Nature Buffers Hurricane Michael in the Florida Panhandle

EXECUTIVE SUMMARY

Hurricane Michael made landfall in the Florida Panhandle on October 10, 2018 as a Category 5 storm. With maximum sustained winds reaching 160 mph, Michael was the first Category 5 storm to impact the Florida Panhandle, as well as the first to make landfall in the United States since Hurricane Andrew in 1992.

The Mexico Beach area in eastern Bay County bore the brunt of the storm's devastation, with storm surge resulting in water levels reaching 9 to 14 feet above ground level, as well as dune overwash and major inland flooding. Large impacts occurred across the broader Panhandle region, including Panama City, Port St. Joe, and Apalachicola, where extensive marshes and wetlands, coastal forests, and bays support the culture and economies of these coastal communities.

Northeastern University and The Nature Conservancy partnered to study the impacts of Hurricane Michael within Bay, Gulf, and Franklin Counties, specifically how nature-based features such as salt marshes and undeveloped green spaces helped protect against the worst impacts of the storm. To explore how nature protected the coast, we:

- researched and synthesized available data sets that characterized Hurricane Michael's impacts on the people and nature of the region;
- conducted household surveys of residents throughout the region to collect household-level data on storm impacts on and recovery of both homes and shorelines;
- used field approaches and remotely sensed (satellite) data to characterize storm impacts on nature-based features, including marshes, shorelines, and residential structures; and
- evaluated relationships between land cover, such as the amount of nearby green space, and storm impacts and recovery, by using spatial modeling approaches.

Key Findings

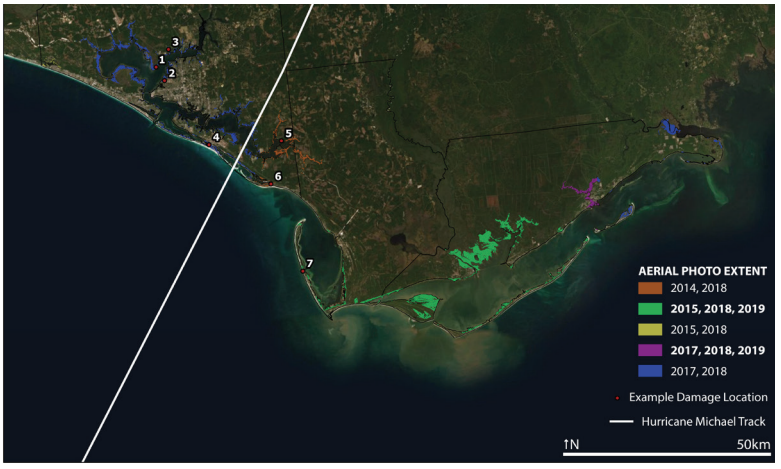
Overall property damage was extensive with 6% of residents describing their homes as ruined, 26% majorly damaged, and 36% moderately damaged. Landscaping was most frequently reported as majorly damaged or ruined (68%), followed by roof (44%), interior (20%), and walls (19%).

Armored shorelines, which can damage ecosystems, did not provide additional storm protection and greatly increased recovery costs for waterfront residents. Home damage states were similar across the different shoreline types. On average, recovery costs were $2,937 for vegetated shorelines and $14,117 for hardened shorelines. In addition, annual maintenance costs were estimated at $312 for vegetated shorelines and $1,094 for hardened shorelines.

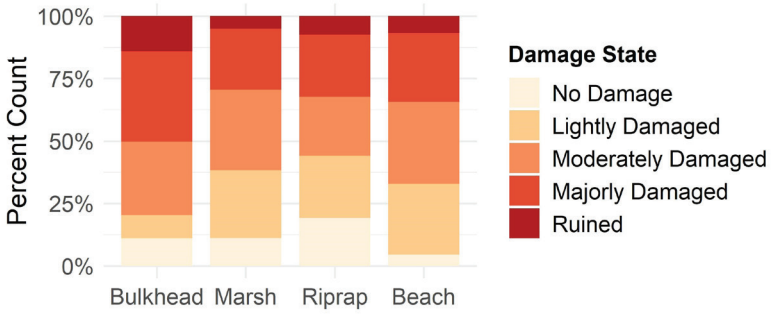
At the community level, bulkheads or seawalls were most frequently categorized as majorly damaged or ruined (50%) and least often perceived as fully recovered (14%). Beaches were perceived as majorly damaged or ruined by 34%, riprap revetments 32%, and marshes 29%.

COLLECTING AND SYNTHESIZING EXISTING DATA ABOUT HURRICANE MICHAEL

About one year after Hurricane Michael, we compiled available data sets and reports from state and federal agencies to help characterize the storm's impacts and identify data gaps for our study to address. Multiple agencies provided quick reconnaissance and impact reports on a variety of topics, ranging from insurance claims to forest damage. For example, the State of Florida's Department of Environmental Protection assessed beaches and exposed coastlines and found that erosion and structural damage was greatest in east Bay County, near Mexico Beach (close to the point of landfall). Property damage data was available through FEMA and insurance claim databases, although it was difficult to distinguish wind from flood damage. The Coastal Emergency Risk Assessment (CERA) program produced data on modeled storm conditions, including inundation, which showed the greatest flooding east of Panama City and along Mexico Beach, Island Pass, and St. George Island. All of these datasets reflect the devastating impacts of Hurricane Michael to the Florida Panhandle and and helped reveal the role that nature played in mitigating Hurricane



Extent of aerial imagery coverage on study marshes. Aerial images were taken of all marshes in October 2018, within 1-2 days of Hurricane Michael's landfall. Areas with bolded dates (green and purple) have aerial imagery from April 2019, six months after landfall, and were used to study the marsh recovery from damage.



Bulkheads and seawalls were broadly perceived as more severely damaged and not fully recovered. Compared with nature-based shorelines, more survey respondents perceived bulkheads and seawalls to be majorly damaged or ruined and less likely to be fully recovered.

Coastal marshes were largely resistant to storm impacts even under extreme conditions. Despite being subject to wind speeds greater than 60 m/s and inundation greater than 3 m, only 2% of coastal marshes in the study area were damaged.

Residents also generally perceived marshes as effective at protecting coastlines against storm waves and inundation.

Damaged marshes did not quickly recover, and actions should be taken to restore damaged marshes. Only 16% of damaged marshes recovered six months after landfall. However, marshes exposed to less extreme environmental conditions (lower wind speeds or less inundation) were more likely to recover.

Increasing green space surrounding a home was associated with higher probability of recovery, after controlling for social and hurricane-impact factors.

More surrounding green space, in contrast with built environments, promotes home and mental recovery for residents. By linking our survey results with land-use data, we developed a spatial model for predicting levels of storm recovery for homes and the recovery of a sense of well-being among residents.

Michael's damage. However, we identified notable data gaps, particularly related to storm impacts on marshes, sheltered shorelines, and coastal residential properties.

STORM PERCEPTIONS, IMPACTS, AND RECOVERY OF COASTAL HOUSEHOLDS

A little over a year after landfall, we surveyed 327 residents who live within 1 km of the coast in Bay, Gulf, and Franklin Counties. The survey consisted of 67 questions that covered the following major categories: a) *Household Property Damage & Recovery*, b) *Household Health Impacts & Recovery*, c) *Community Shoreline Impacts & Recovery*, and d) *Ecosystem Impacts & Recovery*. For each of these categories, we analyzed the potential influence of nearby shoreline type to assess the benefits of armored versus natural and nature-based shorelines. In summary, our survey results revealed that overall property damage was extensive, with 6% of waterfront residents reporting that their property was ruined, 26% majorly damaged, and 36% moderately damaged. Our results also showed that home damage was similar across all shorelines types. However, the cost of repair was much less for a vegetated shoreline ($2,937) than for a hardened shoreline ($14,117). Overall property damage was highly connected with reported mental stress, with only 14% of respondents reporting that they had fully mentally recovered. In addition to providing similar protection to armored shorelines, marshes generally fared well in the storm. When asked about community shorelines, most residents perceived marshes as lightly damaged due to the storm and recovering well a year after, whereas bulkheads and seawalls were often perceived as majorly damaged or ruined. This suggests that marsh shorelines could provide a useful form of coastal protection, as they incurred minimal damage and have a high perceived effectiveness in reducing storm damage in the Florida Panhandle.

DAMAGE, RESILIENCE, AND RECOVERY OF SALT MARSHES

In December 2019, we conducted fieldwork in the Florida Panhandle to document hurricane impacts and recovery. As large areas of marshes were difficult to assess on site, we conducted visual damage and recovery assessments using aerial imagery from Google Earth. These high-resolution images from October 2018 were taken directly after Hurricane Michael's landfall. We used the USFWS National Wetlands Inventory to identify salt marshes in Bay, Gulf, and Franklin Counties. We then visually determined areas of damage and categorized them into seven types: deposition of sediment or marsh, human-made debris, fallen trees, lateral erosion, vegetation loss, conversion to open water, and channel cutting/widening. Lastly, we assessed marsh recovery where available, for parts of Gulf and Franklin Counties.

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In total, out of the 173,259 km^2 of marsh analyzed, only 1.9% of marshes appeared damaged after the storm. This damage was primarily caused by deposition of vegetation or sediment. Although the marshes were largely undamaged, those that did sustain damage had a low percentage of recovery (16%). Recovery was primarily based on the level of storm surge or winds impacting the area of marsh; the marshes were more likely to recover when they were impacted by less extreme environmental conditions during the storm. Marshes were more damaged and less recovered when they were privately owned; this parallels the reported differences between residents' shorelines and community shorelines. Finally, out of the damage types present, marshes recovered most readily from vegetation loss.

EFFECTS OF GREEN TO GREY SPACE ON STORM IMPACTS AND RECOVERY

We used spatial modeling to analyze our survey data on household-level damages and recovery outcomes alongside storm characteristics, land use, and other spatial data in the Florida Panhandle. Using logistic regressions, and controlling for social and hurricane factors, we found that increasing green space surrounding a home was associated with higher probability of recovery. As expected, these analyses also showed that homes exposed to higher winds and situated closer to shorelines received higher damages. These homes also had lower levels of recovery. In addition, as the surrounding environment becomes more built (and less green), the probability of property recovery was also lower. Home damage and mental stress are intertwined. Through our spatial modeling, we found that lower levels of green space also increased the odds that respondents' homes or sense of well-being were less likely to be recovered.

DISCUSSION AND CONCLUSIONS

The overall goal of our study was to understand the societal and ecosystem impacts of Hurricane Michael on the Florida Panhandle, and we were particularly interested in the role of natural and nature-based features at buffering impacts and promoting recovery. We leveraged field reconnaissance, remote sensing, household surveys, and spatial modeling to pursue this goal. A few key findings of our study have direct relevance for hurricane preparedness and recovery, as well as the conservation of coastal habitats and ecosystems. Using remote sensing, we discovered that the vast majority of marshes and natural and nature-based features were resistant to the Category 5 conditions of Hurricane Michael; yet, areas that were impacted were also slow to recover. Through a household survey of waterfront residents, we found that armored shorelines do not enhance coastal protection benefits and instead add to rebuilding and repair costs. More broadly, we also found that coastal communities generally perceived armored shorelines to be among the most damaged and least recovered. By coupling our survey results with data on local land use, we revealed that increased green space directly surrounding the home promoted higher levels of recovery from home damages and mental impacts caused by Hurricane Michael.

Moving forward, these insights will be translated into coastal resilience planning efforts throughout the region. For coastal property owners, our survey results showing added costs but no additional benefits for storm protection provide a compelling case for nature-based solutions along residential shorelines. More broadly, our study highlights the benefits of nature-based solutions and green space for promoting disaster resilience in coastal communities.