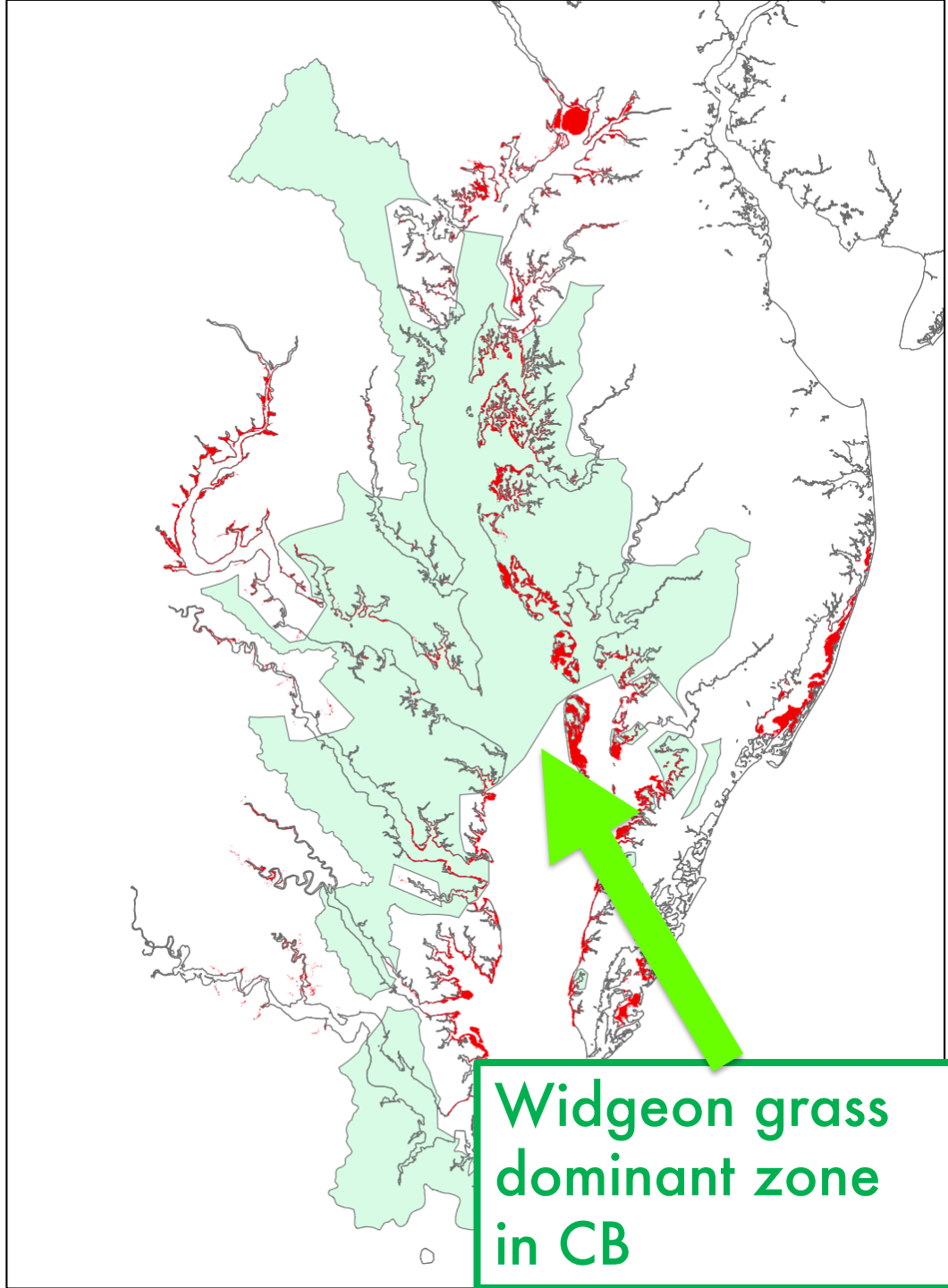
Large-scale patterns and drivers of a keystone SAV species:

Rise of *Ruppia* in the Chesapeake Bay

Marc Hensel, Dave Wilcox, J.J. Orth, Chris Patrick

VIMS | William & Mary
Virginia Institute of Marine Science

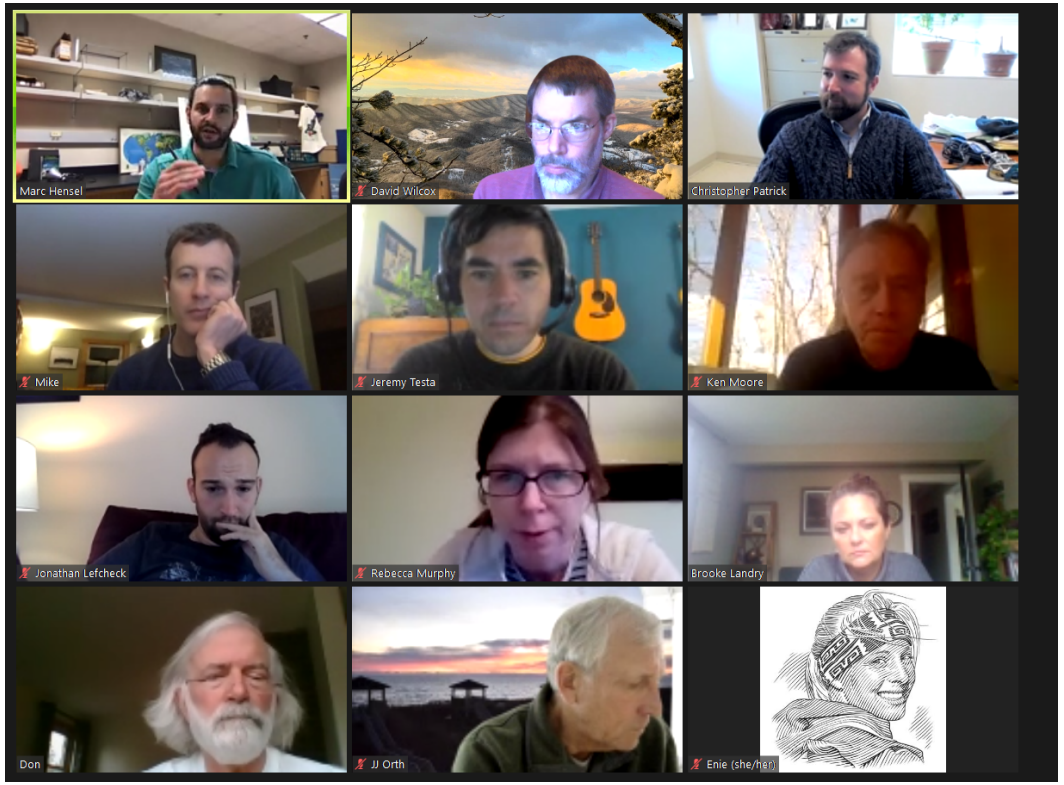
SAV-WG



Large-scale patterns and drivers of keystone SAV species: Rise of *Ruppia*

SAV-SYNTHESIS II

Marc Hensel, Dave Wilcox, J.J. Orth, Chris Patrick, Jon Lefcheck, Mike Hannam, Rebecca Murphy, Don Weller, Ken Moore, Brooke Landry, Cassie Gurbisz, Bill Dennison, Jeremy Testa



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Center for Environmental Science

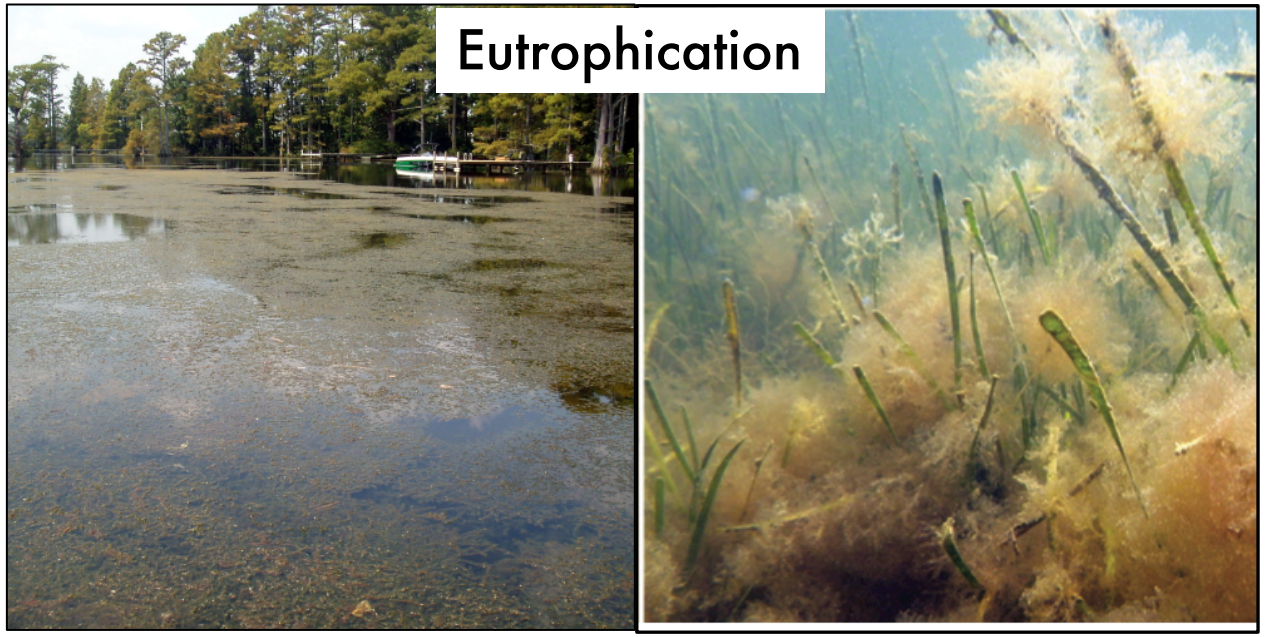
United States Environmental Protection Agency

USGS
science for a changing world

Maryland Department of Natural Resources

Smithsonian

Human and climate stressors threaten long-term resilience of SAV habitats



Local & regional

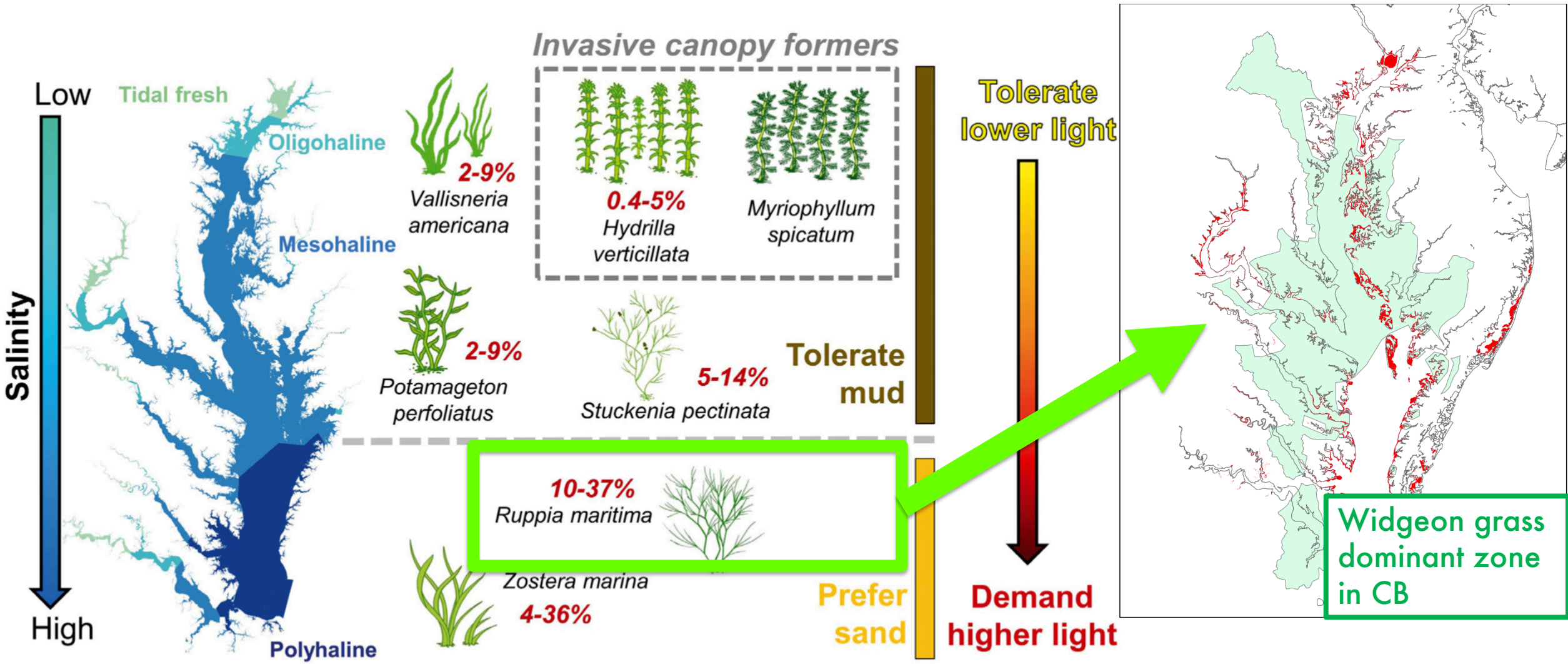
Changing nutrients, flow, shoreline, Water quality

Climate

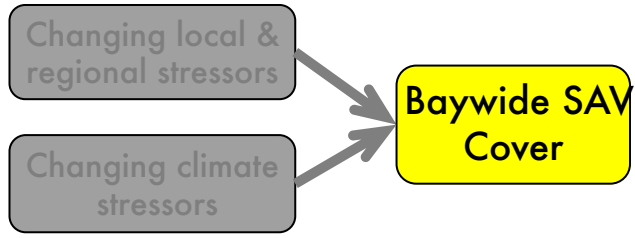
Changing rainfall, Habitat avail (SLR), temperature

Chesapeake Bay SAV Cover

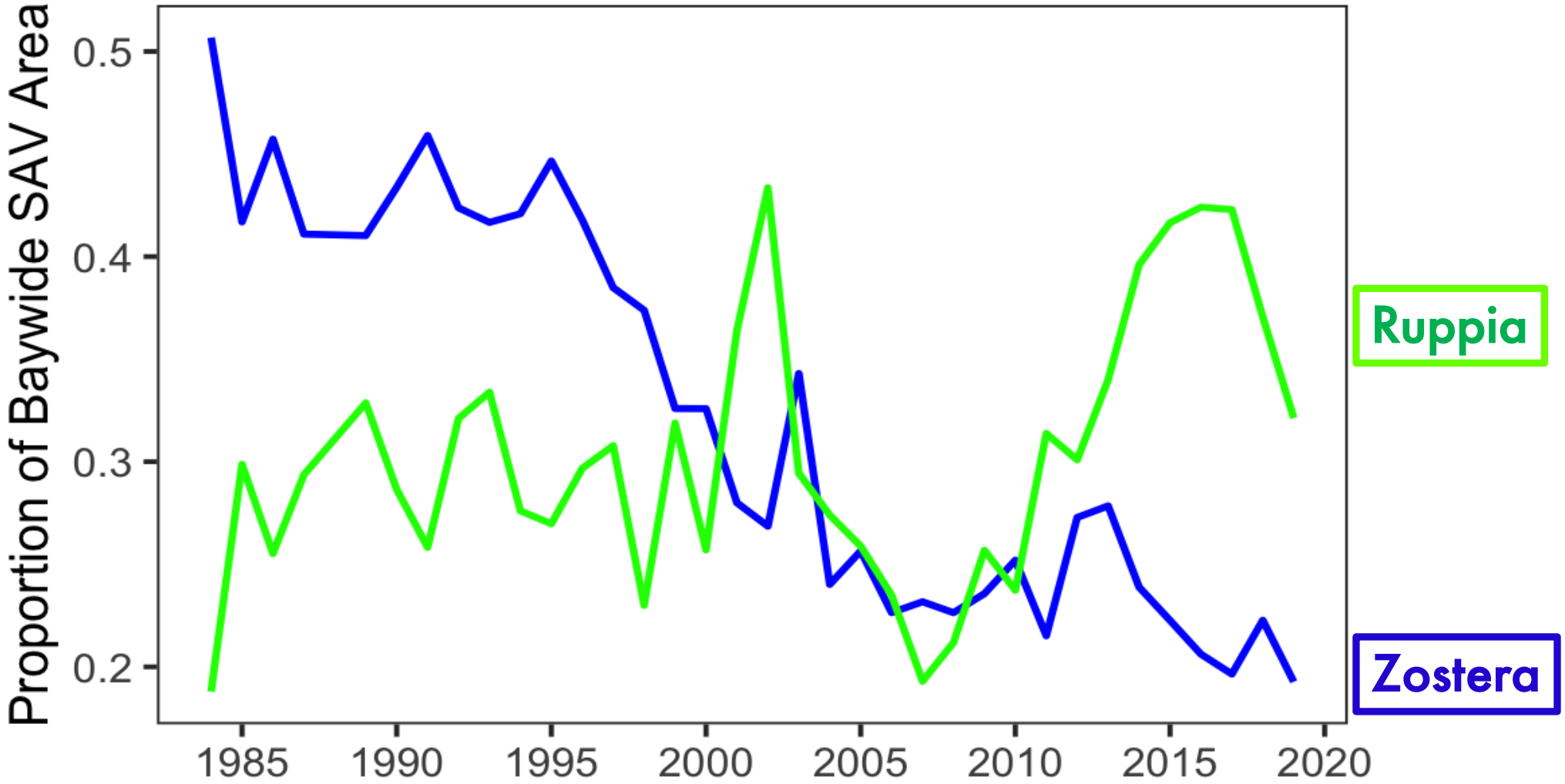
SAV foundation species respond to change differently and require individual management solutions



Patrick et al 2015

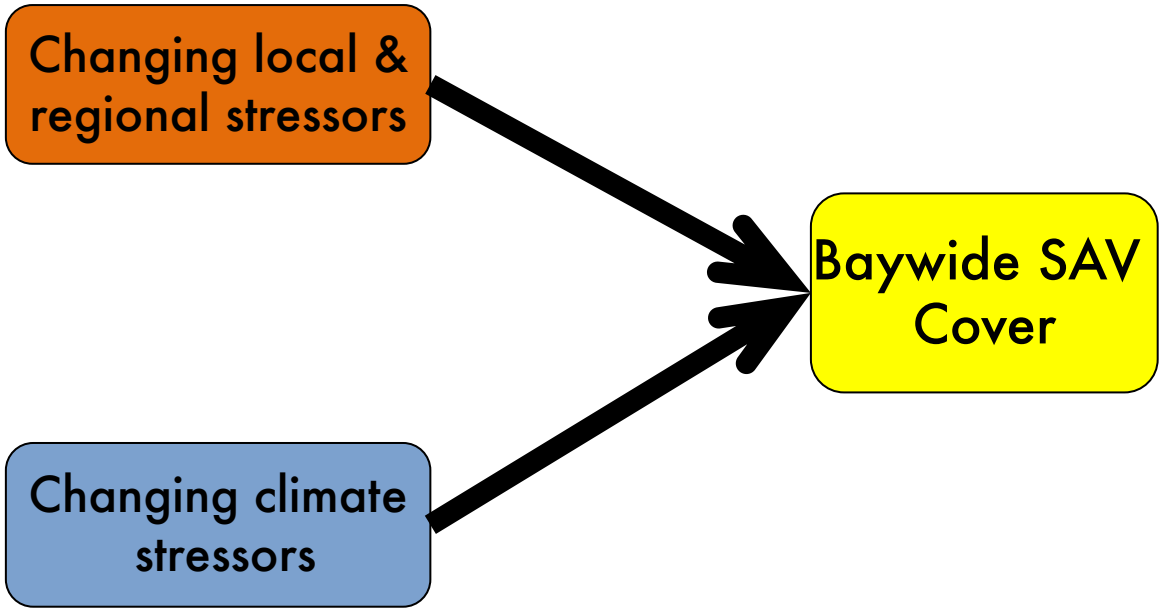


Ruppia occupies most Baywide area for a single species since *Zostera* crash in late '90s



Research Questions|

What is the role of *Ruppia* in Baywide SAV gains and losses?



What environmental variables drive interannual Ruppia change across CB?

Research Questions|

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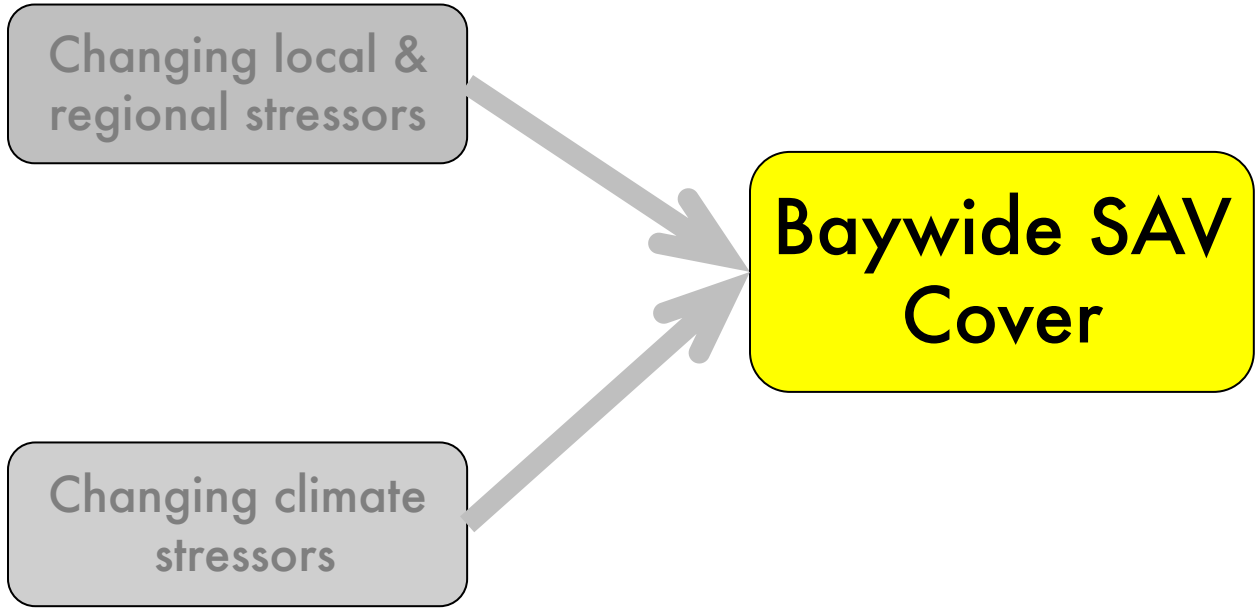


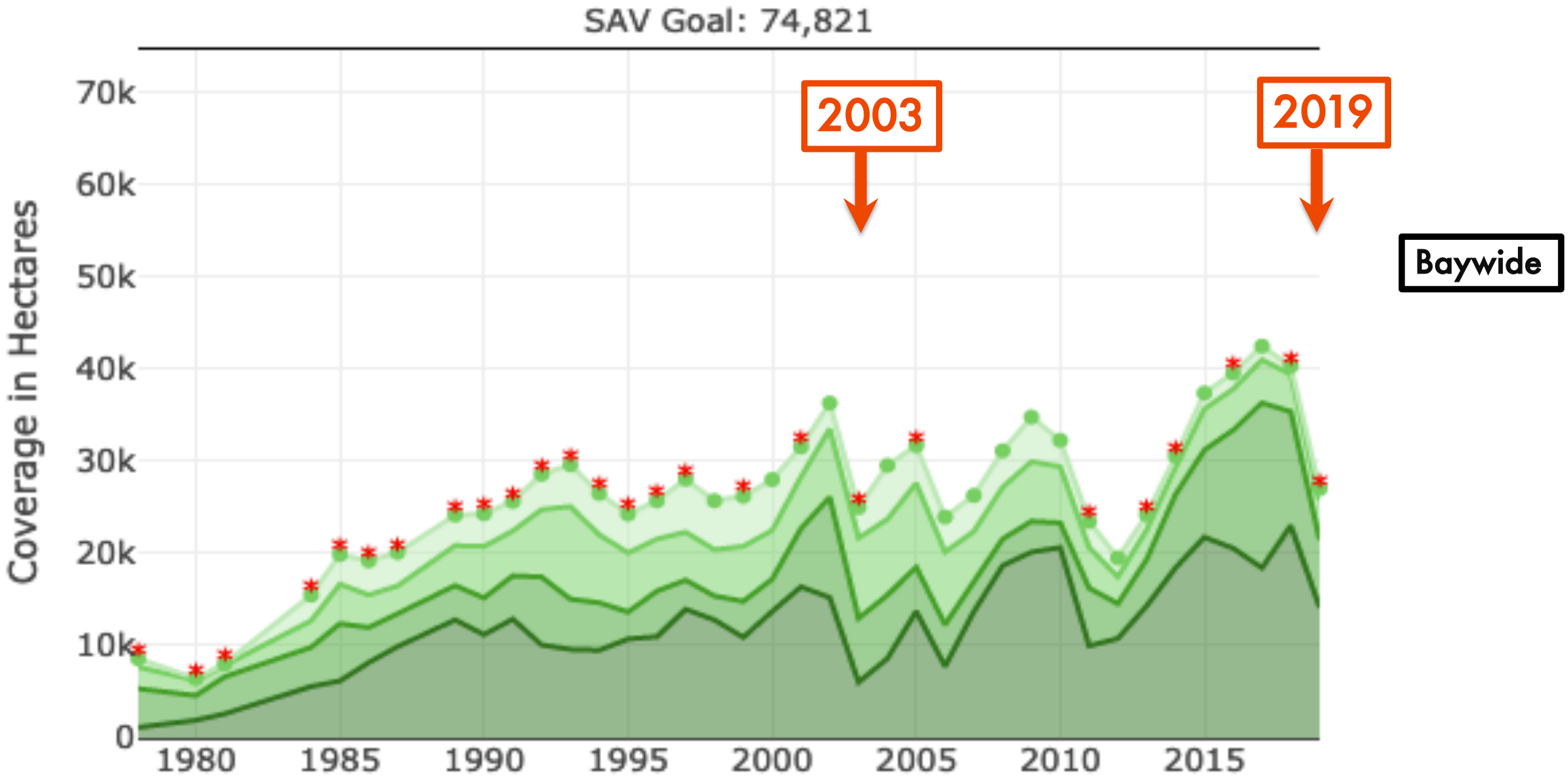
What environmental variables drive interannual Ruppia change across CB?

Chesapeake Bay SAV changes over time

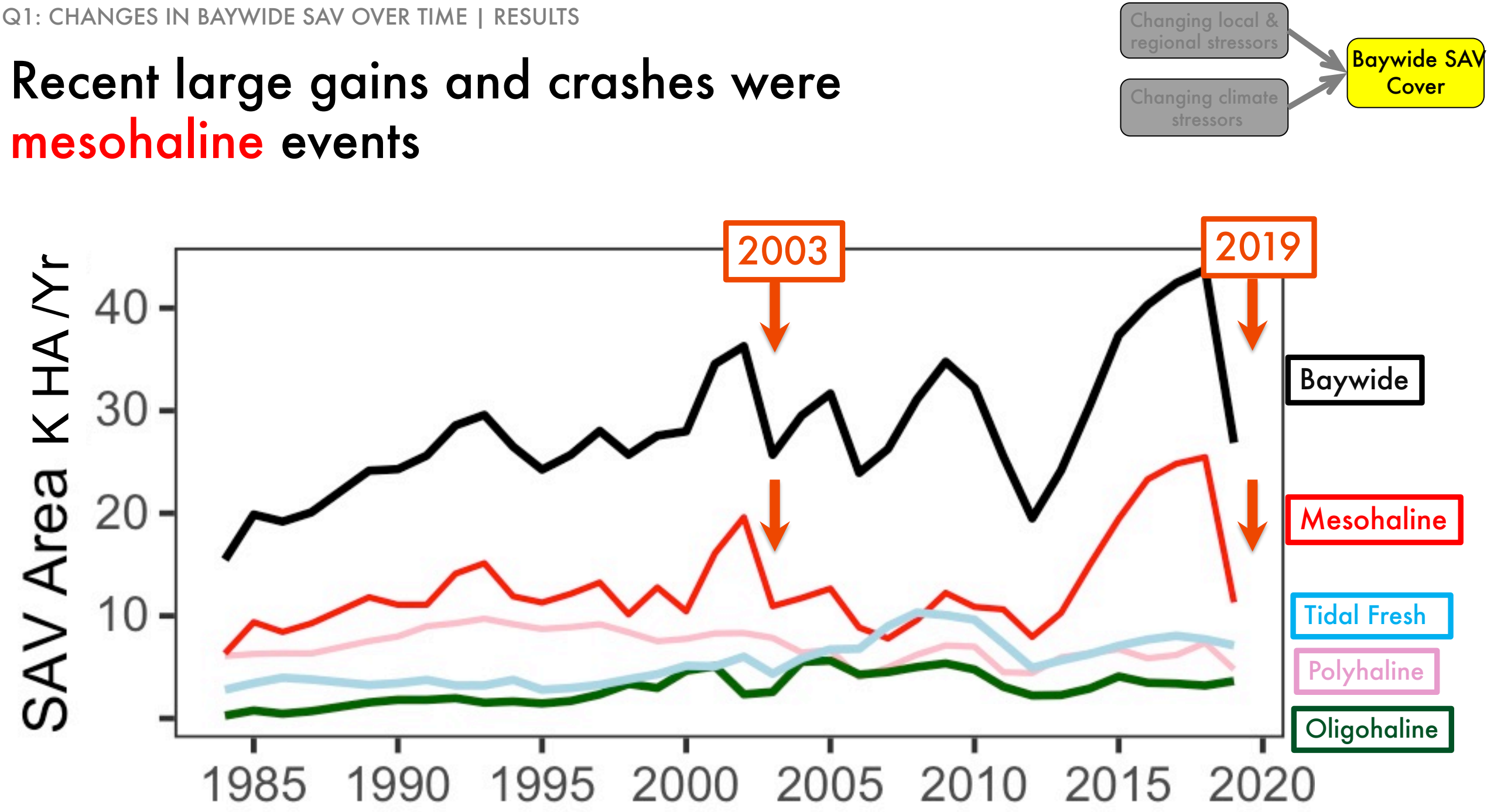
Changing local & regional stressors

Changing climate stressors

Baywide SAV Cover



Recent large gains and crashes were mesohaline events

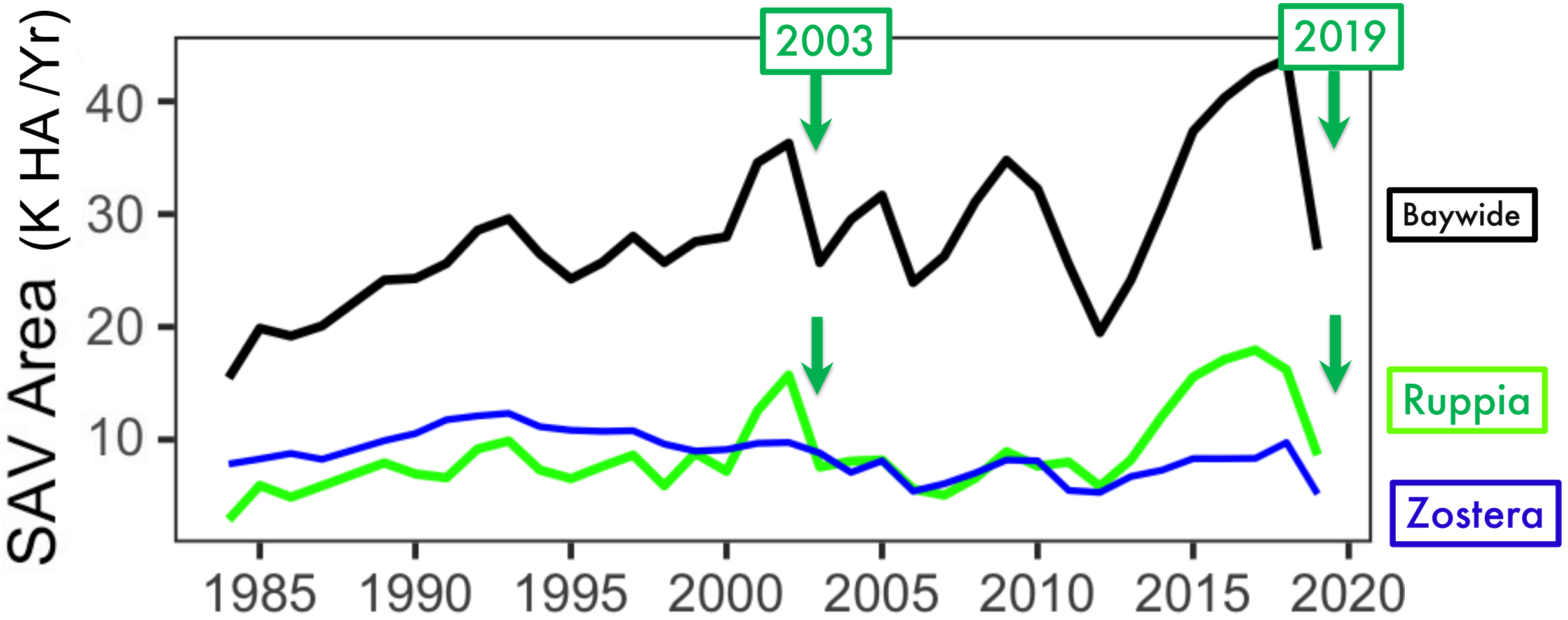


Changing local & regional stressors

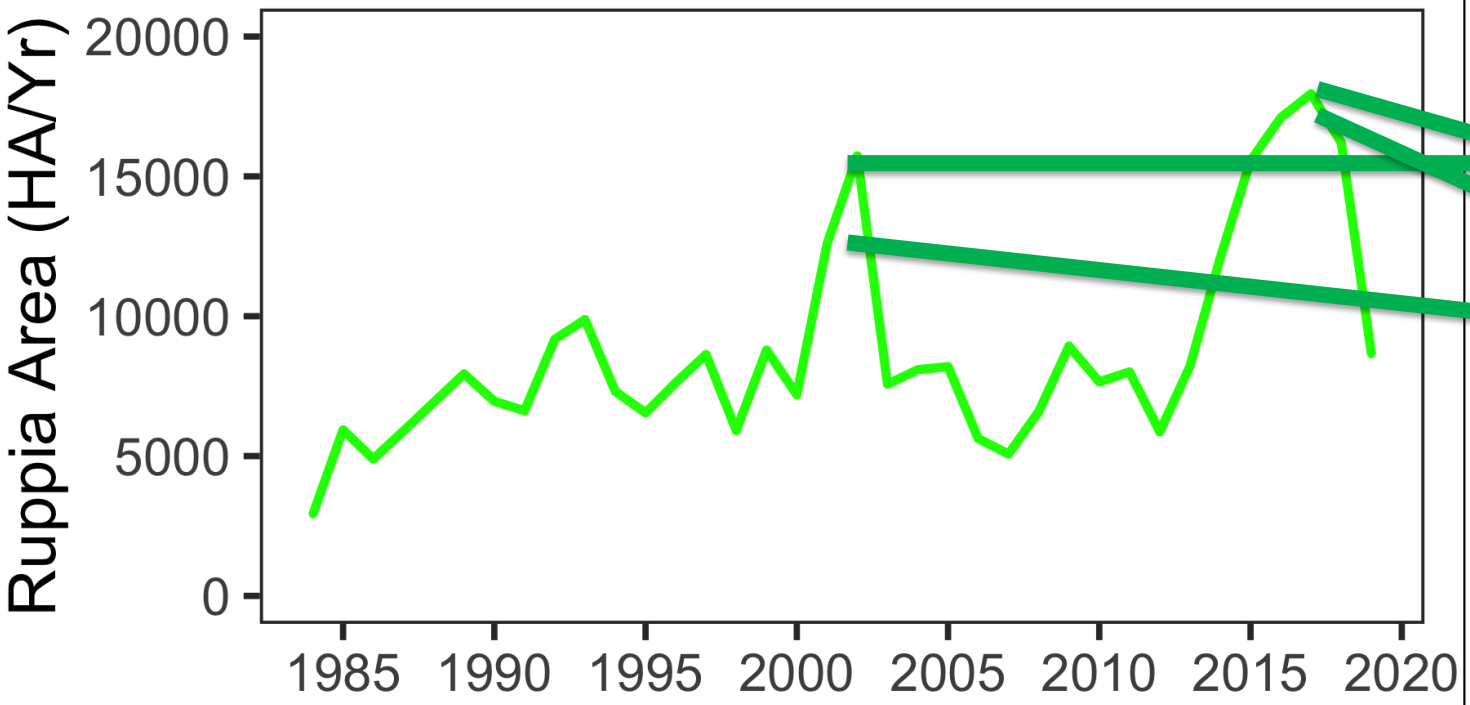
Changing climate stressors

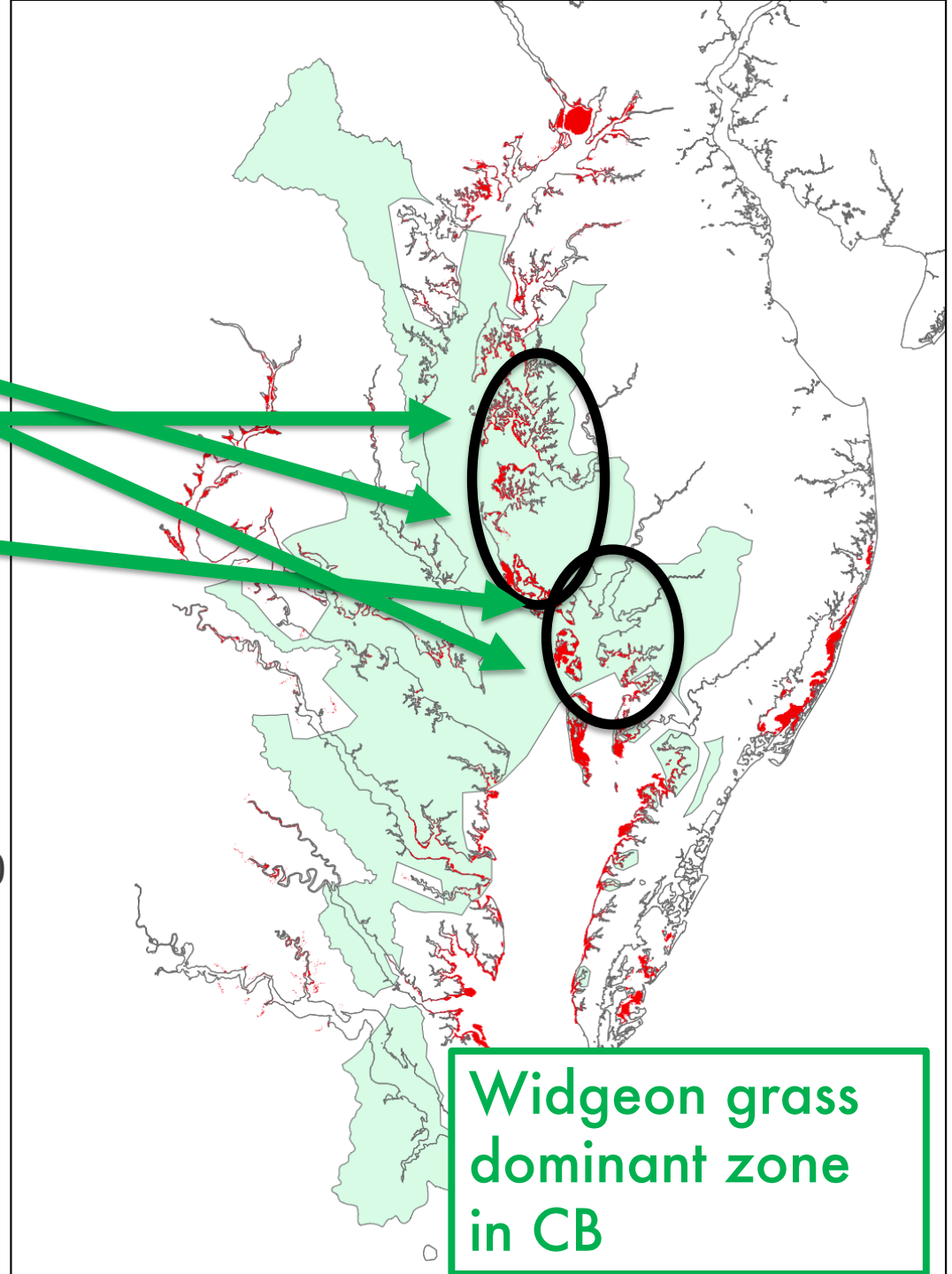
Baywide Ru Cover

Recent large gains and crashes were *Ruppia* events



Recent large gains and crashes were *Ruppia* events

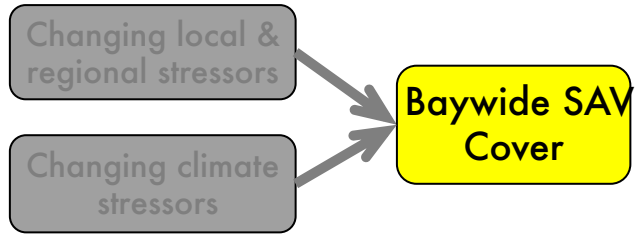




-2001-02, 2015-18 gains (12000HA, 8500)

-2003, 2019 diebacks (8000HA, 9000HA)

Research Questions |



What is the role of *Ruppia* in Baywide SAV trends?

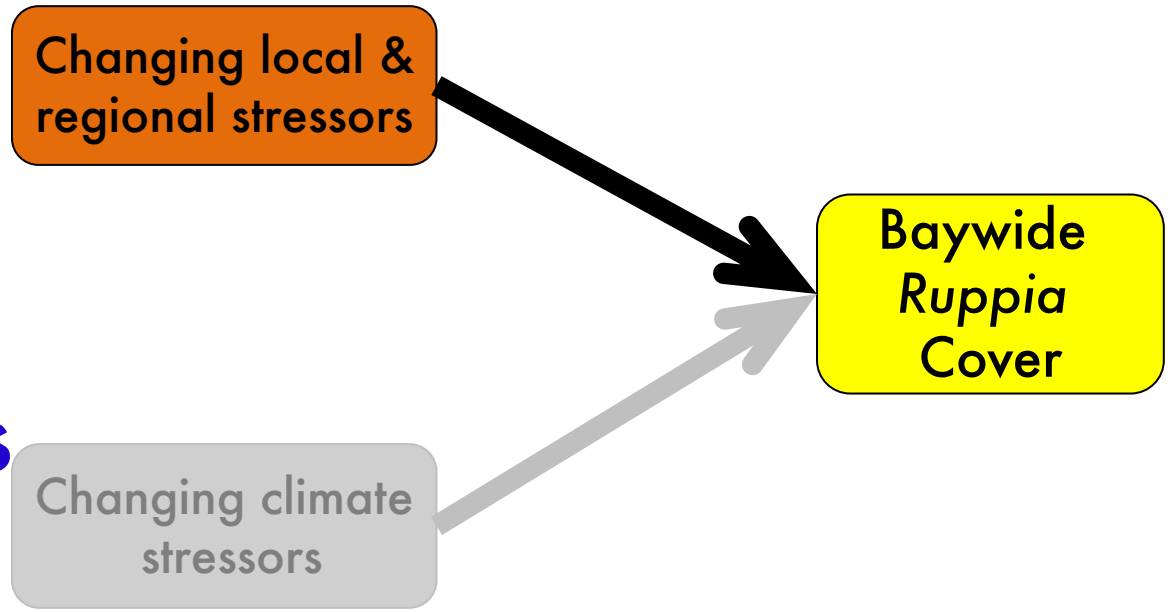
-Ruppia occupies more area than Zostera, largest individual species coverage

-Thousands of HA gains and losses over the last 20 years were mostly *Ruppia* events

What environmental variables drive interannual Ruppia change across CB?

Research Questions |

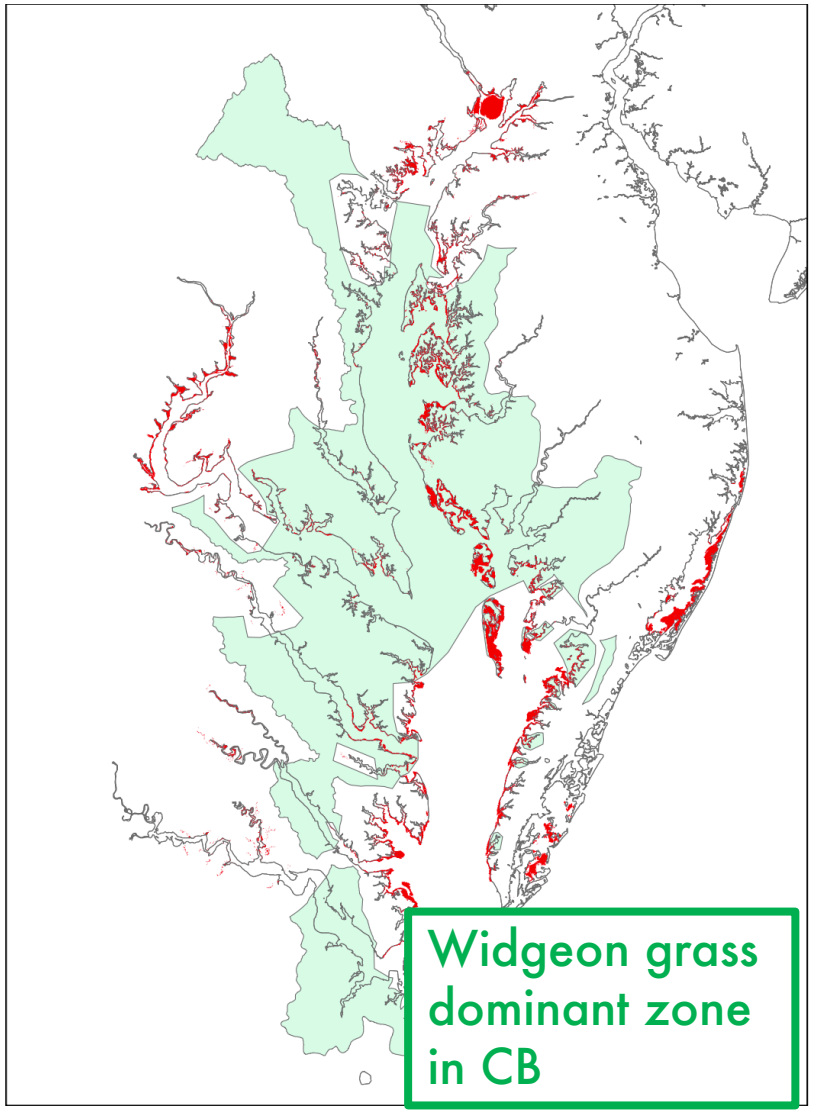
What is the role of *Ruppia* in Baywide SAV gains and losses?



What environmental variables drive interannual *Ruppia* change across the Bay?

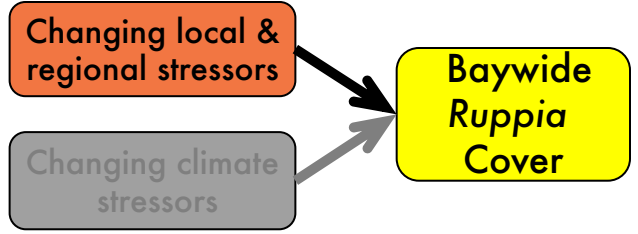
METHODS | Quantifying annual *Ruppia* change:

Ruppia zone



Ruppia monoculture zone:

Mostly mesohaline, some polyhaline



METHODS | Quantifying annual *Ruppia* change:

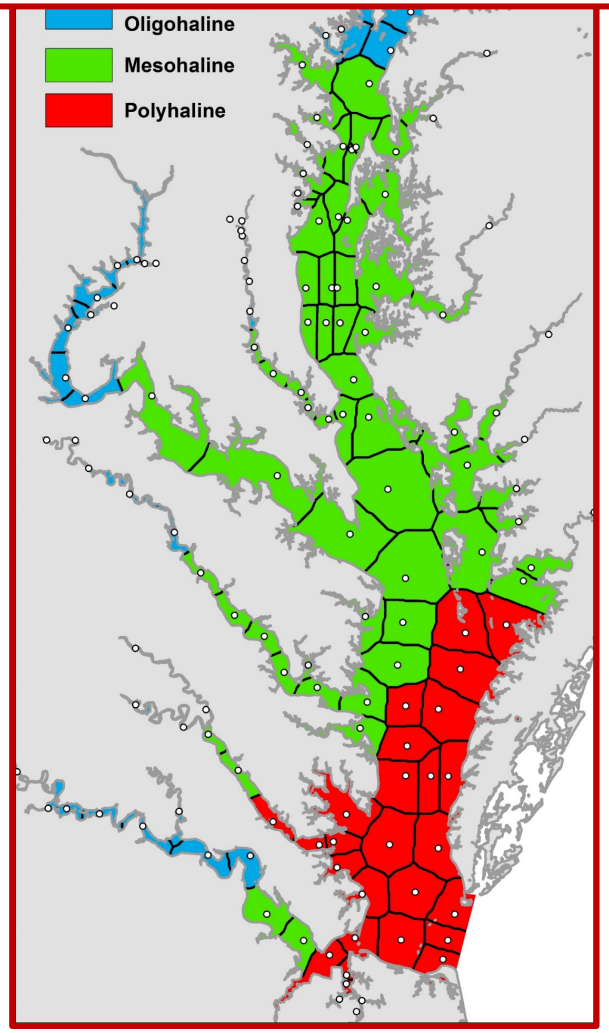
Two analyses: Baywide and Watershed analysis

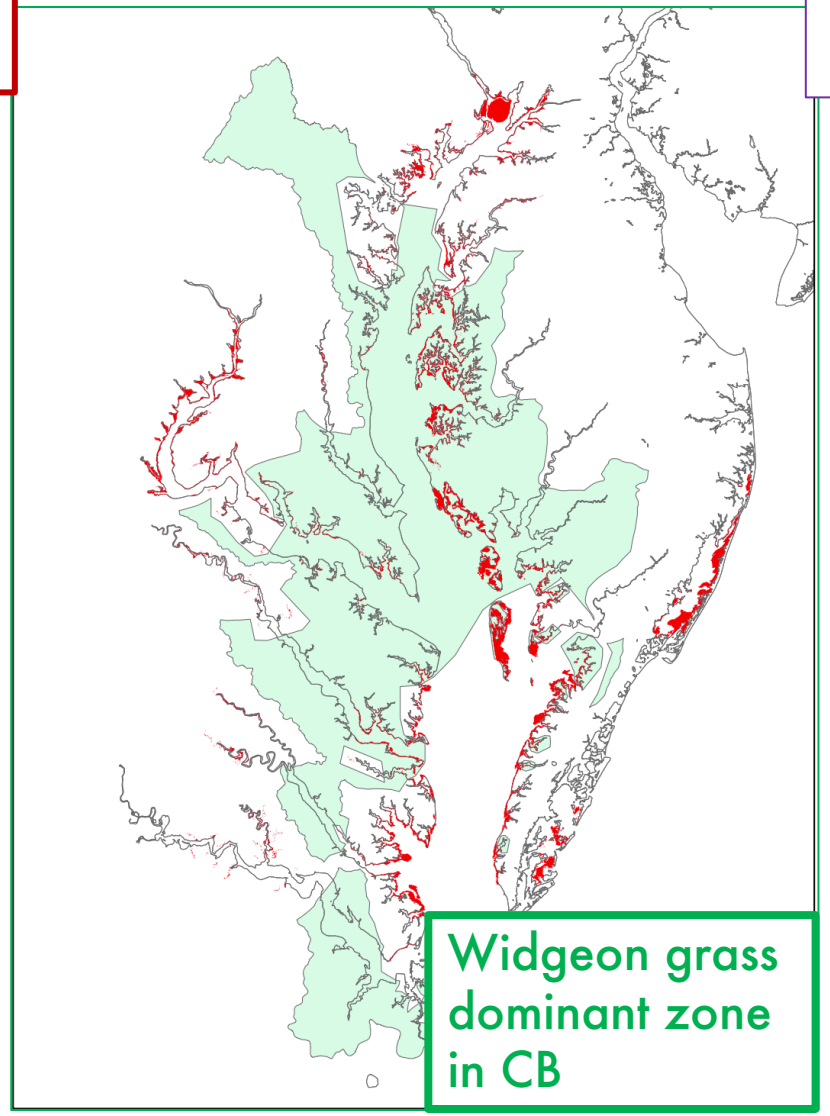
Changing local & regional stressors

Changing climate stressors

Baywide *Ruppia* Cover

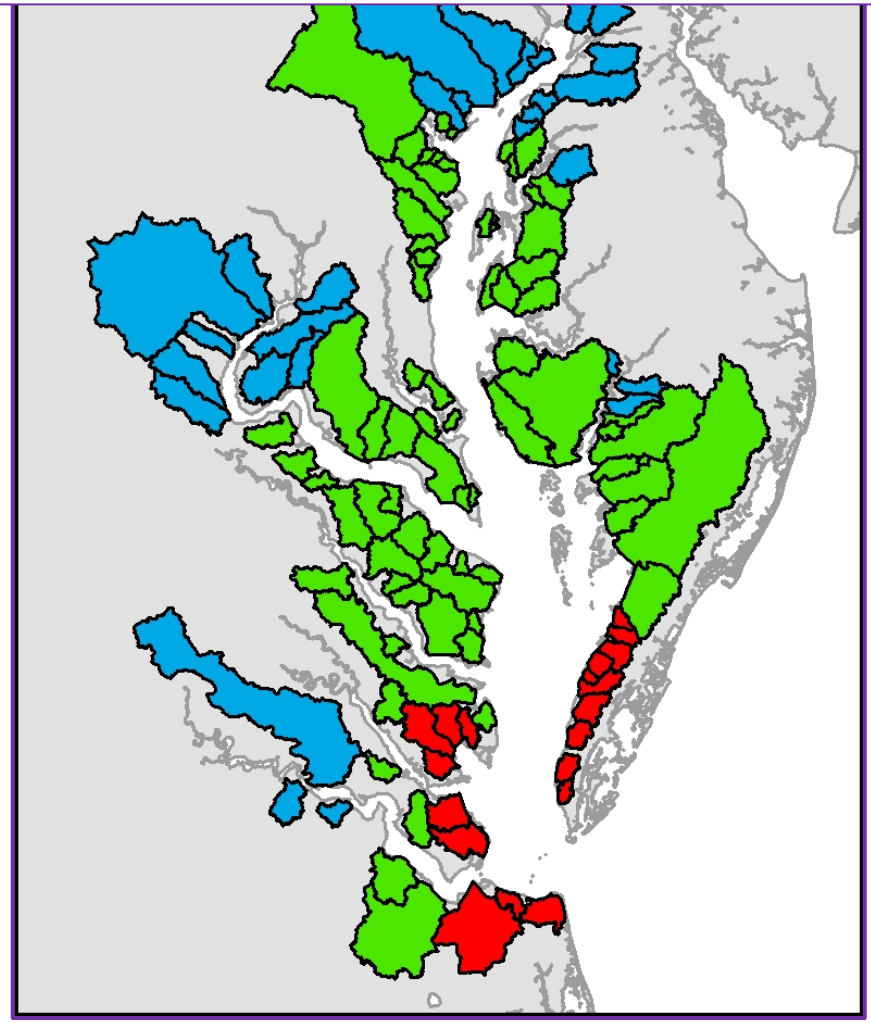
Baywide Water Quality





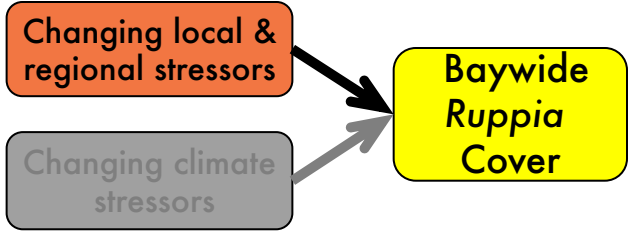
Widgeon grass dominant zone in CB

Watershed nutrient loads

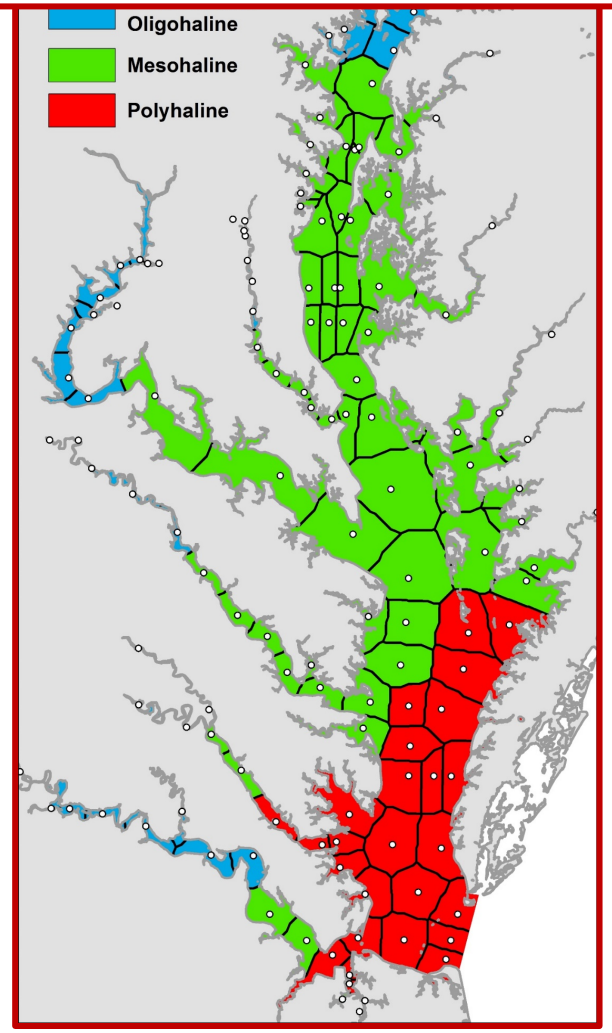


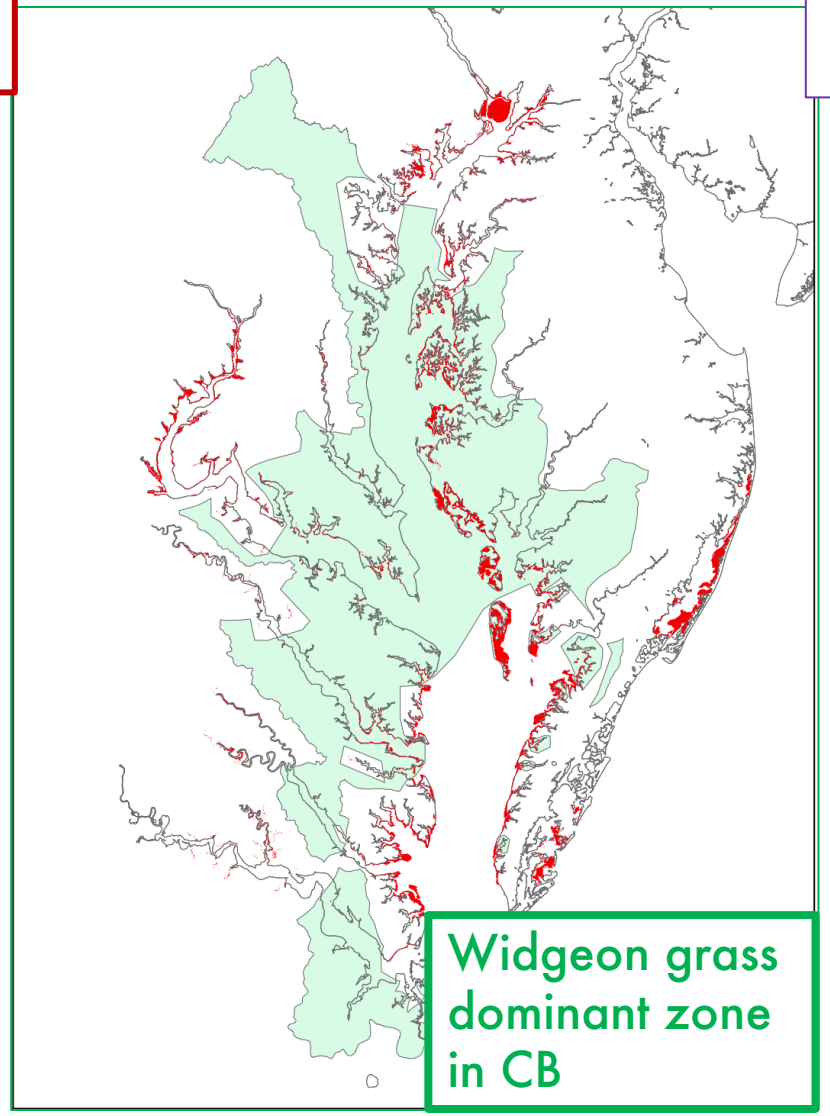
METHODS | Quantifying annual *Ruppia* change:

Two analyses: Baywide and Watershed analysis



Baywide Water Quality





Widgeon grass dominant zone in CB

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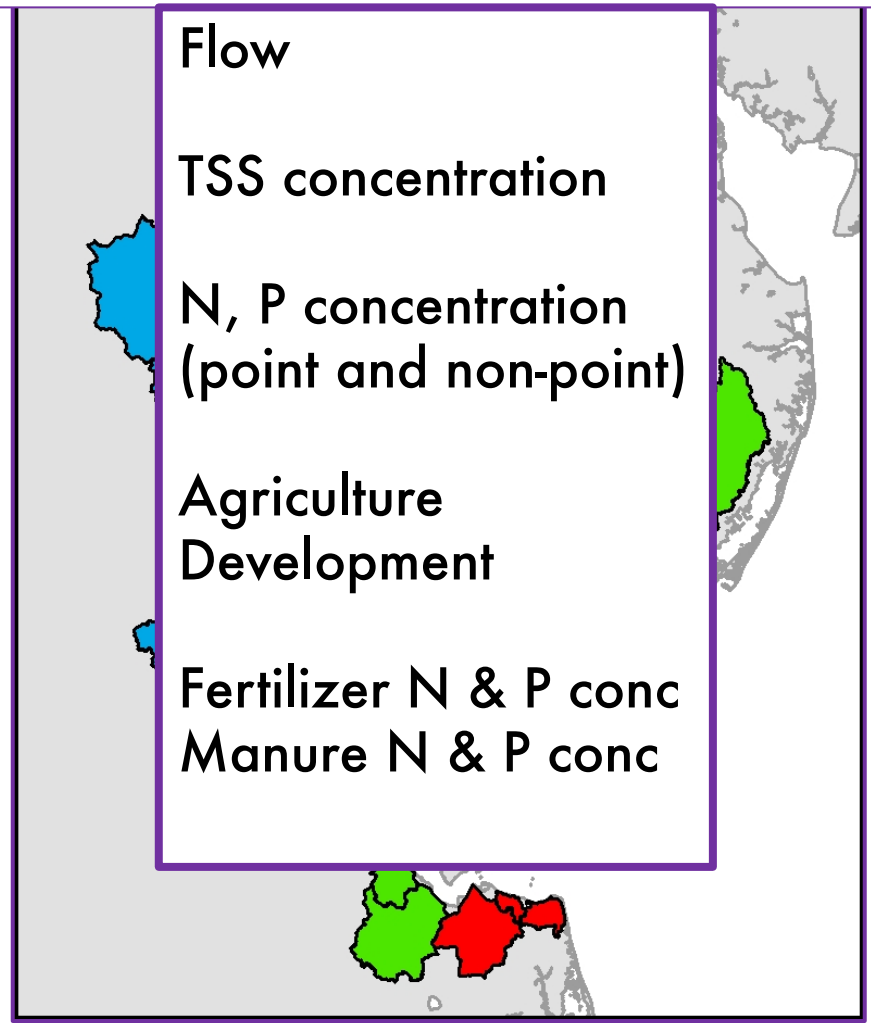
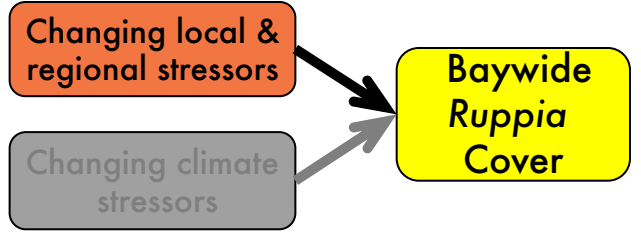


- Flow
- TSS concentration
- N, P concentration (point and non-point)
- Agriculture
- Development
- Fertilizer N & P conc
- Manure N & P conc

METHODS | Quantifying annual *Ruppia* change:

Two analyses: Baywide and Watershed analysis



Baywide Water Quality

SPRING

Temperature

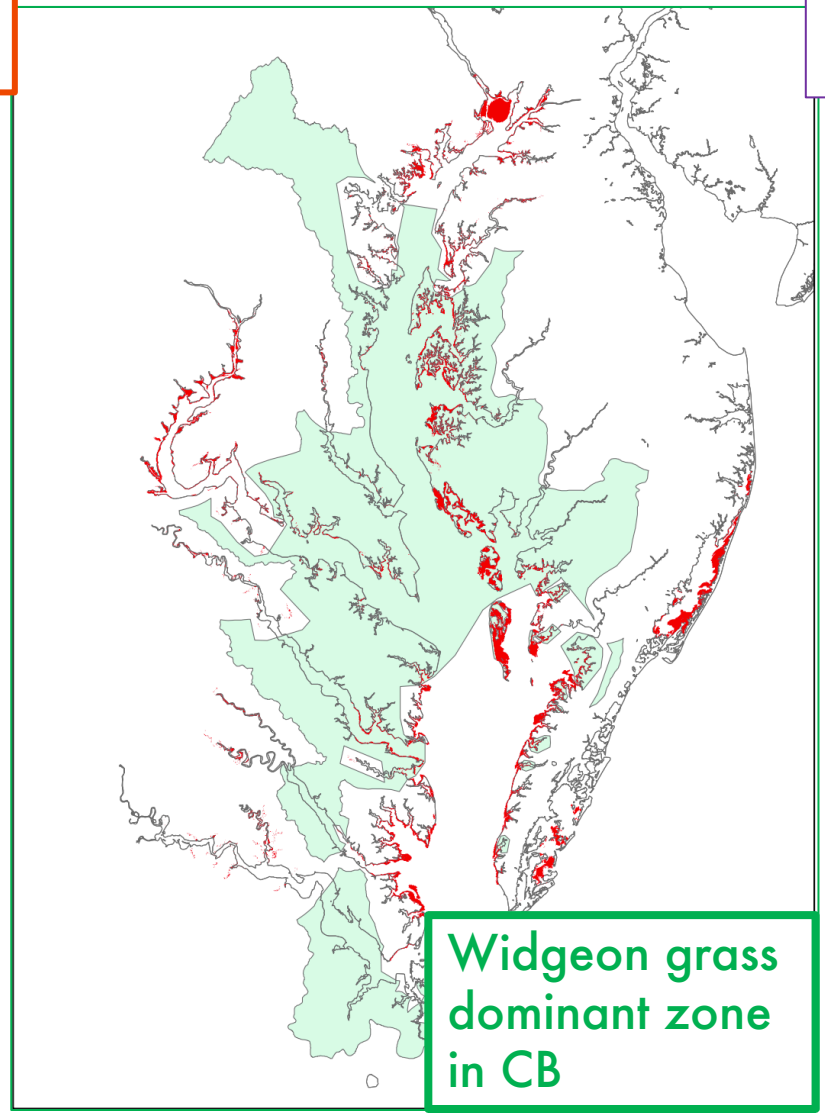
Salinity

ChlA

Secchi

Total Nitrogen, Phosphorus

TSS



Watershed nutrient loads

Flow

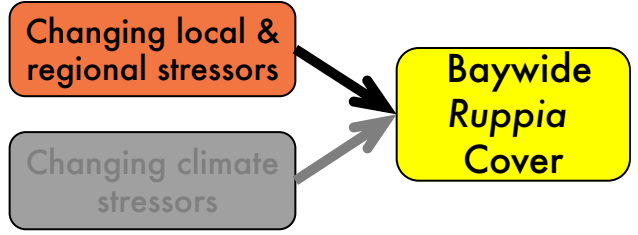
TSS concentration

N, P concentration (point and non-point)

Agriculture
Development

Fertilizer N & P conc
Manure N & P conc

METHODS | Quantifying the role of multiple simultaneous water quality variables on annual *Ruppia* change: Structural Equation Modeling



Piecewise SEM

$$\Delta Ru = (Ru_y - Ru_{y-1}) / Ru_{max\ area}$$

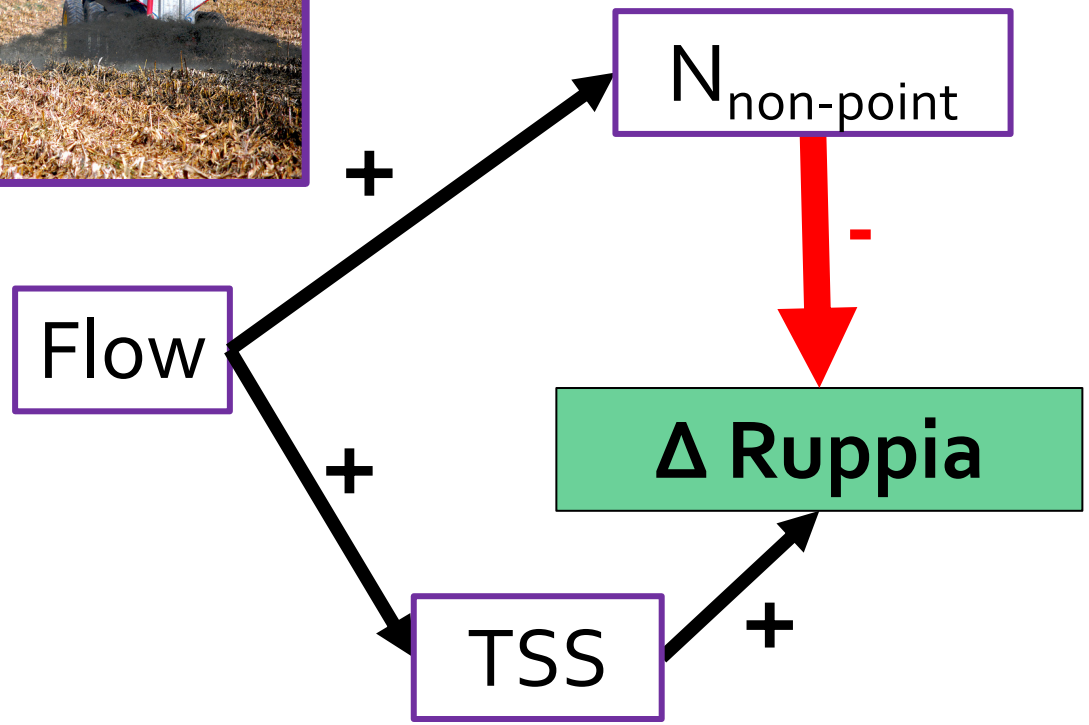
- Linear mixed effects models analyzing *Ruppia* change with Station/Subestuary as random effect

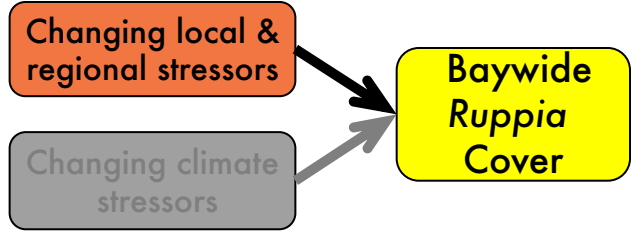
A simple linear regression: NPTN ~ Fertilizer

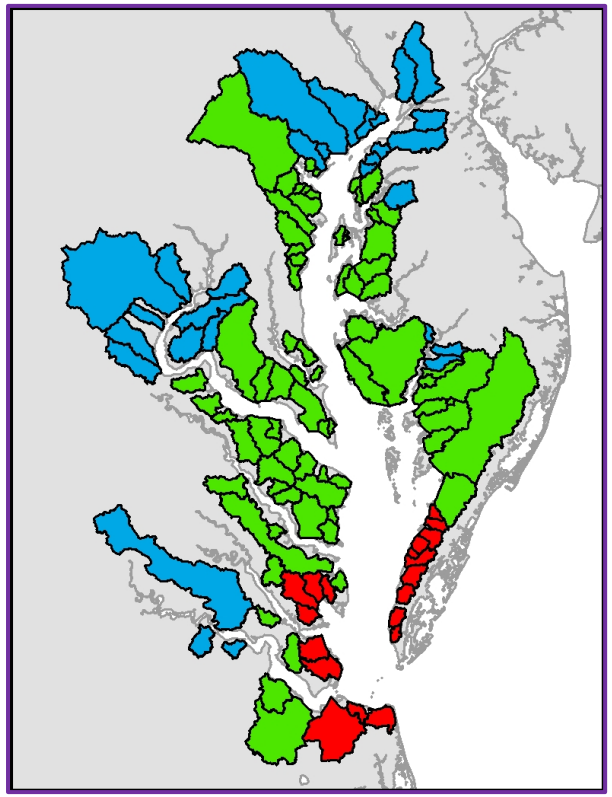
A simple linear regression: Fertilizer ~ Agriculture %

A single causal model (SEM)

RESULTS | Watershed drivers of annual *Ruppia* change: Watershed SEM

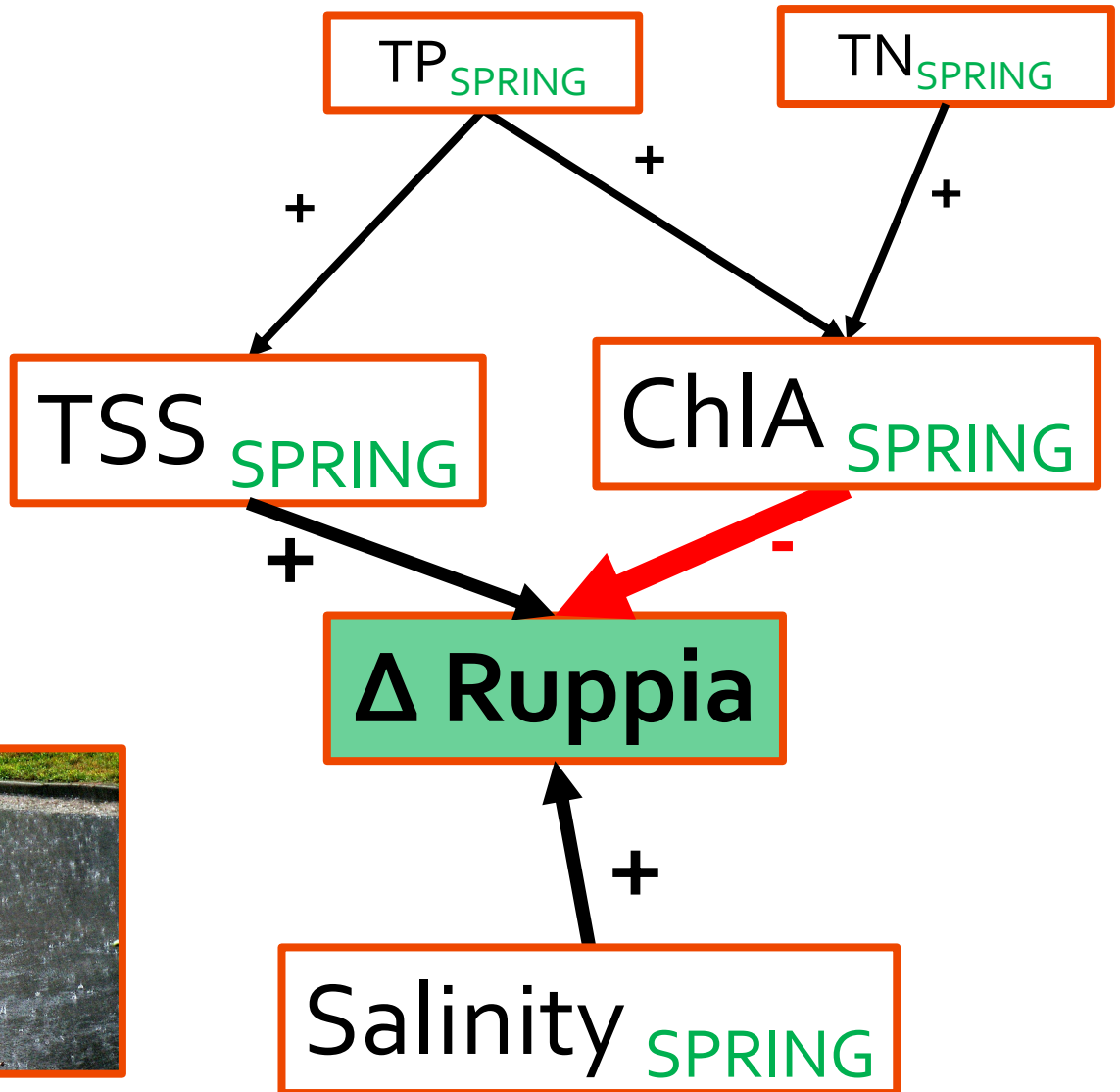


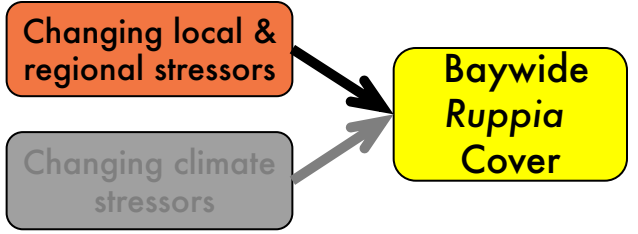


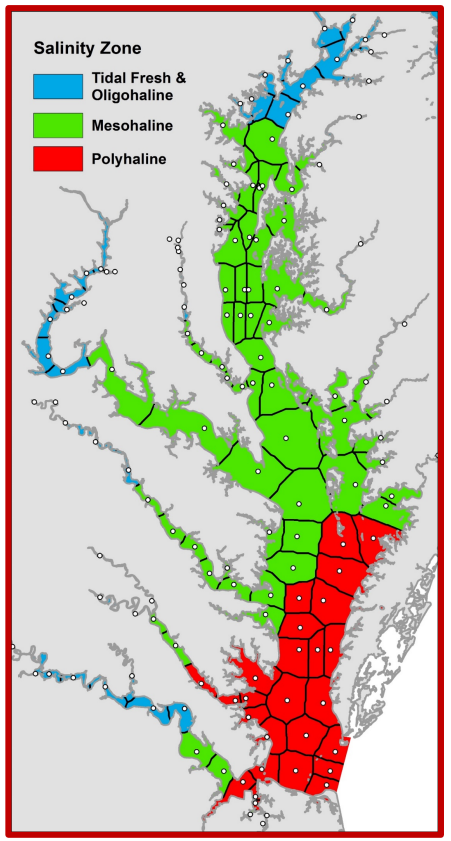


Δ Ru: $R^2_c = 0.46$

RESULTS | Mainstem water quality drivers of *Ruppia* change: Baywide SEM

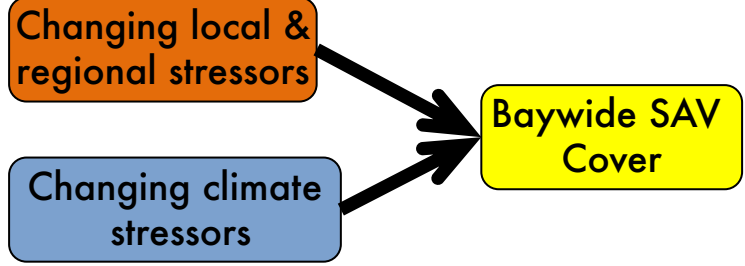


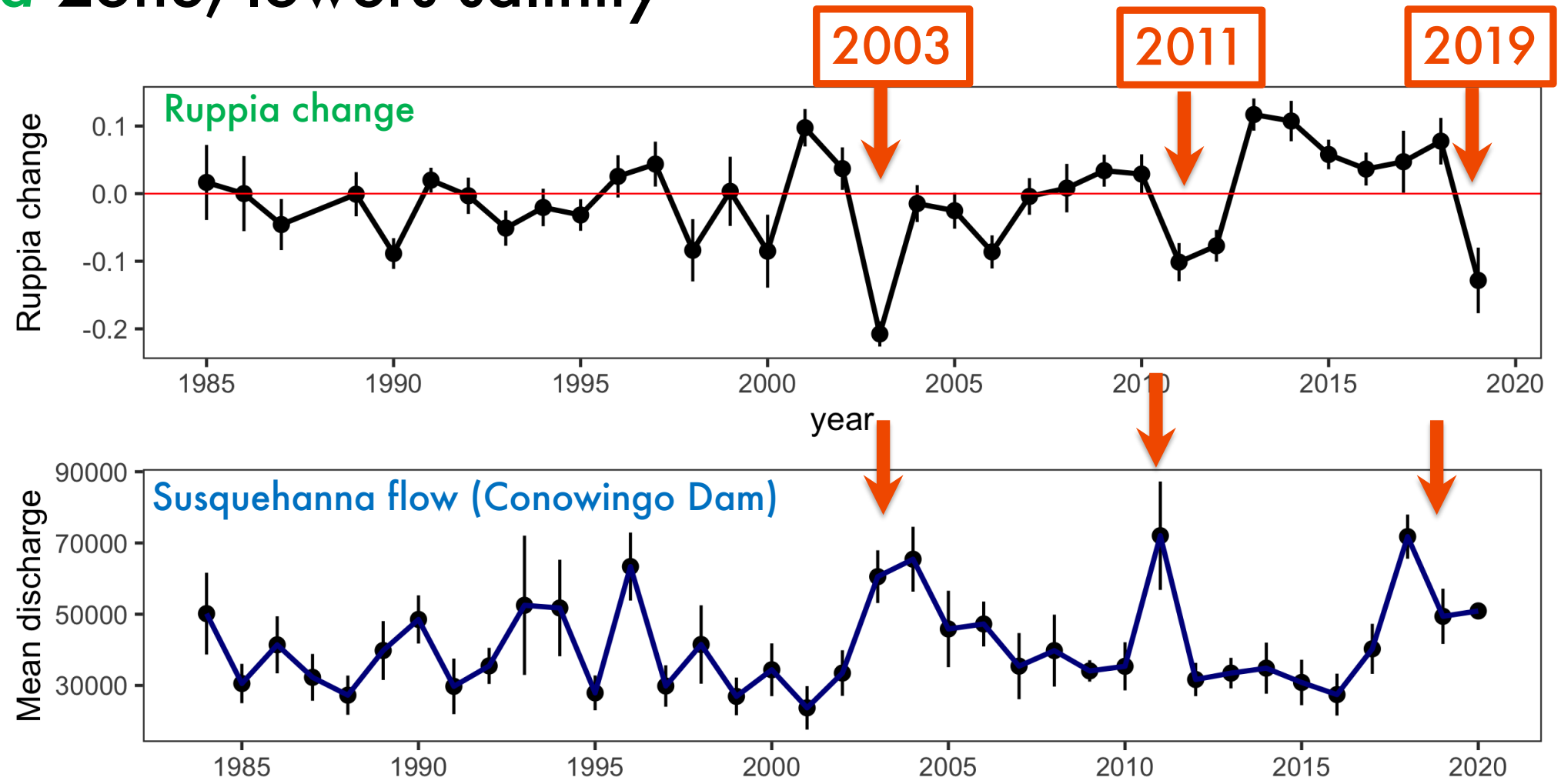


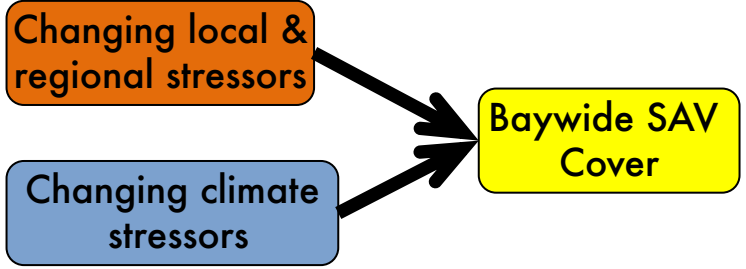


Δ Ru: $R^2_c = 0.59$

Summary | Freshwater influxes bring nutrients, suspended solids through *Ruppia* zone, lowers salinity







Summary |

What is the role of *Ruppia* in Baywide SAV trends?

Ruppia gains and dieback play a huge role in Baywide SAV change over time

What environmental variables drive interannual *Ruppia* change across the Bay?

Freshwater influxes brings nutrients, suspended solids through *Ruppia* zone

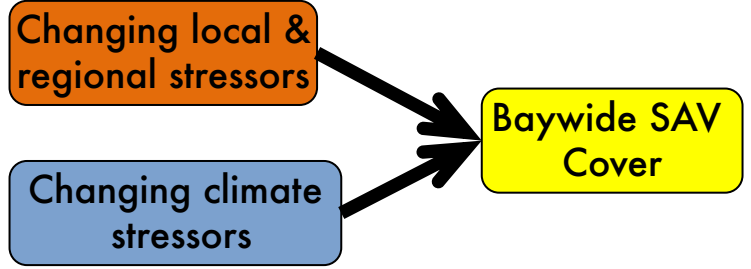
Next Steps |

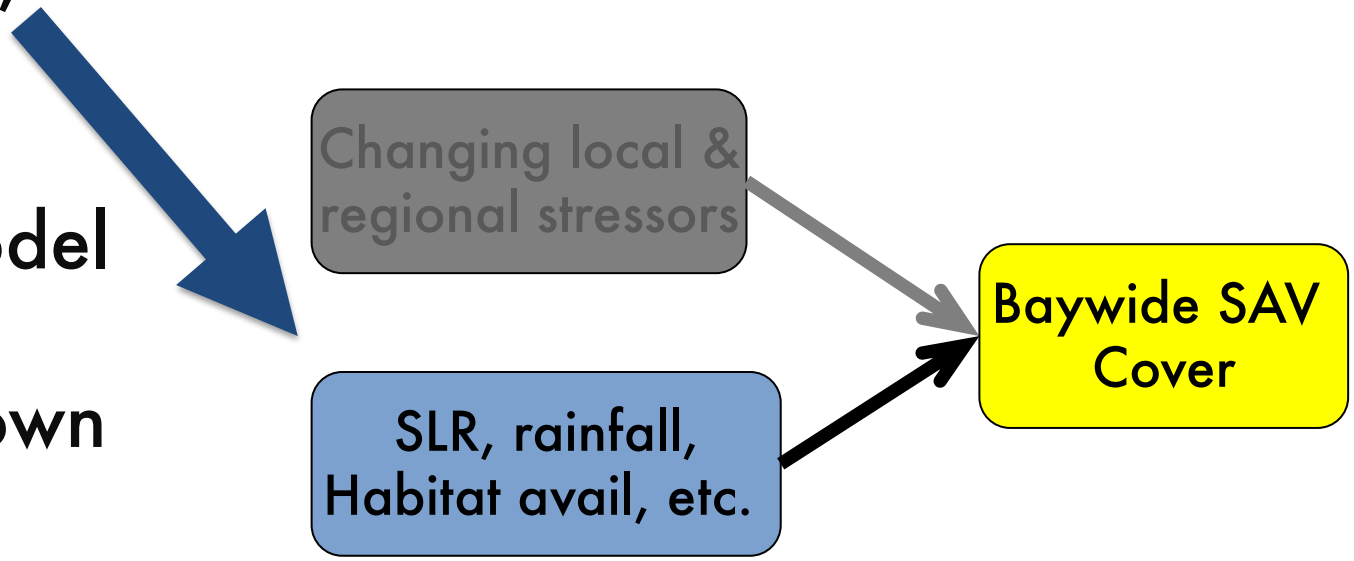
-Incorporate climate stressors (SLR, habitat avail, rain, etc)

-Create and apply a predictive model

-Focusing on specific events or known years

-Apply this technique throughout the Bay, for different communities and species





Next Steps | the Rise of *Ruppia*

How do we manage for healthy *Ruppia* meadows throughout the Chesapeake?

What does *Ruppia* food web composition, structure, function look like (epifauna, fish)? Compared to other SAV species (LA)

Can we use *Ruppia* to reach restoration goals? (EH, AH)?