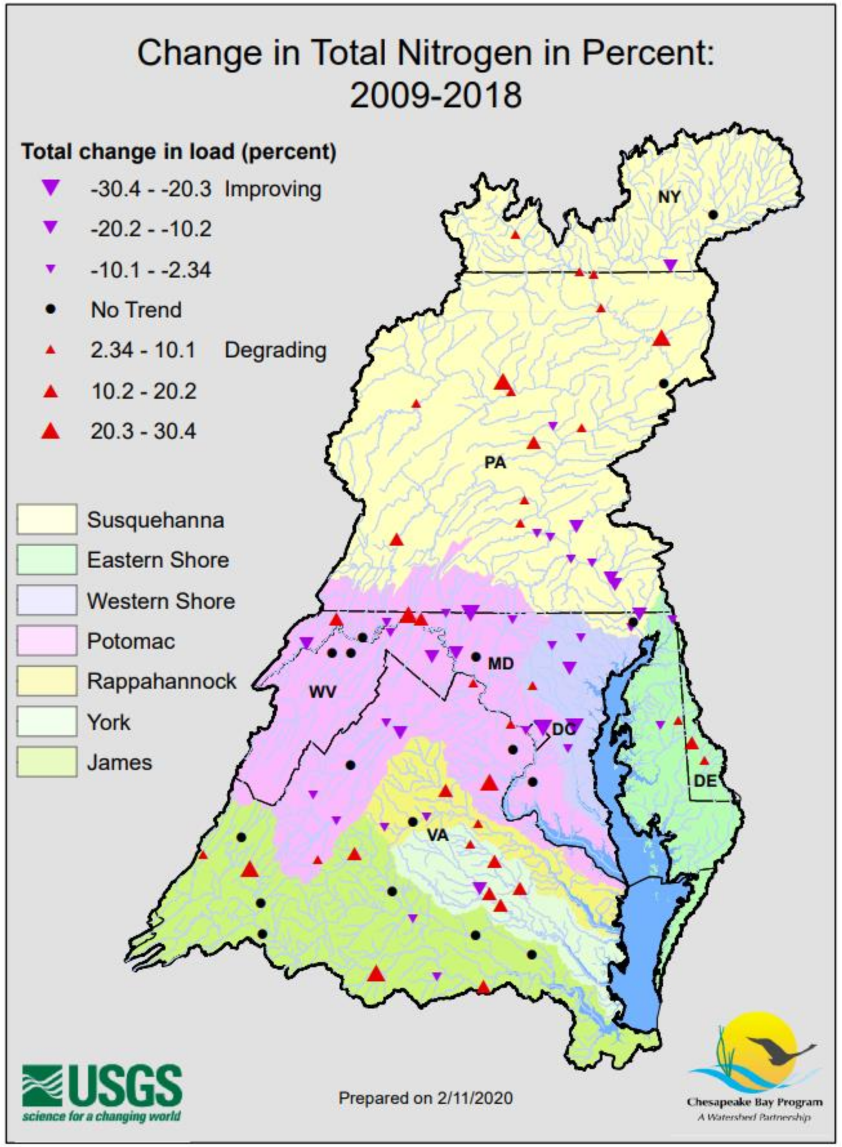
Learn more about these data and developing management plans by viewing CAST training videos: cast.chesapeakebay.net/Learning/FreeTrainingVideos

Courtesy CBP/Olivia Devereux

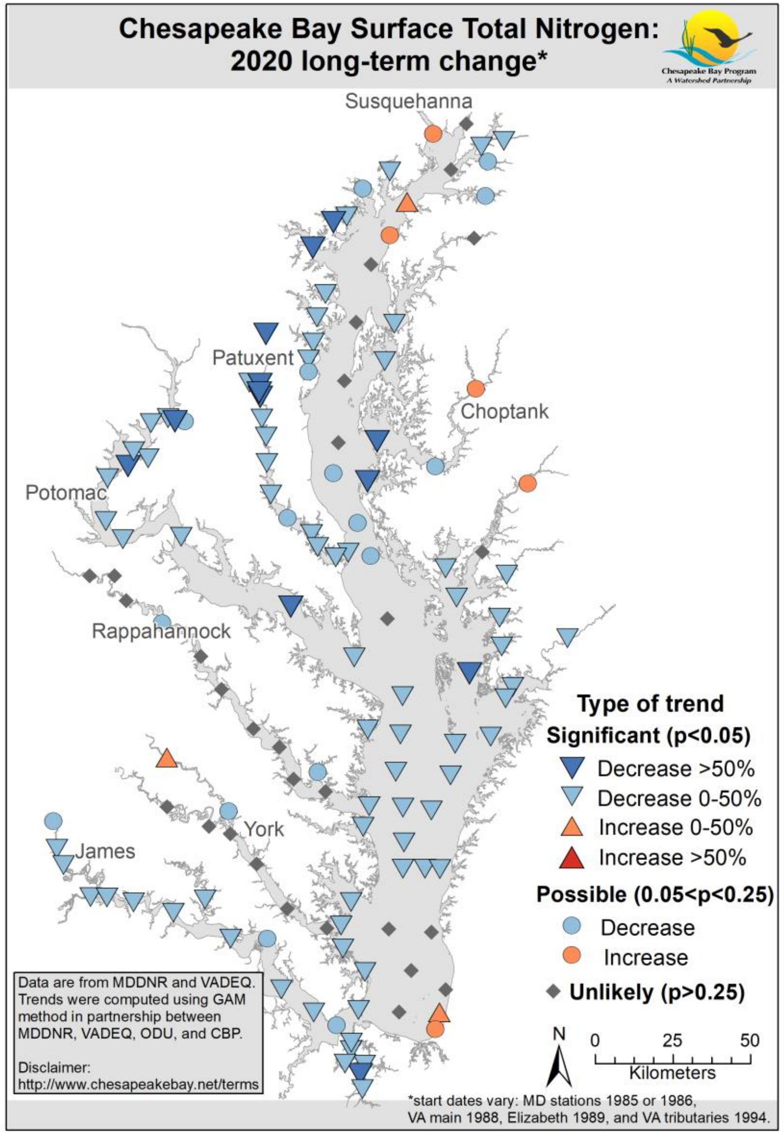
Using Monitoring Data for Model Evaluation

Monitoring Data for Model Evaluation

Trends at monitoring stations produced every 1-2 years



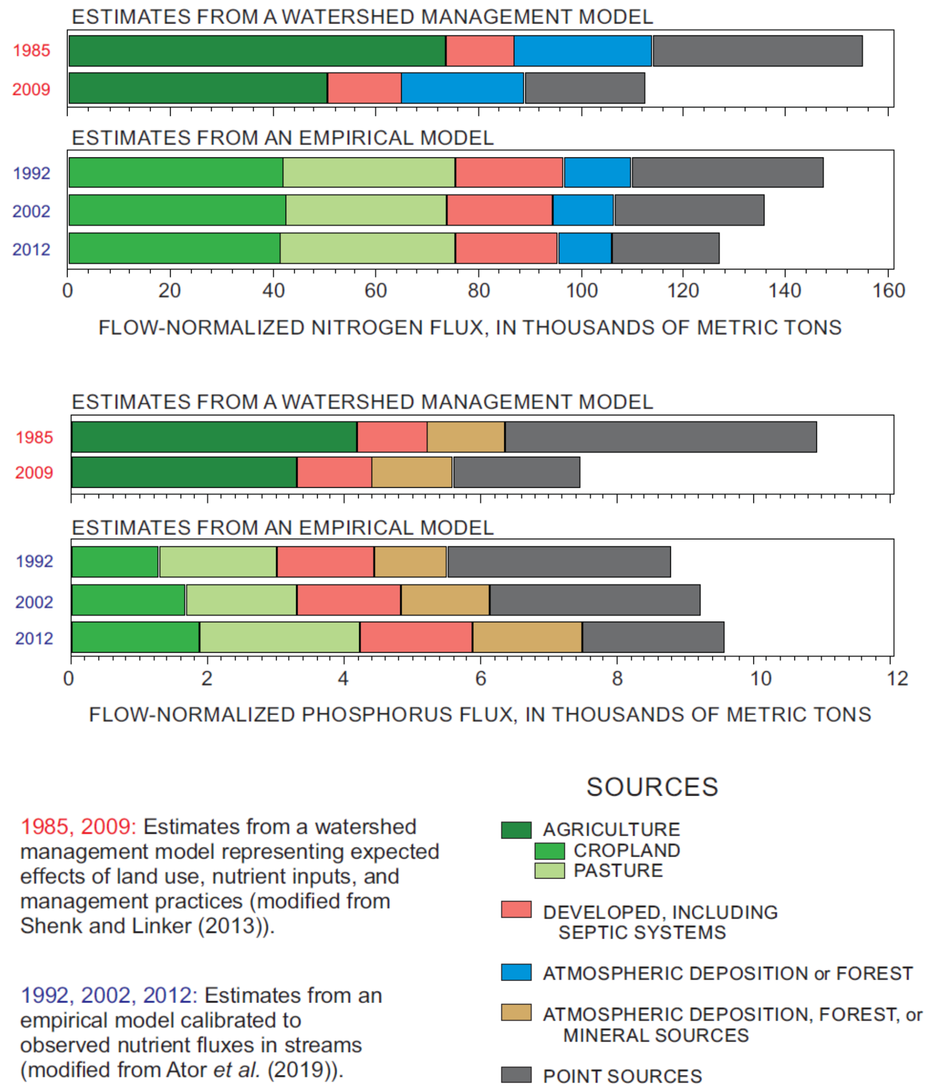
ST-NTN2018TN_TrendPct.pdf (usgs.gov)



tn_s_annual_longterm20.png (2250×3300) (chesapeakebay.net)

Science synthesis and empirical modeling for CBP Model Evaluation

New insights into factors driving complex trends



1985, 2009: Estimates from a watershed management model representing expected effects of land use, nutrient inputs, and management practices (modified from Shenk and Linker (2013)).

1992, 2002, 2012: Estimates from an empirical model calibrated to observed nutrient fluxes in streams (modified from Ator *et al.* (2019)).

Figure 3 in Ator and colleagues *J. Environ. Qual. 2020; 49:812-834*

Linking monitored loads to tidal station trends using data-driven models (GAMs)

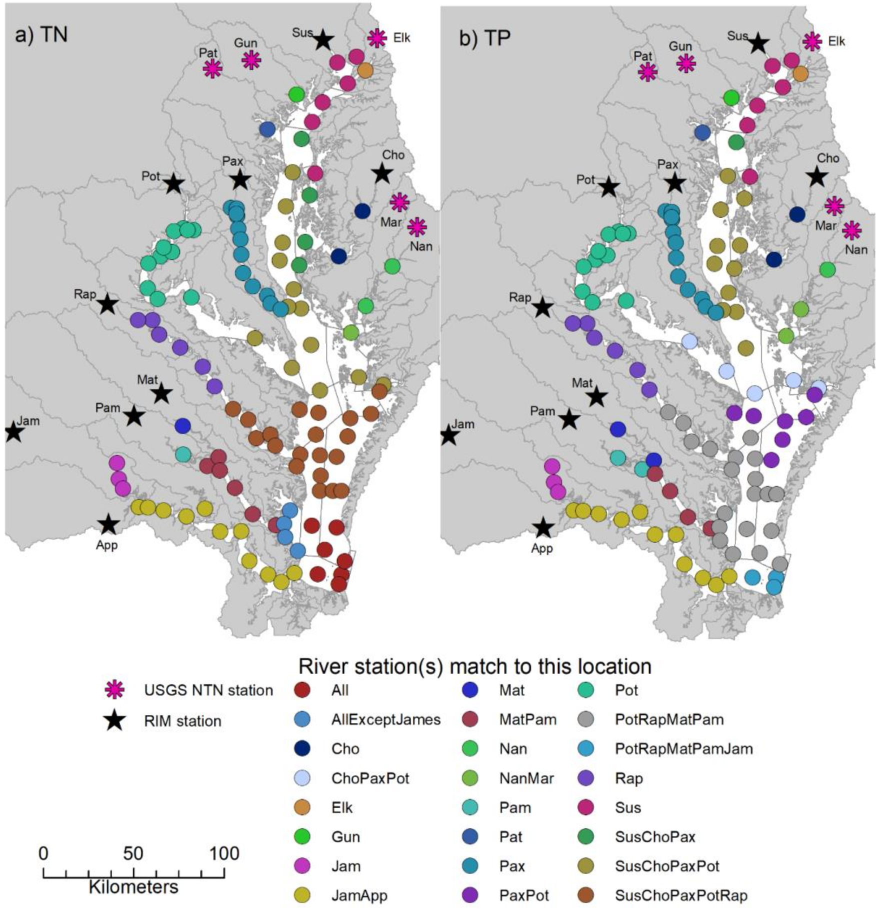
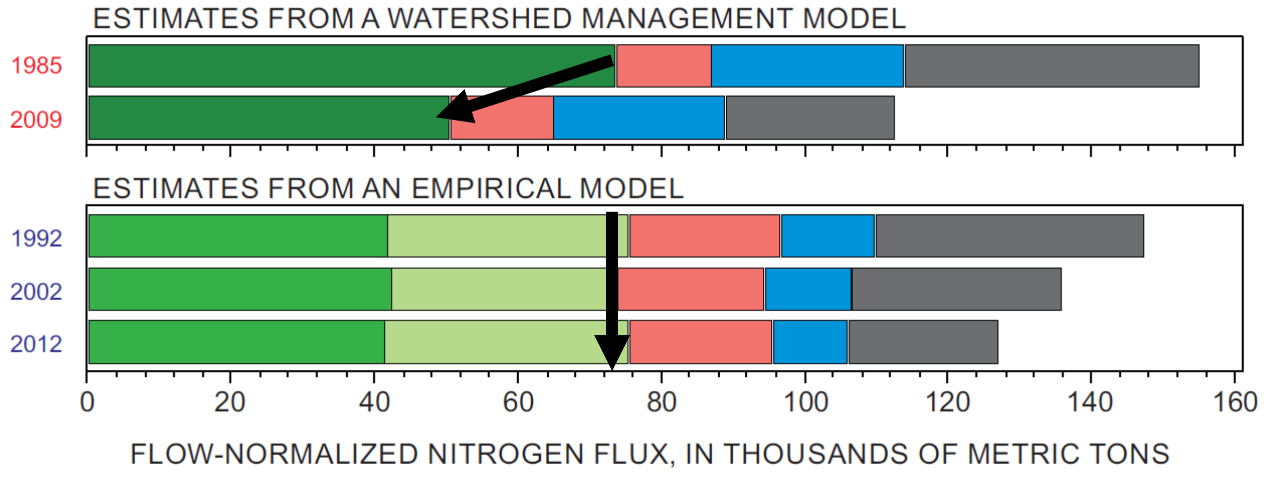


Figure S3. Spatial links of river loads to Chesapeake Bay estuary stations for TN (a) and TP (b). Point source matching follows the same spatial structure.

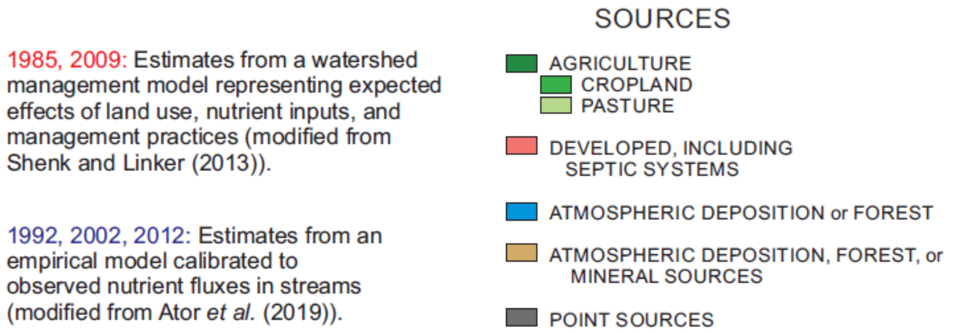
Figure S3 in Murphy and colleagues *Environ. Sci. Technol 2022, 56, 260-270*

Monitoring Data for Model Evaluation

Ph. 5 WSM said N loads from agriculture declined from mid-1980s to mid-2000s

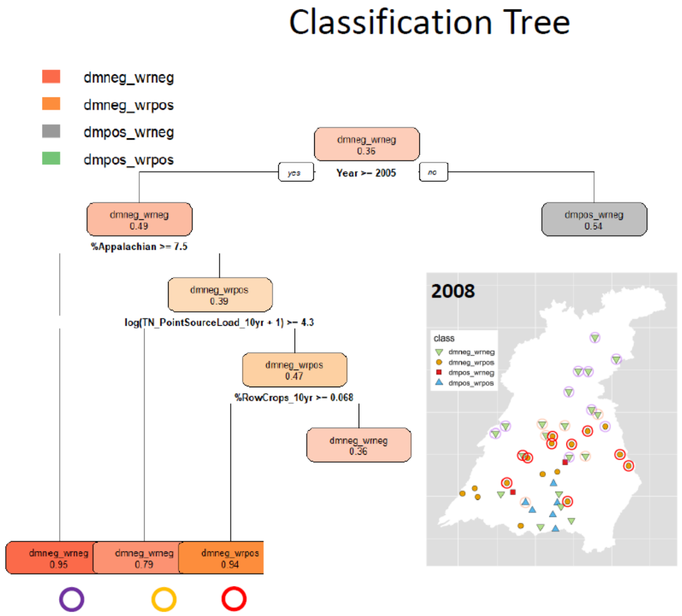


Empirical model calibrated to nutrient fluxes in streams disagreed



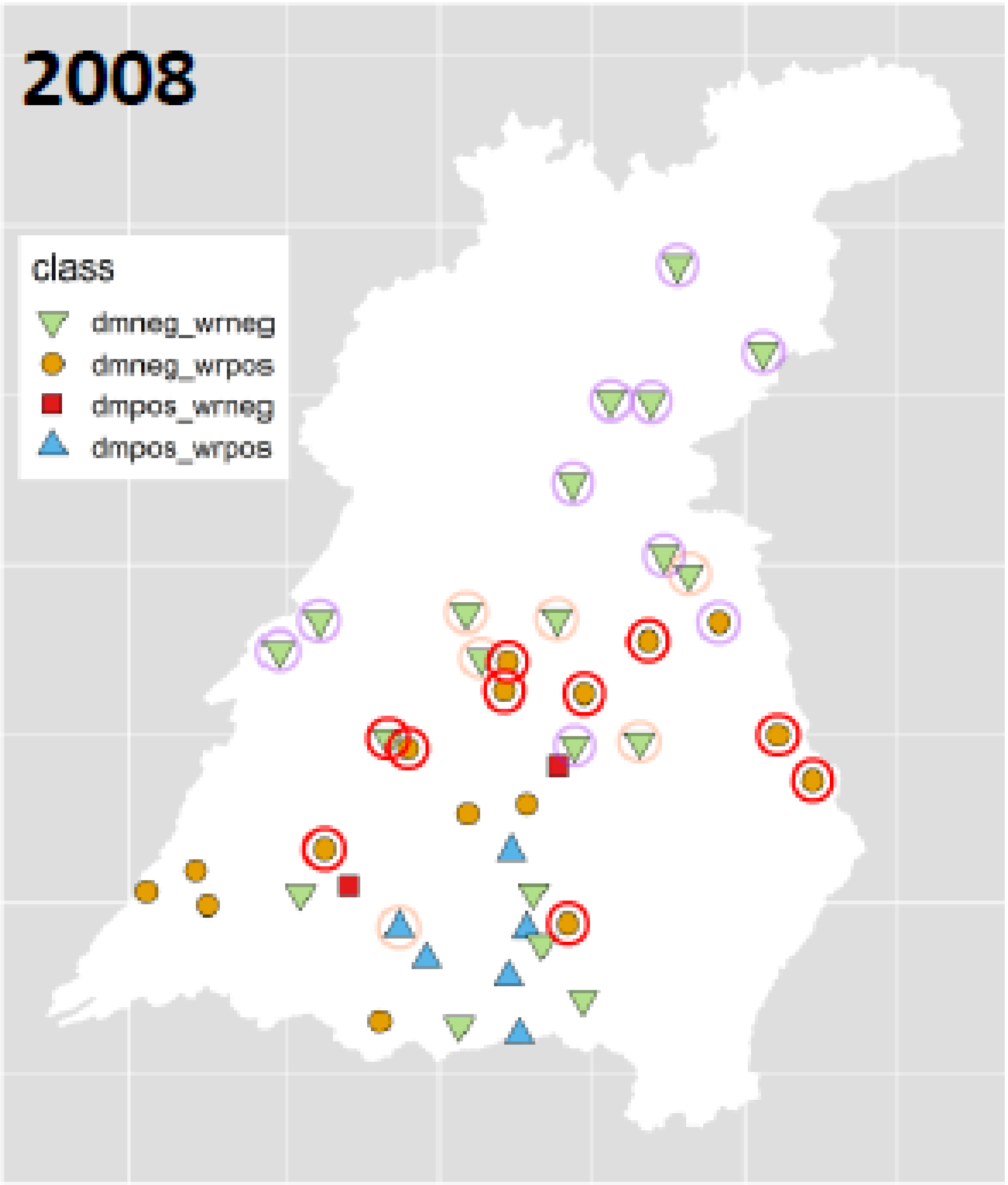
Adapted from Figure 3 in Ator and colleagues *J. Environ. Qual. 2020; 49:812-834*

Monitoring Data for Model Evaluation



Courtesy Isabella Bertani (UMCES) – Very Draft!

“at stations with relatively lower point source loads and larger amounts of row crop land use, WRTDS tends to exhibit a positive trend while DM has a negative trend… *even after lag times considered.”*



Translating to Management Action

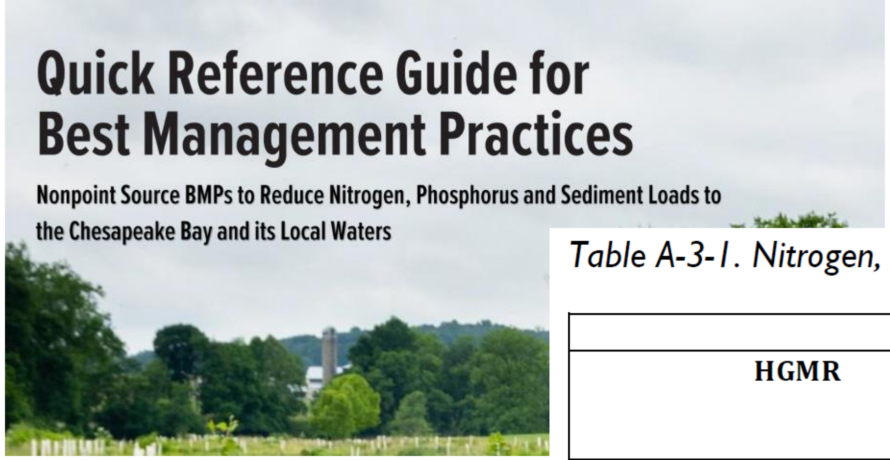
Example: CAST can inform policy decisions

- MD Dept of Agriculture used CAST scenario results to rank BMPs in terms of the most TN reduction.
- They considered this information when setting policies to increase cost share funding for the most effective BMPs.

1	BMP	Geography	Unit	CostPerUnitOfBmp	TNLbsReducedPerUnit	Nitrogen $/lb reduced/year
455	Algal Flow-way Tidal	Maryland (CBWS Portion Only)	Acres	67494.22	545.00	123.84
458	Algal Flow-way Non-Tidal	Maryland (CBWS Portion Only)	Acres	67494.22	434.83	155.22
465	Oyster reef restoration – nutrient assimilatic	Maryland (CBWS Portion Only)	Acres	1167.27	24.00	48.64
513	Forest Harvesting Practices	Maryland (CBWS Portion Only)	Acres	59.27	3.90	15.19
521	Wetland Rehabilitation	Maryland (CBWS Portion Only)	Acres	442.22	3.49	126.57
524	Wetland Enhancement	Maryland (CBWS Portion Only)	Acres	237.63	3.49	68.01
529	Urban Shoreline Management	Maryland (CBWS Portion Only)	Feet	76.87	0.086	890.56
533	Non Urban Shoreline Management	Maryland (CBWS Portion Only)	Feet	13.12	0.086	152
537	Non Urban Stream Restoration	Maryland (CBWS Portion Only)	Feet	105.34	0.060	1760.39
542	Urban Stream Restoration	Maryland (CBWS Portion Only)	Feet	105.34	0.060	1760.39
544	Triploid Oyster Aquaculture Greater than 6.(	Maryland (CBWS Portion Only)	Oysters Harvested	0.11	0.00148	74.48
551	Triploid Oyster Aquaculture 5.0 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.11	0.00097	113.4
562	Diploid Oyster Aquaculture Greater 6.0 Inch	Maryland (CBWS Portion Only)	Oysters Harvested	0.12	0.00068	175.7
563	Triploid Oyster Aquaculture 4.0 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.11	0.00057	191.97
569	Diploid Oyster Aquaculture 5.0 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.12	0.00048	247.42
572	Diploid Oyster Aquaculture 4.0 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.11	0.00033	332.33
578	Triploid Oyster Aquaculture 3.0 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.11	0.00029	383.28
581	Diploid Oyster Aquaculture 3.0 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.12	0.00020	606.06
585	Triploid Oyster Aquaculture 2.25 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.11	0.00013	833.33
587	Diploid Oyster Aquaculture 2.25 Inches	Maryland (CBWS Portion Only)	Oysters Harvested	0.11	0.00011	1000

Courtesy CBP/Olivia Devereux

When CAST assumptions change, implementation scenario outcomes change



BMP-Guide_Full.pdf (chesapeakebay.net)

Table A-3-1. Nitrogen, Phosphorus and Sediment Efficiency Value Reductions for Tillage Practices

	Nitrogen Reductions (%)			Phosphorus Reductions (%)			Sediment Reductions (%)		
HGMR	**Low Residue**	**Conser-vation Tillage**	**High Residue**	**Low Residue**	**Conser-vation Tillage**	**High Residue**	**Low Residue**	**Conser-vation Tillage**	**High Residue**
Appalachian Plateau, Siliciclastic	5	10	14	7	17	27	18	41	79
Appalachian Plateau, Carbonate	5	10	14	7	27	38	18	41	79
Blue Ridge	5	10	14	8	50	63	18	41	79
Coastal Plain Dissected Upland	2	4	12	8	35	47	18	41	79
Coastal Plain Lowland	2	4	15	6	2	11	18	41	79
Coastal Plain Upland	2	4	12	7	16	26	18	41	79
Mesozoic Lowland	5	10	14	7	21	32	18	41	79
Piedmont Carbonate	5	10	14	9	60	74	18	41	79
Piedmont Crystalline	5	10	14	9	58	71	18	41	79
Valley and Ridge Carbonate	5	10	14	9	57	71	18	41	79
Valley and Ridge Siliciclastic	5	10	14	8	49	62	18	41	79

“if a state submits that 100 percent of acres within a county in the Appalachian Plateau Siliciclastic region are covered by High Residue Tillage Management, then nitrogen from all acres will be reduced by 14 percent, phosphorus by 27 percent and sediment by 79 percent as compared to the same land under conventional tillage.”

How does this translate to implementation in the real world?

Why is it so difficult to build an effective Watershed Implementation Plan?

Courtesy James Martin, December 2017 STAC Workshop

How does this translate to the real world?

Technical Challenges

- Knowledge
- Timing
- Scale
- BMP Selection & Performance information
- Co-Benefits
- Uncertainty

Social/Political Challenges

- Fairness/Equity
- Property Rights
- Public Resources
- Communications
- Competition for Resources and Attention

Courtesy James Martin, December 2017 STAC Workshop

Technical Challenges

Knowledge:

- May not know the science exists
- May not be able to translate the science into action

Timing:

- Driven by the CBP’s accountability schedule
  - Midpoint Assessment deadlines
  - Ongoing 2-year milestones in Fall/Winter of odd years
- Is the information available when it is needed?

Scale:

- Science needs to be valid and meaningful at the ***planning scale***
- We are being asked to plan and engage stakeholders at the local scale (city/county)
- What scale of decision making is supported by the models and science synthesis products?

Courtesy James Martin, December 2017 STAC Workshop

Technical Challenges

BMP Performance:

- *"Using a statewide or even countywide approach is easier, but it is almost certainly wrong"*
- Can pick the BMPs with highest reduction and cost efficiencies in the model
- Implementation decisions need to be made at the parcel/field scale.
- Harder to pick the right BMPs for a particular place in the real world
- Need evidence of which (where) actions have proven to be effective/ineffective in observed water quality response

Courtesy James Martin, December 2017 STAC Workshop

Social/Political Challenges

- Fairness/Equity
- Property Rights
- Public Resources
- Communications
- Competition for Resources and Attention

Technical Challenges - Co-Benefits

- How do we maximize the net benefits (ecological, economic, societal, etc.) from our implementation decisions?
- Local implementation partners need to maximize their return on their investment.
- Many are focused on priorities other than Bay restoration

Courtesy James Martin, December 2017 STAC Workshop

The End