

# Protecting Open Space & Ourselves

Reducing Flood Risk in the Gulf of Mexico Through  
Strategic Land Conservation

## ACKNOWLEDGEMENTS

Support for this project provided by the Knobloch Family Foundation, the Landscape Conservation Cooperative Network and the U.S. Fish and Wildlife Service.

Suggested citation for this report:

Shepard C, Majka D, Brody S, Highfield W, and J Fargione. Protecting Open Space & Ourselves: Reducing Flood Risk in the Gulf of Mexico Through Strategic Land Conservation.. Washington DC: The Nature Conservancy. December 2016. 12 pages

# How Protecting Open Space Reduces Flood Risk

Open space protection in the floodplain is a key element of an “avoidance” strategy of flood mitigation.

- Open space land uses do not have people and structures (aside from some recreational buildings) in flood-prone areas, thus eliminating the opportunity for property loss and economic disruption.
- Open space enables the critical natural functions of wetlands to persist; the water storage capacity of the landscape is maximized and flooding beyond the extent of the actual protected area can be reduced.

# Introduction: Protecting open space for multiple benefits

Development and land use change in flood-prone areas have greatly increased the impacts of flooding in the United States. Never before in our nation's history have the effects from both surge and rainfall-based storm events been so damaging to the economic vitality of local communities. Losses from both acute and chronic flood events are especially problematic in low-lying coastal areas, where development has accelerated in recent decades. From 2003 to 2013 alone, property owners in the U.S. claimed over \$3.5 billion per year in insured flood losses. Strategic land protection, where undeveloped open spaces are protected in perpetuity, is a viable nonstructural solution for reducing flood risk. Protecting open space is also imperative for wildlife and the habitats they depend upon. Yet while open space protection is effective for reducing flood risk and conserving biodiversity, until now there have been no guidelines for determining where to target open space protection efforts to provide these multiple benefits.

Scientists at The Nature Conservancy and Texas A&M University partnered to provide that guidance. Together we identified 421 watersheds, out of approximately 2,600 across the Gulf of Mexico (GOM) that are the best targets for strategic land conservation to both reduce flood risk and conserve biodiversity.

To identify the most effective watersheds for land conservation, we took the following approach:

- Identified watersheds with a high probability of future flood damages, using a statistical classification model, and a suite of physical-based predictor variables.
- Identified high conservation opportunity watersheds using the Partnership for Gulf Coast Land Conservation vision footprint and the Protected Areas Database.
- Mapped priority multi-objective watersheds with high likelihood of future flood damage and high conservation opportunity

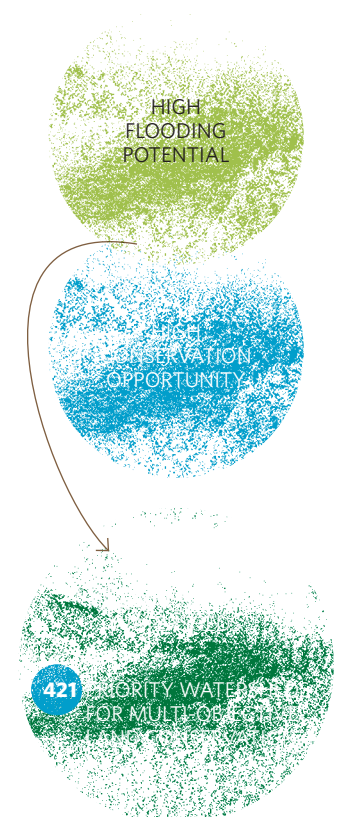
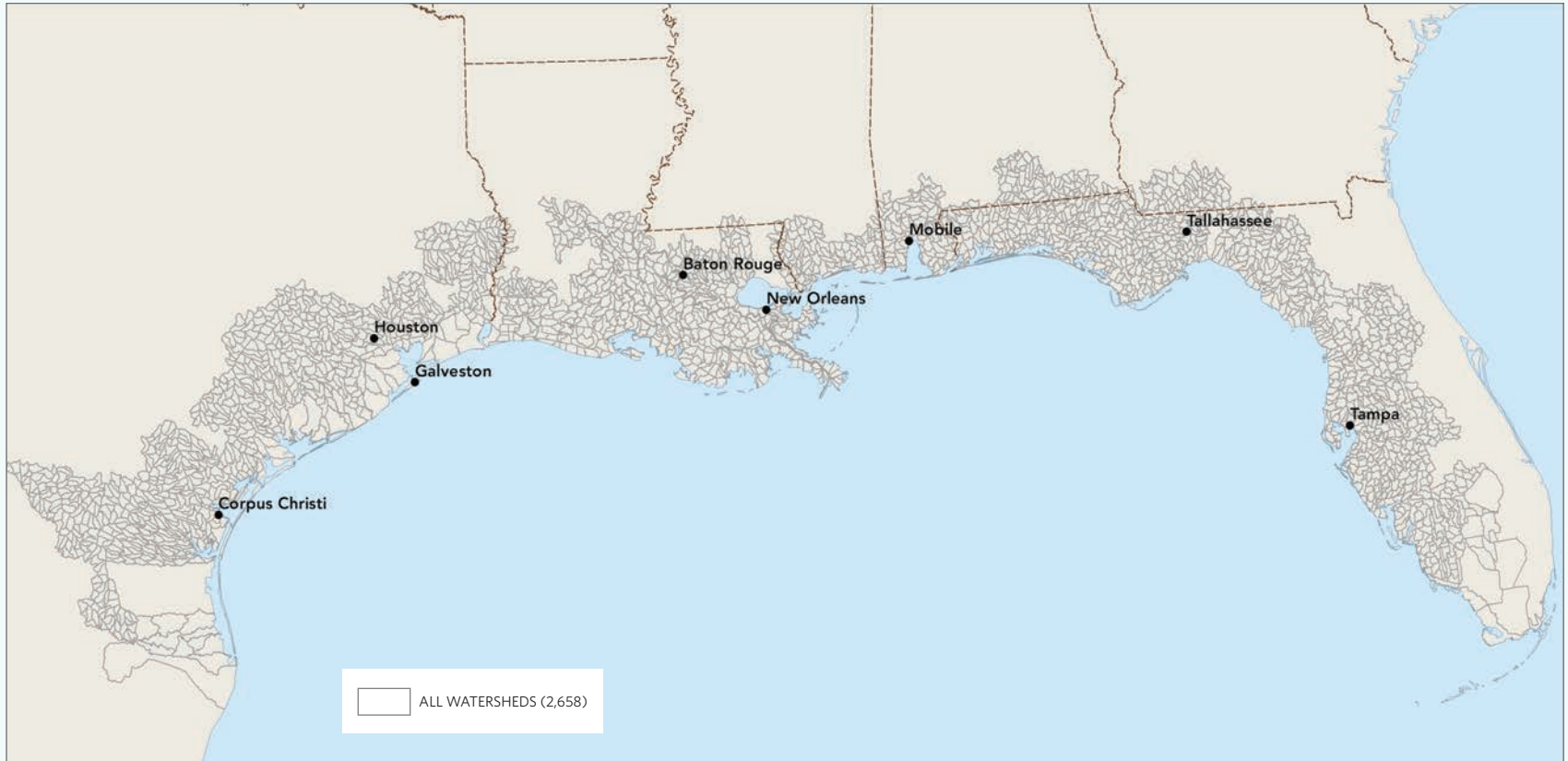


FIGURE 1. STUDY WATERSHEDS



## About the study area

The study area consisted of 12th order watersheds (based on the USGS Hydrological Unit Code (HUC) encompassing 144 counties and parishes adjacent to the Gulf of Mexico. This area includes watersheds from the following six states: Florida, Georgia, Alabama, Mississippi, Louisiana, and Texas. In total, we analyzed 2,651 adjacent watersheds ringing the Gulf coast. (Figure 1). A few watersheds without available flood claims data were excluded from the analysis.

The coastal margin associated with the Gulf of Mexico is an ideal region to examine the relationship between undeveloped open space and flooding for several reasons. First, this low-lying coastal margin contains large

amounts of floodplain (on average, approximately 32 percent of the study area lies within the 100-year floodplain), making it extremely vulnerable to the adverse effects of rainfall and surge-based flooding events. For example, from 1996 to 2007, communities within the study area experienced the largest amount of insured property damage in the U.S. Second, the Gulf coast has a legacy of rapid population growth and associated land use change, creating a diversity of land use and land cover patterns across watersheds. Third, there remain large tracts of undeveloped lands along the Gulf coast that, if protected, will help prevent future flood losses to local communities.

# Identifying watersheds with high probability of future flood damages

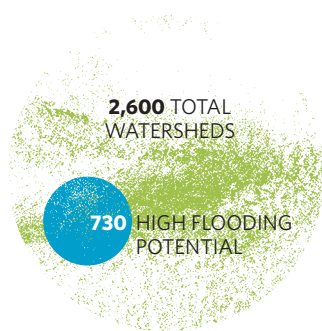
To predict the probability of future flood claims and identify watersheds in which open space protection is likely to reduce future flood risk, we engaged in modeling using a host of techniques to explore the relationships between the amount and configuration of open space and flood damage. Flood damage was measured as the dollar amount (contents and building damage) of claims paid under the National Flood Insurance Program (NFIP) from 2008-2014. While insured loss does not cover all damage incurred from a flood event, it remains a strong and viable indicator of flood damage.

Several contextual control variables were also measured and analyzed in the statistical models. Under socioeconomic and built environment characteristics, we included the median household income. Census block group values were aggregated to the watershed unit. These variables were included in the models to account for the number of structures per watershed and their estimated value (structure and contents) based on household income. Three development-based variables were measured based on the percent of impervious surface cover: high-intensity, low-intensity, and developed open space.

We also included several environmental baseline controls. Precipitation, the biggest predictor of flooding and flood damage, was measured based on the number of days with greater than 1 inch of rainfall. As a measure of risk exposure, we calculated the percent of each HUC in the 100-year floodplain. On average, 32 percent of watersheds in the sample lie within the 100-year floodplain. The average slope of each watershed was calculated because flat, low-lying floodplains and coastal areas tend to pool water and are more prone to inundation.

Hydraulic conductivity of the soil, which measures the speed and ability of soil to absorb water was also included as an environmental control variable in the statistical models. If surface runoff cannot penetrate into the soil, flooding can be exacerbated, especially in developed areas. The Gulf coast study area contains a range of soil characteristics, from clay/clay-loam to sand. The hydraulic conductivity values in the watershed ranged from 0-108.73 micrometers per second.

Finally, we included the size of each watershed in square meters. Larger watersheds should contain more drainage area and greater stream length that could affect flood impacts, particularly in down-stream areas. We also included a variable measuring the number of NFIP policies as an additional measure of risk perception and exposure.

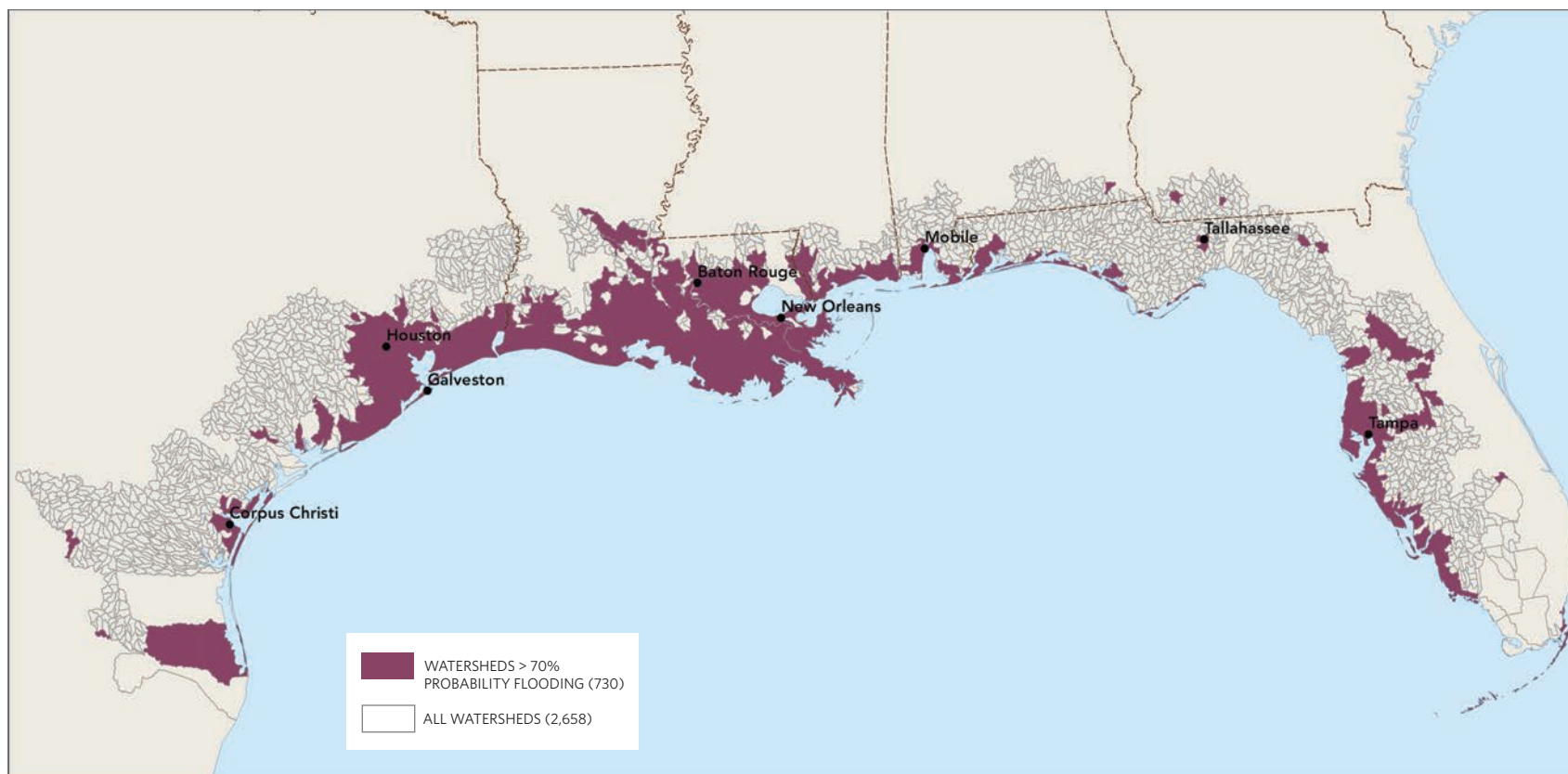


Exploratory modeling using a variety of parametric and non-parametric techniques revealed only very weak correlations between open space patch metrics (size and configuration of open space) and flood damage, and strong correlation with physical variables. We built our final models using a random forests (RF) approach. The best RF model predicting probability of flooding damage included the following variables:

1. soil conductivity,
2. precipitation,
3. percent of watershed in floodplains,
4. mean slope,
5. mean distance to coast,
6. spatial coordinates, and
7. developed land cover.

The final model had an overall accuracy of 85% and we used this model to identify watersheds with a high probability of flood damage. 730 watersheds (nearly one third of the watersheds) were classified as high flooding potential, meaning the model predicts a 70 percent or higher chance of flood claims in the future (Figure 2).

FIGURE 2. HIGH FLOODING POTENTIAL



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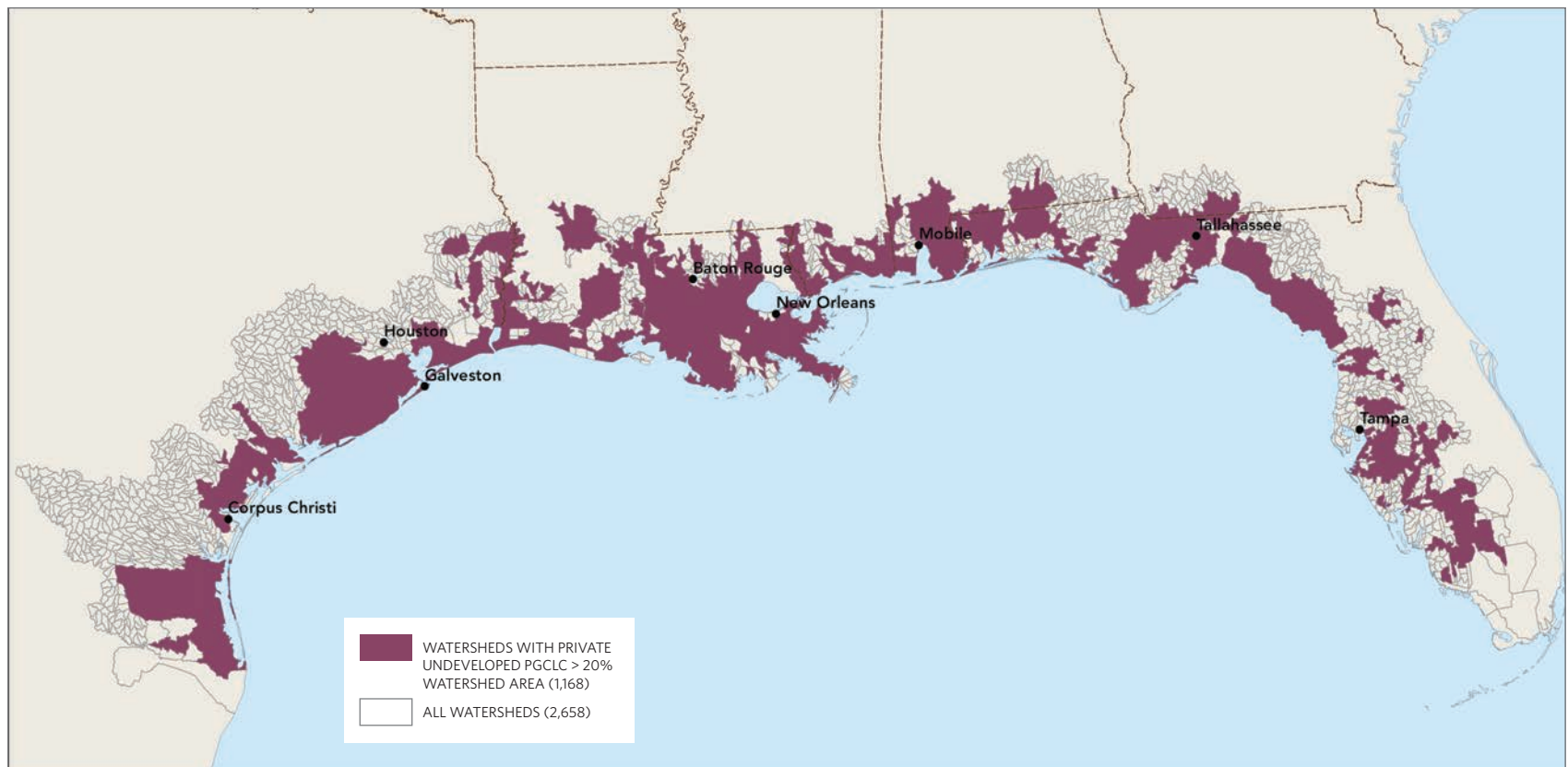


# Identifying unprotected, high conservation opportunity watersheds

In October, 2014, the Partnership for Gulf Coast Land Conservation, in conjunction with The Nature Conservancy and The Conservation Fund, released 'A Land Conservation Vision for the Gulf of Mexico Region', which is a series of maps that identify high-value geographic areas for land conservation. These maps were created by the partner organizations and include:

1. focus areas identified by the partners that reflect local community values,
2. wetlands,
3. migratory bird habitat,
4. scenic rivers, and
5. longleaf pine habitat.

FIGURE 3. HIGH CONSERVATION POTENTIAL





We used the Conservation 'vision footprint' maps to indicate conservation lands that are a high priority for land trusts across the Gulf Coast region. Because we are focused on open space protection, we screened out developed lands within the 'vision footprint' maps using the 2011 National Land Cover Dataset. To identify watersheds with opportunities for conserving land within the "vision footprint", we used the Protected Areas Database to identify open spaces that are not currently protected. 1168 watersheds were classified as high conservation opportunity, meaning 20% or more of the watershed area is undeveloped, unprotected and within the PGCLC conservation vision footprint (Figure 3).

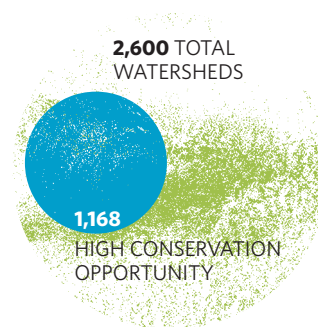
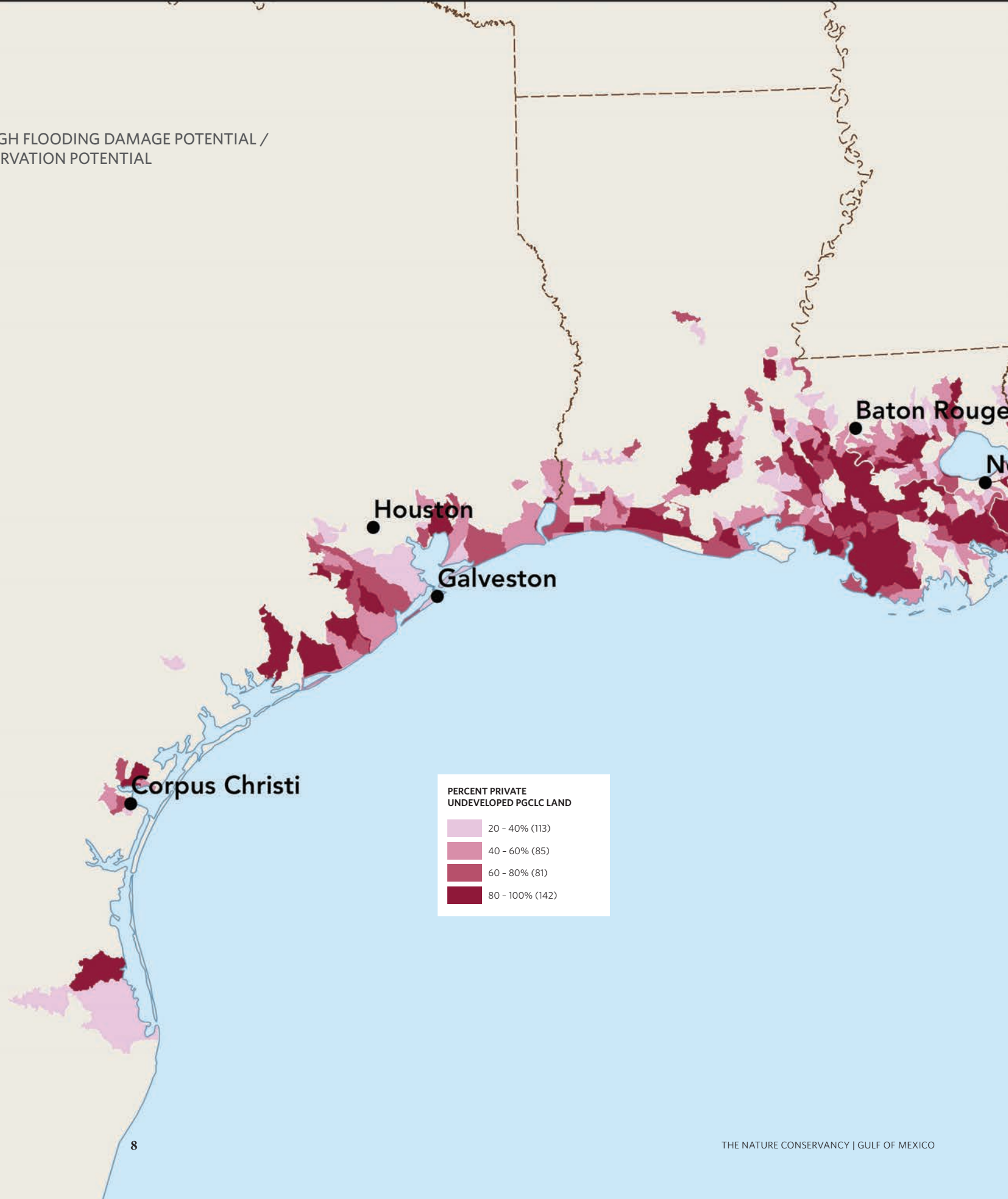
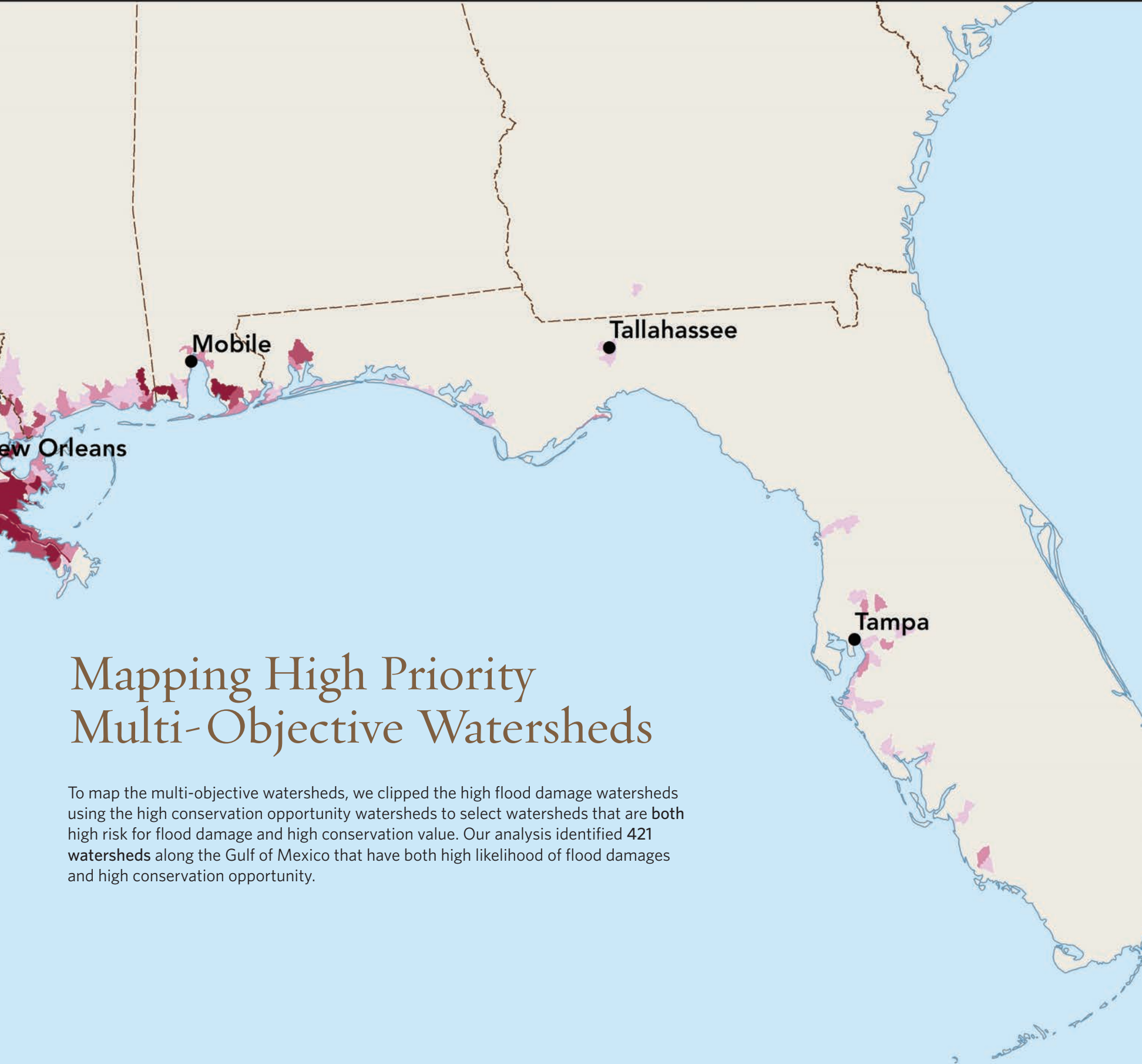


FIGURE 4. HIGH FLOODING DAMAGE POTENTIAL /  
HIGH CONSERVATION POTENTIAL





## Mapping High Priority Multi-Objective Watersheds

To map the multi-objective watersheds, we clipped the high flood damage watersheds using the high conservation opportunity watersheds to select watersheds that are both high risk for flood damage and high conservation value. Our analysis identified 421 watersheds along the Gulf of Mexico that have both high likelihood of flood damages and high conservation opportunity.

JOCELYN AUGUSTINO/FEMA



# How to Use These Maps

Open space protection has long been a cornerstone of land use planning and policy across the U.S. This designation is commonly embedded within local land use or comprehensive plans and often implemented through voluntary land acquisition in fee and easement, and, to a lesser extent, through subdivision, zoning, and building ordinances including transfers of development rights, mitigation, and buffers and setbacks. Open space is employed as a land use strategy for multiple purposes, including establishing public parks and recreation areas, separating conflicting land uses, protecting naturally occurring wetlands and riparian corridors, and providing water retention/detention.

The 421 watersheds identified in our analysis are appropriate locations for further consideration of open space protection as a flood risk reduction and conservation strategy (Figure 4). Municipalities, land trusts and government agencies engaged in land acquisition within these watersheds are best suited to identify specific land protection opportunities within each watershed but should consider opportunities to fund these acquisitions to meet multiple objectives.

FEMA's voluntary Community Rating System (CRS) provides an opportunity to use open space protection to meet multiple objectives by more tightly linking land conservation and flood risk reduction. The CRS is a voluntary program in which communities get points for flood mitigation activities and can earn discounts on their residents' flood insurance premiums. Open space protection has long been a creditable CRS activity but is underutilized despite its likely effectiveness in reducing losses. CRS communities that protect open space (even for reasons other than flood risk reduction) can earn their citizen's an insurance discount.

343 municipalities, counties, and parishes are within or partially within the high priority watersheds. As of 2014, only 100 of these communities were enrolled in the CRS program. Of the 100 CRS communities, the average number of points each community earned for open space was only 131 out of a possible 2020 points for open space preservation. This indicates that there is substantial opportunity to improve CRS scores within key target watershed communities by protecting open space which can reduce flood risk, conserve species and habitats and provide an economic benefit in the form of reduced insurance premiums.



# Summary: Strategic Protection of Open Space to Reduce Flood Risk

Increasing flood losses along the Gulf of Mexico have triggered extensive debate on different strategies to reduce risk and future adverse impacts from storm events. While much of the discussion has focused on structural engineering approaches to flood mitigation, increasing emphasis is being placed on avoidance strategies, such as the protection of undeveloped open spaces. This study is the first of its kind to examine undeveloped lands across approximately 2,600 watersheds along the Gulf of Mexico.

These 421 target watersheds, identified using data-driven research methods, point the way towards identifying specific tracts of land within the Gulf of Mexico study area that if left in a natural state, can help reduce the adverse impacts of floods in the future and provide other benefits such as fish and wildlife habitat, places for outdoor recreation, improved water and air quality, attractiveness for tourism, and retention of the traditional character of the Gulf coast.

*\*To further explore the 421 priority watersheds and the findings in this report, please visit [maps.coastalresilience.org/gulfmex](https://maps.coastalresilience.org/gulfmex). A full technical appendix is also available at [coastalresilience.org](https://coastalresilience.org).*





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