Exploring the Climate and Energy Resilience Benefits of Coastal Ecosystems and Protected Areas in Puerto Rico

10 December 2024

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Introduction

In 2017, Hurricane Maria devastated the electrical grid and caused a humanitarian crisis in Puerto Rico.

Hurricanes and other coastal hazards will continue to intensify due to climate change and sea-level rise.

As a result, Puerto Rico is in need of strategies that reduce the impact of coastal hazards.

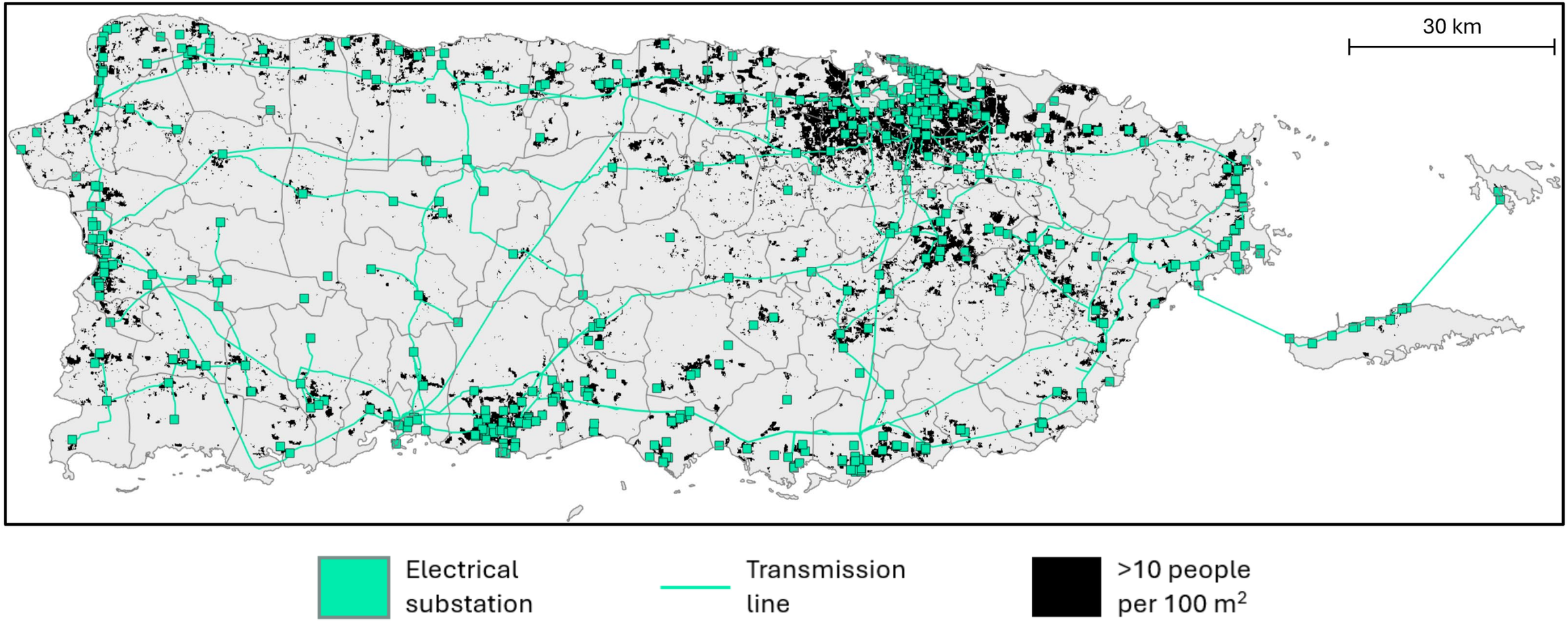
Introduction

Disaster resilience plans are increasingly considering the ability of coastal ecosystems to moderate hazard impacts.

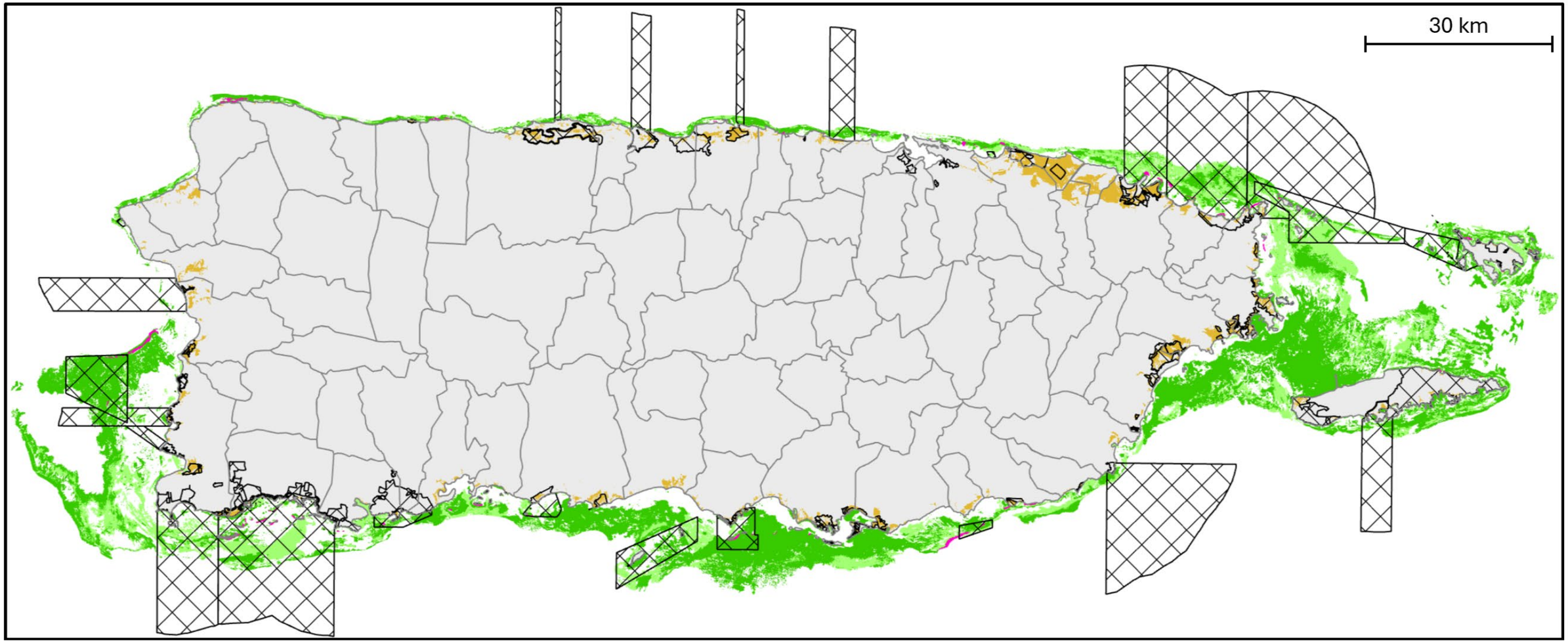
Habitat conservation is a cost-effective and co-beneficial risk reduction approach.

Operationalizing this approach will require collaboration between protected areas managers and critical infrastructure planners.

Population and energy infrastructure are concentrated near the coast



Coastal ecosystems have potential to reduce risk



Research Questions

1. Where are people and energy infrastructure highly exposed to coastal hazards under future sea-level rise in Puerto Rico?

2. Where do coastal ecosystems reduce the risk of coastal hazards to people and energy infrastructure and by how much?

3. How could ecosystem-based risk reduction inform the siting of protected areas?

Methods

InVEST Coastal Vulnerability model

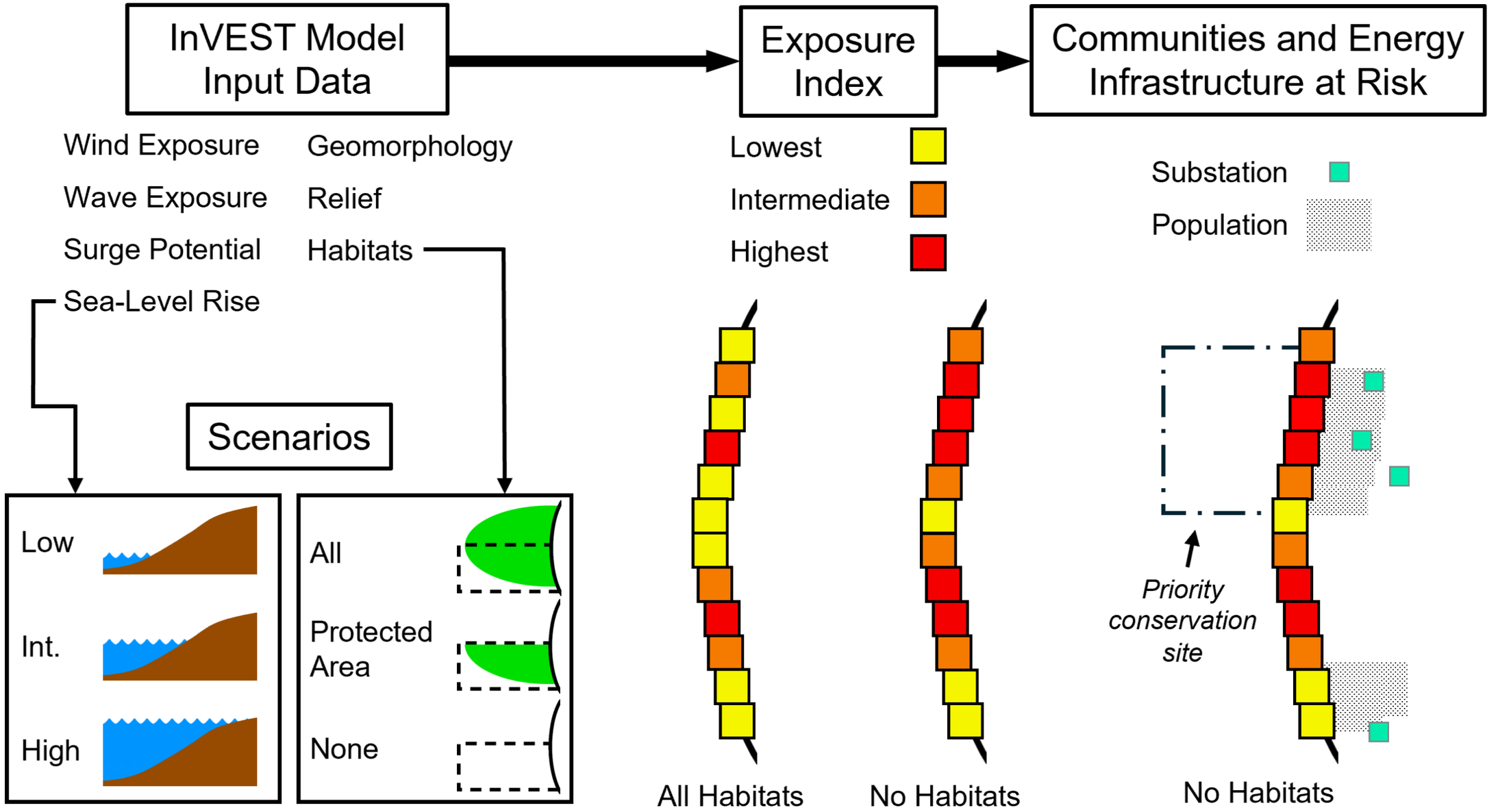
- Takes in biophysical data to estimate an exposure index (EI) variable for each coastline segment.
- Advances previous models by considering the role of habitats, allowing for scenario design.

InVEST

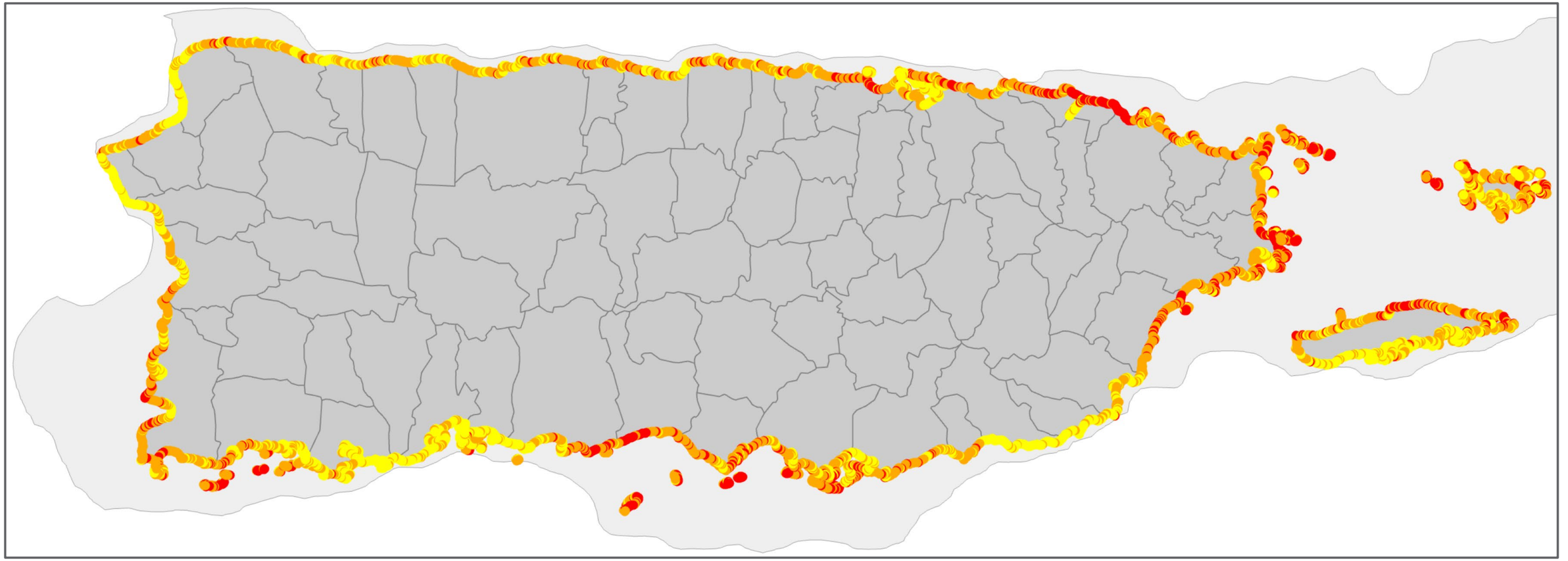
integrated valuation of ecosystem services and tradeoffs

$$EI = (R_{Geomorphology} R_{Relief} R_{Habitats} R_{SLR} R_{WindExposure} R_{WaveExposure} R_{Surge})^{1/7}$$

Steps of the analysis



Exposure with all habitats present



Exposure index:

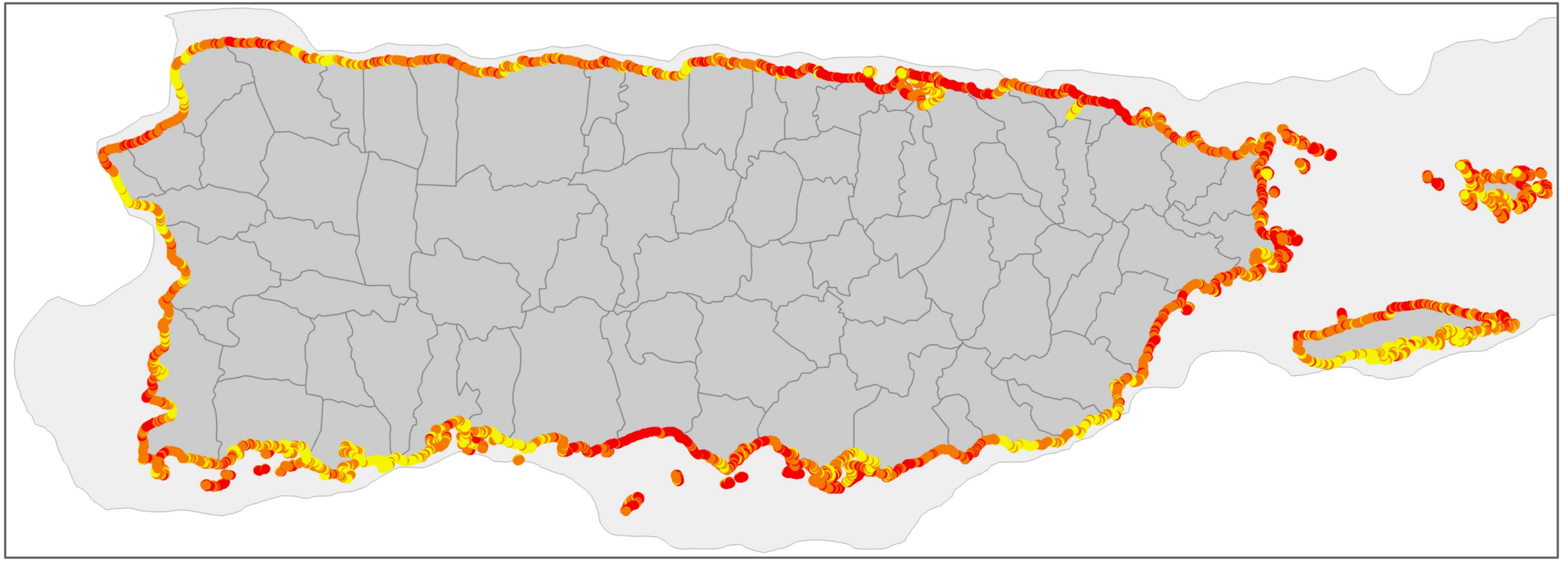
Lowest

Intermediate

Highest

Continental shelf

Exposure with only habitats in protected areas present



Exposure index:

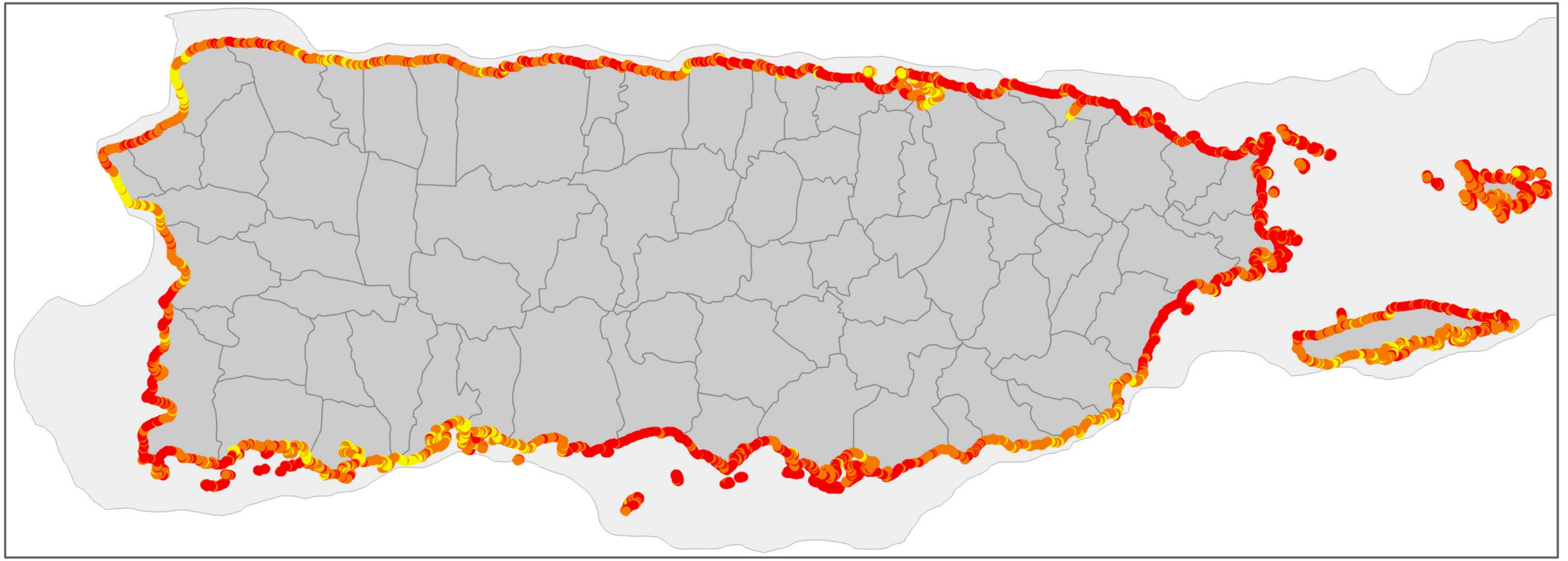
Lowest

Intermediate

Highest

Continental shelf

Exposure with no habitats present



Exposure index:

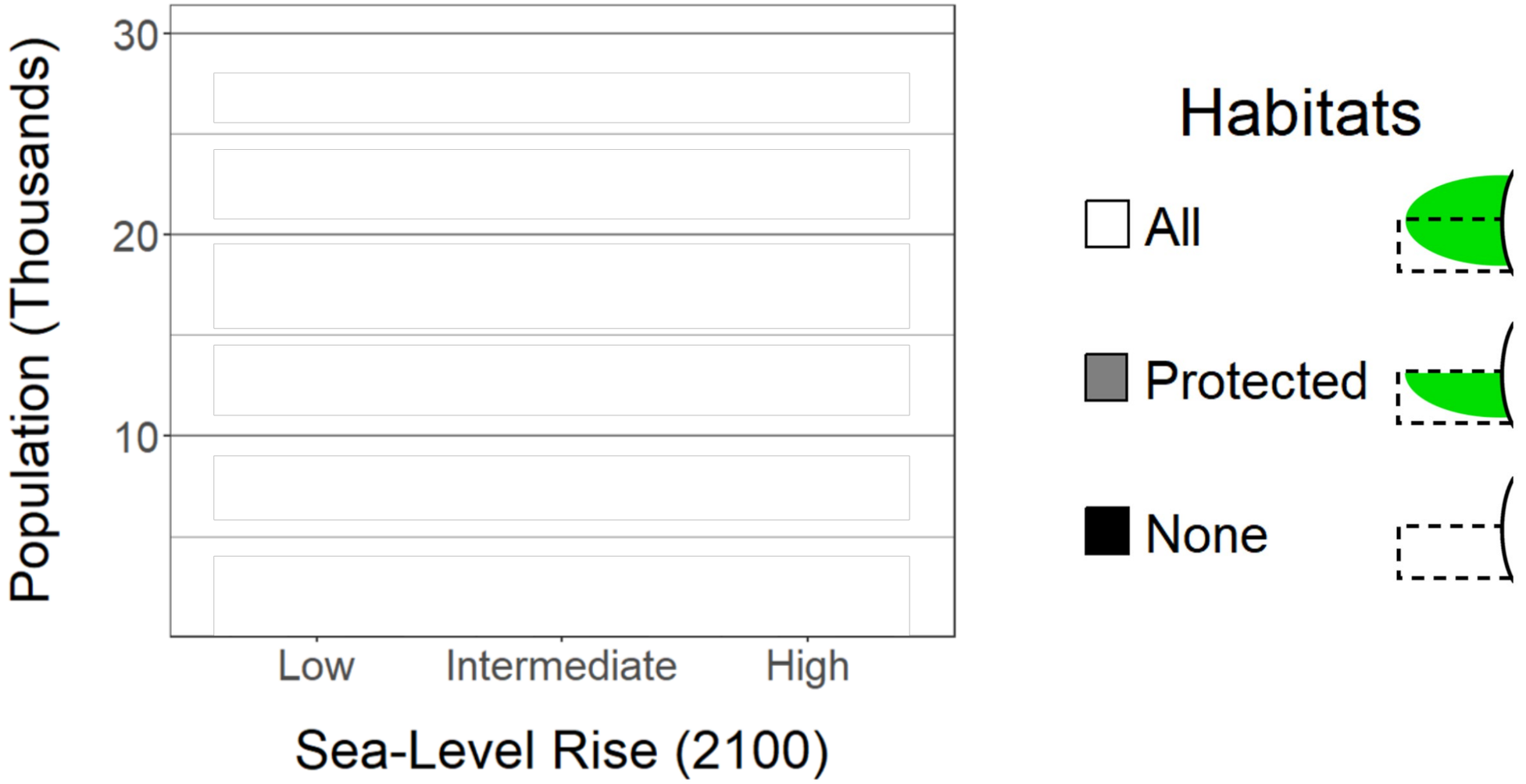
Lowest

Intermediate

Highest

Continental shelf

Population highly exposed to coastal hazards



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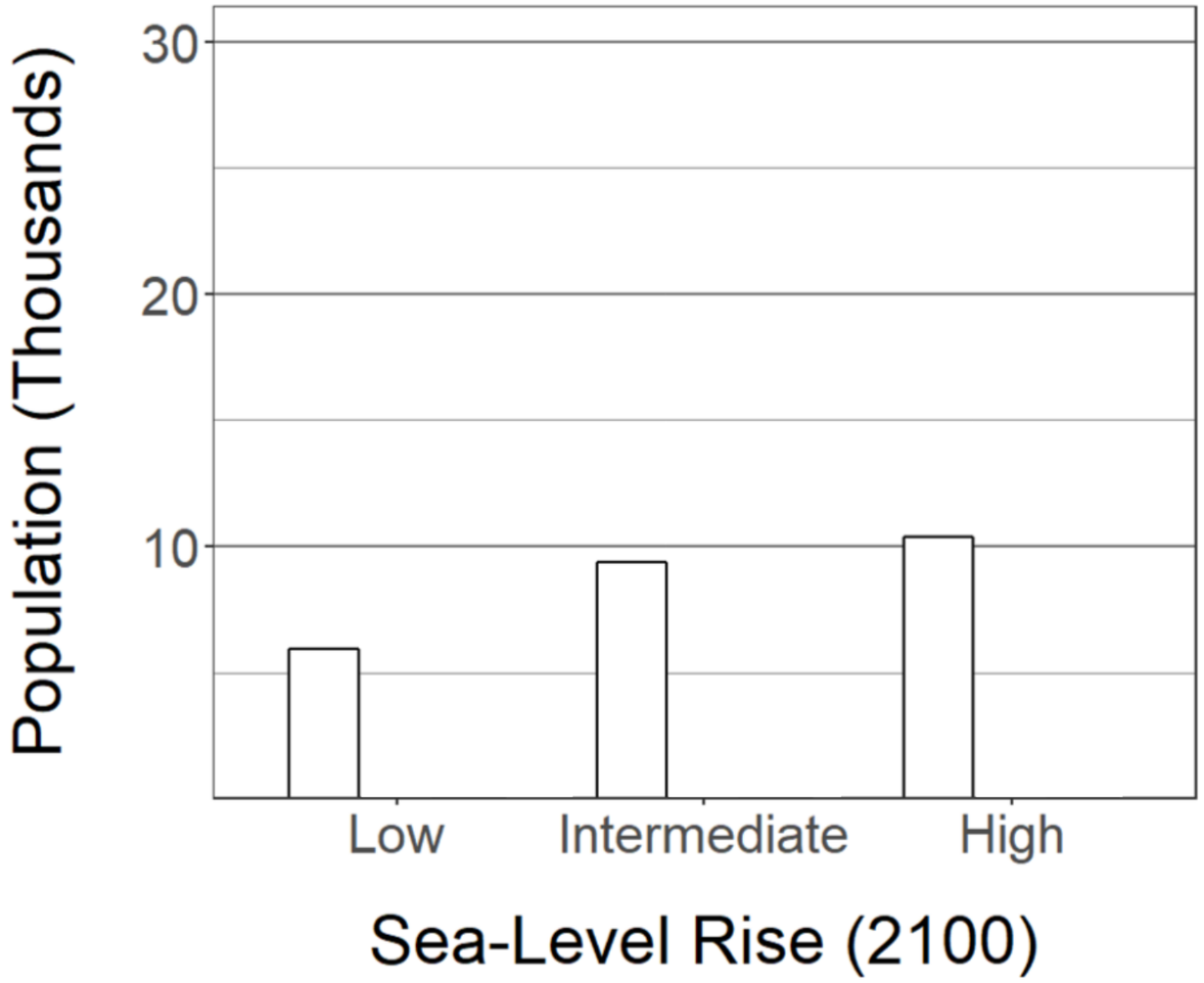

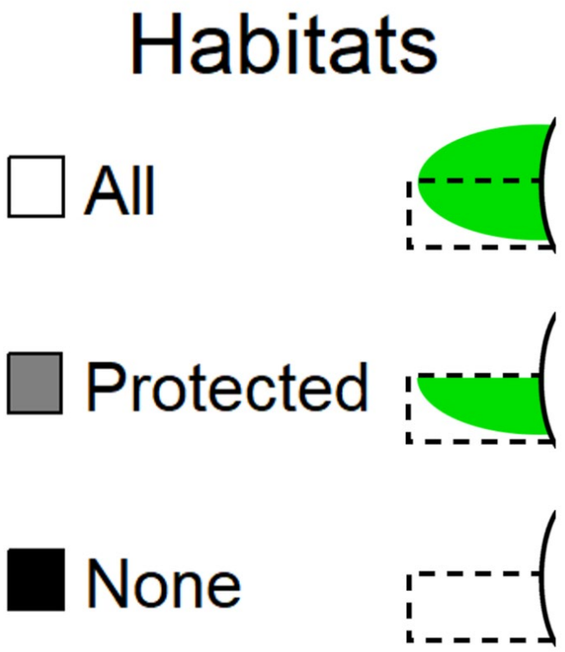

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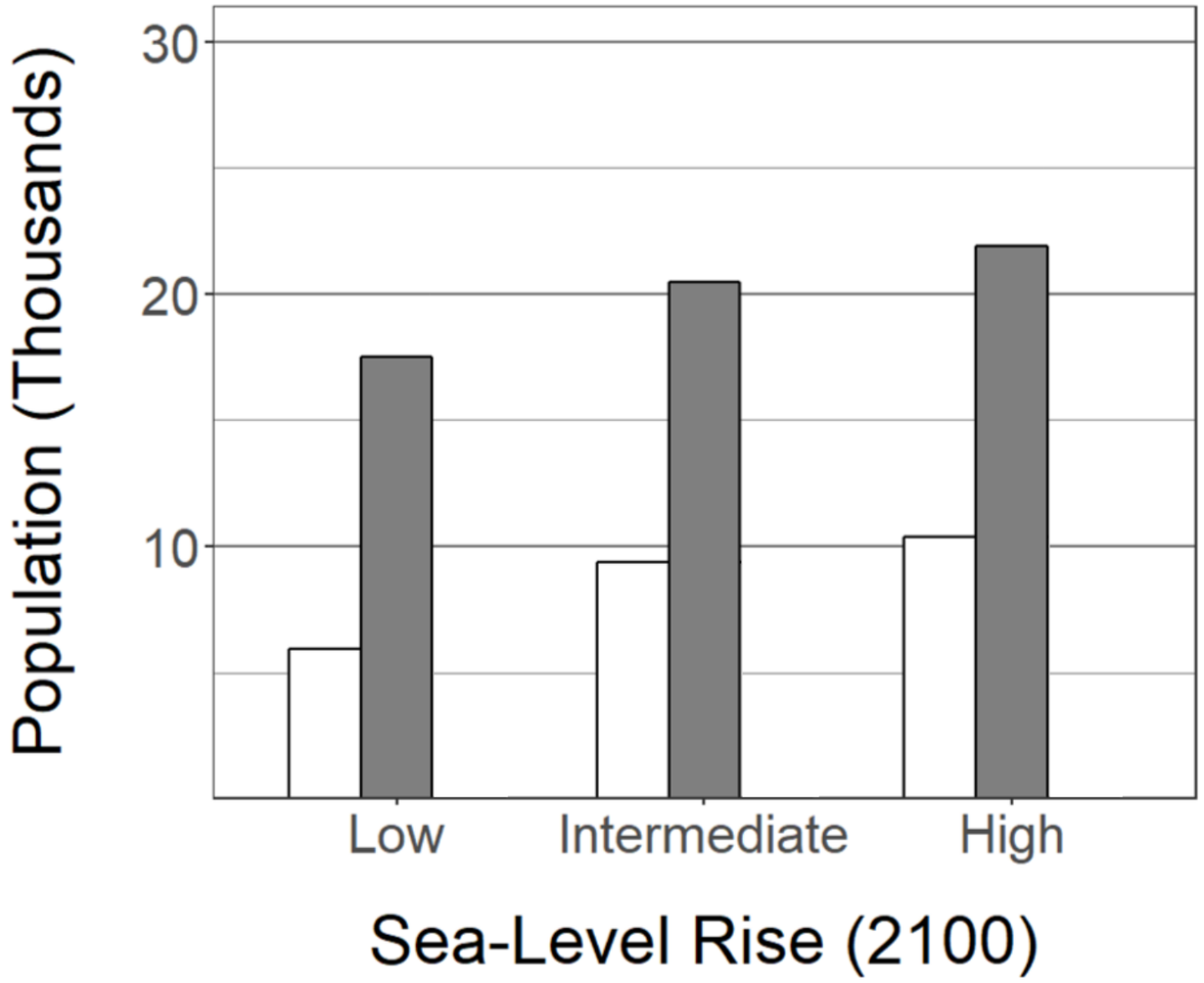
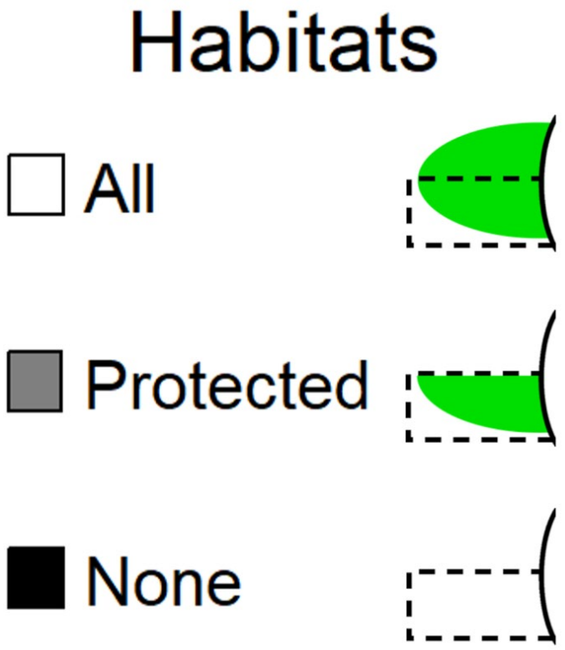
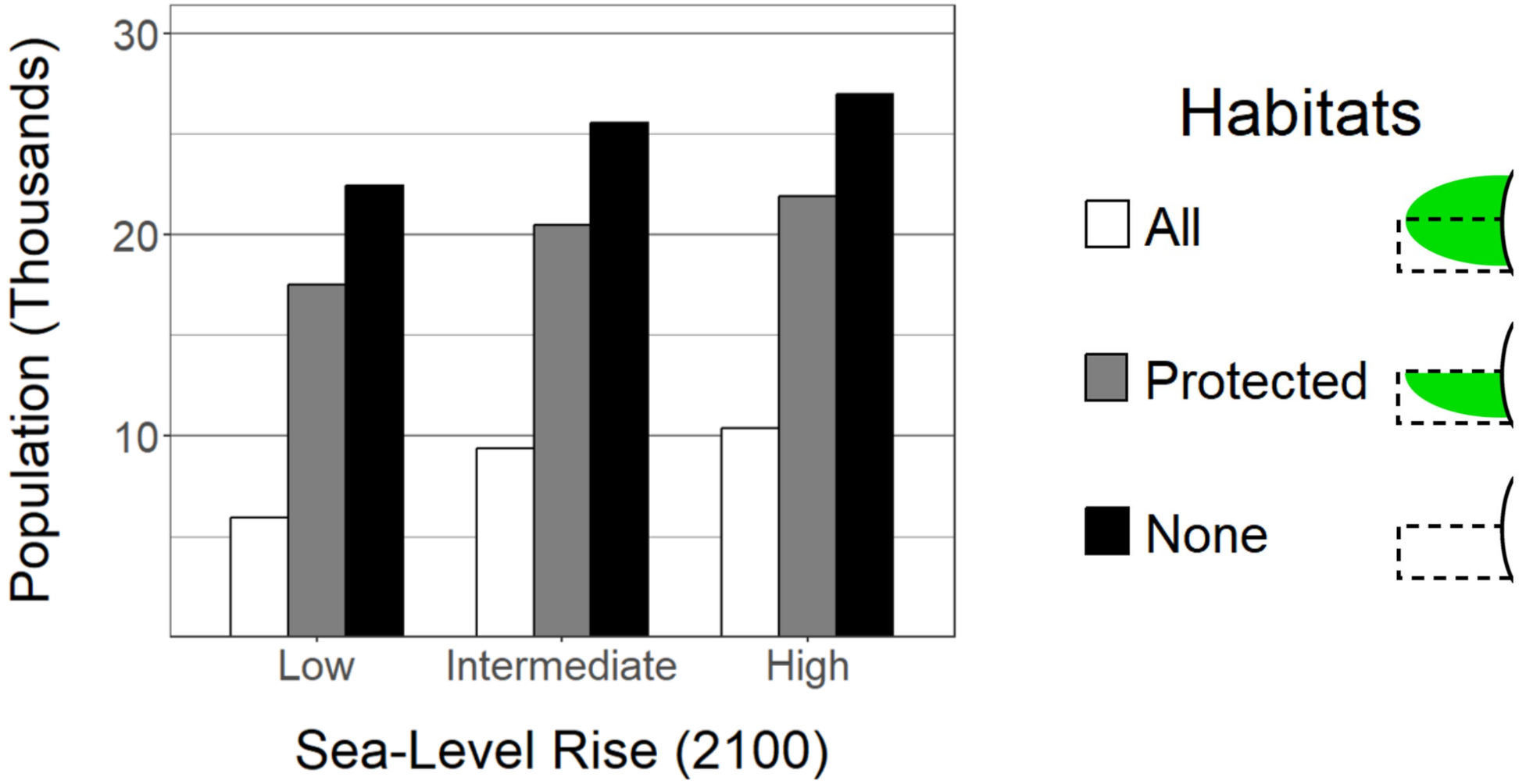
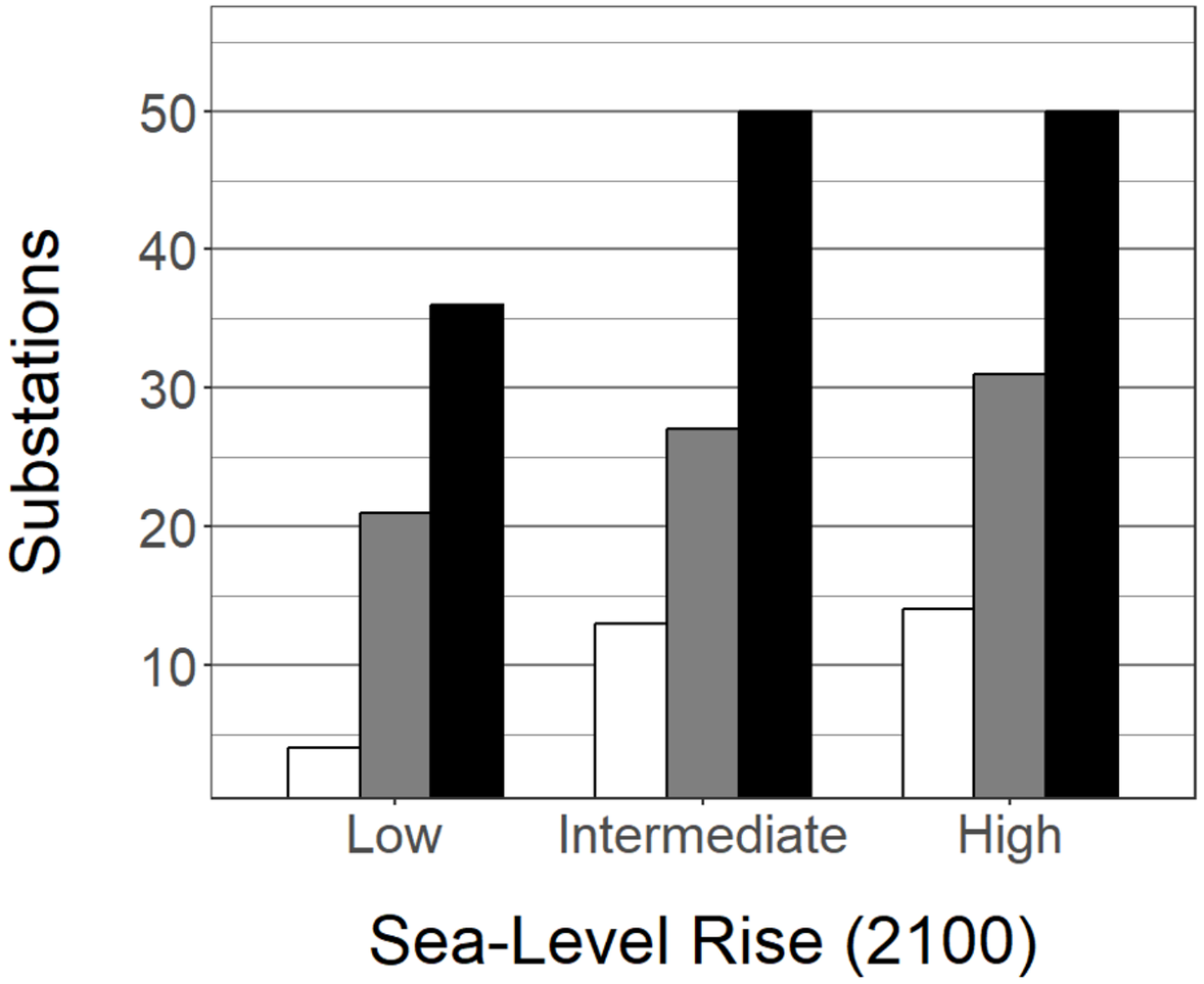


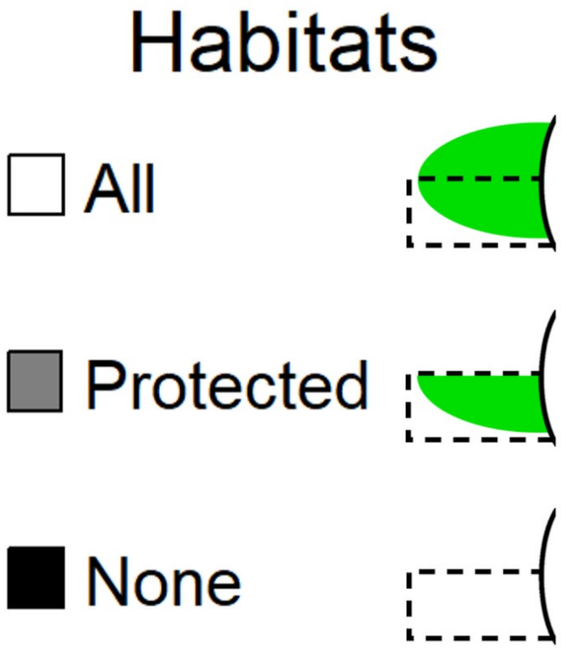


Population highly exposed to coastal hazards

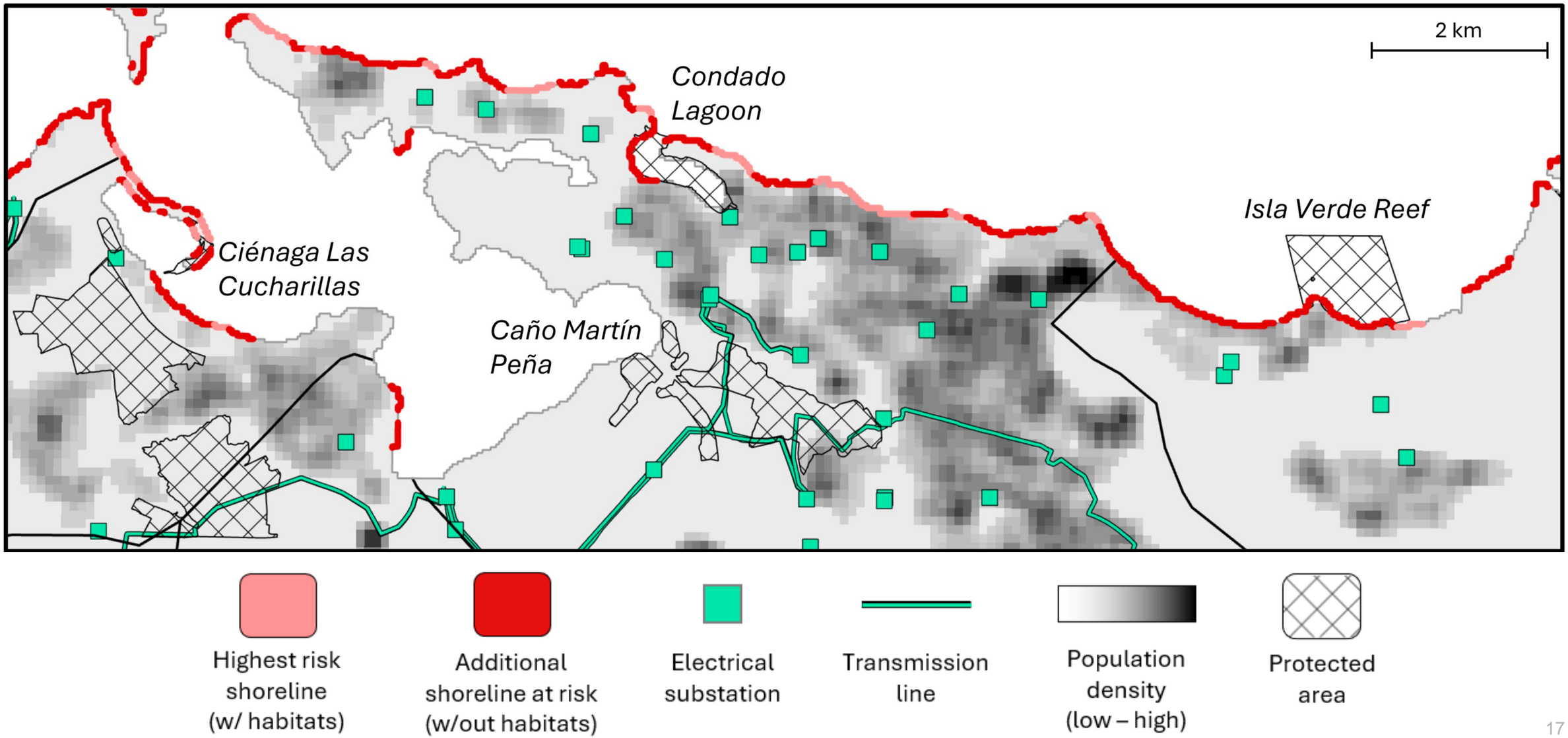


Electrical substations highly exposed to coastal hazards





Results: Coastal habitats and protected areas reduce risk in the San Juan Metropolitan Area



Discussion

Coastal zone managers can use our approach and results to…

- Site new protected areas
- Avoid degrading critical habitats
- Prioritize communities for resilience funding

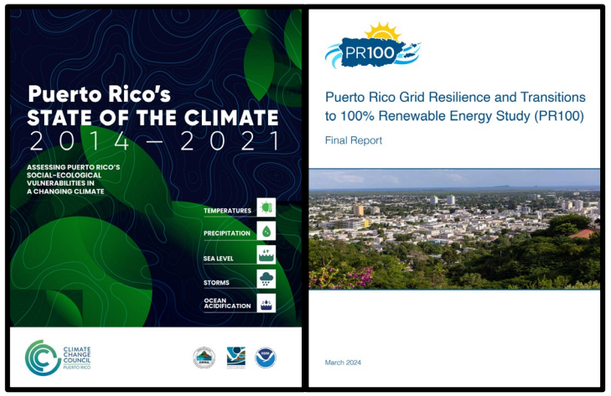
To implement these solutions, diverse stakeholder participation is necessary – especially in cities.

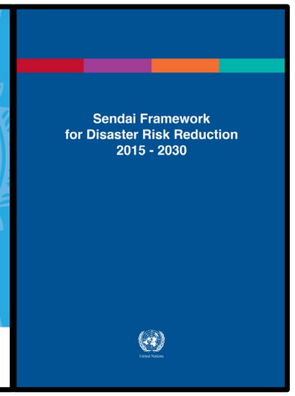
Discussion

Our results support initiatives in Puerto Rico:

- Climate Change Mitigation, Adaptation, and Resilience Act
- 100% renewable energy by 2050

Small Island Developing States could leverage nature-based solutions to sustainably achieve disaster and energy resilience.





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Acknowledgements

Thanks Jessica Silver, Shon Zimmerman, Elise Boos, Katie Morrice, Steve Schill, Andre Coleman, and Karthik Balaguru for your contributions.

This project used methods developed by the Natural Capital Project and Allen Coral Atlas.

This project was advanced by the University of Washington School of Environmental and Forest Sciences Departmental Honors Program.

This project was funded by the U.S. Department of Energy Water Power Technologies Office.

Pacific Northwest National Laboratory is operated by Battelle Memorial Institute for the DOE under contract DE-AC05-76RL01830.

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ALLEN CORAL ATLAS

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Thank you

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Data Sources

Input layer	*File Type*	*Year*	*Source*
Area of Interest	Shapefile	2022	N/a
Landmass	Shapefile	2022	Database of Global Administrative Areas (GADM) [27]
Bathymetry	TIF	2022	General Bathymetric Chart of the Oceans (GEBCO) [28]
Relief	TIF	2018	U.S. Geological Survey EROS Archive [29]
Continental Shelf	Shapefile	2019	Marine Regions (IFREMER – COMARGE) [30]
WaveWatch III	Shapefile	2009	Included in the InVEST download package [11]
Habitats (coral, algae, seagrass)	Shapefile	2022	The Nature Conservancy Caribbean Science Atlas [31]
Habitats (mangrove, emergent marsh)	Shapefile	2010	NOAA Office for Coastal Management C-CAP Regional Land Cover [32]
Geomorphology	Shapefile	2000	NOAA Office of Response and Restoration Environmental Sensitivity Index [33]
Population	TIF	2020	WorldPop Unconstrained Population Density [34]
Sea-level rise	Shapefile	2020	U.S. Army Corps of Engineers Sea Level Tracker [35]
Protected Areas	Shapefile	2018	U.S. Department of Agriculture, Protected Areas Conservation Action Team (PA-CAT) [36]