

Key partnership success associated with ecosystem improvements & addressing gaps in our outcome attainability

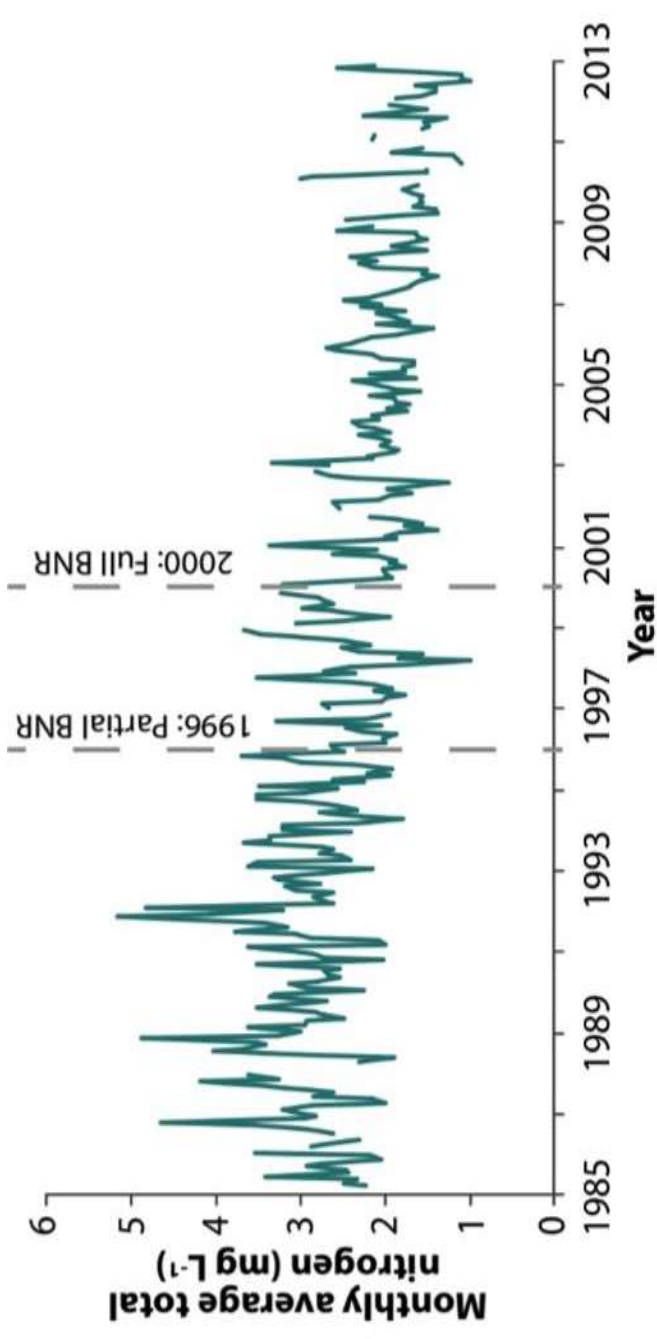
Bill Dennison

Strategy Review System
11 May 2023
Charlottesville, VA

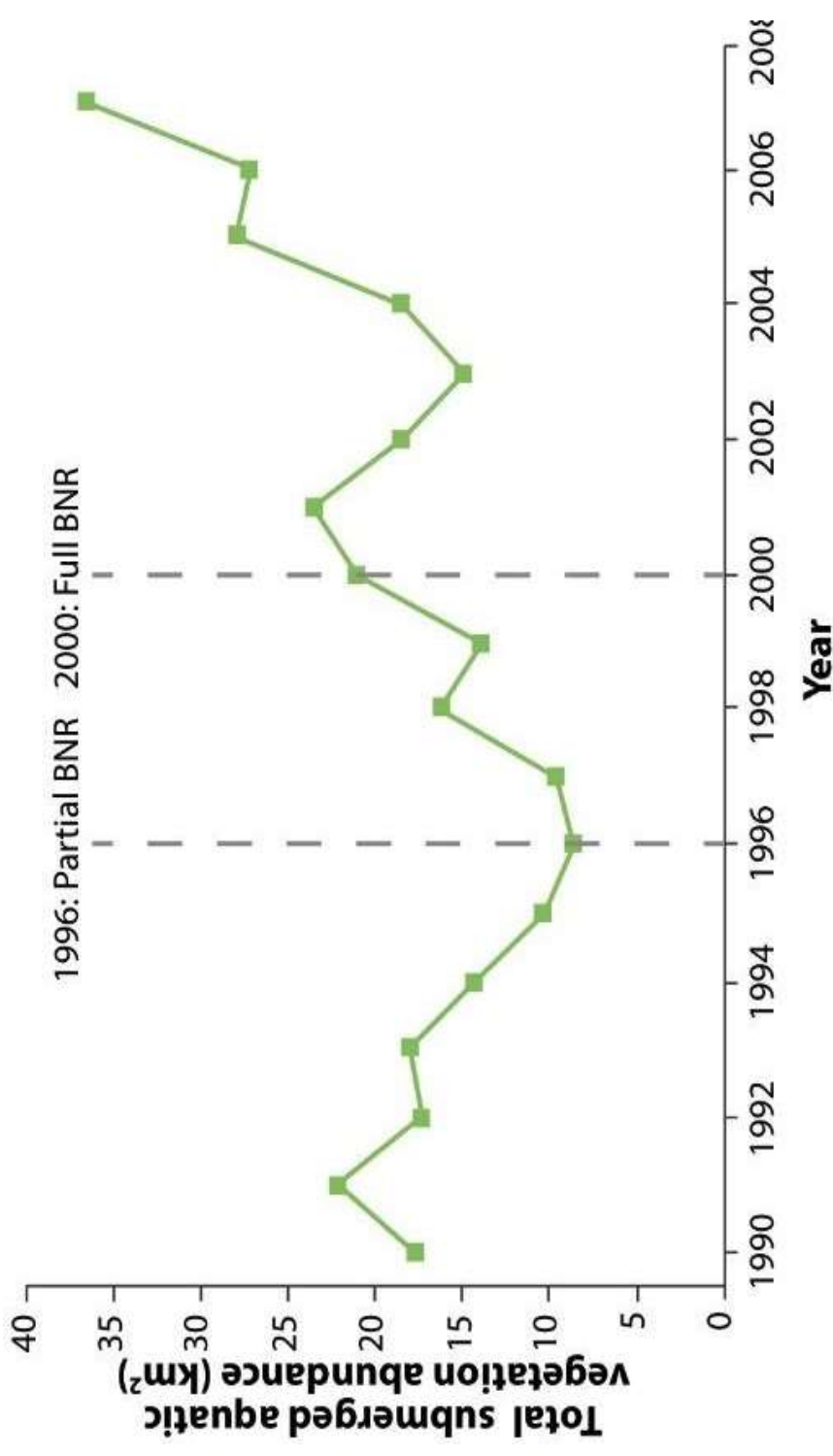


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Sewage upgrades have resulted in significant reductions in nutrient loads attainability

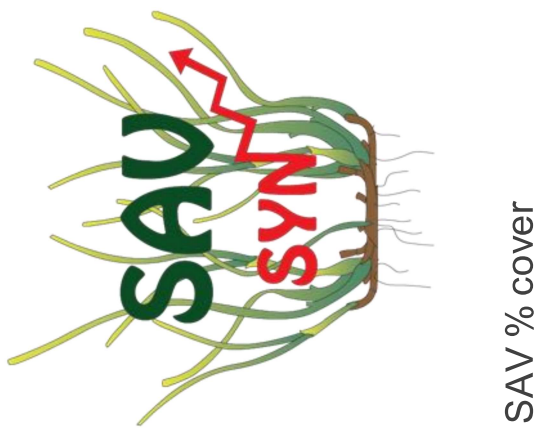
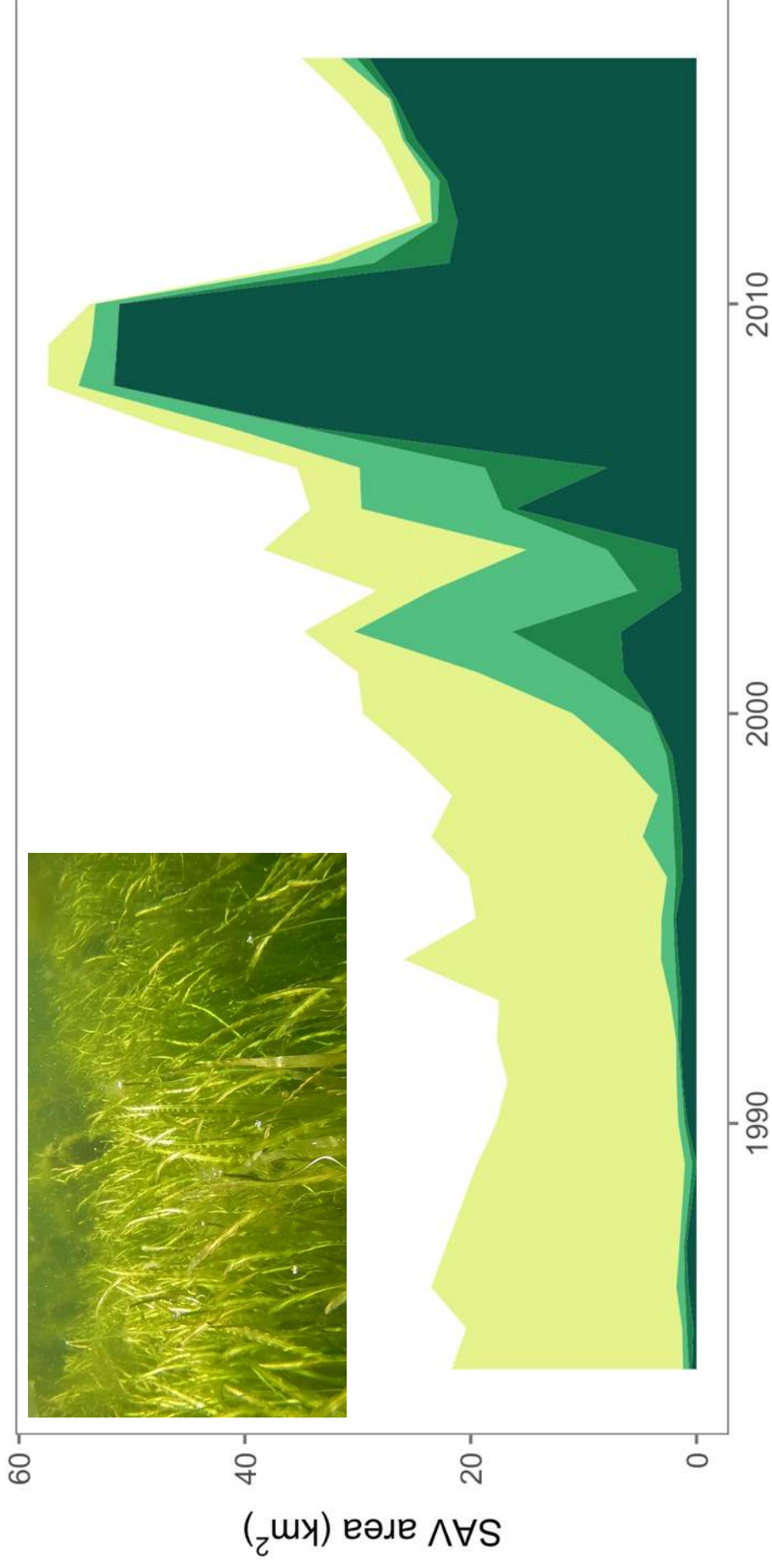


Sewage upgrades have led to SAV resurgence



SAV recovery is resilient

Susquehanna Flats SAV area



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Large media coverage achieved

Energy and Environment
The Chesapeake's 'secret garden' is thriving again, but Trump could end that

By Darryl Fears March 5 [Email the author](#)



Eelgrass in the Chesapeake Bay in summer 2017. (Photo by Jon Lefcheck)

The Post's View • Opinion
Why the Chesapeake Bay is the best in the world

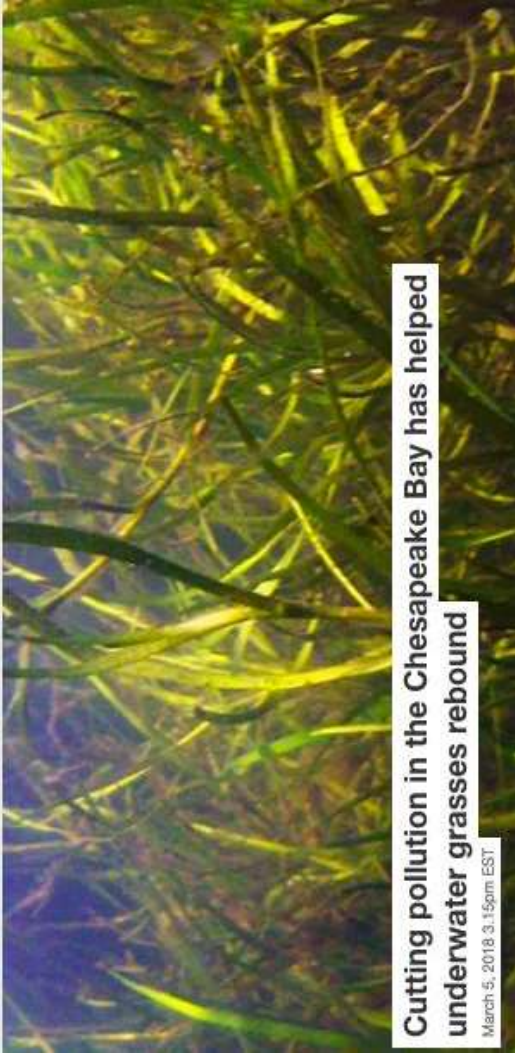
THE CONVERSATION
Academic rigor, journalistic flair

Arts + Culture Economy + Business Education Environment + **Energy** Ethics + Religion Health + Medicine Politics + Society Science + Technology

[Q Search and/or](#)

Cutting pollution in the Chesapeake Bay has helped underwater grasses rebound

March 5, 2018 3:15pm EST

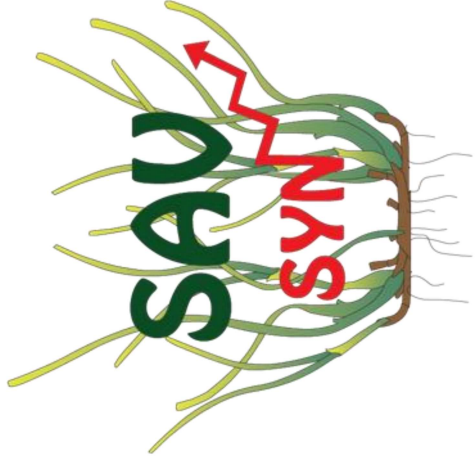


Washington Post editorial supporting Chesapeake Bay Program
56 M people exposed to story via traditional and social media



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Legacy = people and funding



Acting U.S. EPA administrator wants to keep Great Lakes restoration program



TOM HENRY 
The Blade
thenry@theblade.com 

AUG 18, 2018

1:06 AM

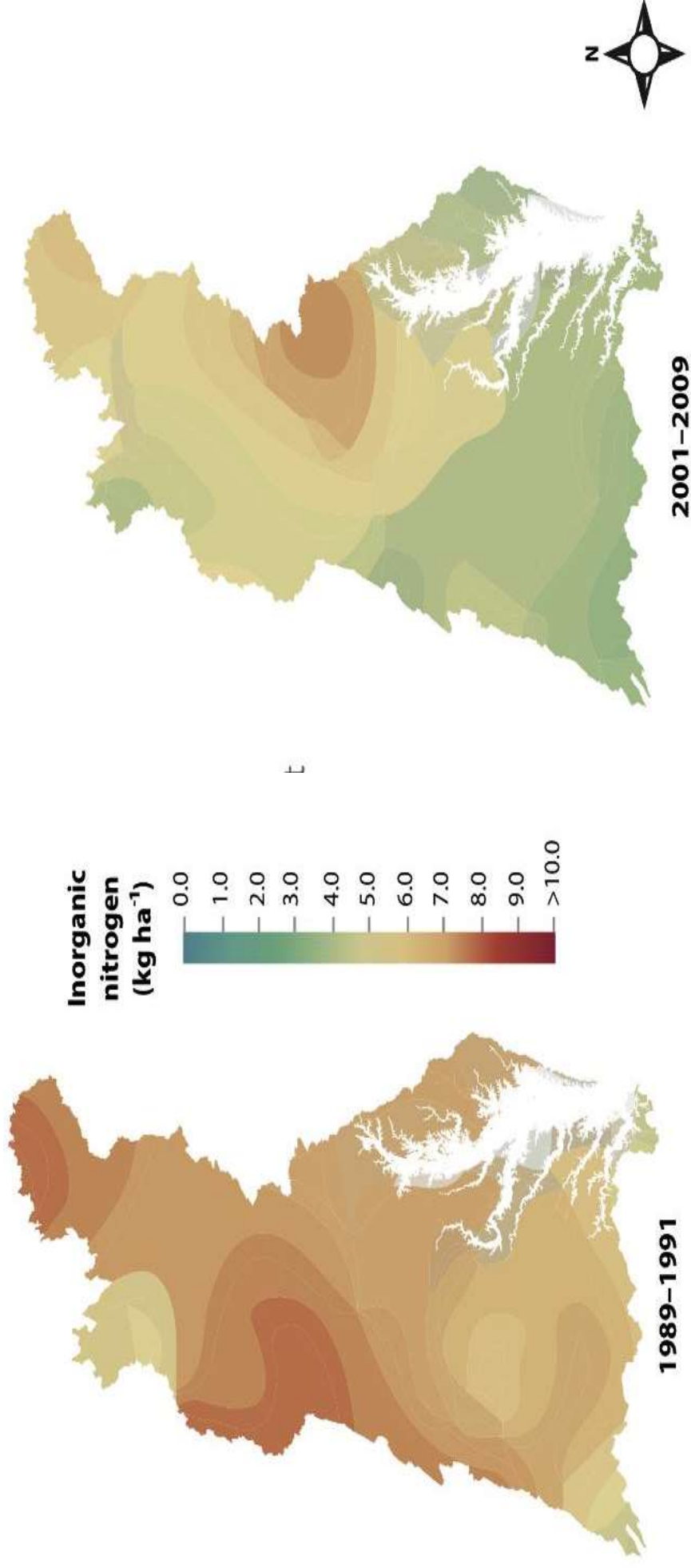
The \$300 million-a-year Great Lakes Restoration Initiative is one Obama-era program that will survive the Trump Administration if the U.S. Environmental Protection Agency's new acting administrator, Andrew Wheeler, gets his way.

And, from Mr. Wheeler's perspective, Chesapeake Bay's highly aggressive cleanup strategy — a strategy that mirrors the sort of regulations some U.S. EPA critics and others want to see implemented for western Lake Erie — has been a success.

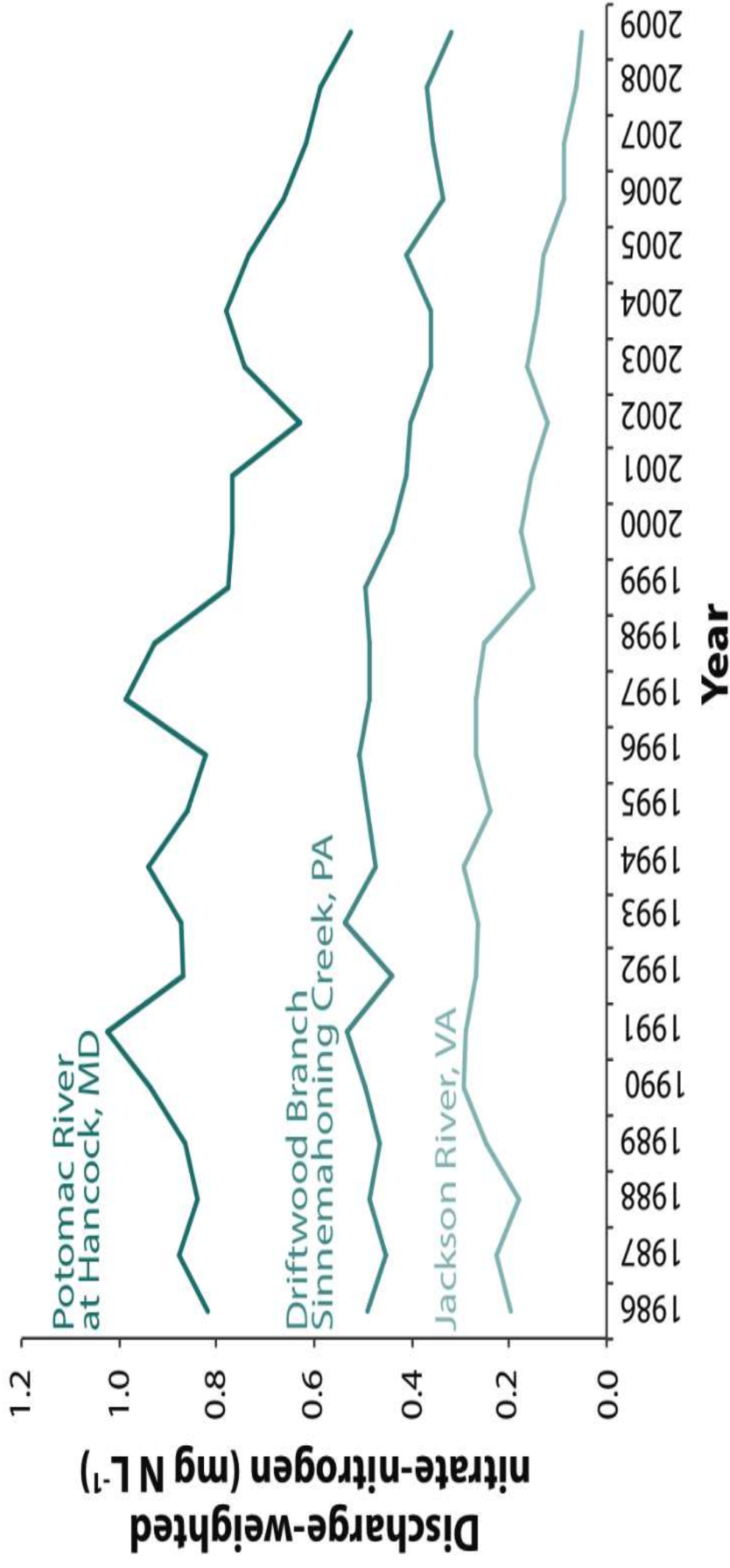


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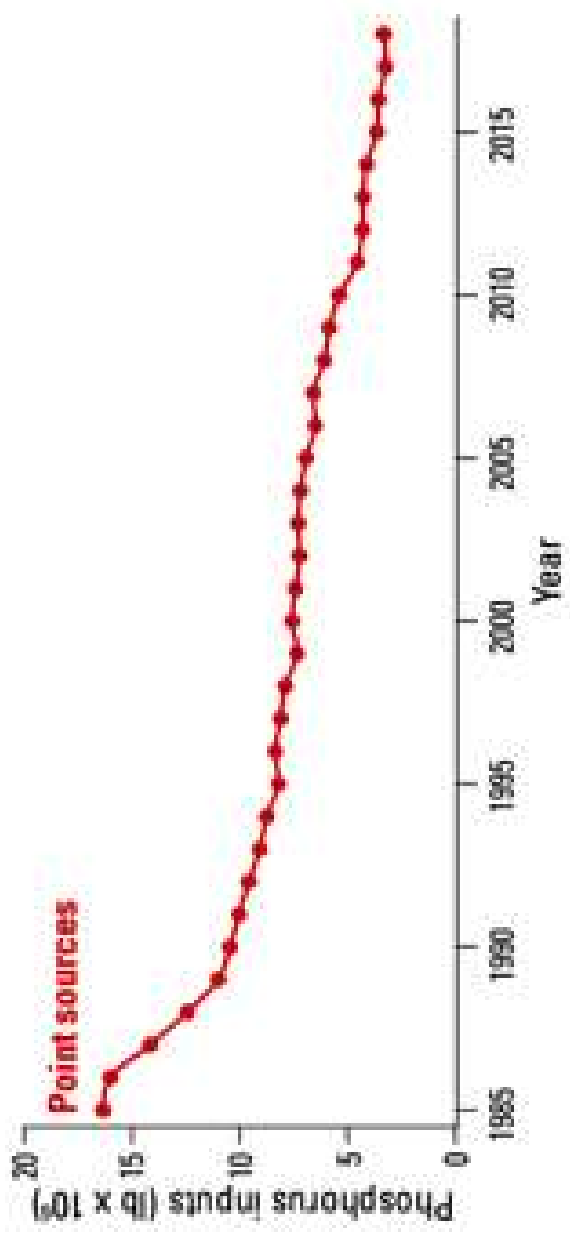
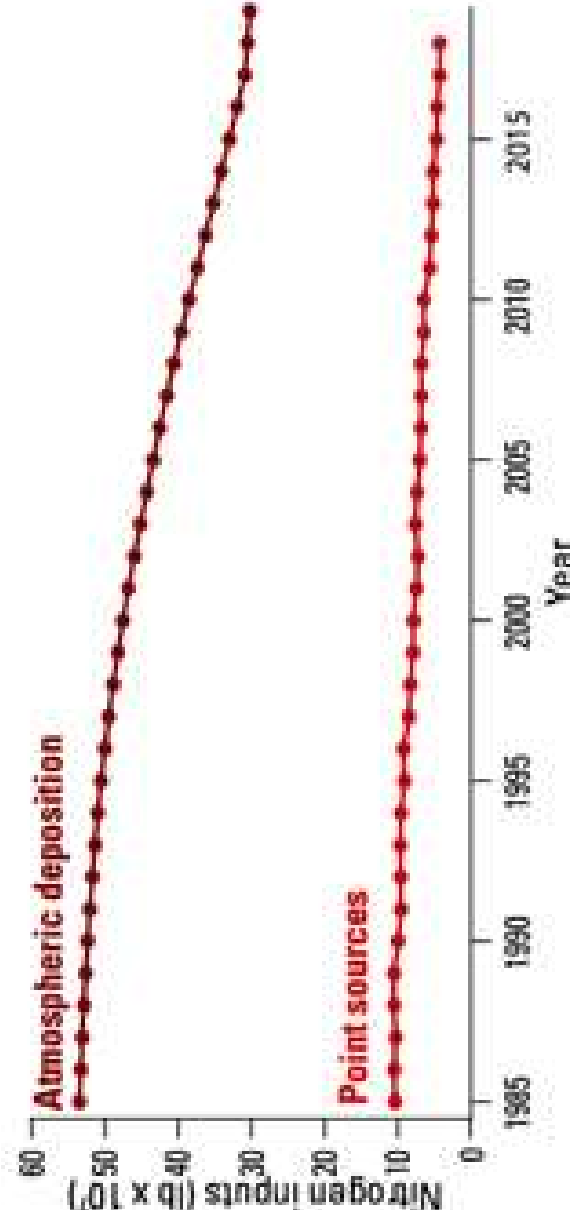
Improvements in air quality due to catalytic converters and smokestack scrubbers have resulted in reduced N deposition



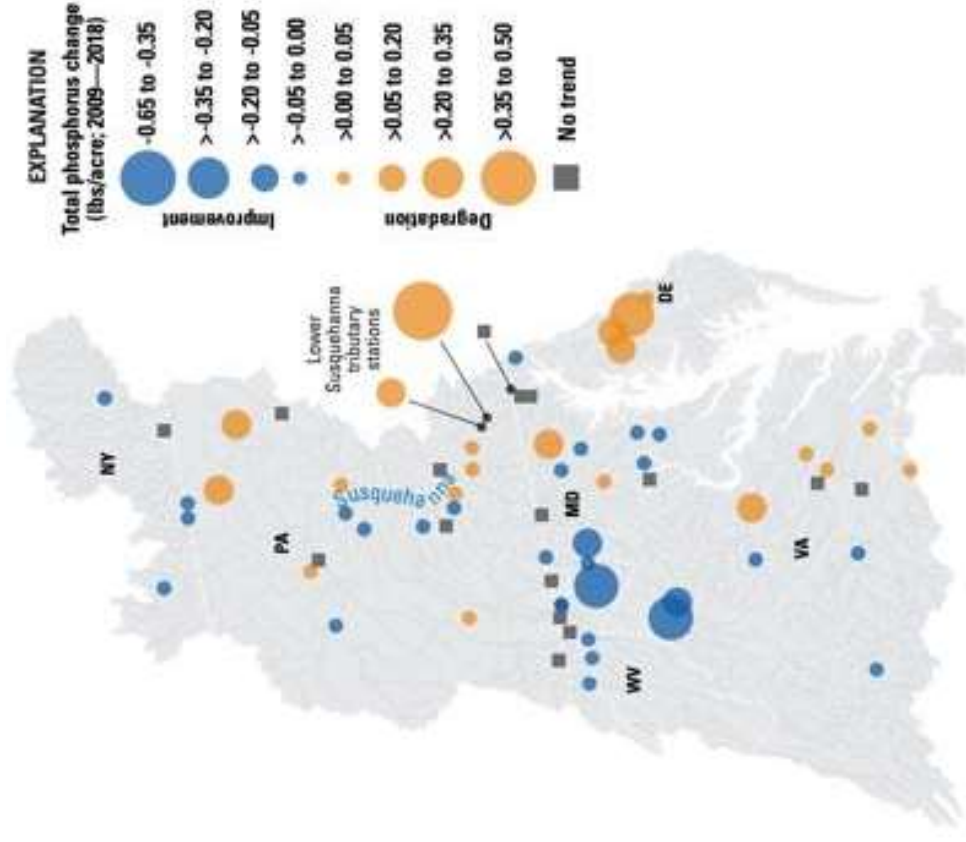
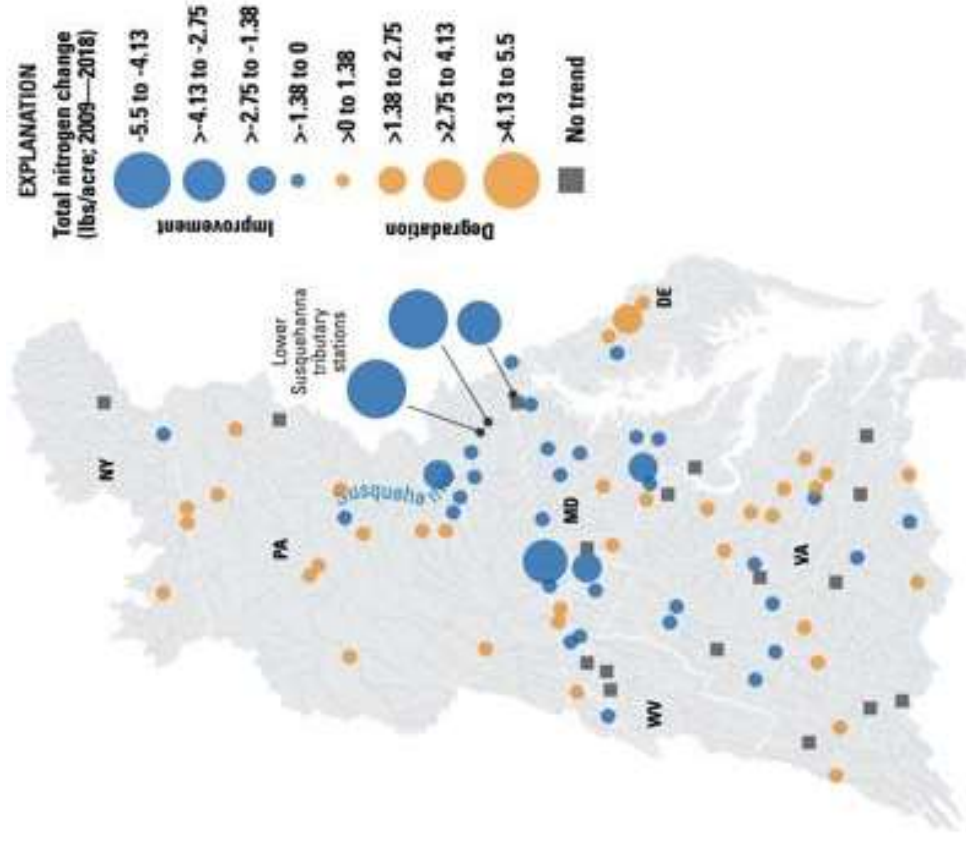
Reductions in N deposition are leading to stream nitrate reductions



Nutrient reductions due to sewage upgrades and reduced NOx emissions



Nutrient trends in nontidal Chesapeake watershed (2009-2018)



Recent increases in agricultural surpluses observed

Major point and nonpoint sources of nutrient pollution to surface water have declined throughout the Chesapeake Bay watershed

Robert D Sabo¹ , Breck Sullivan² , Cuiyin Wu³, Emily Trentacoste⁴, Qian Zhang⁵ , Gary W Shenk⁶ ,
Gopal Bhatt⁷ and Lewis C Linker⁴

¹ U.S. Environmental Protection Agency, Office of Research and Development, Center for Public Health, Washington, DC, United States of America

² U.S. Geological Survey, Chesapeake Research Consortium, Chesapeake Bay Program Office, Annapolis, MD, United States of America

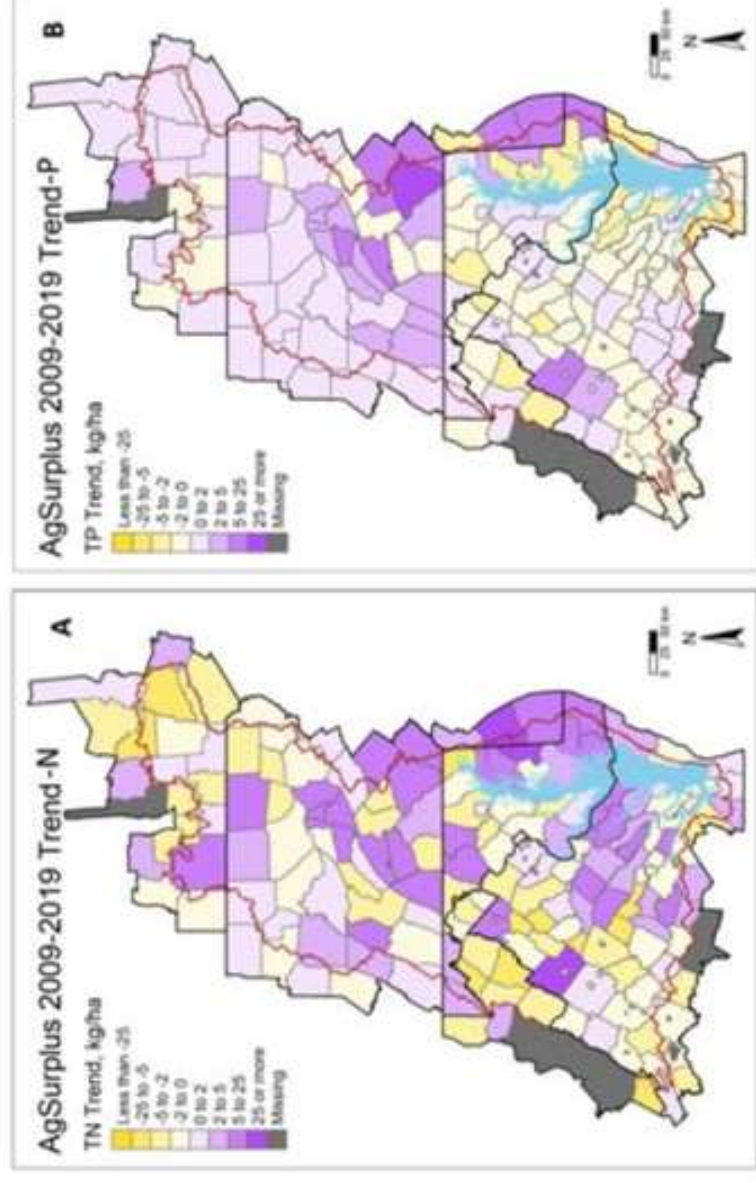
³ ERT, Inc., Laurel, MD, United States of America

⁴ U.S. Environmental Protection Agency, Office of Research and Development, Immediate Office, Washington, DC, United States of America

⁵ University of Maryland Center for Environmental Science, Chesapeake Bay Program Office, Annapolis, MD, United States of America

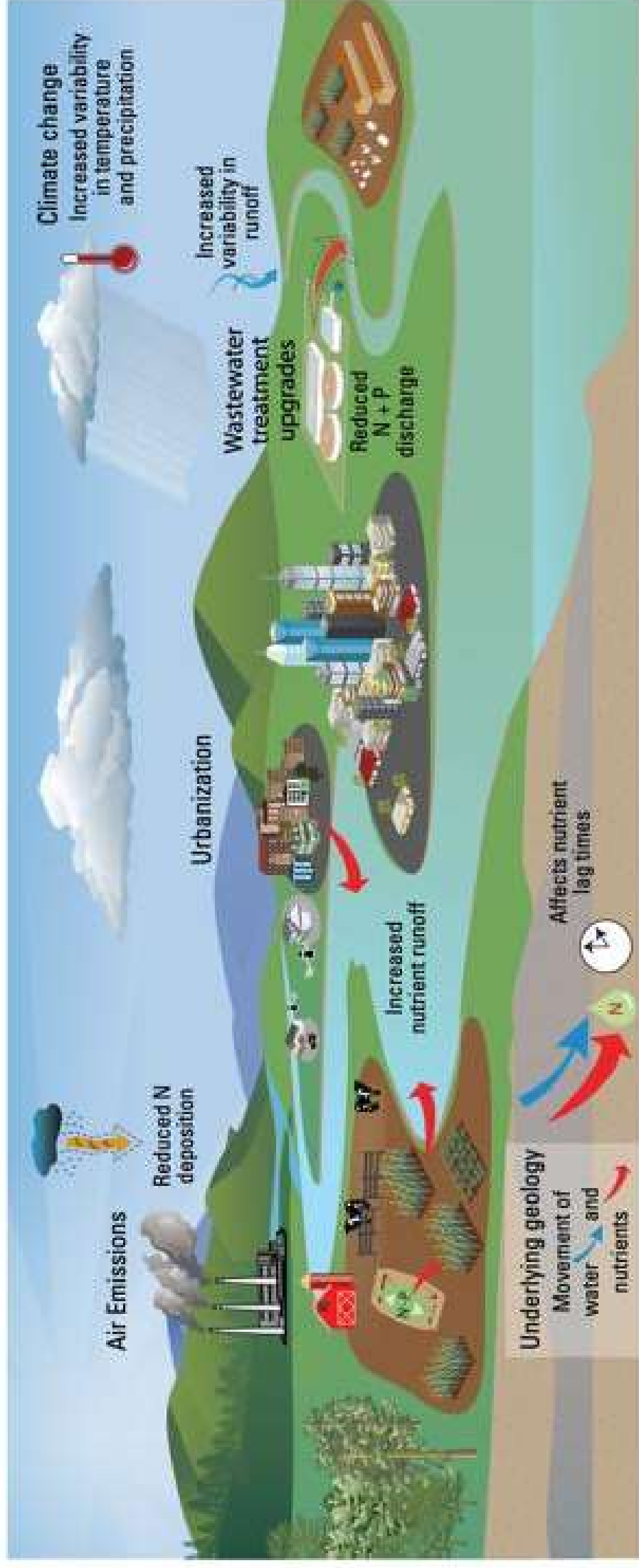
⁶ U.S. Geological Survey, Chesapeake Bay Program Office, Annapolis, MD, United States of America

⁷ Pennsylvania State University, Chesapeake Bay Program Office, Annapolis, MD, United States of America

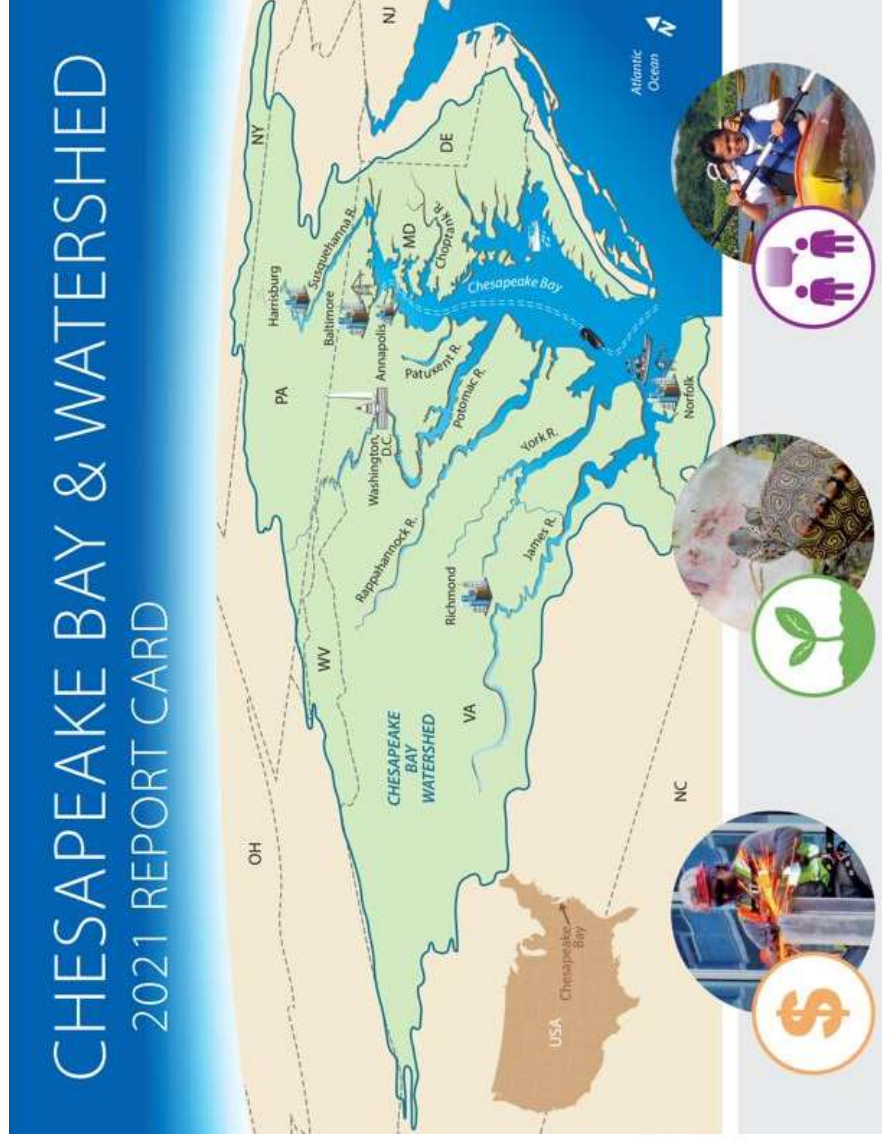


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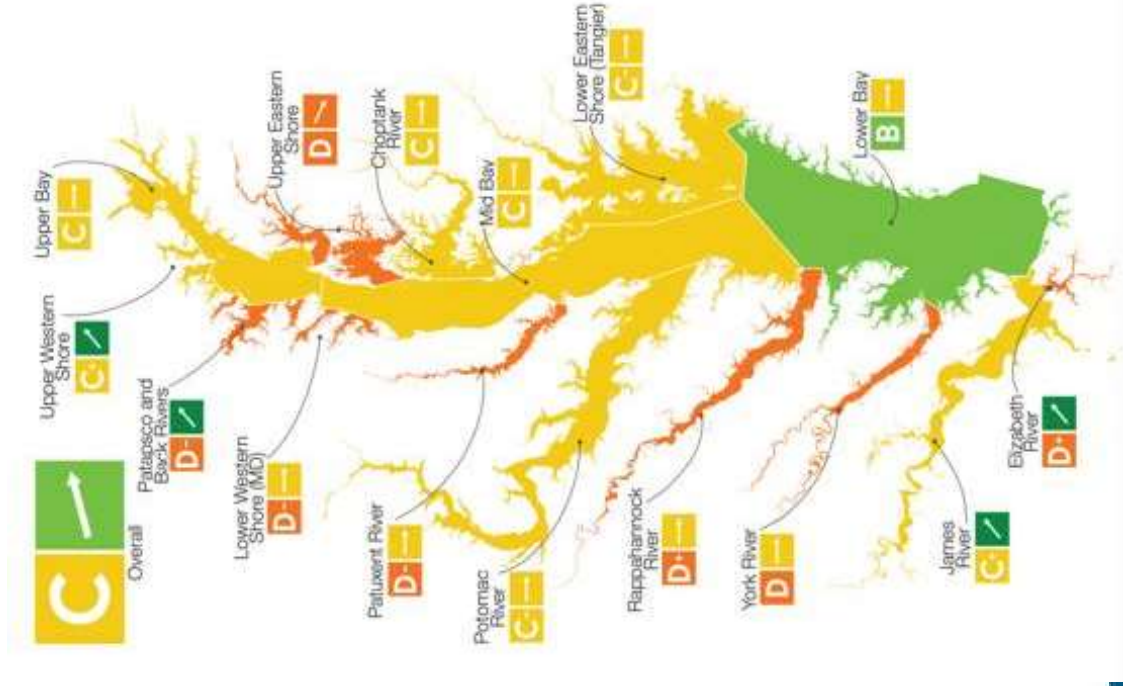
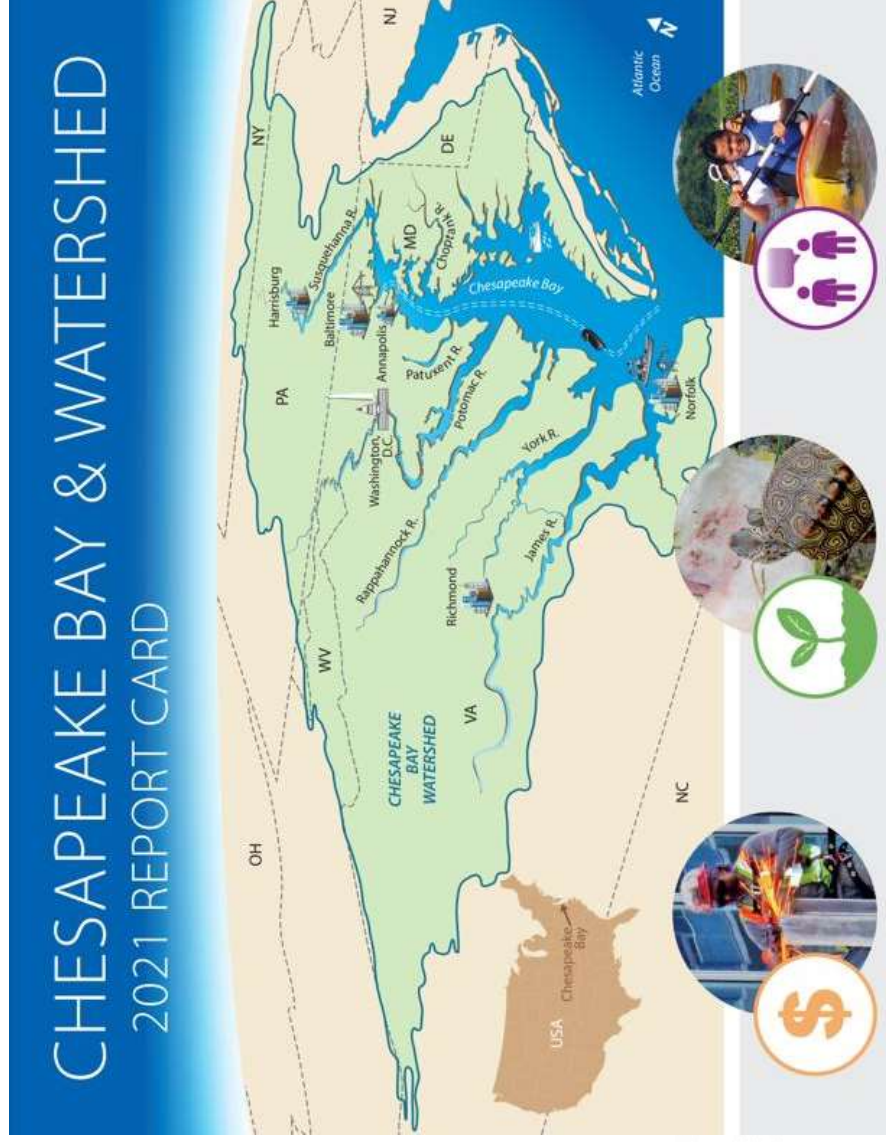
Nutrient cycling in Chesapeake



Chesapeake report card shows positive trajectories for nutrients, SAV & DO; degradation in water clarity & chlorophyll

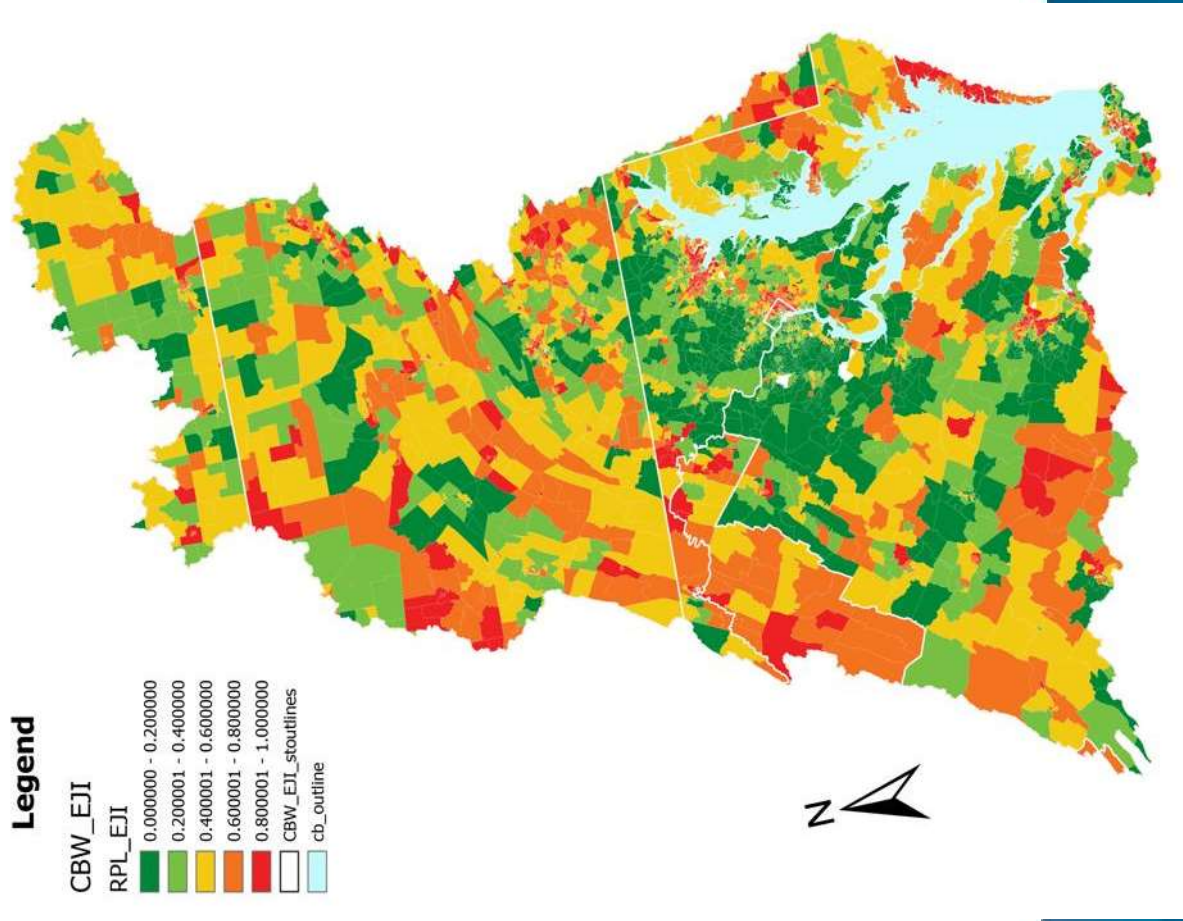


Baywide report card scores improving; 4 reporting regions improving;
10 no change; 1 degrading



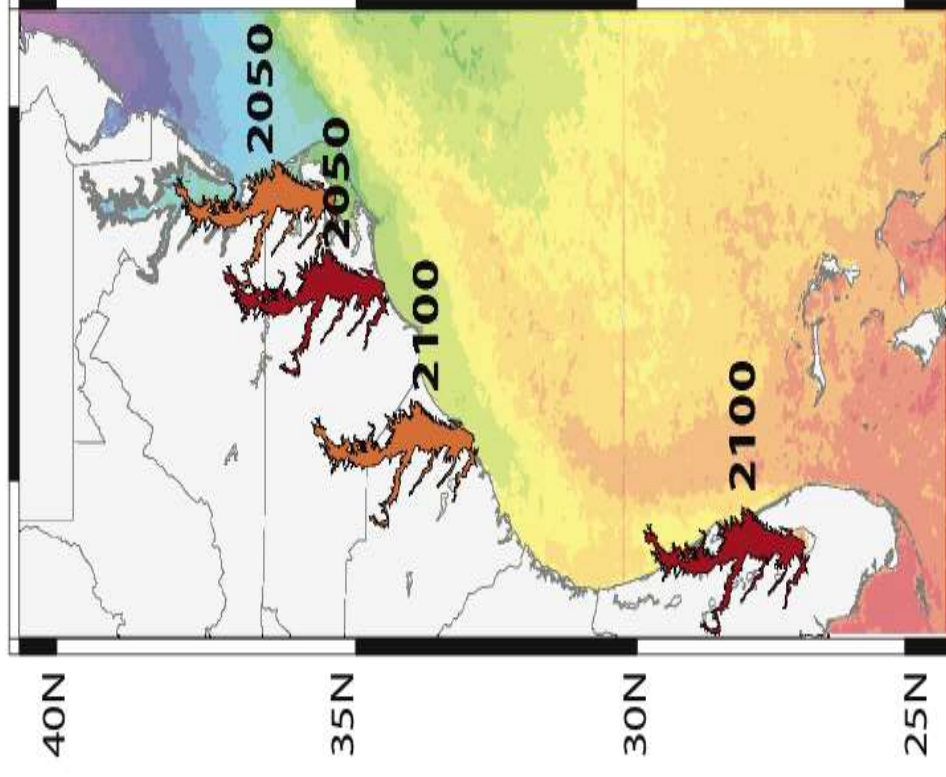
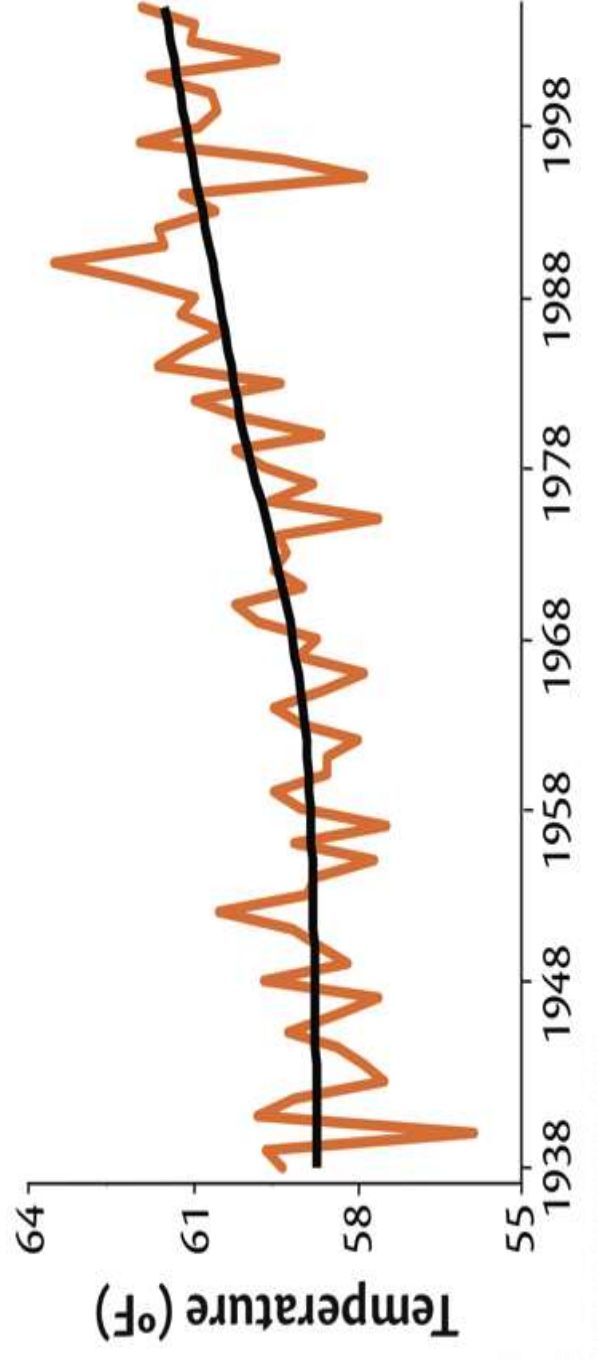
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Environmental Justice has become part of our assessments of the Chesapeake watershed

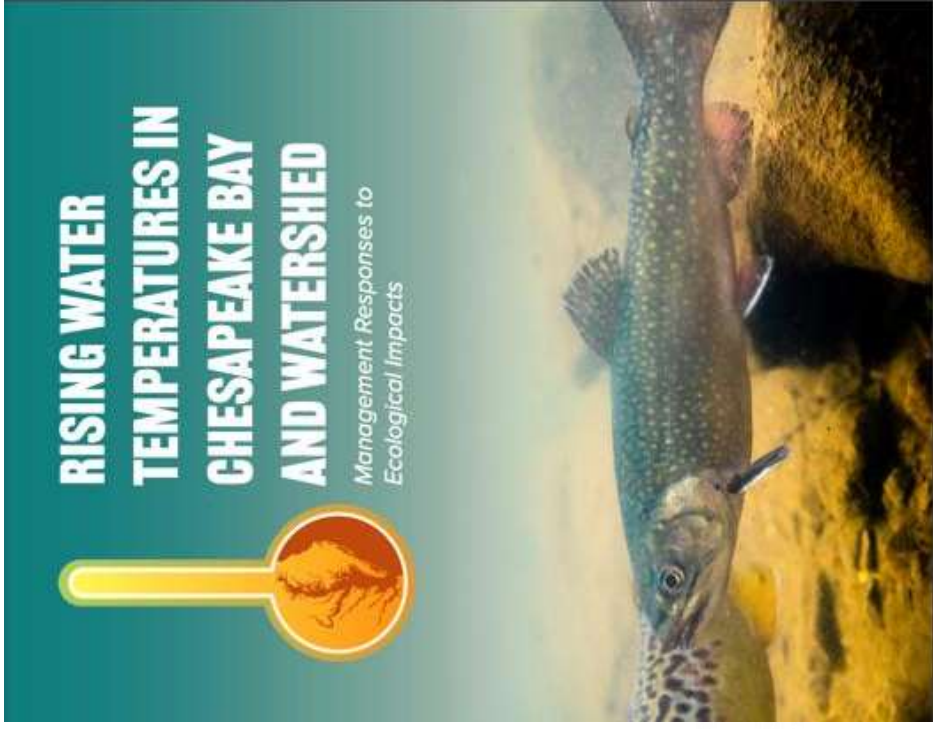


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Climate change is affecting Chesapeake Bay



Rising temperature STAC workshop



Rebecca Hamner
Former CBP Director

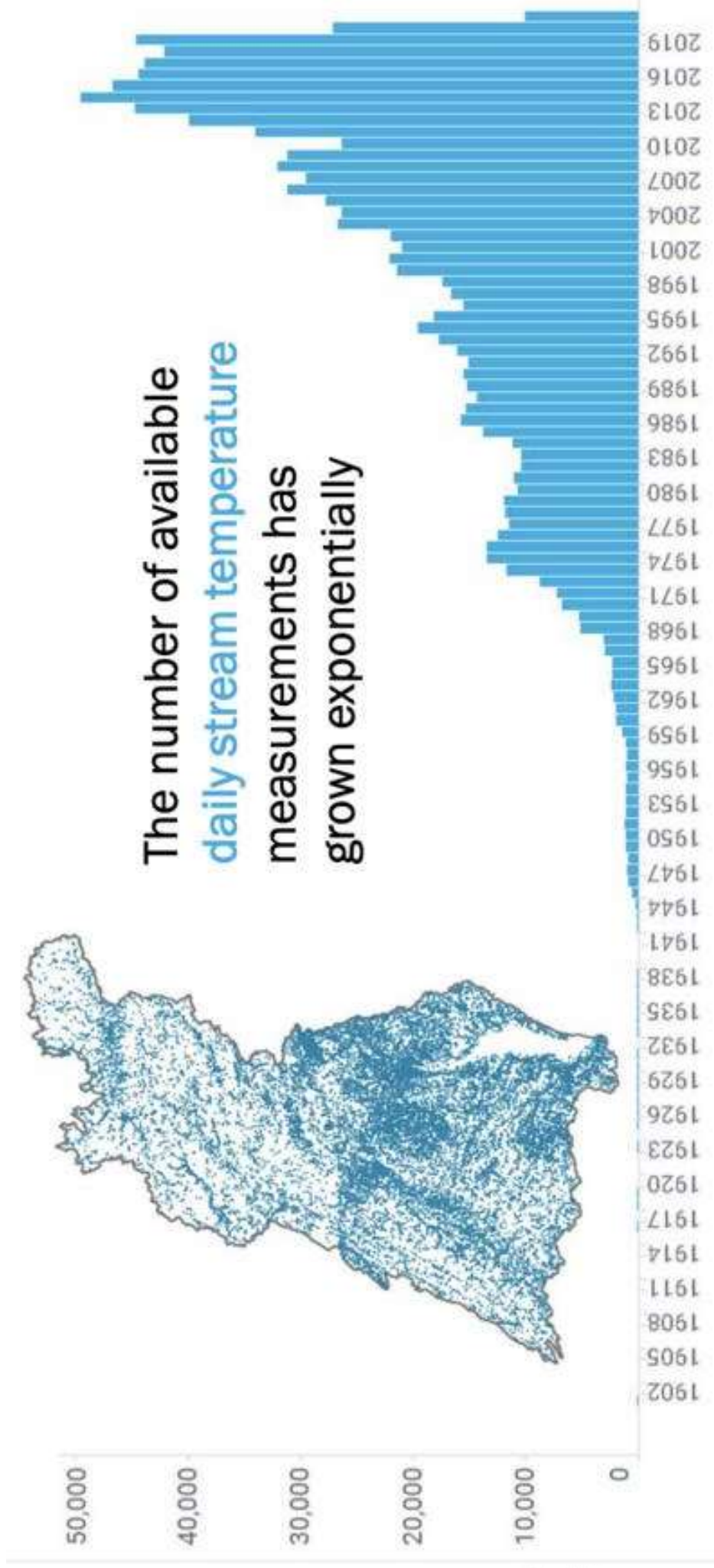


Rich Batiuk
Former CBP Associate Director

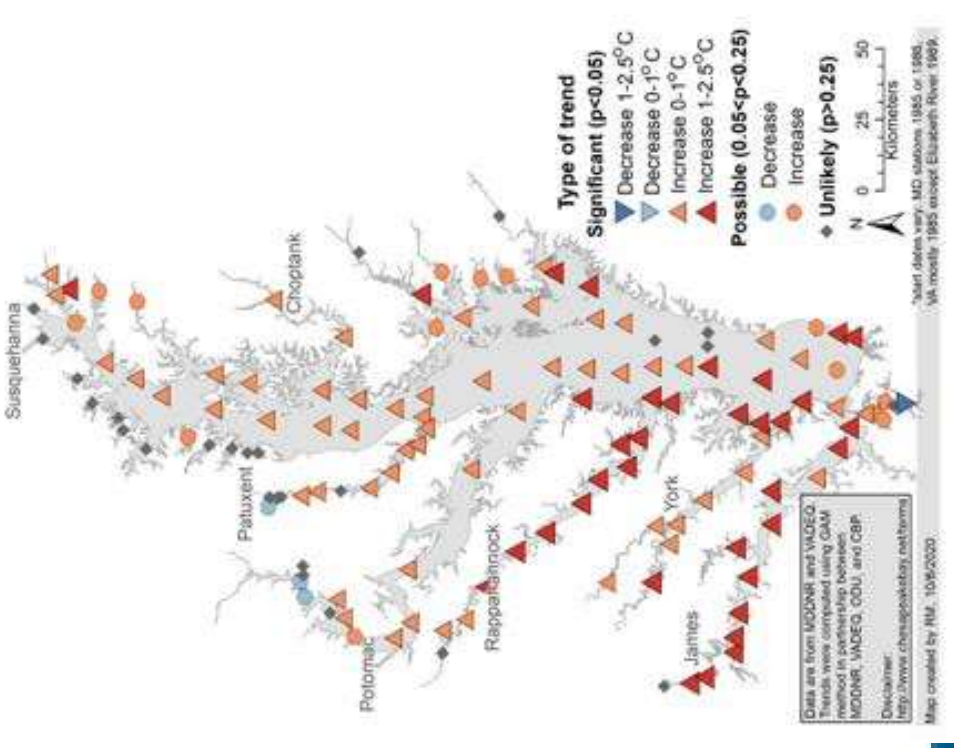
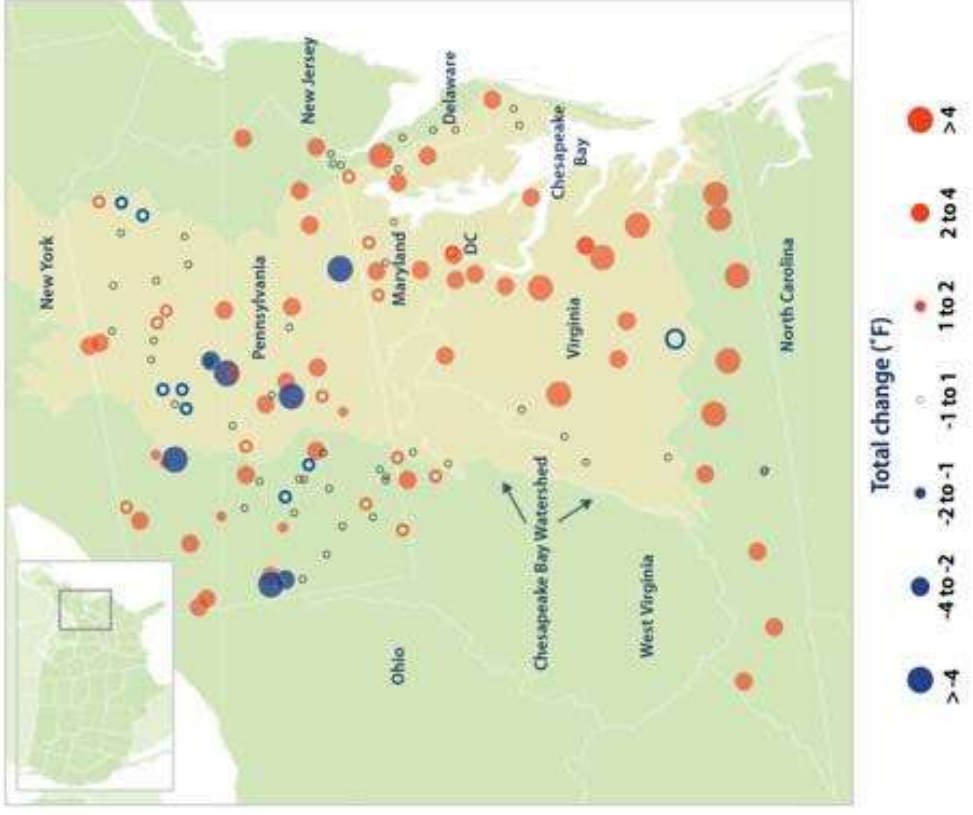


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Expansion of monitoring is occurring



Water temperatures are rising throughout the watershed and throughout the Bay



Recommendations from the rising temperatures STAC workshop

Stay focused

Focus on the Chesapeake Bay TMDL and consider stream temperatures in the context of existing goals.



Keep positive

Despite changes to the watershed and Bay, we must push forward and tell our story as changes unfold.



Prioritize BMPs

Implement cooling BMPs/natural infrastructure that reduce heated runoff from developed areas, farms, & forests.



Integrate monitoring

Link smaller streams, groundwater, living resources and air temperature with water temperature monitoring.



Communicate

Help people to understand why water temperatures are rising and what they can do about it.



Increase trees

Better communicate the benefits of conserving mature trees and don't just rely on new tree planting.



Update standards

State water quality standards need to address climate-related changes to water temperature.



Adapt fisheries

Future management and monitoring of fisheries must adapt as fisheries change with rising water temperatures.



Target restoration

Factor rising water temperatures into our tools for targeting the lands to conserve and where to apply BMPs.



Land-sea opportunities

Consider shorelines/nearshore environments for restoration and habitat protection of at-risk species.



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Rising temperature workshop resulted in TWO songs

Temperature on the Rise

Bill Dennison & Scott Phillips



20 May 2021



Heat Waves

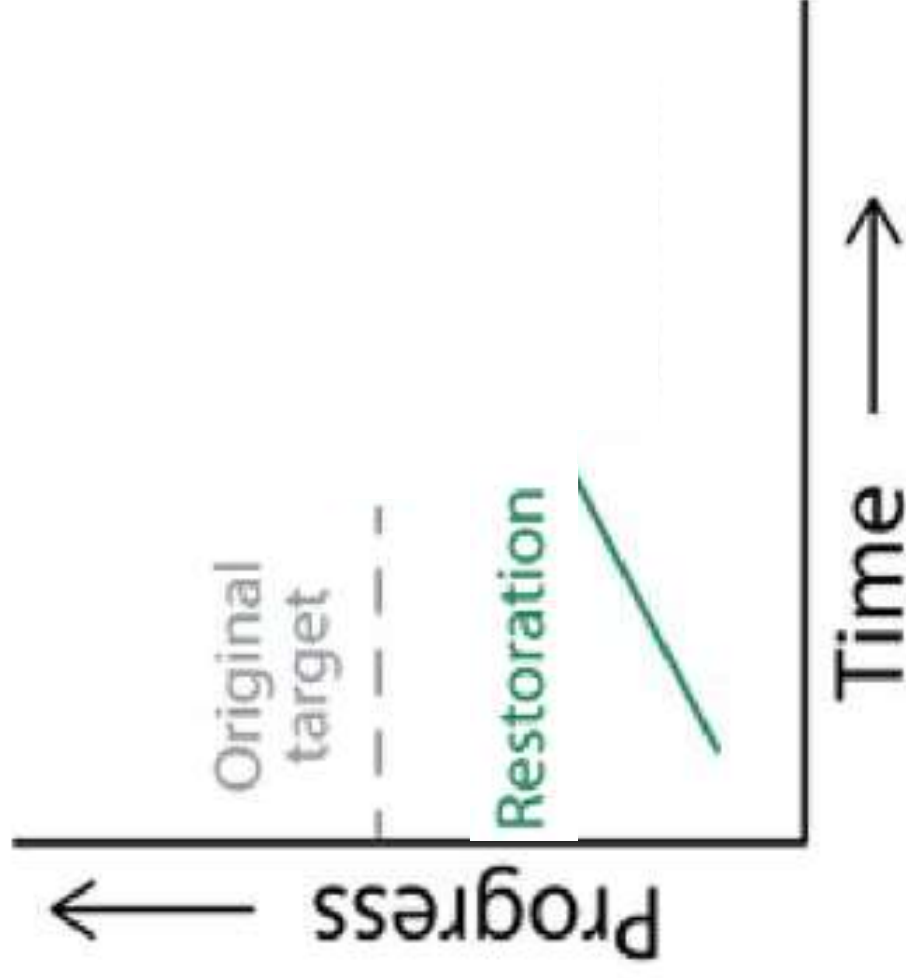
by
Bruce Vogt & Bill Dennison

12 Jan 2022

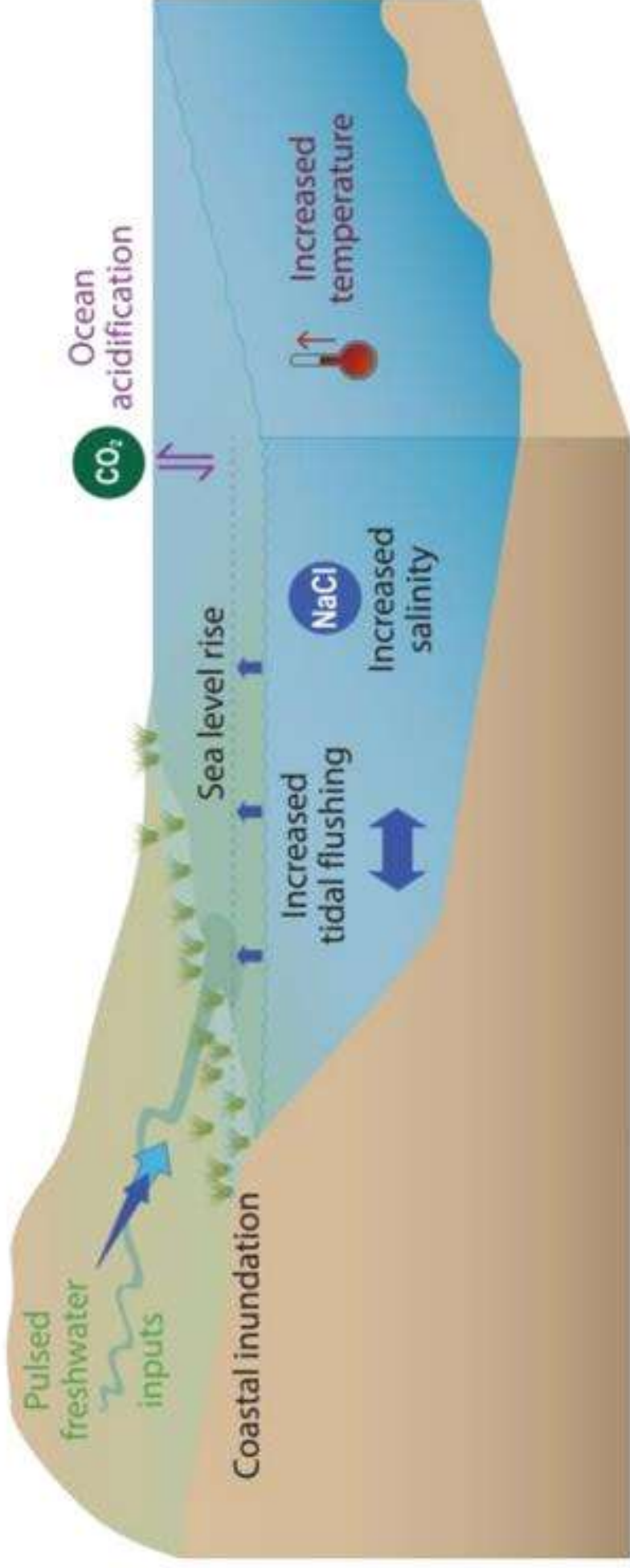


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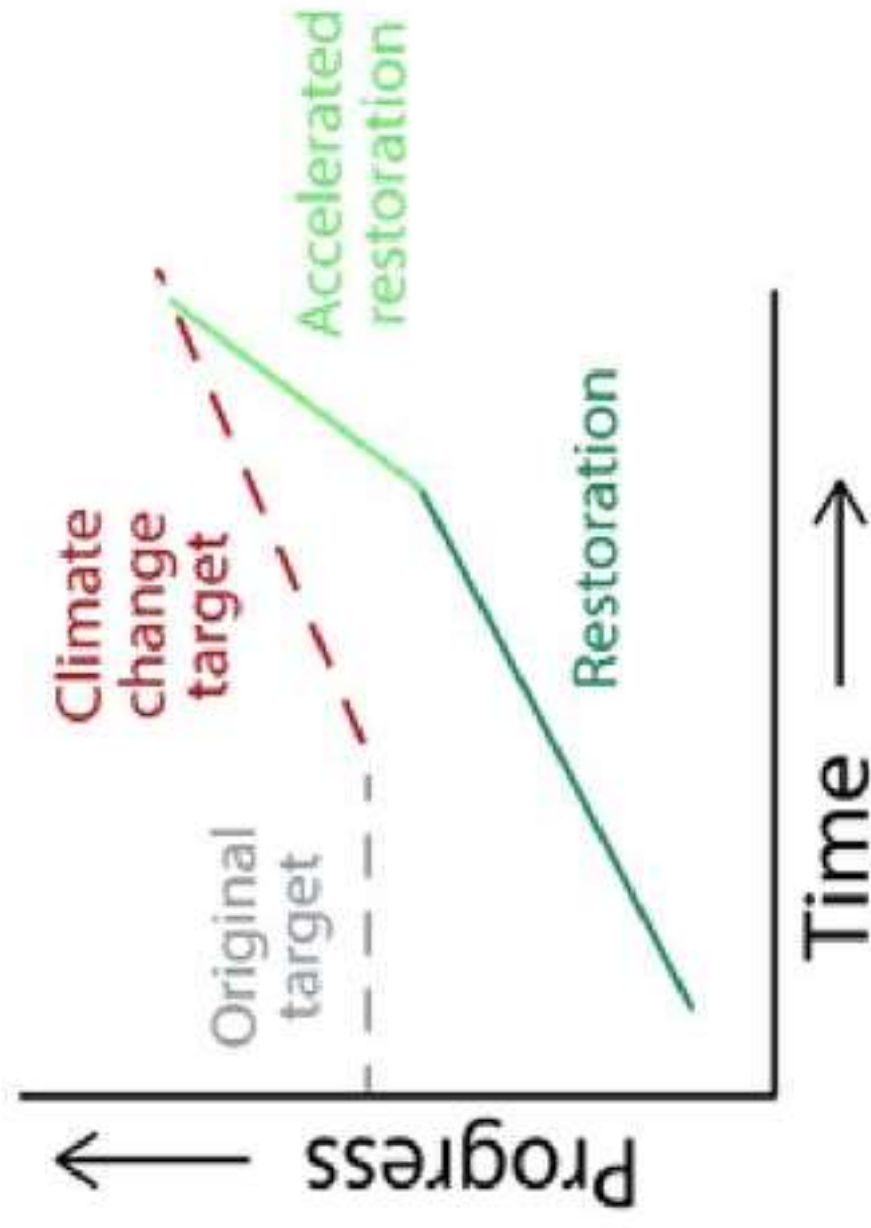
Restoration targets



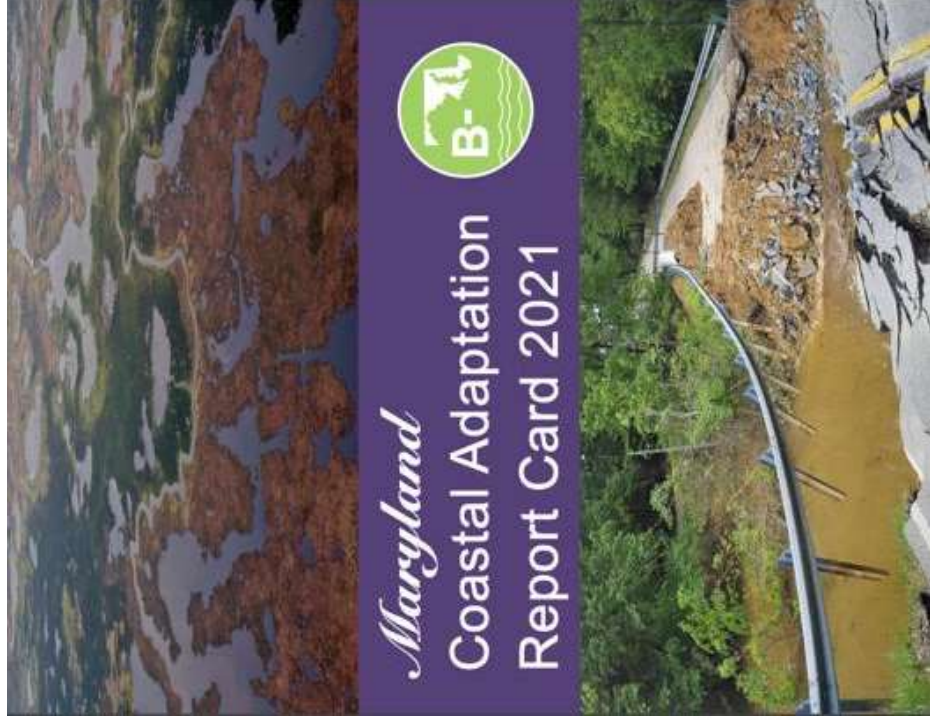
Climate change impacts affect restoration



Climate change impacts require accelerated restoration



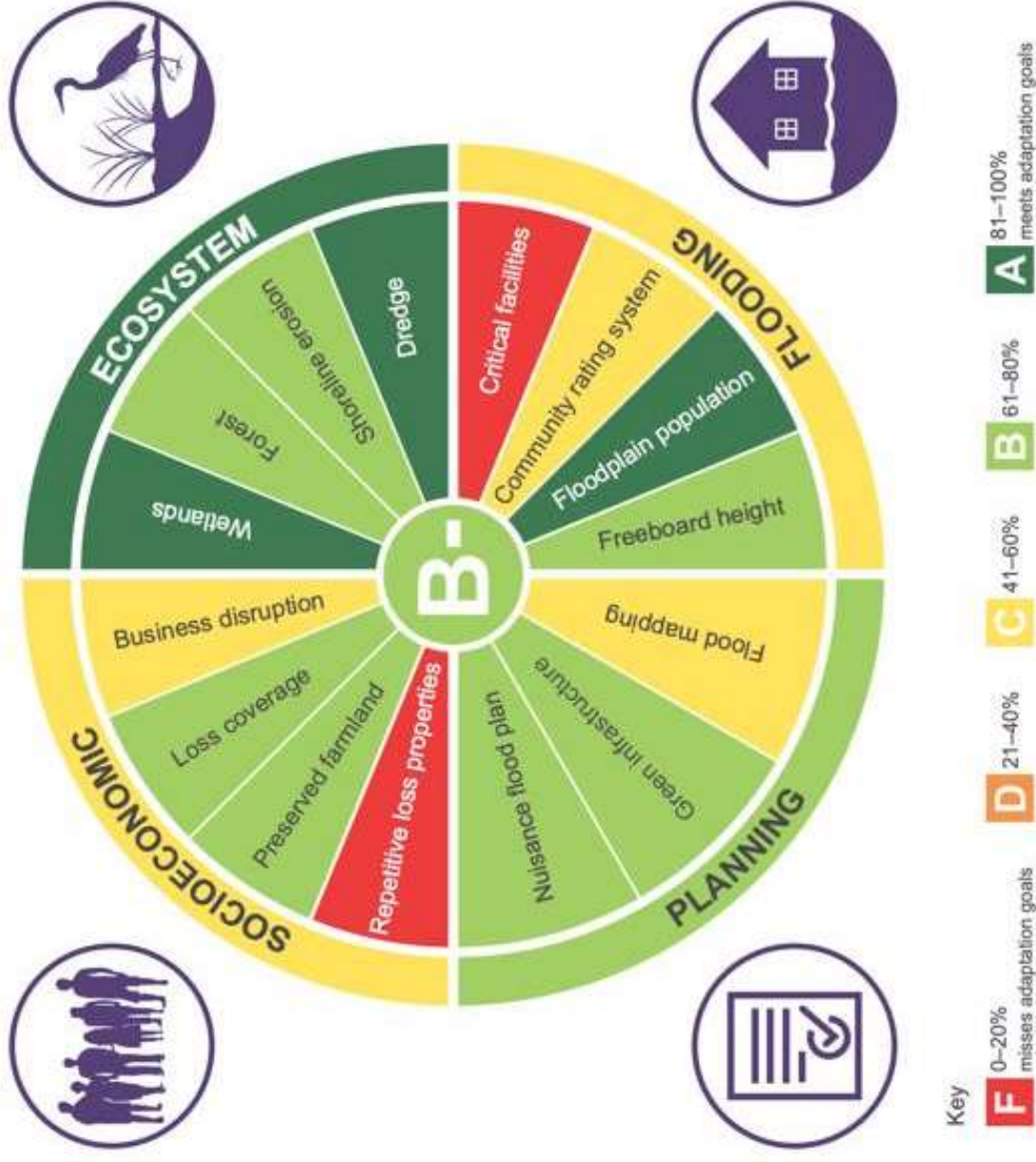
Maryland coastal adaptation report card produced



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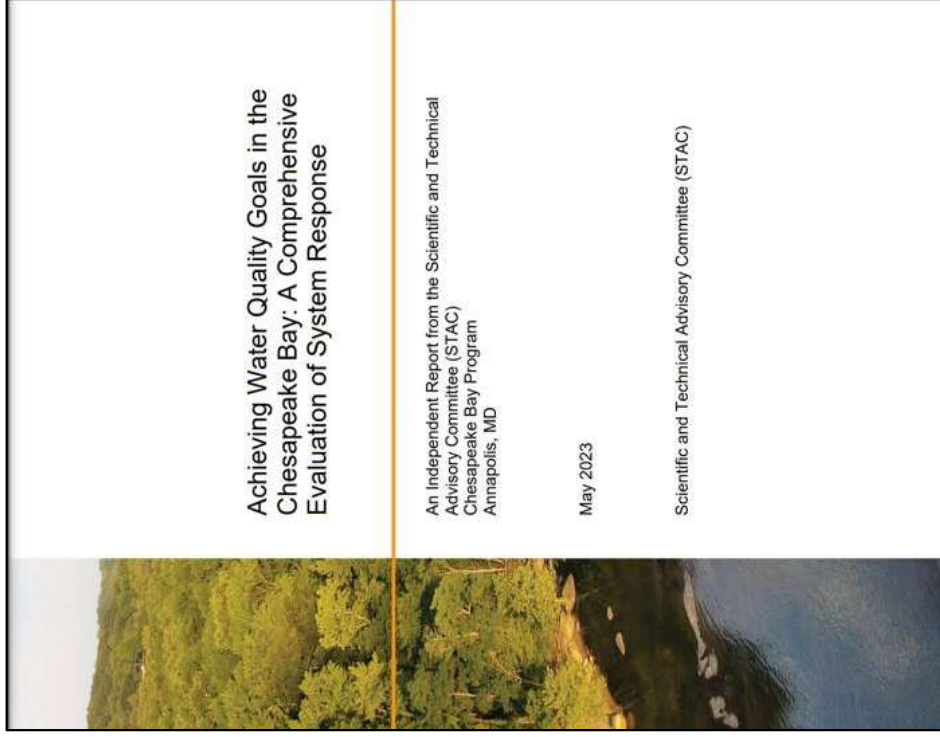
We should consider a Bay wide assessment of coastal resilience

Maryland coastal adaptation scores a **B-**



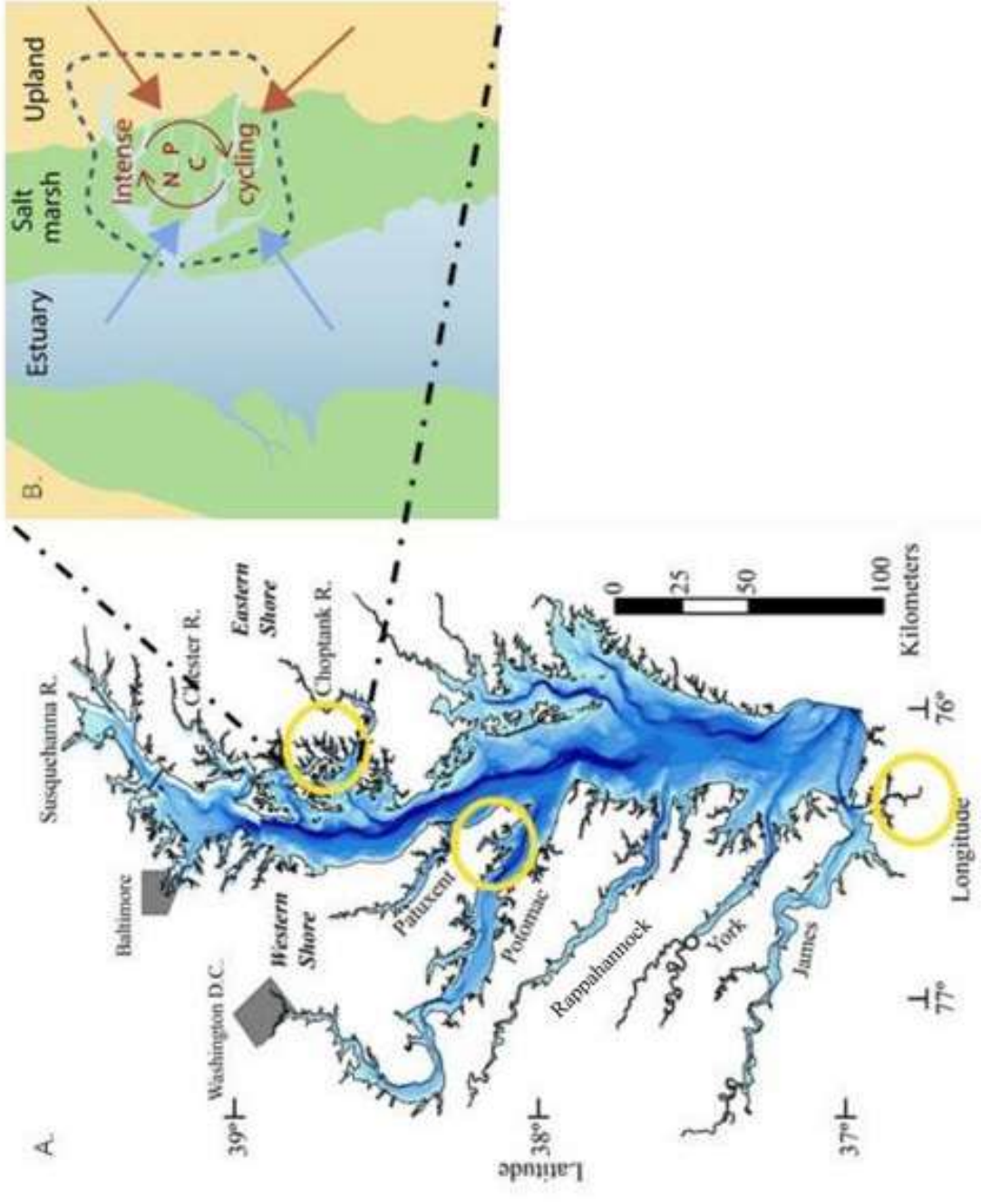
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CESR report is the most significant STAC output since Chesapeake Futures (2003)

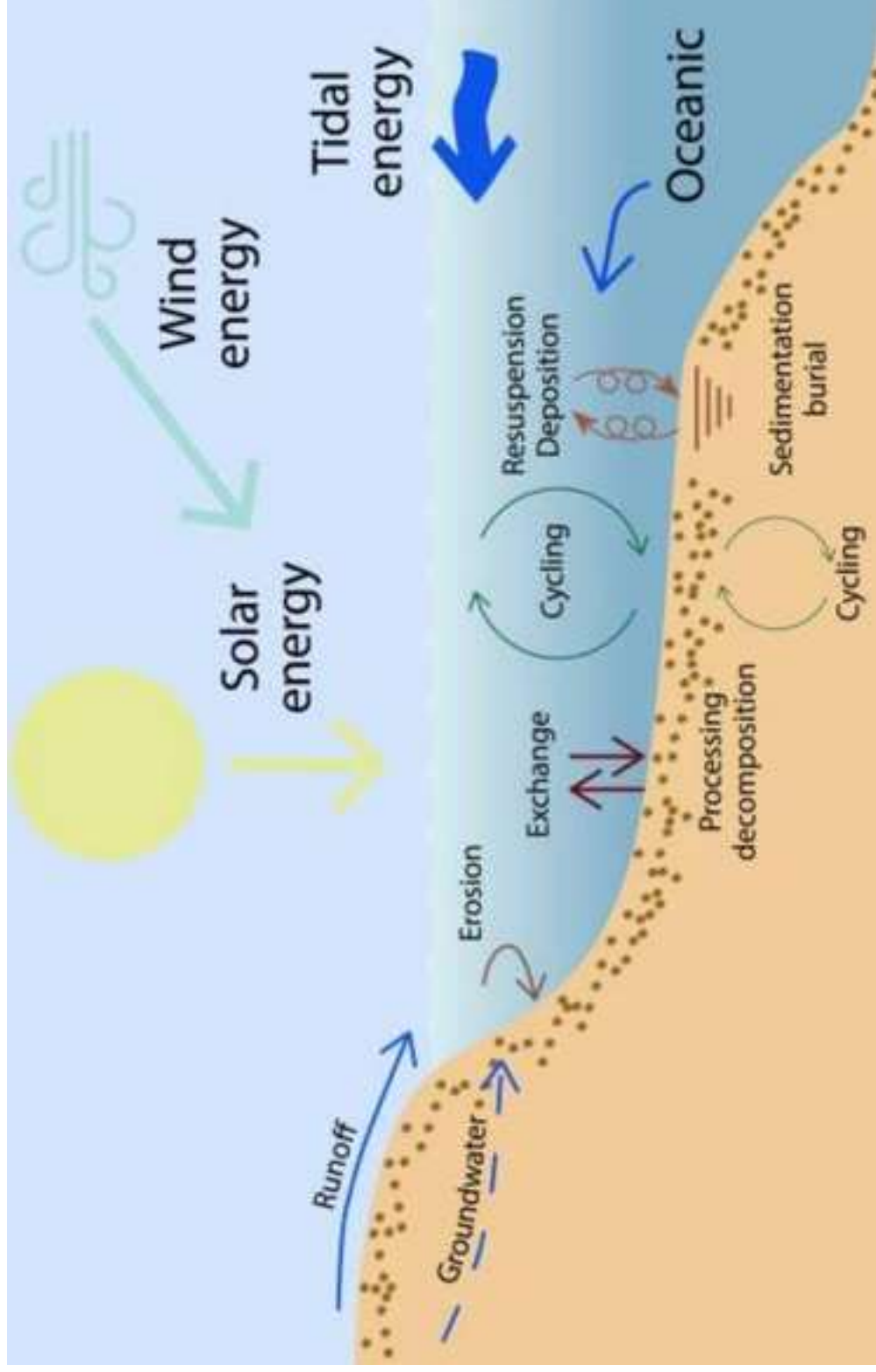


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Transition zones: Intensive cycling; vulnerable to sea level rise and other climate change impacts; abundant in Chesapeake



Shallow water = key interface



Developing new ways to achieve water quality goals



Why should I become an investor?

The **Maryland Water Quality Trading Program** is a market-based initiative designed to generate **cost-effective and innovative ways** to limit **nutrient and sediment pollution** into the **Chesapeake Bay**. Through the exchange of nitrogen, phosphorus, and sediment credits purchased and sold on a public market, it is our intent to accelerate water quality improvement in the Bay, reduce the costs of water quality implementation efforts, and put money into the pockets of Maryland's farmers, watermen, and other businesses going above and beyond to help restore a national treasure and its tributaries.

The benefits of Water Quality Trading

Reduce Nutrient Inputs **Support Local Businesses** **Accelerate Bay Restoration**



Water Improvement Projects

In addition to removing nutrients and sediment, these projects provide co-benefits to Maryland's communities.



Forest Buffers



Oyster Aquaculture



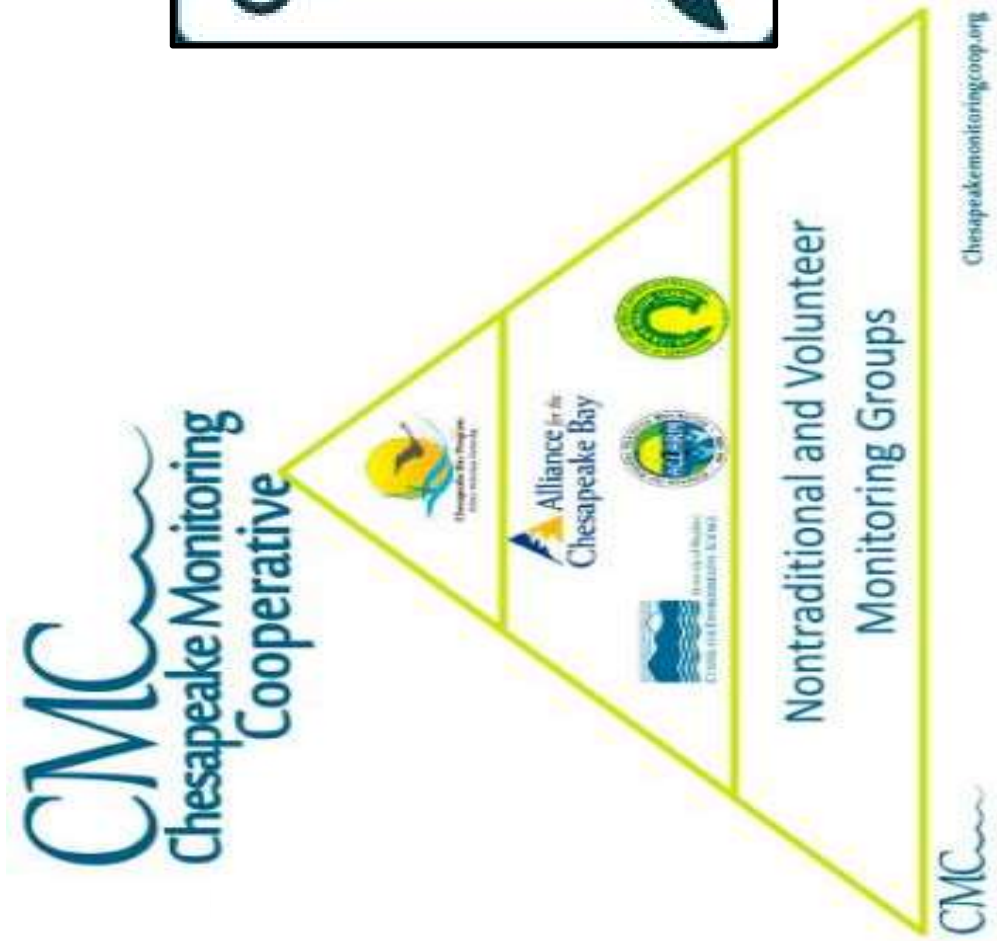
Green Infrastructure

Photo Credit: MD Department of the Environment



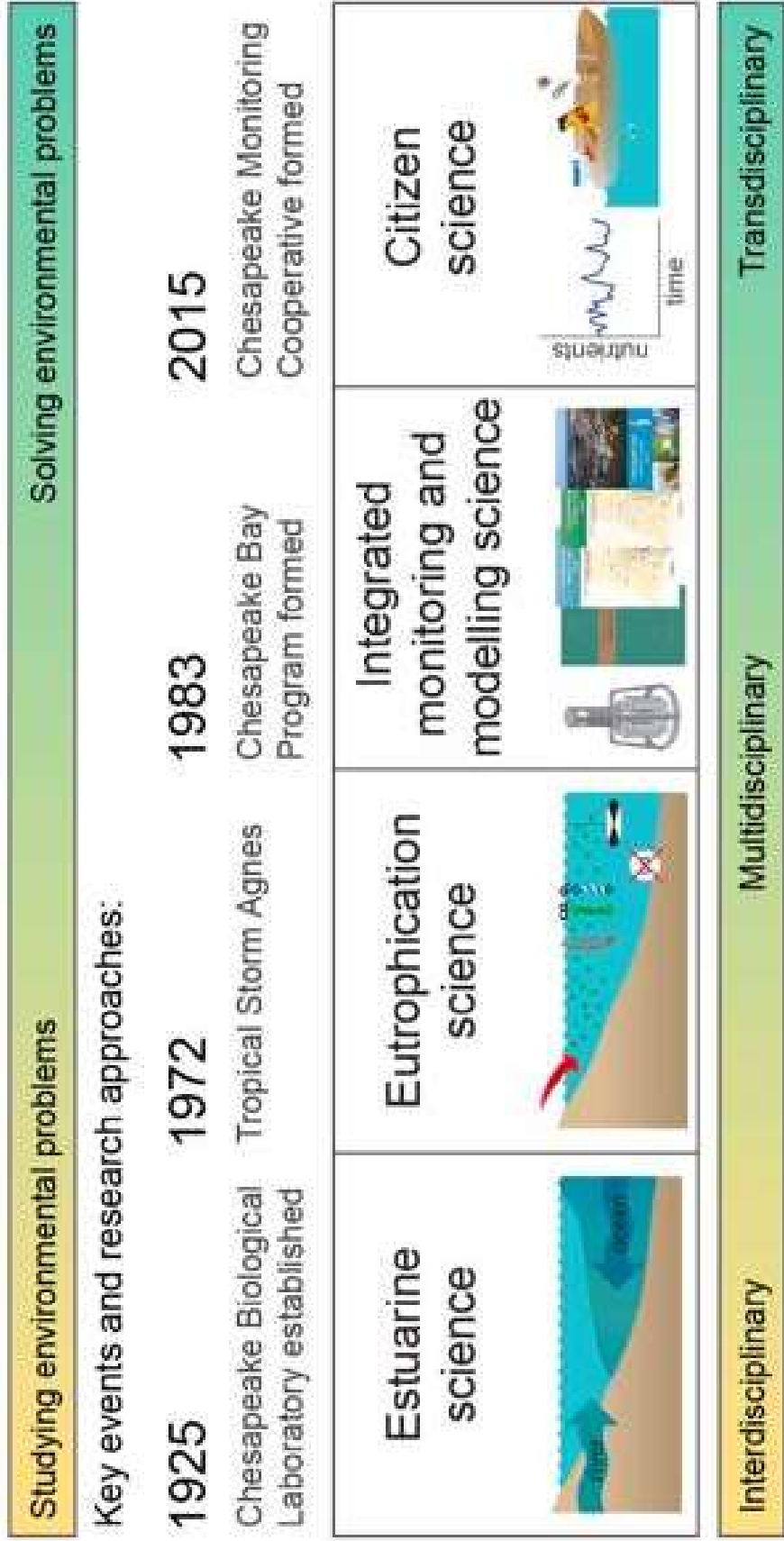
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Citizen science is blossoming in Chesapeake Bay and Watershed

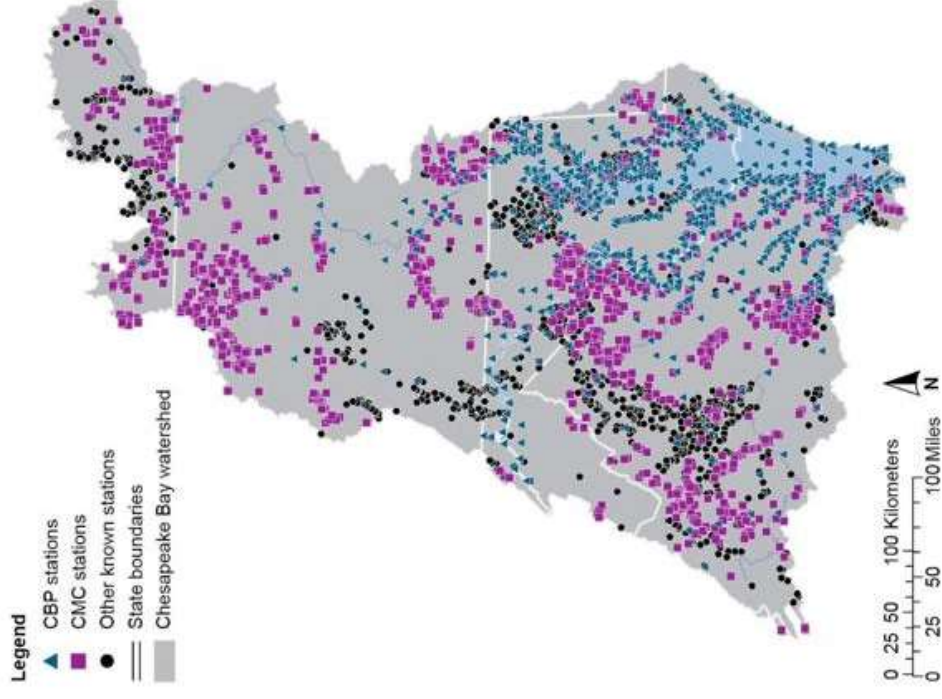
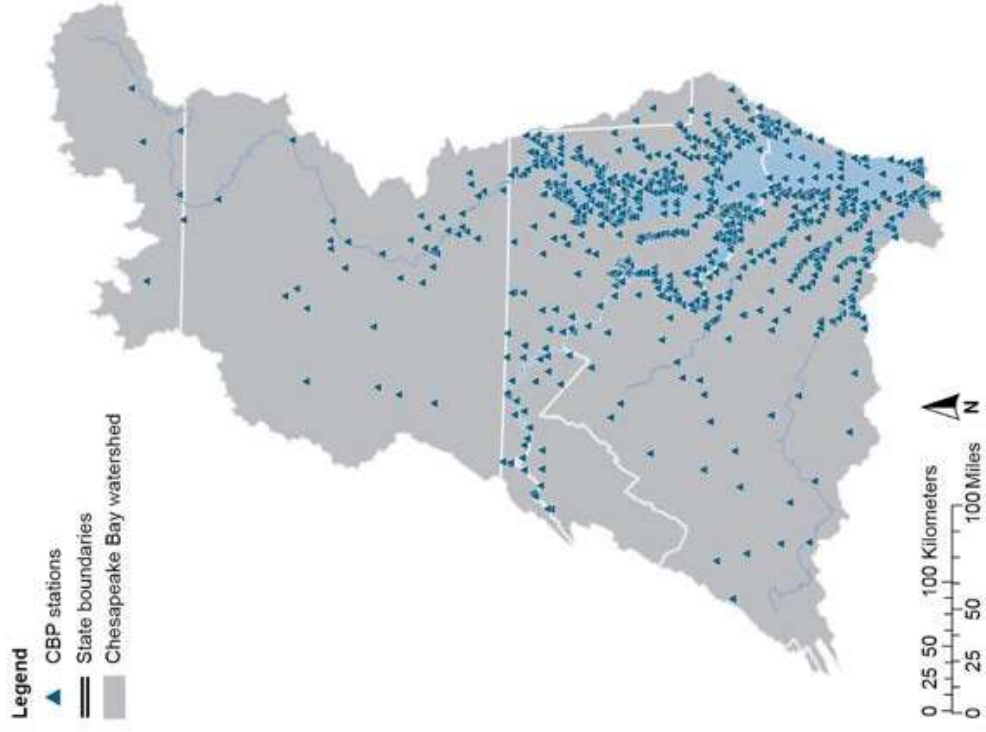


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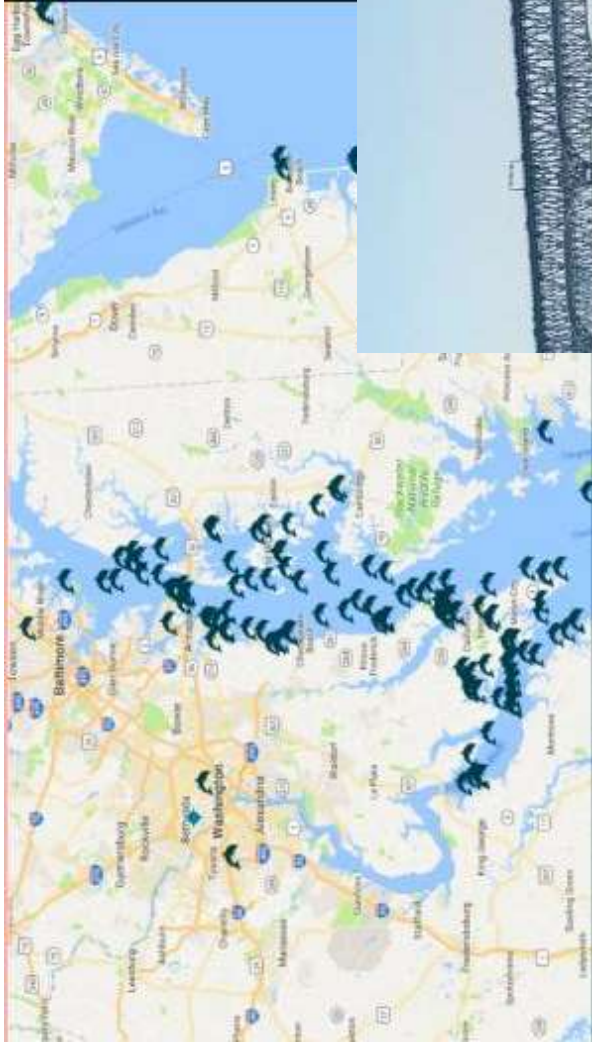
Citizen science is part of the evolution of Chesapeake science



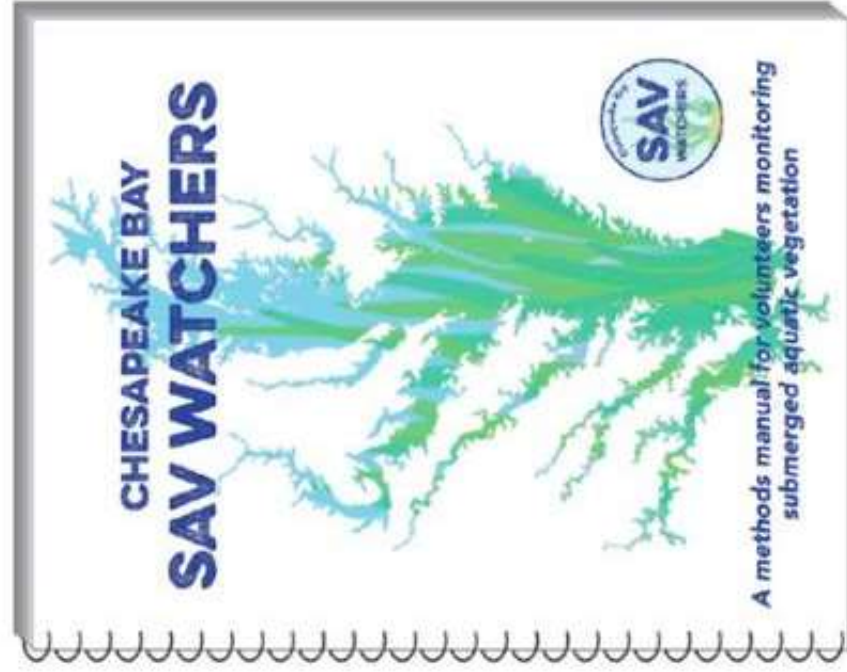
Citizen science increases sampling density



DolphinWatch tracks dolphin sightings in Chesapeake Bay



SAV Watchers program: Ground-truthing for remote sensing



One meter resolution land use mapping achieved



30 m resolution

1 m resolution



Acceleration in Chesapeake publications

Extent and Causes of Chesapeake Bay Warming

Kyle E. Hinson , Marjorie A.M. Friedrichs , Pierre St-Laurent , Fei Da , and Raymond G. Najjar

Research Impact Statement: Since 1985, the Chesapeake Bay has warmed three to four times faster in winter than cooler months; this has been driven primarily by atmospheric changes and by ocean warming in the lower Bay.

ABSTRACT: Coastal environments such as the Chesapeake Bay have long been impacted by anthropogenic stressors resulting from human activities, and these impacts are now being compounded by global warming trends. However, there are few studies documenting long-term estuarine temperature change and the relative contributions of rivers, the atmosphere, and the ocean. In this study, Chesapeake Bay warming, since 1985, is quantified using a combination of cruise observations and model outputs, and the relative contributions to that warming are estimated via numerical sensitivity experiments with a watershed-estuarine modeling system. Throughout the Bay's main stem, similar warming rates are found at the surface and bottom between the late 1980s and late 2010s ($0.02 \pm 0.02^\circ\text{C}/\text{year}$, mean ± 1 standard error), with elevated summer rates ($0.04 \pm 0.01^\circ\text{C}/\text{year}$ and lower rates of winter warming ($0.01 \pm 0.01^\circ\text{C}/\text{year}$). Most (~85%) of this estuarine warming is driven by atmospheric effects. The secondary influence of ocean warming increases with proximity to the Bay mouth, where it accounts for more than half of summer warming in bottom waters. Sea level rise has slightly reduced summer warming, and the influence of riverine warming has been limited to the heads of tidal tributaries. Future rates of warming in Chesapeake Bay will depend not only on global atmospheric trends, but also on regional circulation patterns in mid-Atlantic waters, which are currently warming faster than the atmosphere.

(KEYWORDS: Chesapeake Bay; climate change; water temperature; environmental models.)

INTRODUCTION

the coastal ocean are much less uniform spatially, and temporally (Bolkin 2009; Lima and Wetzel 2012; Liao et al. 2015; Alexander et al. 2018), which can make them more difficult to detect (Henson et al. 2016). Warming in coastal habitats is known to affect rates of biogeochemical cycling that can drive negative impacts like hypoxia (Breitburg et al. 2018; Poncel and Testa 2019). Rising temperatures over the past few decades have been linked to worsened water quality conditions in well-studied coastal

Increasing temperatures in the marine environment are a globally recognized phenomenon, with the world's oceans accounting for approximately 93% of the total increase in global heat content due to the effects of anthropogenic warming in the atmosphere since 1970 (Levitus et al. 2012; Rhein et al. 2013). Compared to the open ocean, warming patterns in

Compared to the open ocean, warming patterns in

Paper No. JAWR-20-0071-P of the *Journal of the American Water Resources Association* (JAWR). Received June 12, 2020; accepted April 8, 2021. © 2021 The Authors. *Journal of the American Water Resources Association* published by Wiley Periodicals LLC on behalf of American Water Resources Association. This is an open access article under the terms of the [Creative Commons Attribution License](#), which permits use, distribution and reproduction in any medium, provided the original work is properly cited. **Discussions are open until six months from issue publication.**

Virginia Institute of Marine Science (Hinson, Fredericks, St-Laurent, Da), William & Mary Gloucester Point, Virginia, USA, and
Department of Meteorology and Atmospheric Science (Najjar), The Pennsylvania State University Park, Pennsylvania, USA
(Correspondence to: Hinson: kohinson@vims.edu)

Citation: Hamez, K.E., M.A.M. Friedrichs, P. St-Laurent, F. Da, and R.G. Najjar. 2022. "Extent and Causes of Chesapeake Bay Warming." *Journal of the American Water Resources Association* 58 (6): 805–825. <https://doi.org/10.1111/732-1688.12916>.

Factors driving nutrient trends in streams of the Chesapeake Bay watershed

Scott W. Ator¹ | Joel D. Blomquist¹ | James S. Webber² | Jeffrey G. Chant²

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Abstract

Despite decades of effort toward reducing nitrogen and phosphorus flux to Chesapeake Bay, water quality and ecological responses in surface waters have been mixed. Recent research, however, provides useful insight into multiple factors complicating the understanding of nutrient trends in bay tributaries, which we review in this paper; as we approach a 2025 total maximum daily load (TMDL) for nitrogen management, improvements in water quality in many streams are attributable to management actions that reduced point sources and atmospheric nitrogen deposition and to changes in climate. Nutrient reductions expected from management actions, however, have not been fully realized in watershed streams. Nitrogen from urban transport sources has declined, although water-quality responses to urbanization in individual streams vary depending on development land use. Evolving agriculture, the largest watershed source of nutrients, has likely contributed to local nutrient trends but has not affected substantial changes in flux to the bay. Changing average nitrogen yields from forest land underlain by carbonate rocks, however, may suggest future trends in other areas under similar management, climatic, or other influences, although drivers of these changes remain unclear. Regardless of upstream trends, phosphorus flux to the bay from its largest tributary has increased due to sediment inflow in the Conowingo Reservoir. In general, recent research emphasizes the utility of rapid reductions over attempts to manage nutrient line load transport at limiting outlets in surface waters. Ongoing research opportunities include evaluating effects of climate change and conservation practices over time and space and developing models to deconvolve and evaluate multiple influences on regional water quality.

1 | INTRODUCTION

Recent efforts toward reducing nutrient flux to Chesapeake Bay from its watershed have been insufficient to meet water-quality and ecological standards in the Bay (Chesapeake Bay Program, 2012a; Kneeman et al., 2009; Linker, 2008; NRC, 2008; NRC, 2012). The Chesapeake Bay Program (CBP) is a partnership between the U.S. Environmental Protection Agency (EPA) and the Maryland Department of the Environment (MDE) to address the water quality issues in the Bay. The CBP is a partnership between the U.S. Environmental Protection Agency (EPA) and the Maryland Department of the Environment (MDE) to address the water quality issues in the Bay.

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Acceleration in Chesapeake publications

Academia
+
Federal
agencies
+
CBP



Water Research 181 (2021) 116407

Contents lists available at ScienceDirect

Water Research

Journal homepage: www.elsevier.com/locate/watres

Nutrient limitation of phytoplankton in Chesapeake Bay: Development of an empirical approach for water-quality management

Qian Zhang^{a,*}, Thomas R. Fisher^b, Emily M. Trentacoste^c, Claire Buchanan^d, Anne B. Gustafson^e, Renee Karr^f, Rebecca R. Murphy^g, Jennifer Keisman^h, Cuiyun Wu^g, Richard Tian^g, Jeremy M. Testa^h, Peter J. Tangoⁱ

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^eMaryland Department of Natural Resources, 580 Taylor Ave, Annapolis, MD 21401, USA
^fU.S. Geological Survey, MD-DE-DC Water Science Center, 5522 Research Park Drive, Croftsville, MD 21228, USA
^gChesapeake Bay Program, 410 Severn Avenue, Annapolis, MD 21403, USA
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ⁱU.S. Geological Survey / Chesapeake Bay Program, 410 Severn Avenue, Annapolis, MD 21403, USA

LONG-TERM CHESAPEAKE WATER QUALITY MONITORING



JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
AMERICAN WATER RESOURCES ASSOCIATION

Chesapeake Bay's water quality condition has been recovering: Insights from a multimetric indicator assessment of thirty years of tidal monitoring data

Qian Zhang^{a,*}, Rebecca R. Murphy^b, Jennifer Keisman^c, Trentacoste^c, University of Maryland Center for Environmental Science, Chesapeake Bay Program, 410 Severn Avenue, Annapolis, MD 21403, USA
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^bU.S. Geological Survey, MD-DE-DC Water Science Center, 5522 Research Park Drive, Croftsville, MD 21228, USA
^cU.S. Geological Survey, MD-DE-DC Water Science Center, 5522 Research Park Drive, Croftsville, MD 21228, USA

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER

10.1029/2020GL090819

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Science of the Total Environment

Journal homepage: www.elsevier.com/locate/scitotenv

Long-term seasonal trends from the non-tidal Susquehanna River: A multimetric indicator assessment of thirty years of tidal monitoring data

Q. Zhang^{a,*}, D.C. Boily^b, W.P. Bal^c

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^cDepartment of Geology and Geophysics, University of Maryland, 101 Shriver Hall, College Park, MD 20742, USA

WILEY

Sediment dynamics and implications for management: State of the science from long-term research in the Chesapeake Bay watershed, USA

Gregory B. Noe^a, Matthew J. Cabanan^a, Katie Skalak^a, Allen Gellis^a, Kristina G. Hopkins^a, Doug Moyer^a, James Webber^a, Adam Benheim^a, Kelly Maloney^a, John Brakobill^a, Andrew Seelick^a, Mike Langland^a, Qian Zhang^a, Gary Shunk^a, Joni Keisman^a, Cliff Hupp^a

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ABSTRACT

Understanding the temporal and spatial roles of nutrient limitation on phytoplankton growth is necessary for developing successful management strategies. Chesapeake Bay has well-documented seasonal and spatial variations in nutrient limitation, but it remains unknown whether these patterns of nutrient limitation have changed in response to nutrient management efforts. We analyzed historical data from nutrient bioassay experiments (1992–2002) and data from long-term, fixed-site water-quality monitoring program (1990–2017) to develop empirical approaches for predicting nutrient limitation in the surface waters of the mainstem Bay. Results from classification and regression trees (CART) matched the seasonal and spatial patterns of bioassay-based nutrient limitation in the 1992–2002 period much better than two simpler, non-statistical approaches. An ensemble approach of three selected CART models satisfactorily reproduced the bioassay-based results (classification rate = 99%). This empirical approach can be used to characterize nutrient limitation from long-term water-quality monitoring data on much broader geographic and temporal scales than would be feasible using bioassays, providing a new tool for informing water-quality management. Results from our application of the approach to 21 tidal monitoring stations for the period of 2007–2017 showed modest changes in nutrient limitation patterns, with expanded areas of nitrogen-limitation and contracted areas of nutrient saturation (i.e., not limited by nitrogen or phosphorus). These changes imply that long-term reductions in nitrogen load have led to expanded areas with nutrient-limited phytoplankton growth in the Bay, reflecting long-term water-quality improvements in the context of nutrient enrichment. However, nutrient limitation patterns remain unchanged in the majority of the mainstem, suggesting that nutrient loads should be further reduced to achieve a less nutrient-saturated ecosystem.

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Nutrient limitation of phytoplankton in Chesapeake Bay: Development of an empirical approach for water-quality management

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LONG-TERM CHESAPEAKE WATER QUALITY MONITORING



JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
AMERICAN WATER RESOURCES ASSOCIATION

Chesapeake Bay's water quality condition has been recovering: Insights from a multimetric indicator assessment of thirty years of tidal monitoring data

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Long-term seasonal trends from the non-tidal Susquehanna River: A multimetric indicator assessment of thirty years of tidal monitoring data

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WILEY

Sediment dynamics and implications for management: State of the science from long-term research in the Chesapeake Bay watershed, USA

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Abstract

To protect the aquatic living partnership has developed ge quality criteria to protect dissolved oxygen (DO), was progress toward meeting the indicator approach was developed to three decades of chlorophyll-a data on annual management segments of tidal segment-DU criterion combined attainment of their water quality record. Since 1985–1987, the from extreme weather events indicator exhibited a positive has been recovering since 19 improvements in open water the improvement in the Bay the improvement in estimate

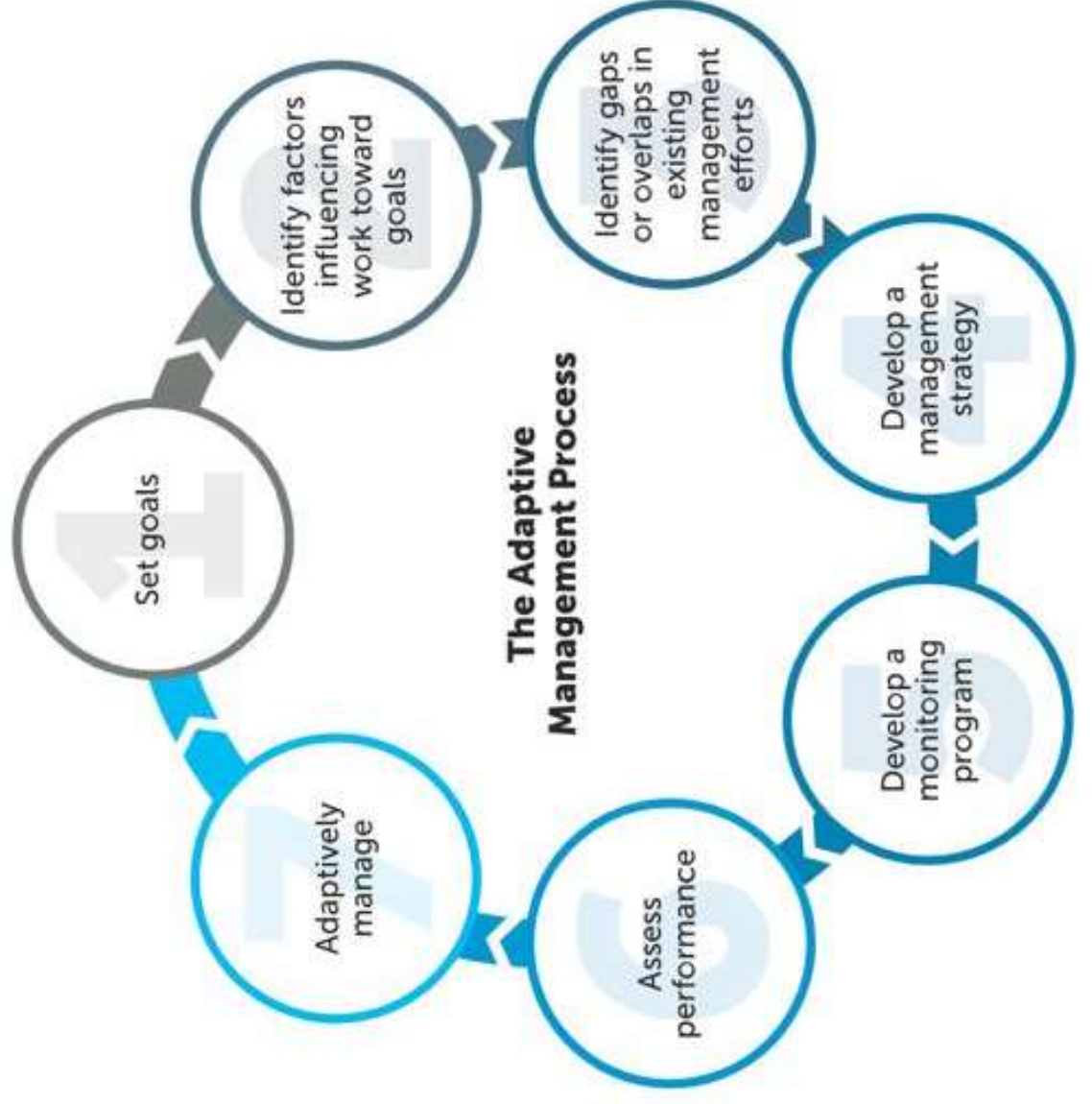
INTRODUCTION

Chesapeake Bay Hypoxia Control
Chesapeake Bay, Ne and a major national
April 20, 2017, 19
North Charles Street, Baltimore, Maryland 21201
Journal of the American Water Resources Association

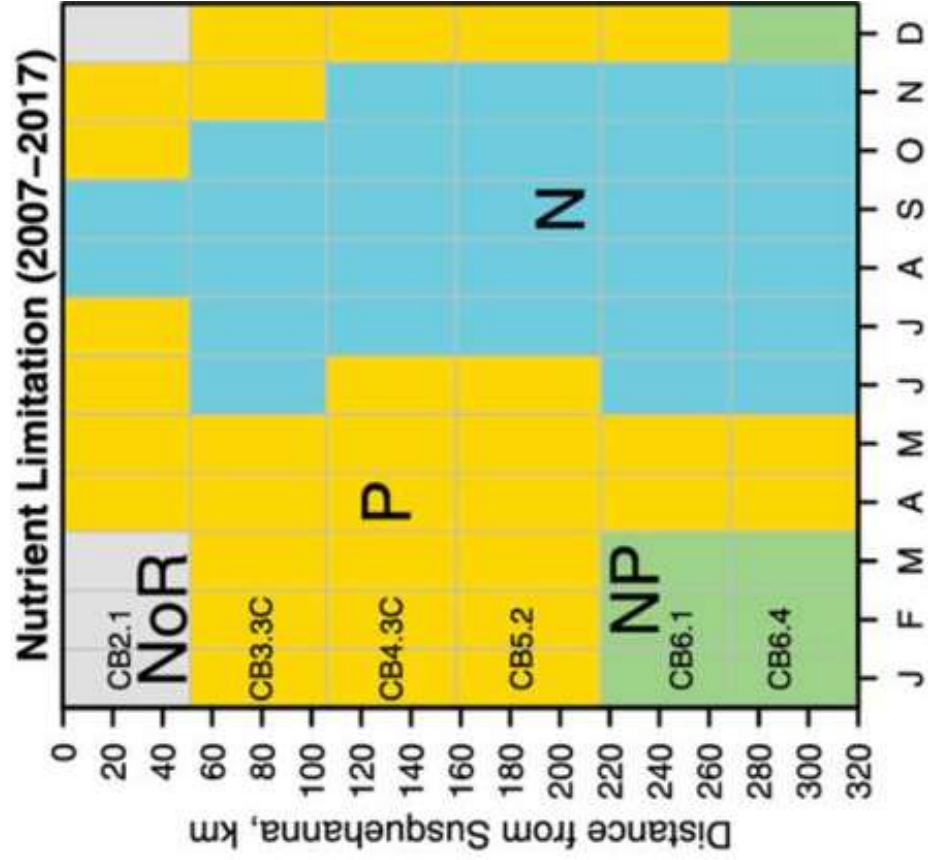
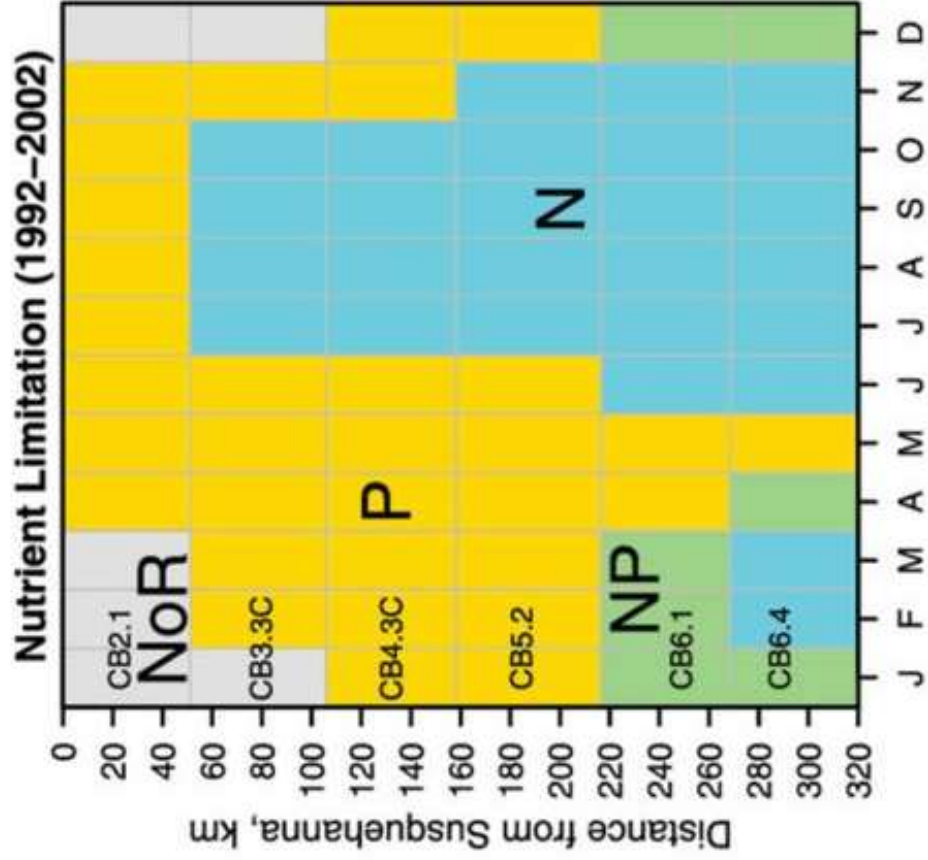
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Adaptive management in Chesapeake Bay



Changes in nutrient limitation in phytoplankton bioassays noted



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Nutrient limitation of phytoplankton in Chesapeake Bay: Development of an empirical approach for water-quality management

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Adaptive science: Follow up on analyses to test hypothesis that nutrient limitation is responding to nutrient reductions

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Chesapeake Bay Program Office Fiscal Year 2023 Request for Applications for: Chesapeake Bay Tidal Water Nutrient Limitation Assessment

Type: Posted • Opportunity: EPA-I-R3-CBP-23-04

Description

Overview

Eligibility

Timing

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DESCRIPTION

EPA seeks to support one recipient to conduct a nutrient limitation assessment (nitrogen and phosphorus limitation) on tidal water samples from the surface waters of the mainstem Chesapeake Bay and select major tributaries over a two-year period.



Nick DiPasquale (1951-2020)

