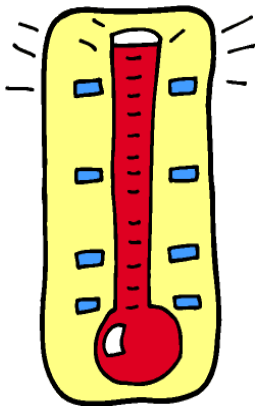
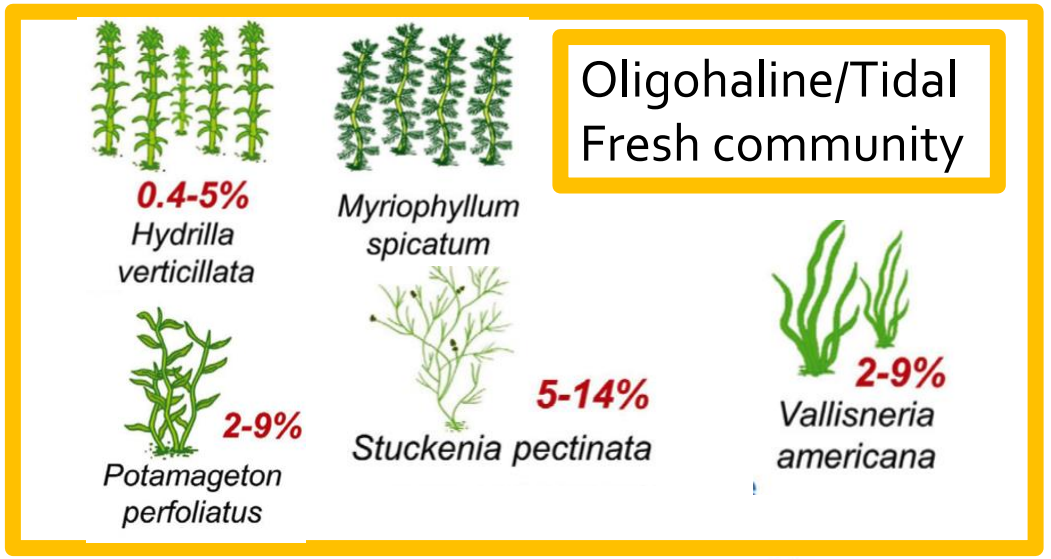
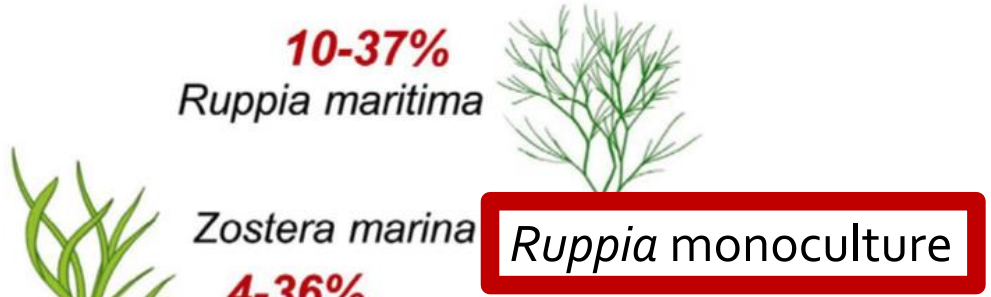
Envisioning the future for Chesapeake Bay SAV under climate change

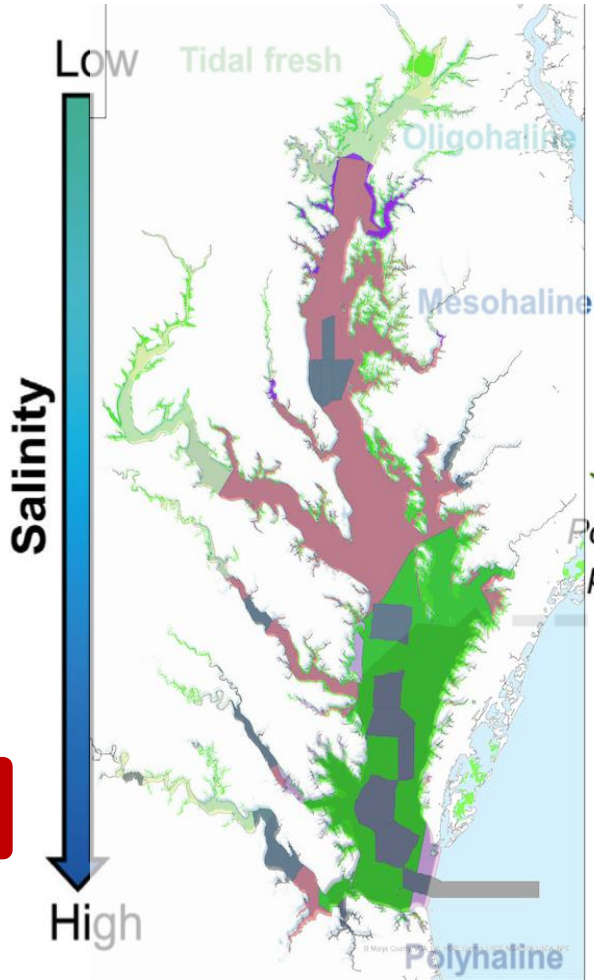
Marc Hensel, Chris Patrick, Jon Lefcheck, Dave Wilcox

Climate Resiliency WG
1.18.23

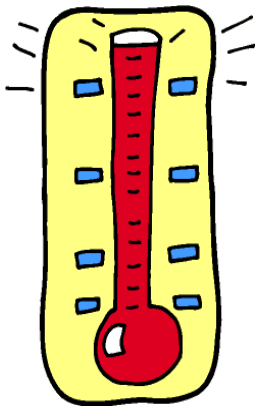


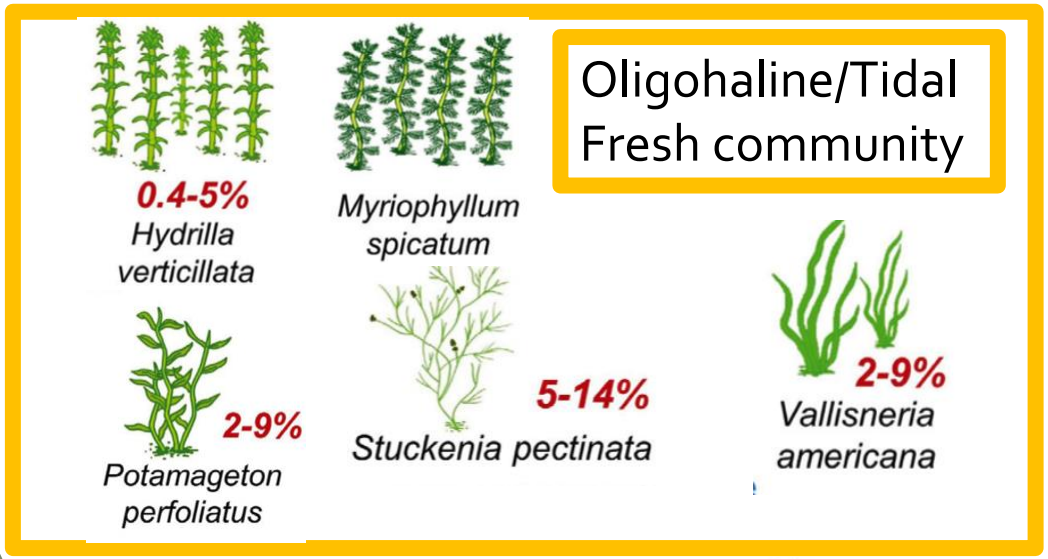


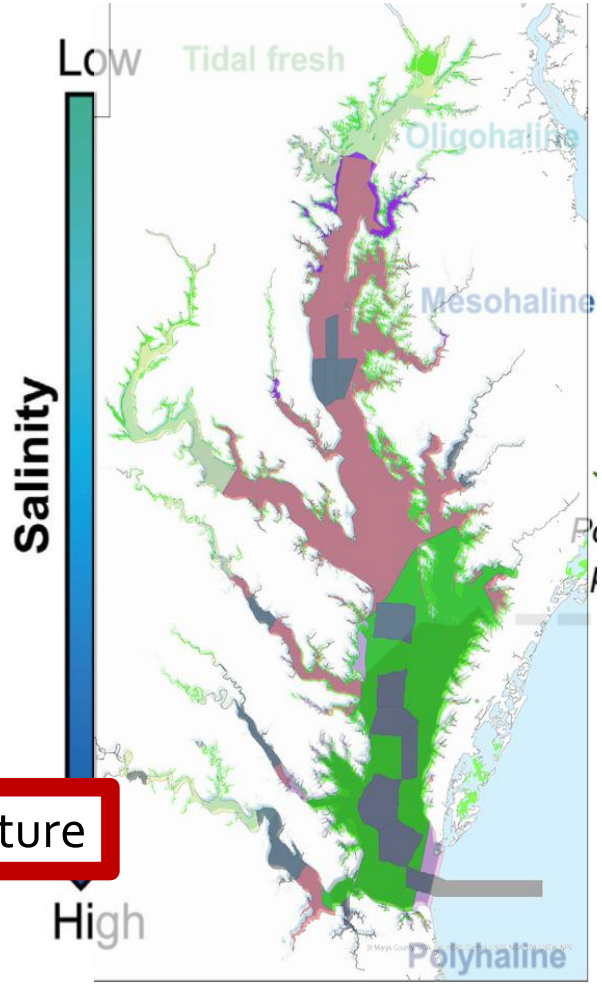




How will climate change and human activities affect the major communities of submersed aquatic vegetation in the Chesapeake Bay?

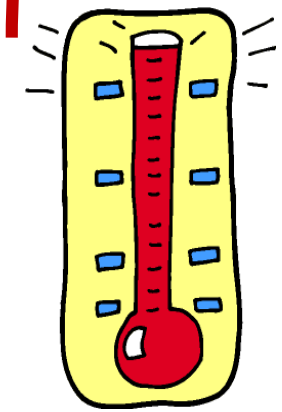






How will climate change and human activities affect the major communities of seagrass and aquatic vegetation in the Chesapeake Bay?

Climate change



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Temperature rise Rainfall variability

Human activities

No further nutrient reductions

OR

More nutrient reductions

Predicting the future in three steps|

Step 1: How have past environmental conditions affected SAV communities?

-***VIMS aerial SAV survey data & CBP water quality data (1984-2020)***

Step 2: How will environmental conditions shift with climate change & with human activities?

Step 3: How will shifting conditions and shifting species affect SAV meadow coverage into the future?

Step 1: ID major communities of Chesapeake Bay seagrass and vegetation

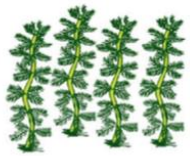
Mixed Mesohaline


5-14%
Stuckenia pectinata


2-9%
Potamageton perfoliatus

10-37%
Ruppia maritima


0.4-5%
Hydrilla verticillata


Myriophyllum spicatum

Oligohaline/Tidal Fresh community


2-9%
Vallisneria americana

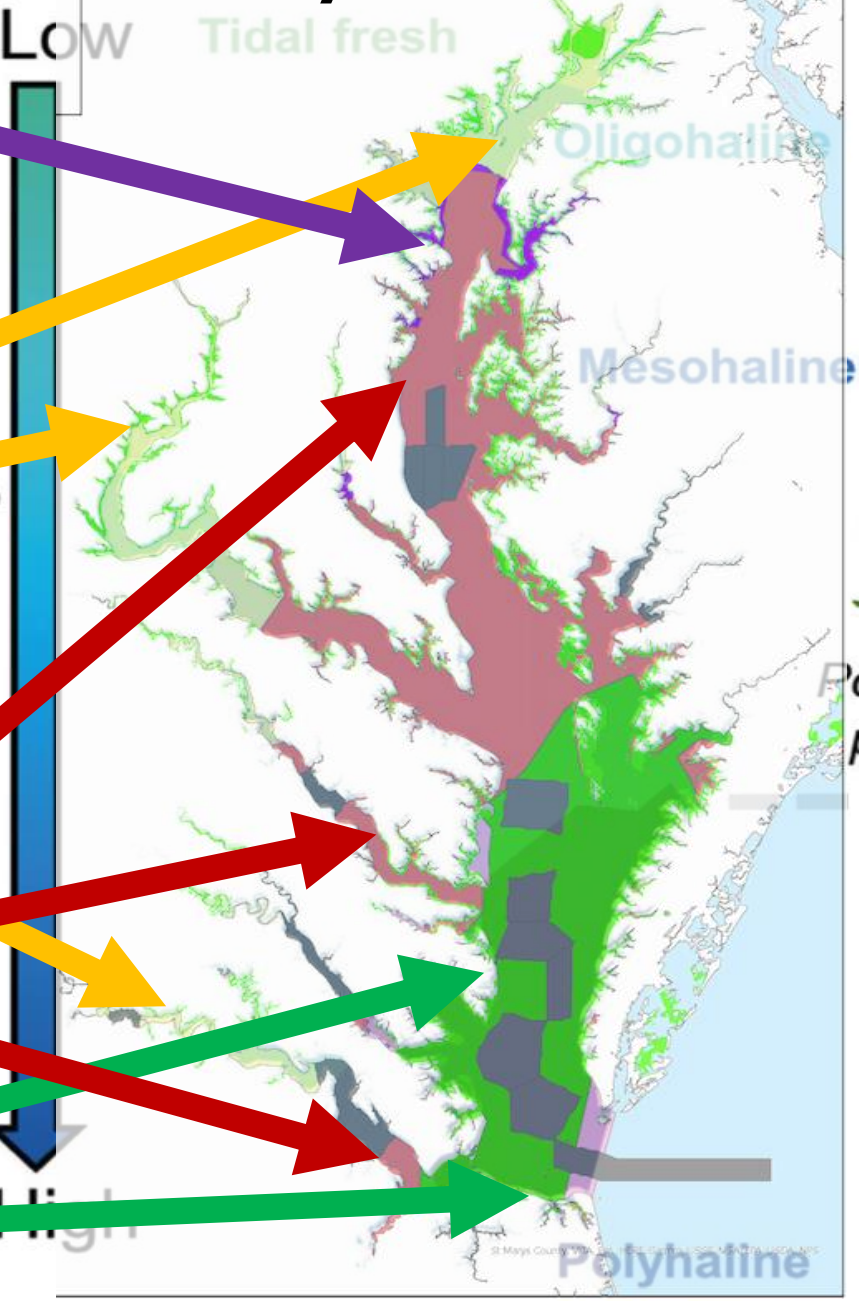
Ceratophyllum demersum
Elodea canadensis
Myriophyllum spicatum
Najas minor

10-37%
Ruppia maritima

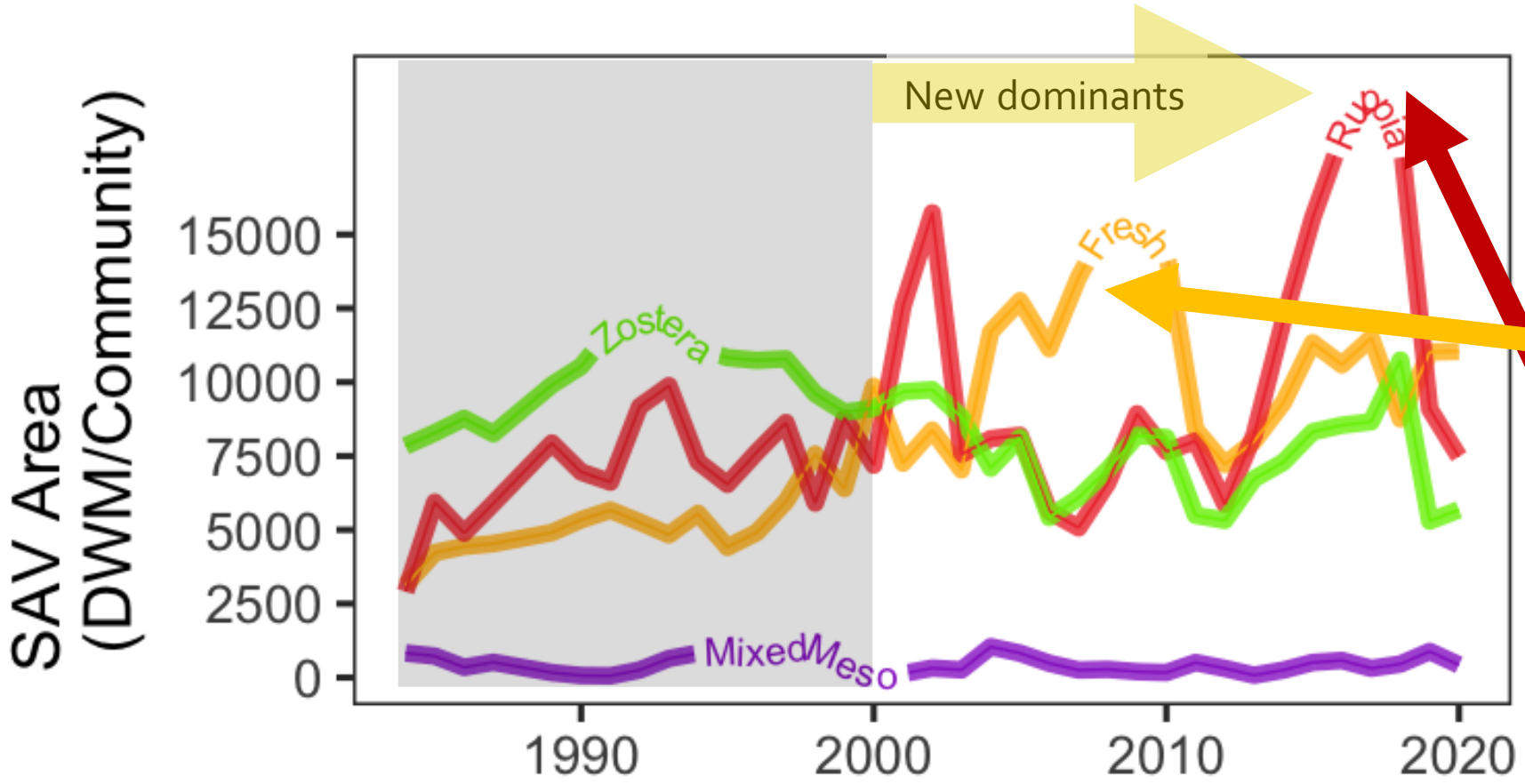
Ruppia monoculture


Zostera marina
4-36%

Zostera monoculture

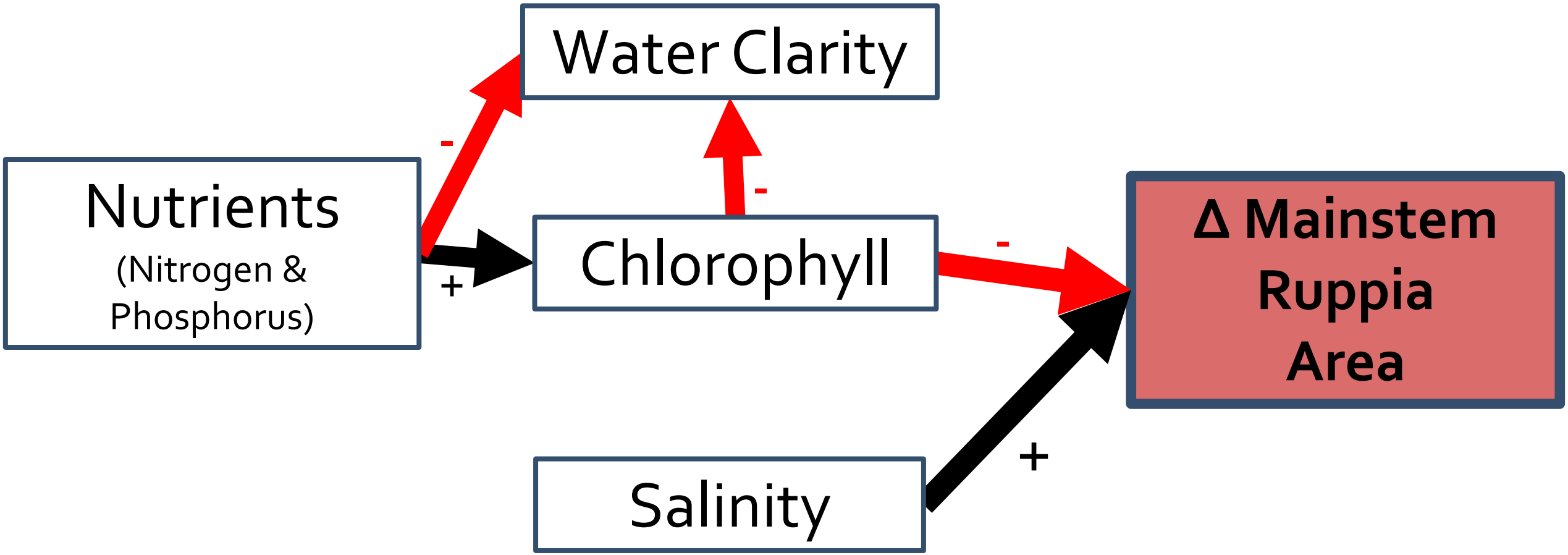


Step 1: Dominant communities have changed over time in response to climate and management

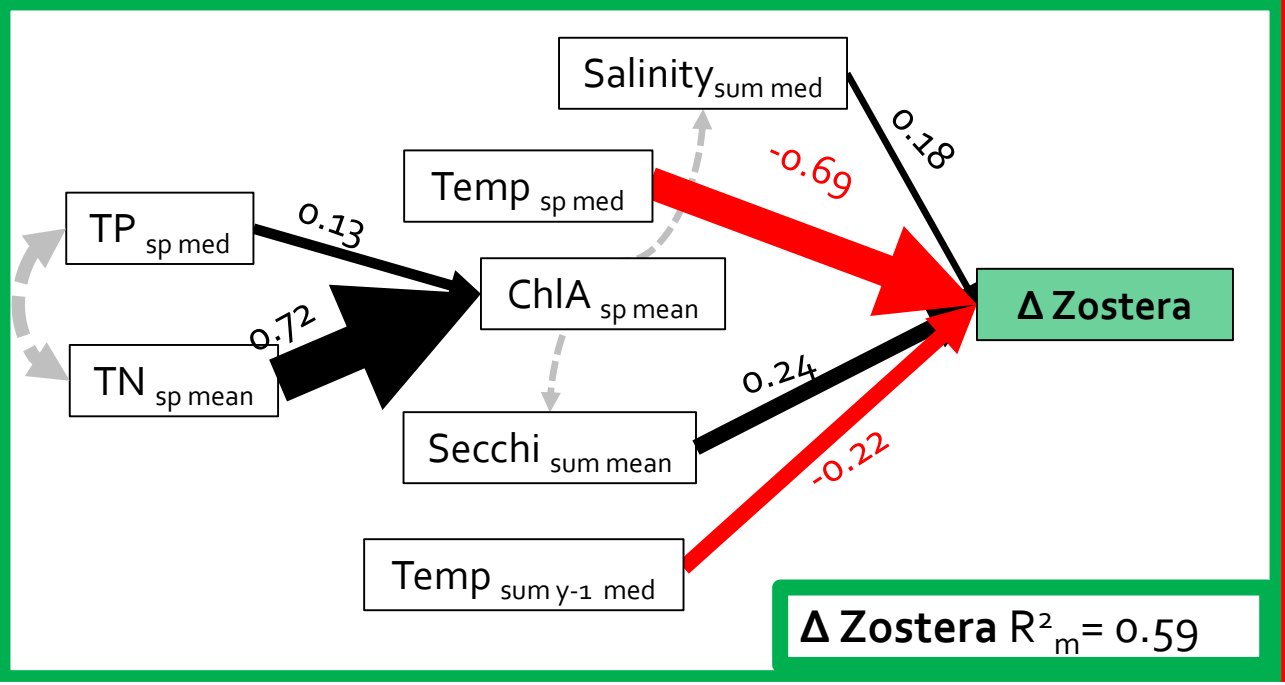


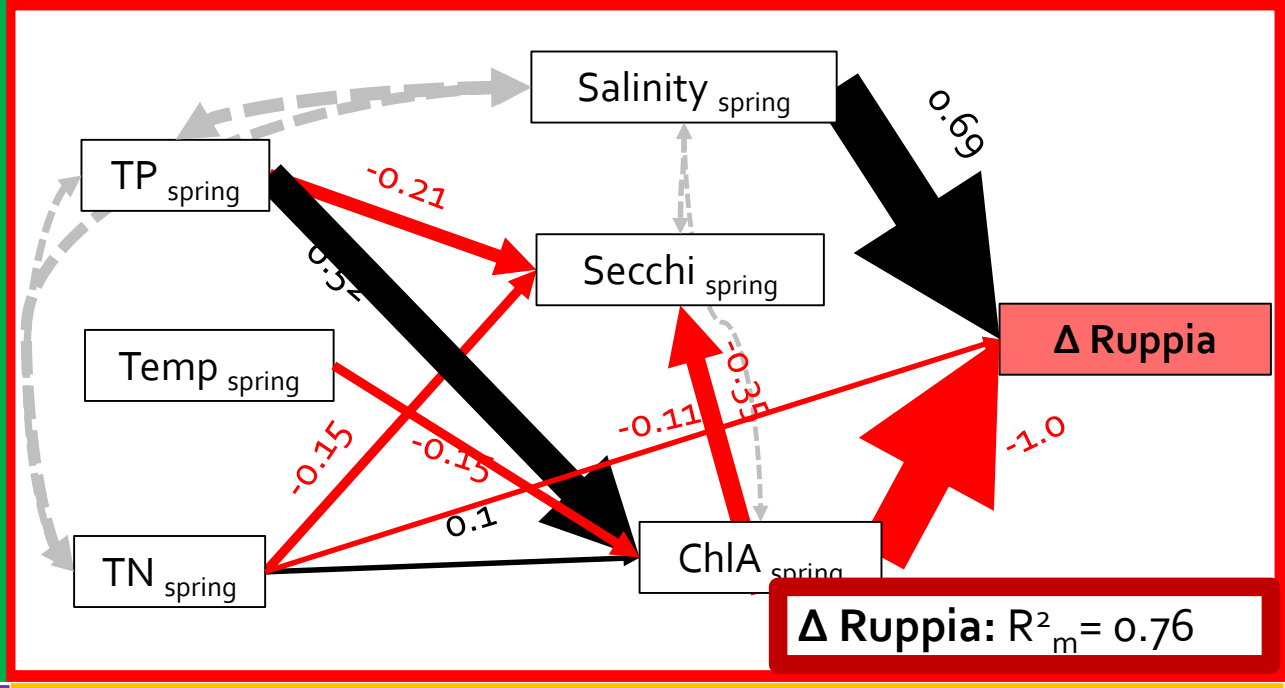
Tidal fresh and widgeongrass are the dominant communities now

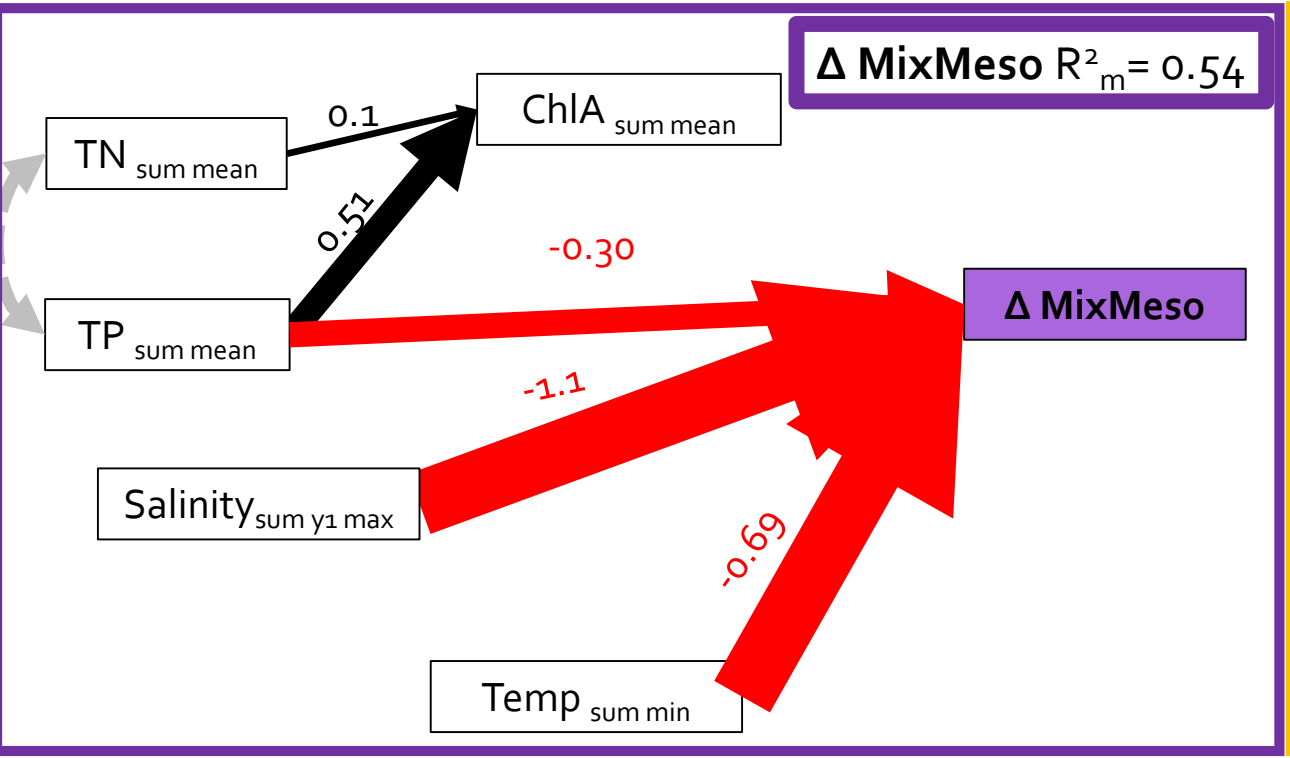
Structural Equation Modelling example from *Ruppia* community

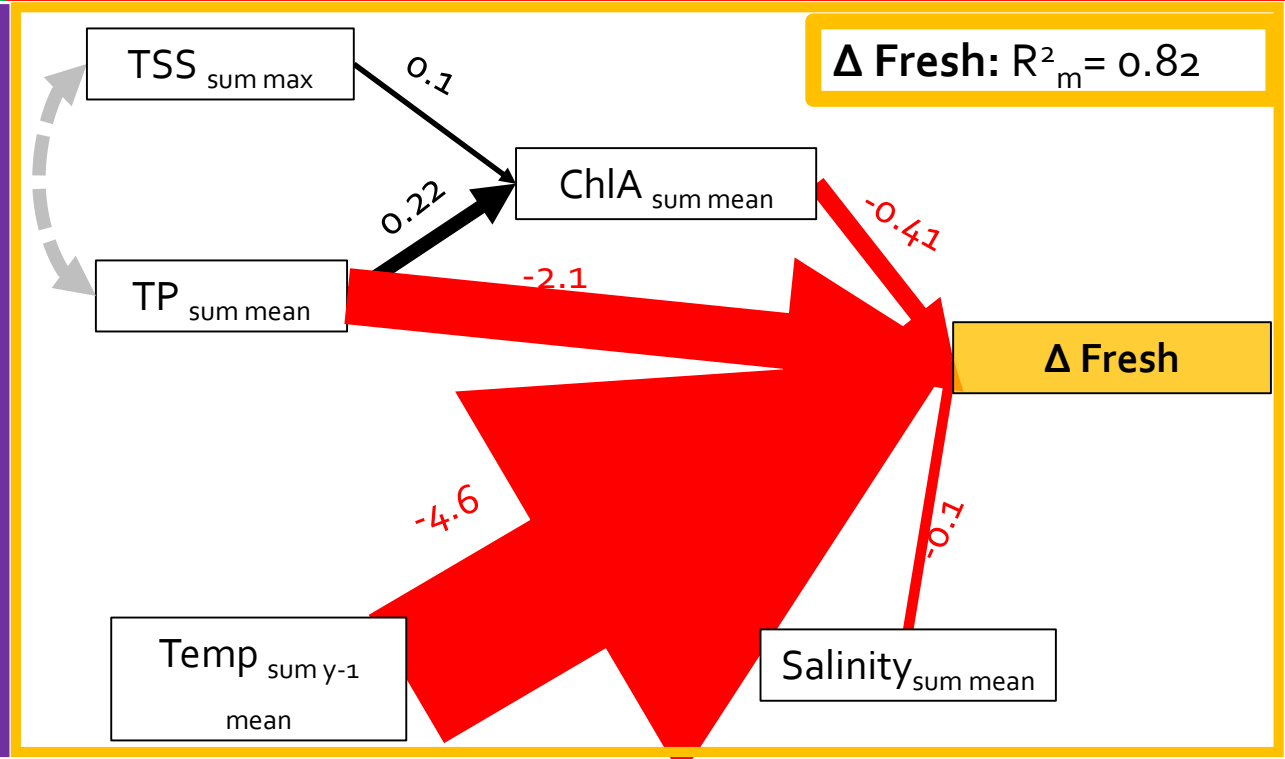


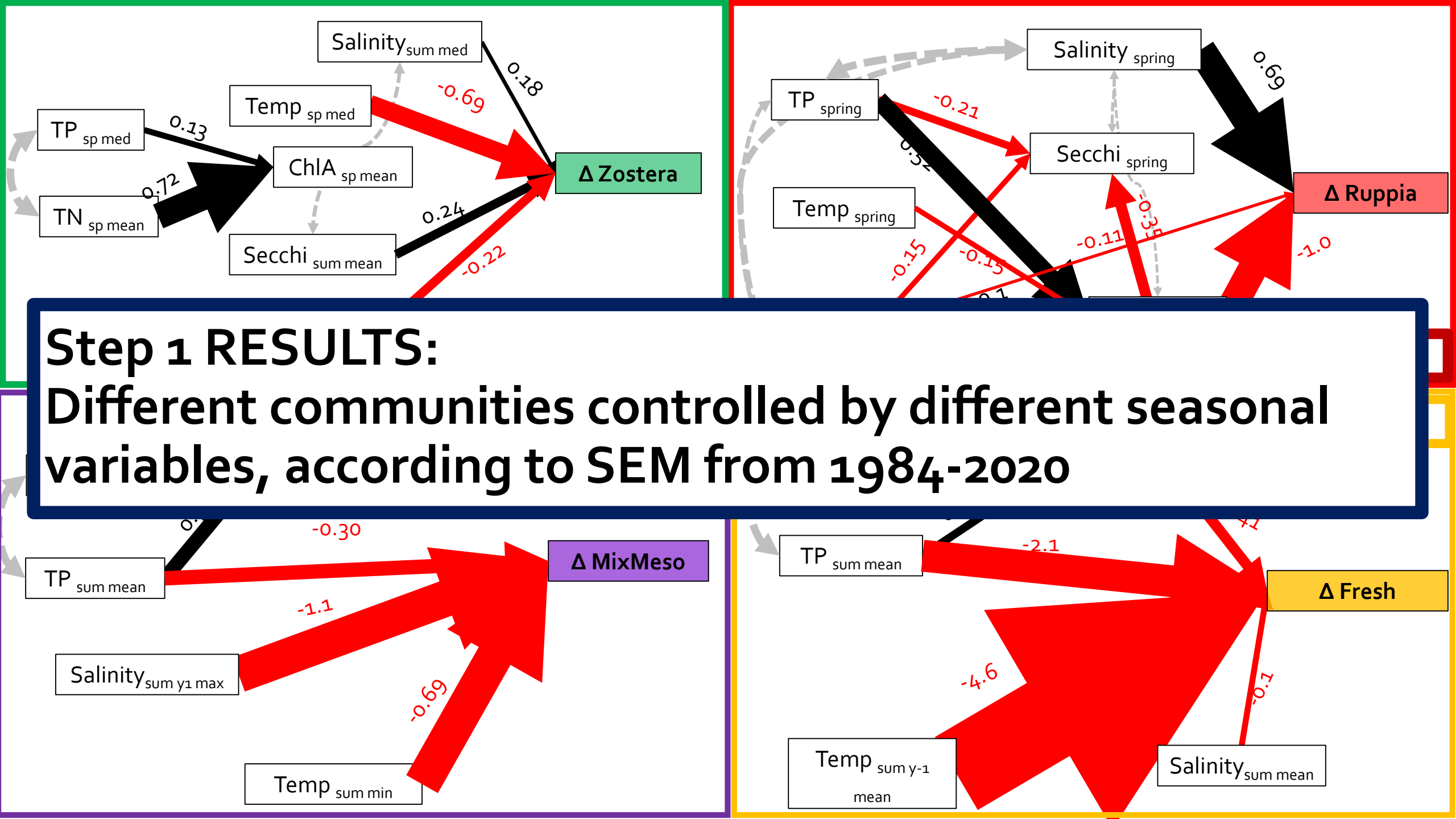
Δ Widg: $R^2_c = 0.59$


Salinity sum med
Temp sp med
TP sp med
ChlA sp mean
TN sp mean
Secchi sum mean
Temp sum y-1 med
0.18
-0.69
0.13
0.72
0.24
-0.22
Δ Zostera
Δ Zostera R²m= 0.59


Salinity spring
TP spring
Secchi spring
Temp spring
TN spring
ChlA spring
Δ Ruppia
0.69
-0.21
-0.15
-0.15
-0.11
-0.35
-1.0
0.1
Δ Ruppia: R²m= 0.76


Δ MixMeso R²m= 0.54
TN sum mean
ChlA sum mean
TP sum mean
Δ MixMeso
Salinity sum y1 max
Temp sum min
0.1
0.51
-0.30
-1.1
-0.69


Δ Fresh: R²m= 0.82
TSS sum max
ChlA sum mean
TP sum mean
Δ Fresh
Temp sum y-1 mean
Salinity sum mean
0.1
0.22
-0.41
-2.1
-4.6
-0.1



Step 1 RESULTS:
Different communities controlled by different seasonal variables, according to SEM from 1984-2020

Predicting the future in three steps|

Step 1: How have past environmental conditions affected seagrass communities?

-New dominants are controlled by flow of nutrients from watershed

Step 2: How will environmental conditions shift with climate change & with human activities?

Step 3: How will shifting conditions and shifting species affect seagrass meadow coverage into the future?

Predicting the future in three steps|

Step 1: How have past environmental conditions affected seagrass communities?

-New dominants are controlled by flow of nutrients from watershed

Step 2: How will environmental conditions shift with climate change & with human activities?

-CBP climate modelling scenarios (2020-2060)

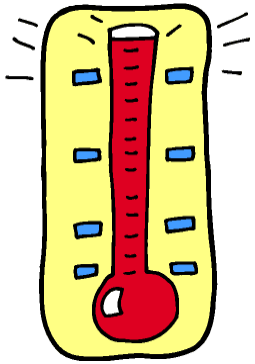
Step 3: How will shifting conditions and shifting species affect seagrass meadow coverage into the future?

Step 2: Two future scenarios from CBP Modelling data|

No Further Action

No further nutrient reductions

Climate change accelerates



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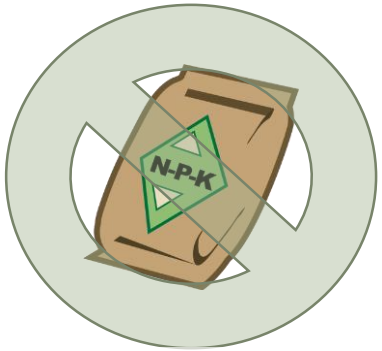
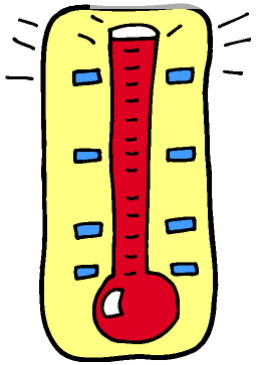
Temperature rise Rainfall variability

Nutrient Reductions



More nutrient reductions

Climate change accelerates



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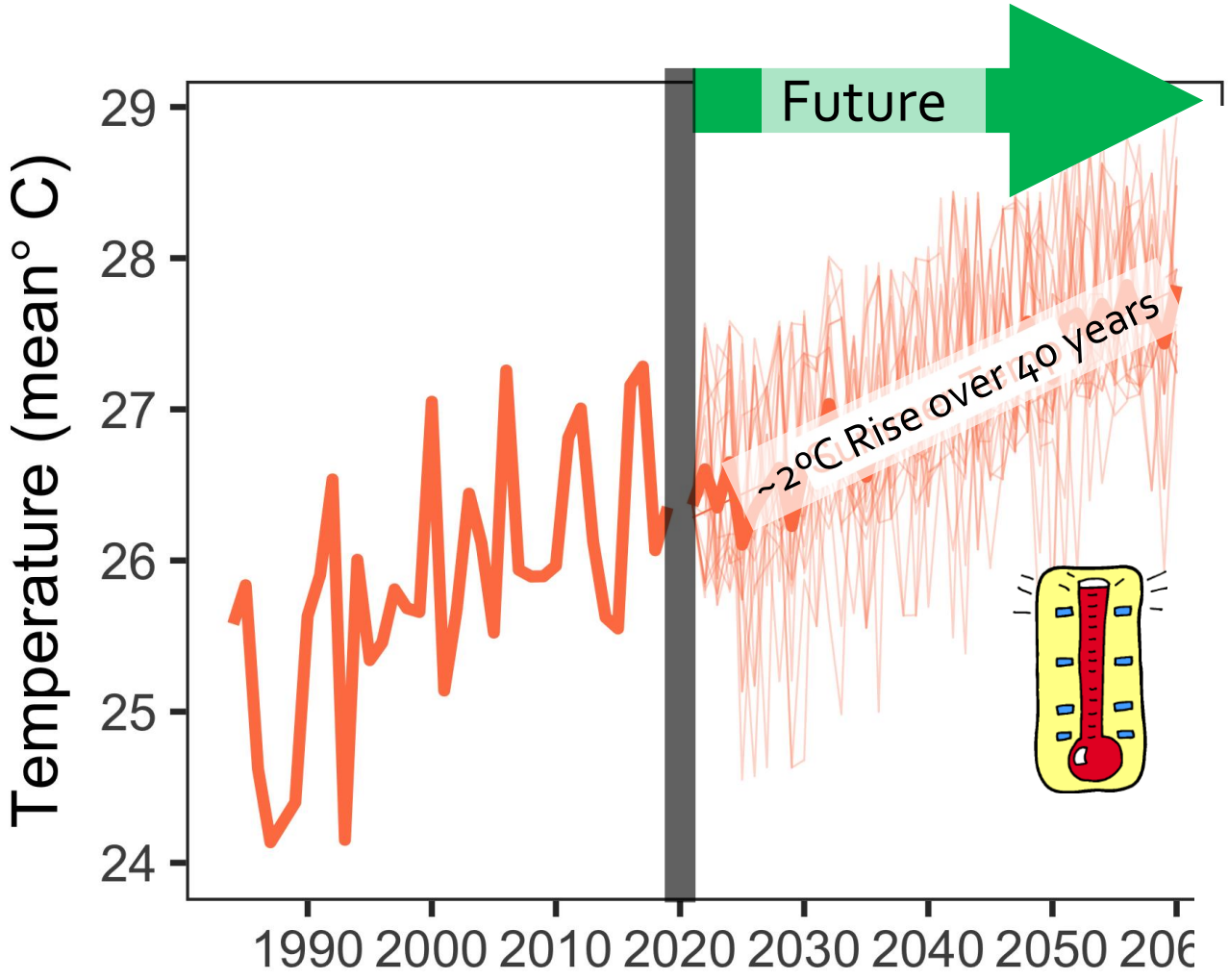
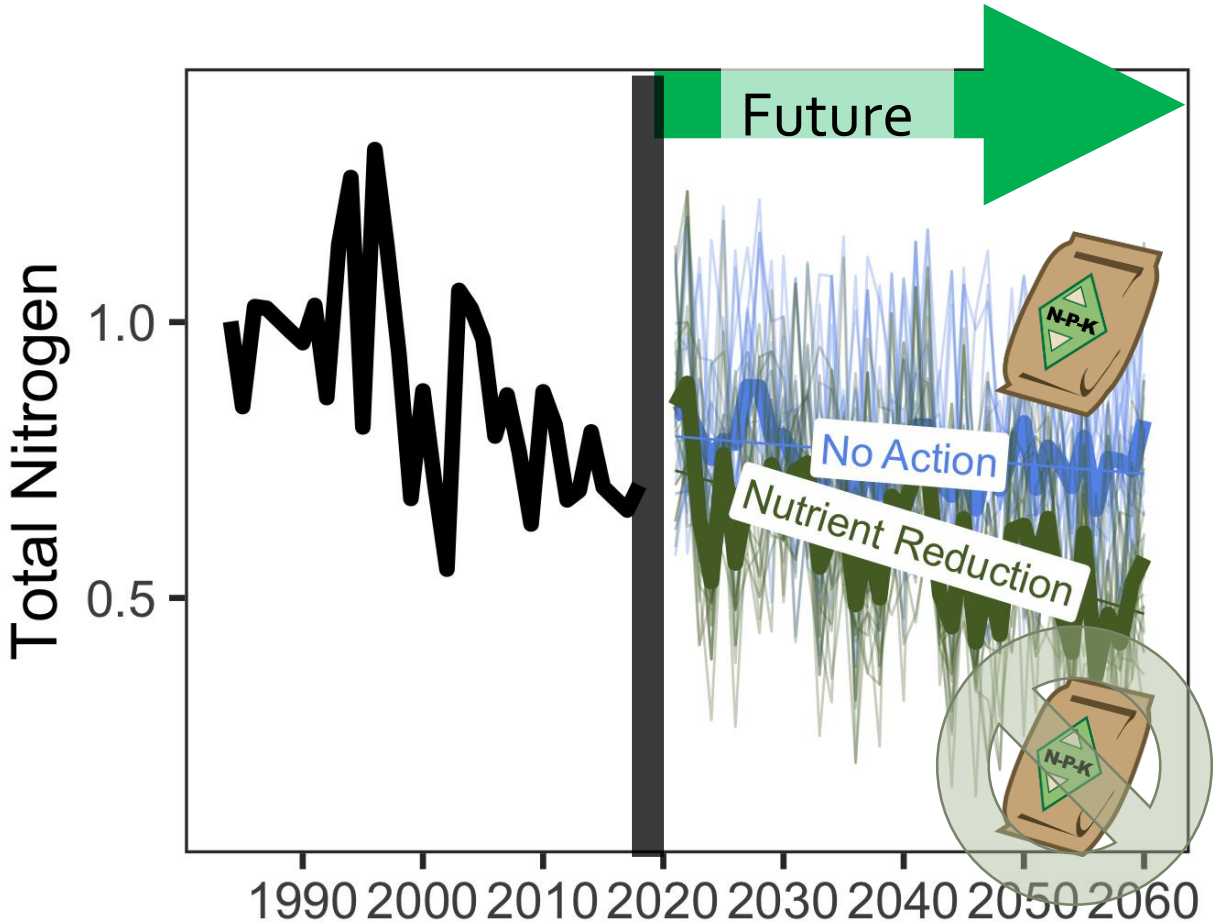
Temperature rise Rainfall variability

Step 2: Temperature increase, rainfall variation in both, further nutrient reductions vs no action





Predicting the future in three steps|

Step 1: How have past environmental conditions affected seagrass communities?

-New dominants are controlled by flow of nutrients from watershed

Step 2: How will environmental conditions shift with climate change & with human activities?

-Created 2+ scenarios:

No Further Action = Climate change, Nutrient levels stagnant

Nutrient Reduction = Climate change, Nutrient levels decrease

(Other comparison scenarios including No CC and even more reductions)

Step 3: How will shifting conditions and shifting species affect seagrass meadow coverage into the future?

Predicting the future in three steps|

Step 1: How have past environmental conditions affected seagrass communities?

-New dominants are controlled by flow of nutrients from watershed

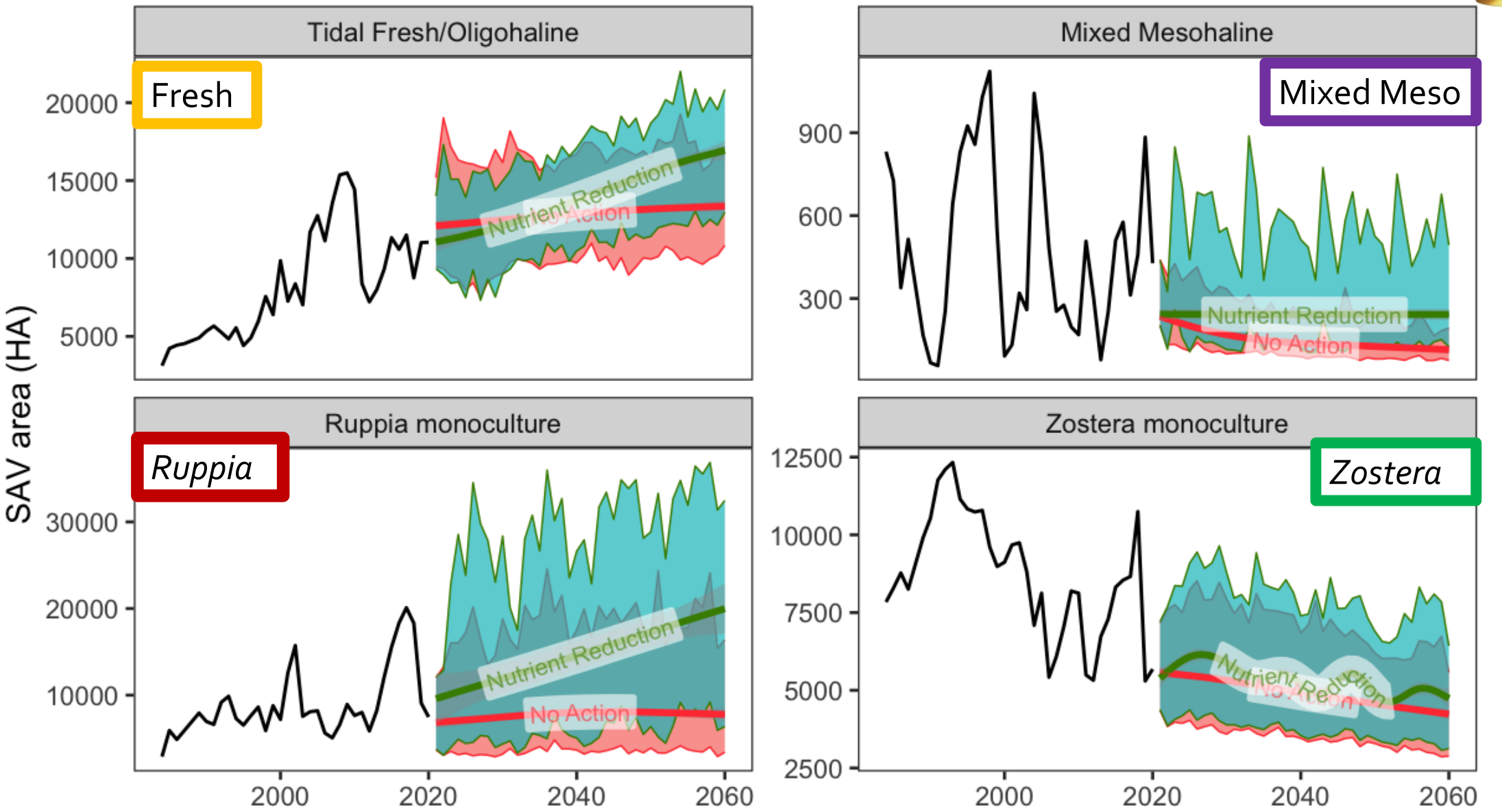
Step 2: How will environmental conditions shift with climate change & with human activities?

-Created 2+ scenarios

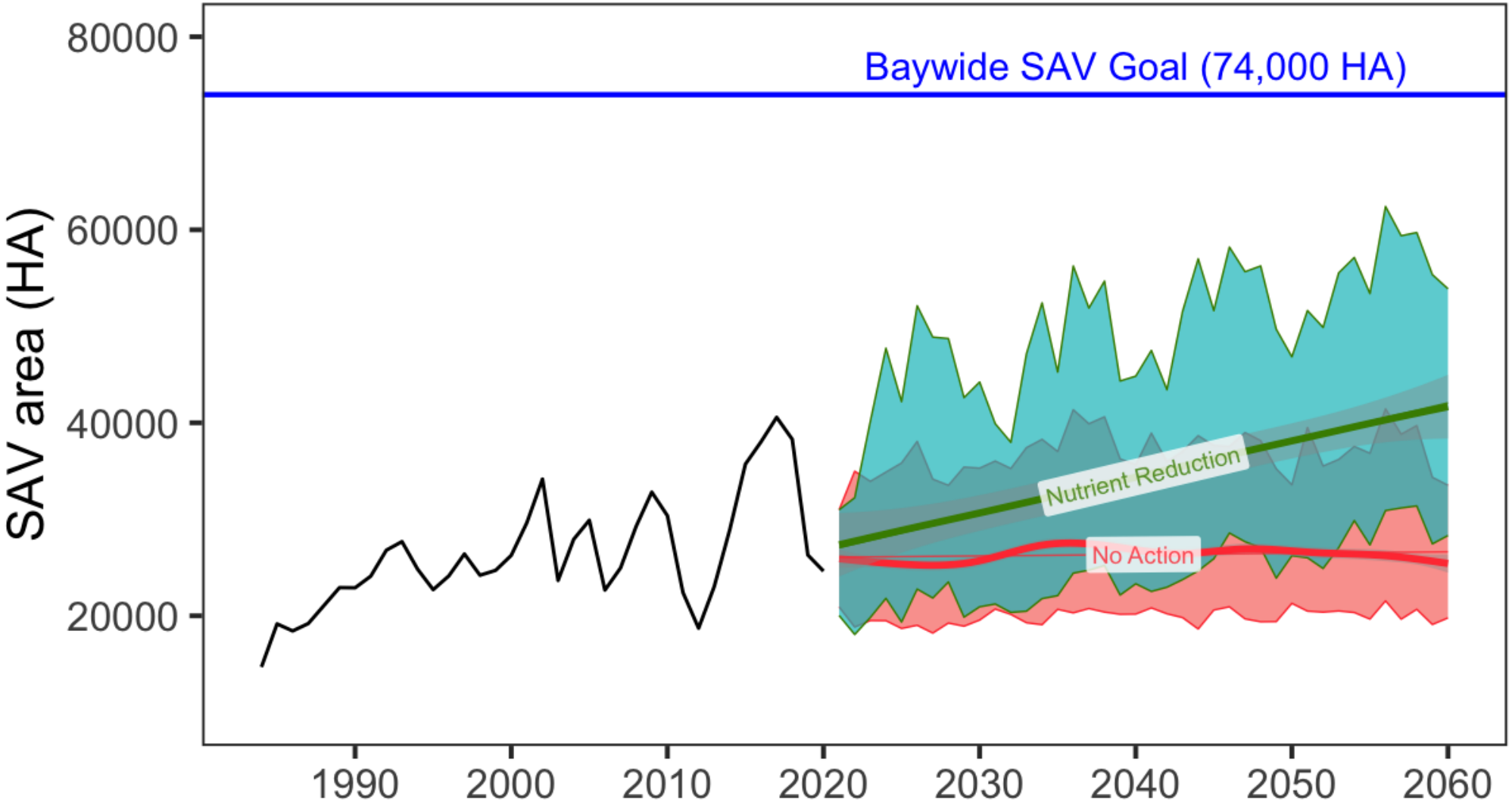
Step 3: How will shifting conditions and shifting species affect seagrass meadow coverage into the future?

-Predictive modelling from 2021-2060 under climate change and nutrient management scenarios

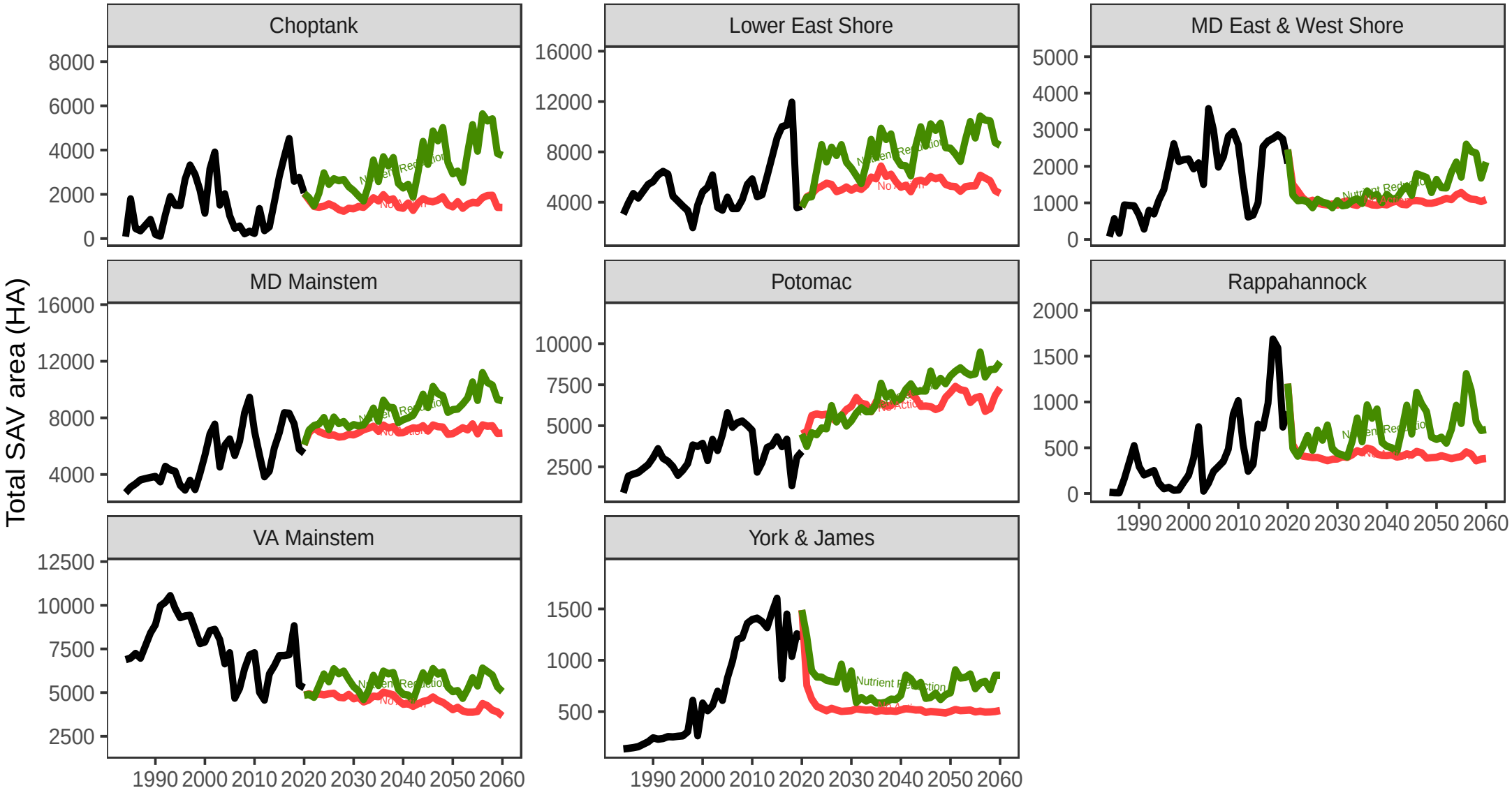
New dominants respond most positively to nutrient reductions!



0% of No Action simulations reach Baywide goals, 0% of Nutrient reduction simulations reach Baywide goals..but get much closer by 2060!



Gains in Choptank, Lower E Shore, MD mainstem offset losses in York/James, VA mainstem…



SUMMARY|

Temperature increases will widen the shift in dominant species, and management must adjust accordingly.

Nutrient reductions in the tidal fresh/oligohaline & *Ruppia* zones are essential, especially because the new dominants respond best to nutrient management

Local/regional action offsets and prevents the effects of global climate change (!!)

-targeted nutrient management that benefits climate-tolerant species encourages continued recovery

LESSONS LEARNED & WHAT WE DO NEXT|

Segment by segment projections, Basin by basin projections in our web app

We have baywide goals, segment goals… next step is community goals

-Sentinel program will help here!

Gauge progress on multi-year chunks of time, because new dominants aren't as stable as eelgrass

We must start modelling and predicting species shifts, food web shifts, and changes in fisheries/blue crabs/services

What would other regions need to do future predictions like this? Can we build a roadmap for data poor regions to follow us in the Bay?

THANKS to our steering committee!

J.J. Orth, Bill Dennison, Rebecca Murphy, Jeremy Testa, Matt Fitzpatrick, Katia Engelhardt, Cassie Gurbisz, Karen McGlathery, Aaron Kornbluth, Joel Carr, Lewis Linker, Kathrynlynn Theuerkauf, Becky Golden & Brooke Landry