Infrastructure reliability and the burden of sea-level rise: Do current planning metrics capture the correct risk?

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THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

UMD Center for Disaster Resilience

Hazard Assessment

Risk in the built environment

Disaster finance and policy

Infrastructure Adaptation

Water Quality, Outreach and Wellness (WOW) Lab

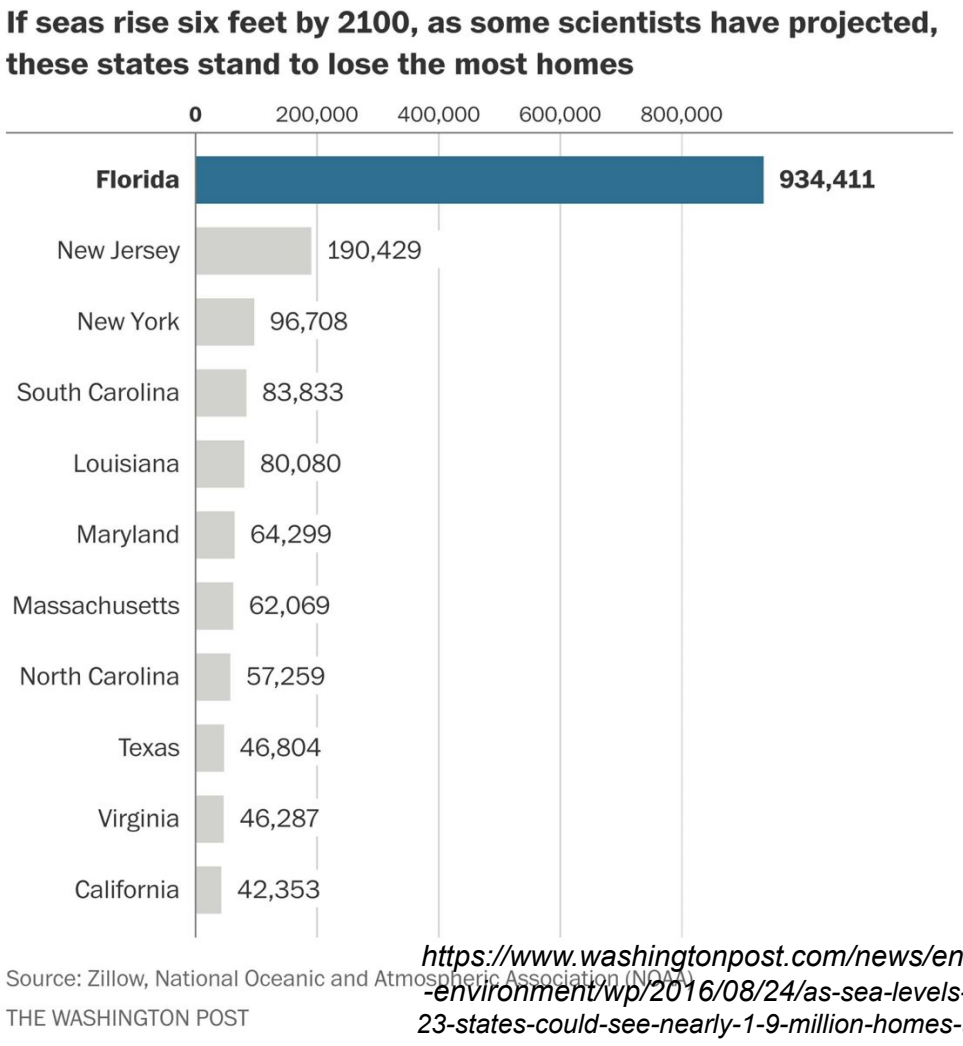
Center for Democracy and Civic Engagement

Center for Values in AI (Info. Studies)

CATT Lab and Maryland Transportation Institute

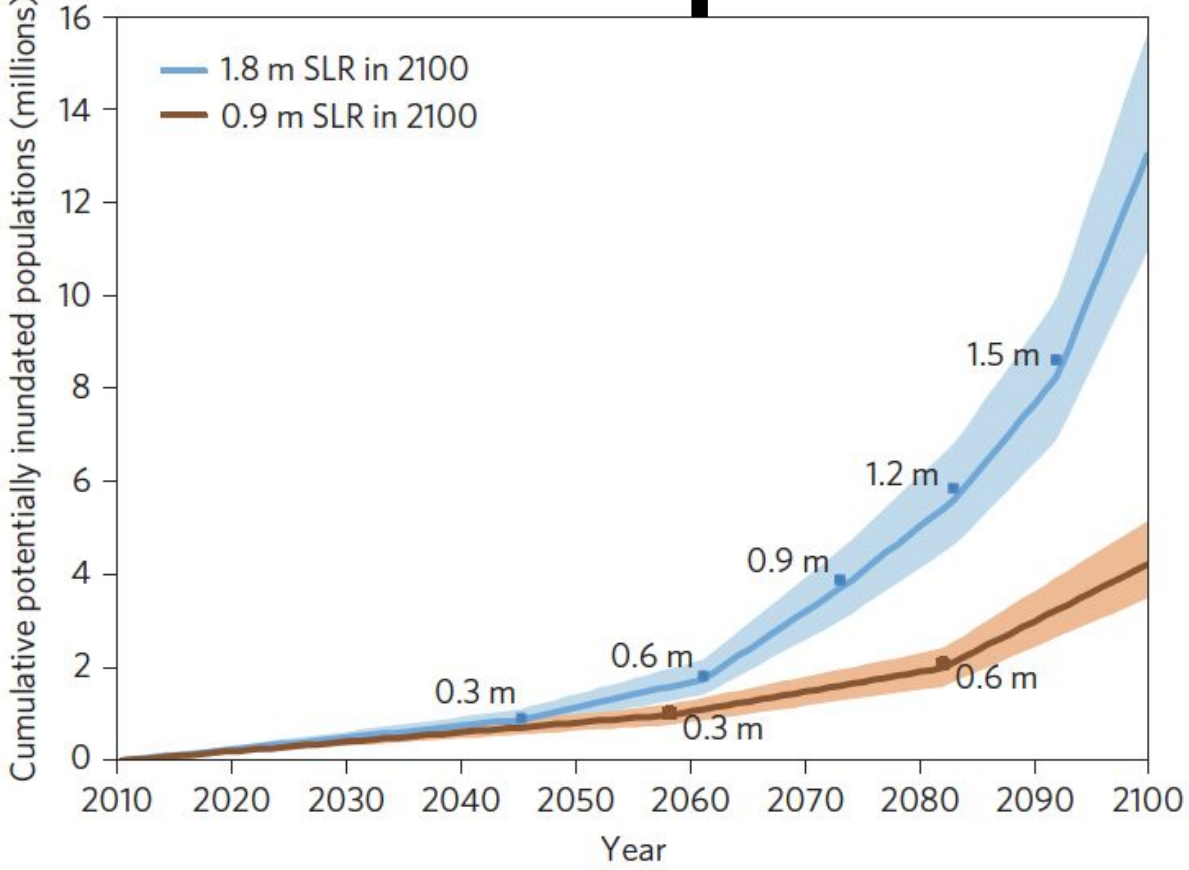
Center for Global Sustainability (School of Public Policy)

Sea-level rise may inundate 1M+ homes in the US by 2100



https://www.washingtonpost.com/news/energy-environment/wp/2016/08/24/as-sea-levels-rise-23-states-could-see-nearly-1-9-million-homes-underwater/

...and force displacement of millions more



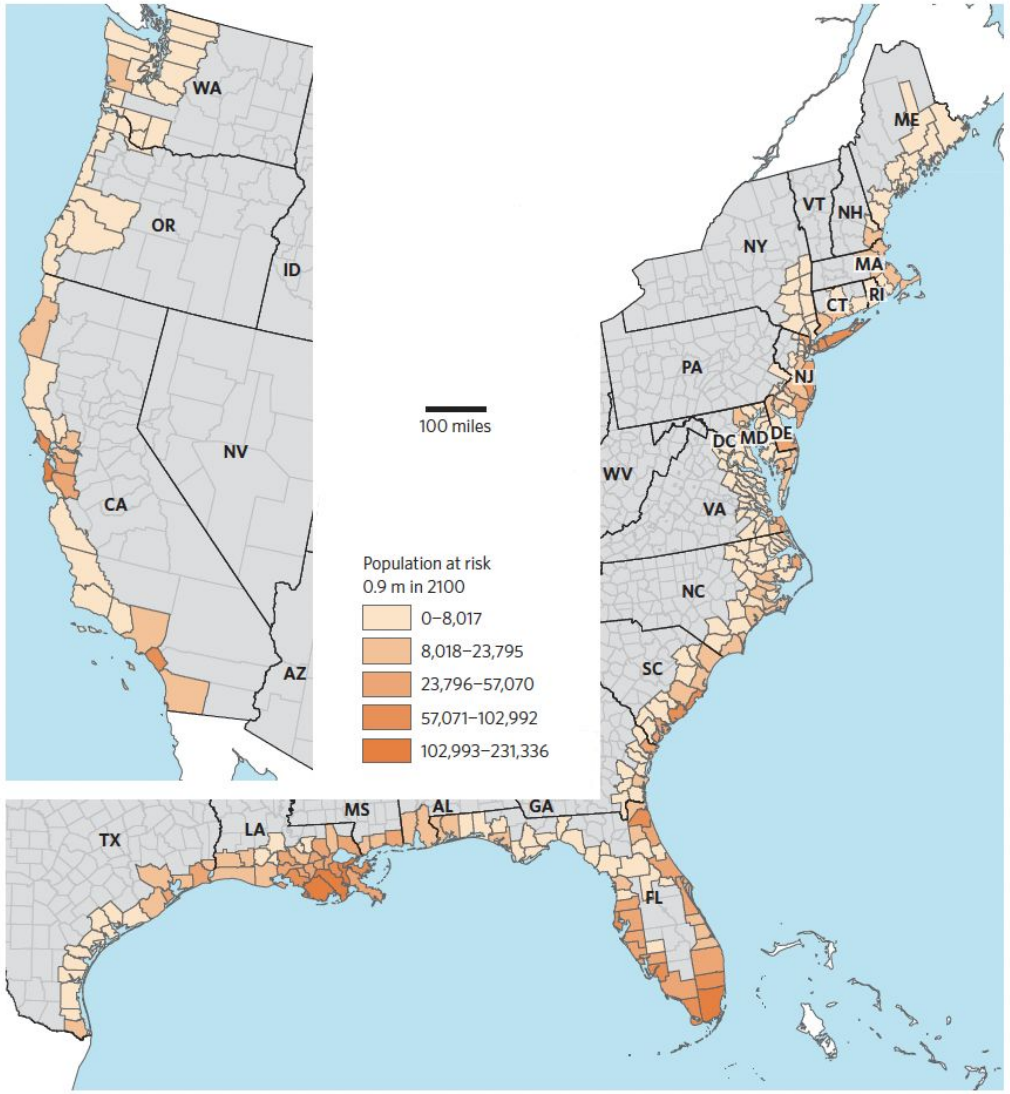


Figure 1 | Cumulative projected at-risk populations for the continental United States, 2010–2100. Projections reflect assumed growth/decline rates for 72,664 census block groups in 319 coastal counties. The shading indicates the 90% confidence interval of the projection models.

Hauer, M. E., Evans, J. M., & Mishra, D. R. (2016). Millions projected to be at risk from sea-level rise in the continental United States. *Nature Climate Change*, *6*(7), 691-695.

Sea-level rise (SLR) will have widespread impacts on infrastructure and communities

What do we miss when we plan only for housing inundation?

- SLR will significantly affect forms of infrastructure other than housing
  - Transportation networks
  - Emergency management
  - Water and wastewater
  - …
- What inundation means for provision of service (beyond housing) is hardly understood
- Burden is not felt evenly, even if hazard exposure is even

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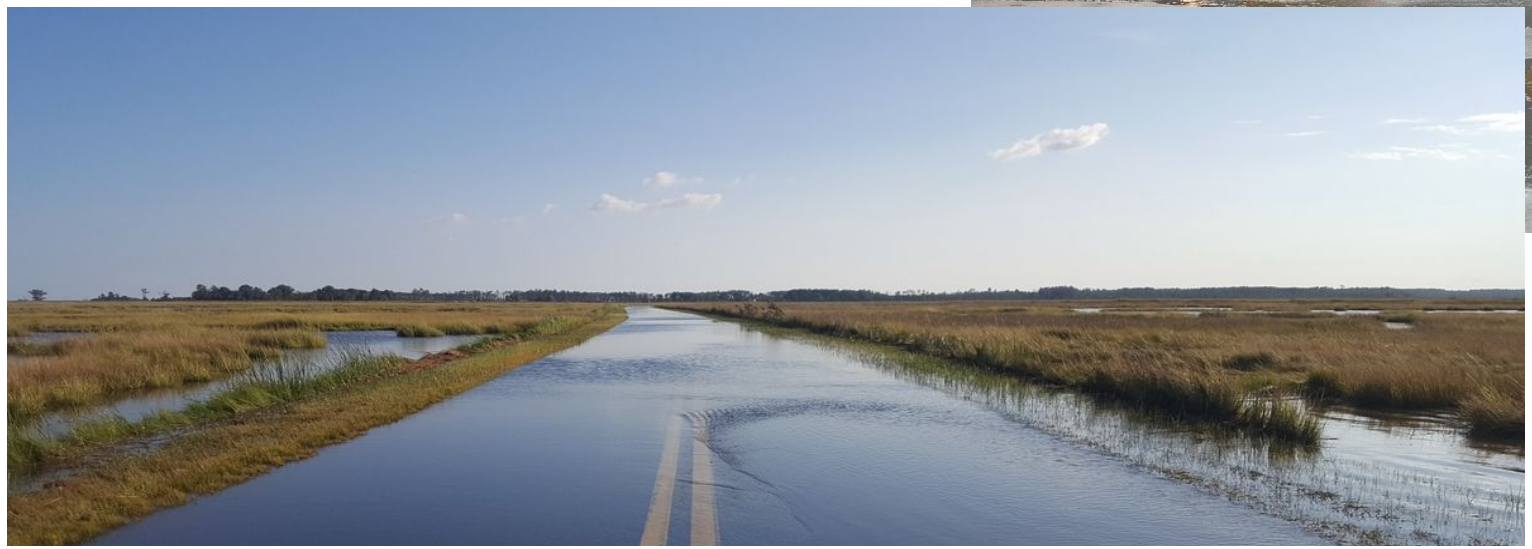
Transportation burden of SLR: Maryland

- 3,700 miles of roadway will be inundated by 5′ of SLR
- Pavement depth > 6′ in parts of Eastern Shore
- Reports of chronic rust and vehicle damage
- Discussion of asset decommissioning



What will loss of roadways mean for residents?

Isolation and the burden of sea-level rise

Isolation is the inability to travel your destination due to flooding

- Reduces **economic, social, and civic opportunities** (e.g., jobs, schools, voting)
- Reduces ability to receive urgent and routine medical care and other emergency services
- Makes region less desirable location, thus suppressing property values, tax base, etc.
- Makes co-located horizontal infrastructure less reliable

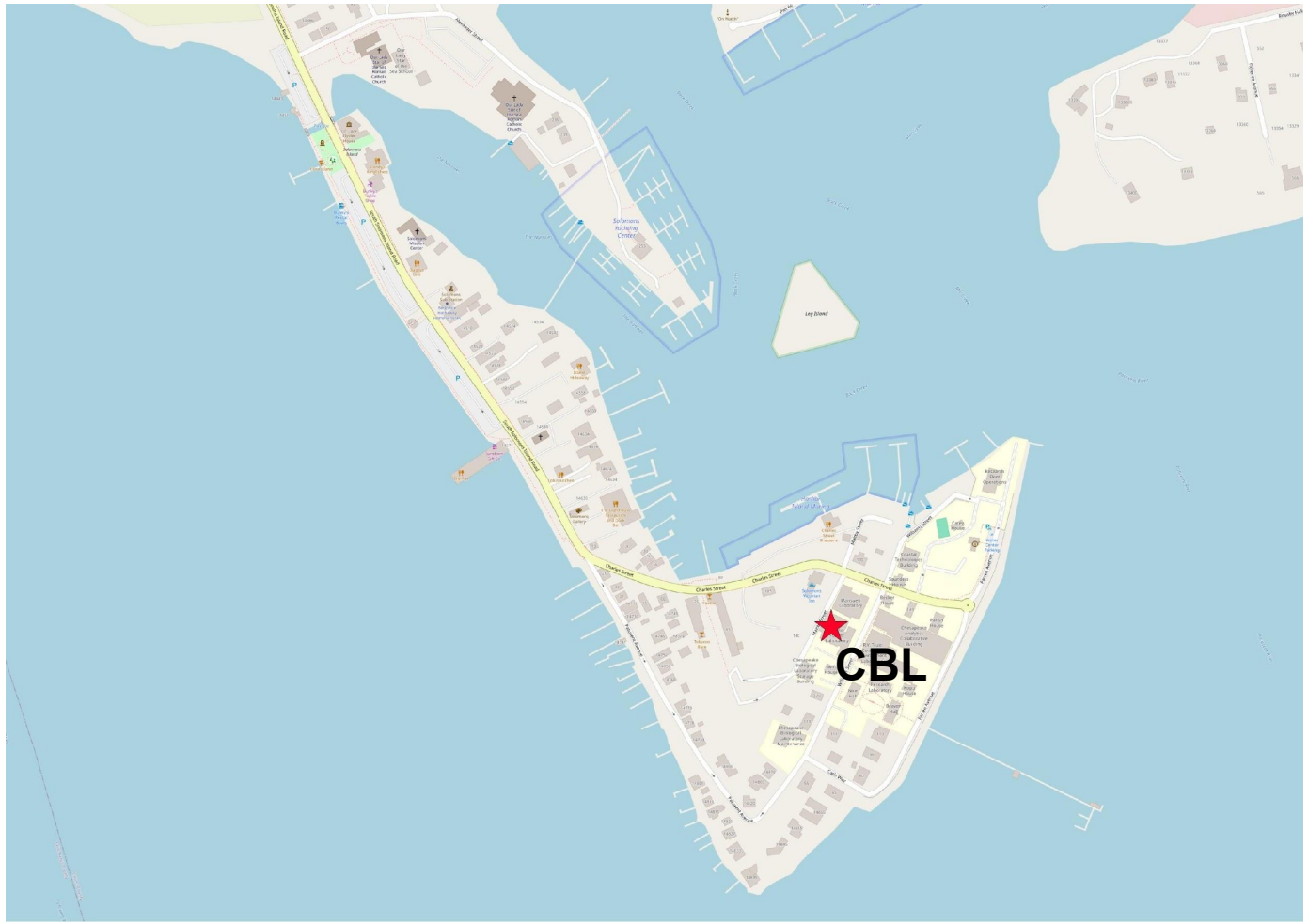
What can this look like?

Isolation is the inability to travel your destination due to flooding

Current day

What can this look like?

Isolation is the inability to travel your destination due to flooding



Current day

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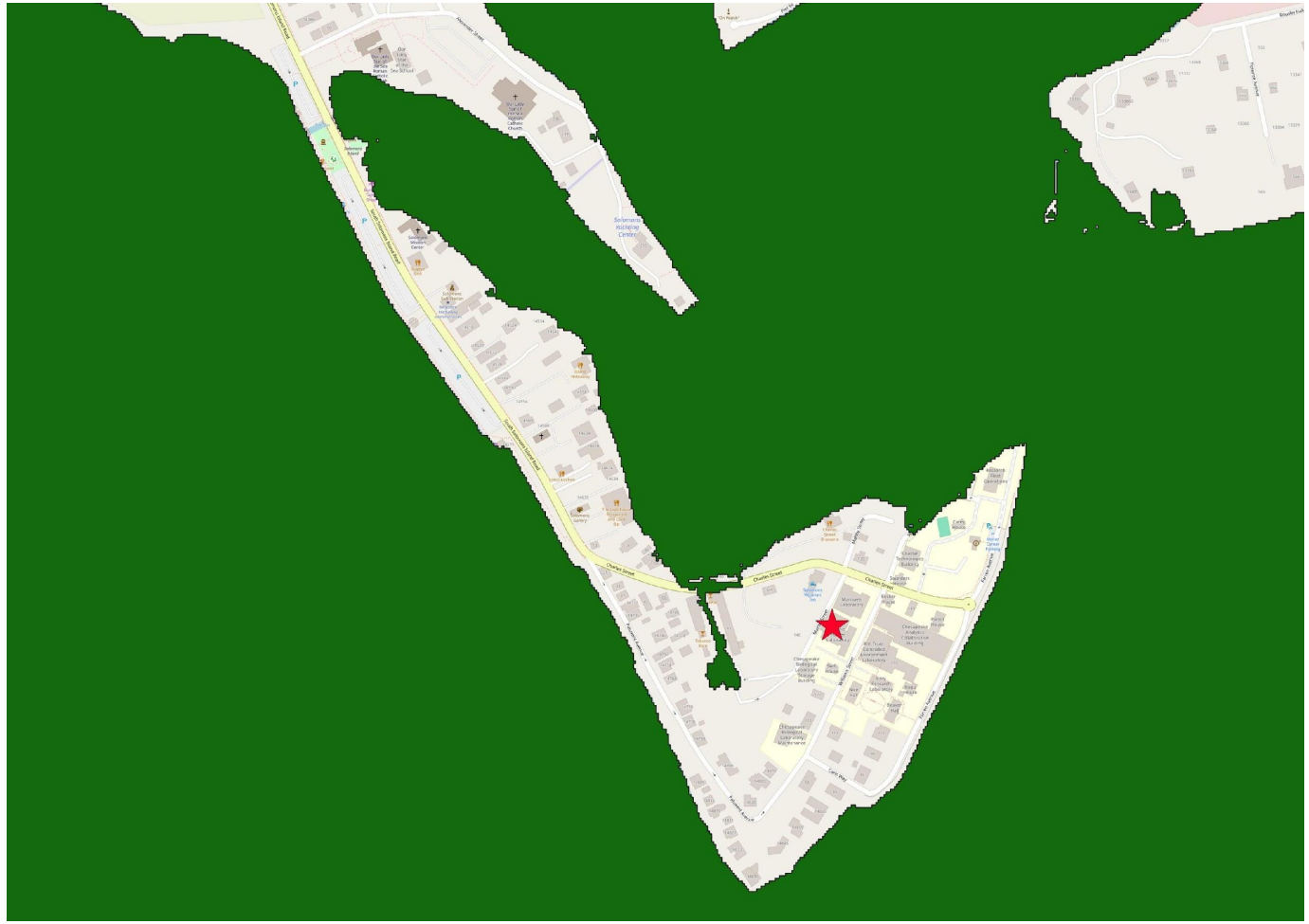
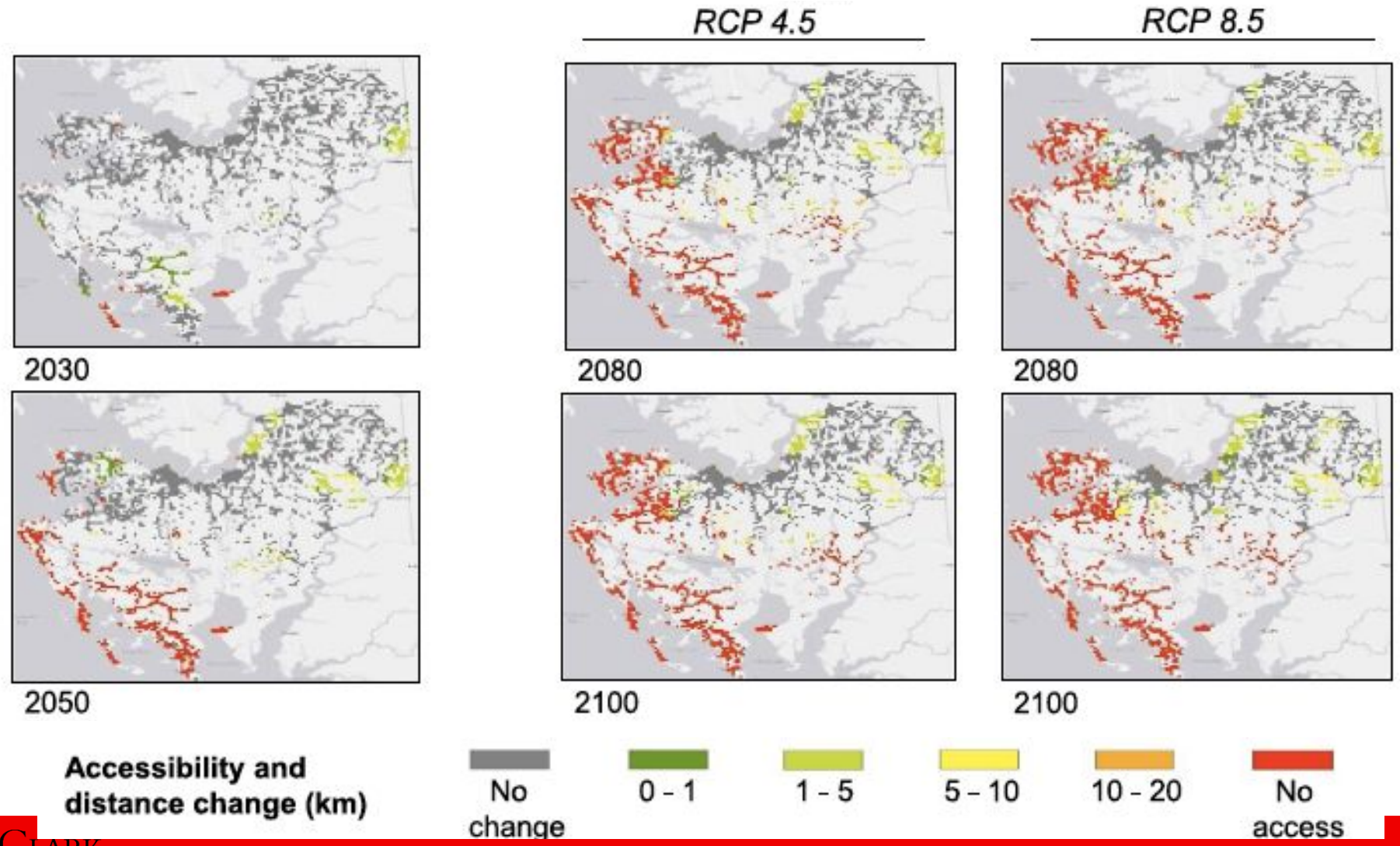


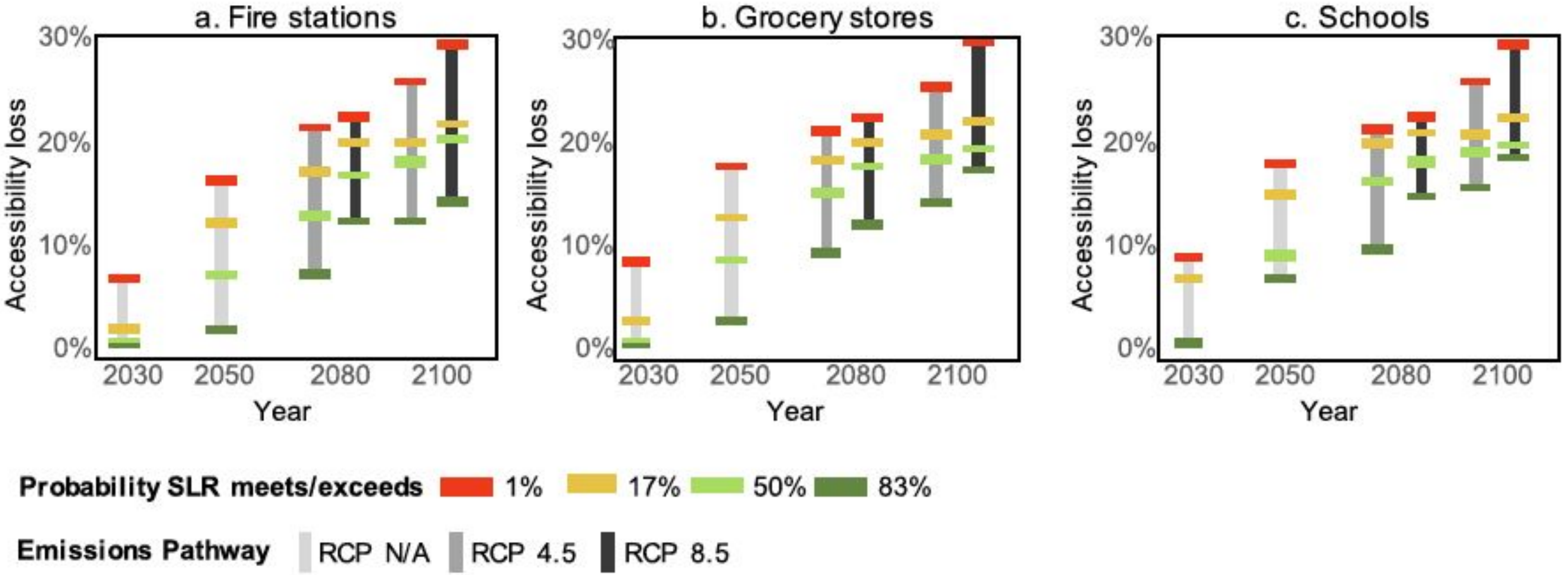
2' SLR

Dorchester County: Isolation

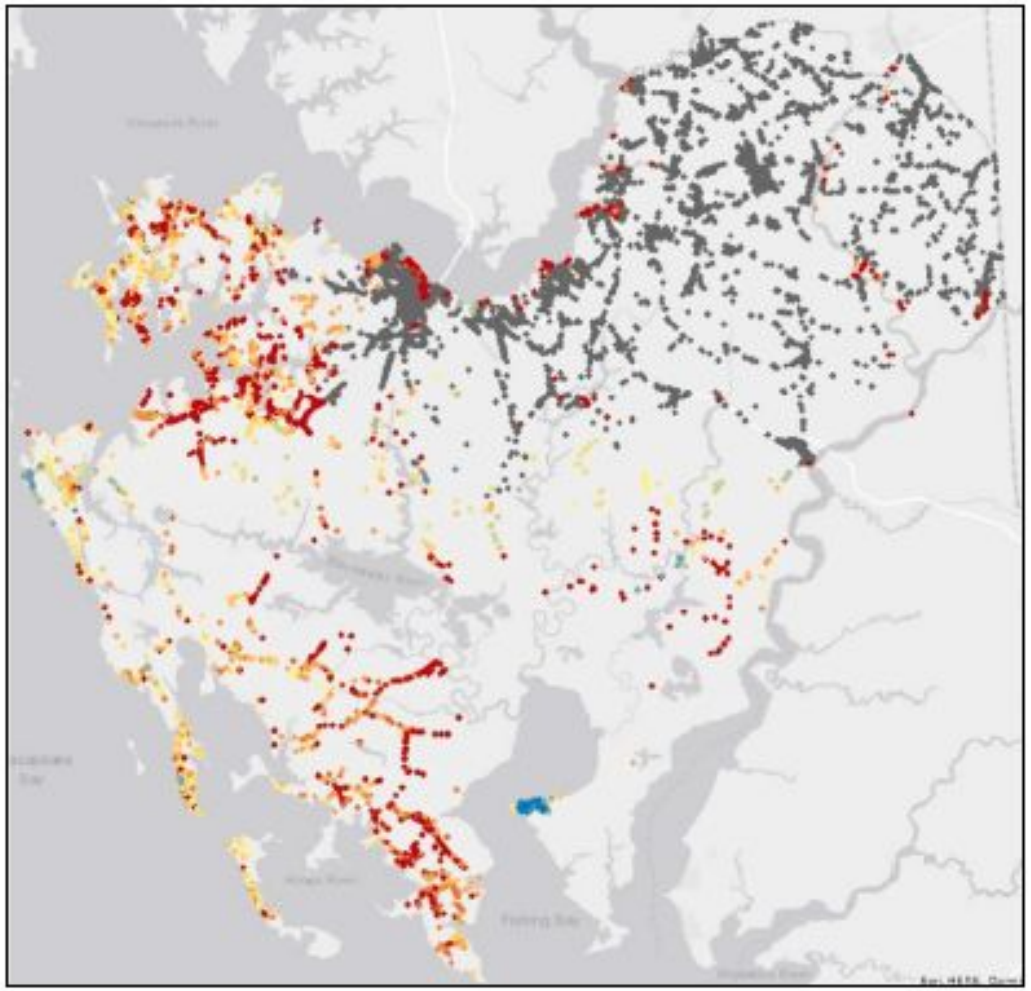
17% Exceedance Probability for RSLR



Dorchester County: Distribution of isolation



Dorchester County: Time between isolation and inundation



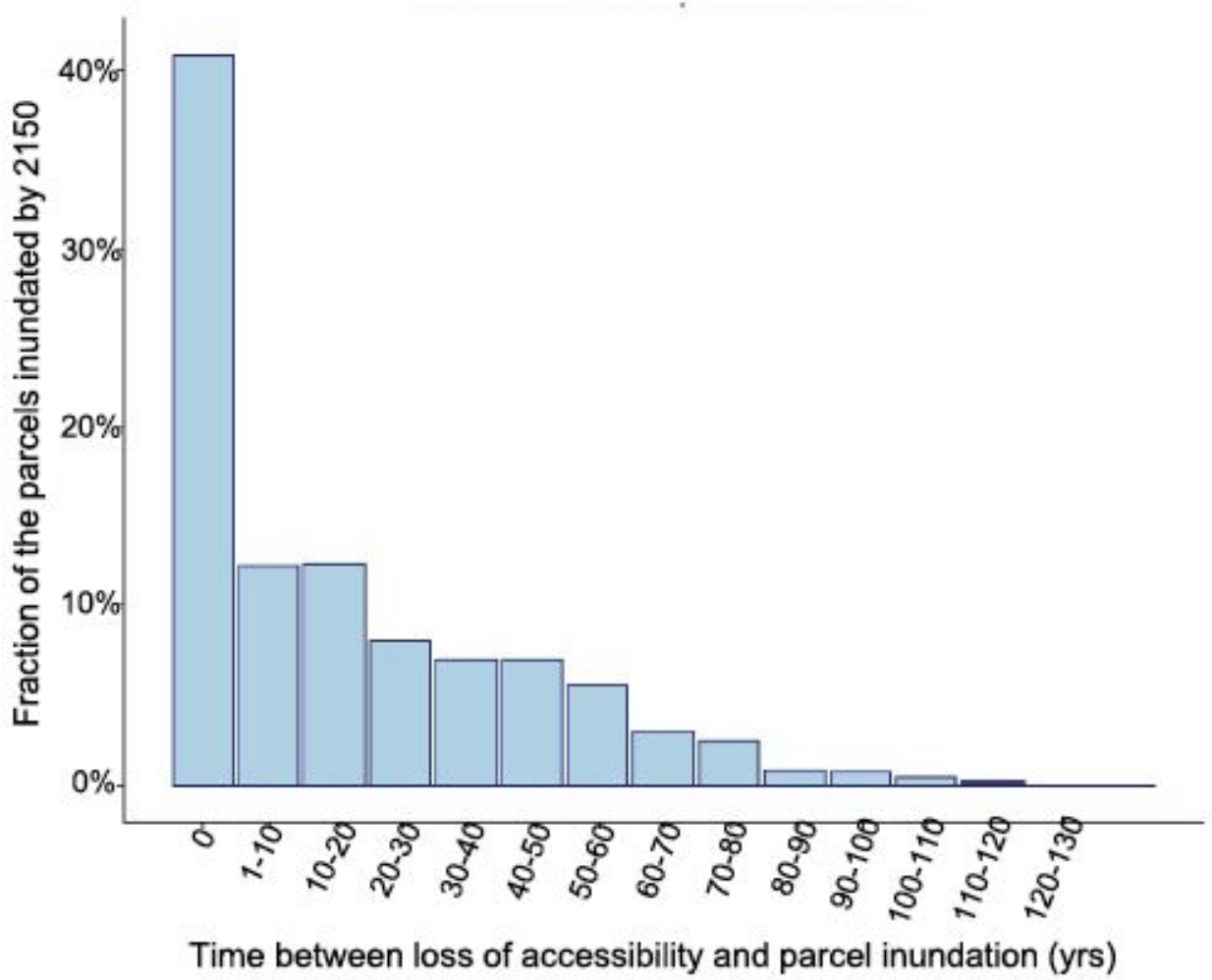
Years between parcel is inundated and loses accessibility to any fire station

- 0
- 40
- 130

Parcels that are not inundated by 2150

Parcels that are inundated before losing accessibility

Dorchester County: Time between isolation and inundation



Jasour, Z. Y., Reilly, A. C., Tonn, G. L., & Ferreira, C. M. (2022). Roadway flooding as a bellwether for household retreat in rural, coastal regions vulnerable to sea-level rise. *Climate Risk Management*, *36*, 100425.

Dorchester County: What do we protect?

M1: Accessibility gain

Total flooded road: 403,776 m
Accessibility gain: 385 parcels

M2: GINI

Total flooded road: 403,416 m
Accessibility gain: 384 parcels

M3: ATK, $\varepsilon = 0.25$

Total flooded road: 403,974 m
Accessibility gain: 349 parcels

M4: ATK, $\varepsilon = 0.75$

Total flooded road: 403,328 m
Accessibility gain: 89 parcels

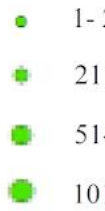
M5: Balanced

Total flooded road: 403,113 m
Accessibility gain: 52 parcels

M6: Balanced Vul/Non-

Total flooded road: 403,577 m
Accessibility gain: 384 parcels

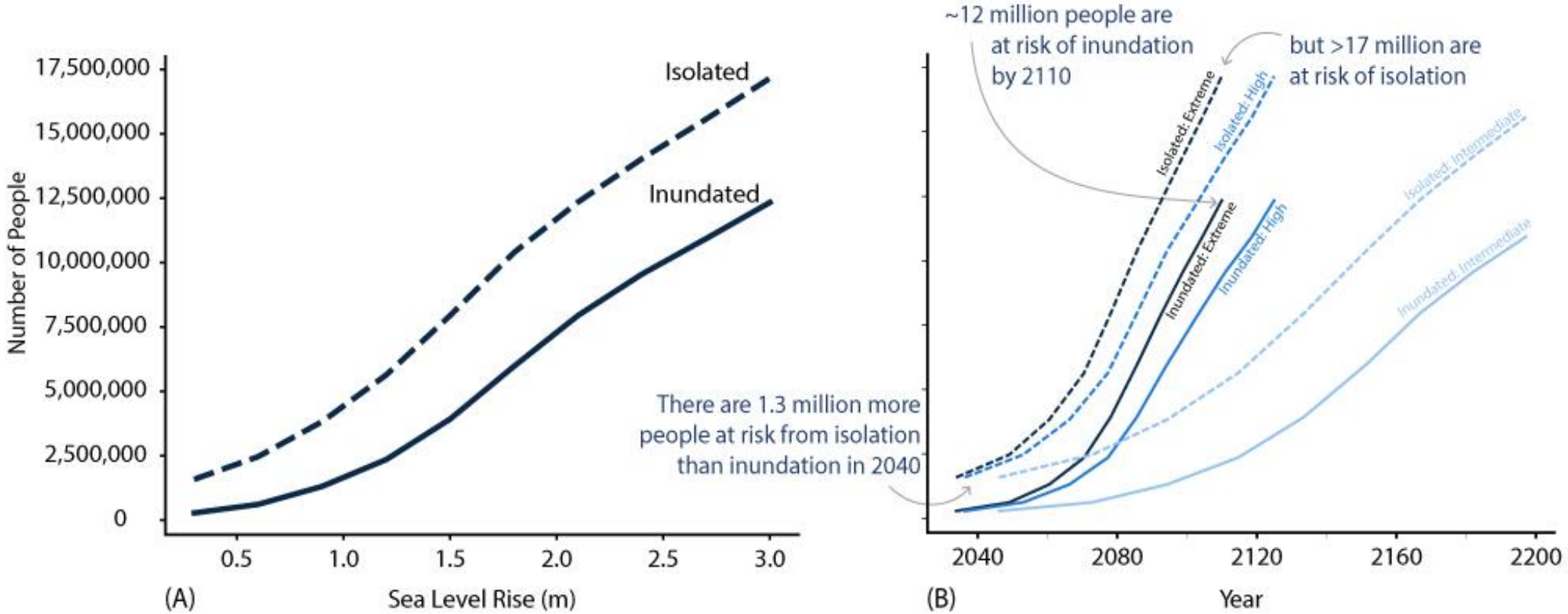
Parcels that maintained their access as a result of protection



Coastal US: Isolation and inundation

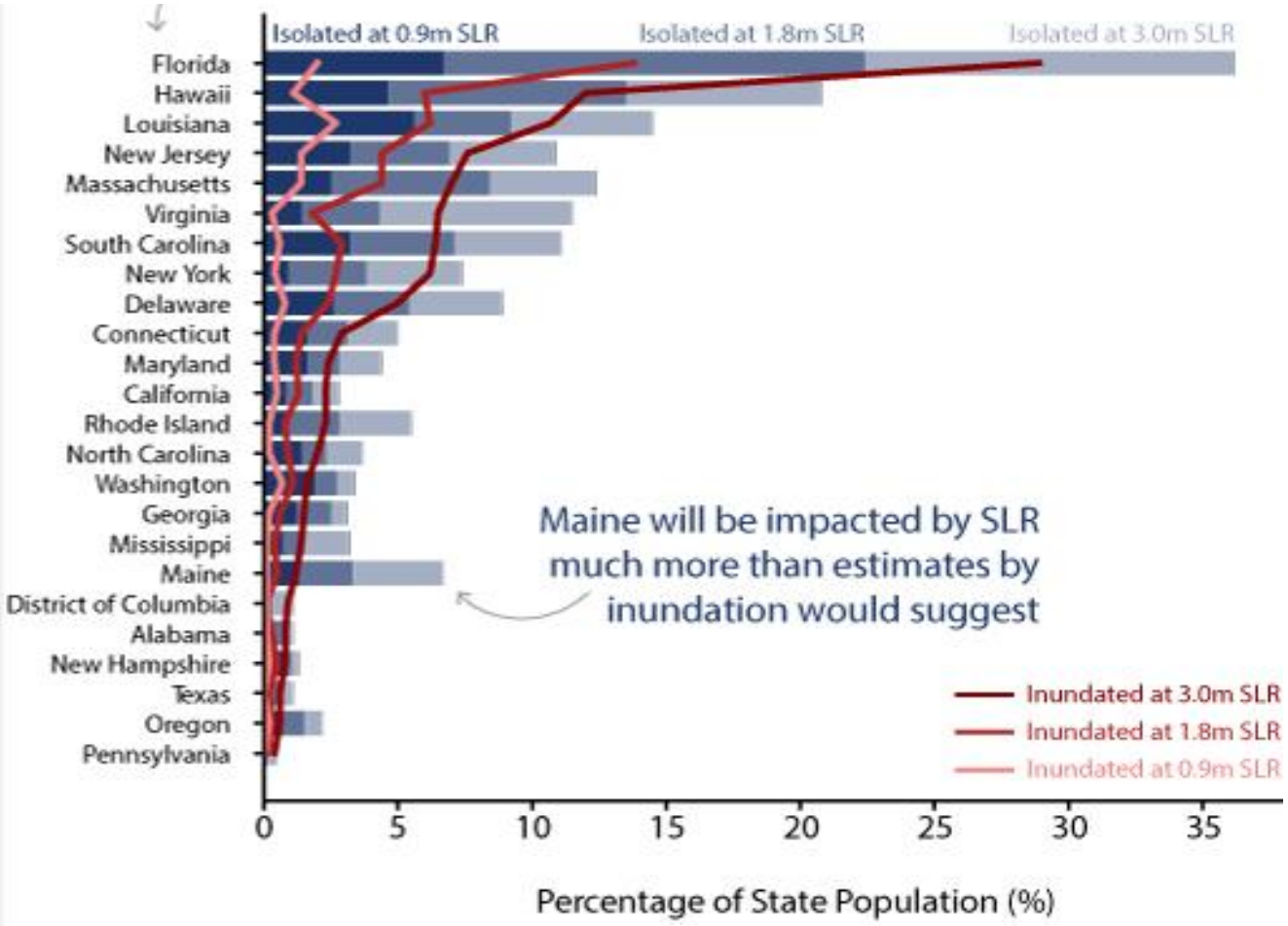
How similar are the measures of inundation and isolation for evaluating sea-level rise impacts?

Risk of inundation underestimates the number of people burdened



Logan, T. M., Anderson, M. J., & Reilly, A. C. (2023). Risk of isolation increases the expected burden from sea-level rise. *Nature Climate Change*, 1-6.

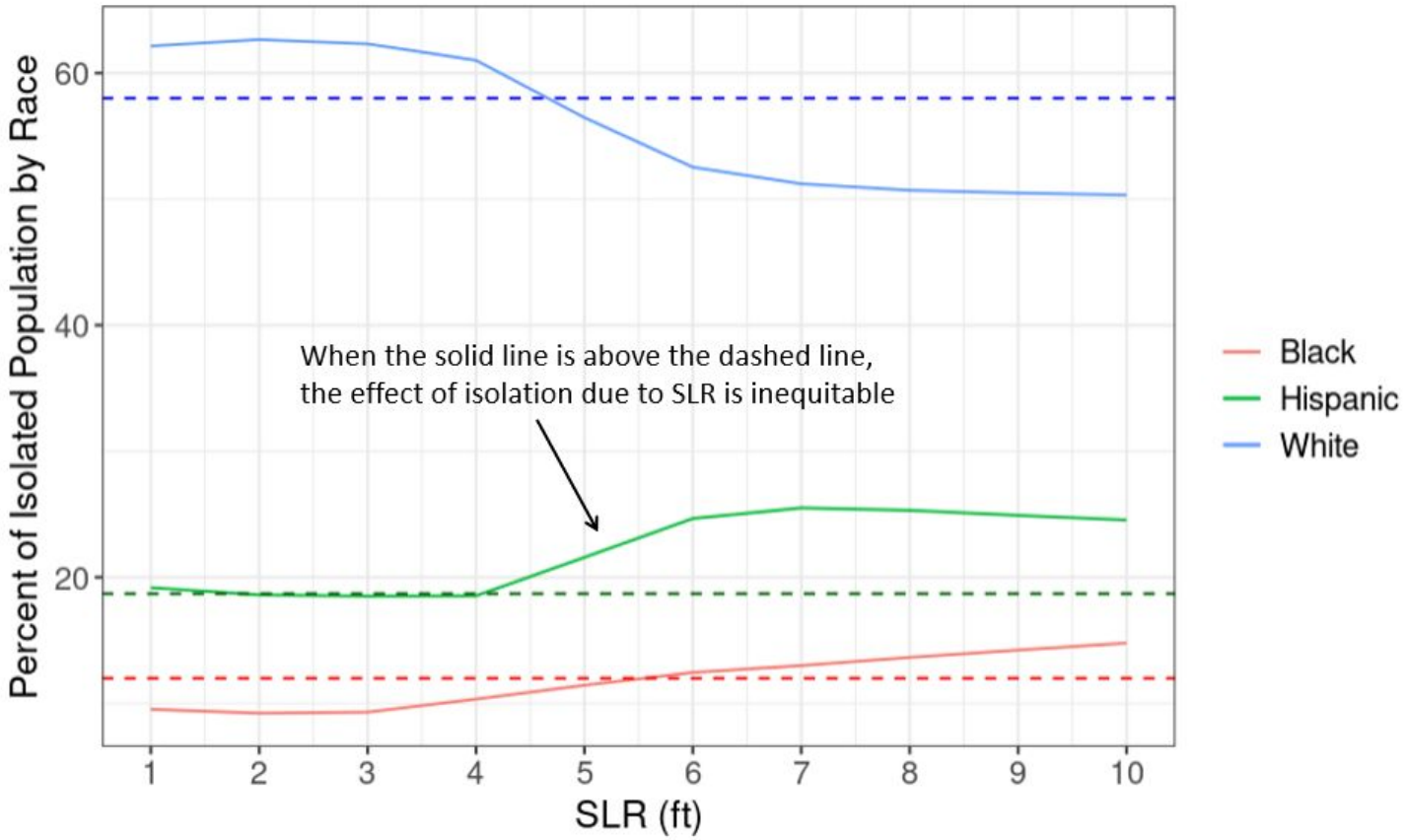
Coastal US: Isolation and inundation by state



Logan, T. M., Anderson, M. J., & Reilly, A. C. (2023). Risk of isolation increases the expected burden from sea-level rise. *Nature Climate Change*, 1-6.

Coastal U.S.: Who is affected?

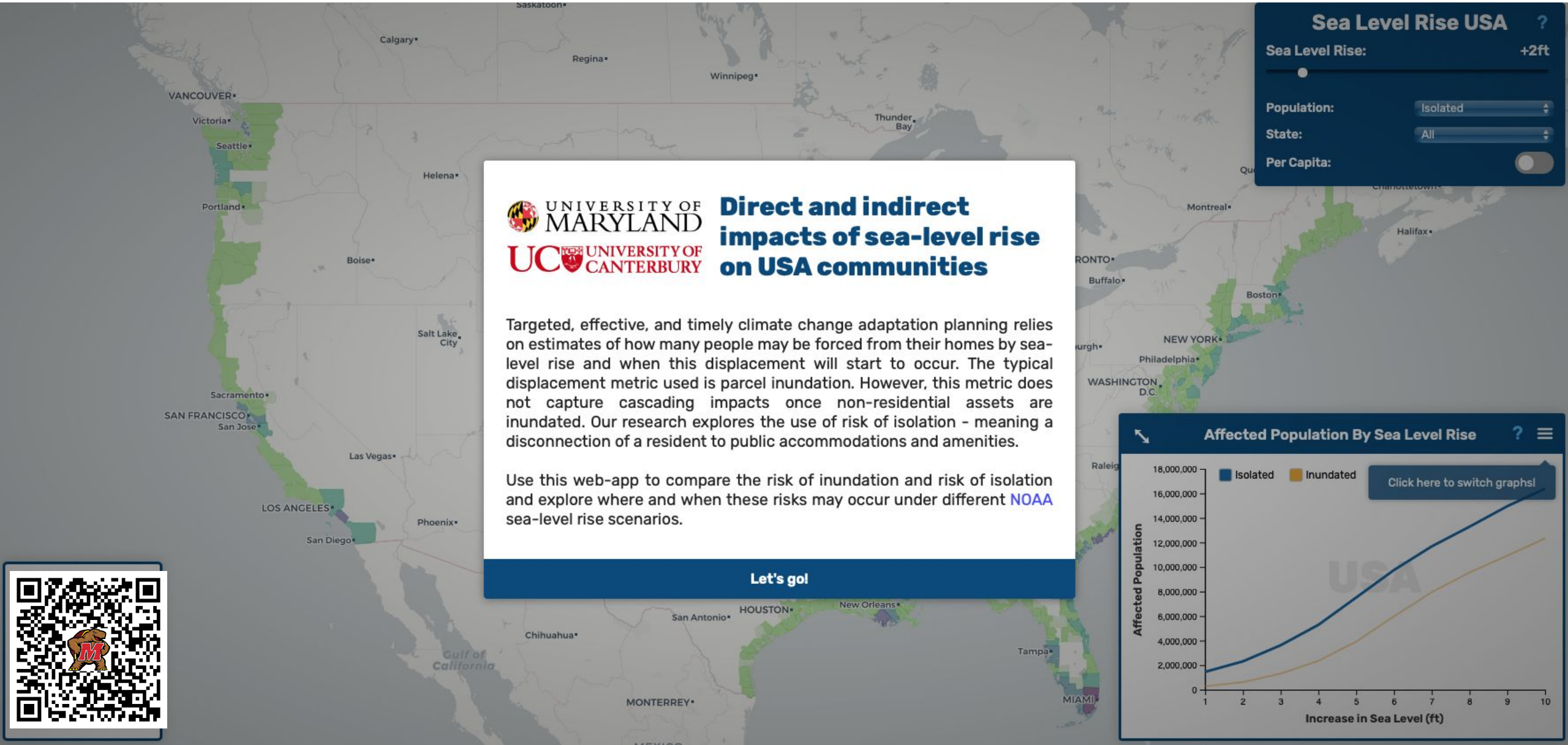
How does isolation risk vary among racial and ethnic groups?



A **disparity** exists when the proportion of the group in the at-risk population is greater than the proportion of the group in the overall population

Best, K., He, Q., Reilly, A. C., Niemeier, D. A., Anderson, M., & Logan, T. (2023). Demographics and risk of isolation due to sea level rise in the United States. *Nature Communications*, 14(1), 7904.

https://projects.urbanintelligence.co.nz/slr-usa/



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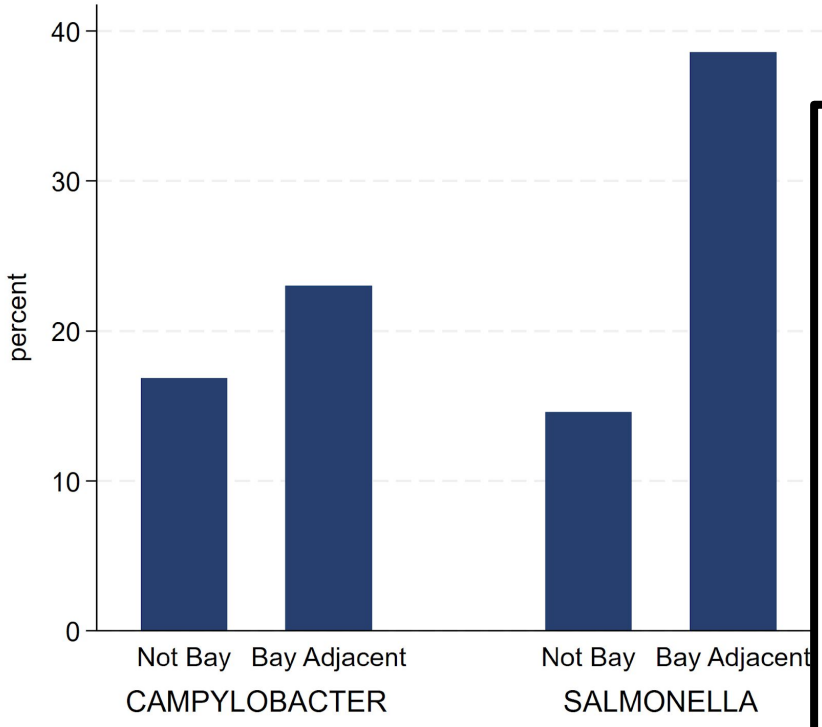
Flooding and Septic Systems

Understanding current risk

Percentage of FoodNet Cases among Septic Users by Adjacency to Chesapeake Bay



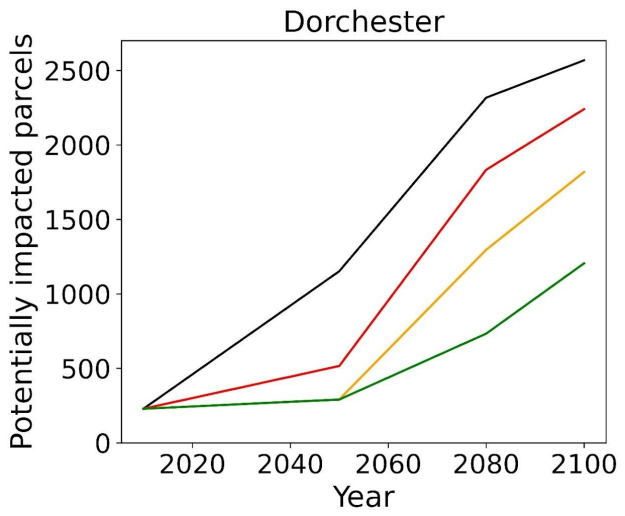
Public health

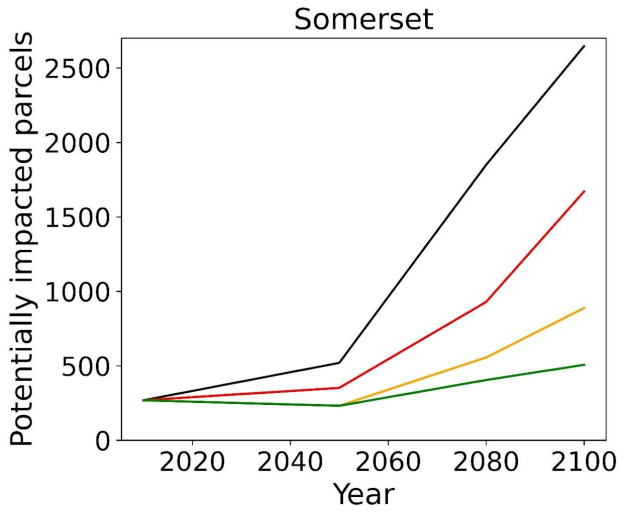
Property Valuation

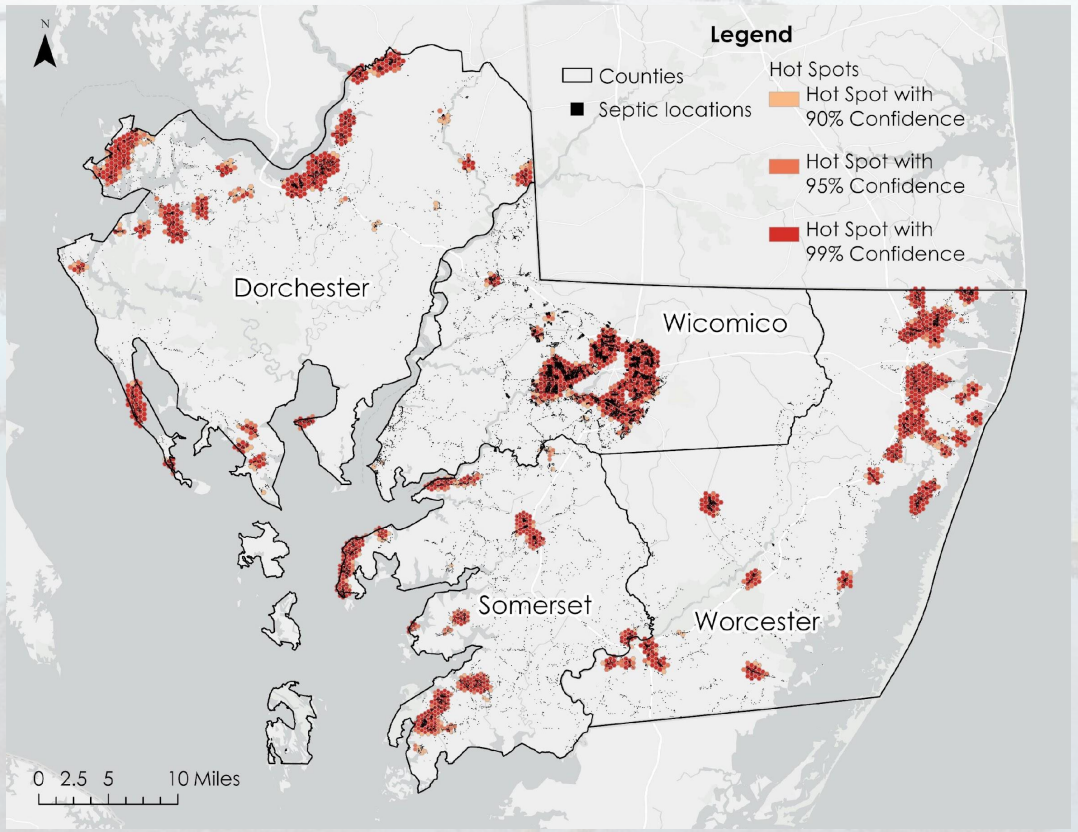
	Dependent variable:					
	log(sales price/lot size)			log(assessment value/lot size)		
	(1)	(2)	(3)	(4)	(5)	(6)
sewer	0.425***	0.308***	0.307***	0.628***	0.457***	0.458***
	(0.072)	(0.067)	(0.068)	(0.088)	(0.086)	(0.086)
crit. area – IDA		0.113***	0.025		0.156***	0.052**
		(0.011)	(0.017)		(0.022)	(0.022)
crit. area – LDA		−0.016	−0.136***		0.014	−0.130***
		(0.041)	(0.038)		(0.054)	(0.047)
crit. area – RCA		−0.316***	−0.411***		−0.516***	−0.625***
		(0.054)	(0.056)		(0.056)	(0.058)
PFA		0.648***	0.664***		0.711***	0.715***
		(0.106)	(0.108)		(0.087)	(0.088)
SFHA			−0.145***			−0.125***
			(0.049)			(0.039)
waterfront			0.252***			0.146***
			(0.040)			(0.046)
log(distance to coast)			−0.081***			−0.102***
			(0.012)			(0.018)
House characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Year and month FE	Yes	Yes	Yes			
Grid FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	506,027	506,027	499,962	785,271	785,271	779,384
Adjusted R^2	0.729	0.740	0.744	0.748	0.759	0.762
Note:						*p<0.1; **p<0.05; ***p<0.01

Nutrient degradation & system failure rates

Understanding future risk





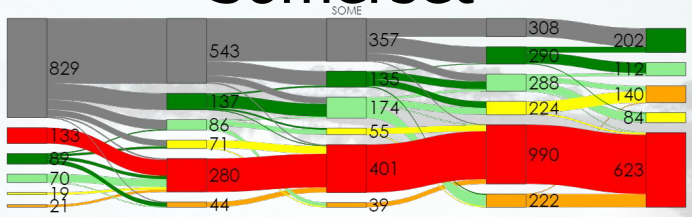


RCP 8.5 - 1% Prob.
RCP 8.5 - Upper limit of likely range
RCP 8.5 - Likely range
RCP 4.5 - Likely range

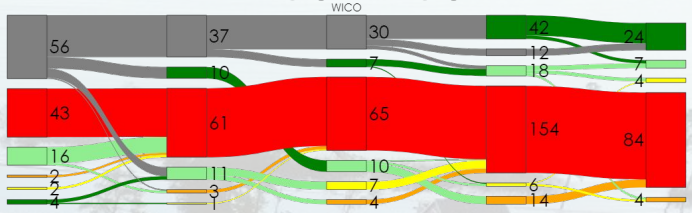
Number of days inundated

Zero
<3
4-7
8-15
16-31
>32

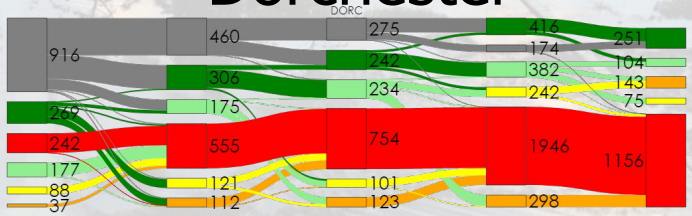
Somerset



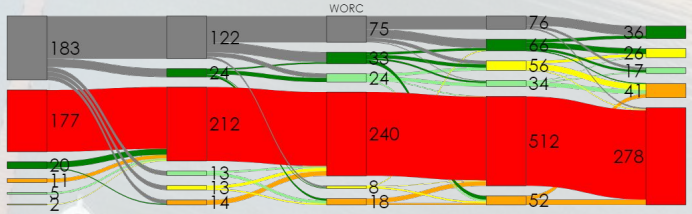
Wicomico



Dorchester



Worcester



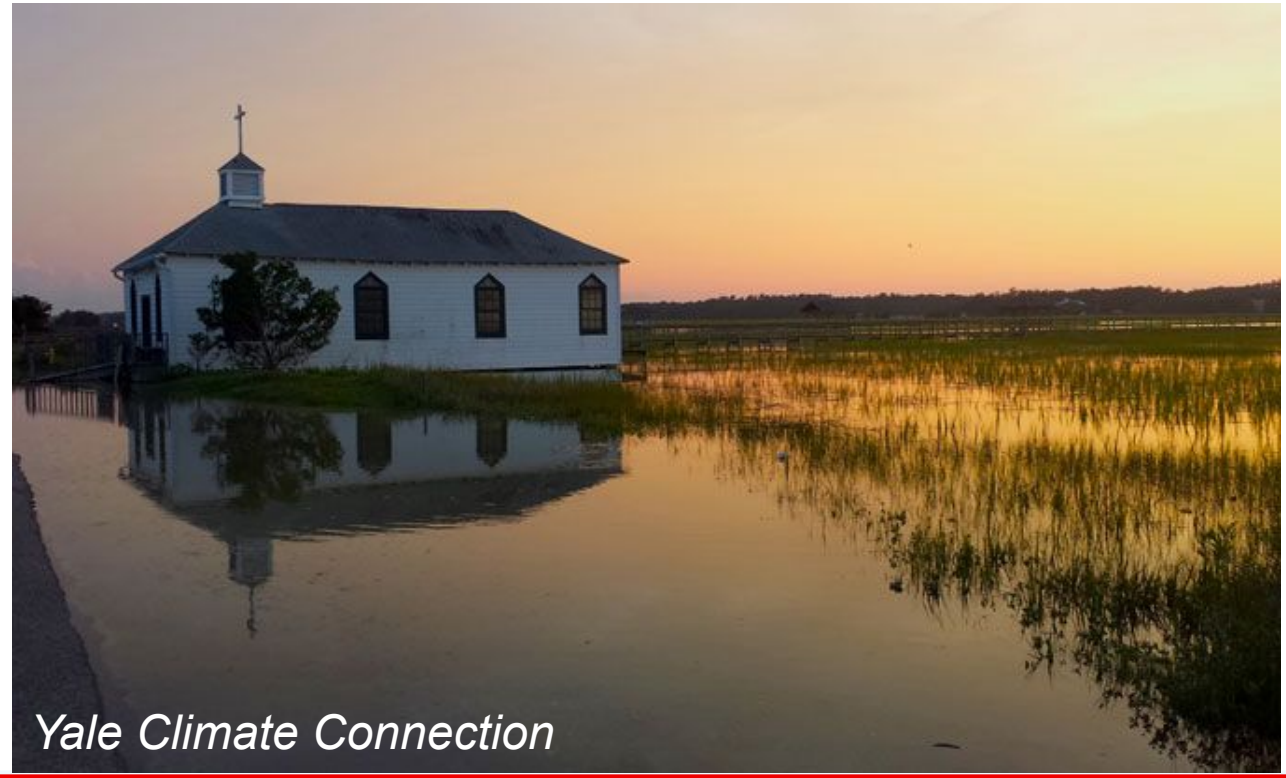
Observations

- Lack of robust data collection
  - VA offers valuable lessons
- Bermed Infiltration Ponds are increasing in numbers
- Sewer service and other engineered solutions
- Chesapeake Bay Restoration Funds

Sea-level rise (SLR) will have widespread impacts on infrastructure and communities

What stymies robust adaptation planning?

- Lack of understanding into the ways residents use and rely on infrastructure, and what "tipping points" will induce climate migration
- Adaptation trade-offs, biases, and political realities
  - Moral hazards
  - Unintended consequences
  - Sunk costs


Yale Climate Connection

Work with us!

Opportunities

- **Students**
  - Give a seminar on your work
  - Let us know about internships and job opportunities
  - Join advisory committee for new program in climate systems science and engineering at UMD
  - Capstone Project!
- **Research**
  - Provide data and insight into pressing problems
  - Partner with us on research proposals
  - Contract with us

Thank you!

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