Preparing for Climate Change Decisions in the 2017 Midpoint Assessment

The Chesapeake Bay TMDL's
Midpoint Assessment
WQGIT Meeting

October 8, 2014

Lewis Linker and the CBP
Modeling Team

Chesapeake Bay Program
Science, Restoration, Partnership

Overview and Background:

2017 Climate Change Analysis - In Part and In Whole (for 2050)

- Land use – synergistic positive feedbacks with climate change
- Rainfall - increased intensity
- Evapotranspiration – New methods to account for stomata resistance and CO_2 levels
- Air temp – reaction rates (10^0 C increase ~ double reaction rates)
-Tidal Water temperature – increase density gradient
- Increased salinity - increase density gradient
- Impacts of sea level rise on tidal wetlands
- Changes in SAV habitat
- Sea level rise & tidal Bay hydrodynamic effects

2017 is the CBP Year of Decision on Climate Change

Options range from:

- Fully incorporate climate change adjustments into the Phase III WIPs.
- Apply climate change adjustments strategically such as protecting investments in nutrient and sediment management.
- Defer application until after the Phase III WIPs.
- Other options.

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

- 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."

- 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."

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

- 2014 Chesapeake Watershed Agreement - Climate Resiliency

Changing climatic and sea level conditions may alter the Bay ecosystem and human activities, requiring adjustment to policies, programs and projects to successfully achieve our restoration and protection goals for the Chesapeake Bay and its watershed. This challenge requires careful monitoring and assessment of these impacts and application of this knowledge to policies, programs and projects.

Monitoring and Assessment Outcome:

Continually monitor and assess the trends and likely impacts of changing climatic and sea level conditions on the Chesapeake Bay ecosystem, including the effectiveness of restoration and protection policies, programs and projects.

Adaptation Outcome:

Continually pursue, design and construct restoration and protection projects to enhance the resiliency of Bay and aquatic ecosystems from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.

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*

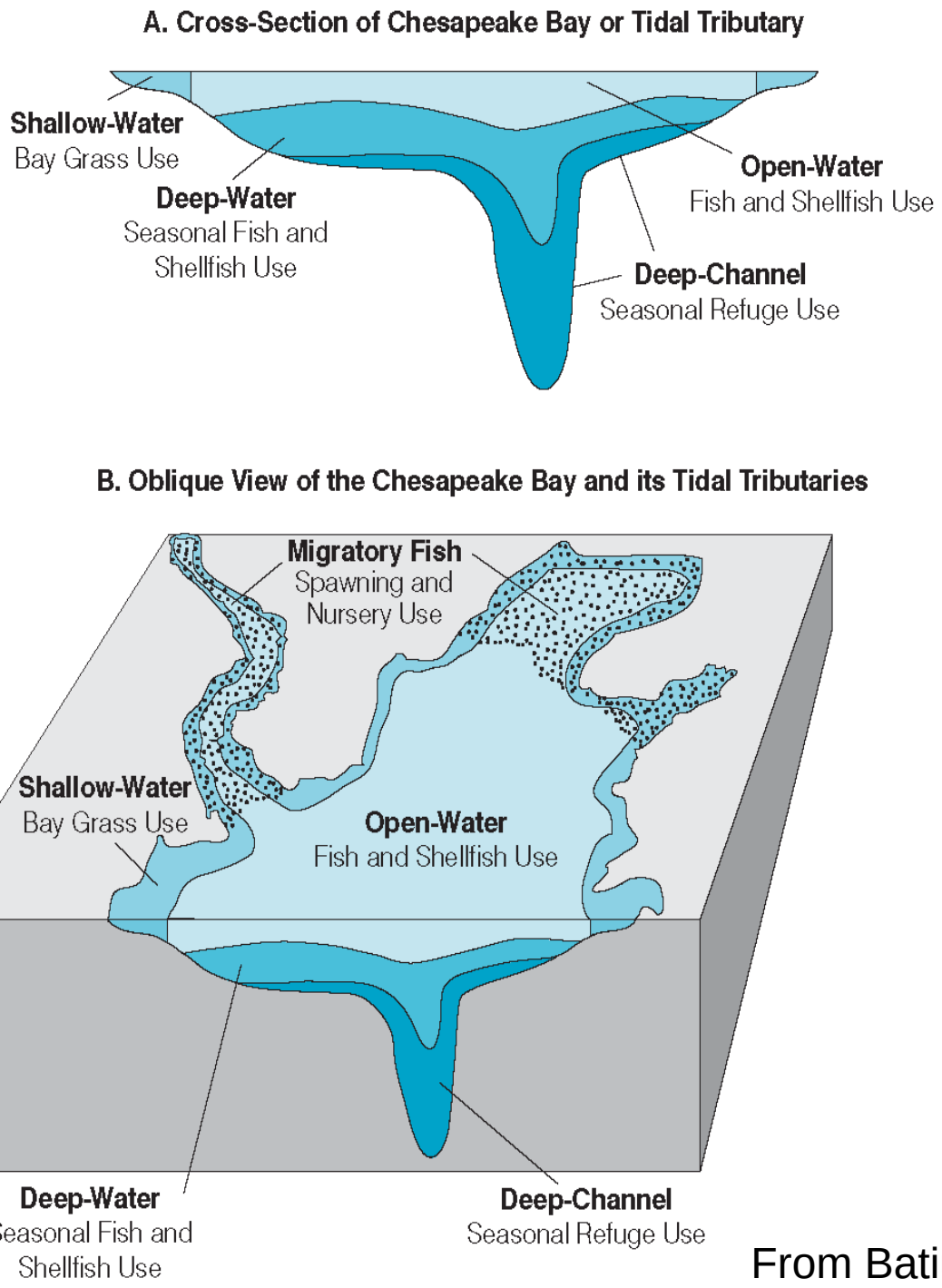
- ***The White House Council on Environmental Quality*** - Progress Report on the Interagency Climate Change Adaptation Task Force: Recommended Actions to Support a National Climate Change Adaptation Strategy (October 5, 2010).

- ***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 an early 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.

We are fortunate to have living resource based water quality standards to assess climate change findings in the Chesapeake.

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)

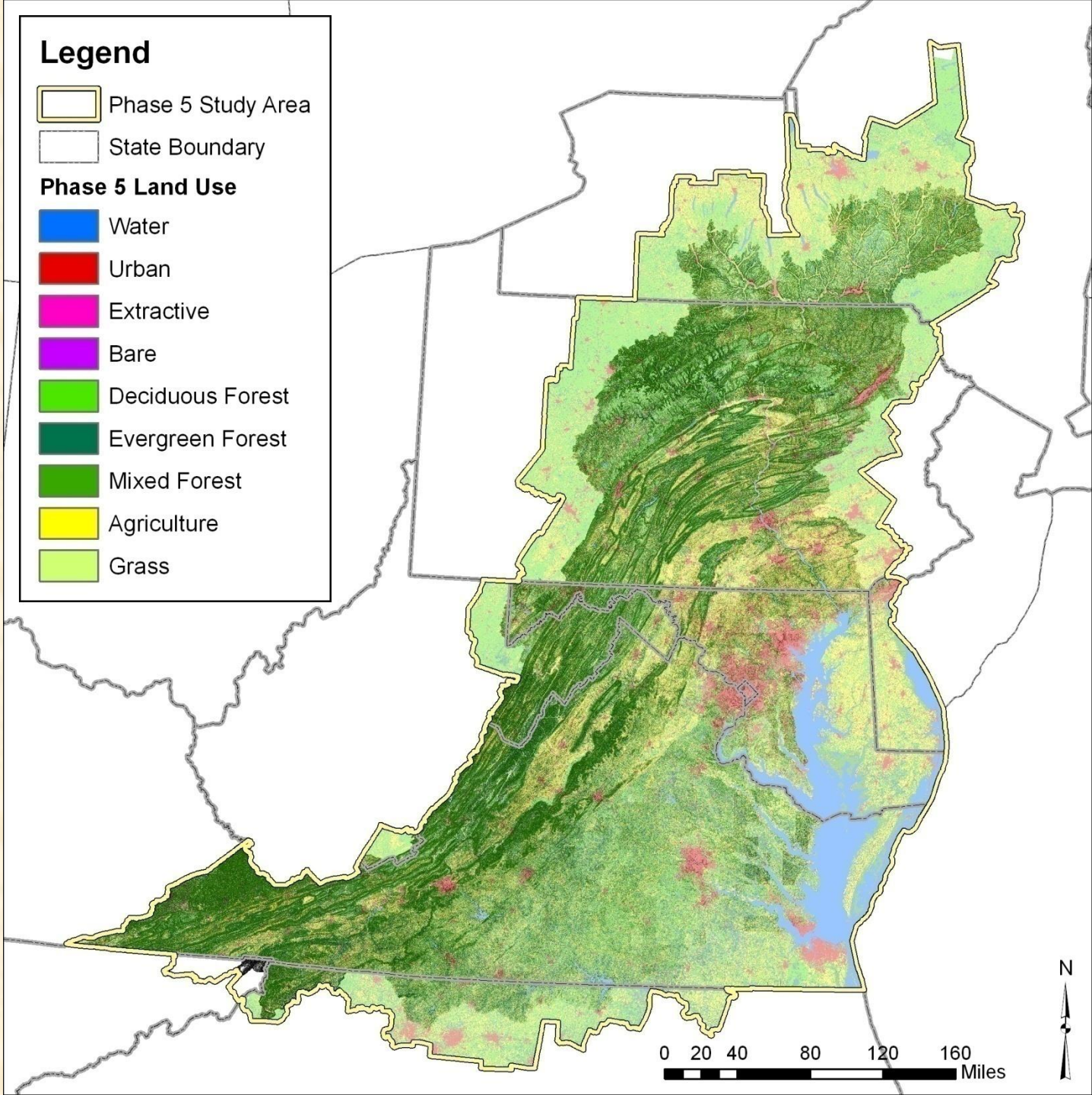
Climate change influences will be wide-ranging and will trigger management responses to current air and water quality standards.

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.*

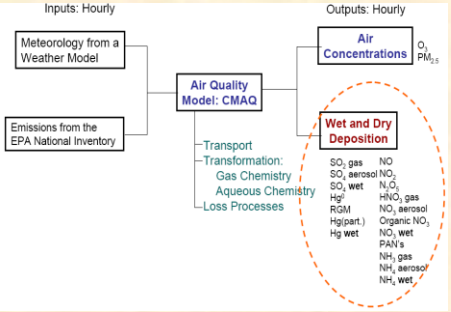
A broad assessment of the influence climate change will have on the Chesapeake will be prepared for the 2017 Midpoint Assessment using the CBP's Airshed, Watershed, Water Quality and Sediment Transport Model (WQSTM), and living resource models.

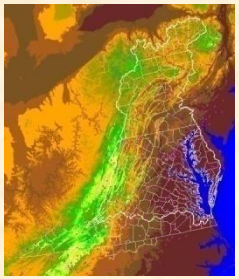
Some factors, such as increased developed land in the CB watershed and climate change will be synergistic and will together generate greater water quality impacts.



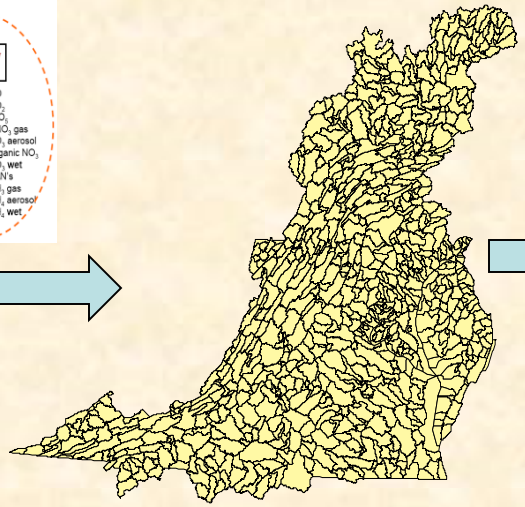
CBP Modeling System

Airshed Model

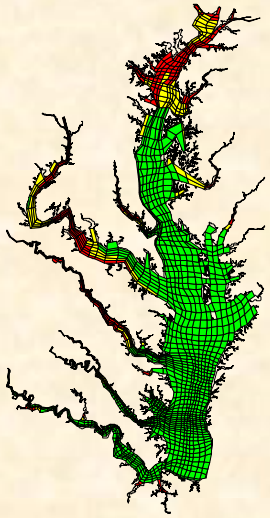




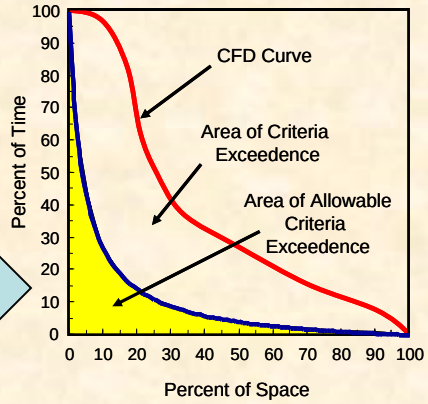
Watershed Model



Bay Model



Criteria Assessment Procedures



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

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 potential evapotranspiration.

CBP Model Assessment

- New tidal Bay hydrodynamics will be required based on projected flows, and sea level rise.
- 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 resources including sea level rise impacts on wetlands and SAV beds.

Collaboration with other CC Assessments

Active collaboration has been 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:

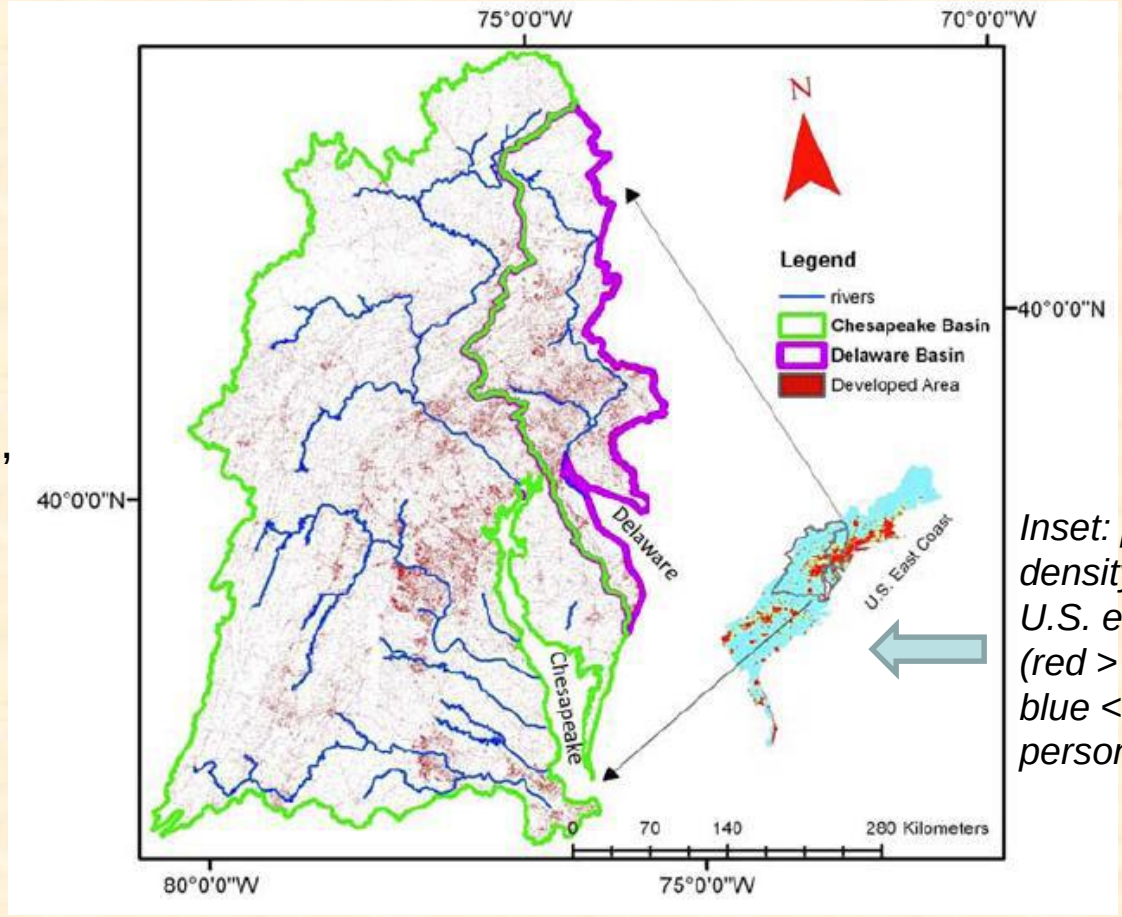
1) Penn State
2) USGS
3) EPA's Global Change Research Program
4) University of Maryland

Synergistic impacts of population growth, urbanization, and climate change on watersheds and coastal ecology of the northeastern United States

A new three-year research project funded by NASA's Interdisciplinary Research in Earth Science Program

PIs: Raymond Najjar (Penn State), Marjorie Friedrichs (VIMS), Eileen Hofmann (ODU), Kimberly Hyde (NOAA), Antonio Mannino (NASA), Hanqin Tian (Auburn), and John Wilkin (Rutgers)

Generate four simulations, 1950s to present:
(a) All forcings
(b) Only climate change
(c) Only changes in land cover and management
(d) Only changes in nutrient inputs



Inset: population density along U.S. east coast (red > 2000 and blue < 500 persons km-2)

Evapotranspiration – New Methods To Account For Stomata Resistance and CO_2 Levels

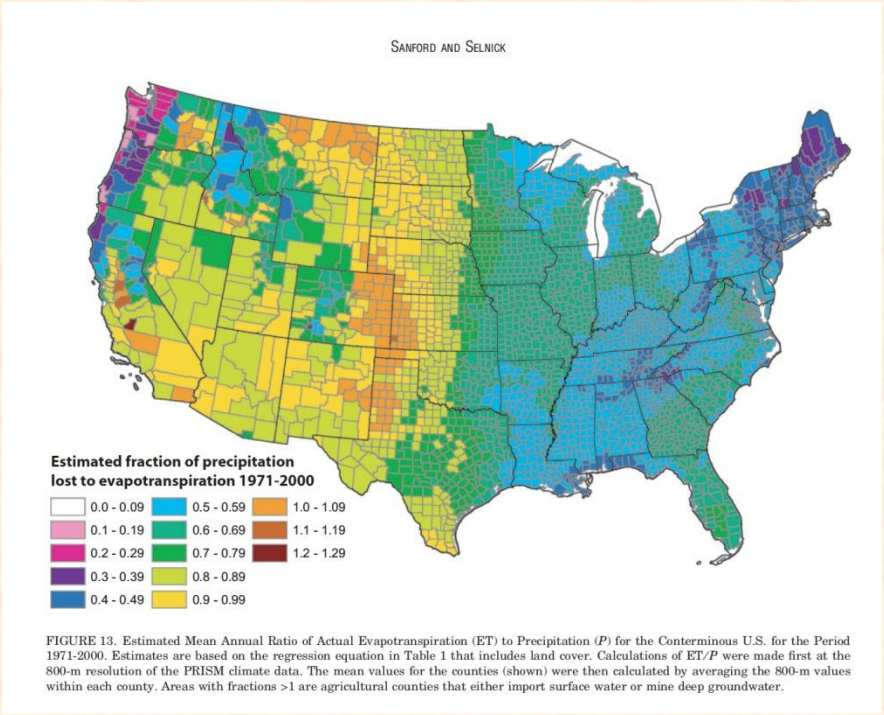
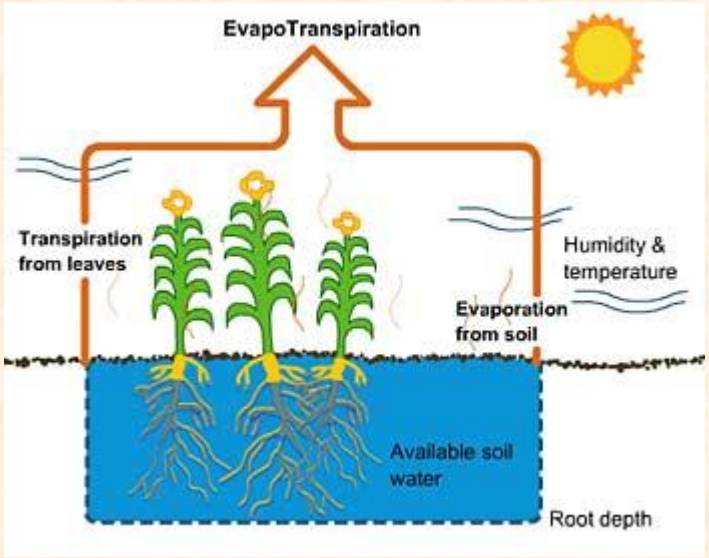
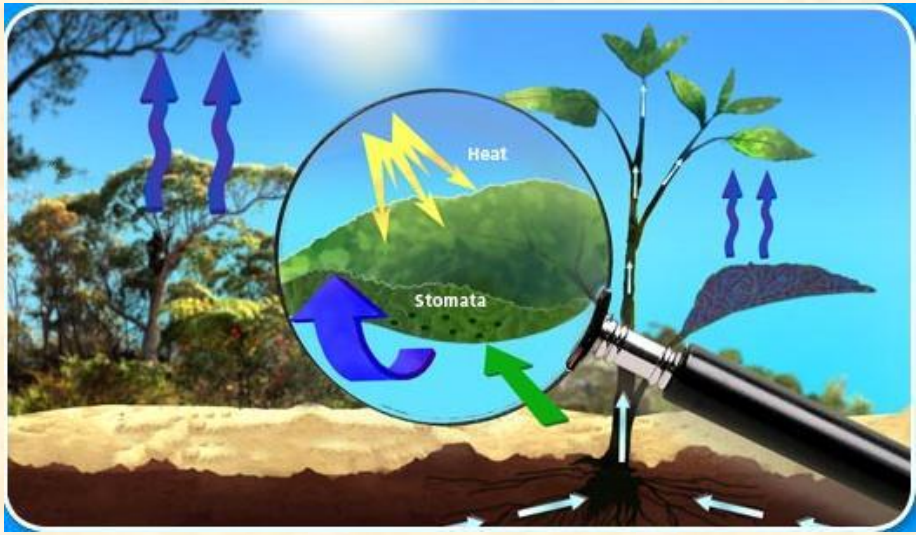


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (*P*) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/*P* were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

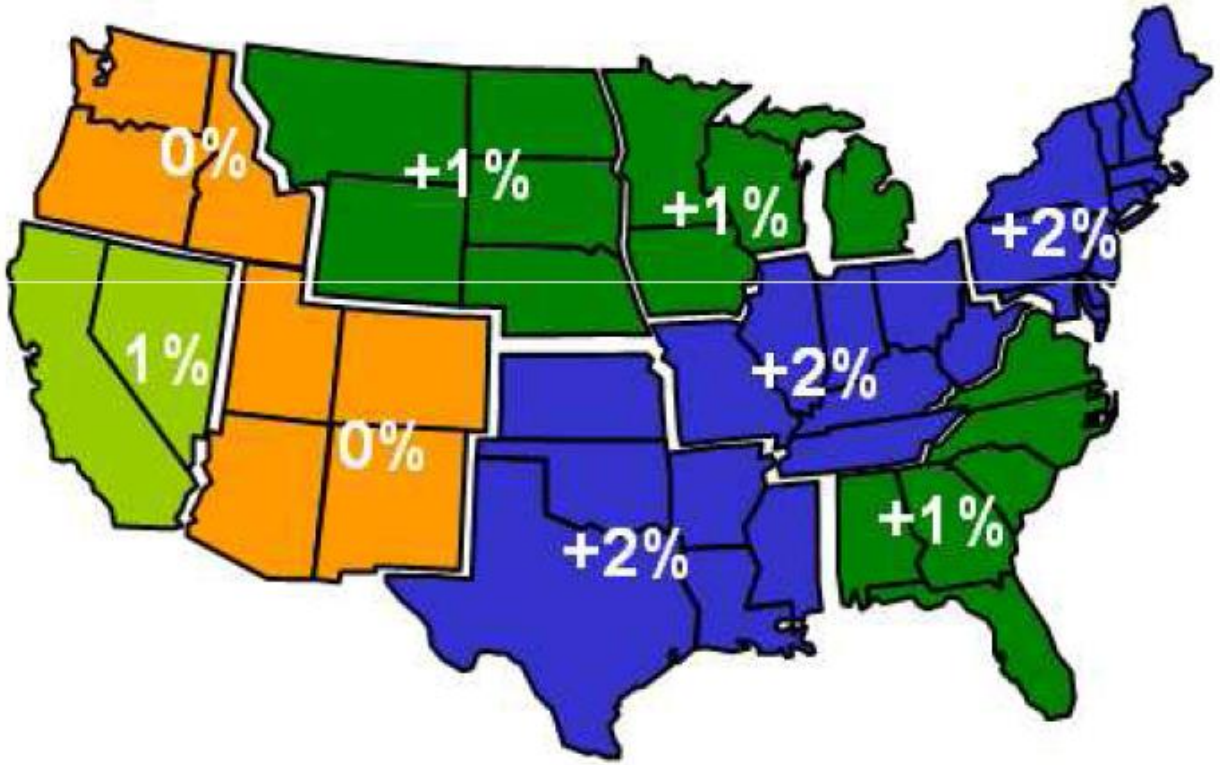




Similar Trends In Rainfall Intensity Are Seen In CBP Model Record of 1985-2011 Simulation Years

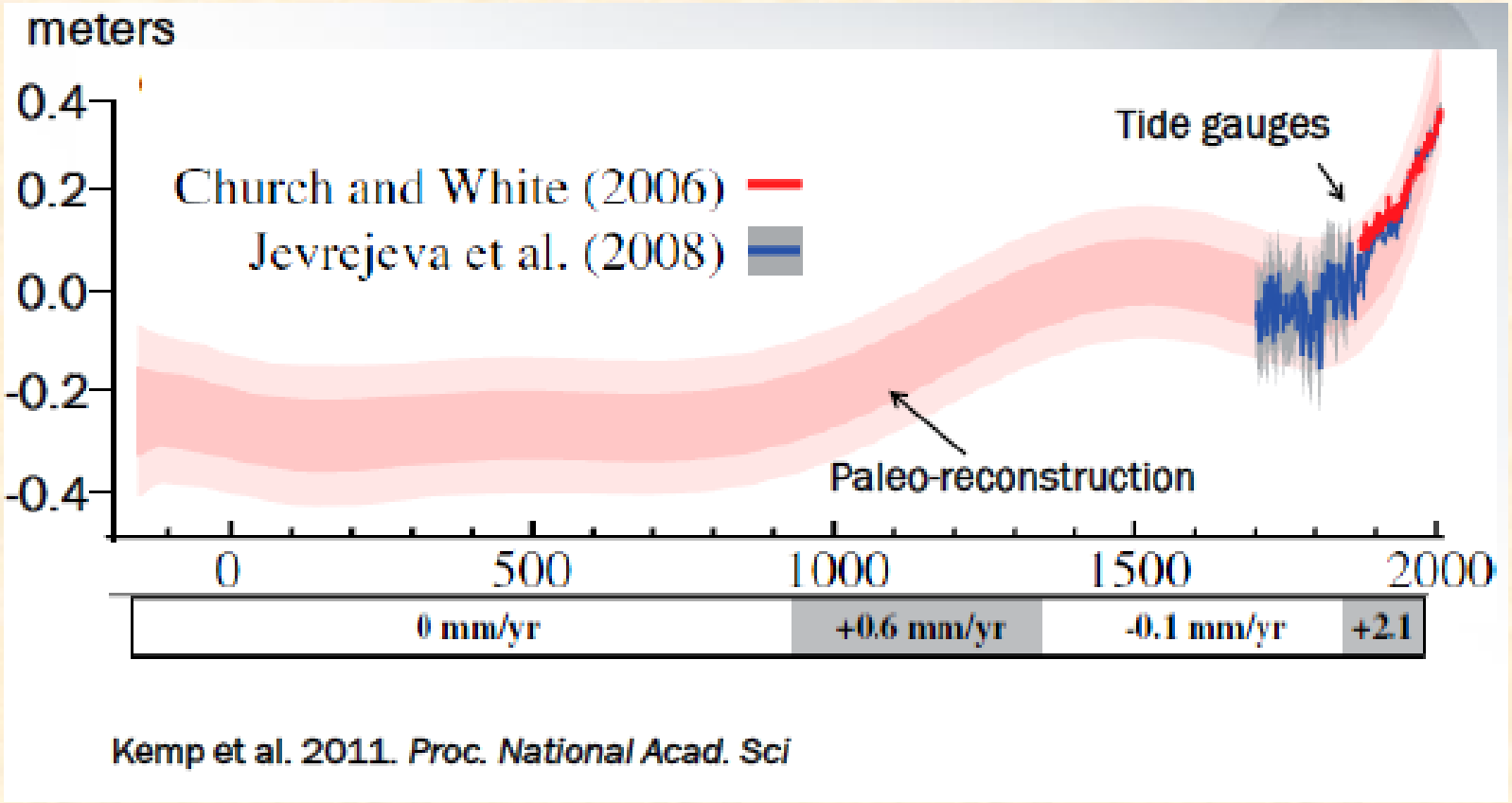
Changes in precipitation intensity during last century

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

Sea Level Had Been Stable 2000 Years, But…



Kemp et al. 2011. *Proc. National Acad. Sci*

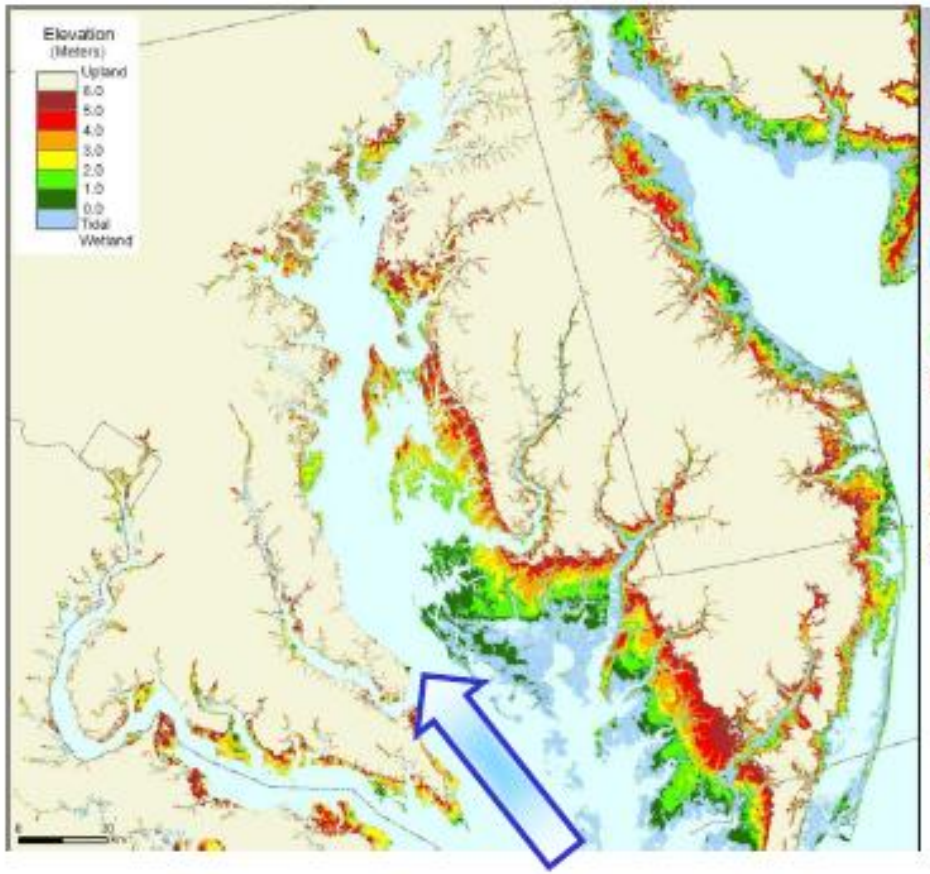
How Much Will Sea Level Rise In the Chesapeake Bay?

Maryland Relative Sea-level Rise	Thermal (m)	Glaciers (m)	Greenland (m)	Antarctica (m)	Dynamic (m)	VLM (m)	Relative SLR meters	Relative SLR feet
2050 best	0.10	0.05	0.03	0.09	0.09	0.075	0.4	1.4
2050 low	0.04	0.05	0.02	0.04	0.07	0.065	0.3	0.9
2050 high	0.19	0.06	0.05	0.16	0.10	0.085	0.7	2.1
2100 best	0.24	0.13	0.10	0.30	0.17	0.15	1.1	3.7
2100 low	0.10	0.12	0.08	0.10	0.13	0.13	0.7	2.1
2100 high	0.46	0.17	0.17	0.58	0.19	0.17	1.7	5.7

Source: Updating Maryland's Sea Level Rise Projections, 2013

Potential Impacts of Sea Level Rise on Tidal Wetlands

Consequences of Sea-Level Rise



Light blue: salt marshes

Greens: < 2 m, susceptible to innundation

Orange-yellow: 2-4 m, susceptible to storm surge

Greater Bay volume, ocean influence

Tasks planned and schedule:

2017 Climate Change Analysis - In Part and In Whole (for 2050)

WSM:

- 2050 Land use [Ongoing, Peter C. lead]
- Rainfall increased intensity [Modeling Team Lead, Initial analysis in January 2015]
- Evapotranspiration – New methods to account for stomata resistance and CO_2 levels [Modeling Team Lead, Compete by summer 2015]
- Air temp – reaction rates (10^0 C increase = double reaction rates) [model simulation]

WQSTM

-Tidal Water temperature – increase density gradient [Modeling Team Lead, Initial analysis in January 2015]
- Increased salinity - increase density gradient [Modeling Team Lead, Initial analysis in January 2015]
- Sea level rise & tidal Bay hydrodynamic effects [Modeling Team Lead, Initial analysis in January 2015]
- Wetland impacts of sea level rise [CoE ERDC Lead, complete by close 2016]
- Changes in SAV habitat [CoE ERDC lead complete by close 2016]

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.
- The objective for the 2017 Midpoint Assessment is to provide decision makers the best available assessment of the influence climate change will have on the Chesapeake TMDL.

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