



# RESEARCH BRIEF

natural  
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PROJECT

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## GREEN INFRASTRUCTURE BENEFITS: LOCATION IS KEY

### BACKGROUND

The urgent need to repair and replace aging infrastructure in the United States is a recognized priority for democrats and republicans alike. The American Society of Civil Engineers has consistently given U.S. infrastructure a “D” rating and estimates of investment needs are in the billions and trillions of dollars. Major weather events, such as 2012’s Superstorm Sandy, have caused severe disruptions to water and electricity infrastructure along the United States’ northeast coast. Similar events have caused nuisance flooding that interrupts transportation and damages homes and businesses in low lying areas

### ABOUT THE STANFORD NATURAL CAPITAL PROJECT RESEARCHERS

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Photo Credit: Yinan Chen

such as Miami Beach and other areas of Florida, provide examples of the particular vulnerabilities to coastal communities and their built infrastructure.

Public- and private-sector decision makers are looking for the most effective and cost-efficient means to defend property, roads and other critical infrastructure from rising seas. Increasingly, they are considering the protection that “green” infrastructure – salt marshes, reefs, mangroves, dunes and other ecosystems – can provide to coastal areas.

This research brief is based on work by representatives of the Natural Capital Project and others that examines where and to what extent coastal ecosystems provide protective benefits. The researchers find that the physical and social vulnerabilities of an area, cost constraints, and the nature of the storm or sea-level rise hazard to be withstood are contributing factors to the level of benefit received from green infrastructure.

## EXAMINING THE “WHERE” FOR GREEN INFRASTRUCTURE

The decision as to whether green infrastructure should be part of a protection and restoration strategy can be informed by first asking: Where do ecosystems provide a significant risk reduction for people and coastal assets, currently and under future climate conditions? To provide an answer requires knowing where habitats are most likely to:

1. lessen exposure to erosion and flooding from storms and future sea levels, and
2. protect vulnerable people and property.

As an example of how this works in practice, the researchers applied the InVEST coastal vulnerability model, which generates a coastal vulnerability index that includes the role of green infrastructure in providing protection and differentiates areas with relatively high or low exposure to erosion and inundation during storms, to the entire U.S. coastline. The results showed that ecosystems reduce coastal community exposure to sea-level rise and storms, and that the contributions of habitat to protection varies greatly by location. At this scale, the model is able to provide broader, regional-scale answers to the “where” question. For example, the InVEST model indicates a fairly consistent moderate-to high exposure of the Texas coast to coastal hazards compared with other parts of the Gulf Coast. At a regional scale, it might therefore make sense to prioritize restoration and protection of natural features in Texas; however, this depends on where ecosystems are most likely to reduce flooding and erosion and their co-location with vulnerable communities and infrastructure.

At smaller scales, such as within Texas, the coastal vulnerability model can highlight the portions of Galveston Bay where oyster reef or wetland restoration is most likely to effectively reduce damage from waves — something that public and private property owners are very interested in determining.



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## “HOW MUCH” PROTECTION CAN GREEN INFRASTRUCTURE PROVIDE?

Simply knowing in which locations habitat is most likely to reduce risk to coastal hazards does not indicate just how much protection habitats are likely to offer. To provide insights into this question, the researchers used a different InVEST model, the Coastal Protection model, which captures how much vegetation will reduce nearshore water levels and erosion thereby protecting communities.

**Case Study: Dow Chemical Company** – Dow has an extensive facility in Freeport, Texas that is mostly protected by levees except for one key area that falls outside the levee system. Dow wanted to know if green infrastructure (wetlands) might be used in combination with their levees to reduce the facility’s risk to storms and sea-level rise. In particular, Dow was interested to determine the amount of flood reduction that could be achieved under alternate conservation and restoration scenarios of their properties in the area. Results of the model in the Freeport region show that although wetlands there can provide significant coastal

protection benefits to properties located closer to the shoreline, wetlands supply a negligible protective value to the Dow facility, which is further inland.

**Case Study: Galveston Bay** – Just around the corner from Freeport Texas, in Galveston Bay, decision makers were interested in knowing the potential value of wetlands in reducing the size of a levee required to provide protection during a typical, moderate strength hurricane. The model again showed great differences in the amount of protection wetlands could provide based on the topography of the location. Where the land is steep with few existing wetlands, their presence has very little effect on the height of the levee needed. Where wetlands are more extensive and the elevation change is more gradual, the wetlands can reduce the required height of a levee by up to 50%.

Additional benefits from coastal wetlands in both Freeport and Galveston Bay, Texas (including nursery habitat for fisheries, carbon storage and sequestration, and recreation opportunities) increased the potential value of protecting or restoring wetlands for the communities along the Gulf Coast.



Photo Credit: Roy Luck

## POINTS FOR POLICY MAKERS

The science and practice are clear that protection or restoration of green infrastructure can be a cost-effective complement to grey infrastructure for protecting communities and critical existing infrastructure from coastal hazards. A few key points on the where and how much green infrastructure can benefit coastal communities include:

- Location is paramount in determining whether investment in green infrastructure makes sense – the condition and location of natural habitats and built infrastructure, communities, and cost of property can affect the desirability of green and grey infrastructure strategies for protection.
- Sophisticated models and tools are now available to match decision maker queries about green infrastructure – these tools can assist stakeholders in identifying the right projects in the most appropriate locations to include in proposals for funding cost-effective restoration or protection strategies.
- Costs of grey infrastructure and property values also contribute to the degree to which green infrastructure adds value.

## CONCLUSION

Communities and coastal regions can improve their resilience and make smarter use of infrastructure spending by identifying strategies to move from single objective planning to integrated planning for green and grey infrastructure that is complementary. The science and tools are available to support action toward these ends now, even as more learning through application continues.

This Brief is based on the paper [Evaluating the benefits of green infrastructure for coastal areas: Location, location, location](#) by Ruckelshaus, M., G. Guannel, K. Arkema, G. Verutes, R. Griffin, A. Guerry, J. Silver, J. Ferries, J. Brenner, A. Rosenthal. 2016 Coastal Management. 44: 504–516.



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