Prepared in collaboration with the National Park Service

Projected Sea-Level Rise and High Tide Flooding at De Soto National Memorial, Florida

View to the north from De Soto Point at De Soto National Memorial (DESO), Florida, in December 2022. Photograph by National Park Service staff, DESO.

Overview

Objective

National parks and preserves in the South Atlantic-Gulf Region (https://www.nps.gov/aboutus/index.htm) contain valuable coastal habitats such as tidal wetlands and mangrove forests, as well as irreplaceable historic buildings and archeological sites located in low-lying areas. These natural and cultural resources are vulnerable to accelerated sea-level rise (SLR) and escalating high tide flooding (HTF) events. Through a Natural Resources Preservation Program-funded project during 2021–23, the U.S. Geological Survey (USGS), in collaboration with the National Park Service (NPS), estimated the probability of inundation at De Soto National Memorial (DESO) and several other parks under various SLR scenarios and contemporary HTF thresholds. The maps produced for this effort can be used to assess potential habitat change and explore how infrastructure and cultural resources within the park may be exposed to future flooding-related hazards. Though the study areas are different, the organization and wording of this publication are largely based on Thurman and others (2024a).

De Soto National Memorial

Located at the mouth of the Manatee River at the southern end of Tampa Bay, Florida, DESO covers 0.12 square kilometer of land (that is, area excluding water and aquatic bed wetlands from the National Oceanic and Atmospheric Administration [NOAA] Coastal Change Analysis Program [NOAA, 2019]) (fig. 1). Most of the park is composed of coastal wetlands dominated by black mangrove (*Avicennia germinans*) (NPS, 2023).

Base from U.S. Geological Survey digital data
Park boundary from National Park Service (2024)
Shaded bathymetry from U.S. Geological Survey, The National Map
Orthoimagery from U.S. Department of Agriculture
National Agriculture Imagery Program, 2017, 1.2 meters
Universal Transverse Mercator, zone 17 north
North American Datum of 1983

Figure 1. Location of De Soto National Memorial (DESO) within the State of Florida.

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Because of SLR, the coastal habitats within DESO and other national parks and preserves in the region are at the forefront of concern. Specifically, these habitats are threatened unless they have the ability to adapt in place (for example, through vertical adjustment; Morris and others, 2002) or migrate to higher ground (for example, through tidal marsh transgression; Enwright and others, 2016). Similarly, SLR exposes important historic, cultural, and recreational sites to risk of damage or loss.

Relative Sea-Level Rise

SLR driven by global climate change is an ongoing and intensifying issue affecting low-lying coastal areas around the world (Sweet and others, 2022). Rates of SLR vary regionally because of factors such as the circulation and density of ocean water, rates of vertical land motion, and the location and volume of ice-mass loss from ice sheets and glaciers (Sweet and others, 2022). These localized rates, referred to as “relative SLR,” are differentiated from the global mean rate.

A recent multiagency report generated five potential global SLR scenarios based on the amount of greenhouse gases emitted into the atmosphere and the rate of ice-mass loss (Sweet and others, 2022). The five scenarios, termed “low,” “intermediate-low,” “intermediate,” “intermediate-high,” and “high,” each predict a different magnitude of future global mean SLR. Along with these global SLR scenarios, we used regional and local projections associated with each scenario to reflect relative SLR rates (fig. 2). Additionally, since there is uncertainty in how various natural processes will affect SLR, rates may vary within a given scenario. Whereas the median SLR projection can be represented by a single value, the “likely” SLR can be represented by a range of values (that is, 17th to 83d percentile) (fig. 2).

High Tide Flooding

HTF occurs when spring tides (that is, maximum tides occurring during a full or new moon when the Earth, Moon, and Sun are aligned), high winds, or storms cause extreme water levels in coastal areas. For this effort, we used HTF thresholds defined by NOAA, which include thresholds designated “minor,” “moderate,” and “major” that vary on the basis of location (that is, latitude and longitude) (Sweet and others, 2022). Minor HTF events can cause disruptions such as flooding along trails and other infrastructure (fig. 3), moderate HTF events can cause greater disruptions and possibly damage, and major HTF events can cause destruction and lead to evacuations (NOAA, 2023).

Today, minor HTF events typically occur only a few days each year along the eastern Gulf of Mexico coast, and moderate and major HTF events typically occur less than once per year (Sweet and others, 2022). However, these events are exacerbated by relative SLR, and rapid increases in HTF frequency are expected within the next few decades (Thompson and others, 2021). By 2100, minor HTF is projected to occur more often than every other day under the intermediate-low SLR scenario, meaning that the threshold for a flood today could become the high tide level in the future (Sweet and others, 2018).

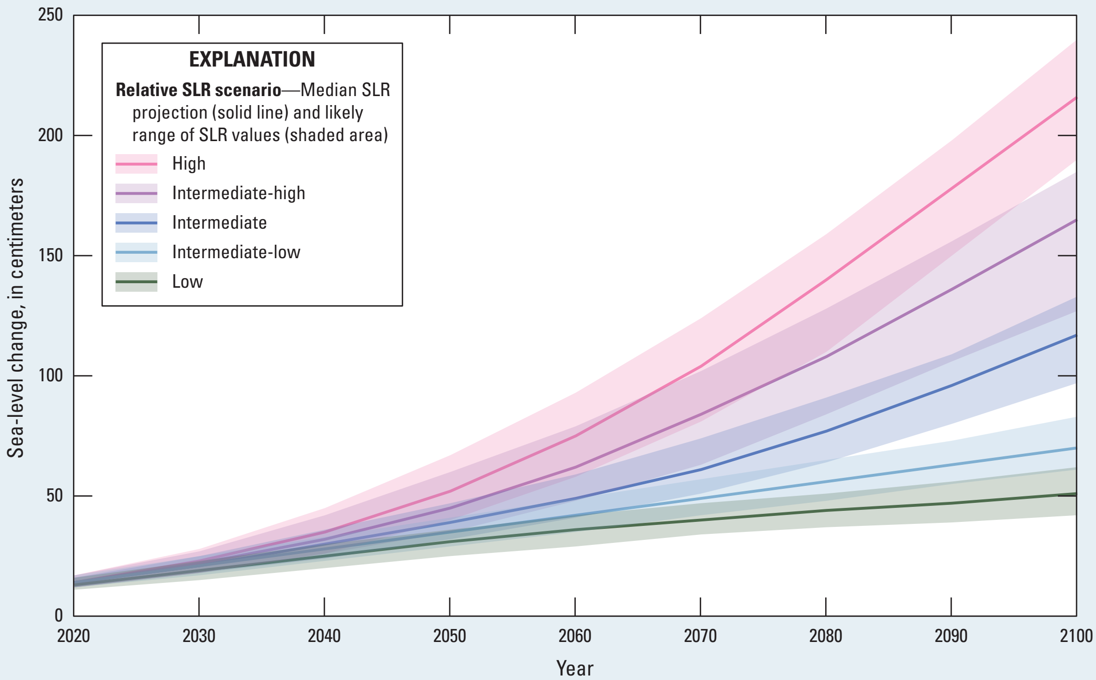

Figure 2. Relative sea-level rise (SLR) scenarios for De Soto National Memorial (DESO), Florida, associated with the five global SLR scenarios from Sweet and others (2022). Sea-level change projected in this figure (modified from Thurman and others [2024b]) is relative to the year 1992.

Figure 3. Trail on the north shore of De Soto National Memorial (DESO), Florida, flooded by a high tide flooding event in July 2017. Photograph by National Park Service staff, DESO.

The increasing frequency and severity of HTF mean that even minor flooding events are no longer just a nuisance but are becoming a serious issue (Thompson and others, 2021). Cumulatively, the effects of many flooding events can be destructive to infrastructure and assets in low-lying areas (Sweet and others, 2018). Tidal flooding represents a contemporary effect of SLR and may be an indicator of challenges to come (Sweet and others, 2022).

Key Findings

Relative Sea-Level Rise

Inundation probabilities were mapped for DESO under the intermediate-low and intermediate-high SLR scenarios for the years 2050 and 2100 by using 1992 as the base year (fig. 4). For these scenarios and timesteps, the median SLR projection and likely range of values (that is, 17th to 83d percentile) are 35 centimeters (cm) for the intermediate-low scenario in 2050 (range: 29–41 cm), 70 cm for the intermediate-low scenario in 2100 (range: 61–83 cm), 45 cm for the intermediate-high scenario in 2050 (range: 35–60 cm), and 165 cm for the intermediate-high scenario in 2100 (range: 127–185 cm) (fig. 2) (Thurman and others, 2024b).

Under the intermediate-low scenario in 2050, about 53 percent of the park's nonwater area was classified as likely be inundated (that is, probability greater than 0.66); under the same scenario, this percentage increased to about 71 percent by 2100 (fig. 4). For the intermediate-high scenario, about 60 percent of the park's nonwater area was classified as likely to be inundated by 2050 and about 87 percent by 2100 (Thurman and others, 2024b).

High Tide Flooding

Inundation probabilities were mapped for DESO under NOAA's minor, moderate, and major HTF thresholds (fig. 5). The minor threshold is 53 cm (plus or minus [±] 19 cm, the root mean square error of linear regression, which is the square root of the average of the squared difference between projected values and actual values) above mean higher high water, and the moderate and major thresholds are 82 cm (±25 cm) and 120 cm (±39 cm) above mean higher high water, respectively (Sweet and others, 2018, 2022). Under all three HTF thresholds, most of the park's nonwater area was classified as likely to be inundated. The likely inundation area increased from about 63 percent under the minor threshold to about 80 percent under the major threshold (Thurman and others, 2024b).

Applications of Maps

These maps of projected inundation from SLR and HTF can be used to assess current and future impacts of rising water levels to natural habitats, historic and cultural resources, and infrastructure within the park and can provide a resource for management decisions such as implementation of the resist-accept-direct (RAD) framework (Schuurman and others, 2020). Additionally, this mapping approach can be utilized to quantify and depict future habitat change driven by SLR, such as tidal saline wetland migration.

Methods

Data associated with this effort, along with details on the methods for the approximation of park areas that may be inundated from SLR and HTF, can be found in a USGS data release (Thurman and others, 2024b).

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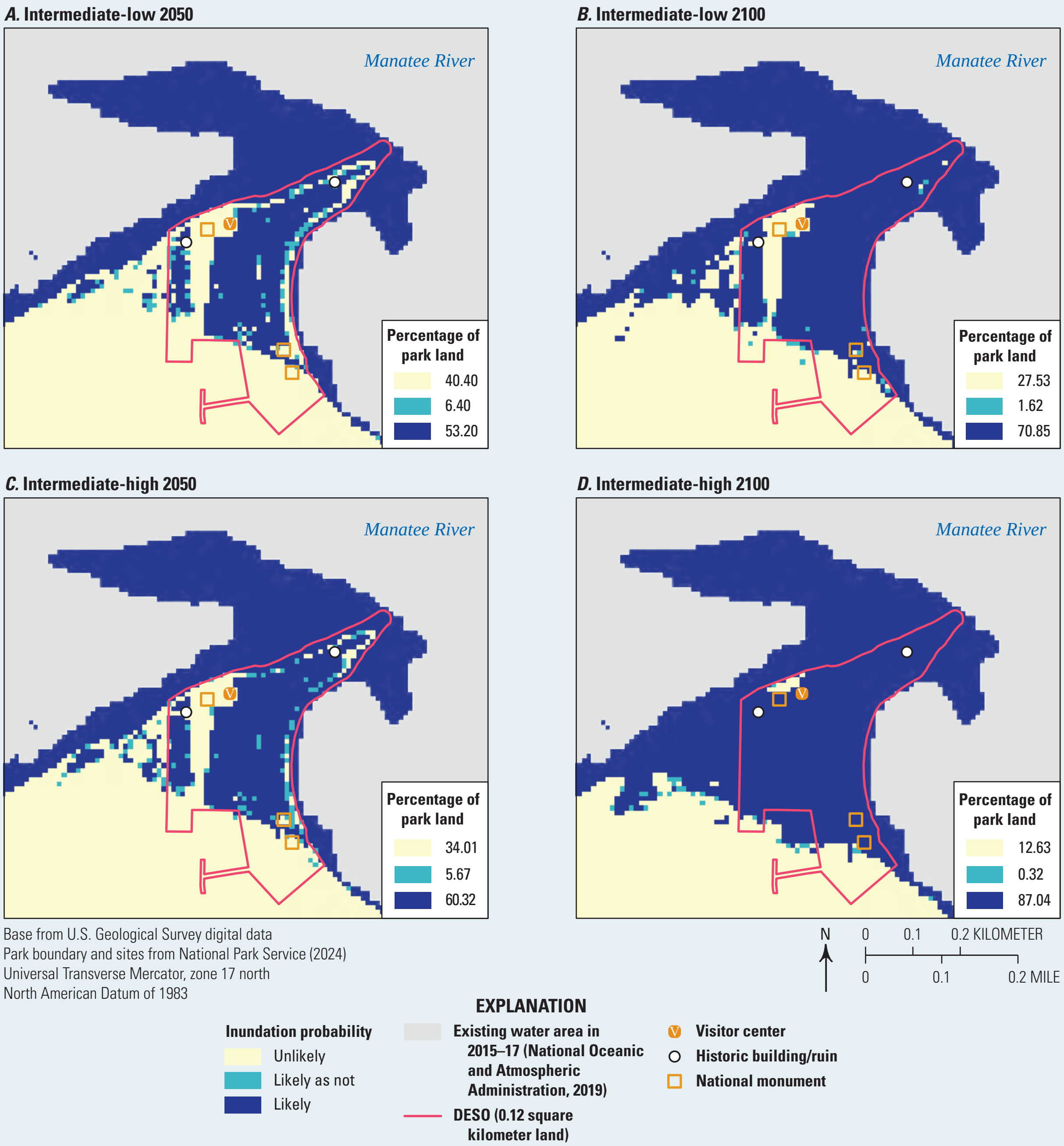

Figure 4. Sea-level rise (SLR) inundation probabilities for De Soto National Memorial (DESO), Florida, under the SLR scenarios (Sweet and others, 2022) intermediate-low for the years *A*, 2050 and *B*, 2100 and intermediate-high for the years *C*, 2050 and *D*, 2100 (Thurman and others, 2024b). Sea-level change projected in this figure is relative to the year 1992. Probability is shown using three bins developed for the Intergovernmental Panel on Climate Change (2022): unlikely, probability less than or equal to 0.33; likely as not, probability greater than 0.33 and less than or equal to 0.66; and likely, probability greater than 0.66. Existing water areas were excluded from the analyses and area calculations.

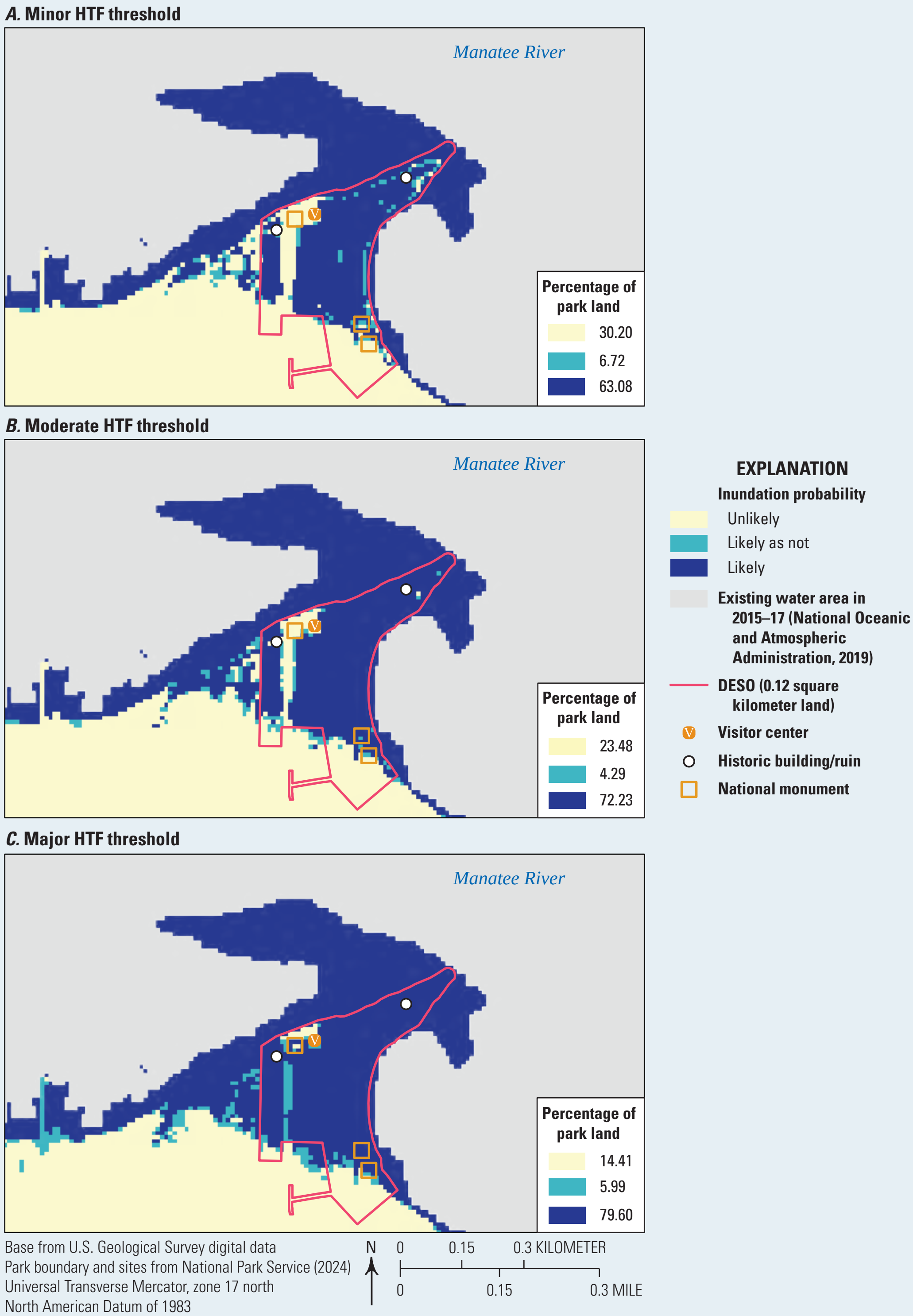

Figure 5. High tide flooding (HTF) inundation probabilities for De Soto National Memorial (DESO), Florida, under the National Oceanic and Atmospheric Administration (Sweet and others, 2022) *A*, minor, *B*, moderate, and *C*, major HTF thresholds (Thurman and others, 2024b). Probability is shown using three bins developed for the Intergovernmental Panel on Climate Change (2022): unlikely, probability less than or equal to 0.33; likely as not, probability greater than 0.33 and less than or equal to 0.66; and likely, probability greater than 0.66. Existing water areas were excluded from the analyses and area calculations.

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