Application of SLAMM to Estimate N removal services in tidal wetlands

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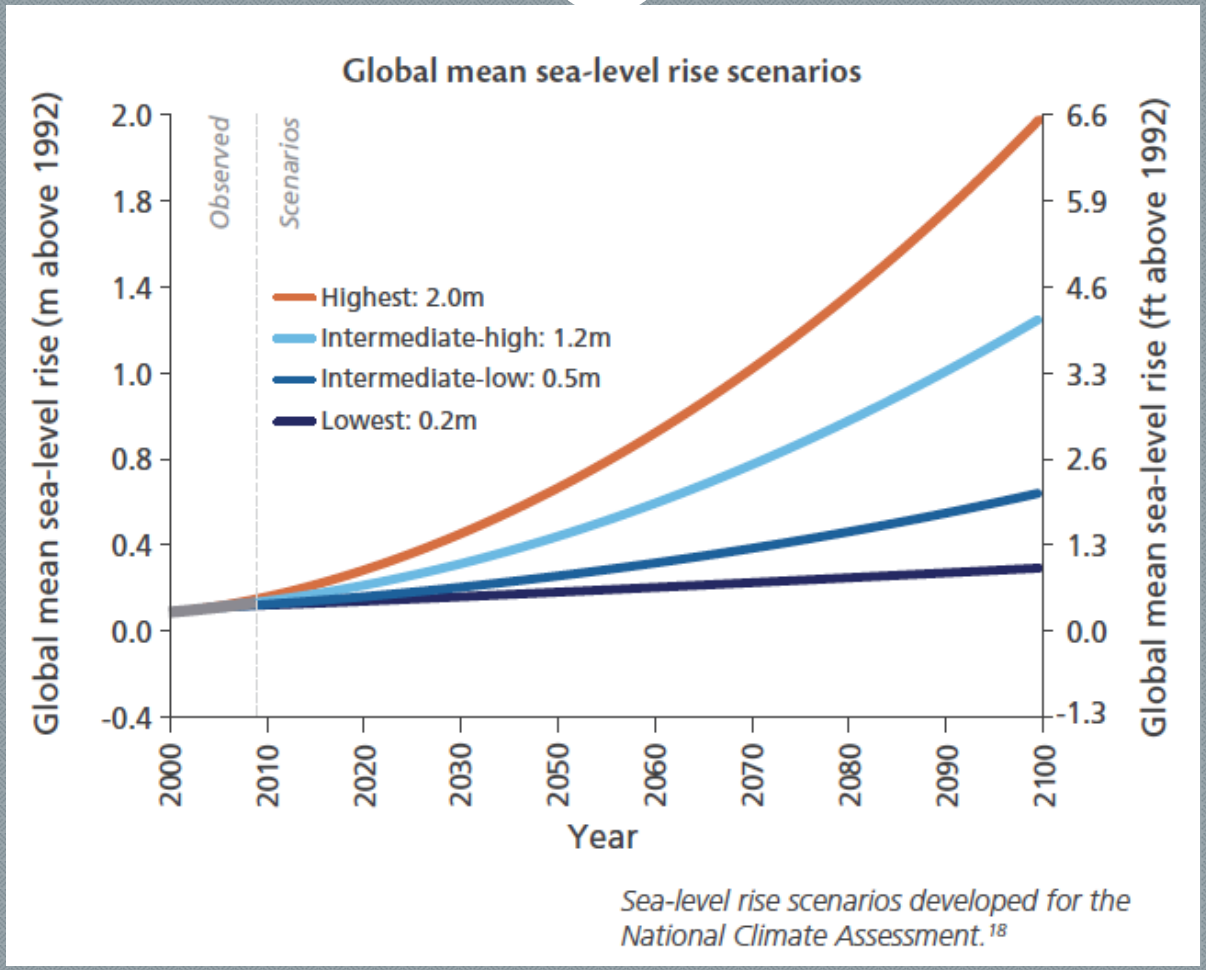
Sea Grant
Maryland

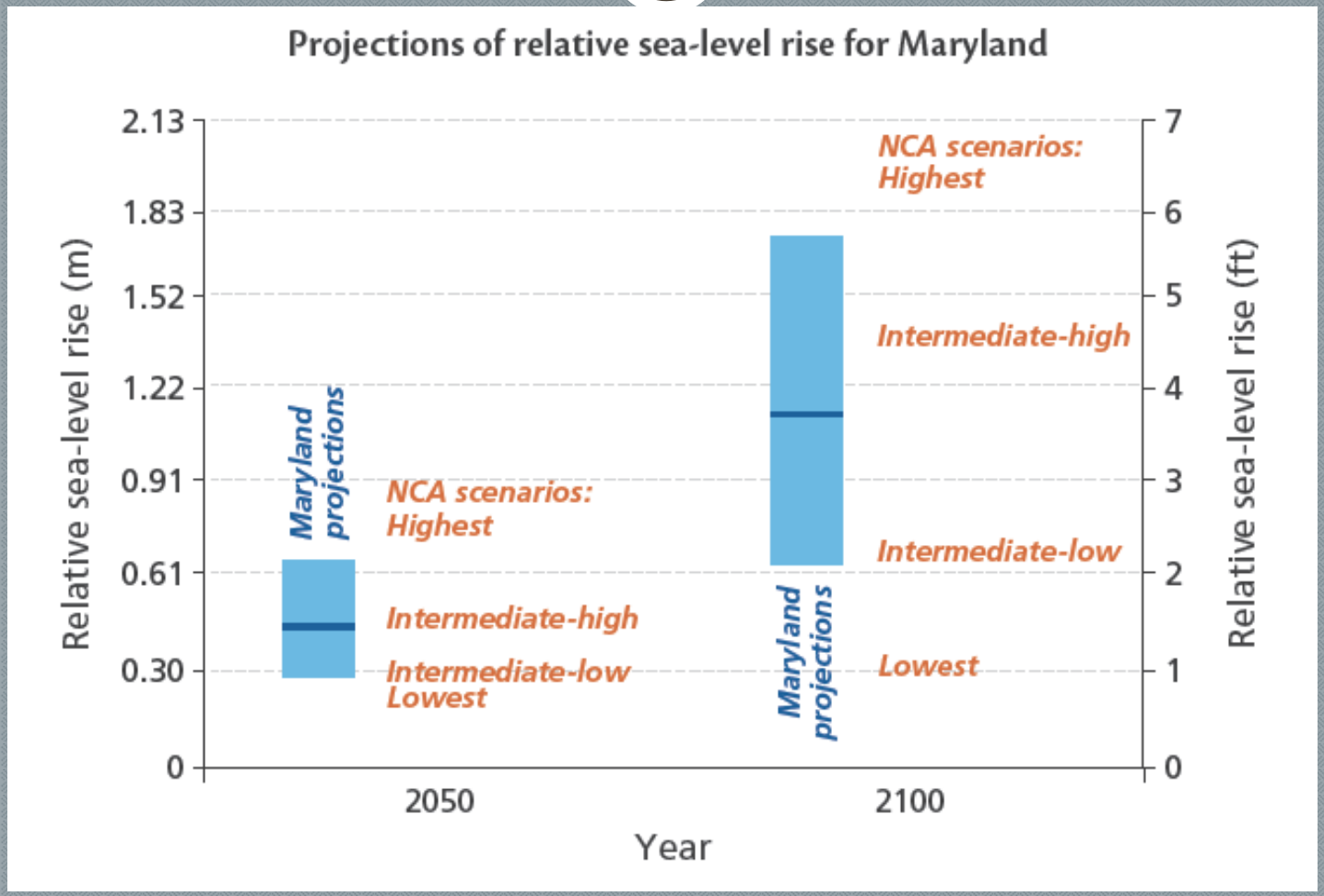
Chesapeake Bay
National Estuarine Research Reserve
Maryland

Global Mean SLR



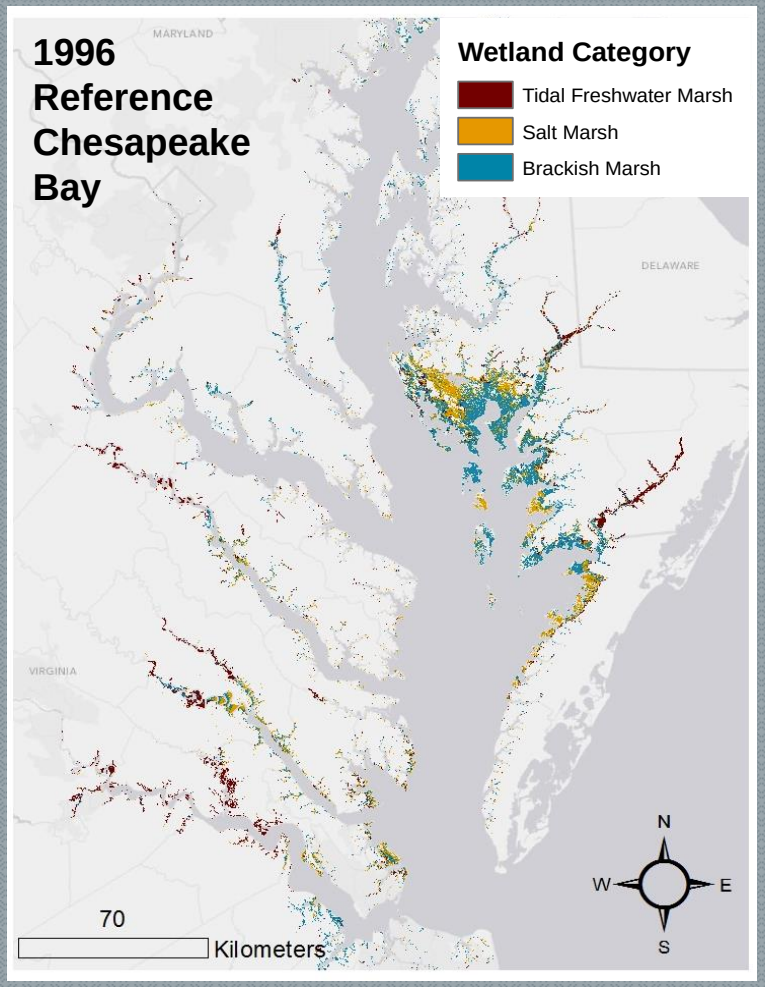
Boesch et al. 2013

Maryland SLR Estimates



Boesch et al. 2013

SLAMM Implementation



Glick et al. 2008

Chesapeake Bay Tidal Wetlands

Salinity Regime

- Tidal Fresh
  - Oligohaline
  - Salinity < 0.5-2
- Brackish
  - Mesohaline
  - Salinity 1-10
- Salt
  - Polyhaline
  - Salinity 18-30

Ecosystem Services

- Filtration of toxins and pollutants
- Uptake and transformation of nutrients
- Floodwater attenuation
- Groundwater recharge
- Habitat

Nitrogen Removal

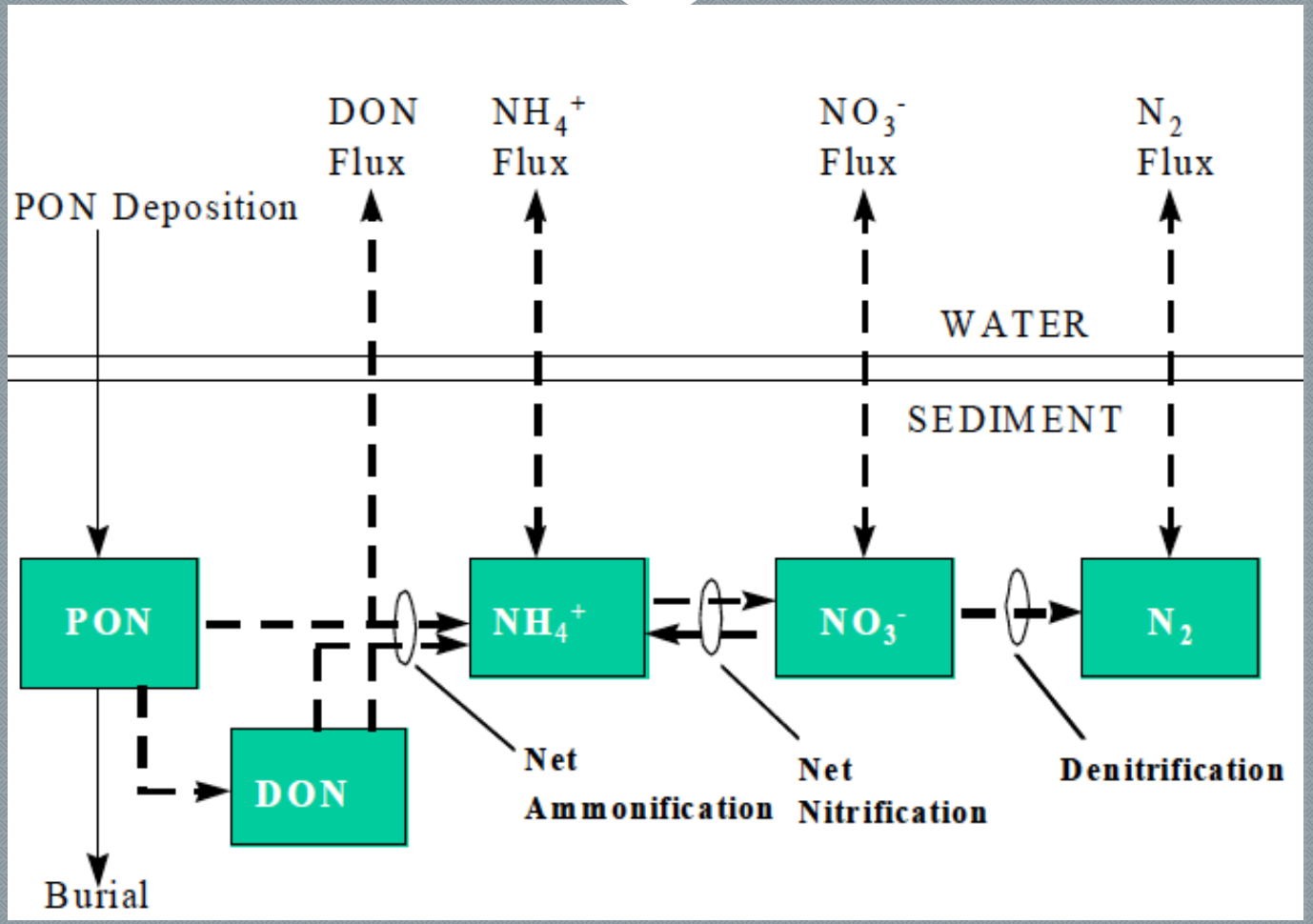


Image Courtesy of J. Cornwell

Not All Tidal Wetlands Are Created Equal When it Comes to Nitrogen Removal Services!

Wetland Category	Nitrogen Removal Services	Source
	Denitrification ($gN m^{-2} yr^{-1}$)	
Brackish	7.4	Kemp 2006
Salt	0.6	Thomas & Christian 2001
Tidal Fresh	14.7	Greene 2005
	Nitrogen Burial ($gN m^{-2} yr^{-1}$)	
Brackish	13.6	Merrill & Cornwell 2000
Salt	4.3	Thomas & Christian 2001
Tidal Fresh	23.4	Merrill & Cornwell 2000

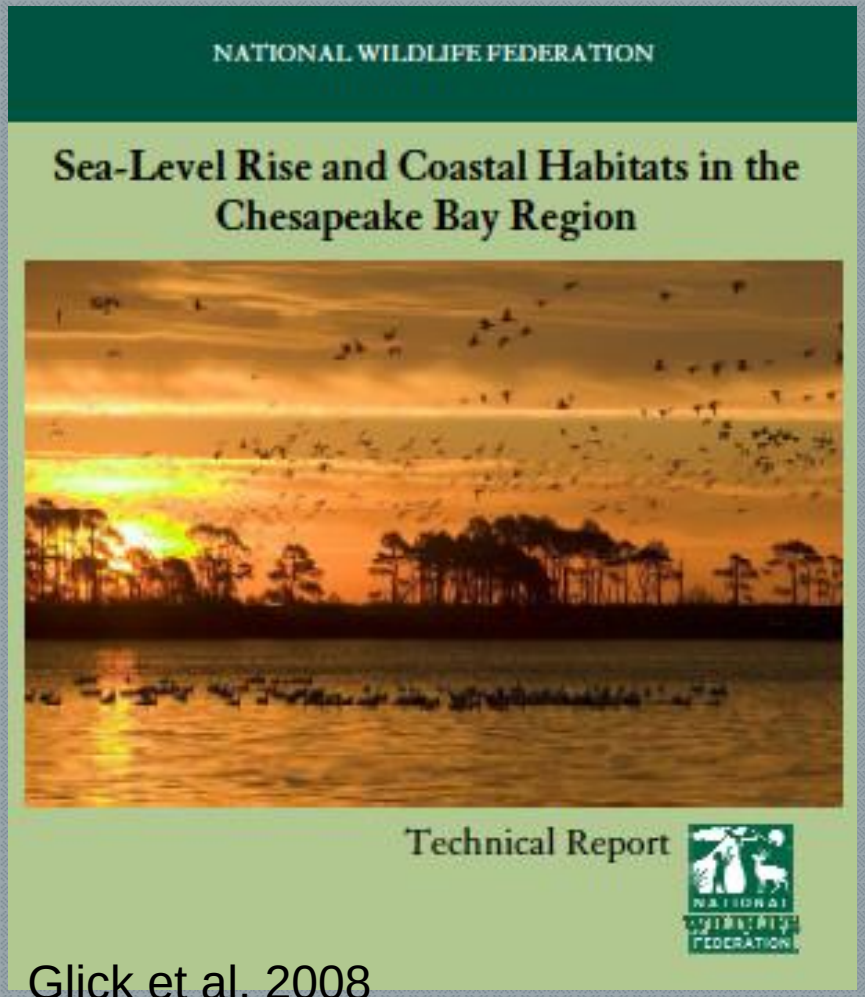
Research Questions

1. What role do tidal wetlands play in nitrogen removal in relation to current nitrogen loads?

1. How will projections of SLR that include changes to wetland area affect loading goals set by the TMDLs?

1. How does spatial scale affect our understanding of these questions from Bay-wide, to basin scale, to 12-digit watersheds?

Data Set



Glick et al. 2008

Sea Level Affecting Marsh Model (SLAMM):

- Ecosystem-based model
- Major processes affecting wetland fate
- IPCC emission scenarios vs. 1996 reference condition
- Incremental time steps
- Data Inputs

Narrowing Data Set

GIS

- Raster-based dataset
- Narrowed spatial extent in GIS
- Extracted Chesapeake Bay, Maryland, and Calvert County
- Broad categories of tidal wetlands
  - Tidal fresh
  - Salt
  - Brackish

Scales/Scenarios

- Chesapeake Bay by 2100
  - A1B max (0.69 m), 1.0 m, and 1.5 m rise
- Maryland Major Basins by 2025
  - 0.17m, 0.25 m rise
- Calvert County 12-digit watersheds by 2025
  - 0.17m, 0.25 m rise

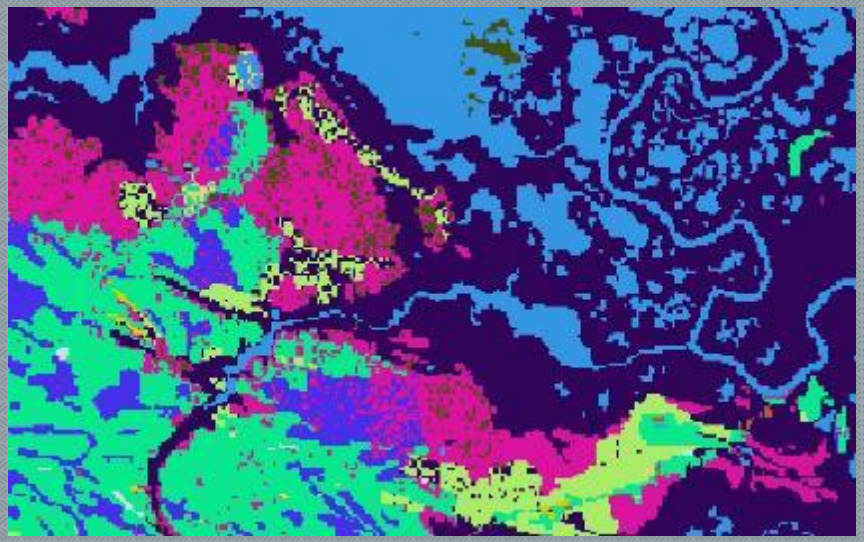
Computations

Tidal wetland area:

- Ex: “Count” * raster cell size (30m x 30m)

Nitrogen removal:

- Denitrification and N burial
- Comparison to TMDLs, when applicable
- Percent change from the reference



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Nitrogen removal:

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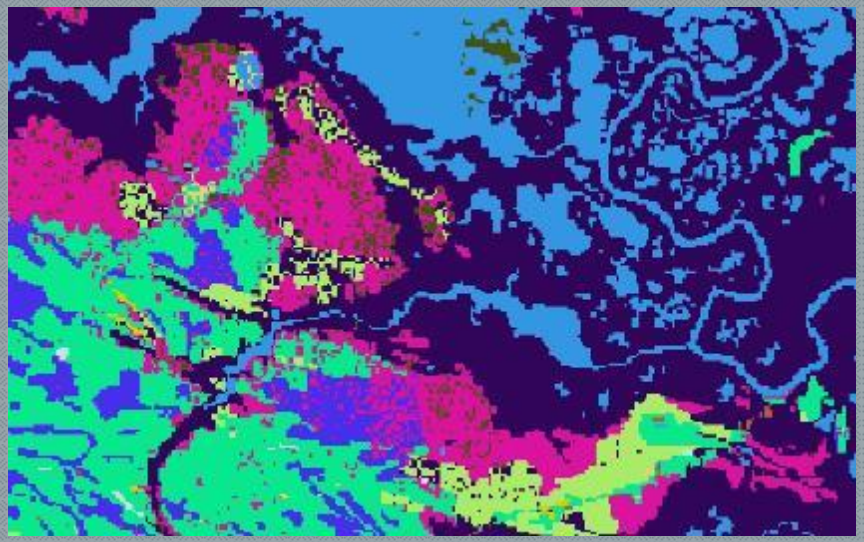
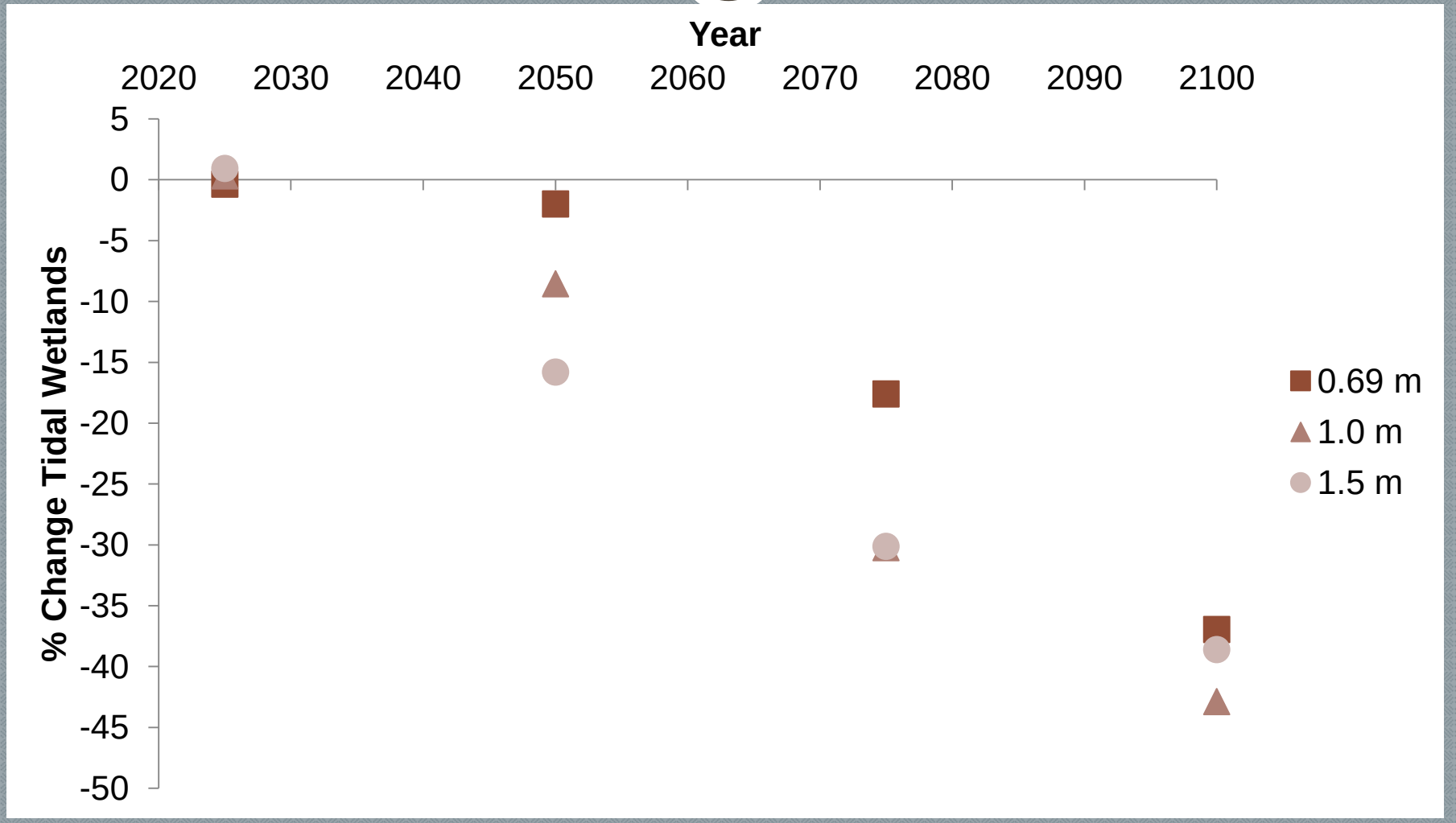
- Percent change from the reference – needs revision in Bryan thesis

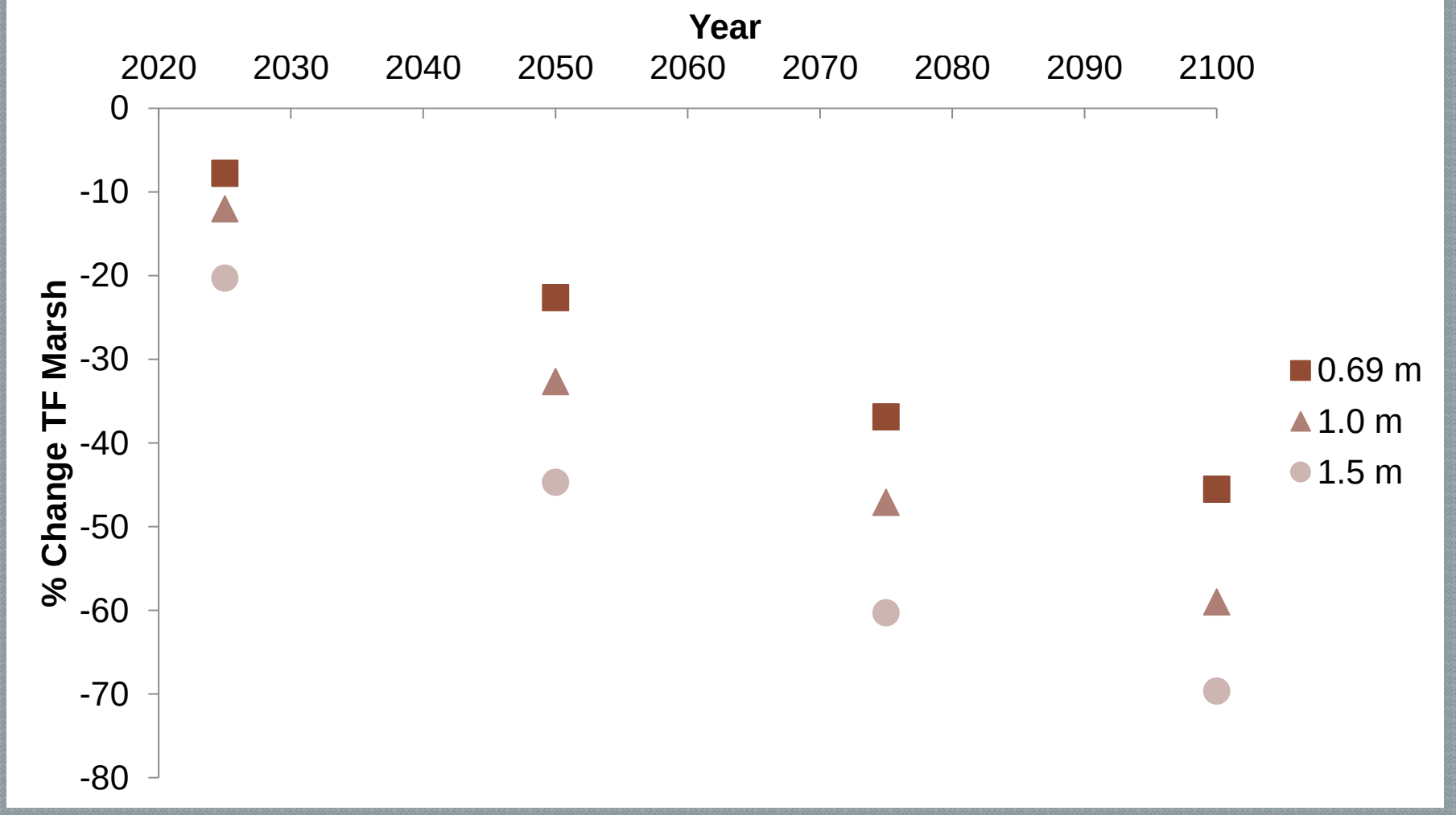


Chesapeake Bay

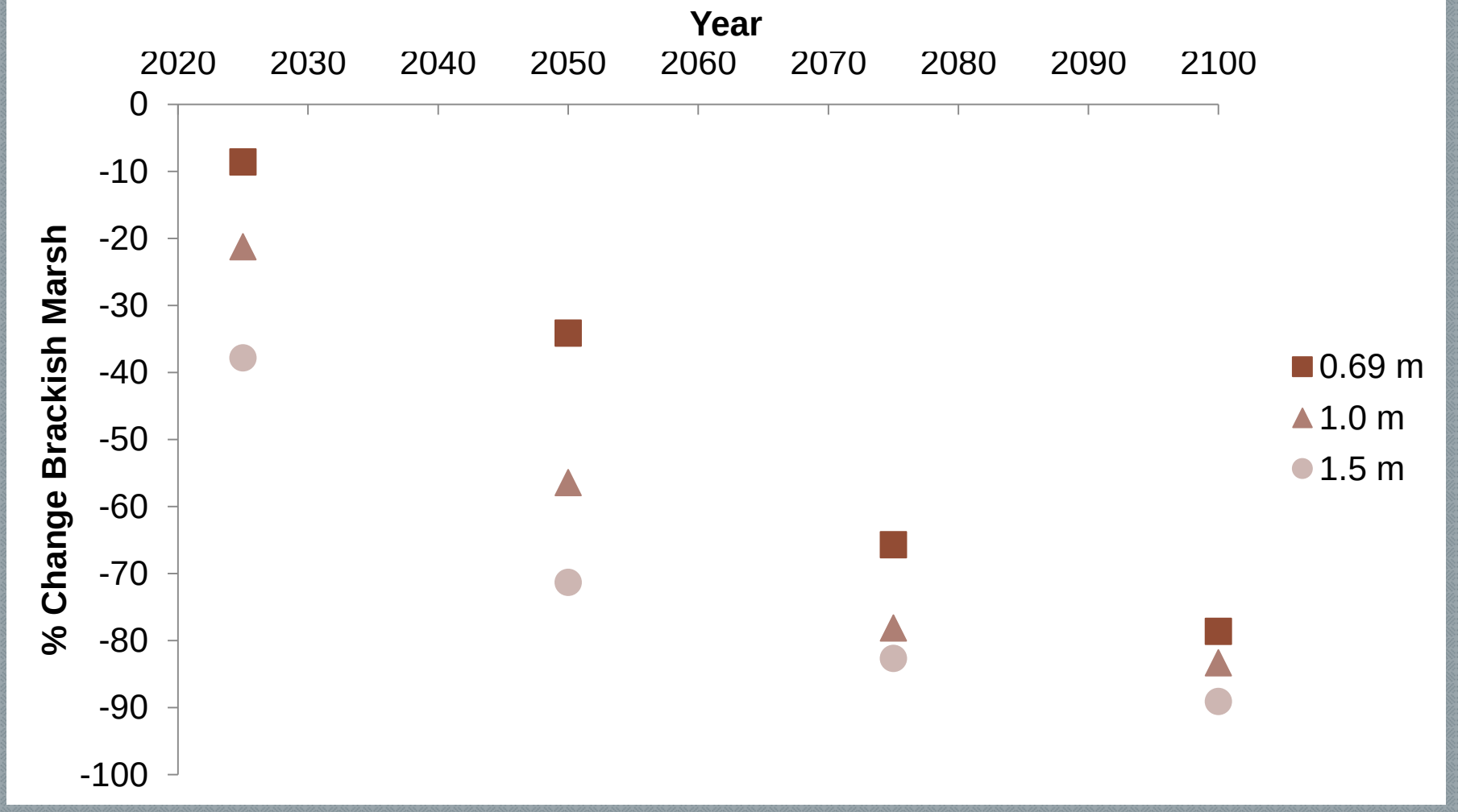
Projected Tidal Wetland Area



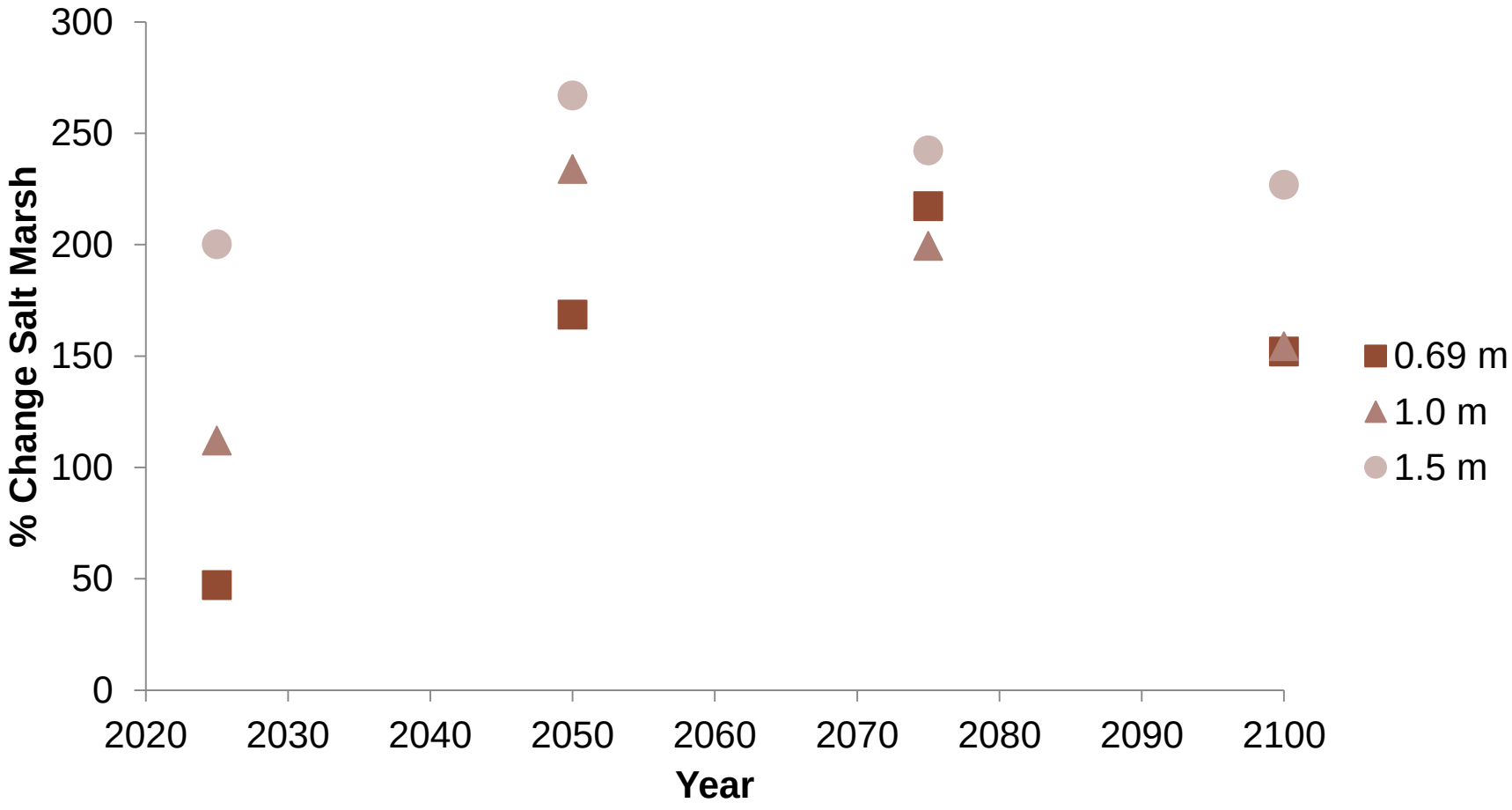
Projected Tidal Fresh Marshes

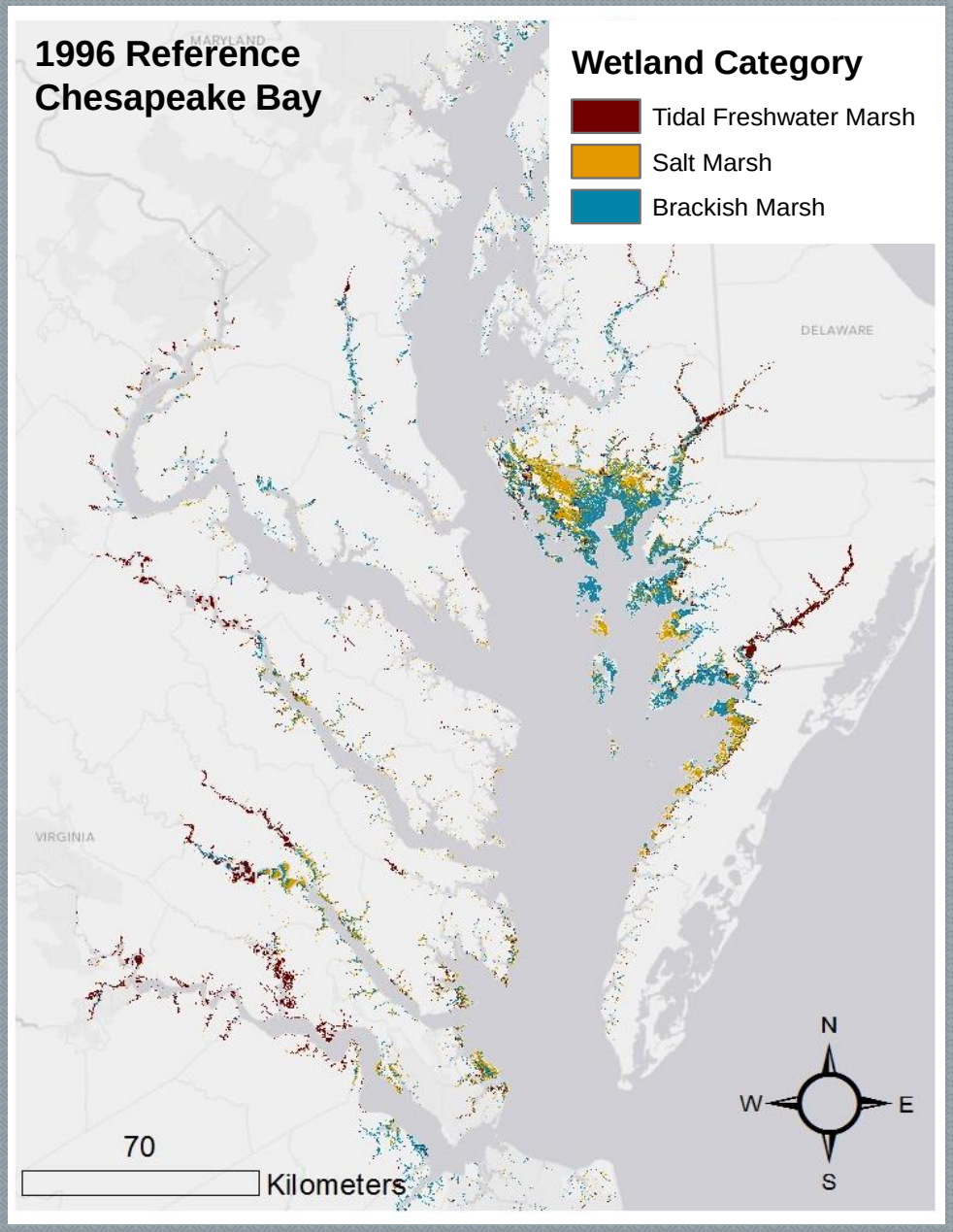


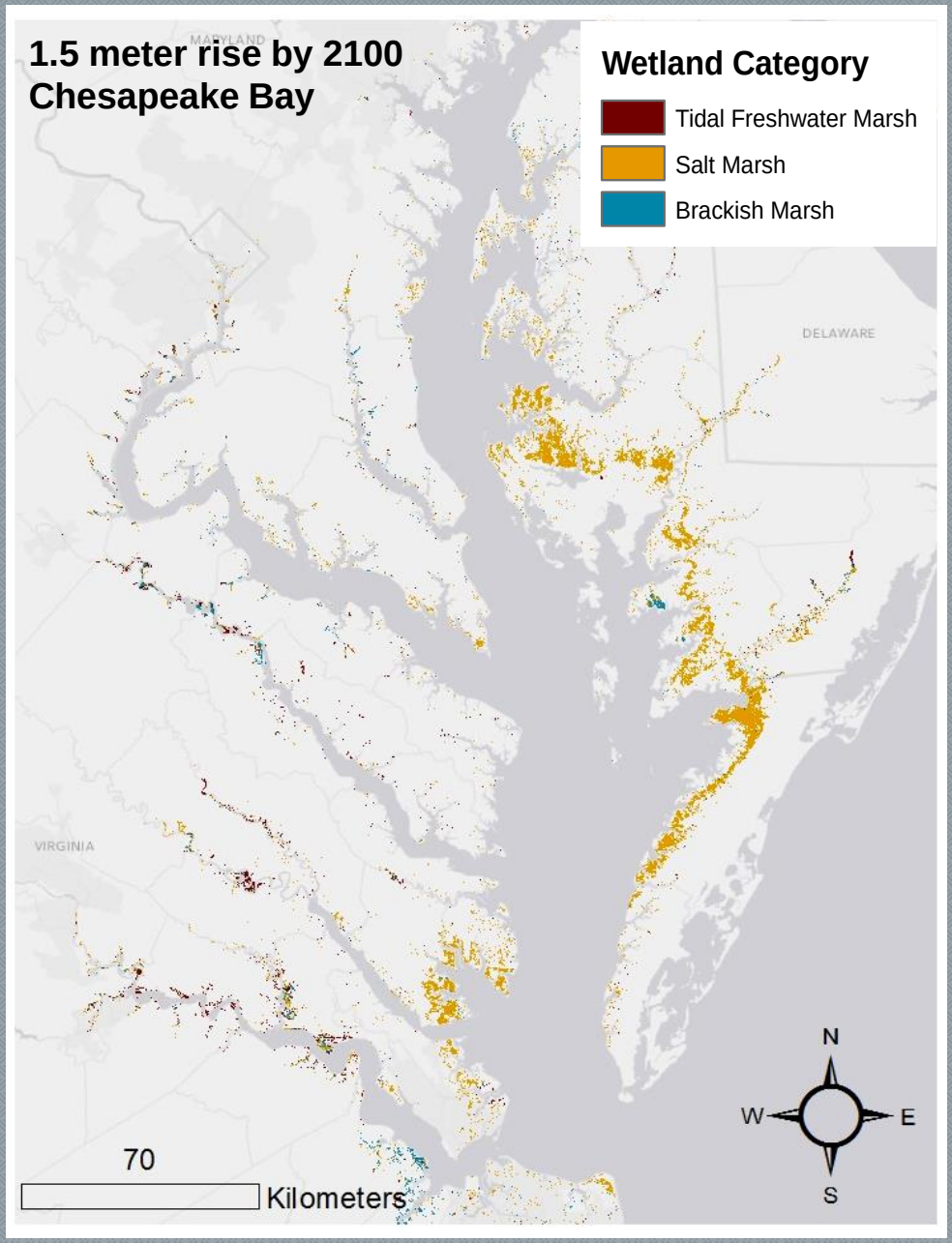
Projected Brackish Marshes



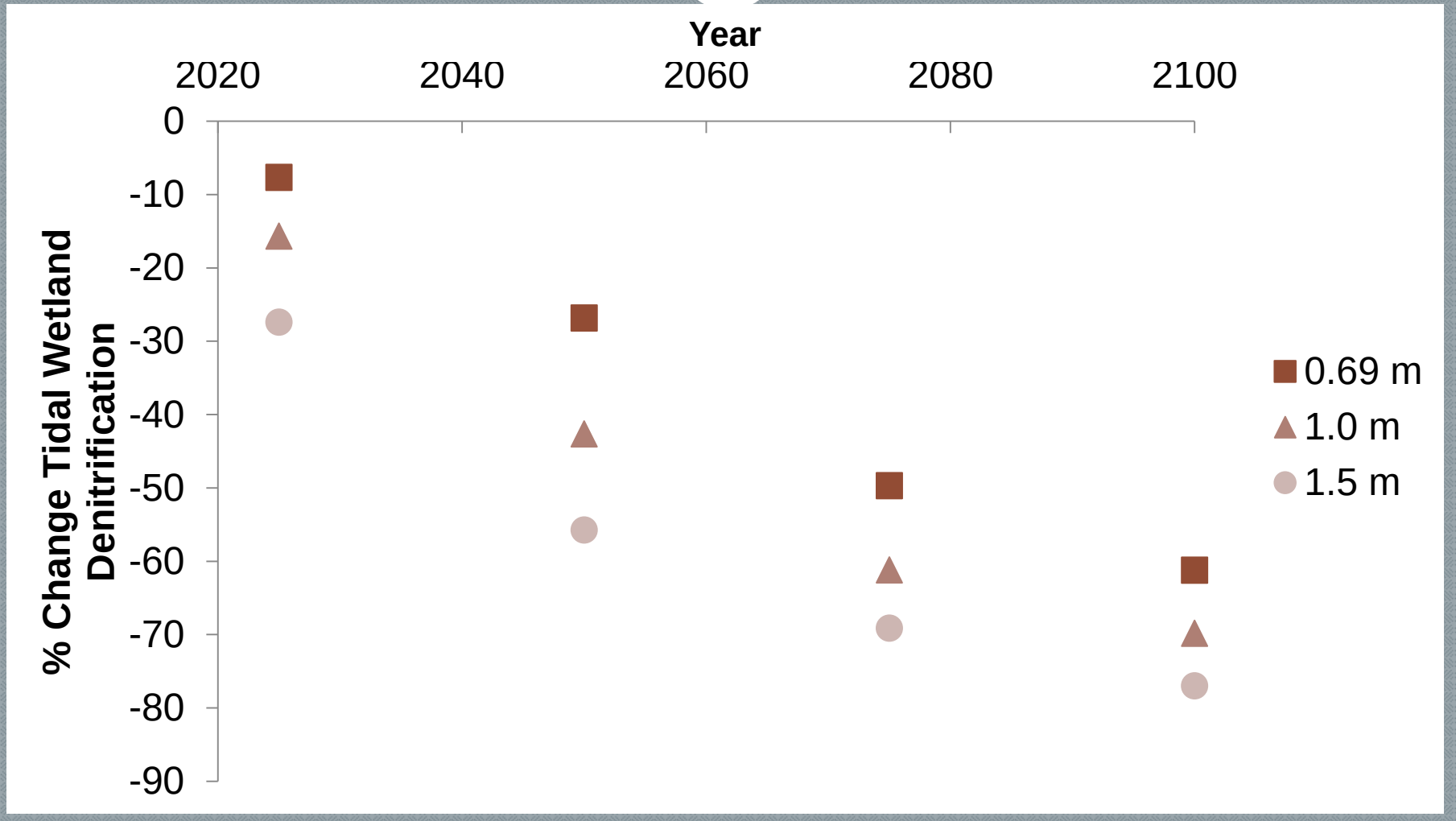
Projected Salt Marshes




1996 Reference
Chesapeake Bay
Wetland Category
Tidal Freshwater Marsh
Salt Marsh
Brackish Marsh
MARYLAND
DELAWARE
VIRGINIA
70
Kilometers
N
W
E
S


1.5 meter rise by 2100
Chesapeake Bay
Wetland Category
Tidal Freshwater Marsh
Salt Marsh
Brackish Marsh
MARYLAND
DELAWARE
VIRGINIA
N
W
E
S
70
Kilometers

Projected Tidal Wetland Denitrification



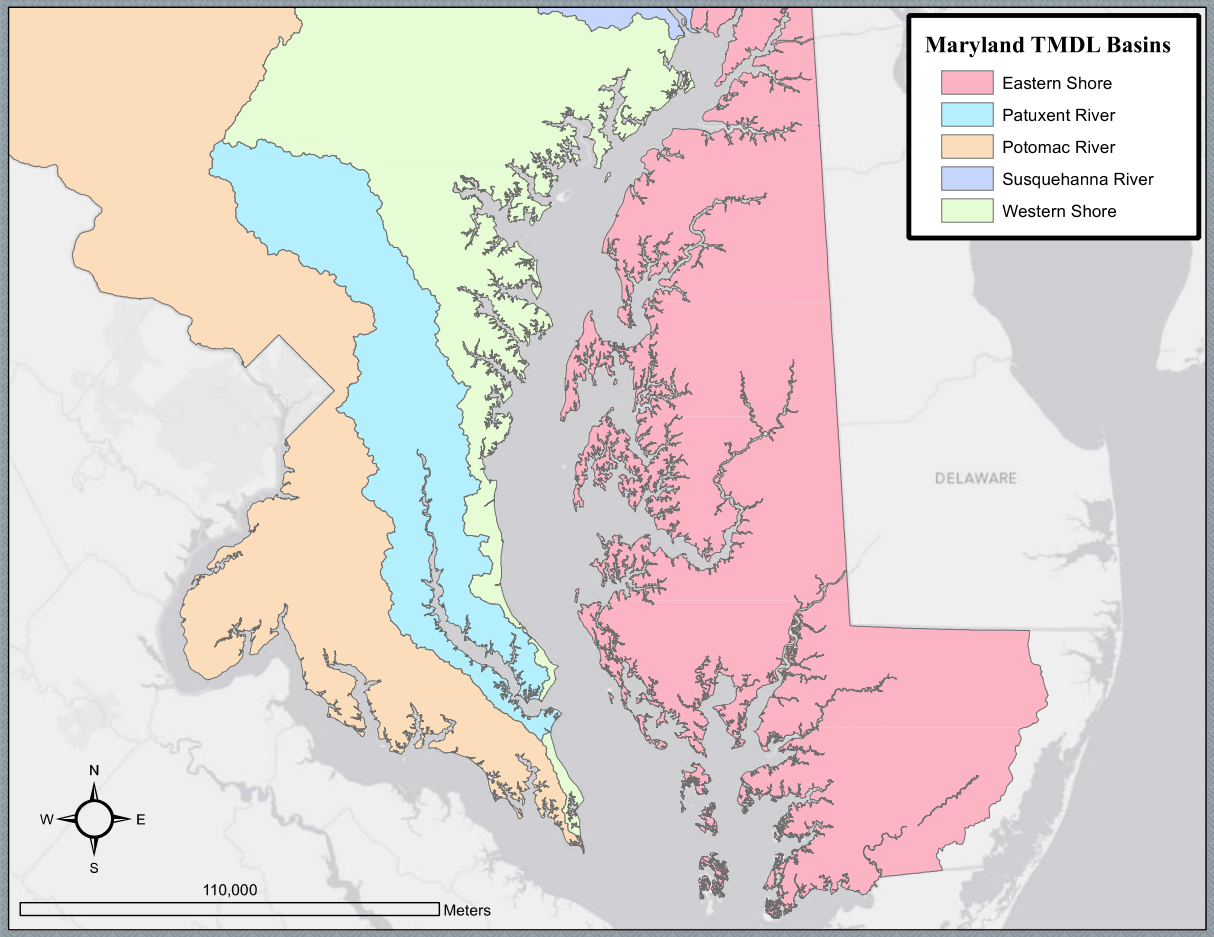
Summary

- Overall:
  - Estimated increase salt marshes, decrease tidal fresh and brackish marshes
  - Estimated decrease in N removal services

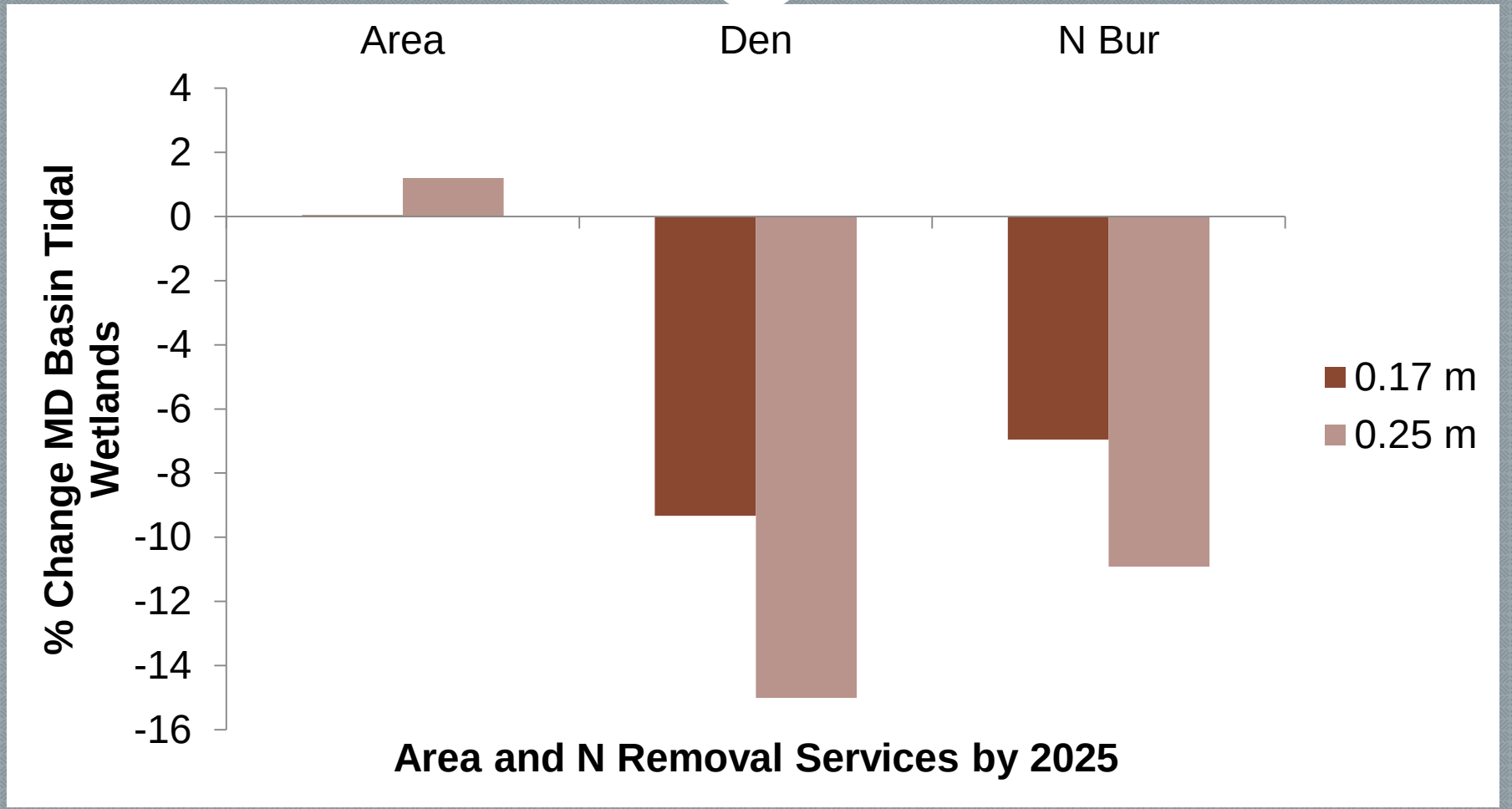
- If salt marshes are increasing, why are N removal services decreasing?
  - Salt water intrusion
  - N removal efficiency
    - Salt denitrification: 0.6 g N m^{-2} yr^{-1}
    - Tidal fresh denitrification: 14.7 g N m^{-2} yr^{-1}

Maryland Major Basins

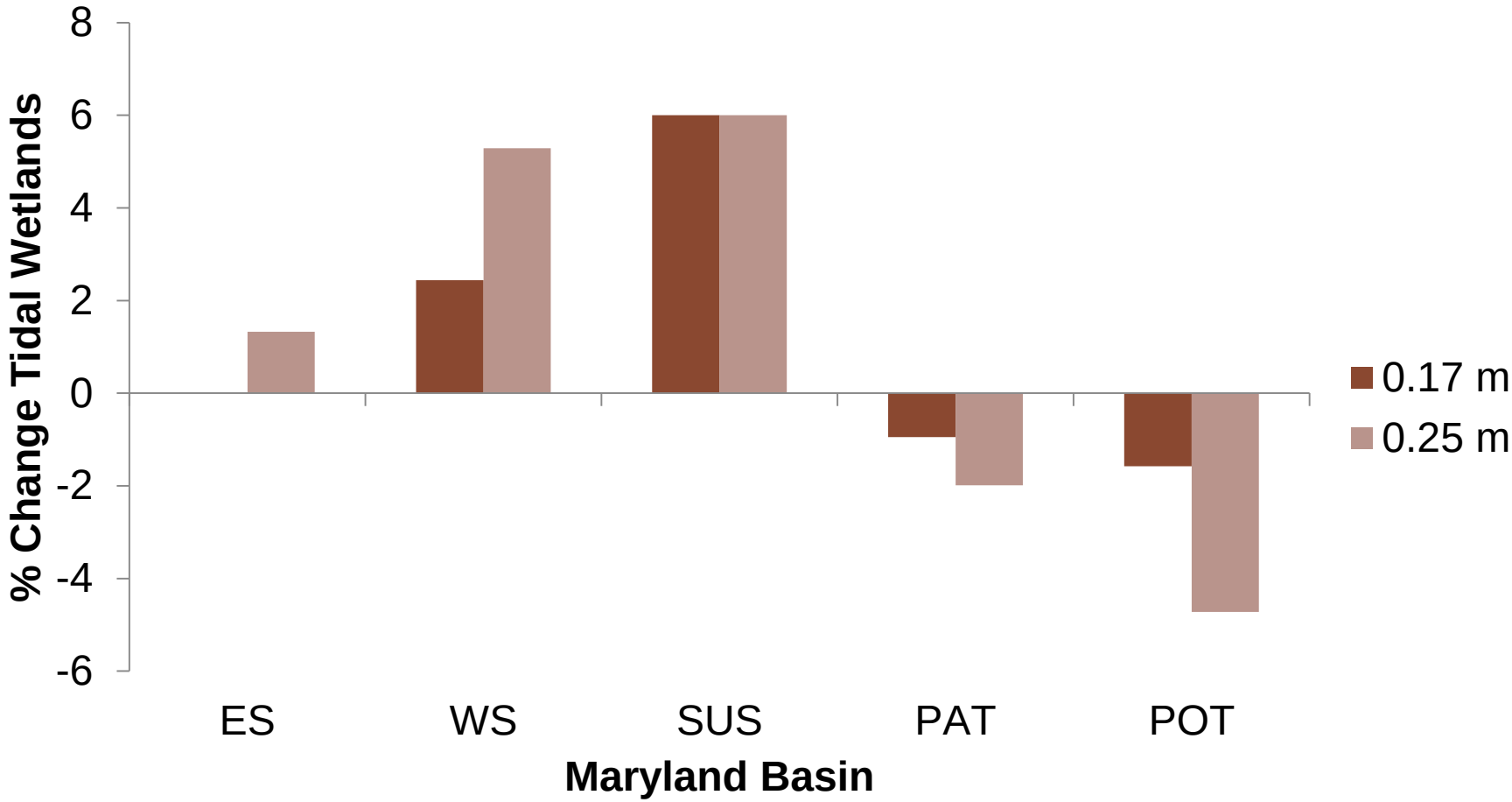
Maryland Major Basins



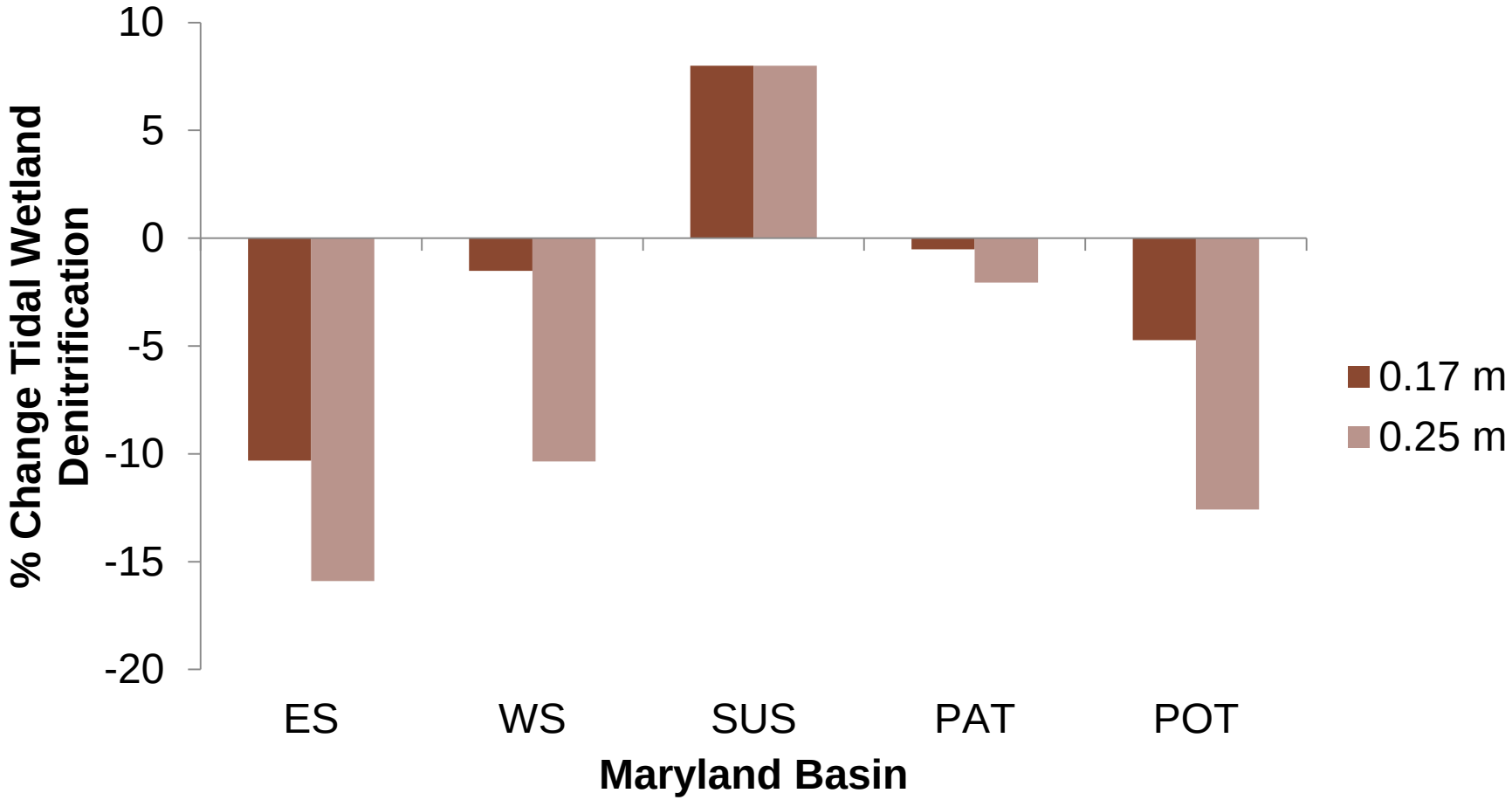
Maryland Major Basins



Maryland Major Basin Tidal Wetlands



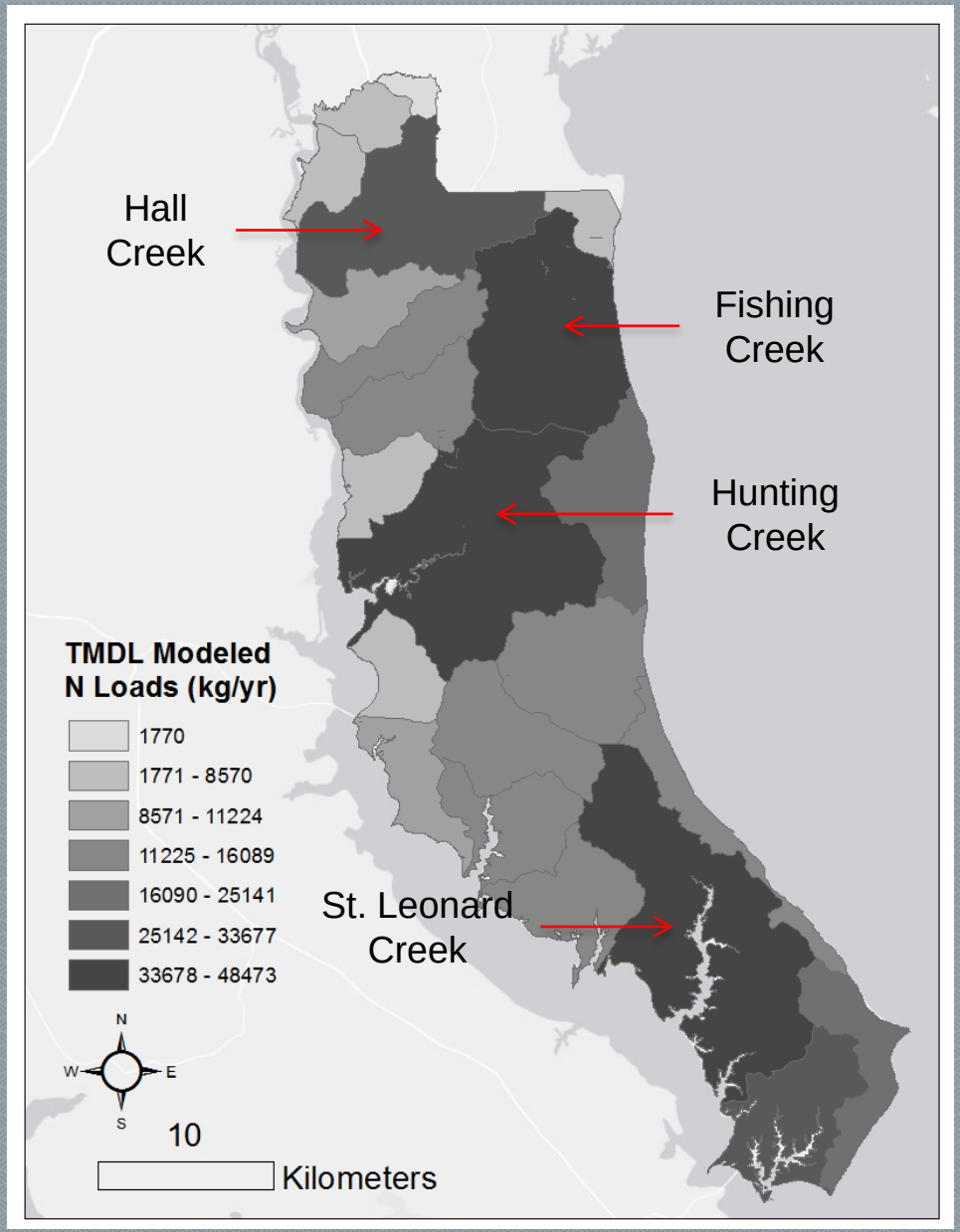
Maryland Basin Denitrification

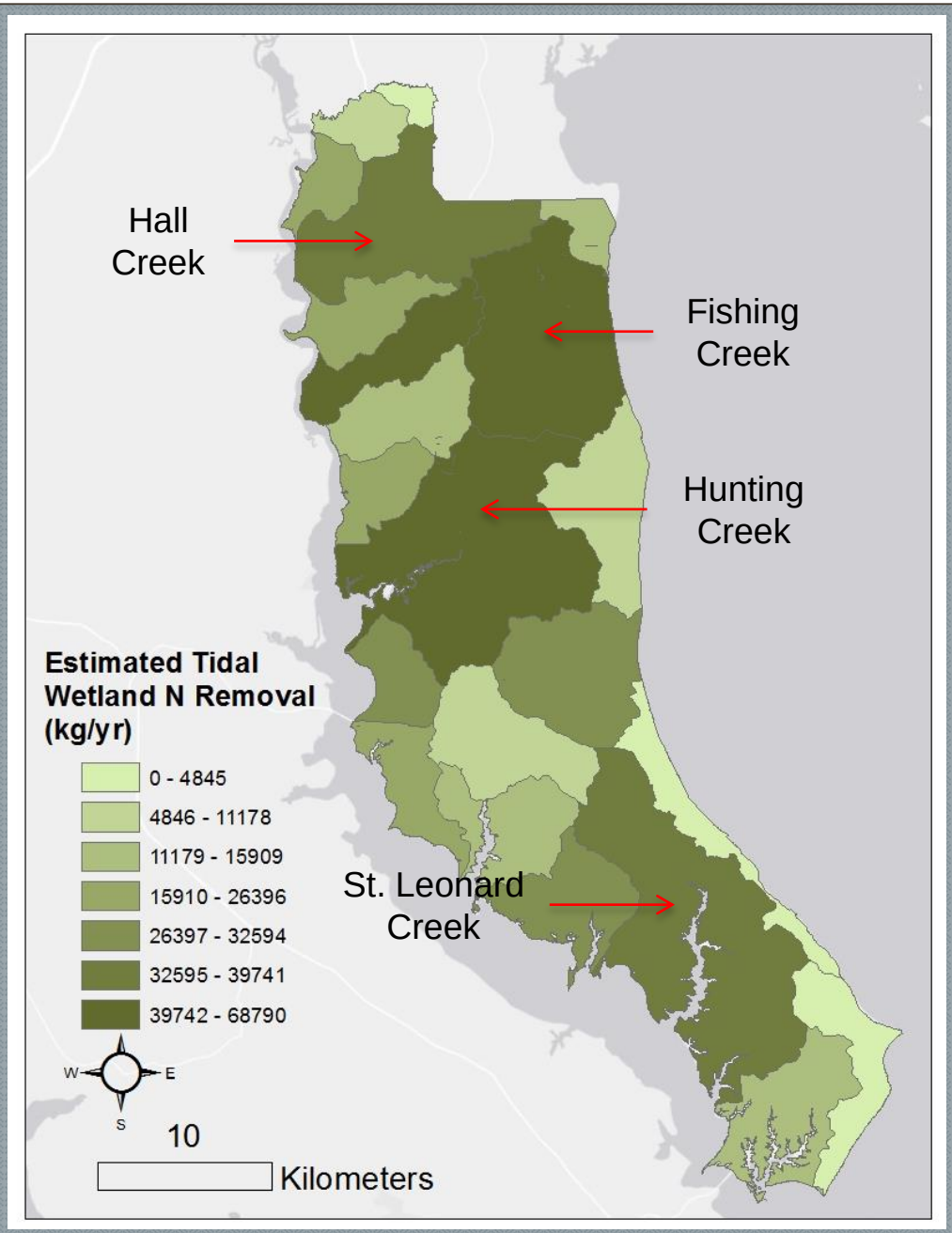


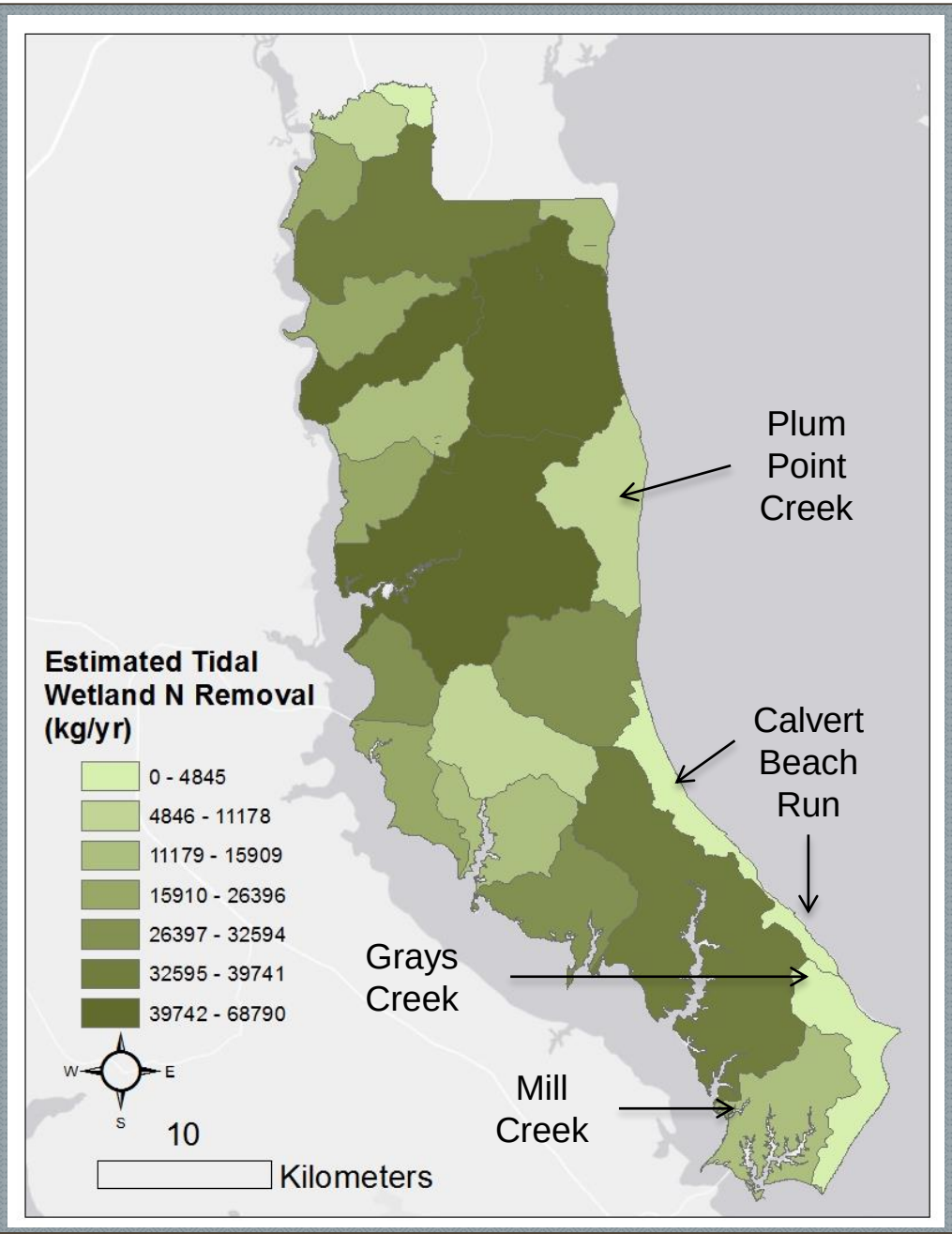
Tidal Wetland N Removal vs. TMDL

- Total estimated N removal for the Maryland basins:
  - ~ 30 billion g N yr^{-1} under 0.25 m rise by 2025
- Total TMDL N allocation for the Maryland basins:
  - 18 billion g N yr^{-1} (USEPA 2010)

Calvert County 12-digit Watersheds


Hall Creek
Fishing Creek
Hunting Creek
St. Leonard Creek
TMDL Modeled N Loads (kg/yr)
1770
1771 - 8570
8571 - 11224
11225 - 16089
16090 - 25141
25142 - 33677
33678 - 48473
N
W
E
S
10
Kilometers


Hall Creek
Fishing Creek
Hunting Creek
St. Leonard Creek
Estimated Tidal Wetland N Removal (kg/yr)
0 - 4845
4846 - 11178
11179 - 15909
15910 - 26396
26397 - 32594
32595 - 39741
39742 - 68790
W
E
S
10
Kilometers


Plum Point Creek
Calvert Beach Run
Grays Creek
Mill Creek
Estimated Tidal Wetland N Removal (kg/yr)
0 - 4845
4846 - 11178
11179 - 15909
15910 - 26396
26397 - 32594
32595 - 39741
39742 - 68790
W
E
S
10
Kilometers

Conclusions

- Tidal wetlands provide a natural buffer against nitrogen pollution
- Estimates suggest little change by 2025 due to projected SLR
  - Maryland restoration goals – how are tidal wetlands indirectly incorporated into these?
- Tidal wetlands may not fare as well under long term SLR
- Concerns: Salt water intrusion and barriers to migration
- Thesis work did compare conversion of wetland to subtidal sediment removal rates and found that wetland services were high relative to subtidal.

Assumptions and Uncertainty

- SLAMM has limits & shortcomings, is not mechanistic:
  - No mass balance of solids (sediments disappear)
  - Assumes linear changes over time
  - Underlying datasets – bathymetry to topography – causes uncertainty
- N removal assumptions:
  - Rates of denitrification and burial constant in space and time for a given wetland type
  - Not a function of N availability
  - Could submerged wetlands have higher denitrification rates than subtidal sediments?

Next Steps

- Areas of uncertainty can be identified where spatial resolution results in unrealistic predictions
- More subwatershed scale analyses possible.
- Extend to entire Chesapeake Bay
- Could be re-done with updated SLAMM or other inundation maps
- Finer scale elevation data would allow for some finer scale resolution of denitrification and burial rates
- Empirical relationships with NO3 availability may be possible to futher fine tune denitrification rates
- Could be extended to phosphorus