SAV Status & Trends

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Bill Dennison

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Water Quality Goal Implementation Team

Why SAV Status and Trends now?

- Long term, solid data sets available
- Access to new analytical tools and expertise
- Understanding the drivers of SAV trends can have important management relevance
- Input to 2017 TMDL reassessment is timely
- Transition to new generation of scientists

We have been envisioning this synthesis for nearly a decade

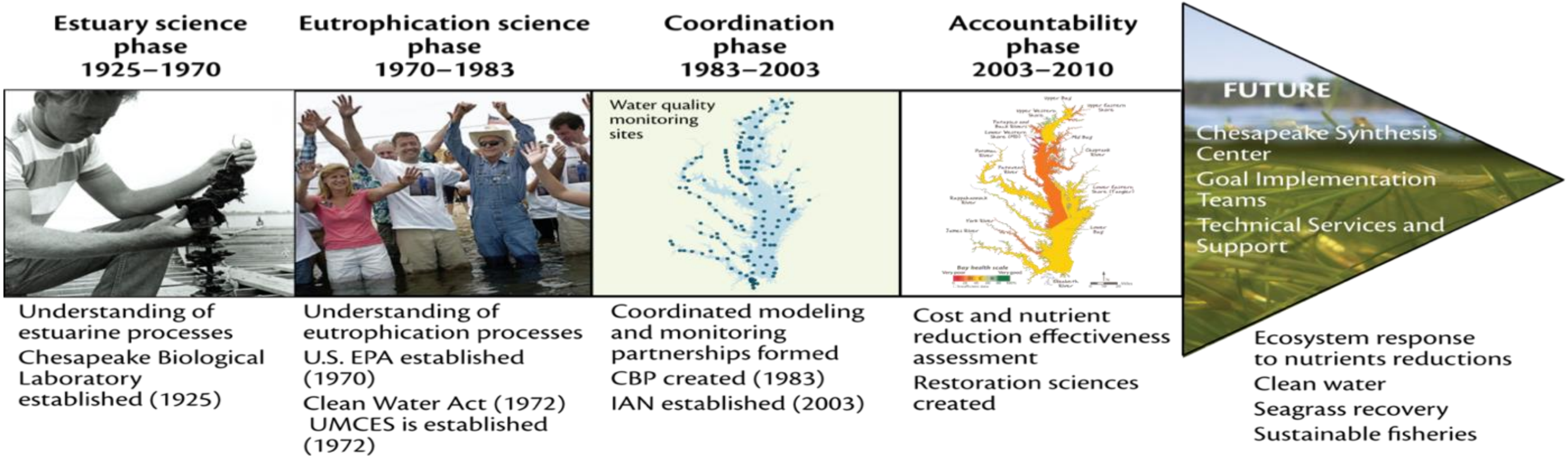
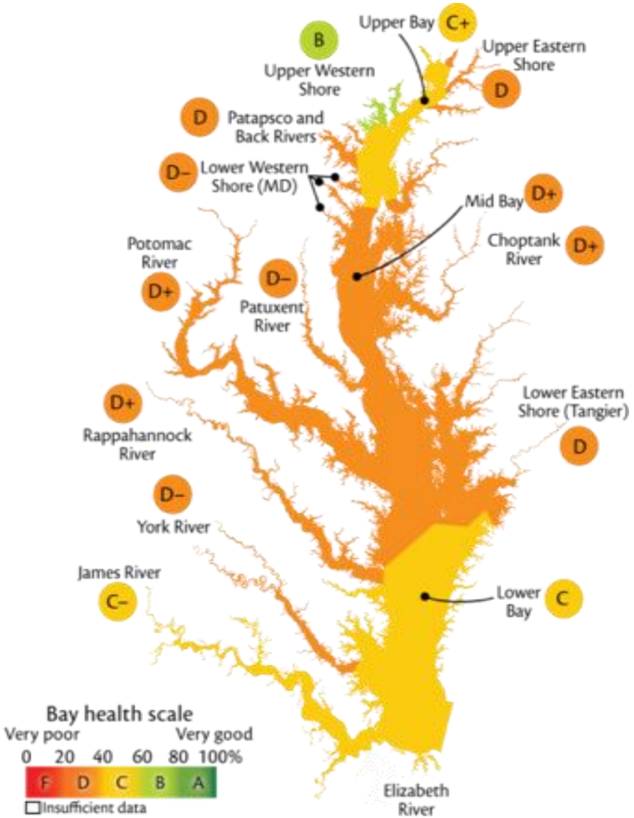
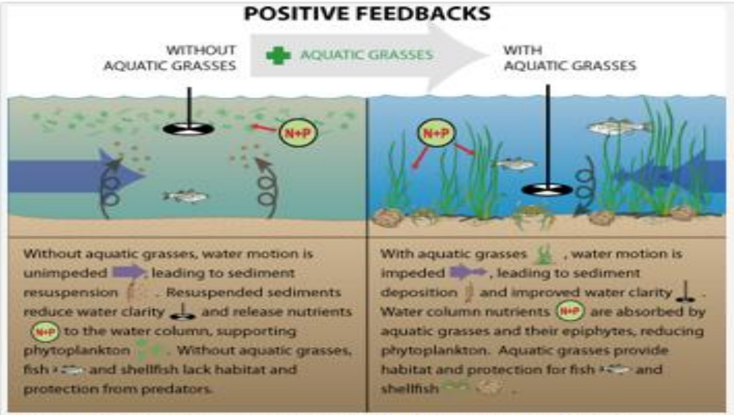


Figure from proposal to develop a Chesapeake Synthesis Center (2009)

Interpretation of Chesapeake Bay report cards have hypothesized SAV ecological tipping points





The resurgence of aquatic grasses in the Upper Bay results in the positive feedbacks to water quality.

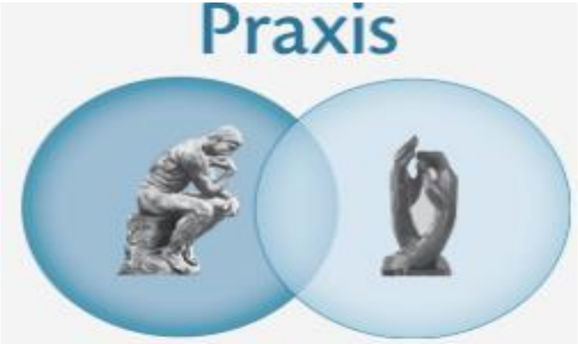
Positive ecological feedbacks resulting in improving water quality trajectories.

Our premise is that SAV act as the ‘coastal canaries’ for water quality

- Integrate environmental conditions
- Responsive to perturbations
- Widespread distribution
- Ecologically important

Participants were carefully selected

- Excellent scientists
- Focus on analysis and interpretation
- Commitment to Chesapeake Bay
- Willingness to work collaboratively towards a common cause



We assembled a diverse and talented scientific team

Goals of SAV SYN workshops

Productive

Workshop summary produced, bookmarks event, document progress

Interactive

Activities & breakouts lead to input & exchange

Condensed

Workshops limited to necessary contact hours

Participatory

Multiple opportunities for input

Fun

We created an immersive environment

SAV SYN produced 3 papers and working on a segment analysis

1. Eelgrass declines (Global Change Biology, published)
2. SAV as sentinel species (Bioscience, published)
3. Nutrient reductions (Proc. Natl. Acad. Sci., in review)
4. SAV segment analysis (in progress)

1. Eelgrass paper

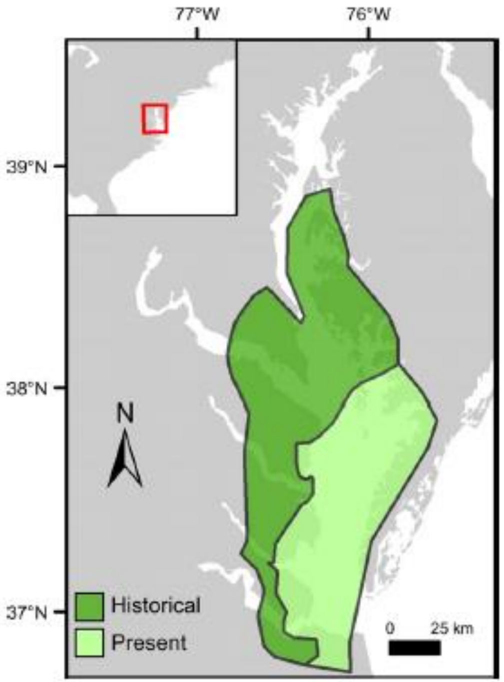
Global Change Biology (2017), doi: 10.1111/gcb.13623

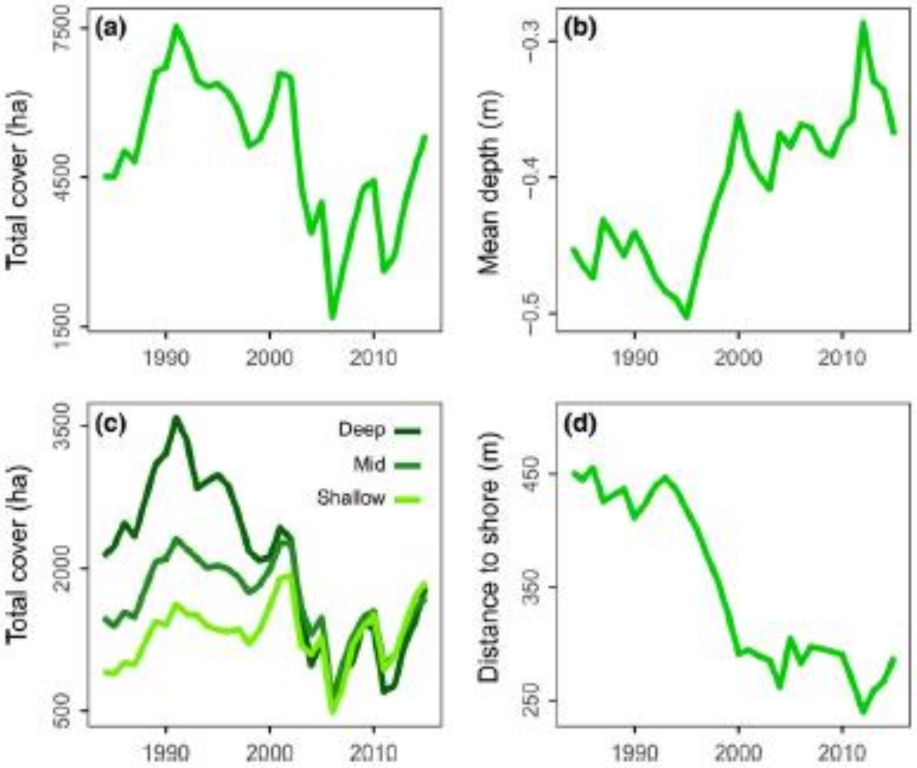
Multiple stressors threaten the imperiled coastal foundation species eelgrass (*Zostera marina*) in Chesapeake Bay, USA

JONATHAN S. LEFCHECK[1], DAVID J. WILCOX[1], REBECCA R. MURPHY[2], SCOTT R. MARION[3] and ROBERT J. ORTH[1]

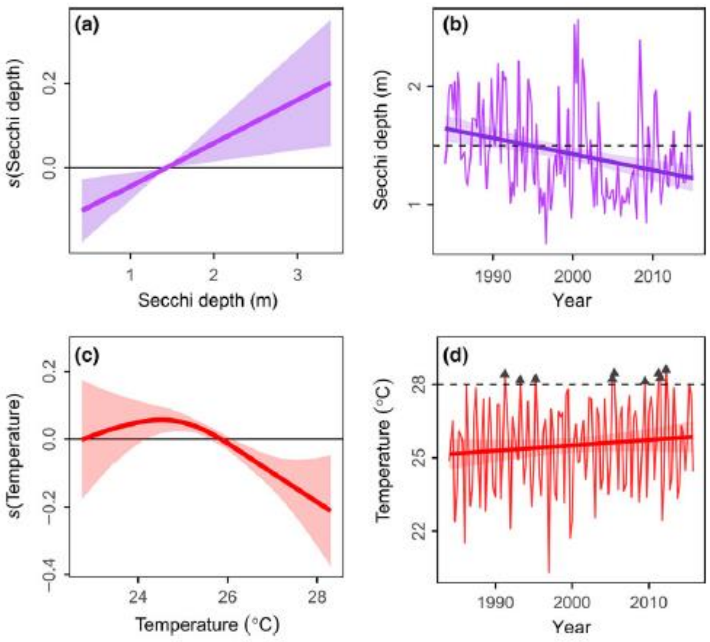
[1]*Virginia Institute of Marine Science, The College of William & Mary, Gloucester Point, VA 23062, USA,* [2]*University of Maryland Center for Environmental Science, Chesapeake Bay Program, Annapolis, MD 21403, USA,* [3]*Oregon Department of Fish & Wildlife, Marine Resources Program, Newport, OR 97365, USA*

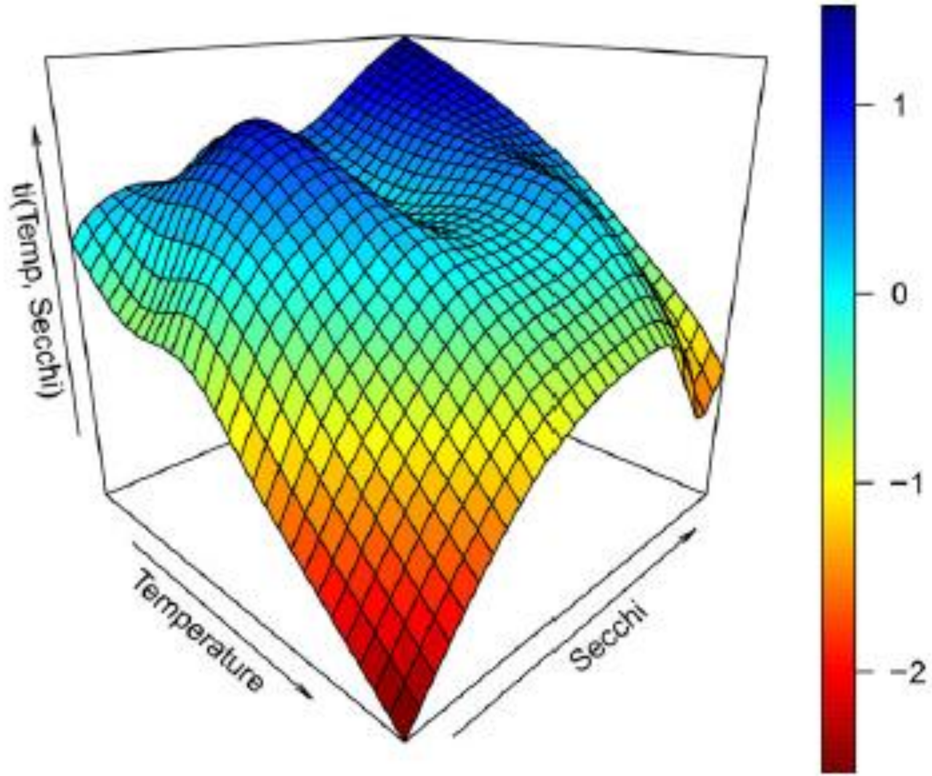
Shrinking eelgrass distribution





Synergistic effects of water clarity and temperature





Significant economic impacts

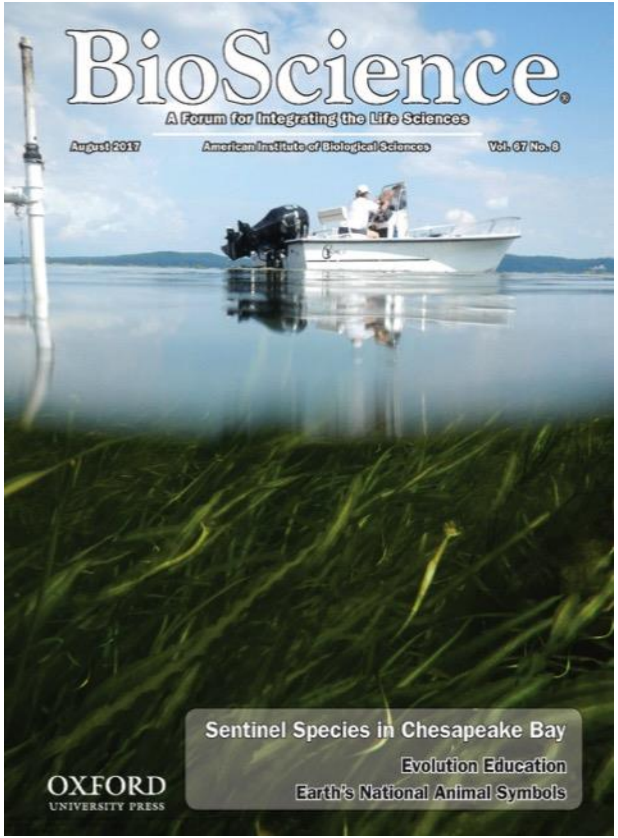
Table 1 Loss of ecosystem services concurrent with loss of eelgrass. Values are means ± 1 SD, estimated based on change in eelgrass cover from its peak in 1991 to present, and to the maximum observed loss in 2006.

Service	Response	Present loss (1991–2015)	Maximum loss (1991–2006)
Nutrient cycling	Carbon stock (kt C)	693 ± 150	1859 ± 401
	N_2 fixation (kt N)	2.53 ± 0.25	4.25 ± 0.16
Secondary production and export	Epifaunal biomass (Mt)	141.1 ± 75.2	236.6 ± 126.1
	Blue crab density (millions of juveniles)	523 ± 600	1403 ± 1609
	Silver perch biomass (kt)	47.8 ± 5.2	80.2 ± 8.8
Total economic loss	Integrated value ($2011 US)	$1.51 billion	$2.54 billion

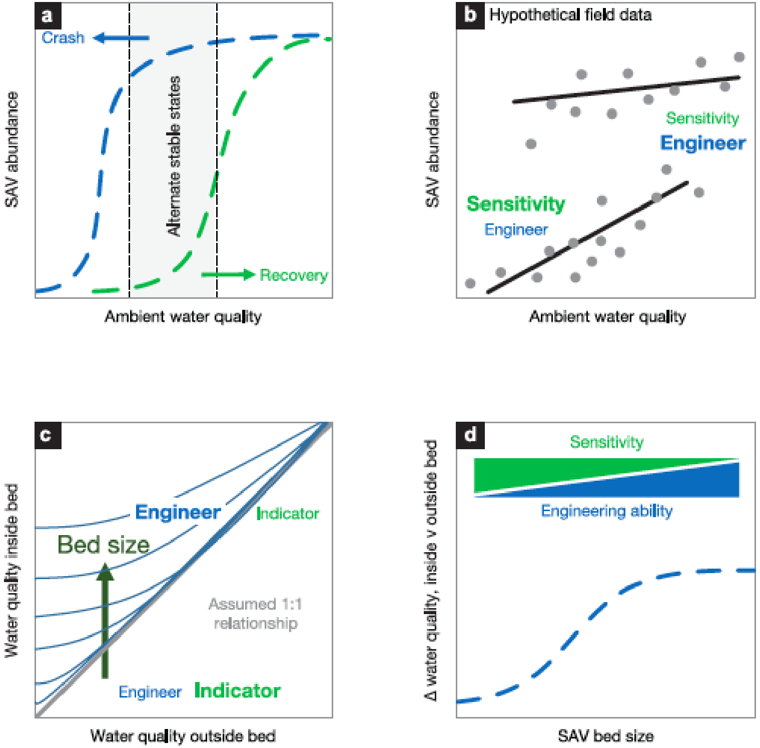
2. SAV as sentinel species paper

Submersed Aquatic Vegetation in Chesapeake Bay: Sentinel Species in a Changing World

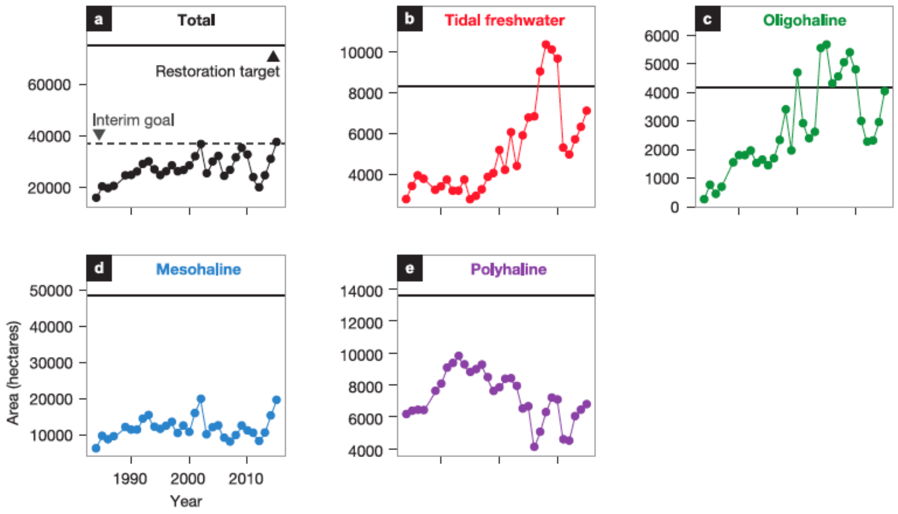
ROBERT J. ORTH, WILLIAM C. DENNISON, JONATHAN S. LEFCHECK, CASSIE GURBISZ, MICHAEL HANNAM, JENNIFER KEISMAN, J. BROOKE LANDRY, KENNETH A. MOORE, REBECCA R. MURPHY, CHRISTOPHER J. PATRICK, JEREMY TESTA, DONALD E. WELLER, AND DAVID J. WILCOX

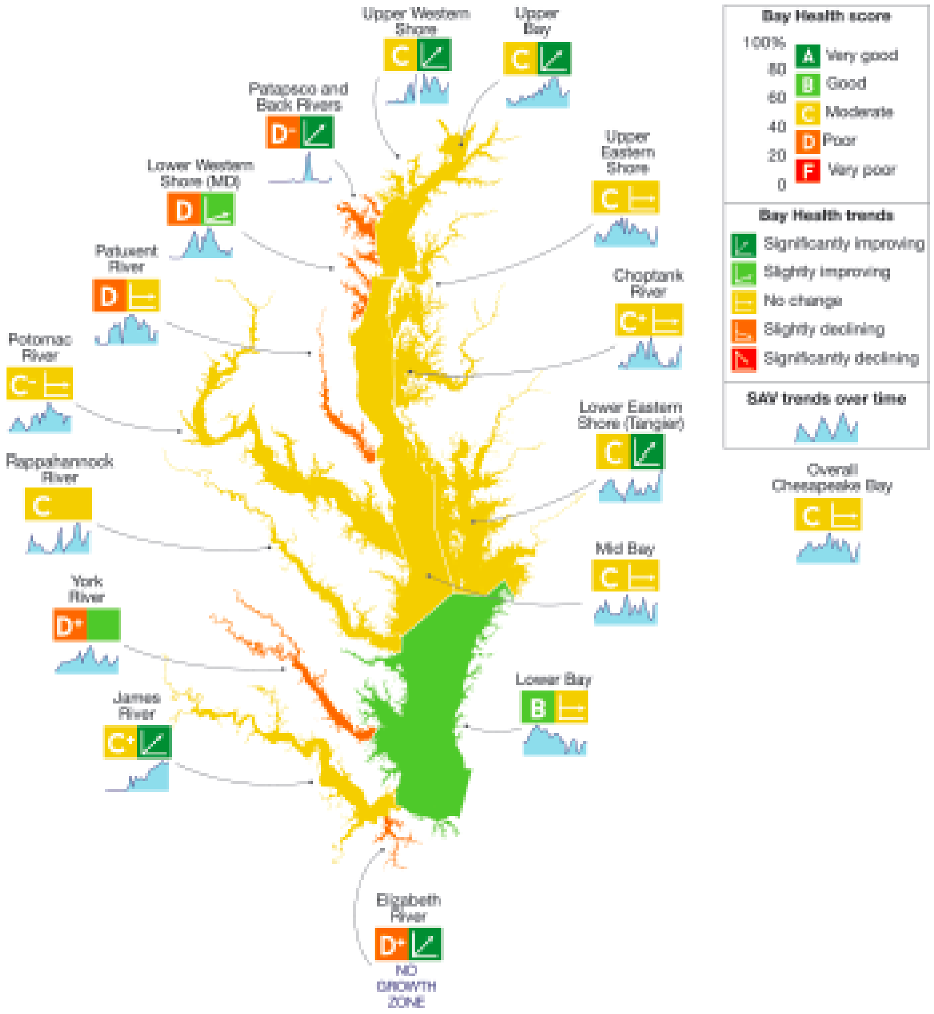


Impacts on SAV

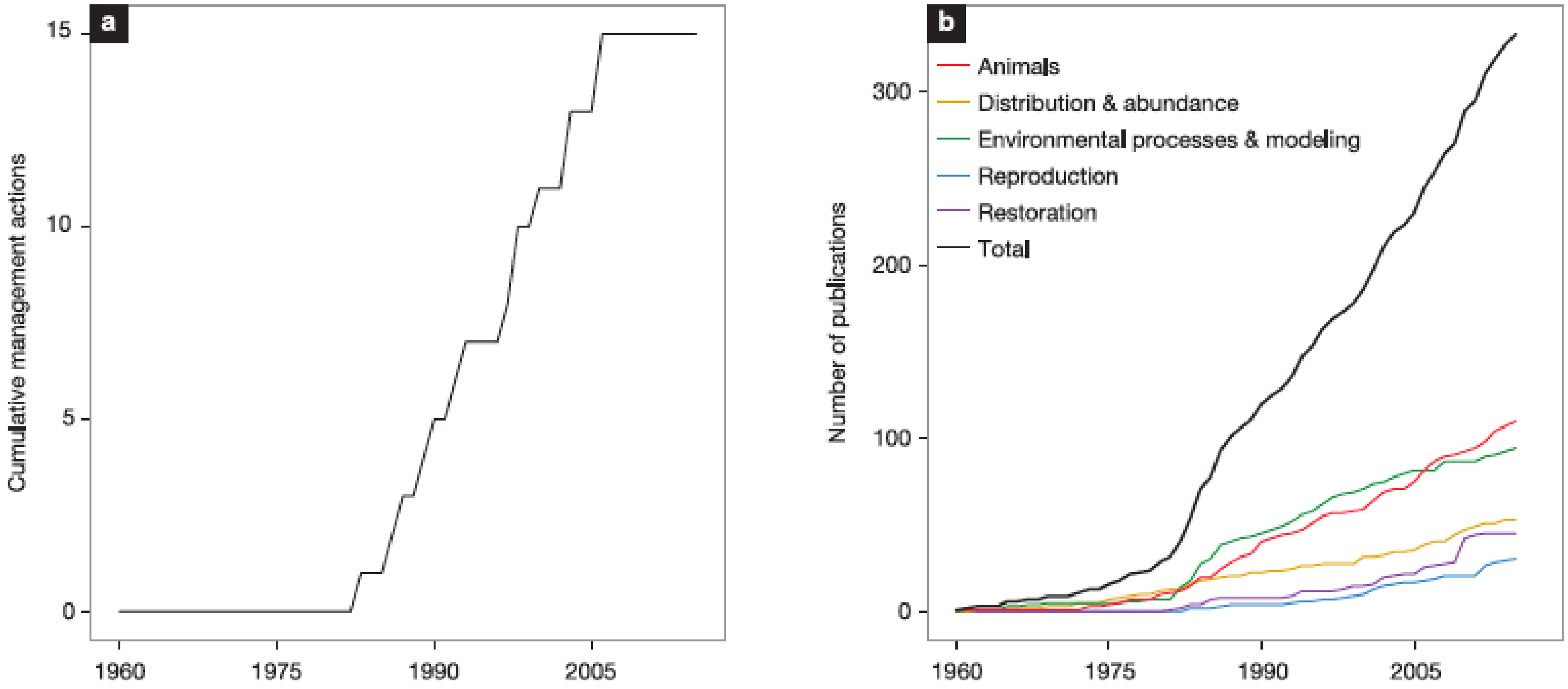


SAV trends

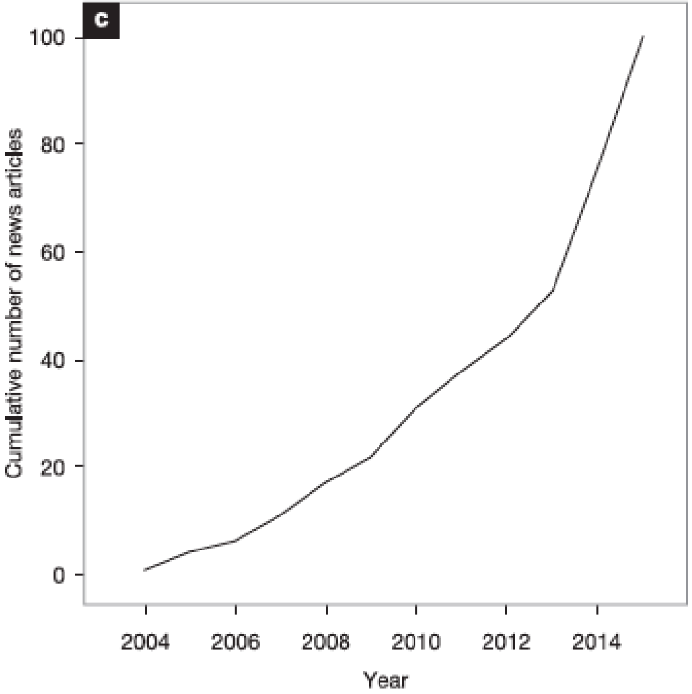

a
Total
Restoration target
Interim goal
60000
40000
20000
b
Tidal freshwater
10000
8000
6000
4000
c
Oligohaline
6000
5000
4000
3000
2000
1000
0
d
Mesohaline
50000
40000
30000
20000
10000
Area (hectares)
1990
2000
2010
Year
e
Polyhaline
14000
12000
10000
8000
6000
4000

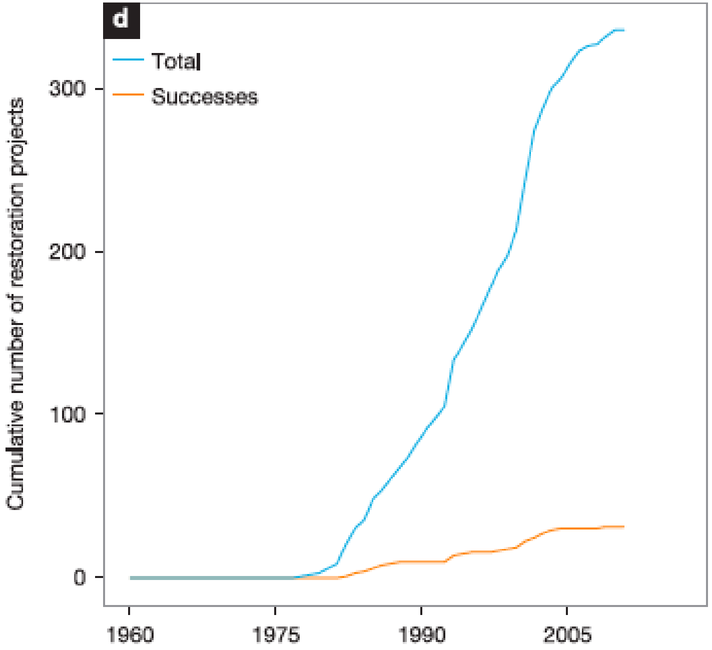

Upper Western Shore
C
Upper Bay
C
Patapsco and Back Rivers
D-
Lower Western Shore (MD)
D
Upper Eastern Shore
C
Patuxent River
D
Choptank River
C+
Potomac River
C-
Lower Eastern Shore (Tangier)
C
Rappahannock River
C
Mid Bay
C
York River
D+
Lower Bay
B
James River
C+
Elizabeth River
D+
NO GROWTH ZONE
Bay Health score
100%
80
60
40
20
0
A Very good
B Good
C Moderate
D Poor
F Very poor
Bay Health trends
Significantly improving
Slightly improving
No change
Slightly declining
Significantly declining
SAV trends over time
Overall Chesapeake Bay
C

Increase in SAV management & research

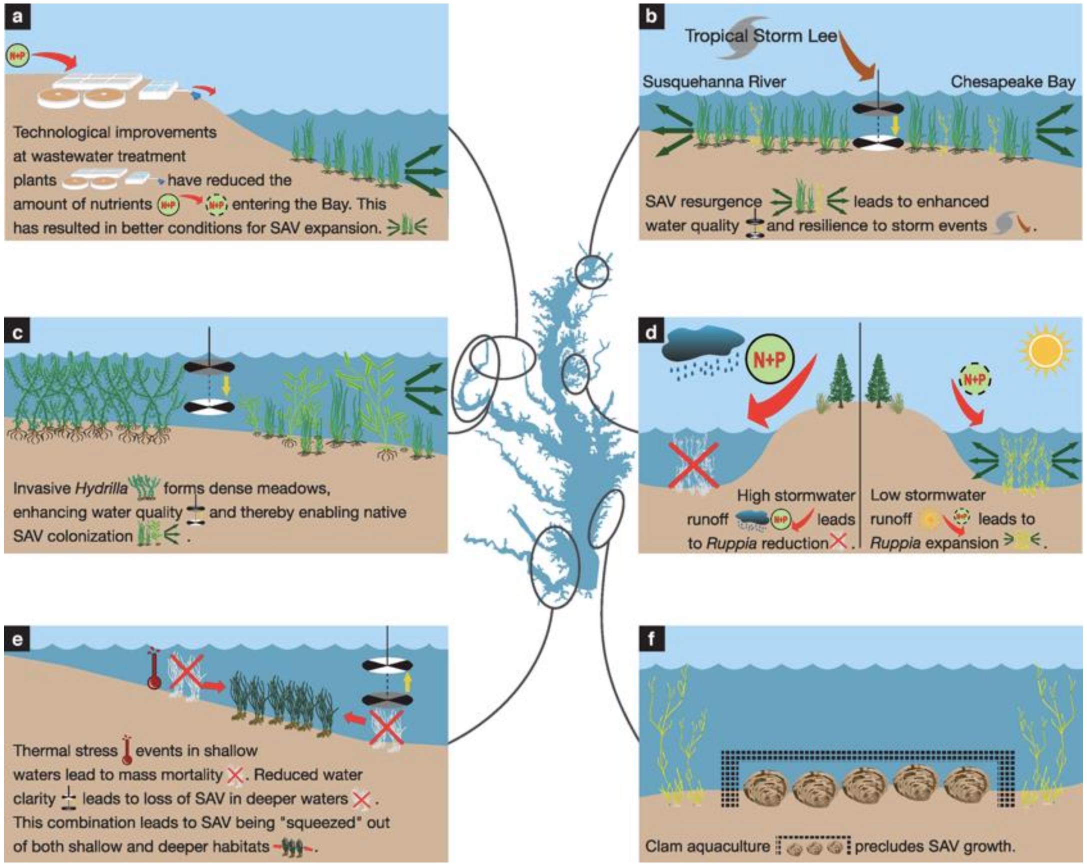


Increase in SAV media attention & restoration projects





SAV conceptual diagrams



3. Paper submitted to Proc. Natl. Acad. Sci.

Nutrient reductions lead to unprecedented recovery of a temperate coastal ecosystem

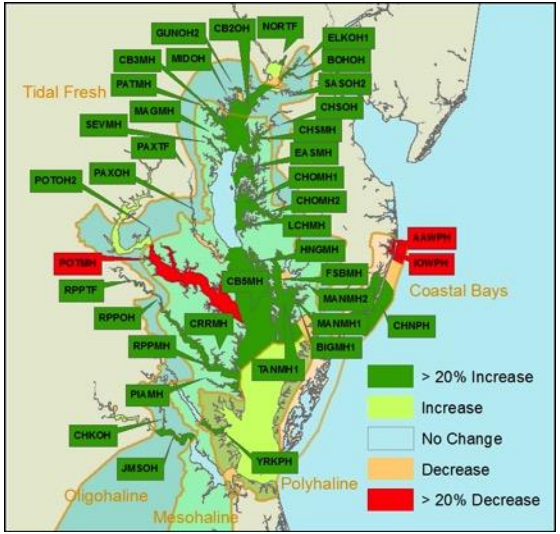
Jonathan S. Lefcheck[1,2*], Robert J. Orth[2], William C. Dennison[3], David J. Wilcox[2], Rebecca R. Murphy[4], Jennifer Keisman[5], Cassie Gurbisz[6,7], Michael Hannam[8,9], J. Brooke Landry[10], Kenneth A. Moore[2], Christopher J. Patrick[11], Jeremy Testa[12], Donald E. Weller[8], Richard A. Batuik[13]

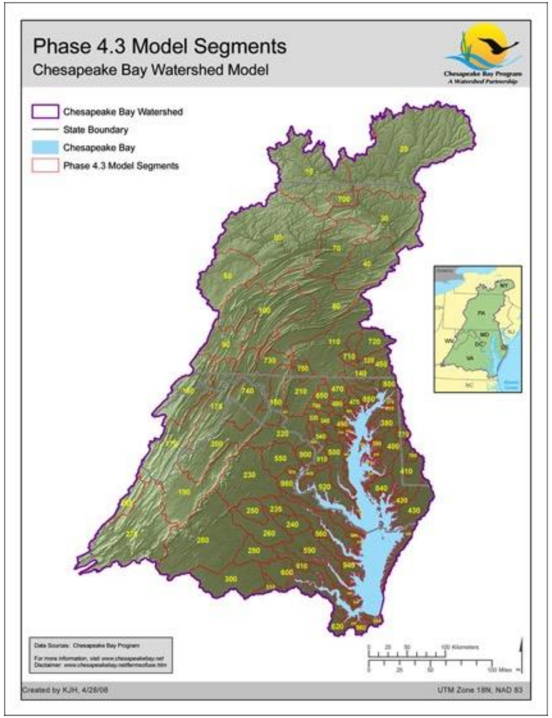
Two key questions addressed

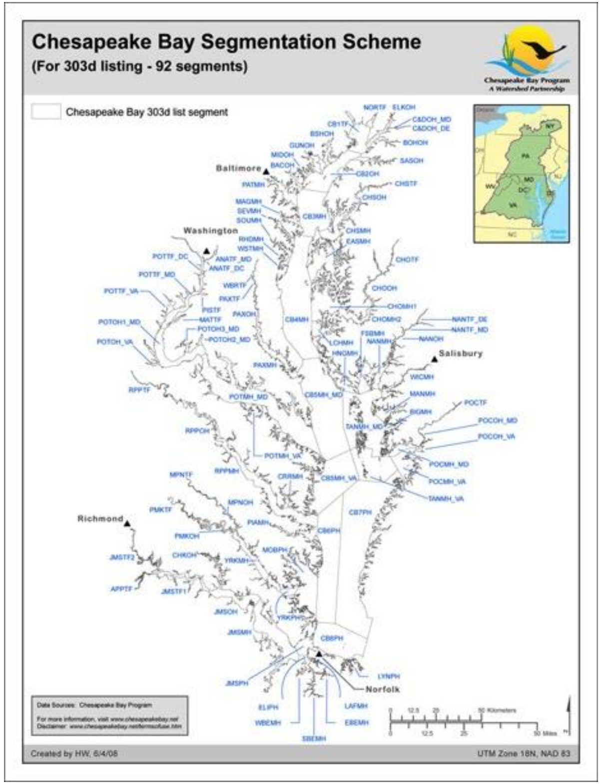
1. What are the long term SAV trends in Chesapeake Bay?
2. How are the trends related to human activities?
   - Watershed
   - Water column

Long term data sets (1984-2015)

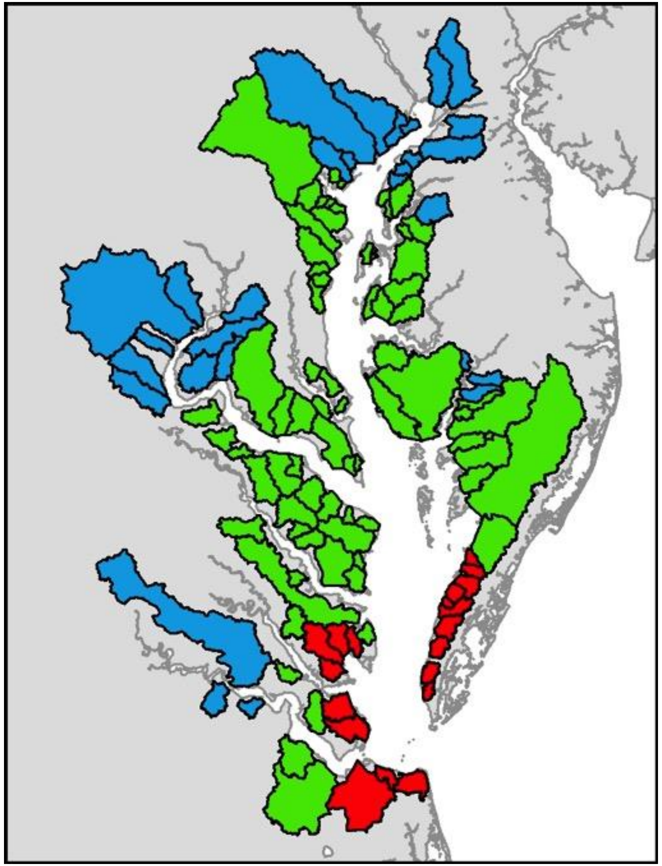
VIMS SAV mapping, CBP watershed model, CBP water quality monitoring

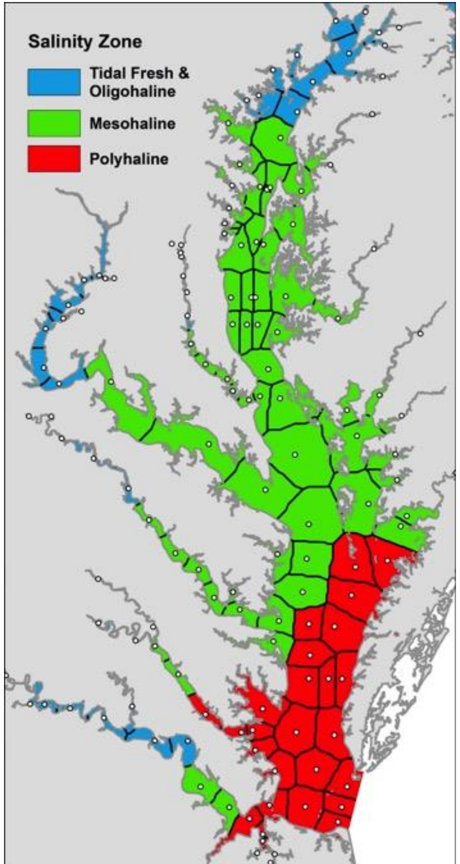






Subestuary & Baywide analyses





Structural Equation Modeling (SEM)

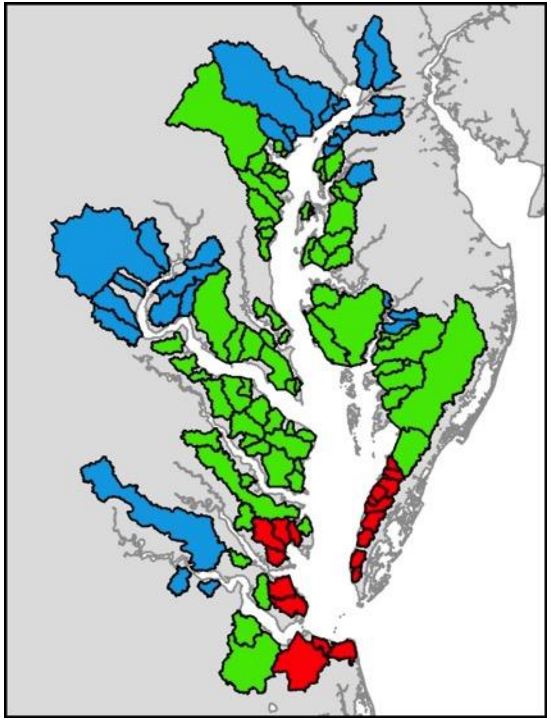
- Unites variables in a single causal network
- Ideal for testing cascading or indirect effects
- Traditional linear regression under the hood

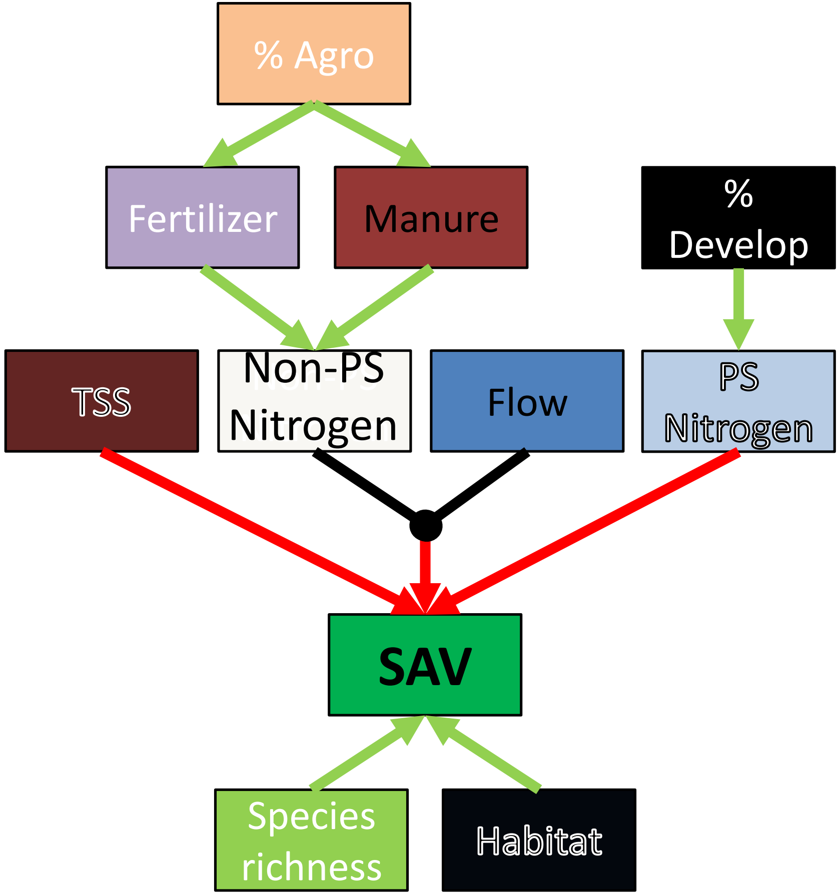
A simple linear regression: $Z \sim Y$

A simple linear regression: $Y \sim X$

A single causal model (SEM)

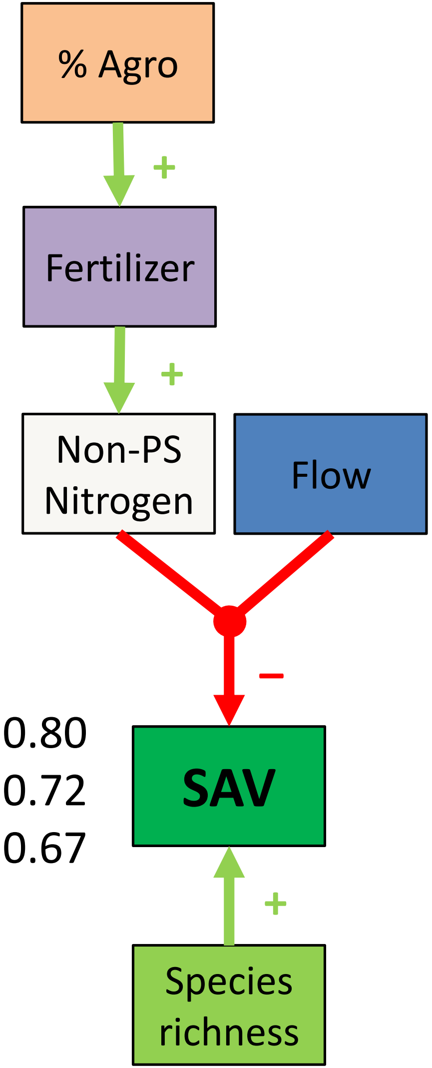
Hypothesized SEM



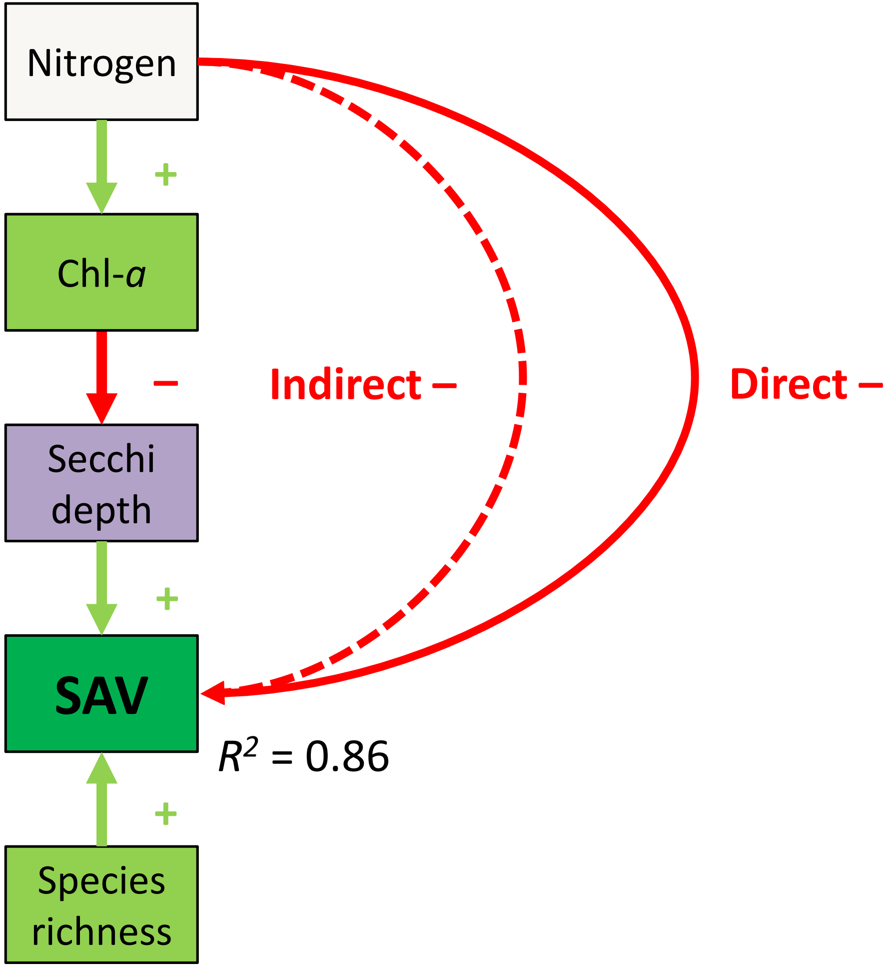


Watershed SEM

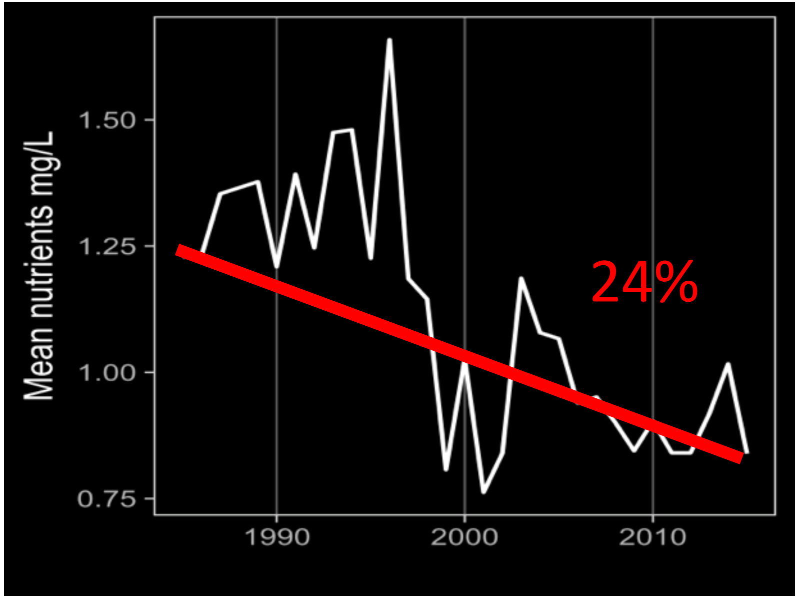
Freshwater R^2 = 0.80
Mesohaline R^2 = 0.72
Polyhaline R^2 = 0.67

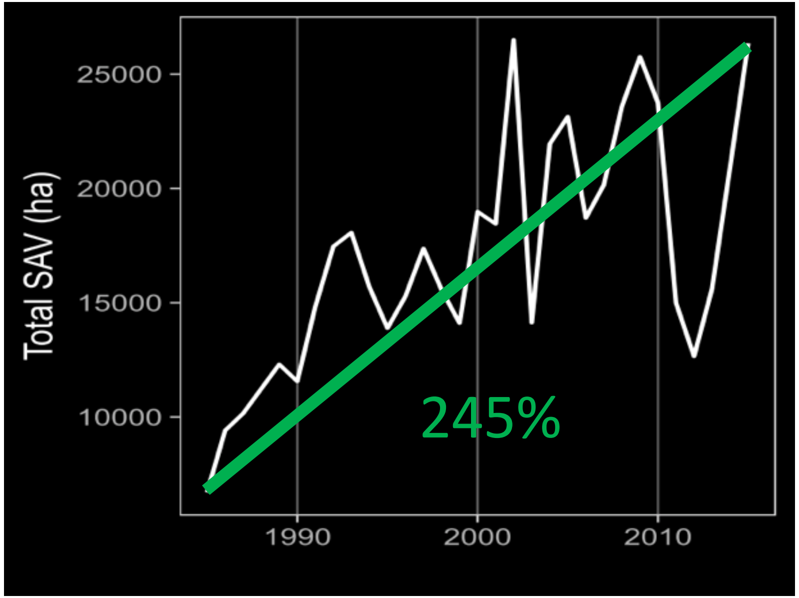


Water column SEM



Nutrient declines → SAV resurgence





Two key questions addressed

1. What are the long term SAV trends in Chesapeake Bay?

   Nutrient reductions have led to SAV recovery since the 1980s

2. How are the trends related to human activities?

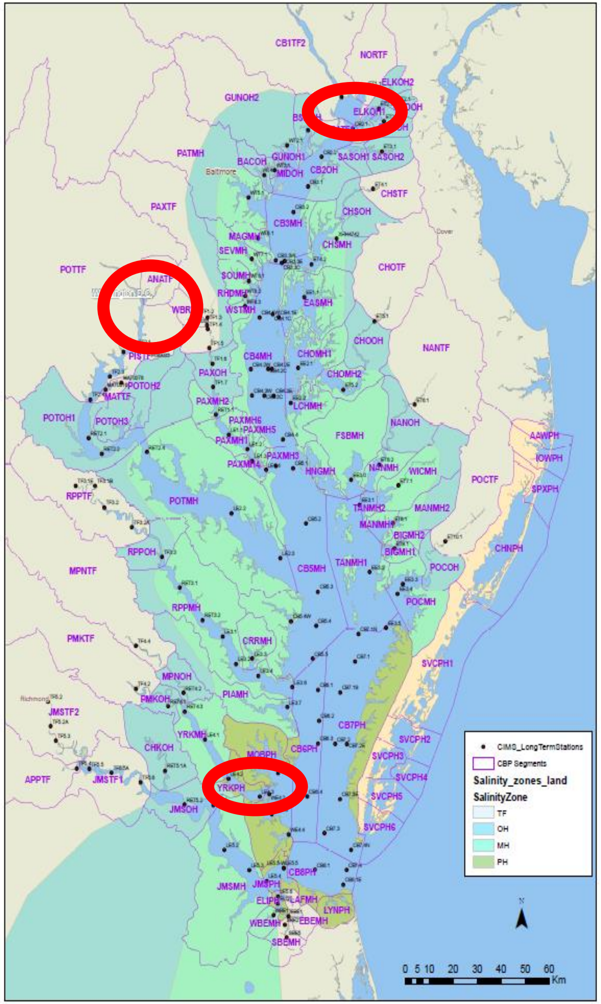
   Nutrient pollution reduces SAV; species enrichment enhances SAV

4. SAV segment analysis challenges

- Water quality stations vs. SAV locations
- Inside vs. outside SAV
- Temporal integration water quality vs. SAV
- Event impacts (e.g., storms, thermal)
- Inter-annual variability vs. long term trends
- Shoreline, seedbanks, land use influence on local SAV

Segment analysis

- 97 segments
- Some segments combined for analysis
- Three examples have been developed
  - Susquehanna flats
  - Upper Potomac River
  - York River polyhaline



Susquehanna Flats

SAV Segment Susquehanna Flats (CBTF2 and NORTF)

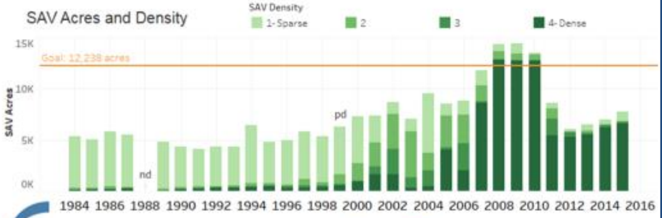
(http://vims.edu/bio/sav/SegmentAreaChart.htm)

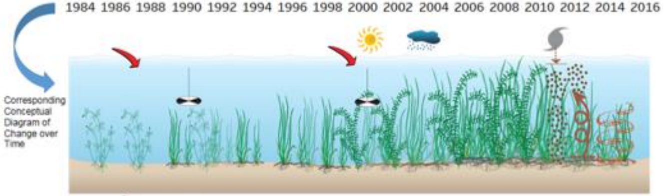
Current Expansive Freshwater SAV Beds in the Upper Chesapeake Bay near Havre de Grace

Executive Summary

While historic records indicate that SAV once covered over 12,000 acres of the Susquehanna Flats and supported large populations of migrating waterfowl, those beds were in serious decline by the mid-1900s. Stress to native SAV populations allowed for non-native Eurasian watermilfoil to dominate the SAV that persisted and when Tropical Storm Agnes tore over the Flats in 1972, most of the remaining SAV was lost with the rapid onslaught of sediment and nutrient pollution to the estuary. After two decades of minimal recovery, SAV beds on the Susquehanna Flats began to experience a resurgence as a result of reductions in total nitrogen and the consequent improvements in water clarity. By 2008, SAV reached and surpassed its restoration goal in these associated segments until 2011 when Tropical Storm Lee hit the region. Scour and turbidity reduced SAV in the Flats by approximately 1/3 following the storm, but steady recovery since then has been facilitated by the dense, resilient SAV bed that persisted.

SAV Acres and Density





Nutrient Reduction
Improved Water Clarity
Drought (1998-2002)
Followed by Wet Period (2003-2004)
Major Resurgence 2005-2010
Tropical Storm Lee Turbidity
Resuspension Followed Tropical Storm Lee (2012-)
Lyngbya Expansion after Tropical Storm Lee

Take Home Points

- Goal is attainable
- Extreme Runoff Event Susceptibility, but Resilient
- Resuspension following Tropical Storm Lee
- Changing patterns in SAV species diversity and habitat quality
- SAV Meadow Critical Mass
- *Lyngbya* Expansion
- Management Implications

Footnotes:

Susquehanna Flats (Synthesis of 2 segments - CBTF2 and NORTF)
http://vims.edu/bio/sav/SegmentAreaChart.htm)

Goal is attainable.

The goal is 12, 237 acres. This goal was achieved from 2008-2010, following a decade of increasing of improving water quality, reduction in total nitrogen, and expanding SAV. In September 2011, Tropical Storm Lee led to the second highest flow amount recorded from the Susquehanna River at the Conowingo dam, resulting in high turbidity in the upper bay, resulting in the decline of SAV primarily at the deeper sections of the SAV beds.

Extreme runoff event susceptibility but resilient.

SAV that had been recovering following the loss of milfoil in the 1960s which had outcompeted native species in the late 1950 through the early 1960s were decimated by Tropical Storm Agnes in 1972, , leading to a two decade period without appreciable SAV presence. Following the resurgence of SAV in the region through 2011, Tropical Storm Lee in Sept., 2011 (http://ian.umces.edu/ecocheck/summer-review/chesapeake-bay/2011/indicators/influ-encing_factors/)
, led to a dramatic decline of SAV because of prolonged turbidity. However, the large dense beds protected the interior of the meadow from the river-borne turbidity, with losses primarily in the deeper, south and east ends of the Flats. But these beds proved to be resilient in that unlike Tropical Storm Agnes, large and dense grass beds persisted, facilitating a steady recovery in the years following Lee.

Resuspension following Tropical Storm Lee

The fine grain sediments that overtopped the Conowingo Dam were resuspended and persisted for years following their deposition. This shows the resuspension following storm events and fine grain sediment deposition can have lingering long term effects in water clarity and SAV abundance, influencing the trajectory of the recovery.

Changing patterns in SAV species diversity and habitat quality

This region historically supported a dense, diverse SAV assemblage which provided habitat for a myriad of migratory waterfowl. The Susquehanna Flats was the premier wintering waterfowl habitat of the mid-atlantic coast. The appearance of milfoil in the late 1950s dramatically altered the presence of native species. The disappearance of milfoil beginning in the late 1960s allowed some native species to return but in 1972, the passage of Agnes was the coup de gras for the native SAV species. Over the next two decades, some recovery of native species occurred on the flanks of the Susquehanna Flats, but little recovery on the main flats. Over the last two decades, the flats have become colonized by a dense and diverse SAV community of up to 15 species.

Lyngbya Expansion

Expansion of invasive bluegreen cyanobacteria shades SAV from light. *Lyngbya* thrives in warm, clear water. Lyngbya can also fix nitrogen and produce toxins. It forms dense floating mats, and loosely attaches to SAV. In other regions of the world, *Lyngbya* has been known to decrease SAV density. *Lyngbya* can be very ephemeral, disappearing quickly due to viral lysis.

Managment Implications

The two major issues that will influence the continued abundance and diversity of SAV in this region will be additional sediments that will be released from behind the Susquehanna Dam now that it is full, and nitrogen loads coming into the river. While we have shown the resiliency of this vast expanse of SAV following Tropical Storm Lee, the persistent release of sediments have the potential of altering the dynamics of SAV, either by the shoaling of the Flats, or the smothering of SAV by the sediments.

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Segment summary

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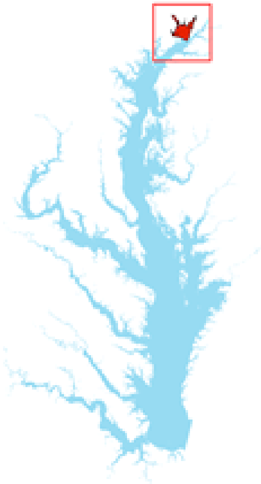

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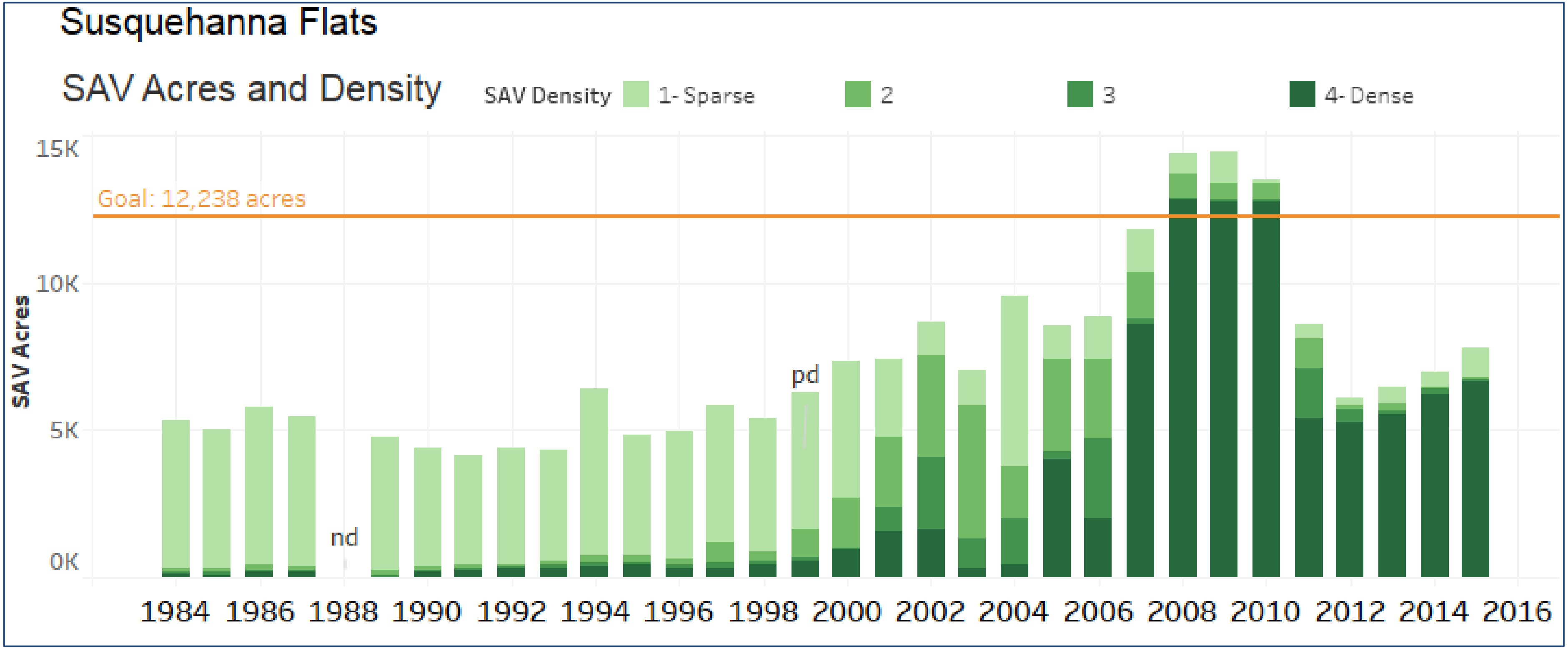
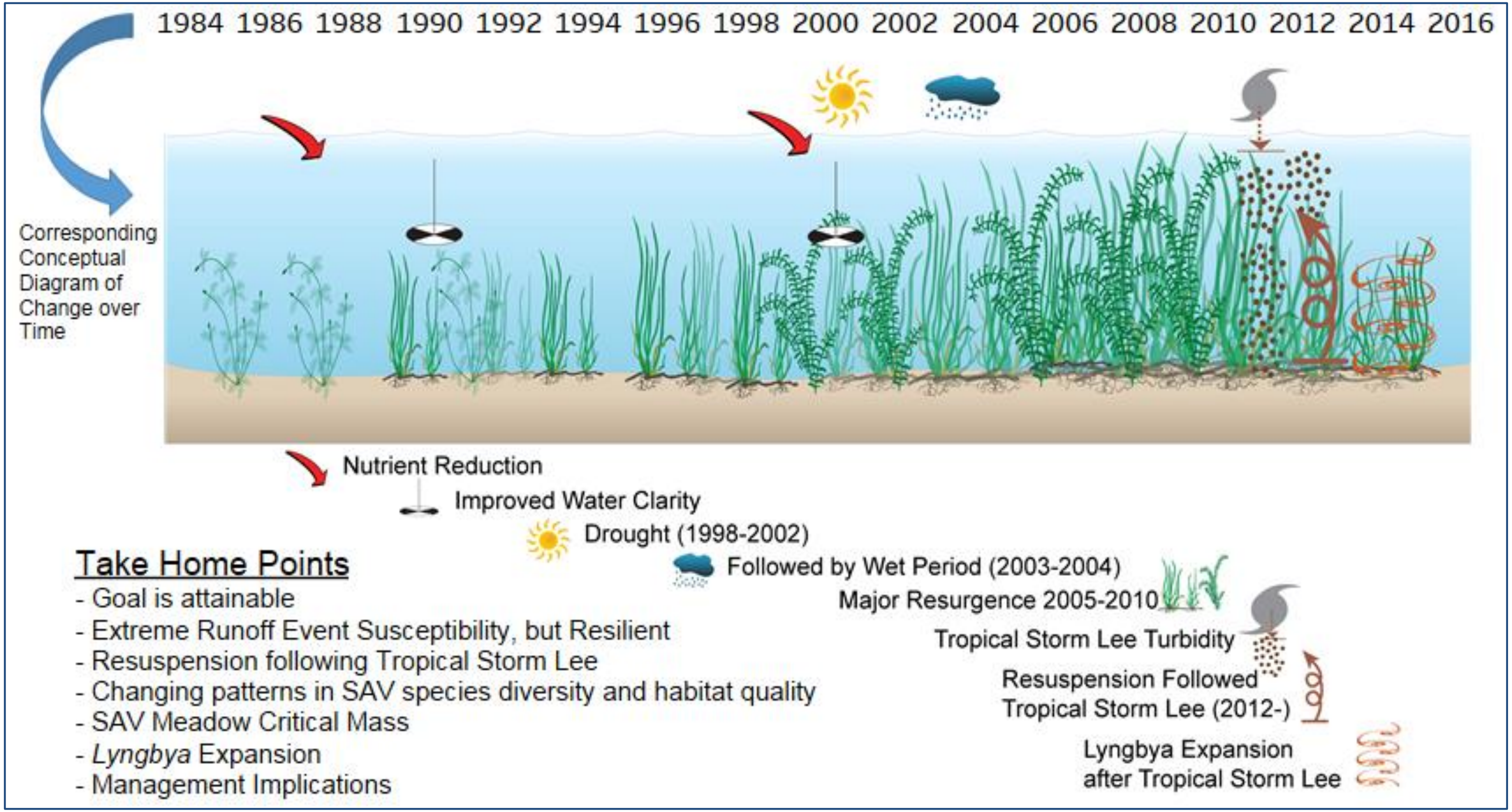
SAV acres & density graphs



Time course conceptual diagram & take home points



Extensive footnotes

- Goal is attainable
- Extreme runoff event susceptibility but resilient
- Resuspension following Tropical Storm Lee
- Changing patterns in SAV species diversity and habitat quality
- *Lyngbya* expansion
- Management implications
- References

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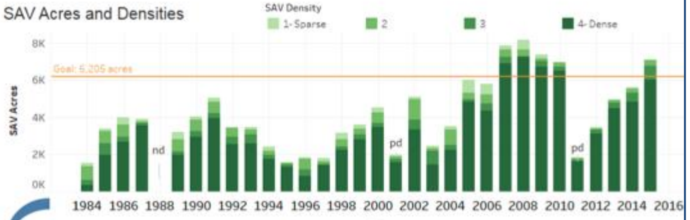
Upper Potomac River

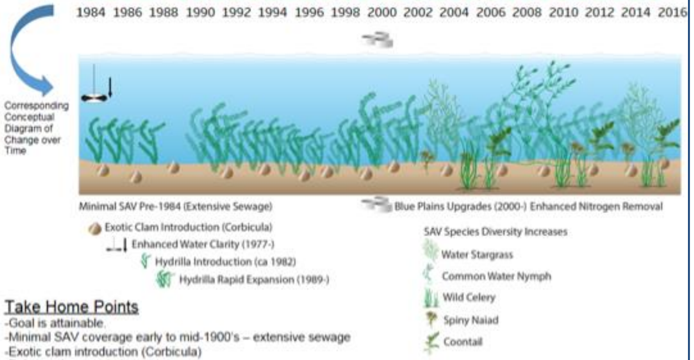
SAV Segment Upper Potomac (MATTF, PISTF, POTTF, ANATF)
(http://vims.edu/bio/sav/SegmentAreaChart.htm)

Expansive SAV beds of multiple species dominate the shoal areas around Washington, DC.

Executive Summary
The upper Potomac River, while playing an important role in the history of the region, was almost a dead river in the early 20th century due to the dumping of raw sewage. SAV was totally absent during this time period. Beginning in the 1970s, upgrades to the STP's began and continued through the early 2000s. During this period, there was a significant removal of nitrogen from the Blue Plains Sewage STP. Concurrently, around 1982, the non-native SAV *Hydrilla* was introduced and spread rapidly throughout the river, and facilitated the recolonization by many native SAV species. In addition, the appearance on the non-native filter feeding benthic clam, *Corbicula*, may have contributed to the improved water clarity conditions that led to the rapid spread of SAV. Today, dense and diverse SAV beds occupy much of the shoals of this region, and despite some of the interannual variations, the SAV beds have persisted since they first appeared.

SAV Acres and Densities





Take Home Points
-Goal is attainable.
-Minimal SAV coverage early to mid-1900's – extensive sewage
-Exotic clam introduction (Corbicula)
-Enhanced water clarity
-*Hydrilla* introduction
-Blue Plains upgrades (N removal)
-Management Implications

Footnotes

Upper Potomac (MATTF, PISTF, POTTF, ANATF) http://vims.edu/bio/sav/SegmentAreaChart.htm

Goal is attainable.
This goal of 6,205 acres was achieved from 2007-2010, following decades of increasing of improving water quality, reduction in total nitrogen from advance wastewater treatment plants, and expanding SAV. In September 2011, Tropical Storm Lee undoubtedly contributed to SAV loss, although SAV data were not available for the entire segment in 2011. SAV had rebounded after Lee and again reached its goal in 2015.

Minimal SAV coverage early to mid-1900's – extensive sewage
An early report in 1916 revealed the presence of extensive SAV along the shoals of the upper Potomac River. However, with rapid growth of the DC area in the early 1900s and inadequate sewage facilities, the river became a cesspool. SAV rapidly declined that by the 1930s SAV was absent from this portion of the river until the early 1980s. There was evidence on an outbreak of the invasive *Trapa natans* in the 1930s in this portion of the river, which may have contributed to the demise of the native SAV.

Exotic clam introduction
The Asiatic clam, *Corbicula fluminea*, was first observed in this river in 1977, and subsequently rapidly expanded in this portion of the river. At the same time, phytoplankton chl a showed a gradient from low to high abundance which was hypothesized to due to the filtration by phytoplankton by the clam.

Enhanced water clarity
Water clarity that was likely due to a combination of nitrogen reduction by the STPs and presence of dense concentrations of the Asiatic clam most likely facilitated the improvement in water clarity that allowed the non-native Hydrilla to take hold and develop large dense beds that improved their own water clarity.

***Hydrilla* introduction and its influence of SAV diversity**
In the early 1980s, *Hydrilla* was accidently introduced into the Potomac River, near the Dyke Marsh area, an area that was then completely unvegetated. The plant was mis-identified as common elodea, a native plant that looks similar to *Hydrilla* but does not have serrated leaves. While the initial reaction of government officials was to use herbicides or harvest every last piece of *Hydrilla*, ultimately the decision was made to allow nature to take its course. Since that initial introduction, *Hydrilla* has expanded downriver to Potomac Creek, being limited by salinity. *Hydrilla* has also spread throughout the watershed, now being found in almost every low salinity tributary. One very positive aspect of the *Hydrilla* expansion is it created a favorable environment for the colonization of numerous native species. Today the dense beds found throughout this section of the river contain up to 12 different species of SAV.

Blue Plains upgrades (N removal)
Nutrient removal from the Blue Plains STP played a vital role in facilitating the recovery of SAV here. In 1980, nitrification was implemented. Phosphorus –effluent filters were installed in 1982. And a new nitrification-denitrification system was added between 1998 and 2001. These improvements led to a significant reduction in nitrogen.

Management Implications
The main source of nutrients is from humans and the majority of human waste goes through the Blue Plains STP. While improvements over the last few decades have removed much nitrogen, the effort must continue to focus on nitrogen removal. In addition, efforts to maintain separate systems for Storm water overflow is critical to even lower nutrient and sediment levels in this river

References: Cumming et al. 1916; Stevenson and Confer, 1978; Carter et al. 1980; Cohen et al. 1984; Orth and Moore 1984; Ruhl and Rybicki 2001; Rybicki and Landwehr 2007.

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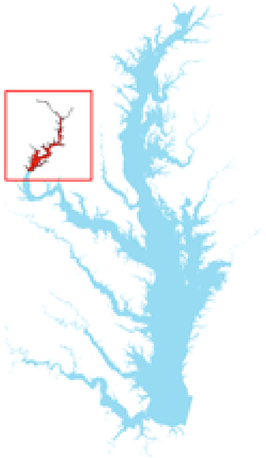

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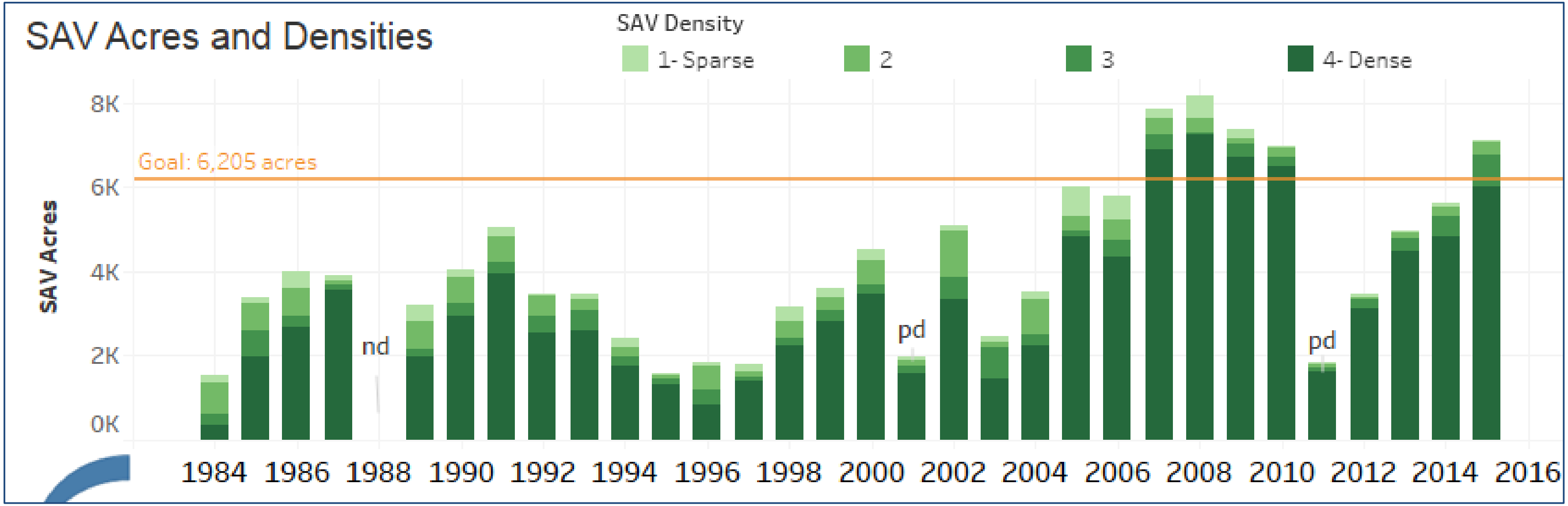
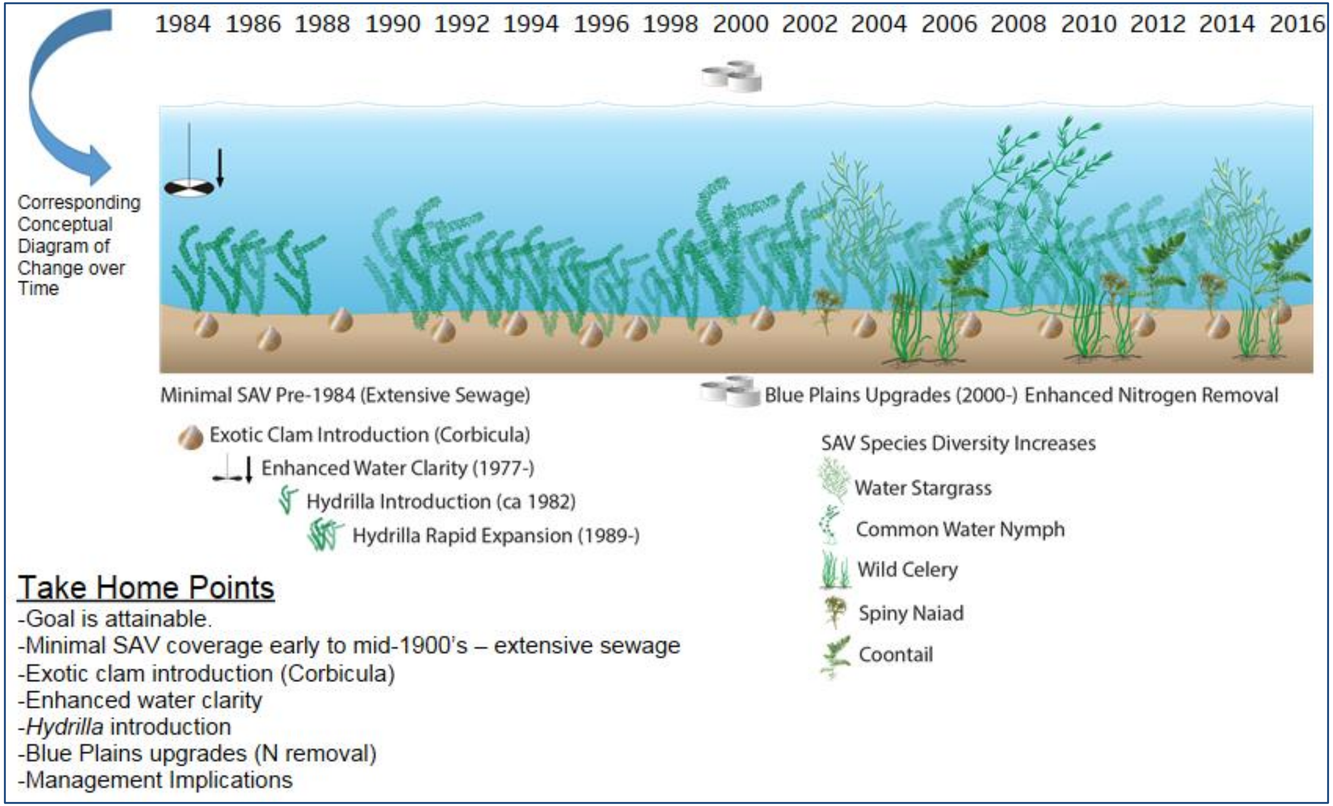
SAV acres & density graphs



Time course conceptual diagram & take home points



Extensive footnotes

- Goal is attainable
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- *Hydrilla* introduction and its influence of SAV diversity
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York River polyhaline

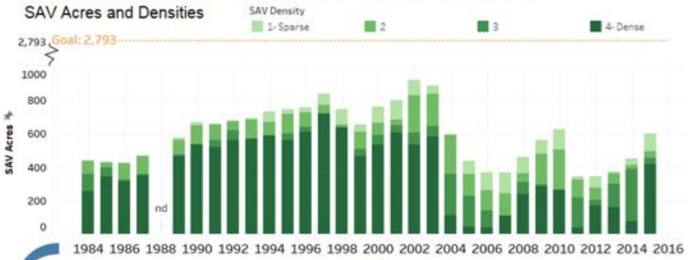
SAV Segment York Polyhaline (YRKPH)

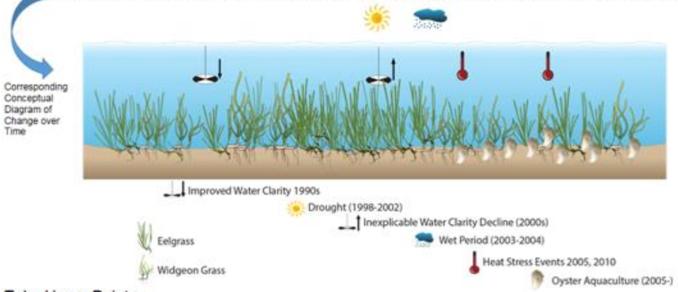
(http://vims.edu/bio/sav/SegmentAreaChart.htm)

Shoals of the lower York River dominated by eelgrass and widgeongrass.

Executive Summary

SAV beds consisting of eelgrass and widgeon grass once dominated the shoal areas of the polyhaline region. SAV acreage achieved maximum coverage in the 1960s correlated with the driest period recorded in recent history. The passage of tropical storm Agnes in 1972 triggered a dramatic decline in SAV in this segment. SAV began a slow recovery in the 1980s through the early 2000s, coupled to consistent good water clarity to allow eelgrass to expand. SAV began declining in the late 1990s due to declining water clarity. Heat events in 2005 and 2010 contributed to a significant declines of eelgrass in 2006 and 2011. Recovery did occur in the interim of these two periods, more related to generally improving water clarity. The only hope for reaching the goal of 2,793 SAV acres for this segment is the resurgence of SAV species widgeongrass and a significant improvement in water clarity for eelgrass to recolonize this region.





Take Home Points

- -Goal is attainable if water clarity can be improved
- -Eelgrass recovery following Agnes
- -Eelgrass is susceptible to heat events
- -Recovery between heat events
- -Widgeongrass is less susceptible to heat than eelgrass
- -Expanding shellfish aquaculture can influence overall abundance of SAV
- -Management Implications

Footnotes

York Polyhaline (YRKPH) http://vims.edu/bio/sav/SegmentAreaChart.htm

Goal is attainable if water clarity can be improved.
Improving water quality and clarity results in increases of eelgrass. This indicates that some of the thermal stress on eelgrass from heat events could be mitigated by improved water quality and clarity. The goal is attainable but probably not with eelgrass, but more likely with widgeongrass.

Eelgrass recovery following Agnes
There was a precipitous decline of eelgrass following tropical storm Agnes. Recovery was recorded through early 2000s, reaching a peak in 2003. This was related to long term, consistent improving water clarity. This recovery was slowed by inexplicable declining water clarity prior to heat events.

Eelgrass is susceptible to heat events
Eelgrass is a temperate seagrass species in the Chesapeake Bay near the southern distributional boundary of the mid-Atlantic. Shallow water summertime extreme temperatures led to mass mortality of eelgrass. Mortality of the meristematic tissue caused the plants to dislodge and float away. Small remnant populations persisted. High turbidity exacerbates high temperature stress. This occurred in Aug 2005 and June 2010. The SAV surveys do not fully assess this loss until the following year.

Recovery between heat events
The majority of eelgrass recovery was by seedlings and remnant rhizomes. The years following the heat events were cooler, with seedlings able to survive and grow. Because of the nature of eelgrass flowering and lack of a seedbank, two successive years of heat events could be devastating for eelgrass populations.

Widgeongrass is less susceptible to heat than Eelgrass
Widgeongrass is much more tolerant than eelgrass of temperature extremes. Widgeongrass has a broader global distribution and wider salinity tolerance. Widgeongrass populations can be highly variable on an annual basis.

Expanding shellfish aquaculture can influence overall abundance of SAV
Shellfish aquaculture could provide a boost to local economy, help replace declining wild stocks, and lead to water clarity improvements due to biofiltration.
Shellfish aquaculture, clams and oysters, that use up shallow water habitat, potential SAV habitat, limit the recovery of SAV into those regions if water clarity improvements lead to a resurgence.

Management Implications
Managers will need to focus on improving water clarity by both reducing sediments and nutrients. Managers will be unable to do much about temperature as this is a more global issue. However, by improving water clarity, plants may be able to tolerate periods of warmer water when clarity allows plants to photosynthesize. In addition, if and when water clarity improves, managers will have to deal with aquaculture requests, as well as existing leases where SAV may begin colonizing once unvegetated areas.

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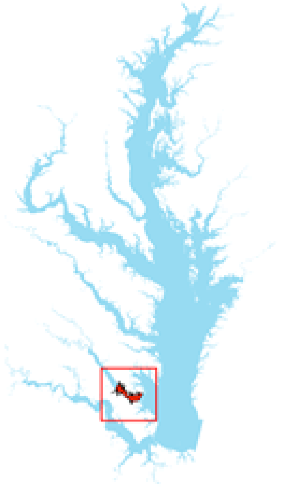

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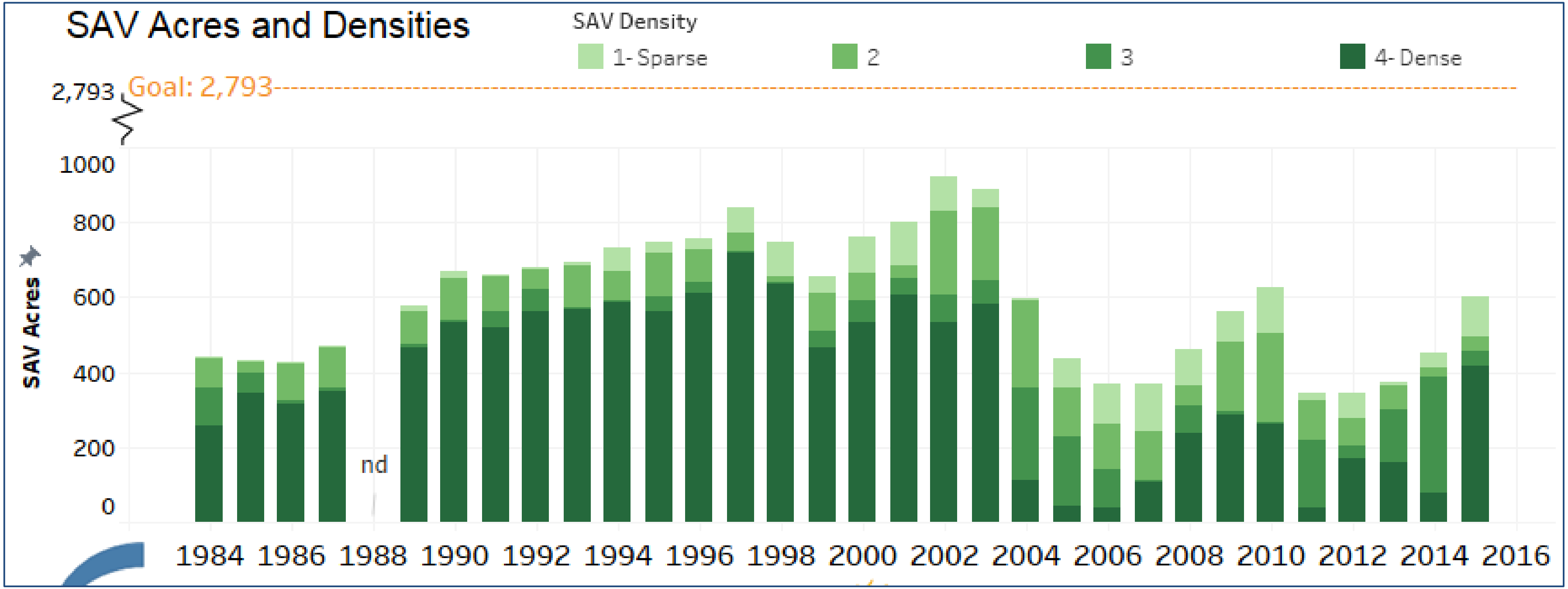

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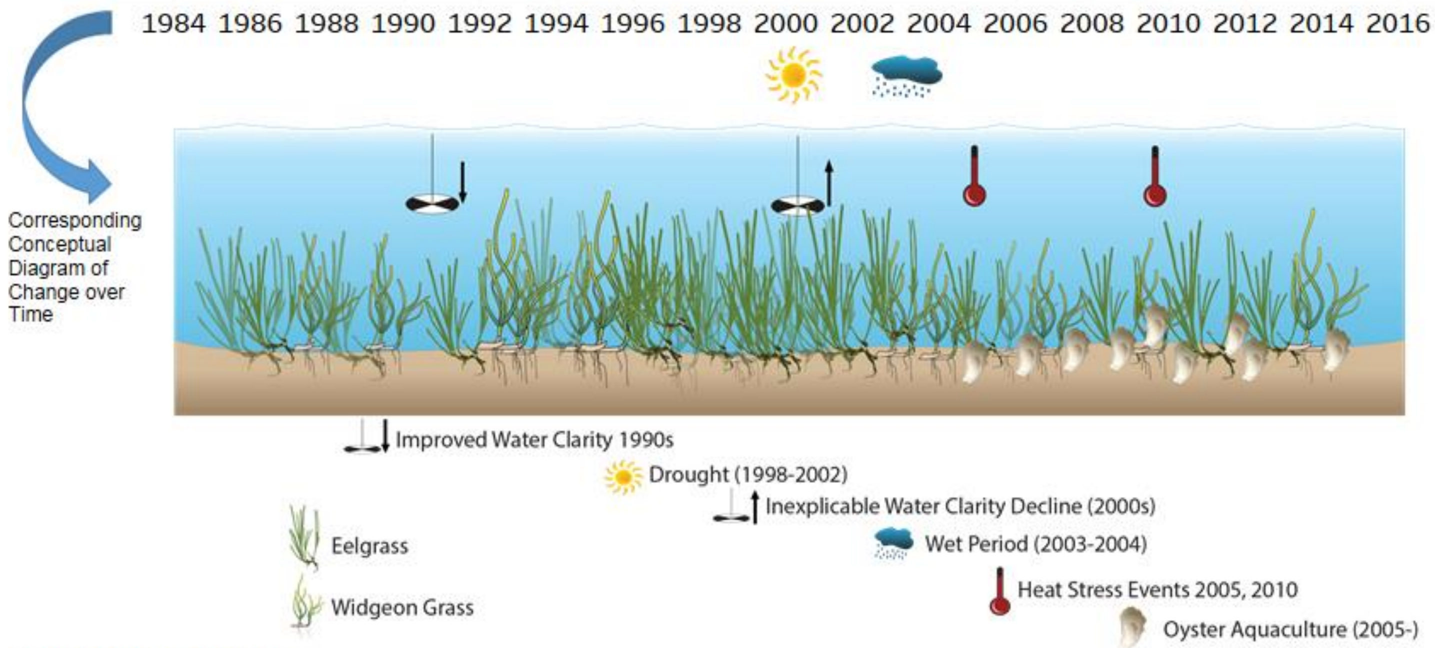

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SAV SYN produced 3 papers and working on a segment analysis

- Eelgrass declines (Global Change Biology, published)
- SAV as sentinel species (Bioscience, published)
- Nutrient reductions (Proc. Natl. Acad. Sci., in review)
- SAV segment analysis (in progress; April 2018)

Workshop blogs posted

January 19, 2017

Developing scientific stories for Chesapeake Bay submerged aquatic vegetation

The Integration and Application Network, University of Maryland Center for Environmental Science (UMCES) is supp… bett… can… worl… deca…

Con…

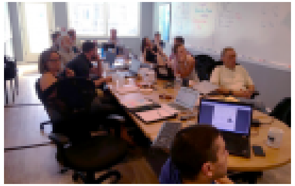
February 13, 2017

The Chesapeake Sentinels

A new paper on Chesapeake Bay Submerged Aquatic

June 5, 2017

SAV SYN One Last Time



We recently gathered the submerged aquatic vegetation synthesis team (SAV SYN) at the University of Maryland Center for Environmental Science Annapolis office. This fourth and final working group meeting was convened to make progress on our two remaining publications, using Structural Equation Modeling (led by Jon Lefcheck) and seagrass trait analysis (led by Chris Patrick). [...]

Continue Reading »

SAV SYN poem

The Chesapeake Sentinels

27 Jan 2017

William C. Dennison

Submerged aquatic vegetation are an important mainstay

They provide homes to many of the little critters

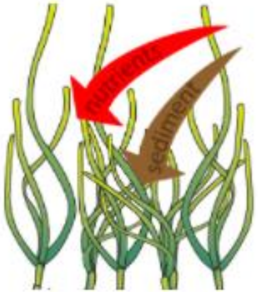
So if we lost the sentinels, the critters would get the jitters.

Defending against erosion and protecting the coastline

These aquatic grasses are not at all benign

They suck up nutrients, and cause sediments to drop out

Cleaning the water in the Bay beyond any doubt.



Indicators for water quality, acting as a coastal canary

Declining when water gets too warm or too cloudy

They are sensitive to subtle changes in nature

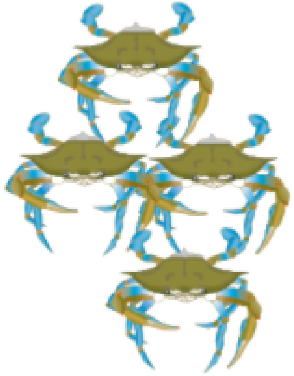
So we can recognize signs of imminent danger.

But these Chesapeake sentinels have been under siege

So we have been working to maintain the Chesapeake prestige

Upgrading sewage which help the grasses rebound

Which works to keep the crab populations sound.



We imposed a nutrient diet for Chesapeake Bay

To insure that the Bay gets healthier every day

But we need to enlist these sentinels for further duty

So that the Bay regains its natural beauty.

**Symbols from the Integration and Application Network*

Synthesis blogs posted

LESSONS

- Experienced leadership
- Limited size
- Multiple immersive workshops
- Regular communication
- Flexibility
- Product focus
- Conducive location
- Clear goals & objectives
- Fun

NEXT TIME

- Include graduate students/staffers
- Longer immersive workshops
- Flexible project funding

February 6, 2017

Lessons on how to synthesize science

We recently completed our third SAV SYN workshop, which is an effort to synthesize (SYN) data related to the submerged aquatic vegetation (SAV) of Chesapeake Bay. We have been analyzing a variety of data sets to better understand how SAV are responding to changes in the Bay and to understand what we can infer about [...]

June 9, 2017

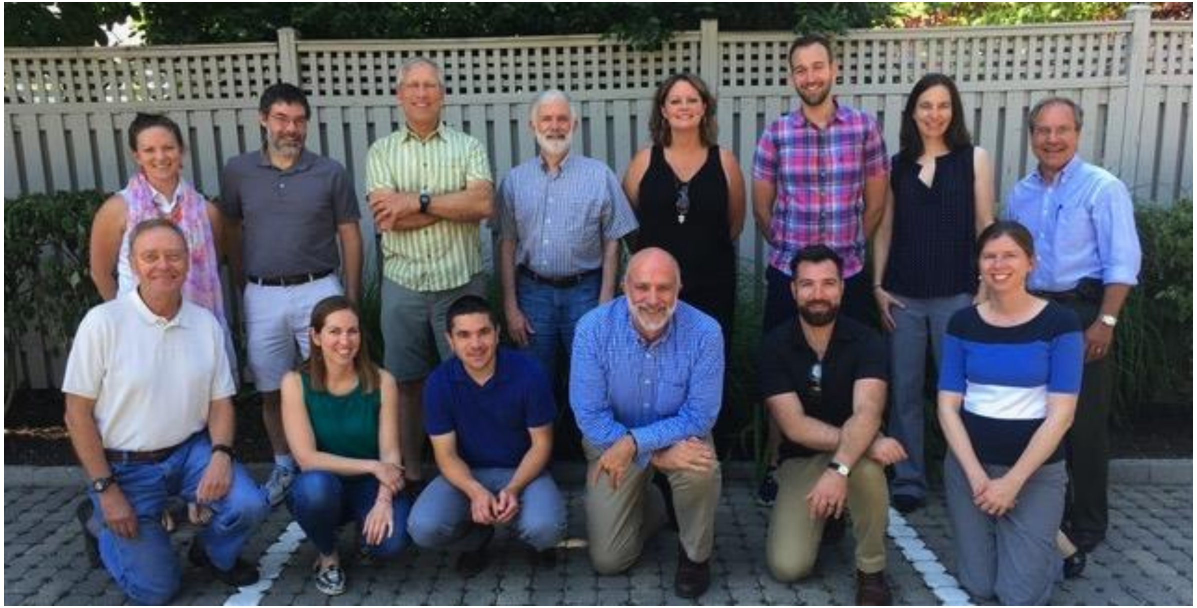
More lessons on how to synthesize science

In a previous blog, I suggested six elements for science synthesis that we have employed in the Submerged Aquatic Vegetation Synthesis (SAV SYN) effort. These six elements were the following: Experienced leadership Limited size Multiple immersive workshops Regular communication Flexibility Product focus I also discussed the following enabling conditions: compelling topic with enabling data resource [...]

Continue Reading »

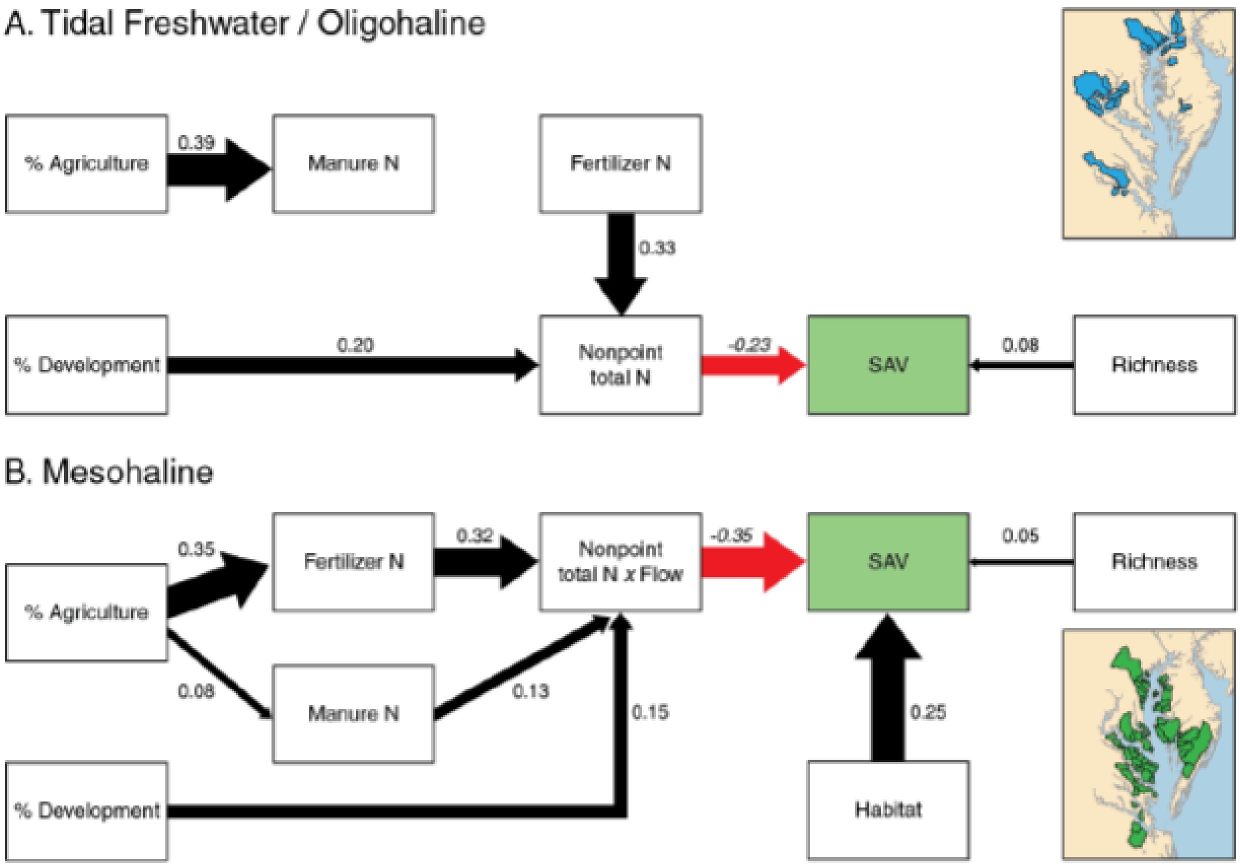
SAV SYN results presented at CERF

SAV SYN

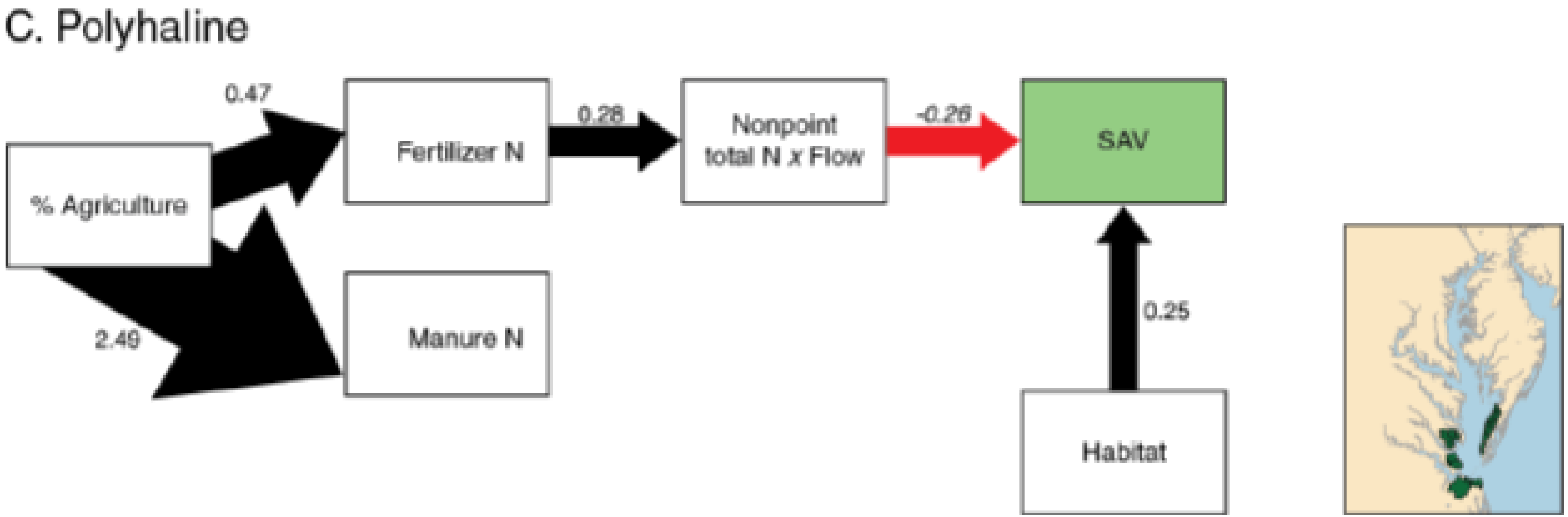


Extra slides

Subestuary analysis



SAV conceptual diagrams



SAV increase & N and P decrease