Chesapeake Bay Submerged Aquatic Vegetation: A Third Technical Synthesis

Coordinated and produced by members of the Chesapeake Bay Program's SAV Workgroup

STAR Presentation
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Chesapeake Bay Program
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MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

TS I and TS II

903-R-92-001

Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis

Annapolis, Maryland
December 1992

Printed by the United States Environmental Protection Agency
for the Chesapeake Bay Program

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1992

Chesapeake Bay
Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis

August 2000

Printed by the United States Environmental Protection Agency
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Chesapeake Bay Program
A Watershed Partnership

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2000

TS I and TS II defined and then revised habitat requirements and restoration targets for SAV in the Chesapeake Bay.

TS III vs. SAV Syn

14-14-1853 CBG 14201

Agreement Number

Chesapeake Bay Submerged Aquatic Vegetation (SAV): A Third Technical Synthesis

A multi-institutional effort to synthesize the state of the science regarding submerged aquatic vegetation in Chesapeake Bay

December, 2016

Editor and Project Lead: J. Brooke Landry

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Project Abstract:

Chesapeake Bay is one of the most widely studied estuaries in the world, with extensive research focused on one of the Bay's most important habitats: submerged aquatic vegetation (SAV). SAV provides a myriad of ecosystem services, from nursery grounds and habitat for ecologically and economically important fish and invertebrates, to sediment stabilization and shoreline erosion control, to carbon sequestration. While the first two SAV Technical Syntheses (published in 1992 and 2000) focused primarily on the identification, development, and refinement of five specific and measurable habitat requirements that limit SAV growth, including light attenuation, chlorophyll a, total suspended solids, dissolved inorganic nitrogen and dissolved inorganic phosphorus, this third SAV Technical Synthesis reviews advancements in our knowledge and understanding of SAV ecosystem dynamics as they relate to SAV habitat requirements, but also genetics, the effects of land-use and shoreline alterations on SAV, climate change impacts, and ecosystem services and their potential monetary value. New information and analyses are reviewed in the context of restoration and management implications and suggest that managers and policy makers must maintain or strengthen protection to SAV and must continue to improve water quality and clarity in the Chesapeake Bay in hopes of counterbalancing the impacts of climate change and increased pressures from a growing watershed population.

Below, find summary points for each chapter submitted to this third SAV Technical Synthesis.

A review of the advancements in our knowledge and understanding of SAV ecosystem dynamics as they relate to:

- -SAV habitat requirements
- -genetics
- -land-use and shoreline alterations
- -climate change impacts
- -ecosystem services and valuation

New information and analyses are reviewed in the context of **restoration and management implications** and suggest that managers and policy makers **must maintain or strengthen protection to SAV and must continue to improve water quality and clarity in the Chesapeake Bay in hopes of counterbalancing the impacts of climate change and increased pressures from a growing watershed population**

TS III vs. SAV Syn

The SAV Status and Trends Synthesis Project, or SAV Syn, uses the 30+ year SAV coverage, density, and species dataset produced by VIMS in combination with other bay-wide data sets (water quality, land-use, nutrient loads, etc.) and new methods of analysis to determine baywide and segment-specific drivers of change in SAV density, distribution, and community composition in the Chesapeake Bay.

TS III Chapters and Topics Covered

- Shifting patterns in SAV species diversity and community structure
- SAV feedback processes: Implications for restoration and resilience
- Genetic diversity and connectivity in the restoration of SAV beds
- Effects of land-use and shoreline armoring on SAV
- 21st century climate change and SAV in the Chesapeake Bay
- Evaluation of ecosystem services of SAV in the Chesapeake Bay

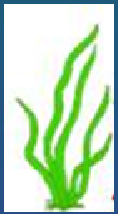
SHIFTING PATTERNS IN SAV SPECIES DIVERSITY AND COMMUNITY STRUCTURE

Nancy B. Rybicki, Christopher E. Tanner, Erin C. Shields, Kenneth A. Moore, Stanley Kollar, David J. Wilcox, and Katharina A. M. Engelhardt

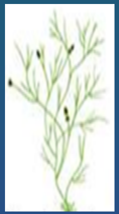
SHIFTING PATTERNS IN SAV SPECIES DIVERSITY AND COMMUNITY STRUCTURE

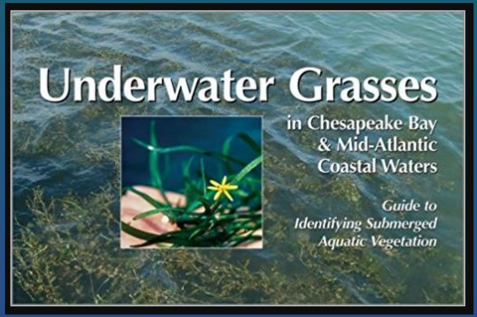
Nancy B. Rybicki, Christopher E. Tanner, Erin C. Shields, Kenneth A. Moore, Stanley Kollar, David J. Wilcox, and Katharina A. M. Engelhardt

- There are twenty-seven species of SAV found in the tidal Chesapeake Bay. Seventeen are common. Four are non-native.





SHIFTING PATTERNS IN SAV SPECIES DIVERSITY AND COMMUNITY STRUCTURE

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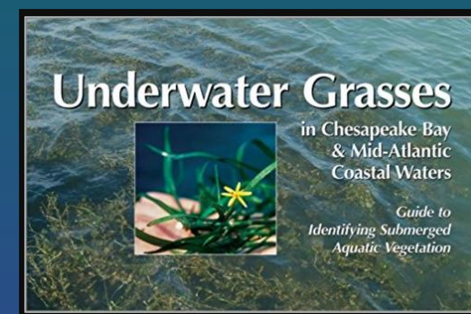
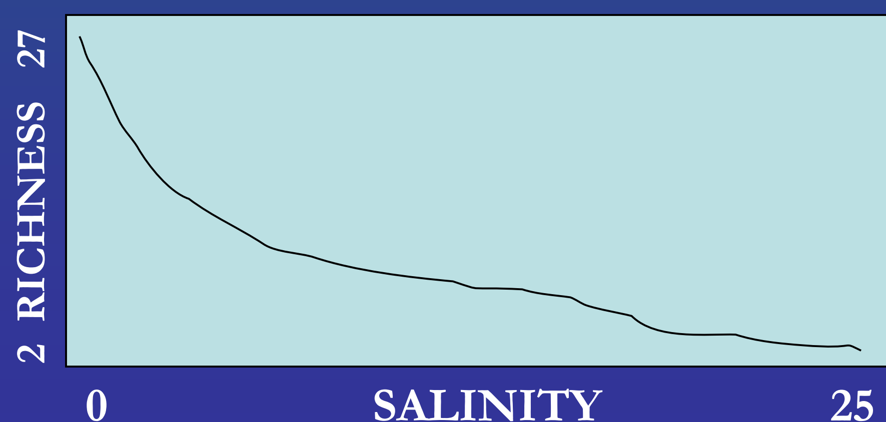


- Distributions of SAV species and species richness within the Chesapeake Bay are largely controlled by salinity, with higher species richness in low salinity SAV communities.

*Not actually a graph from the chapter. Just a crude depiction of the richness/salinity relationship… →



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- Most low salinity SAV species have expanded their distributions within the Bay, whereas the distributions of medium and high salinity species have either not changed or decreased.

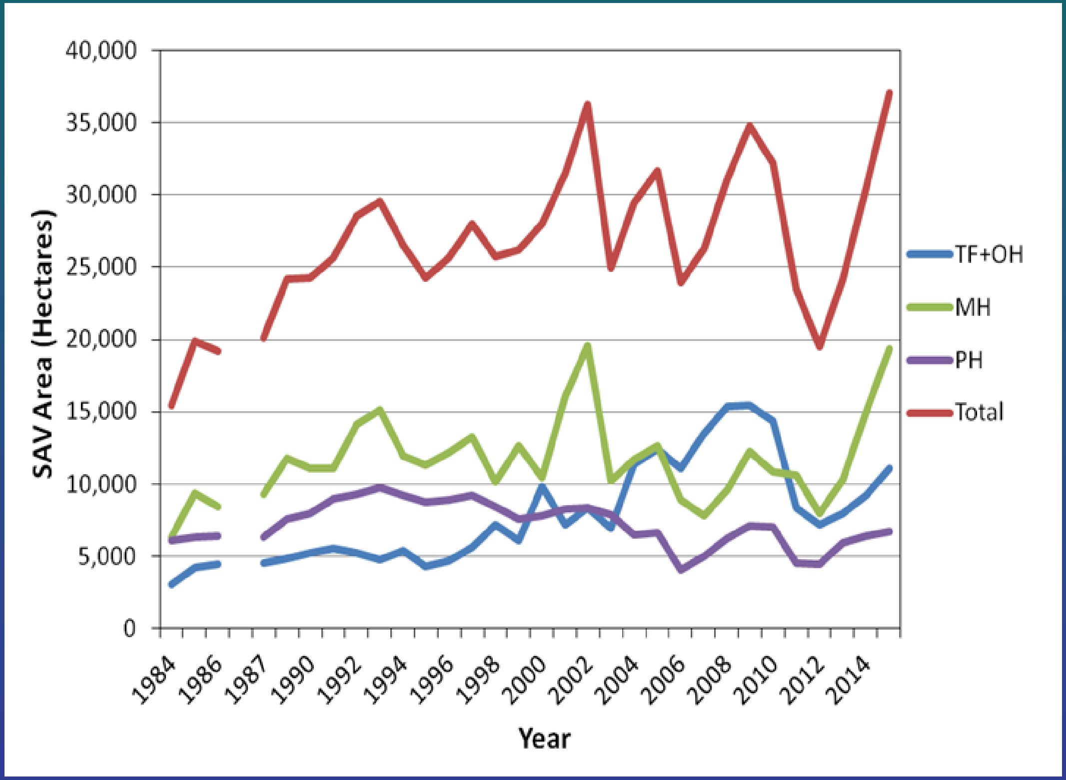

Fig. 2 SAV coverage by salinity zone for 1984 through 2015. Data from annual surveys by the Virginia Institute of Marine Sciences; TF = tidal fresh (salinities of 0 to < 0.5), OH = oligohaline (salinities of 0.5 to < 5), MH = mesohaline (salinities of 5 to < 18), PH = salinities of 18 < 30). Note: no data was available for 1988.

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- Two non-native species (*Hydrilla verticillata, Najas minor*) have increased their distributions while the distributions of two other non-native species (*Myriophyllum spicatum, Potamogeton crispus*) have not.

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- For low salinity SAV communities, **diversity** is negatively correlated with chl a concentration, total suspended solids, and nitrogen and phosphorous concentrations.

Chl a

TSS

Nutrients

Diversity

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- The proportion of natives to non-natives is higher in years with better water quality conditions.

SHIFTING PATTERNS IN SAV SPECIES DIVERSITY AND COMMUNITY STRUCTURE

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- The dominance of the non-native *Hydrilla verticillata* increases during periods of disturbance. However, *H. verticillata* may facilitate establishment of native species in previously un-vegetated areas.

→

→

SHIFTING PATTERNS IN SAV SPECIES DIVERSITY AND COMMUNITY STRUCTURE

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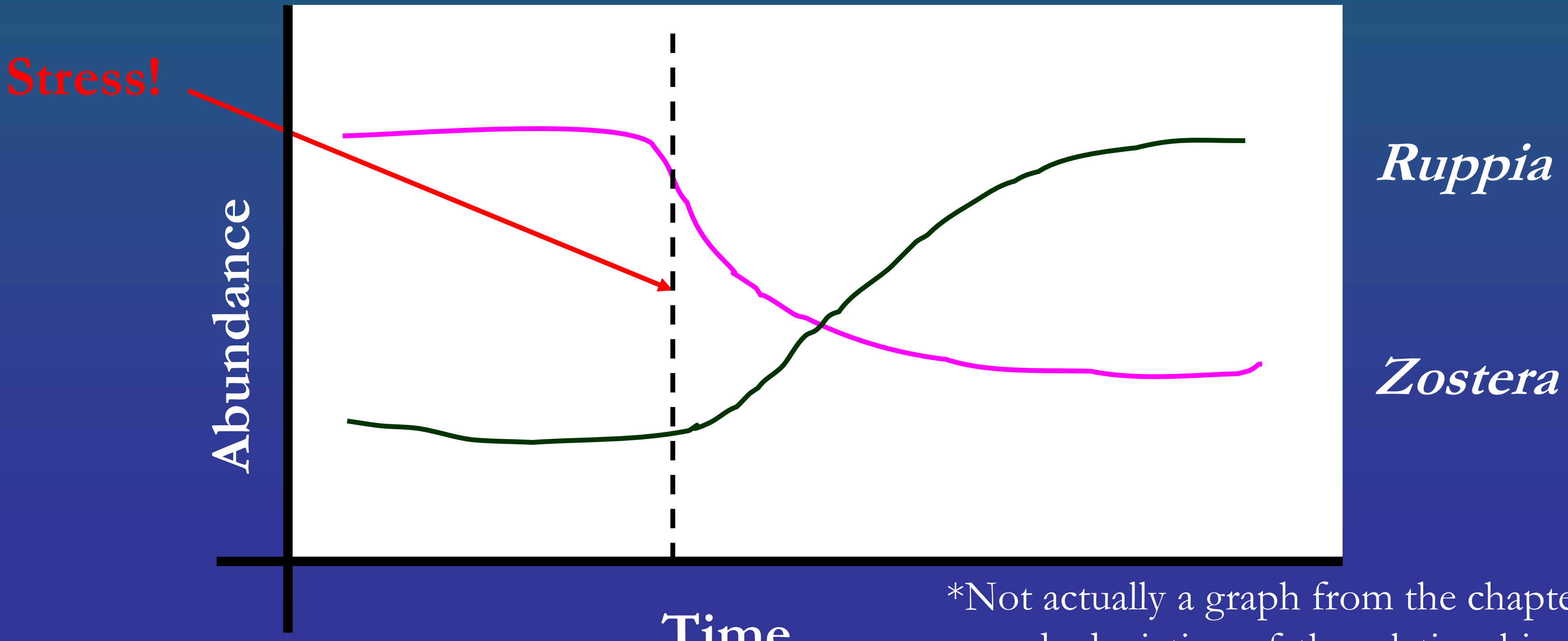
- Short time scale stressors can cause shifts in species dominance and/or loss of species. Stressors can include changes in salinity, during both abnormally wet and dry years, and summer high temperature events.



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SHIFTING PATTERNS IN SAV SPECIES DIVERSITY AND COMMUNITY STRUCTURE

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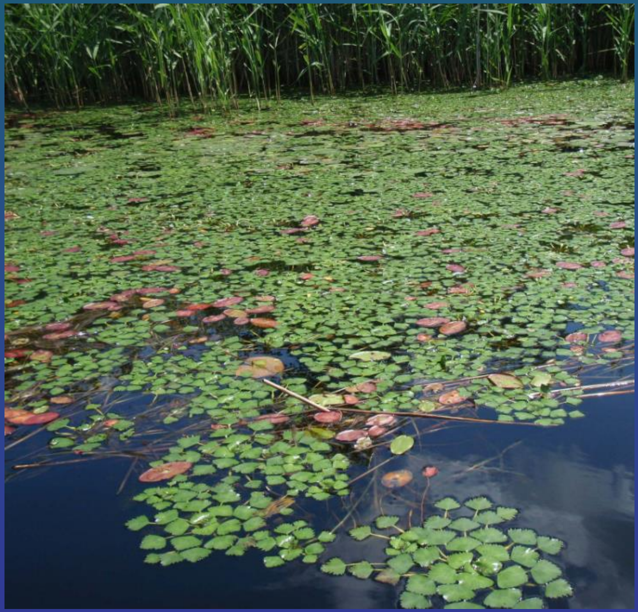
- Factors other than salinity that affect SAV community structure include:
  - water quality conditions
  - water movement
  - sediment quality
  - temperature
  - disease
  - water fowl herbivory
  - competitive interactions
  - propagule availability
  - shading from the invasive floating aquatic vegetation, *Trapa natans*



SHIFTING PATTERNS IN SAV SPECIES DIVERSITY AND COMMUNITY STRUCTURE

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In a Nutshell

- -27 species of SAV in the Bay
- -Diversity decreases with increased salinity
- -Freshwater plants are expanding their distributions while mesohaline and polyhaline communities are not
- -Non-native plants may be beneficial to the Bay
- -Communities shift in response to disturbance

SUBMERSED AQUATIC VEGETATION AND FEEDBACK PROCESSES: IMPLICATIONS FOR RESTORATION AND RESILIENCE

Cassie Gurbisz, W. Michael Kemp, Rebecca Golden, and Cindy Palinkas

SUBMERSED AQUATIC VEGETATION AND FEEDBACK PROCESSES: IMPLICATIONS FOR RESTORATION AND RESILIENCE

Cassie Gurbisz, W. Michael Kemp, Rebecca Golden, and Cindy Palinkas

- Feedback processes in SAV beds are controlled by biophysical interactions between SAV, water flow and wave height, suspended sediment concentrations, and water clarity and/or biogeochemical interactions between the plants, ambient nutrient concentrations, algal growth, and water clarity.
- The larger the SAV bed, the stronger the feedback.

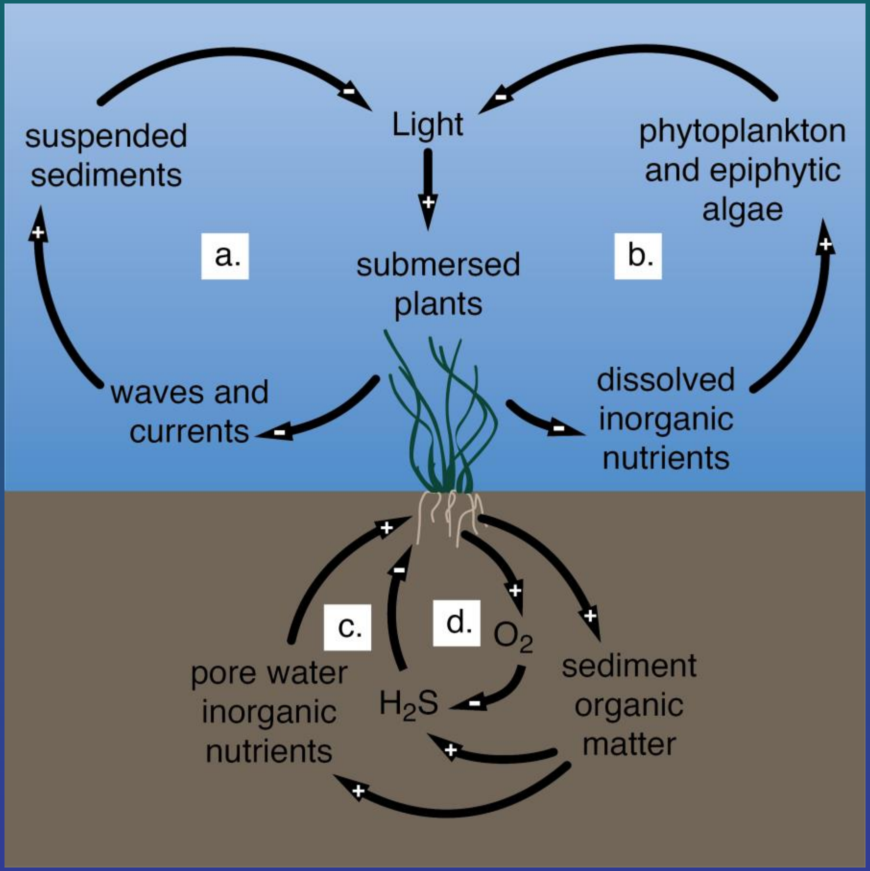

Figure 2. Sequences of regulatory interactions that drive positive feedback loops in SAV beds, including feedbacks between a) plants, hydrodynamics, suspended sediment concentration, and light, b) plants, dissolved inorganic nutrient concentration, algal growth, and light, c) plants, sediment organic matter, and sediment pore water nutrient concentration, and d) plants, oxygenation of the rhizosphere, and hydrogen sulfide concentration. Plus and minus signs indicate whether the relationship between linked elements is positive or negative.

SUBMERSED AQUATIC VEGETATION AND FEEDBACK PROCESSES: IMPLICATIONS FOR RESTORATION AND RESILIENCE

Cassie Gurbisz, W. Michael Kemp, Rebecca Golden, and Cindy Palinkas

- Feedbacks can stabilize an SAV bed against changes in external conditions, but only to a critical threshold. Beyond that threshold, an SAV bed suddenly disappears and the bare sediment state dominates (and vice-versa).
  - If feedbacks are sufficiently strong, the threshold for SAV bed decline is different from the threshold for recovery (this is known as hysteresis).
  - Chronic stressors, such as nutrient loading, control resilience

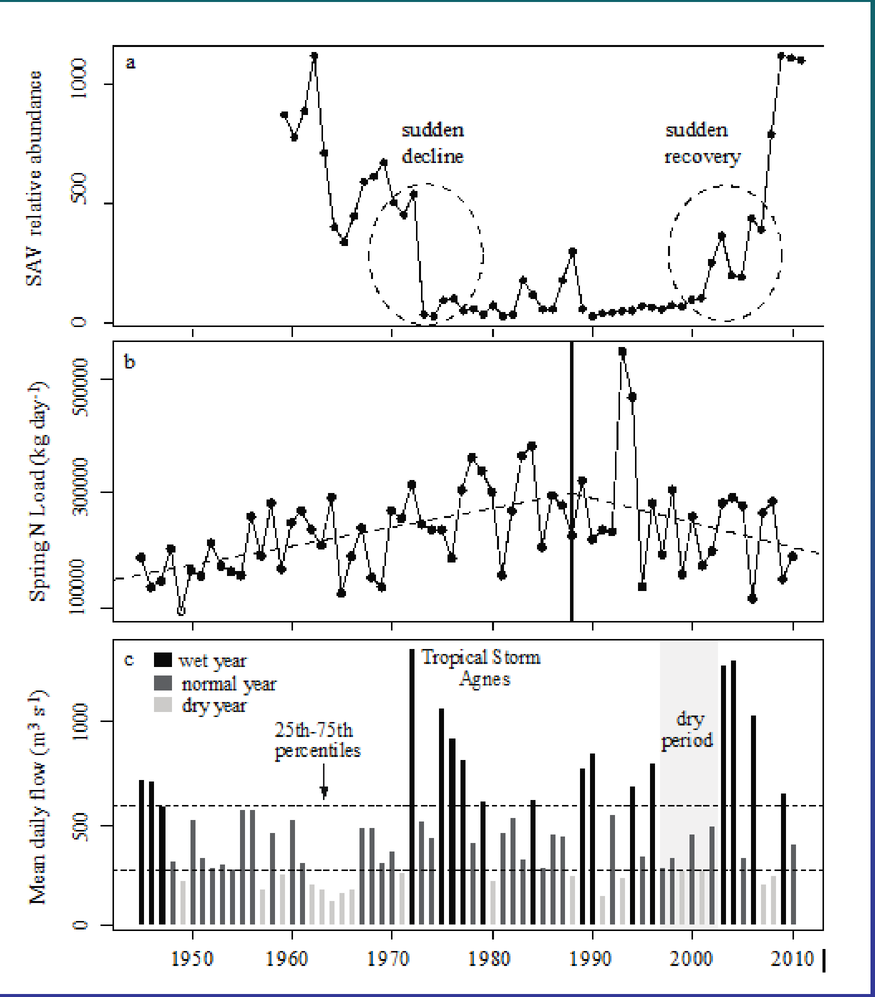

Figure 6. An abrupt SAV decline in upper Chesapeake Bay (a) coincided with long-term increases in nutrient loading (b) coupled with the largest flood event on record (Tropical Storm Agnes) (c). Meanwhile, the sudden recovery was associated with gradually decreasing nutrient loads and several consecutive dry years. These patterns support the idea that long-term changes in environmental stressors affect the resilience of a system, or its capacity to absorb a perturbation, whereas weather extremes tip the system into a new state. Adapted from Gurbisz and Kemp (2014).

SUBMERSED AQUATIC VEGETATION AND FEEDBACK PROCESSES: IMPLICATIONS FOR RESTORATION AND RESILIENCE

Cassie Gurbisz, W. Michael Kemp, Rebecca Golden, and Cindy Palinkas

- The original habitat requirements described in TS I and TS II were largely derived using data collected near existing beds. Based on this analysis, already established beds can, in theory, withstand worse conditions than a recovering bed because of self-stabilizing feedbacks. Therefore, recovering SAV beds may require more stringent habitat requirements than those established for existing SAV beds. Further analysis is needed to explore this possibility.

- Direct SAV plantings could also benefit from considering the role of feedbacks in stabilizing SAV beds. Large plantings of closely-spaced propagules are generally more successful due to the presence of feedbacks once a critical SAV bed size and density is surpassed.

- Mitigating nutrient loads to the system will not only facilitate SAV restoration, but also enhance SAV bed resilience.

SUBMERSED AQUATIC VEGETATION AND FEEDBACK PROCESSES: IMPLICATIONS FOR RESTORATION AND RESILIENCE

Cassie Gurbisz, W. Michael Kemp, Rebecca Golden, and Cindy Palinkas

In a Nutshell

- -The bigger the SAV bed, the more resilient it is
- -SAV beds control their environment and mitigate poor water quality, creating positive feedback loops
- -There are critical thresholds beyond which the positive feedback crumbles
- -Stable beds and recovering beds may need different habitat requirements
- -Mitigating nutrient loading facilitates recovery as well as resilience

THE ROLE OF GENETIC DIVERSITY AND CONNECTIVITY IN THE RESTORATION OF SUBMERSED AQUATIC VEGETATION BEDS

Maile C. Neel, and Katharina A. M. Engelhardt

THE ROLE OF GENETIC DIVERSITY AND CONNECTIVITY IN THE RESTORATION OF SUBMERSED AQUATIC VEGETATION BEDS

Maile C. Neel, and Katharina A. M. Engelhardt

- **There are three decisions to be made regarding genetics and SAV restoration:**

<u>1. Is active restoration necessary?</u>

-Active restoration may be necessary if genetic assessments indicate local populations have very low genetic diversity.

<u>2. Where should restoration sites be located?</u>

-Information on long-term spatial patterns of SAV beds is essential for setting goals for desirable levels of connectivity. Goals would be dependent on historical levels of connectivity.

<u>3. Where should restoration material come from?</u>

-There are two contradictory paradigms for selecting restoration source materials: Local vs. Foreign. There are arguments for and against each.

THE ROLE OF GENETIC DIVERSITY AND CONNECTIVITY IN THE RESTORATION OF SUBMERSED AQUATIC VEGETATION BEDS

Maile C. Neel, and Katharina A. M. Engelhardt

- ***Decision 1: Is active restoration necessary? (Maybe)***

  It depends on whether or not:

  1) genetic diversity is low in existing populations,

  2) existing populations and unoccupied habitat are isolated such that natural recolonization is precluded, and

  3) recovery rates and ecosystem functioning could be enhanced by intentionally introducing genetic diversity to restoration sites.

  - *V. americana* and *Z. marina* have moderate to extremely high (respectively) genetic diversity at the level of the whole Chesapeake Bay and within most populations, thus, widespread active restoration for genetic rescue is not necessary.
  - BUT, if low diversity patches are isolated by long distances, supplementation could be warranted.
  - AND, active restoration may enhance the rate of SAV bed recovery and functioning even when meadows have the capacity to naturally recolonize.

GENETICS Cont.

Decision 2: Where should restoration sites be located? (DEPENDS)

- Site selection will depend on overall restoration goals. Typically, CB goals focus on increasing habitat amount. If increasing connectivity (to facilitate increased natural recovery) is also a restoration goal, decisions regarding site selection need to incorporate dispersal potential to determine where it would be beneficial to reconnect populations that are isolated. Dispersal data is limited.

GENETICS Cont.

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- One study found that at dispersal distances of <10 km, the majority of patches within tributaries and in the northern and central regions of the Bay formed connected networks.

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- Potential for recruitment from seeds depends fundamentally on seed longevity. *Z. marina* produces a transient seed bank (viability decreases after 6 months and after 15 months, no seeds remain viable) which increases susceptibility to disturbance and decreases the resilience of populations to repeated stress events.

GENETICS Cont.

Decision 3: Where should restoration material come from?

- Local vs. Foreign: Scientific arguments can be made for and against all points on the continuum.

Represent amounts and patterns of genetic diversity ⟷ Augment genetic diversity

Stock Selection	Select from local sites; Move within local areas	Move within regions; From non-local repositories	Managed relocation across regions
Perceived Benefit	Reduce the risk of genetic dilution, maladaptation, and outbreeding depression	Increase diversity and genetic rescue	Attempt to match adaptation to conditions
Risks	Diversity too low for acclimation and adaptation; low fitness if inbreeding depression is present	Genetic dilution; outbreeding depression	Even more genetic dilution; outbreeding depression
Use When	"High" diversity "Low" inbreeding "High" differentiation and local adaptation	"Low" diversity "High" inbreeding	Persistence is not possible due to effects of climate change and dispersal limitations preclude recolonization

GENETICS Cont.

Decision 3: Where should restoration material come from?

- To date, arguments regarding which of these goals are most important for the Chesapeake Bay have often been presented as mutually exclusive choices: either maximize genetic diversity or plant with local stock for ease of local adaptation

- Given the high diversity of most populations in the Bay, this polarized thinking poses a false dichotomy. It is possible to increase diversity at sites and to do so using stock that comes from donor sites close to the planting bed. As natural recolonization proceeds, donor beds become increasingly available.

GENETICS Cont.

Decision 3: Where should restoration material come from?

- RECOMMENDATIONS: Restoration within each of the genetic regions identified by Lloyd et al. - Potomac (tidal and non-tidal), Central Bay, and North Bay - could be done with propagules from any site within the regions. All indications are that gene flow *within* regions is far higher than it is *among* regions and there is no evidence of isolation by distance within the North Bay and Central Bay regions.

- By contrast, moving propagules *among* regions should be avoided until fitness consequences can be evaluated. To date, a lack of information precludes a comparison of genetic diversity of the Bay with populations outside of the Bay. Until such information indicates sufficient similarity, using propagules from the abundance of sources in the Bay is a reasonable precautionary approach.

GENETICS Cont.

In a Nutshell

-Advances in molecular approaches have given scientists insights into evolution among SAV species as well as fine scale variation in genetic diversity within and among SAV populations.

-When considering genetics with regards to SAV restoration, ask WHETHER, WHERE, and HOW

-The two keystone species in the Chesapeake Bay have moderate to high diversity in the Bay.

- Use local seeds for restoration (keep seeds within regions of the Bay).

EFFECTS OF LAND USE AND SHORELINE ARMORING ON SUBMERGED AQUATIC VEGETATION

Donald E. Weller, Christopher J. Patrick, Cindy M. Palinkas,
J. Brooke Landry, Rebecca R. Golden

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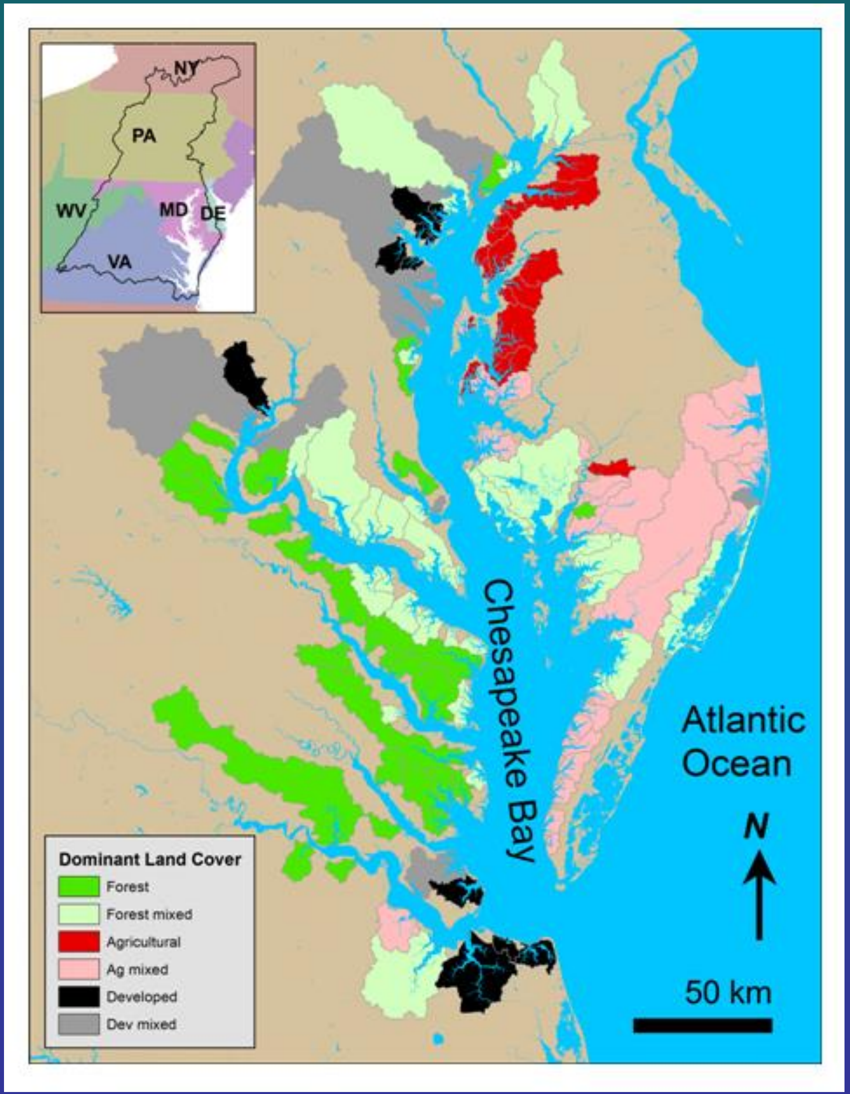
- SAV abundance is significantly lower in subestuaries with watersheds dominated by developed or agricultural land than in subestuaries dominated by forest.

- Human land uses release nutrient and sediments that reduce water clarity and limit light for SAV.



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- Armored shorelines can deepen adjacent shallow water and reduce water clarity through sediment resuspension and therefore negatively impact SAV.

- Bulkheads are worse for SAV than rip rap

- We need more information on the impacts of living shorelines.



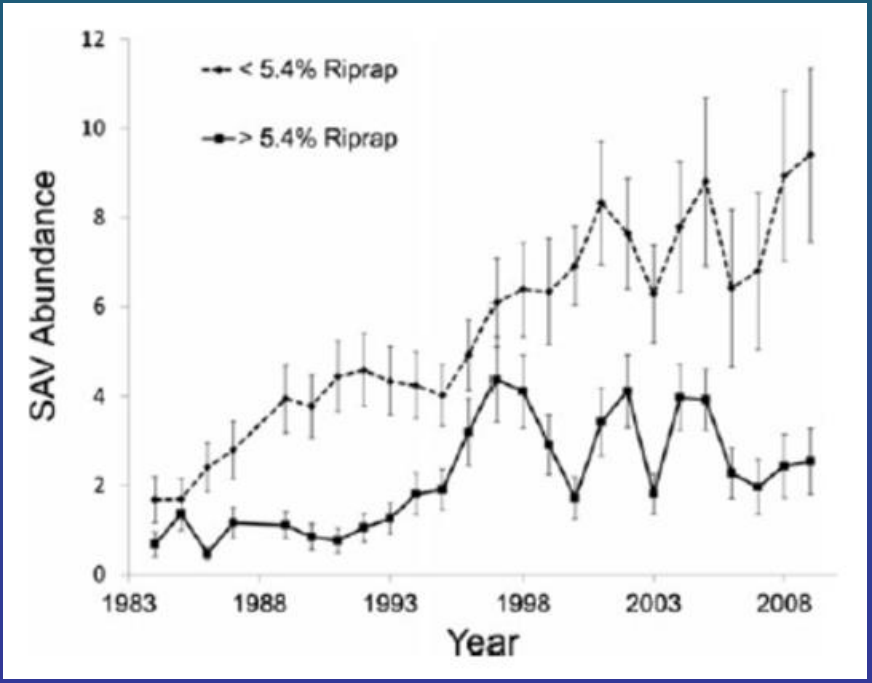

Fig. 5 Subestuaries with little riprap (dashed lines) have significantly greater SAV abundance and have showed continued recovery since 1984. In contrast, subestuaries with more riprap (>5.4% of the shoreline) have lower abundance and little recovery since 1995 (Patrick et al. 2014). The 5.4% breakpoint was the first split in a classification tree analysis of 65 potential predictors of SAV abundance (Patrick et al. 2014)

EFFECTS OF LAND USE AND SHORELINE ARMORING ON SUBMERGED AQUATIC VEGETATION

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In a Nutshell

- Natural is good for SAV. Developed is bad for SAV.

- Land-use and shoreline type impact SAV abundance and diversity

- Sometimes shoreline alteration increases SAV – this is generally in freshwater where non-native species like Hydrilla or Milfoil take advantage of the harsher conditions and outcompete native grasses.

-Further research is needed to understand the impacts of different living shorelines on SAV compared to riprap, bulkhead, and natural shoreline.

- Models and management plans should incorporate information on local land use, shoreline armoring, and community-specific responses to better understand SAV dynamics and to better manage SAV conservation and restoration.

21ST CENTURY CLIMATE CHANGE AND SUBMERGED AQUATIC VEGETATION IN THE CHESAPEAKE BAY

Thomas M. Arnold, Richard C. Zimmerman, Katharina A. M. Engelhardt, and J. Court Stevenson

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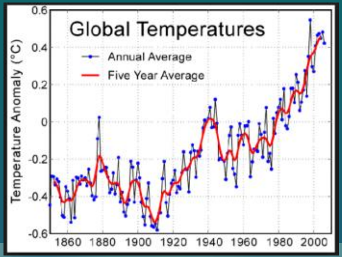


- During the 21st century, three components of climate change will impact Chesapeake Bay SAV directly:
  - increasing temperatures (2-6°C),
  - coastal zone acidification (50-160% increase in CO_2 concentrations), and
  - sea level rise (0.7-1.6m).

Atmospheric carbon dioxide levels now exceed 400 ppm, on average.

One-third of the CO_2 has been absorbed by the oceans.

Average ocean pH has dropped from 8.21 to 8.10. It will fall another 0.3 to 0.4 units by 2100.

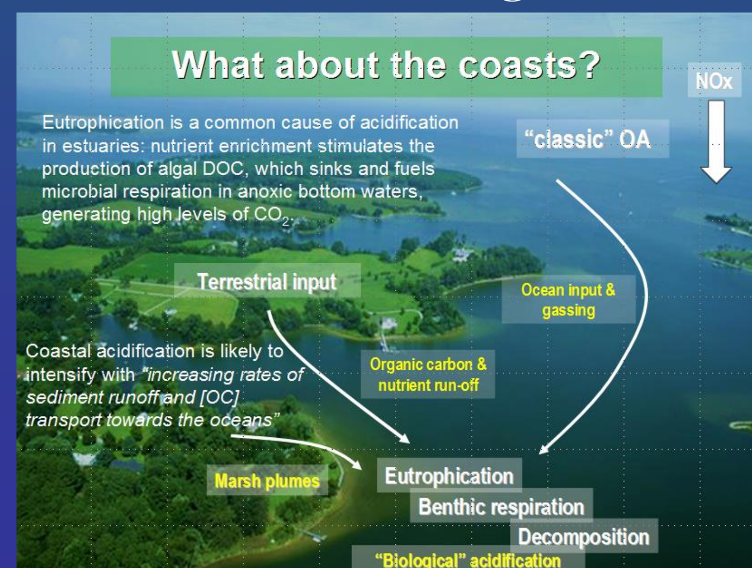
This represents a 150% increase in hydrogen ions and a 50% decrease in levels of carbonate ions (CO_3^{2-}).

21ST CENTURY CLIMATE CHANGE AND SUBMERGED AQUATIC VEGETATION IN THE CHESAPEAKE BAY

Thomas M. Arnold, Richard C. Zimmerman, Katharina A. M. Engelhardt, and J. Court Stevenson

- Eelgrass is a cold water plant and near its southern limit in the Chesapeake Bay. Heat stress negatively impacts its abundance already.

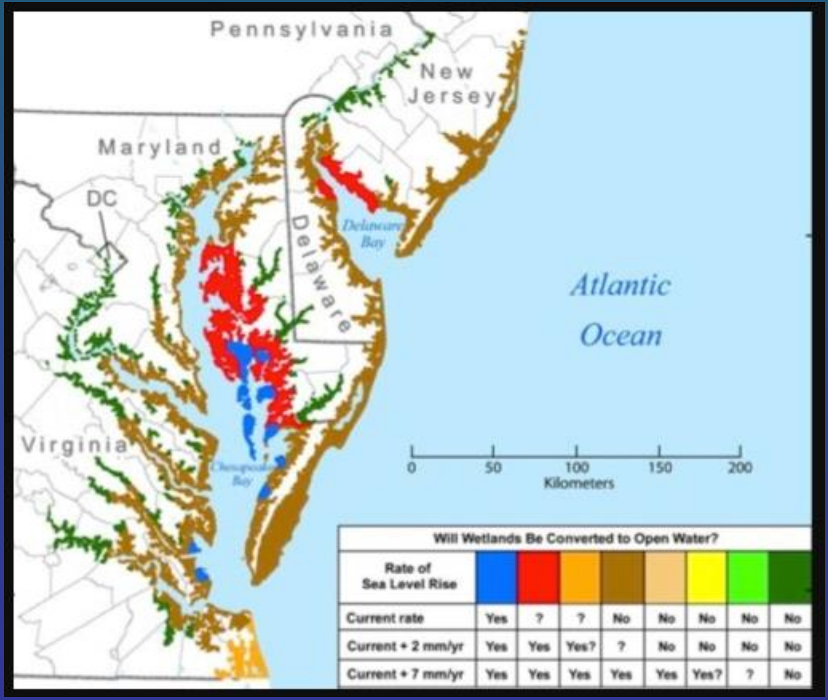
- Coastal zone eutrophication drives acidification. The resulting high CO_2 / low pH may benefit SAV. The *"CO2 fertilization effect"* of coastal acidification has the potential to stimulate photosynthesis and growth in at least some species of SAV. This may offset some of the deleterious effects of thermal stress and may facilitate the survival of eelgrass in regions of the Chesapeake Bay.



21ST CENTURY CLIMATE CHANGE AND SUBMERGED AQUATIC VEGETATION IN THE CHESAPEAKE BAY

Thomas M. Arnold, Richard C. Zimmerman, Katharina A. M. Engelhardt, and J. Court Stevenson

- Sea level rise will reshape our shorelines. Where they are permitted to migrate landward, suitable SAV habitat may persist. However, where shorelines are hardened, suitable SAV habitat is likely to be lost.



21ST CENTURY CLIMATE CHANGE AND SUBMERGED AQUATIC VEGETATION IN THE CHESAPEAKE BAY

Thomas M. Arnold, Richard C. Zimmerman, Katharina A. M. Engelhardt, and J. Court Stevenson

- If the current trajectory of climate change continues, the Chesapeake Bay could develop some characteristics of a subtropical estuary by the next century. Predicted warming has the potential to eliminate populations of temperate eelgrass (*Zostera marina*), favoring native heat-tolerant species such as widgeon grass (*Ruppia maritima*). A variety of subtropical plants and animals are likely to become more common in the region; however colonization by tropical seagrasses is unlikely in the near future due to continued low winter temperatures and winter ice.

21ST CENTURY CLIMATE CHANGE AND SUBMERGED AQUATIC VEGETATION IN THE CHESAPEAKE BAY

Thomas M. Arnold, Richard C. Zimmerman, Katharina A. M. Engelhardt, and J. Court Stevenson

- The predictions are limited by a poor understanding of the indirect effects of climate change on organisms associated with seagrass die-offs, including fouling organisms, grazers, and microbes. These indirect effects may be powerful and may trigger abrupt, unforeseen changes in SAV communities. …..

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21ST CENTURY CLIMATE CHANGE AND SUBMERGED AQUATIC VEGETATION IN THE CHESAPEAKE BAY

Thomas M. Arnold, Richard C. Zimmerman, Katharina A. M. Engelhardt, and J. Court Stevenson

In a Nutshell

-Chesapeake Bay SAV will be impacted by increasing temperatures, coastal acidification, and sea level rise.

-Eelgrass will likely decrease, but may be positively buoyed by CO_2 fertilization.

-As sea levels rise, SAV's inland migration will be hampered by shoreline armoring.

-The Bay may begin to exhibit characteristics of a sub-tropical estuary.

- The indirect effects of climate change on associated organisms, including fouling organisms, grazers, and microbes, are poorly understood. These indirect effects are likely to prevent smooth transitions, triggering abrupt phase changes in estuarine and freshwater SAV communities subjected to a changing climate.

EVALUATION OF ECOSYSTEM SERVICES OF SAV IN THE CHESAPEAKE BAY

Chris J. Kennedy and Lisa A. Wainger

EVALUATION OF ECOSYSTEM SERVICES OF SAV IN THE CHESAPEAKE BAY

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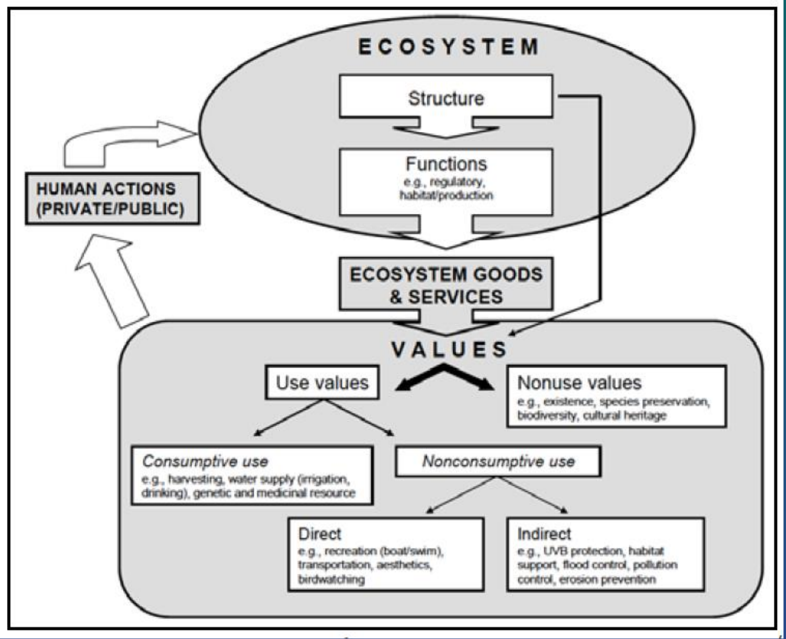
- SAV habitats provide numerous ecosystem services to human populations, including but not limited to:
  - fishery enhancement,
  - carbon sequestration,
  - erosion control, and
  - nutrient cycling.



- We review the theory and methods supporting the measurement and monetization of ecosystem service benefits associated with SAV habitats and synthesize the current literature on ecosystem service benefits provided by SAV in the Chesapeake Bay.

- Numerous services have been quantified and monetized, including fishery enhancement and carbon sequestration, and this review suggests that the value of SAV habitats to humans is non-trivial.

Information produced with MANAGEMENT IMPLICATIONS

- Water quality affects diversity as well as cover/distribution. Diversity is positively correlated with resilience, so should be managed.
  - -stay the course with TMDLs
- Non-native SAV often facilitate recovery of native SAV.
  - -do not manage against them
- SAV beds undergo positive feedback processes, whereby SAV modify ambient growing conditions in ways that enhance their own growth.
  - Increased protection of existing beds
- Larger SAV beds are more resilient to short and long term stress because of positive feedback.
  - Increased protection of existing beds
- Restoration efforts are more successful when large areas are planted with closely spaced propagules – critical density thresholds are more easily reached to initiate positive feedback loop.
  - Increased funding for large scale restoration??

MANAGEMENT IMPLICATIONS

- Mitigating nutrient load facilitates SAV recovery, but also enhances bed resistance.
  - Maintain TMDLs
- Restoration site selection should include genetic analysis when possible.
  - Add genetic diversity to restoration goals?
- Land-use and shoreline armoring both impact SAV distribution, abundance, and diversity.
  - Implications for watershed management
- Developed and agriculturally dominated watersheds impact SAV negatively.
- Shoreline armoring negatively affects adjacent SAV bed size and species richness.
- When a sub-estuary's shoreline reaches 5.4% riprap, the SAV recovery trajectory changes. Subestuaries with less than 5.4% riprap recover more rapidly than those with more.
  - Establish shoreline armoring limits in every jurisdiction

MANAGEMENT IMPLICATIONS

- Shoreline armoring eliminates the possibility of inland migration by SAV as sea levels rise.
  - Limit armoring
- Increasing temperatures will change the community structure of SAV in the Chesapeake Bay, but some deleterious effects may be offset by increasing CO_2.
  - Limit greenhouse gases
- SAV is a highly valuable coastal resource – both economically and ecologically.
  - Protect existing SAV
- SAV is a major player in global carbon sequestration.
  - Protect existing and promote recovery of SAV