

# Climate Change and the Chesapeake TMDL

Gary Shenk

Presentation to STAC BioChar Workshop 5/25/23



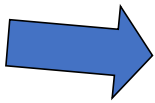
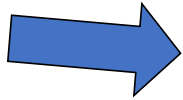
Less of  
This



More of  
This

# Conceptual Model

Nutrient sources . . .



. . . acting in different landscapes . .

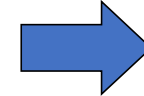
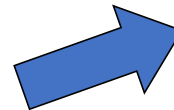


...with different management...

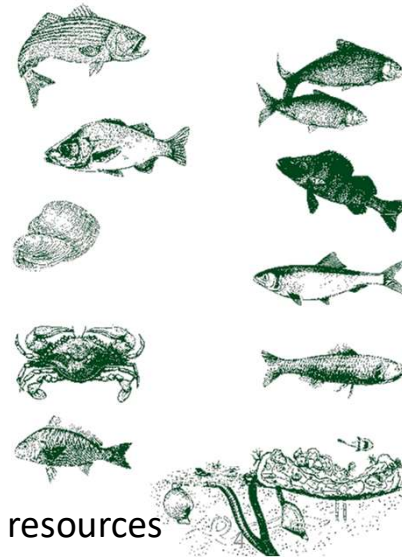


. . . affects oxygen...

O<sub>2</sub>



...which affects living resources

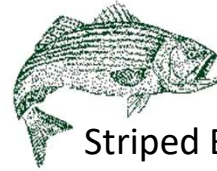


# Bay Dissolved Oxygen Criteria

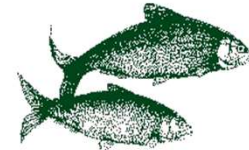
Minimum Amount of Oxygen (mg/L) Needed to Survive by Species

Migratory Fish Spawning & Nursery Areas

6



Striped Bass: 5-6



American Shad: 5

Shallow and Open Water Areas

5



White Perch:



Yellow Perch: 5

4



Hard Clams: 5

Deep Water

3



Crabs: 3

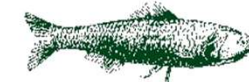


Alewife: 3.6

2



Spot: 2



Bay Anchovy: 3

Deep Channel

1

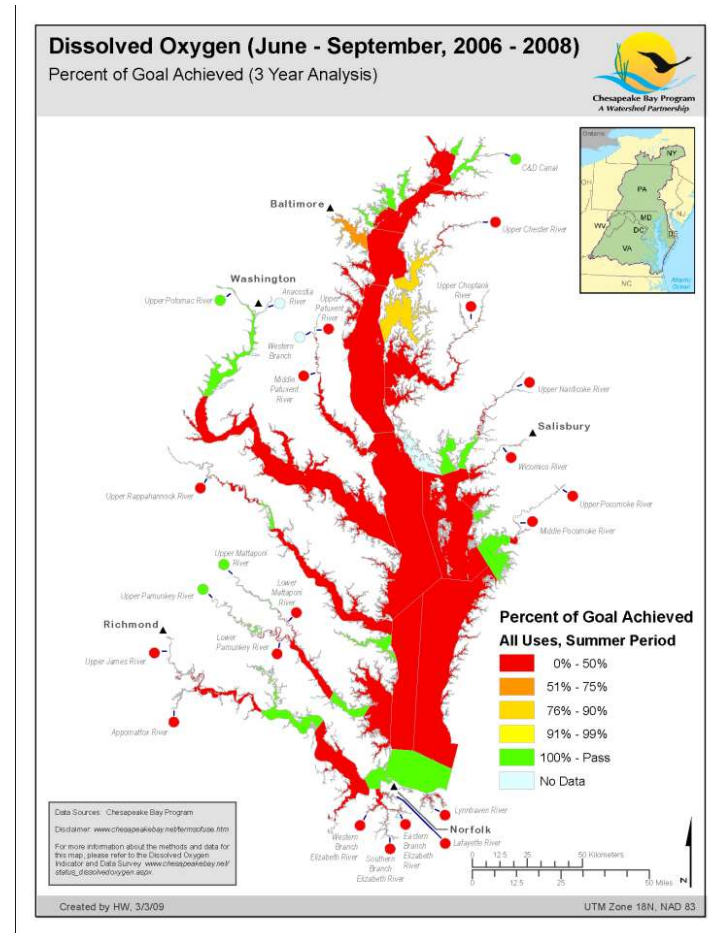


Worms: 1

0

# Chesapeake Bay TMDL

Necessitated by failure to meet water quality standards



# TMDL Models



If we change what we do on the landscape...

...how will that change nitrogen, phosphorus, and sediment?

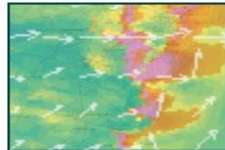
...and what will be the oxygen, clarity, and chlorophyll in the Chesapeake Bay?

## Data and Model Inputs

- Pollution Control Data
- Land Use Data
- Point Sources Data
- Septic Data
- U.S. Census Data
- Agricultural Data



Land Use Change Model



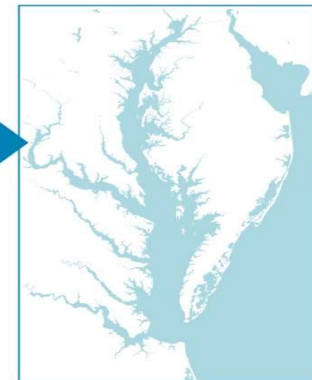
Airshed Model

- Precipitation Data
- Meteorological Data
- Elevation Data
- Soil Data

## Phase 6 Watershed Model/CAST



## Estuary Model



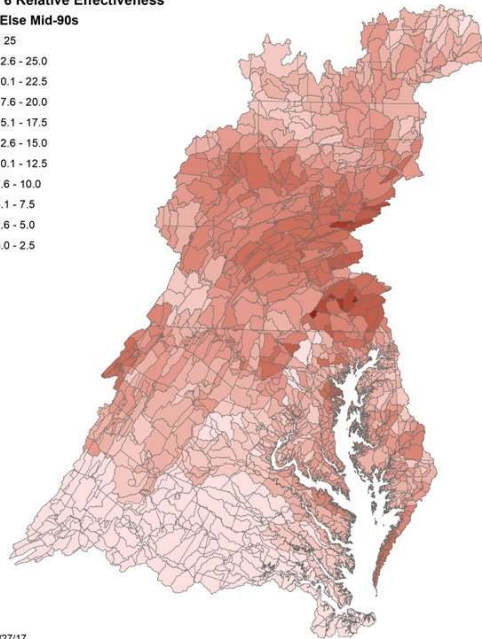
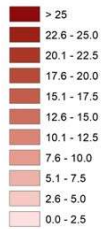
*Dissolved Oxygen effect per pound of nutrient released in the watershed*

# Dividing up the effort: More Impact, Do More

## Nitrogen

Phase 6 Relative Effectiveness

TN All Else Mid-90s

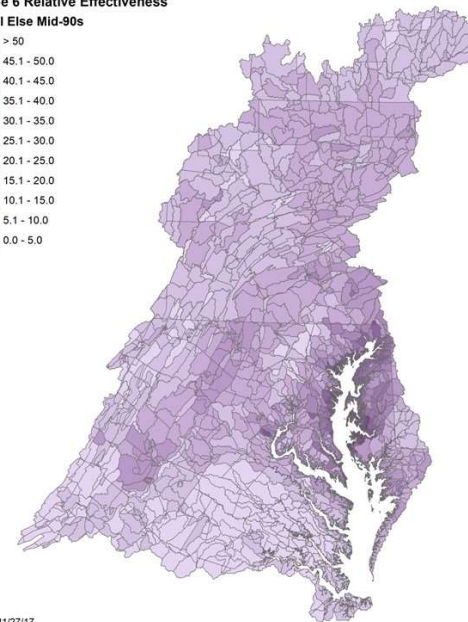
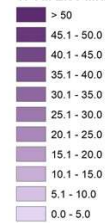


11/27/17

## Phase 6 Phosphorus

Phase 6 Relative Effectiveness

TP All Else Mid-90s

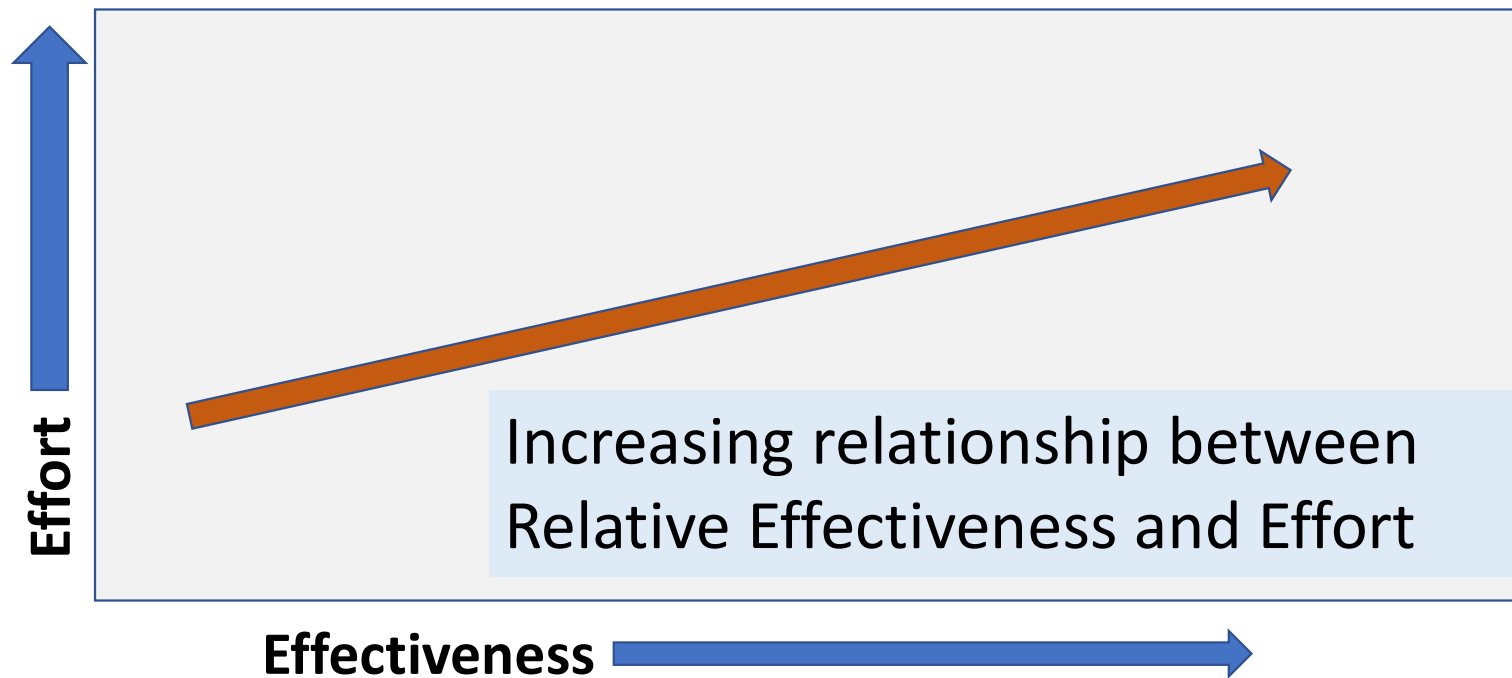


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# Guidelines for Reduction Goals

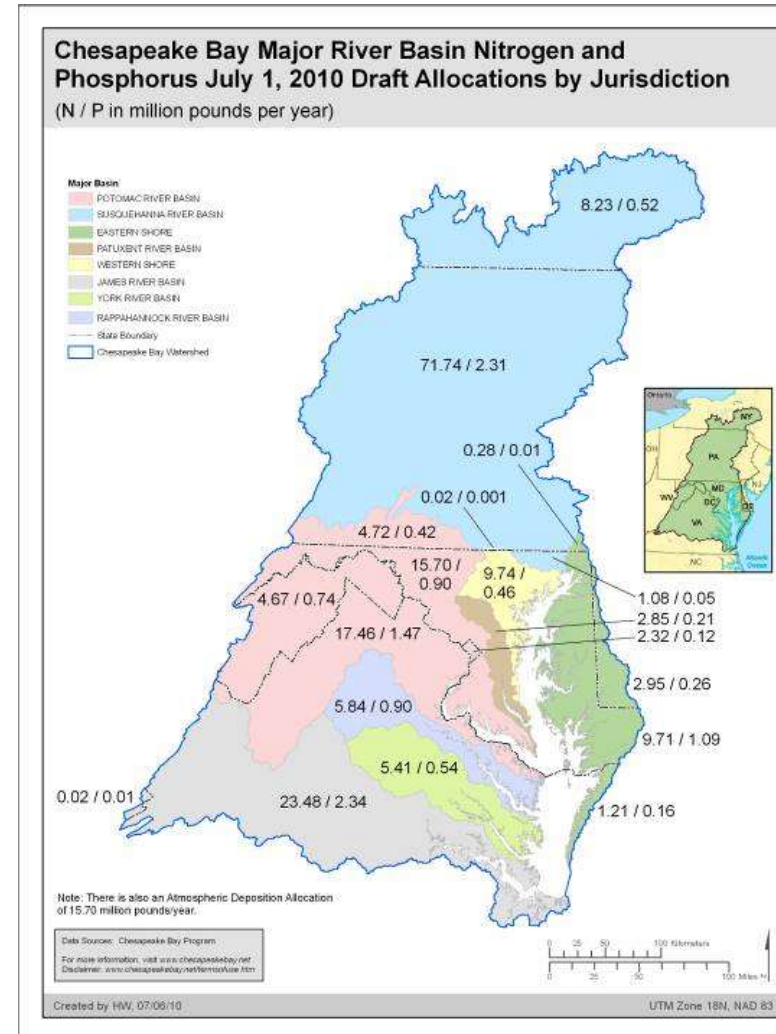
- Areas that contribute the most to the problem must do the most to resolve the problem.



# TMDL Decision

## State-basin allocations

Nitrogen, Phosphorus, and Sediment  
Sufficient to meet oxygen, clarity, and  
chlorophyll water quality standards



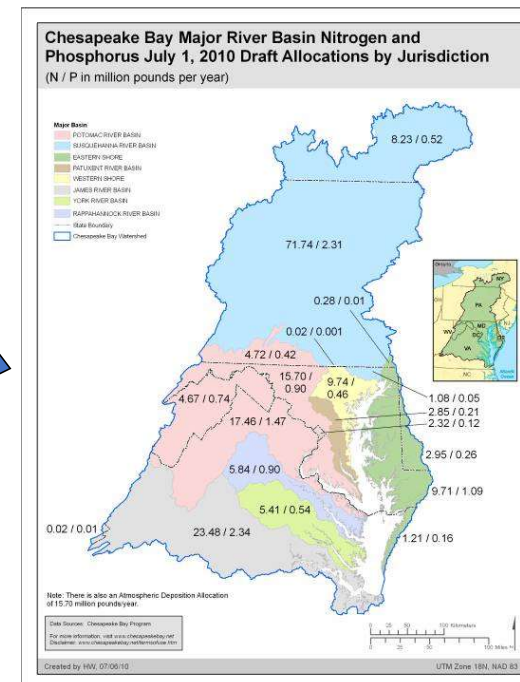
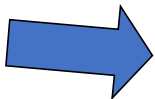
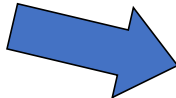
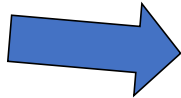
# Watershed Implementation Plans (WIPs)

Reduce sources...

... Protect landscapes ...

...install management practices...

... to hit nutrient targets



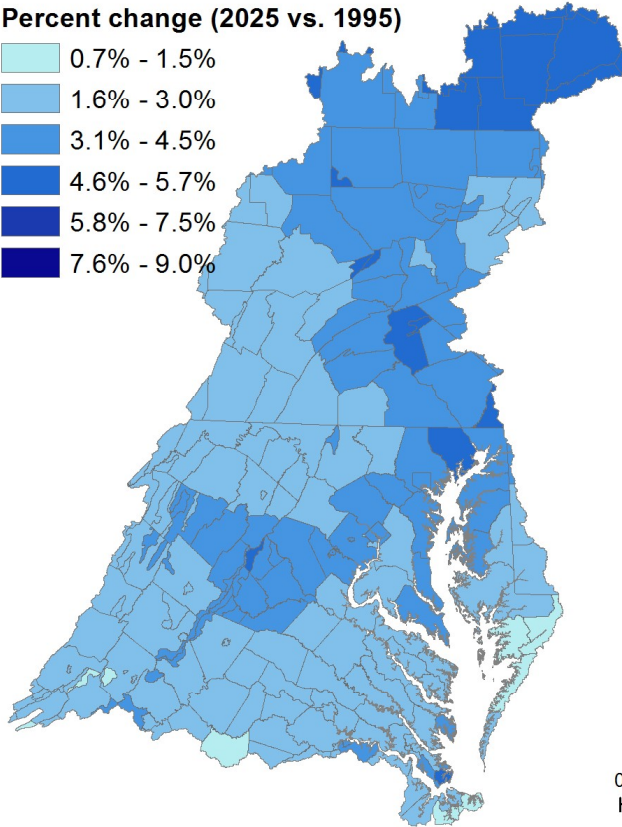
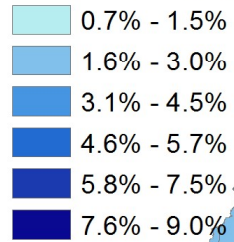
# TMDL is a continuation of previous goals

Year	Phase	Goal
• 1987	0	40% reduction (Watershed & Bay models unlinked)
• 1992	2	40% of controllable loads (forest, air, NY, DE, WV unlinked)
• 1997	4.1	Added VA Tribs. (Rappahannock, York, & James with controls)
• 2003	4.3	Reallocation of Tributary Strategies
• 2010	5.3.0	2010 Chesapeake TMDL
• 2011	5.3.2	Phase 2 WIP targets
• <b>2017</b>	<b>6</b>	<b>Phase 3 WIP targets (You are here!)</b>
• 2028	7	TBD

## YEAR 2025

2025 Extrapolation of Long-term Trends

Percent change (2025 vs. 1995)

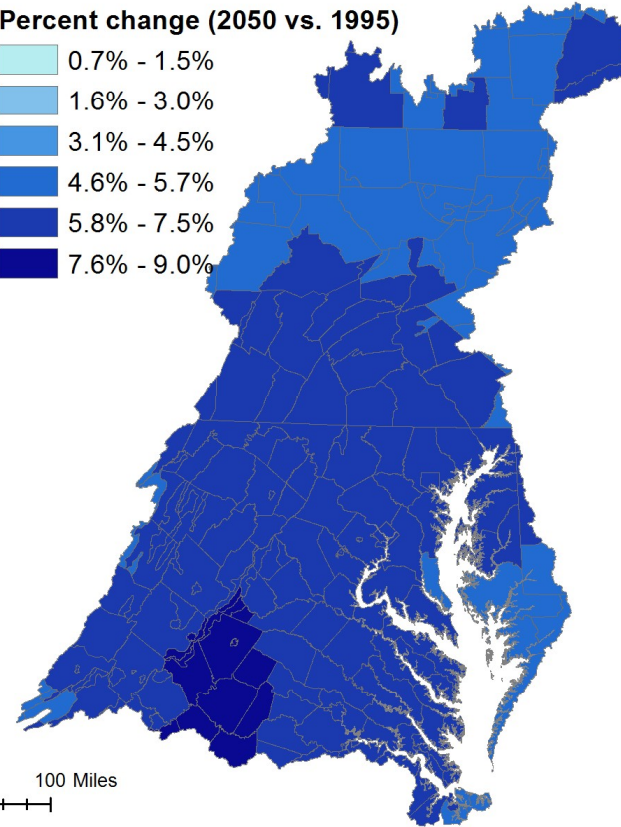
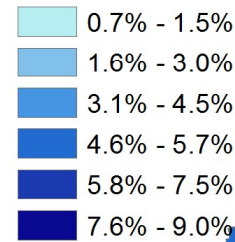


**3.11% increase in average annual rainfall volume**

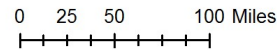
## YEAR 2050

RCP 4.5 31 Member Ensemble Median

Percent change (2050 vs. 1995)

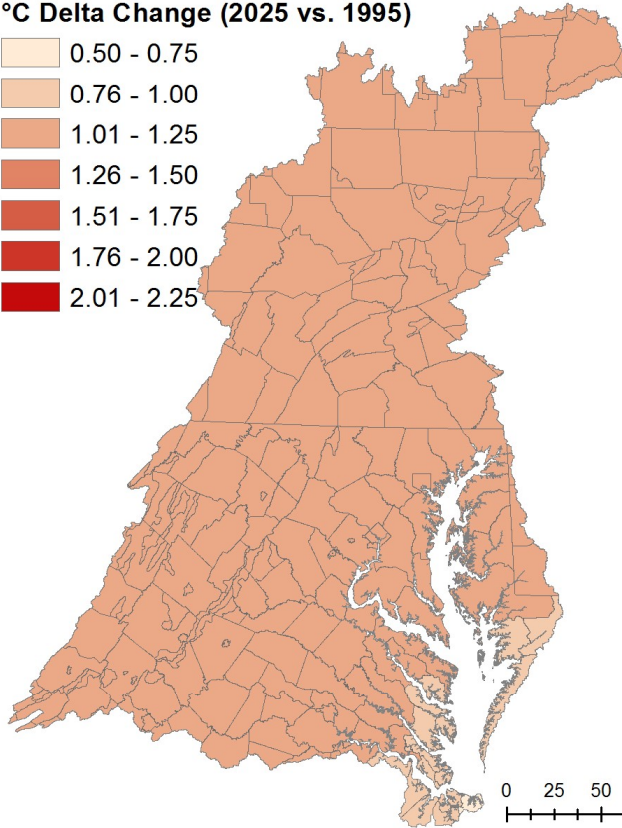
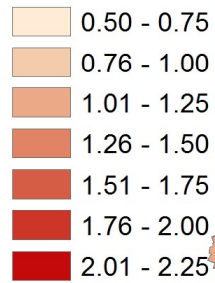


**6.28% increase in average annual rainfall volume**



## YEAR 2025

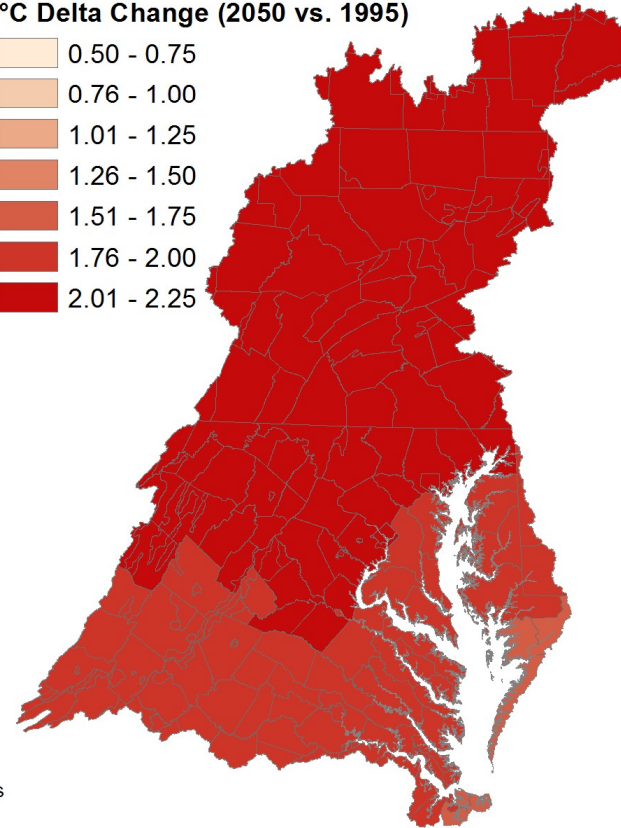
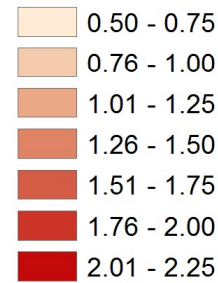
RCP 4.5 31 Member Ensemble Median  
°C Delta Change (2025 vs. 1995)



**1.12°C increase in average  
annual temperature**

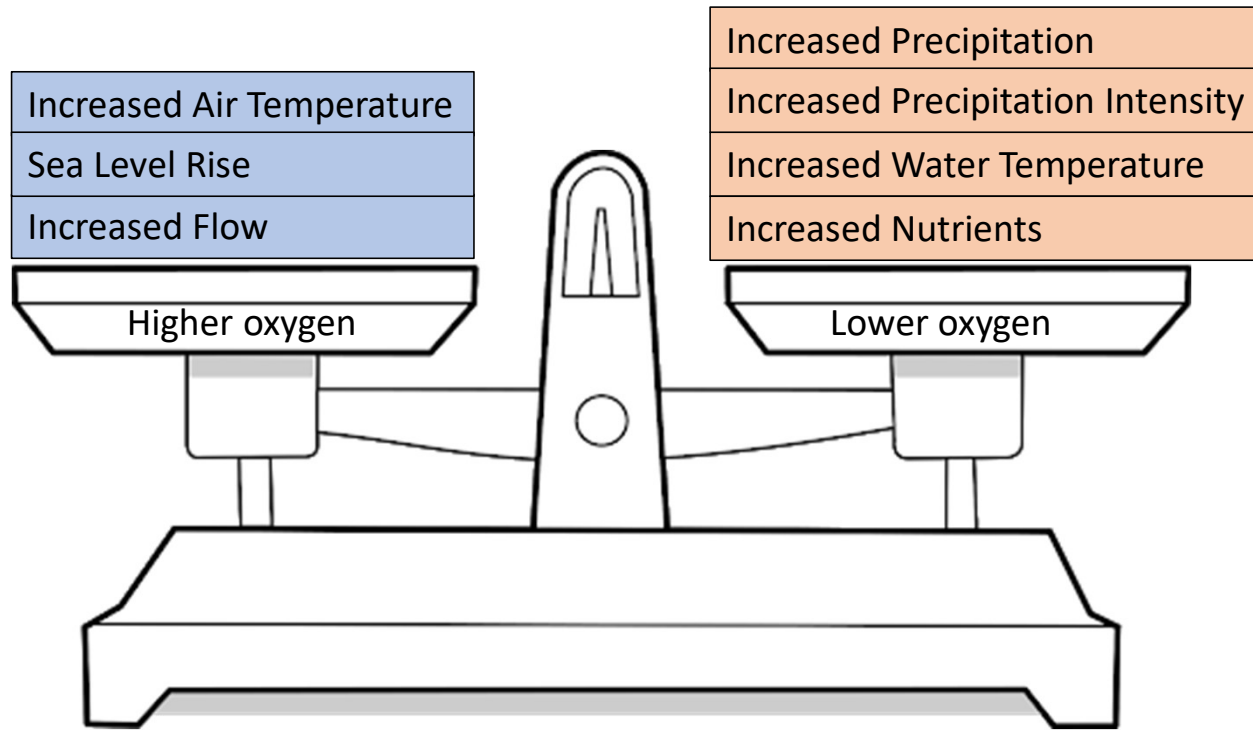
## YEAR 2050

RCP 4.5 31 Member Ensemble Median  
°C Delta Change (2050 vs. 1995)



**2.03°C increase in average  
annual temperature**

# Balance of effects – Science Question

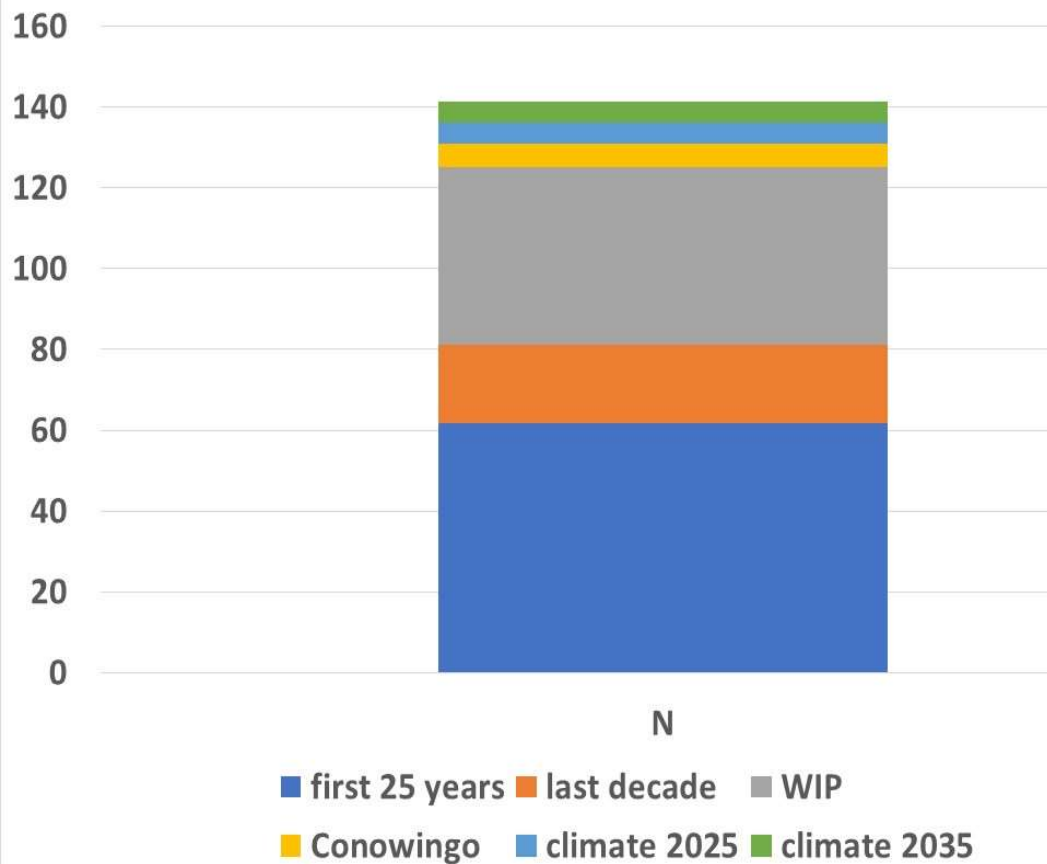


*CBP studied 21 different effects producing an overall lower level of oxygen*

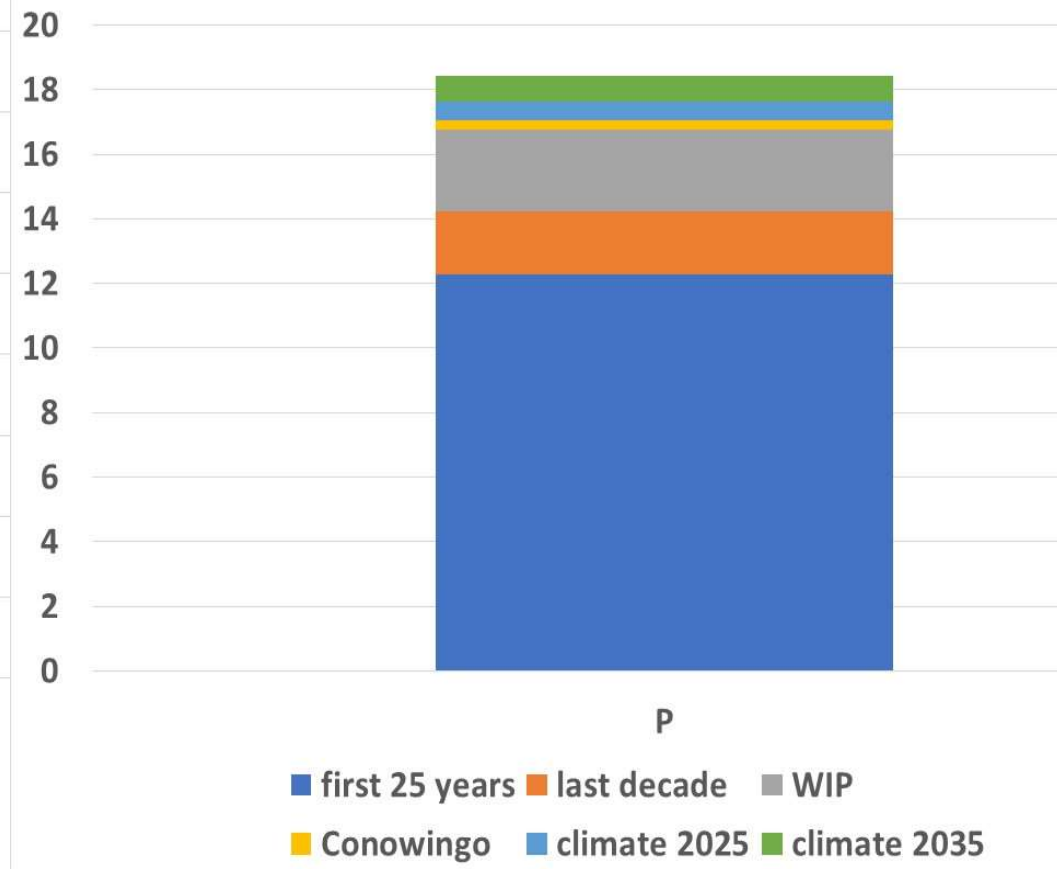
# Climate effects in perspective

Modeled load reductions from CAST-2019  
(current version of the CBP watershed model)

### Nitrogen Reductions in the CB watershed



### Phosphorus Reductions in the CB watershed

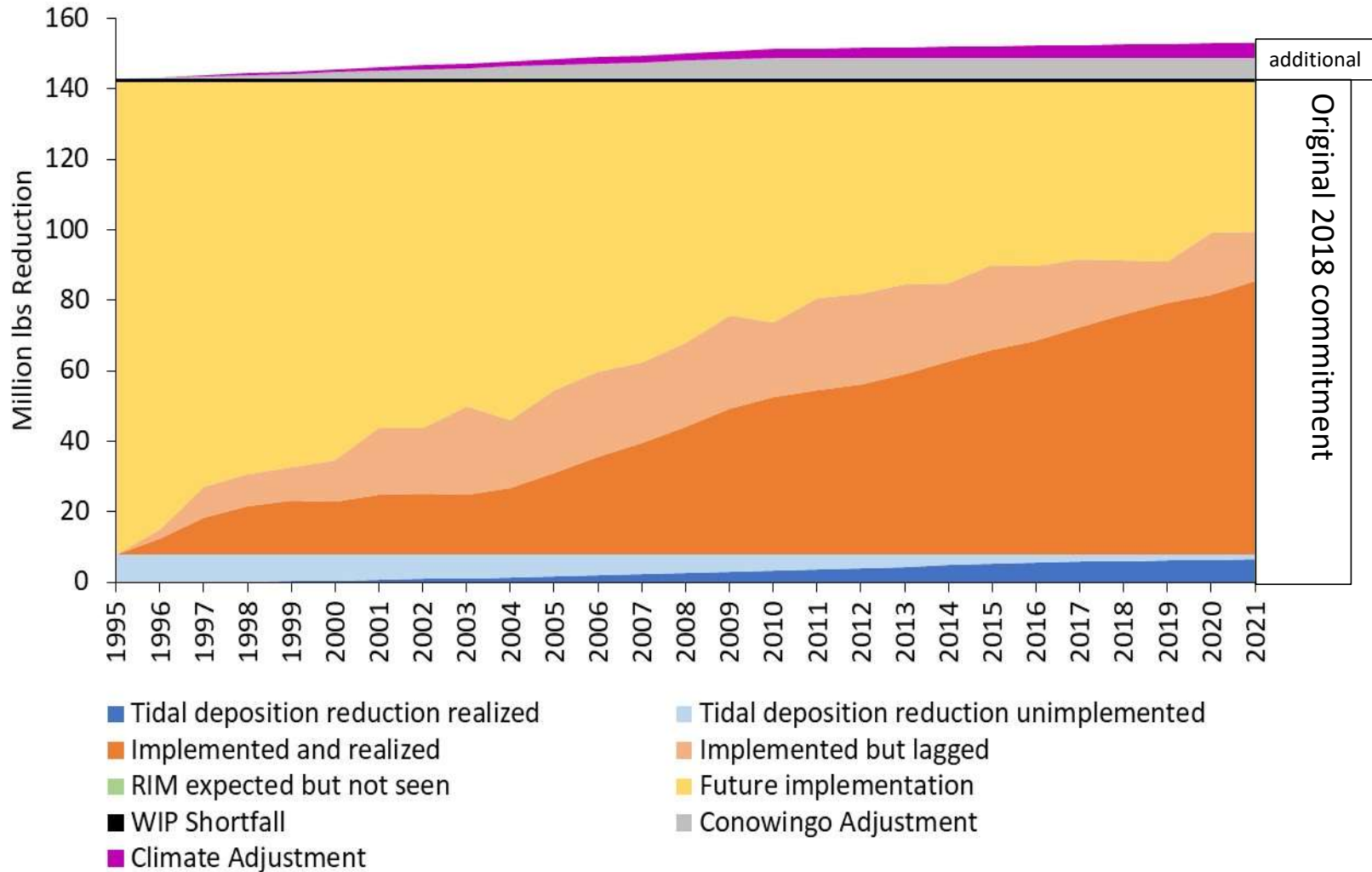




# Public Indicator

Updated Annually

## Chesapeake Bay TMDL Load Indicator Total Nitrogen

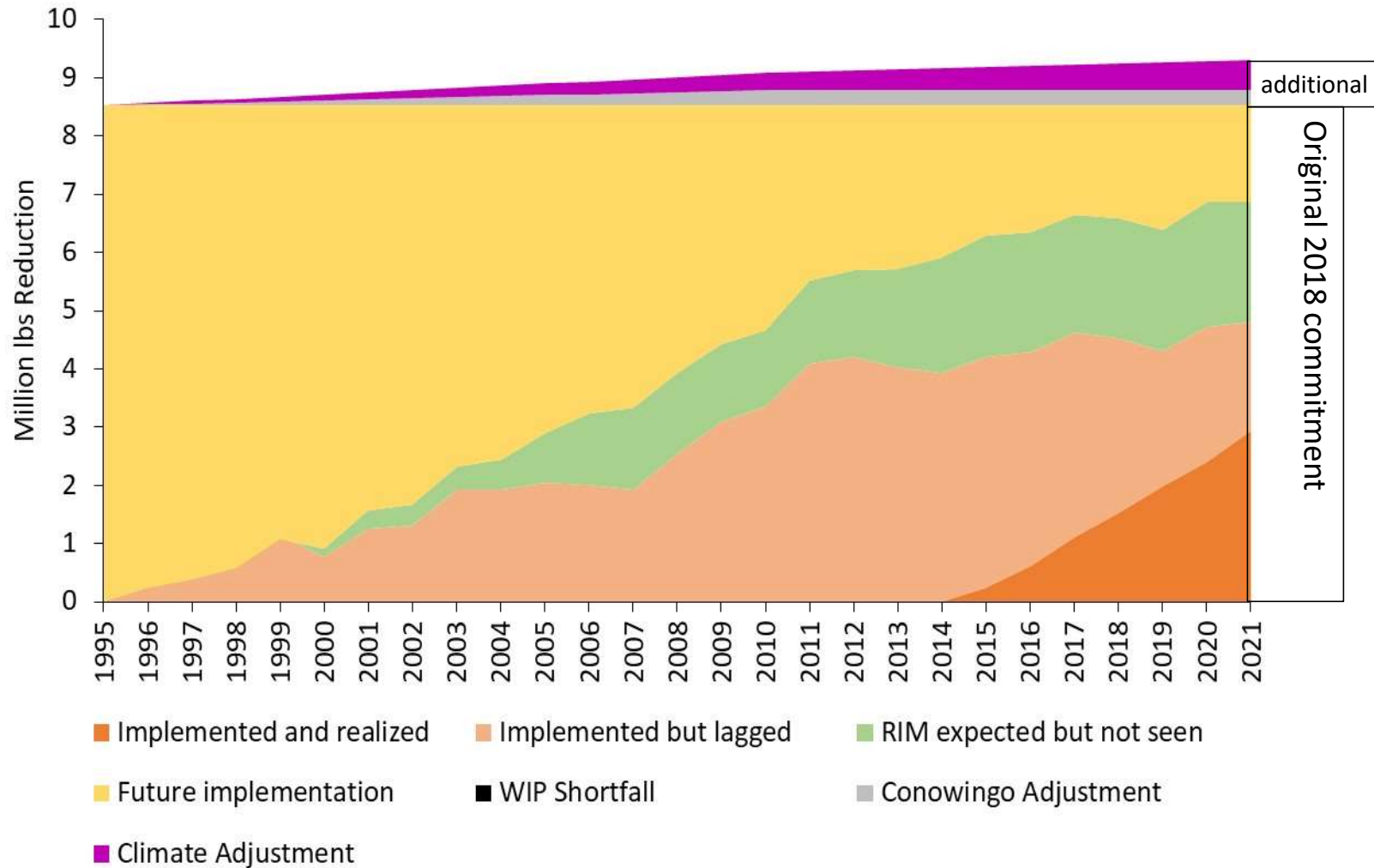


Web team will reformat  
Including addressing  
accessibility

# Public Indicator

Updated Annually

## Chesapeake Bay TMDL Load Indicator Total Phosphorus



Web team will reformat  
Including addressing  
accessibility

# CAST Structure

CAST is a simple model

**Inputs (Fertilizer, Manure, Atmospheric Deposition, Fixation, Wastewater)**

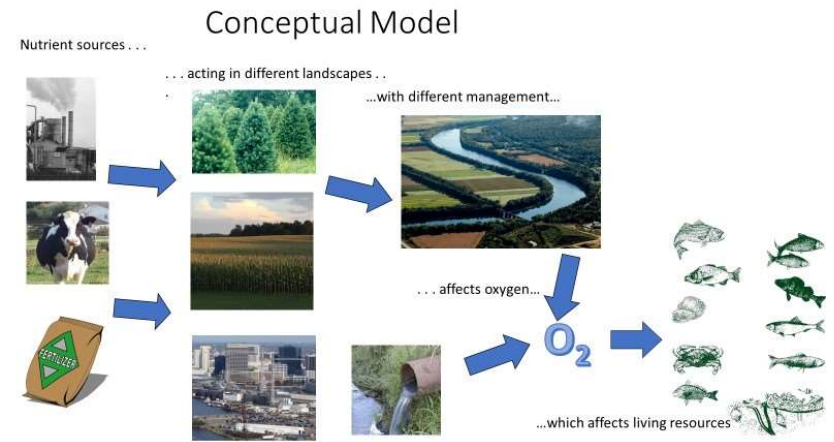


**Land management**



**Watershed Delivery**

Load by land-river segment and land use



CAST is a simple model

## CAST Structure

Inputs (Fertilizer, Manure, Atmospheric Deposition, Fixation, Wastewater)

\*

Land management

\*

Watershed Delivery

Load by land-river segment and land use

## CAST Structure

Average Load

+

$\Delta$  Inputs \* Sensitivity

\*

BMPs

\*

Acres

\*

Land to Water

\*

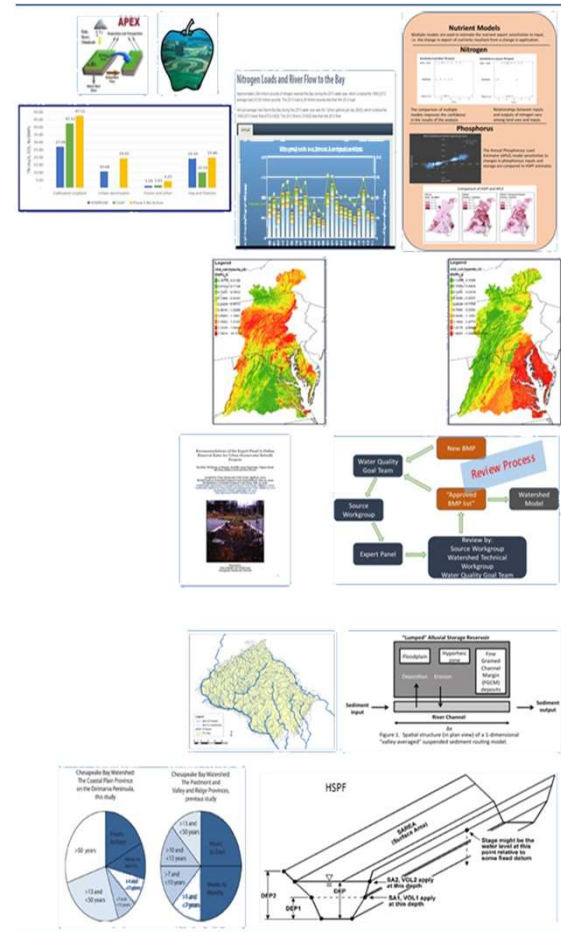
River Delivery

Load by land-river segment and land use

# Keep it Simple

**Average Load**  
 +  
**Δ Inputs \* Sensitivity**  
 \*  
**BMPs**  
 \*  
**Acres**  
 \*  
**Land to Water**  
 \*  
**River Delivery**

# Include Everything



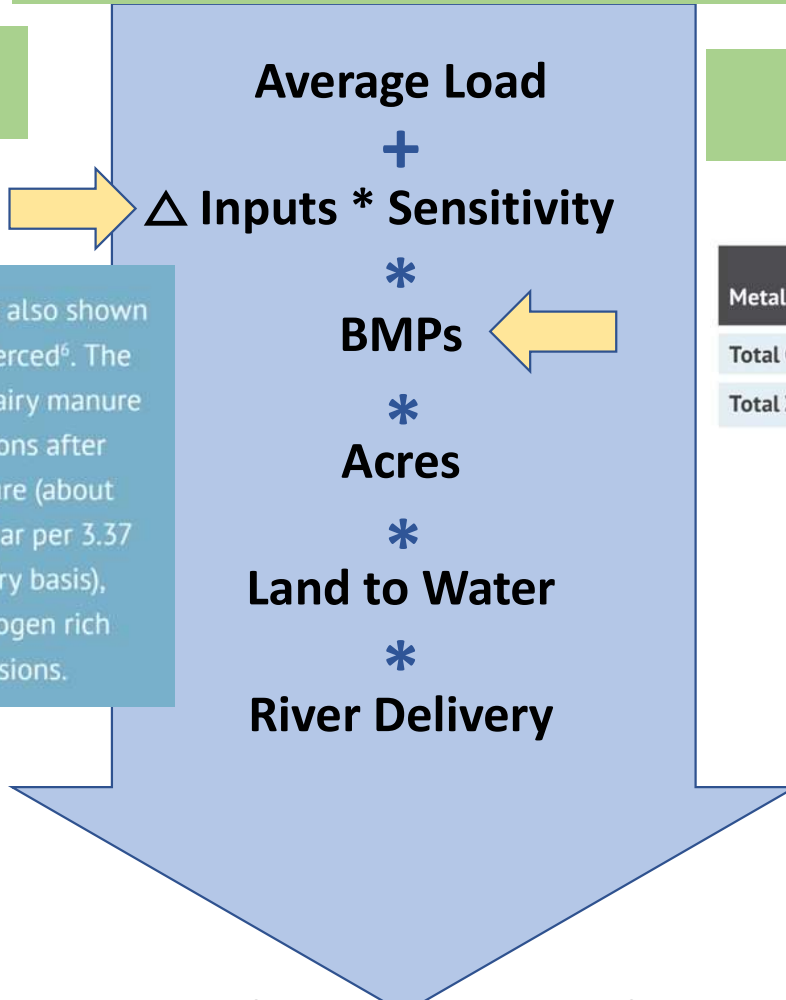
Load by land-river segment and land use distribution

Preliminary Information-Subject to Revision. Not for Citation or

# Keep it Simple

Biochar

Biochar



Biochar's ability to reduce nitrogen runoff was also shown in a recent study by University of California Merced<sup>6</sup>. The researcher investigated biochar additions to dairy manure and found a 79% reduction in methane emissions after adding one ton of biochar per 15 tons of manure (about 6% biochar on a wet basis) or 0.9 tons of biochar per 3.37 dry tons of manure (nearly 20% biochar on a dry basis), they found. In addition to creating a more nitrogen rich compost, it also reduced greenhouse gas emissions.

Metal	Initial concentration ug/L	Post biochar filter ug/L	% removed
Total Copper	54.2	7.88	71.1%
Total Zinc	1,018	39.0	92.6%

Preliminary Information-Subject to Revision. Not for Citation or  
 Load by land-river segment and land use



Thank you