Assessment of Climate Change Influence on the Chesapeake TMDL

CAC Climate Change Panel

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Rationale and Motivations for an Analysis of Climate Change Influences on the Chesapeake TMDL

- EO Commitments

Executive Order on the Chesapeake Bay (May 12, 2009) directive to assess the influence of climate change on the Chesapeake TMDL and in the *Strategy for Protecting and Restoring the Chesapeake Bay Watershed (May 12, 2010)* (p.41) to "Ensure TMDL allocations account for climate change impacts. EPA and USGS will work in conjunction with the states to conduct an analysis by 2017 to consider accounting for uncertainties of climate change in TMDL allocations."

- 2010 TMDL CBP Commitments

2010 TMDL Section 10.5 "EPA and its partners are committed to conducting a more complete analysis of climate change effects on nitrogen, phosphorus, and sediment loads and allocations in time for the mid-course assessment of Chesapeake Bay TMDL progress in 2017 as called for in Section 203 of the Chesapeake Executive Order 13508 (May 12, 2009). To do that will require building the capacity to quantify the impacts of climate change at the scale of the Bay TMDL—92 Bay segments and their surrounding watersheds at the scale of the Phase II Watershed Implementation Plans' target loads—and incorporate that information into the full suite of Bay models and other decision support tools. EPA has committed to take an adaptive management approach to the Bay TMDL and incorporate new scientific understanding of the effects of climate change into the Bay TMDL, in this case during the mid-course assessment."

Rationale and Motivations for an Analysis of Climate Change Influences on the Chesapeake TMDL *(continued)*

Other Motivations

- ***EPA OW CC Strategy***

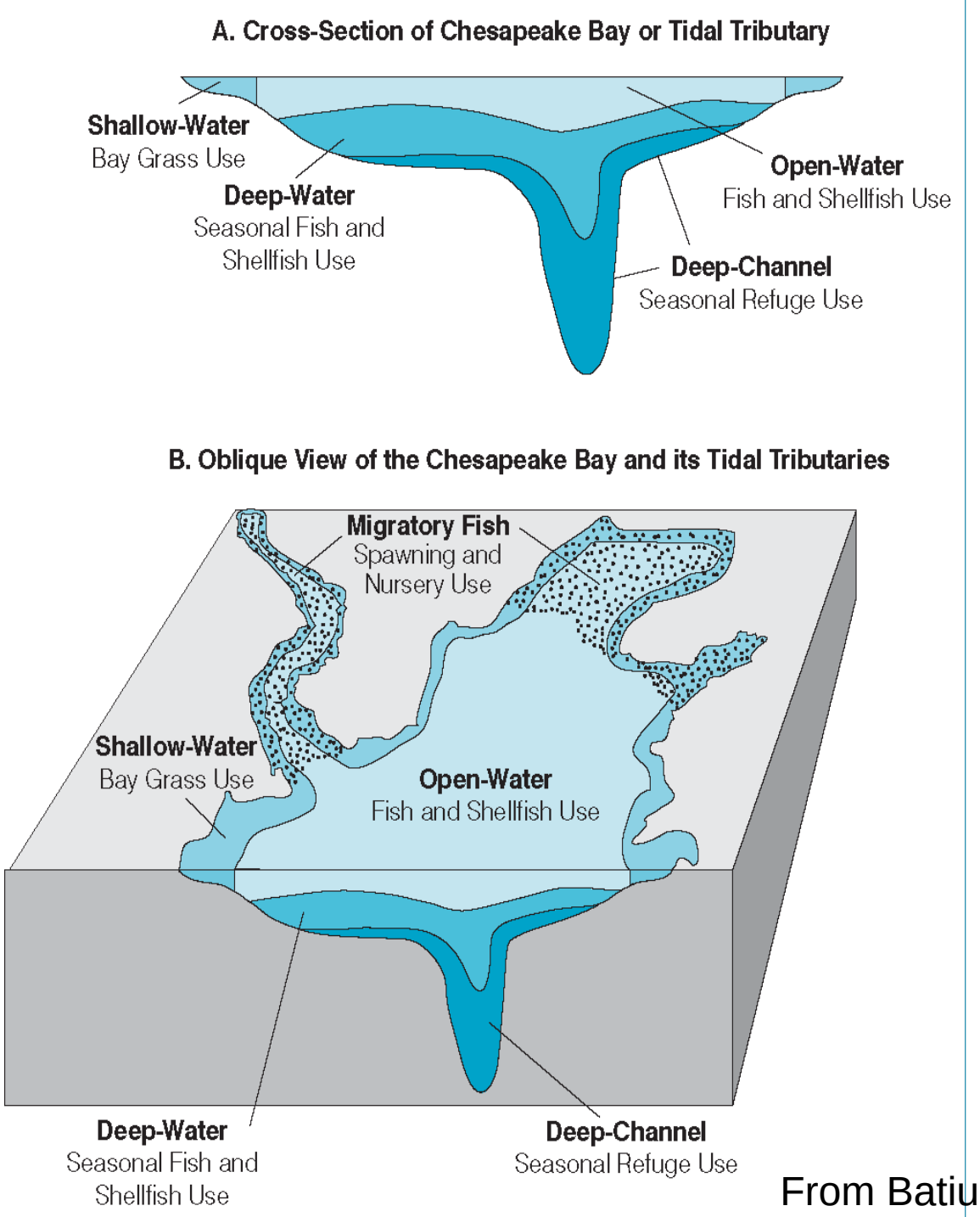
EPA's *National Water National Water Program 2012 Strategy: Response to Climate Change (December 2012)* *http://water.epa.gov/scitech/climatechange/upload/epa_2012_climate_water_strategy_full_report_final.pdf*

- ***The White House Council on Environmental Quality*** - Progress Report on the Interagency Climate Change Adaptation Task Force: Recommended Actions to Support a National Climate Change Adaptation Strategy (October 5, 2010).

- ***State specific strategies*** – Maryland has a fully developed climate change strategy of adaptation in place. In Virginia, municipalities and counties that are currently impacted by sea level rise, including Norfolk, Hampton Roads, and the Tidewater counties, have taken the lead in climate change adaptation.

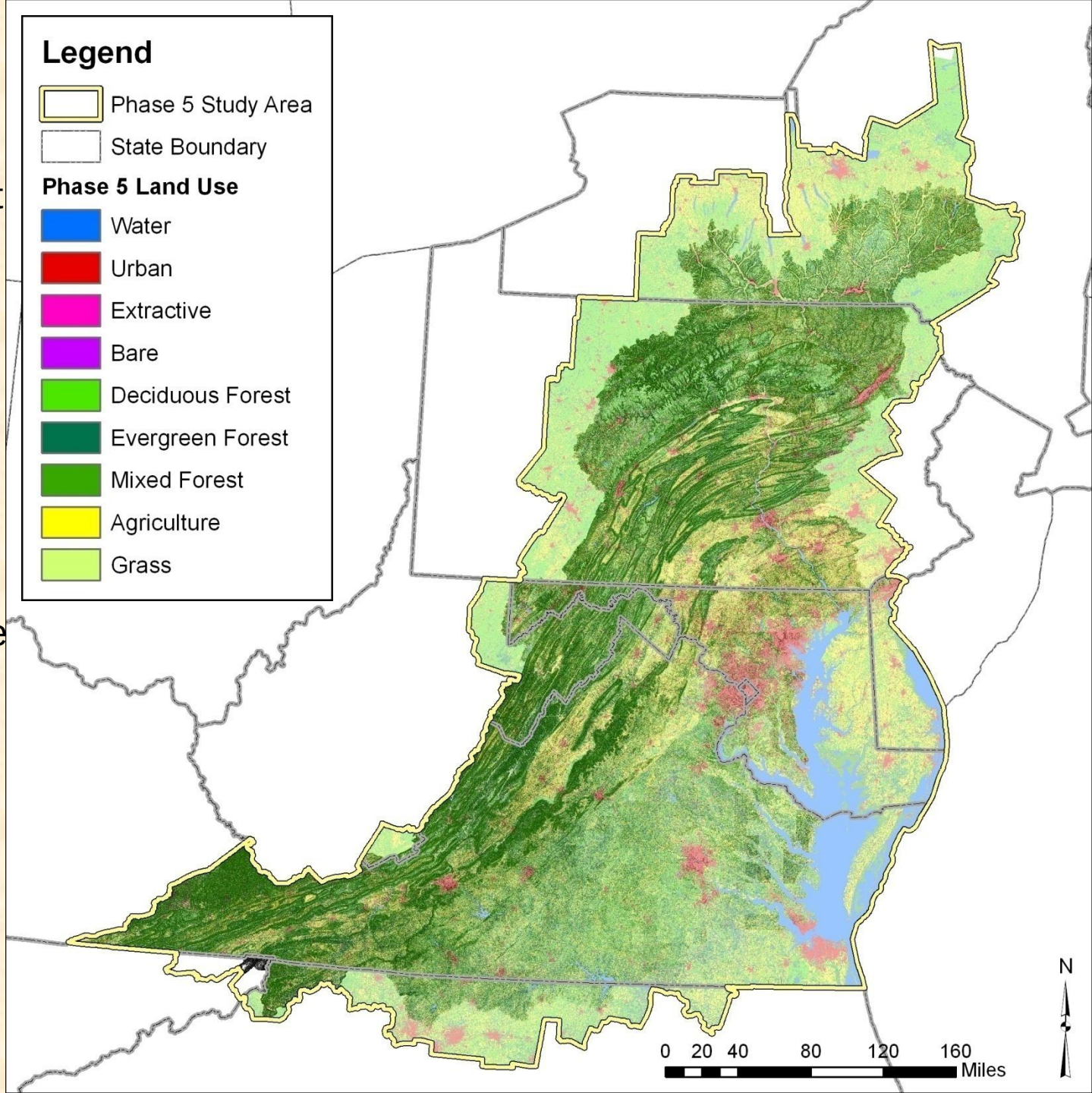
- ***STAC's interest in climate change*** is broad and far reaching and includes interests in 1) Precipitation and Sea Level Rise Impacts, 2) Changes in Landscape Ecology, 3) Impacts on Human Health, 3) Impacts on Agriculture and Food Supply and impacts on the Chesapeake TMDL. Two major workshop reports have been developed by STAC and are focused on estimating the range of impacts, and adaptation measures and strategies that can be applied in the CBP.

In the Chesapeake TMDL, the water quality standards of Deep Water, Deep Channel, and Open Water dissolved oxygen (DO) are key for the protection of living resources. The chlorophyll and SAV/clarity standards are also designed to protect living resources.



From Batiuk (2003)

In the assessment of the influence that climate change will have on the Chesapeake TMDL we need to use the CBP integrated models of the airshed, watershed, tidal Bay, and living resources. Together they relate the watershed under climate change conditions loads to water quality and living resource impairments in the Chesapeake.



Climate change influences will be wide-ranging and will trigger management responses to current air and water quality standards.

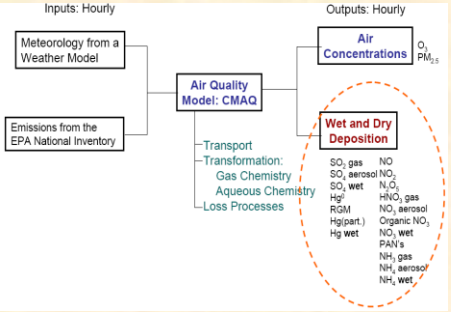
For example, future increased temperatures could increase ground-level ozone beyond levels the Clean Air Act air quality standards deem acceptable for human health. This in turn could trigger reductions in the NOx precursor of ozone and have a knock-on effect of reducing nitrogen loads in the Chesapeake region. The key point here is that the *air quality standards, based on what's required to maintain human health, are forever. Future management actions will be adjusted as needed to maintain the air quality standards.*

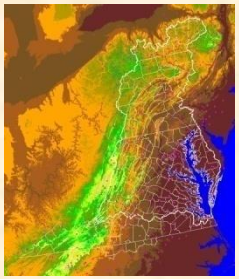
In the same way, the *Chesapeake water quality standards, based on what's required to maintain ecological health in the Bay, are forever. Future management actions will be adjusted as needed to maintain the standards despite changes that climate change will bring.*

A broad assessment of the influence climate change will have on the Chesapeake will be prepared for the 2017 Midpoint Assessment using the CBP's Airshed, Watershed, Water Quality and Sediment Transport Model (WQSTM), and living resource models.

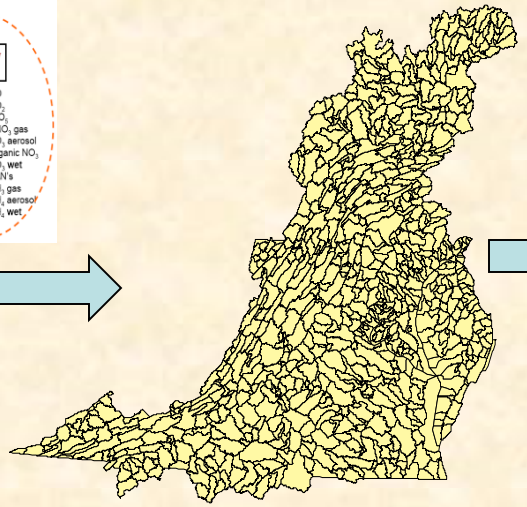
Nutrient Allocation Decision Support System

Airshed Model

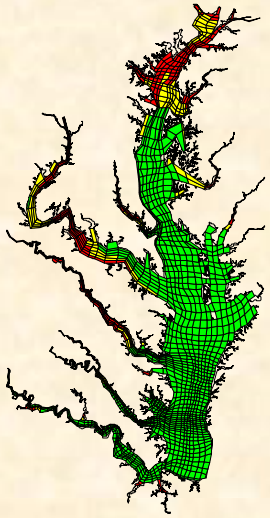




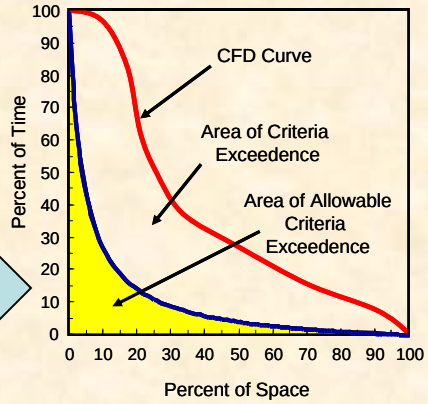
Watershed Model



Bay Model



Criteria Assessment Procedures



Effects

Allocations

CBP Model Assessment

- Current efforts are to frame an initial future climate-change scenario based on estimated 2050 conditions.

- Conditions to be described include land use, rainfall, air temperature, water temperature, sea level rise, and wetland loss due to sea level rise.

- The Watershed Model will be employed to predict flows and loads from the watershed based on the projected conditions of temperature, precipitation, and PET.

CBP Model Assessment

- New tidal Bay hydrodynamics will be required based on projected flows, sea level, and shoreline geometry.
- Multiple eutrophication model and living resource model runs will be made based on the projected conditions and management plans including the TMDL.
- Particular attention will be devoted to the effects of climate change on living resource regions including SAV beds and wetlands.

Collaboration with other CC Assessments

Active collaboration is ongoing with other researchers and the work is providing the CBP with additional high quality climate change analysis using a multiple model approach.

Collaborators include:

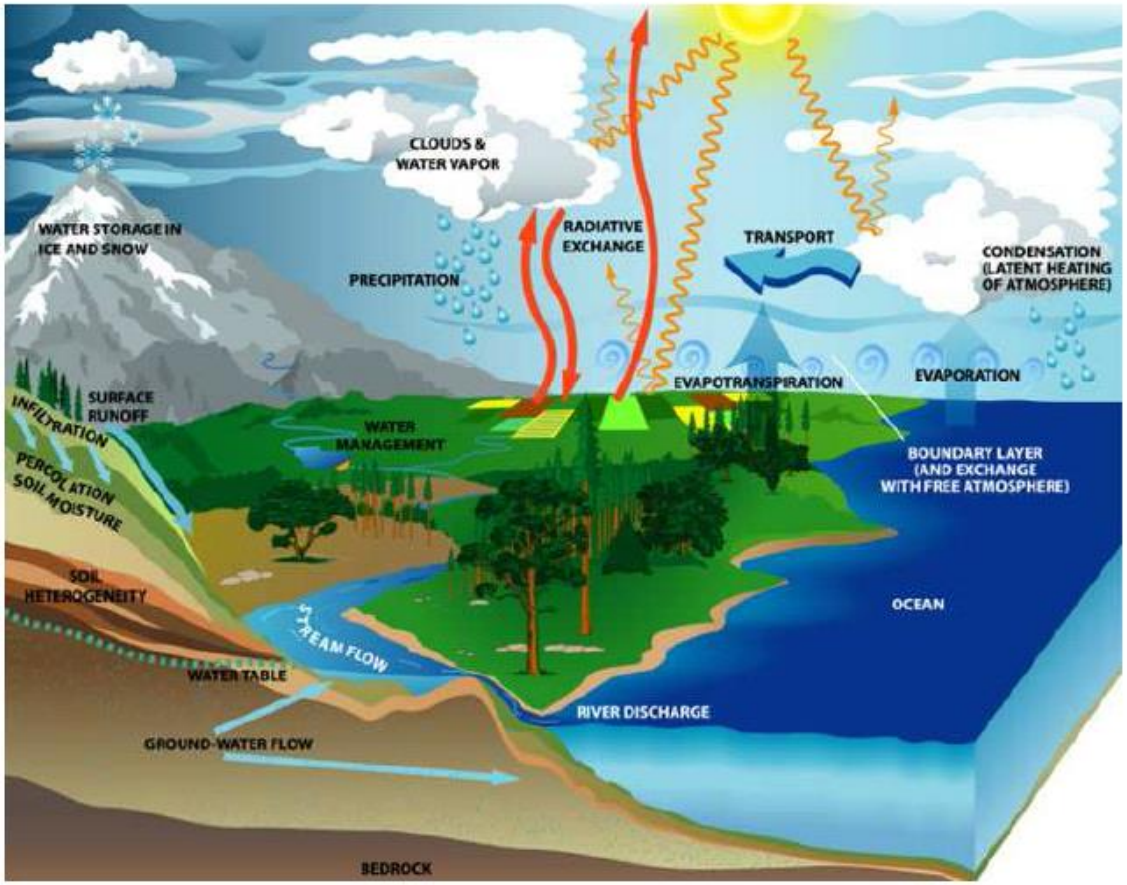
1) Penn State
2) USGS
3) EPA's Global Change Research Program
4) University of Maryland

Penn State Collaboration

The Penn State analysis of climate change examines how to best simulate watershed hydrology under future climate conditions particularly with appropriate representations of evapotranspiration.

Penn State Collaboration

Potential effects of climate change on watersheds



Major flows and storage of water characterized by water balance:

Ppt = RO + Et + **Δ**S

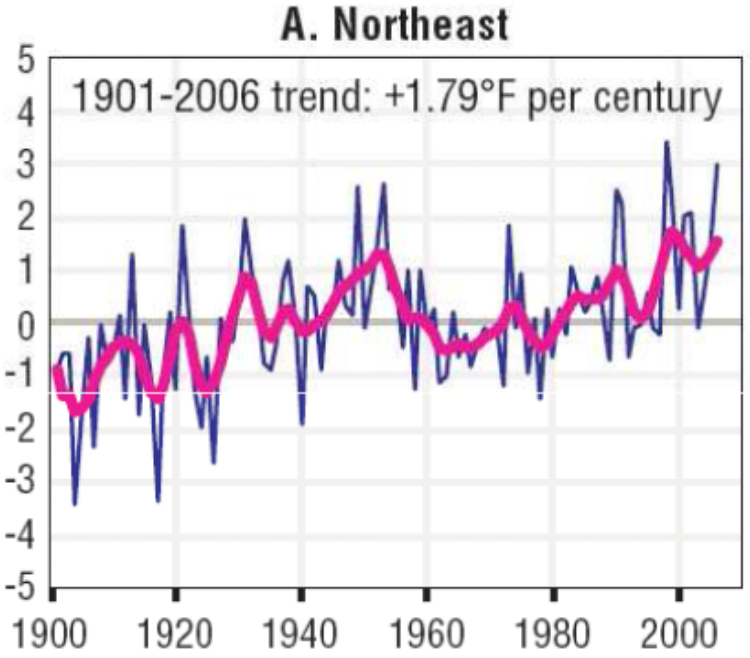
Each term affected by climate

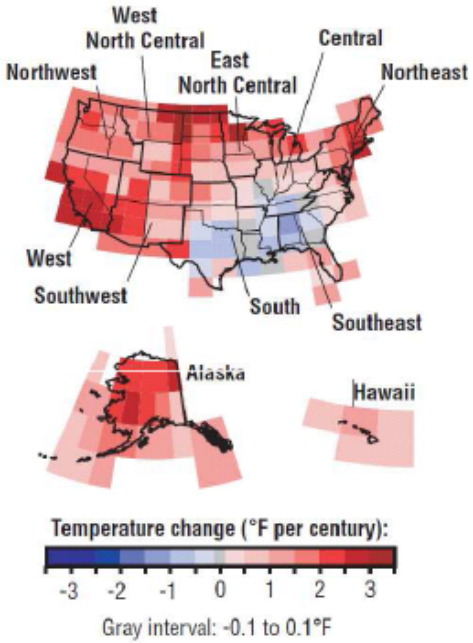
Specific effects on:

- Streamflow
- Water quality
- Infrastructure
- Ecosystems

Penn State Collaboration

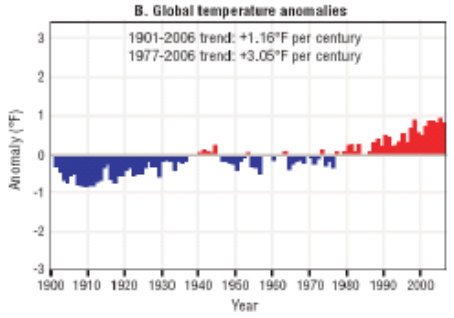
Annual temperature anomalies in the U.S. by region, 1901-2006





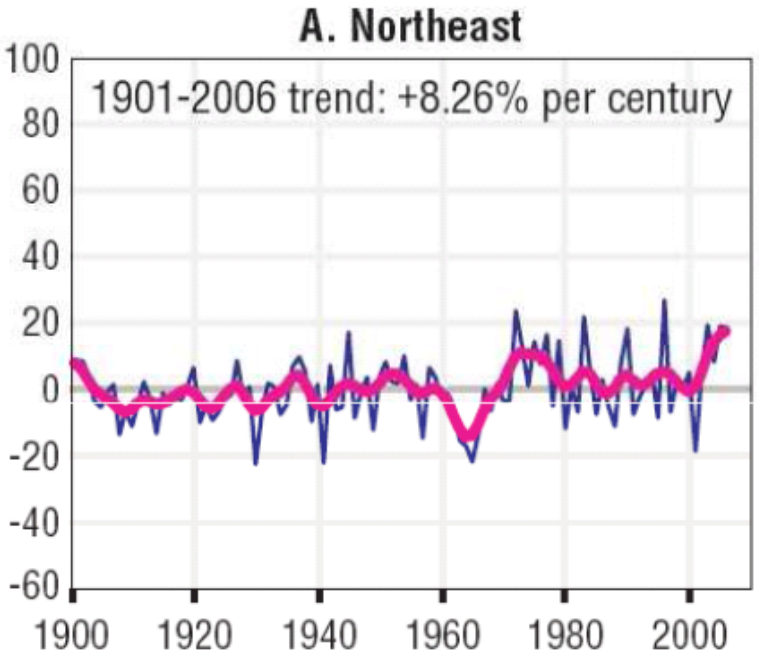
Data source: NOAA NCDC (figures from EPA 2008 Report on the Environment)

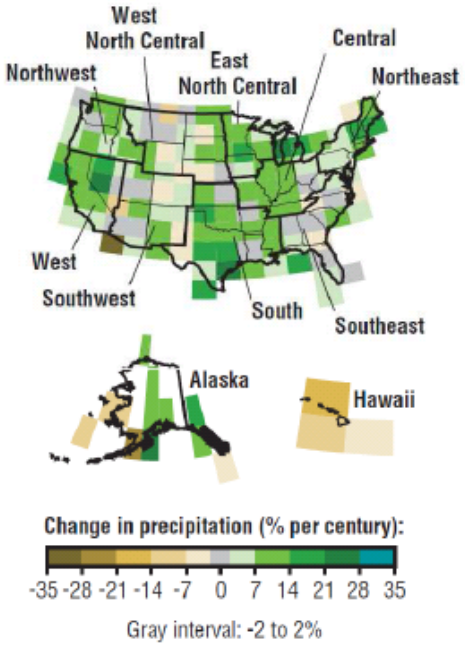
- Anomalies are calculated with respect to the 1961-1990 mean
- Time series were smoothed using a 9-point binomial filter



Penn State Collaboration

Annual precipitation anomalies in the U.S. by region, 1901-2006





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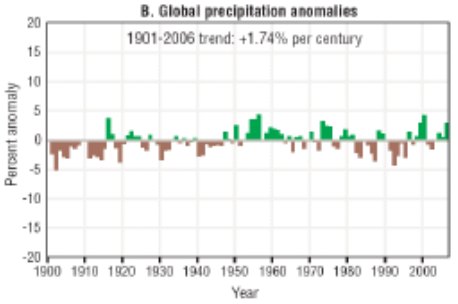
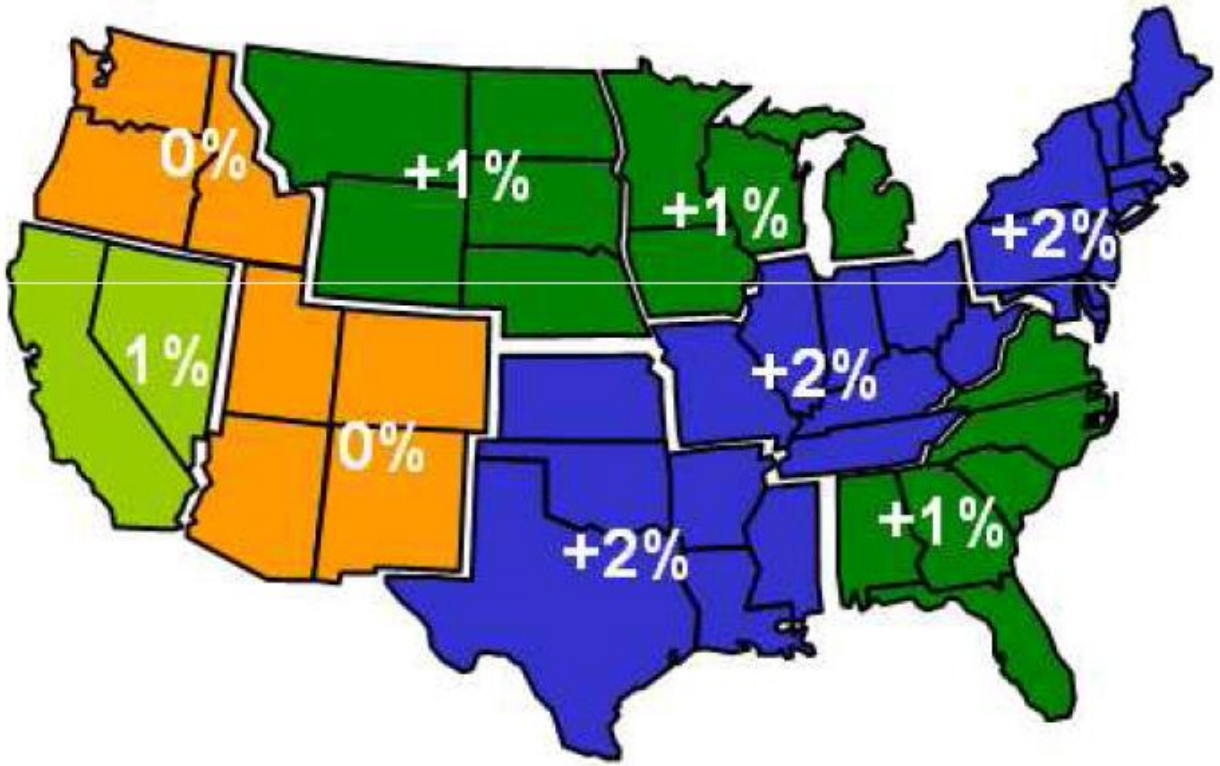


Penn State Collaboration

Changes in precipitation intensity during last century

Trends in proportion of annual precipitation occurring as extreme events (more than 2 in. per day), 1910-1995



Source: Karl and Knight, 1998. BAMS, Vol 79(2), pg 231-41

USGS Collaboration

• The USGS analysis involves the examination of Chesapeake watershed hydrology under future climate change conditions.

• The assessment uses 72 Watershed Model runs based on:

- 6 climate change models (BBCR, INM, CSIRO, NCAR, CCSM, MIROC),
- 3 Intergovernmental Panel on Climate Change (IPCC) scenarios (SRES A1B, SRES A2, and SRES B1), and
- 4 future time periods covering 2025-2035, 2035-2045, 2055-2065, and 2085-2095.

EPA's Global Change Research Program Collaboration

- The Global Change Research Program of EPA's Office of Research and Development is applying a decision framework called RDM (Robust Decision Making) to an assessment of the Patuxent watershed under estimated 2050 climate change conditions.

- The RDM will provide quantitative estimates of uncertainty related to management decisions and climate change, in the management of storm water in the Patuxent under estimated 2050 conditions.

University of Maryland Collaboration

- The University of Maryland's Center for Environmental Science study focuses on the Patuxent watershed and estuary with respect to the potential impacts of climate change on water quality and living resources, and how changes in climate can exacerbate or ameliorate the impacts of other stressors such as land use change.

- In particular, stream restoration strategies and intertidal marshlands performance under changing climatic conditions will be examined.

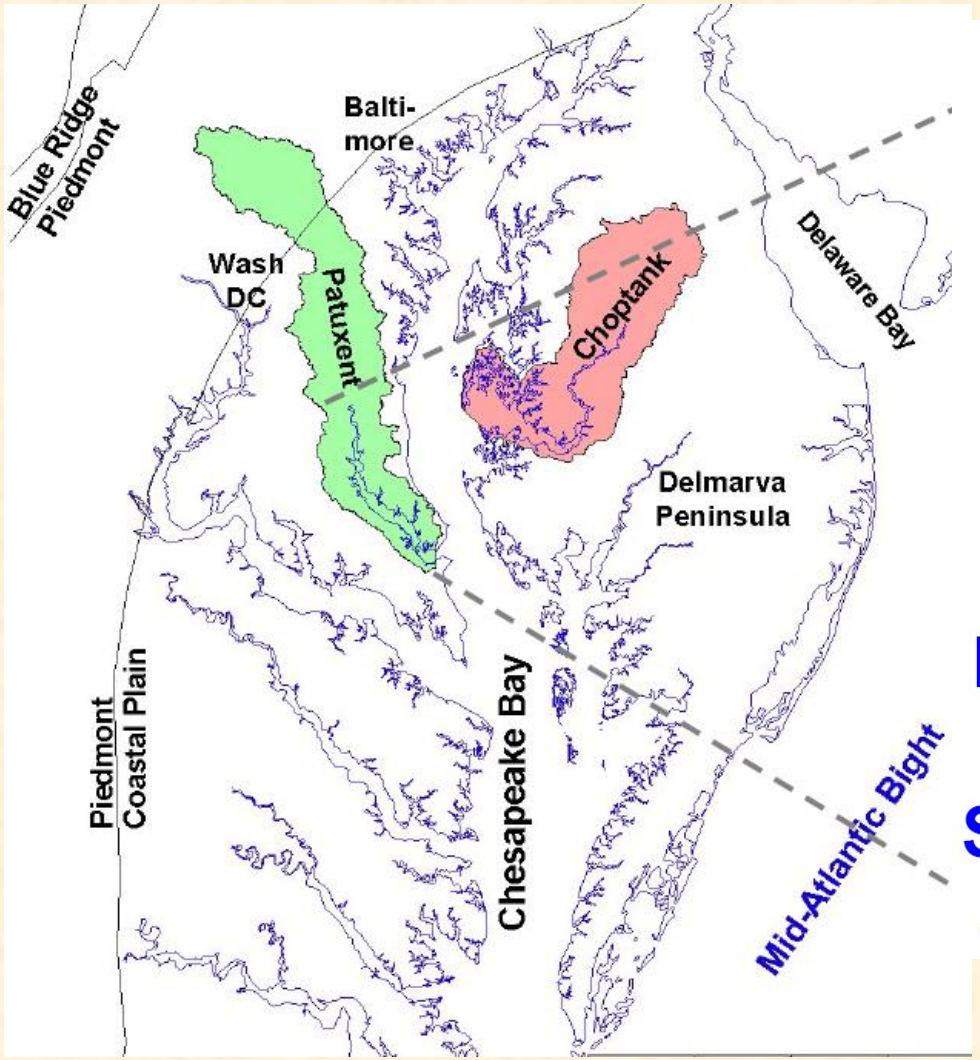
Patuxent Case Study

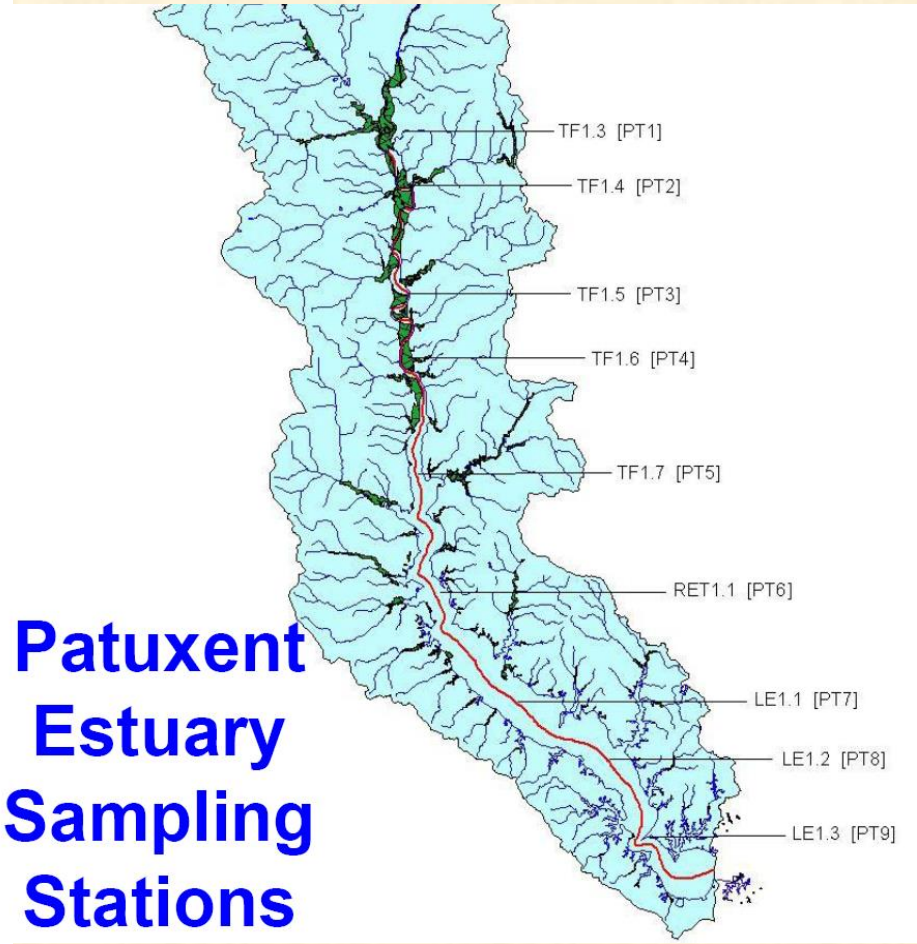
Understanding the sensitivity of flow and WQ constituents to climate change in the Patuxent watershed

• Use CBP linked modeling system with potential modifications (i.e., land use change model, marshland coverage, SLR, increased water temperature, etc.)

• Assess:
– interactions with other stressors (e.g., urban and agricultural land use)
– performance of stream restoration and intertidal marshlands under changing conditions

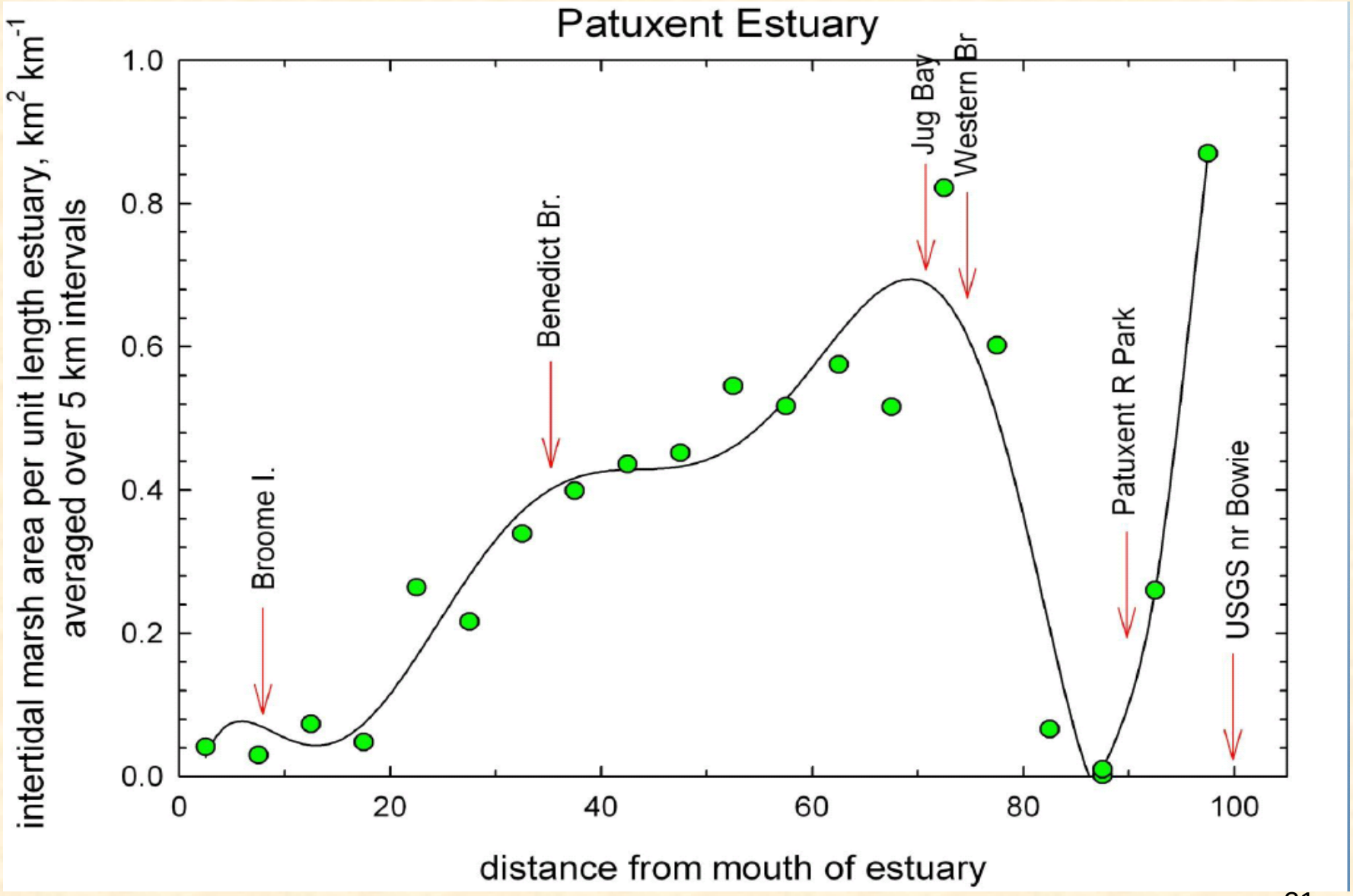
Patuxent Location & Tidal Wetlands





Patuxent Estuary Sampling Stations

Marsh Averaged Over 5 km Area



Conclusions:

- Multiple stressors, such as continued population growth in addition to warming and sea-level rise associated with global change, will be challenges to the restoration efforts in Chesapeake Bay.
- Changes in precipitation intensity, flow, and temperature could change nutrient and sediment loads. Higher temperatures are already placing stress on *Zostera* (eel grass) a key SAV species.
- Our objective for the 2017 Midpoint Assessment is to provide decision makers our best assessment of the influence climate change will have on the Chesapeake TMDL.