Unpublished Report – (Code: 114535)

Actions

Title: An inventory of surface elevation tables installed on National Wildlife Refuge System lands

Description: Between 1992 and 2017, 985 surface elevation tables (SETs) were installed by the US Fish and Wildlife Service, US Geological Survey, State of Louisiana's Coastal Reference Monitoring System, National Estuarine Research Reserve, National Aeronautics and Space Administration, Water Institute of the Gulf and the University of Louisiana on 71 refuges within in Department of the Interior regions 1, 2, 4, 6, 8, 9 and 10. The purpose of these SETs is to improve our understanding of marsh and mangrove response to relative sea level rise, anthropogenic stressors (e.g., development, impoundment, highways) and subsidence, where it occurs. This report contains the number of SETs on each participating refuge and a generalized map location for the refuge. Individual refuge SET locations will be provided upon request.

Full Citation: Covington, J.S. 2020. An inventory of surface elevation tables installed on National Wildlife Refuge System lands. U.S. Fish and Wildlife Service, Falls Church, VA. 16 pp.

INTRODUCTION

Coastal areas (e.g., tidal freshwater marshes, saltwater marshes, and mangrove forests) contain highly productive ecosystems rich in aquatic and wildlife diversity. They play important ecological roles and provide human benefits such as buffers against storm damage, nurseries for commercial fish species; carbon sequestration and improved water quality (Millennium Ecosystem Assessment, 2005; IPCC, 2014). Coastal habitats depend upon a complex interplay of periodic water inundation through tidal action, terrestrial sediment delivery, and nutrients that promote plant growth.

Understanding how these habitats respond to sea level rise (SLR) is important to resource managers responsible for the habitats on which these focal conservation species depend. For example, under natural conditions, coastal marshes should be self-sustaining. Their surface elevation is established through tidal flooding, where sediments are deposited allowing a rich medium for salt tolerant plants to grow (Kirwan and Gunterspergen 2010). However, when SLR exceeds the capacity for sediment deposition to occur and plant roots become submerged for too long, plant growth slows until the plant dies, which in turn can cause the marsh to transition into a mud flat and eventually open water (Wang and Temmerman 2015).

Surface elevation tables (SETs) are portable mechanical leveling devices that measure precisely the changes in elevation of wetland sediments. This provides scientists and managers an

understanding of the processes responsible for elevation change (Lynch et al 2015). SETs are typically surveyed in to a known vertical datum (e.g., NAVD 88) by using leveling to a known benchmark or static occupation (e.g., real time kinematics) so users can understand their relationship to local sea level conditions. By understanding the trends occurring at SET sites over time, managers can determine if the marsh is gaining, maintaining or losing elevation, relative to SLR. This information can be used to help decide if management intervention is needed to maintain the marsh (e.g., thin layer application of sediment to increase marsh surface elevation).

The US Fish and Wildlife Service (Service), through the National Wildlife Refuge System (NWRS), manages 180 coastal refuges around the US, including Alaska, the Caribbean and the Pacific. Since some SLR predictions suggest that up to 60% of coastal wetlands will be inundated (Craft et al. 2009), the Service is very concerned about the long-term viability of these habitats. To address local questions related to SLR and marsh elevation changes, 71 refuges have had SETs installed. With SET's common data collection protocols and widespread acceptance across the US and other countries, it is important for the NWRS to understand:

1. Gaps in SET station distributions, which can be identified among and across areas;
2. Local and regional trends in elevation changes that can be analyzed and identified, useful in determining if intervention is needed as well as prioritizing restoration funding; and
3. Encourage cooperation across regional and agency boundaries to:
    a. Provide local assistance in reading SETs and collecting vegetation transect data; and
    b. Standardize trend analysis and use of the National Surface Elevation Table Database (NSETD; https://ecos.fws.gov/SET/).

METHODS

The Service, through its NWRS Inventory and Monitoring (I&M) Program has developed a NSETD, which houses SET location data, including individual pin data (see Lynch et al. 2015 for SET protocols). The NSETD is national in scope and the intent is to populate it with information from all refuges. Not all SETs on refuges were established by the Service, however, nor are their data included in the NSETD. I reached out to I&M biologists in Interior Regions (IR) 1, 2, 4, 6, 8, 9 and 10 to determine SET data availability. I identified sources that had collected SET data in IR 1, including the Saltmarsh Integrity Project, USGS, who had SETs on Blackwater NWR and other refuges in Chesapeake Bay, and individual staff at Virginia refuges that had installed and were annually reading SETs. For SET location data from IR 2 and 4, multiple entities established and read SETs, including Service staff. Osland et al. 2018 compiled data on SETs throughout the Gulf States, so I was able to extract location, installation data and the names of the data stewards. Merritt Island National Wildlife Refuge (NWR) had 39 SETs established and read by the National Aeronautics and Space Administration (Cape Canaveral, FL). USGS, University of Louisiana (UL) and National Estuarine Research Reserve (NERR) biologists established SETs in Florida, while Jeremy Conrad, wildlife biologist at Ding Darling, established SETs on southern Florida refuges. IR 6 did not use the NSETD, so I requested specific SET data for their refuges directly from the I&M biologist. Since IR 8, 9 and 10 rely on

USGS for their SET establishment and readings, I contacted the USGS West Coast SET lead (Karen Thorne). Without further documentation, I have assumed that the remainder of the refuges have SETs that were installed by refuge staff with assistance or direction of the USGS or contractors.

RESULTS

Between 1992 and 2017, at least 985 surface elevation tables (SETs) were installed by the Service, USGS, State of Louisiana's Coastal Reference Monitoring System (CRMS), NERR and the UL on 71 refuges within IR 1, 2, 6, 8, 9 and 10 (Table 1; Figures 1-10). While I was unable to obtain complete records for each SET, I am able to report these data *for most of the SETs*:

- Agency Name that installed the SET;
- Point of Contact and their email;
- Year Installed; and
- Latitude/Longitude.

Based on the data collected, I determined that, at a minimum, the USGS installed 290 SETs on 16 refuges, the CRMS established 41 SETs on six refuges, the NERR program established 20 SETs on three refuges and the UL installed 17 SETs on one refuge. The average number of SETs installed on each refuge was 13 and the median was six. Blackwater NWR has the highest number of SETs (119) for a single refuge.

Of the SETs installed to date, 454 have been in place long enough to have trend data. Seven years is the minimum amount of time to collect two data points (in years six and seven), because SETs need five years to equilibrate from the initial disturbance of the sediment when the SET is installed or recover from large storm events (Lynch et al. 2015). By 2022, over 200 SETs will have been in place long enough to add to the trend record.

DISCUSSION

While there are identified omissions in the existing dataset, this report should be considered a living document that will be updated as those data are revealed and when new SETs are added. Eventually, the NSETD's use should be incorporated into routine data collection activities and entities that collect SET data on refuges will be identified as well in the NSETD. There is no reason to duplicate their data if it is available to others through a common metadata exchange format that is currently in development by the Service, NPS, Natural Resource Conservation Service, National Oceanic and Atmospheric Administration, and USGS under the auspices of the US Global Change Research Program.

In addition to tracking new SETs, the next steps should include standardizing SET trend analysis. This could incorporate statistical approaches that become integrated into the NSETD. For example, Ladin and Schriver (2017) developed analytical tools in program R (R Development Core Team 2015) to determine temporal trends in the change in salt marsh surface elevation.

This type of analysis could provide a method to organize a national effort by which local and regional trends could be easily compared.

ACKNOWLEDGEMENTS

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Table 1. National Wildlife Refuges (listed in alphabetical order) with the number of individual Surface Elevation Tables (SET) on each refuge. Superscripts refer to the entity that established the SETs on the refuge. Refuges without superscripts mean refuge staff established the SETs (or entity is unknown).

National Wildlife Refuge	No. of SETs	National Wildlife Refuge	No. of SETs
Alligator River	6	Mackay Island	3
Anahuac	6	McFaddin[1]	28
Aransas	13	Merritt Island[7]	39
Back Bay[1]	18	Monomoy	7
Bandon[1]	9	Moosehorn	12
Bayou Savage[2]	4	Ninigret	6
Big Branch Marsh[1, 2, 3]	14	Nisqually[1]	14
Blackbeard Island	3	Oyster Bay	3
Blackwater[1]	119	Parker River	47
Bombay Hook	25	Pea Island	3
Brazoria	6	Pelican Island	6
Cameron Prairie[2]	5	Petit Manan	7
Cape May	31	Pinckney Island	3
Cape Romain	5	Pocosin Lakes[1]	15
Cat Island[1]	4	Prime Hook	21
Cedar Island	3	Rachel Carson	62
Cedar Key	6	Roanoke River	3
Chincoteague	27	Sabine[2]	22
Croc Lake	6	Sachuest Point	6
Currituck	3	San Bernard	12
Delta[1, 2]	14	San Pablo Bay[1]	4
Ding Darling	18	Savannah-Pinckney	4
Eastern Shore Of Virginia	6	Seal Beach[1]	25
Edwin B. Forsythe	91	Seatuck	9
Ernest F. Hollings Ace Basin	3	St. Mark's[1]	7
Fisherman Island	6	Stewart B. Mckinney	13
Grand Bay[4]	15	Supawna Meadows	6
Great Dismal Swamp[1]	9	Swanquarter	3
Harris Neck	3	Ten Thousands Islands[1]	30
Hobe Sound	6	Tijauna River[6]	4
Humboldt[1]	8	Waccamaw	3
John H. Chafee	15	Wallops Island	3
Key Deer - Sugar Loaf[5]	8	Wassaw	3
Key Deer - Big Pine[5]	9	Wertheim	12
Lacassine[2]	1	White River[1]	4
Lower Suwannee	8	Wolf Island	3
SET TOTAL			**985**

[1] USGS [2]Louisian Coastal Reference Monitoring System [3]Water Institute of the Gulf [4]Grand Bay NERR [5]University of Louisiana [6]Tijauna River NERR [7]National Aeronautics and Space Administration

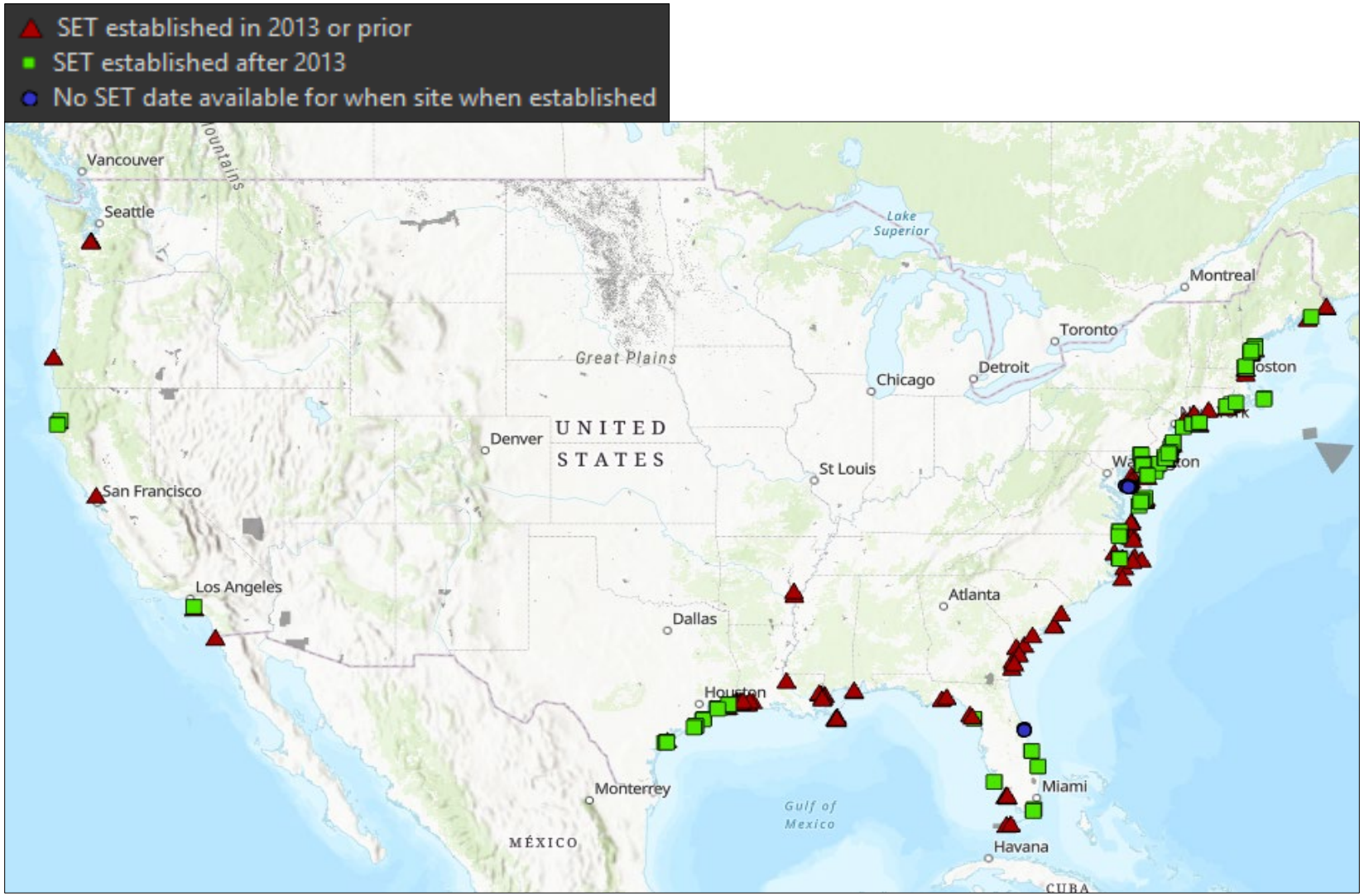

Figure 1. Map of the continental United States indicating locations of national wildlife refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

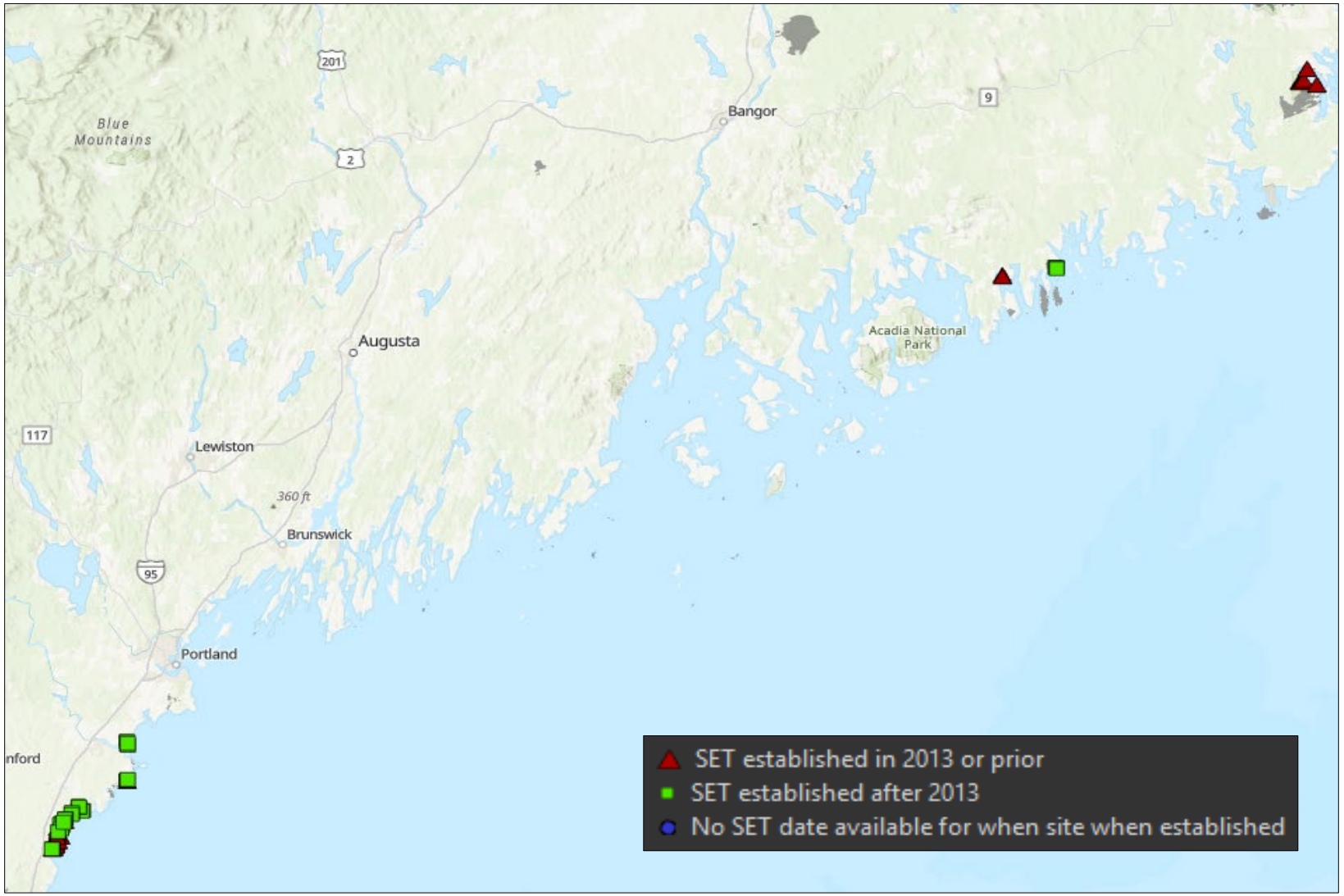

Figure 2. Map of Maine indicating locations of national wildlife refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

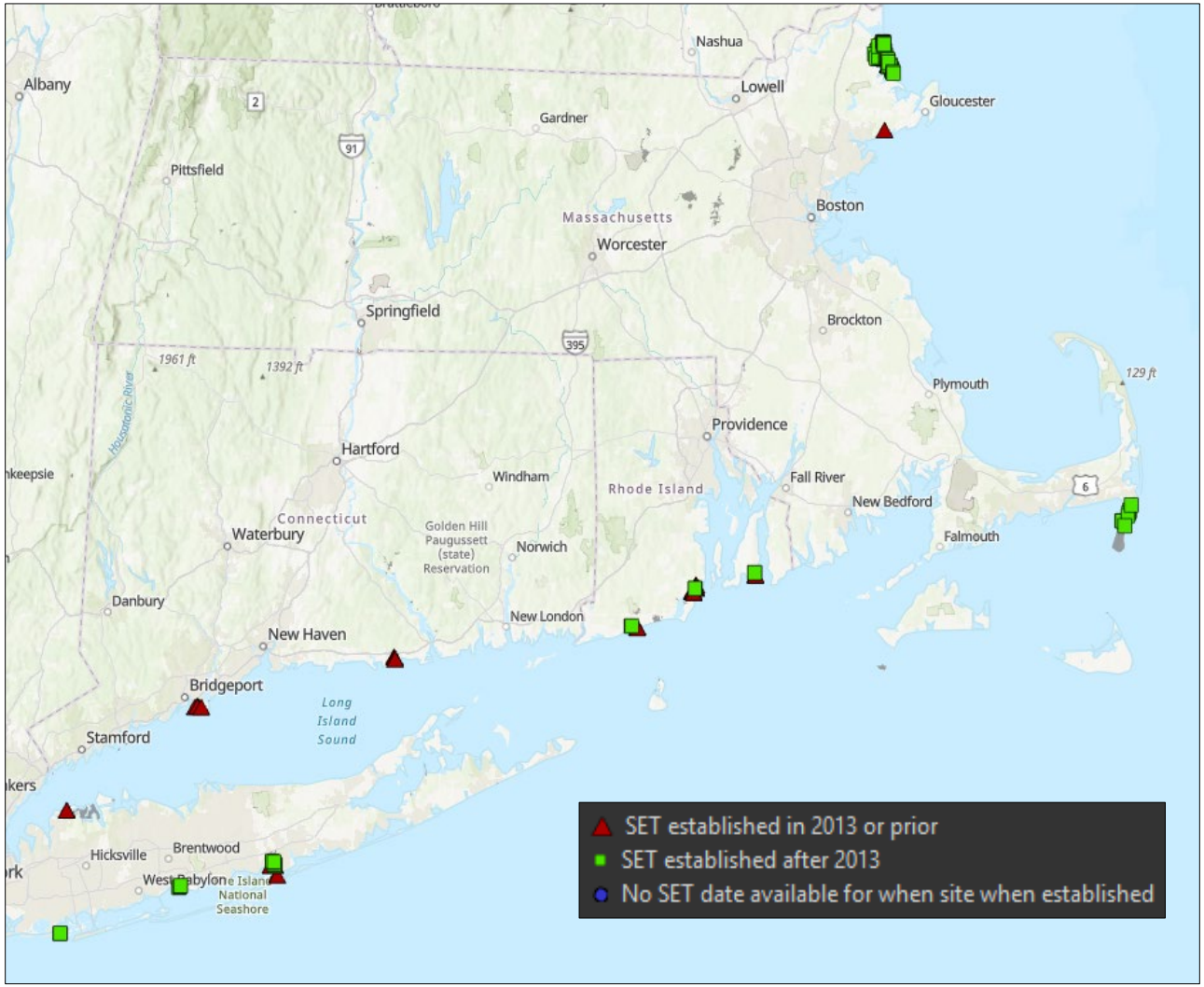

Figure 3. Map of New Hampshire, Massachusetts, Rhode Island, Connecticut and New York indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

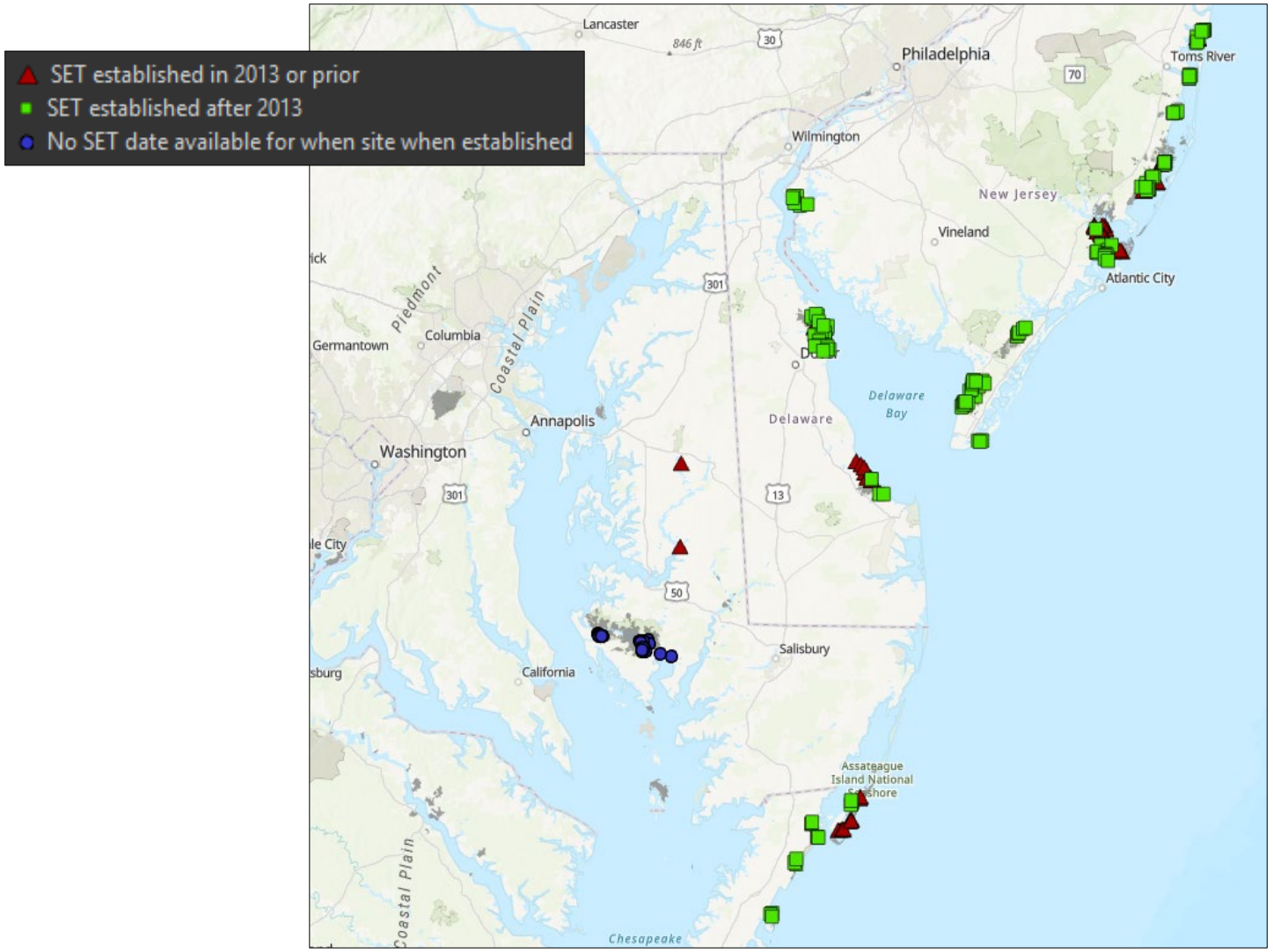

Figure 4. Map of New Jersey, Delaware, Maryland and the Eastern Shore of Virginia indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

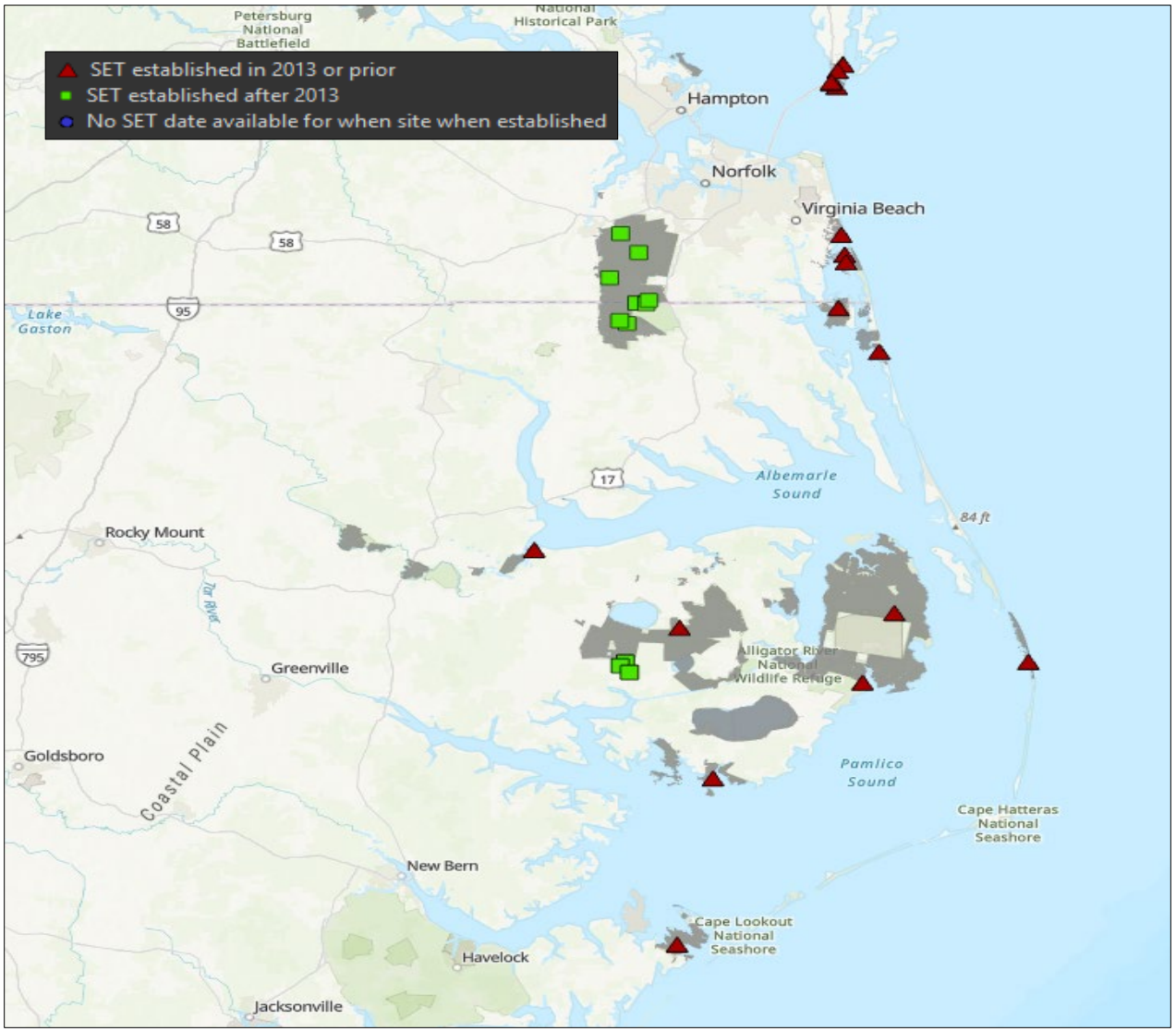

Figure 5. Map of southern Virginia and North Carolina indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

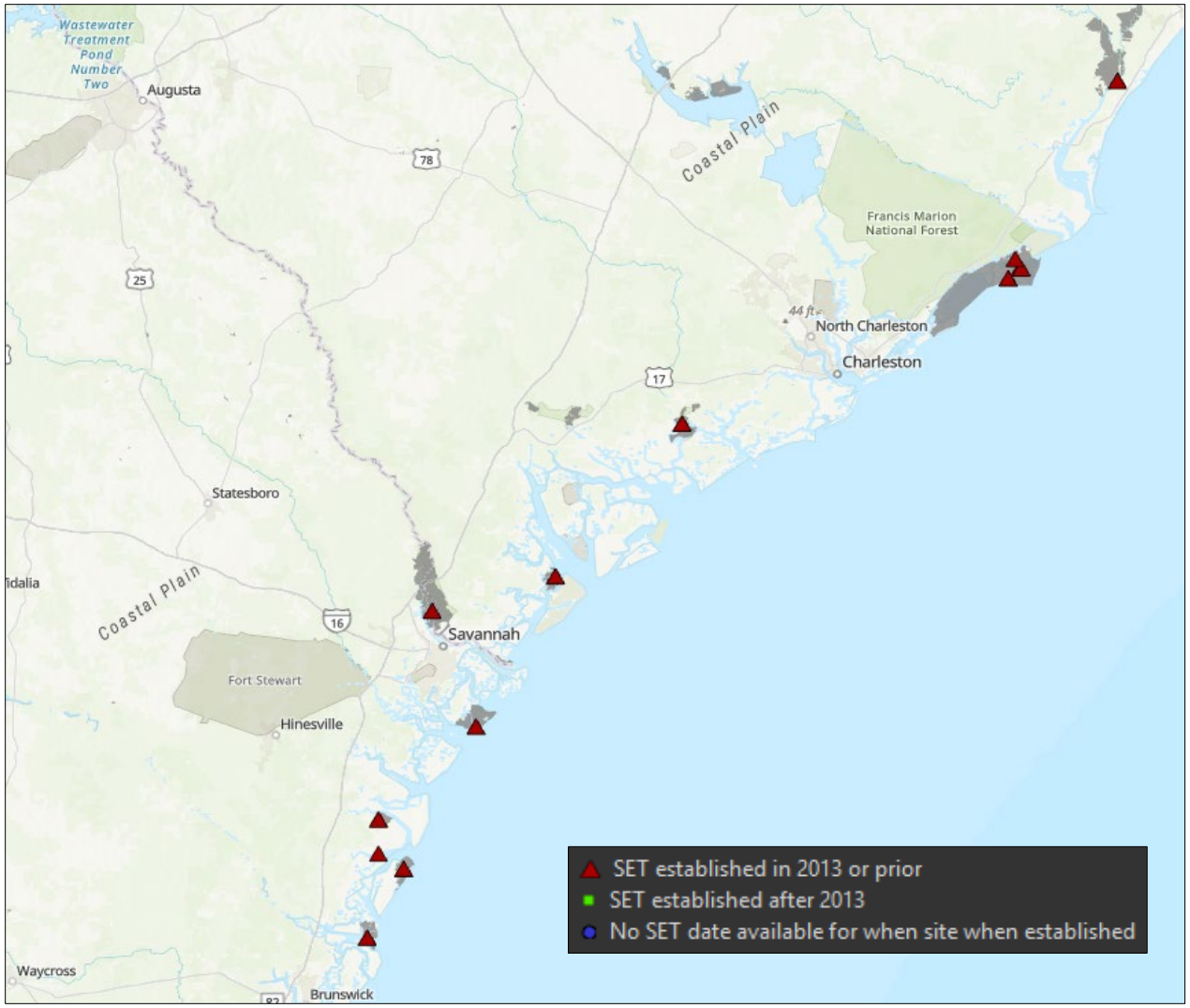

Figure 6. Map of South Carolina and Georgia indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

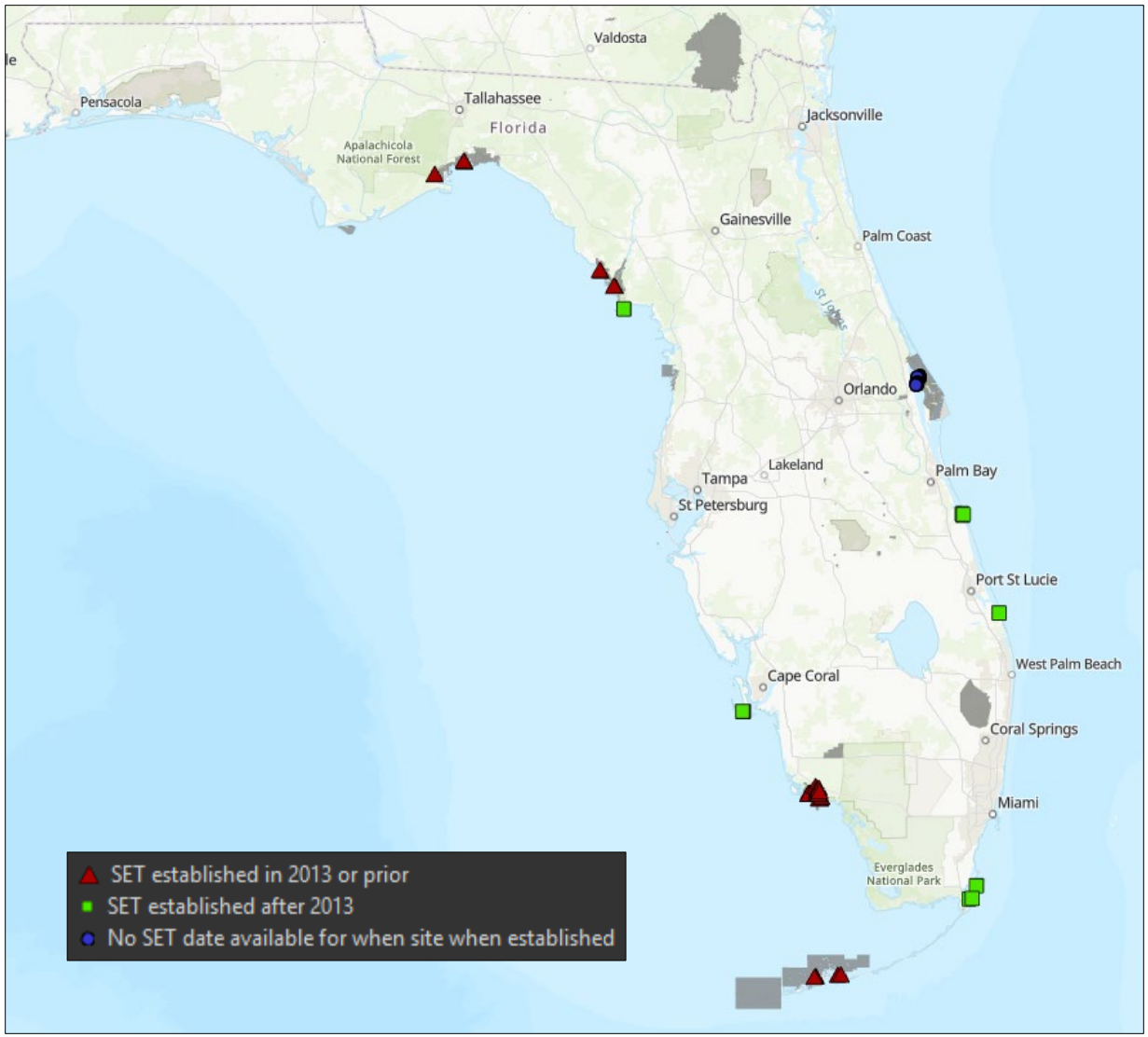

Figure 7. Map of Florida indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

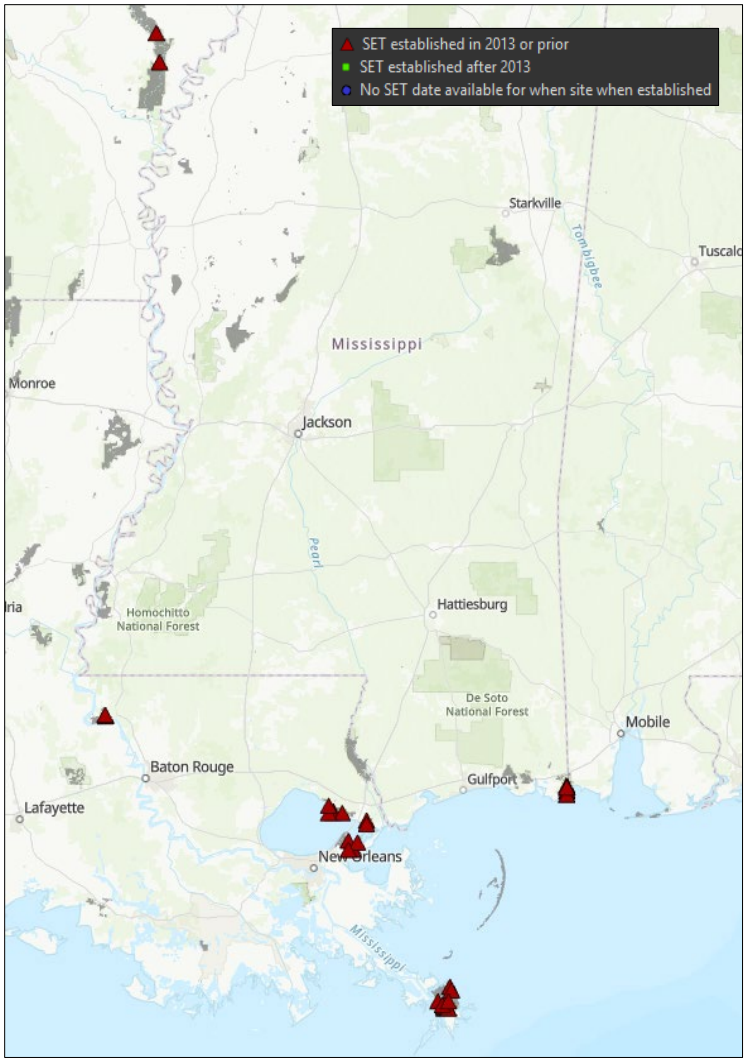

Figure 8. Map of Alabama, Mississippi and western Louisiana indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

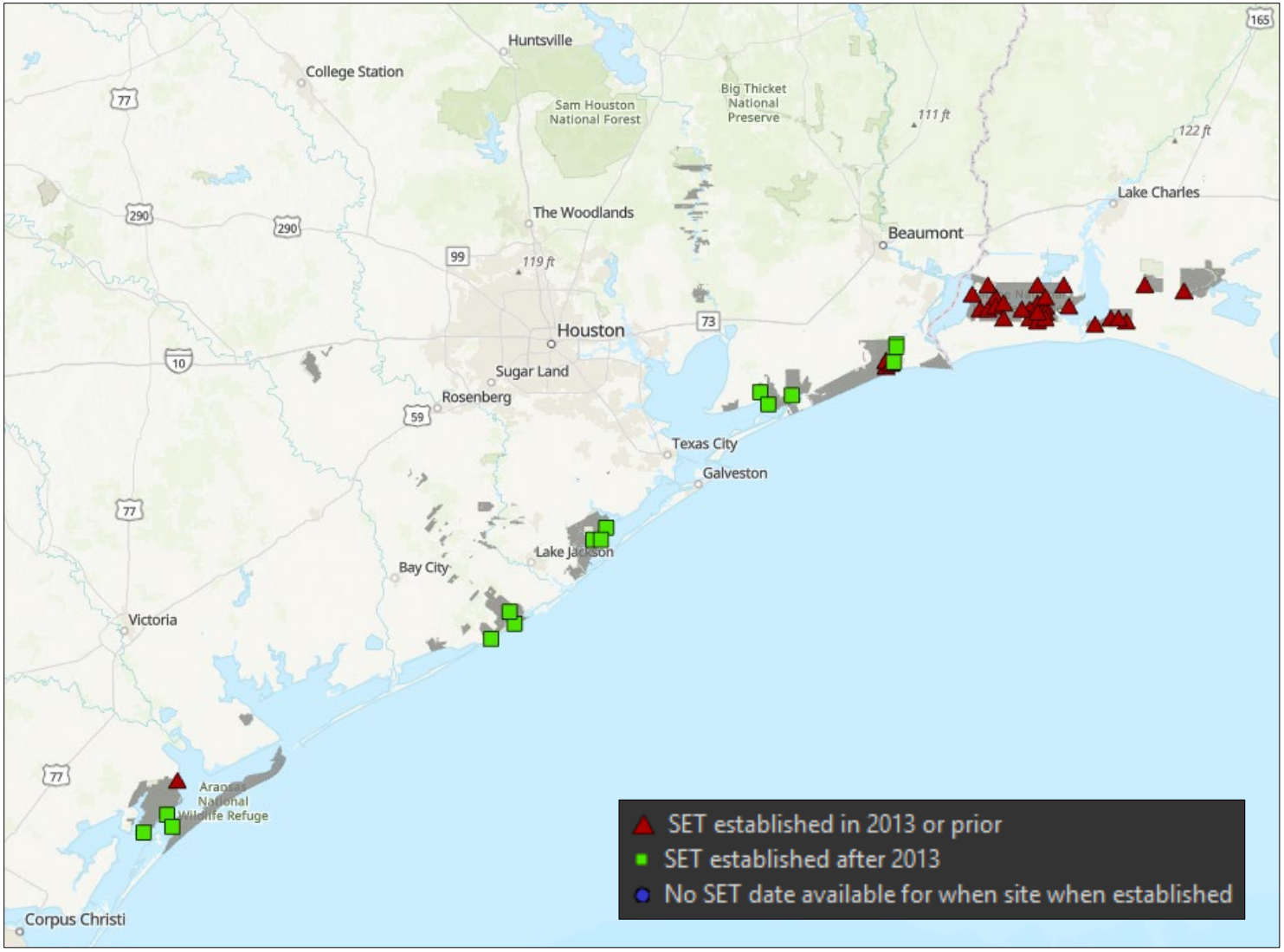

Figure 9. Map of eastern Louisiana and Texas indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

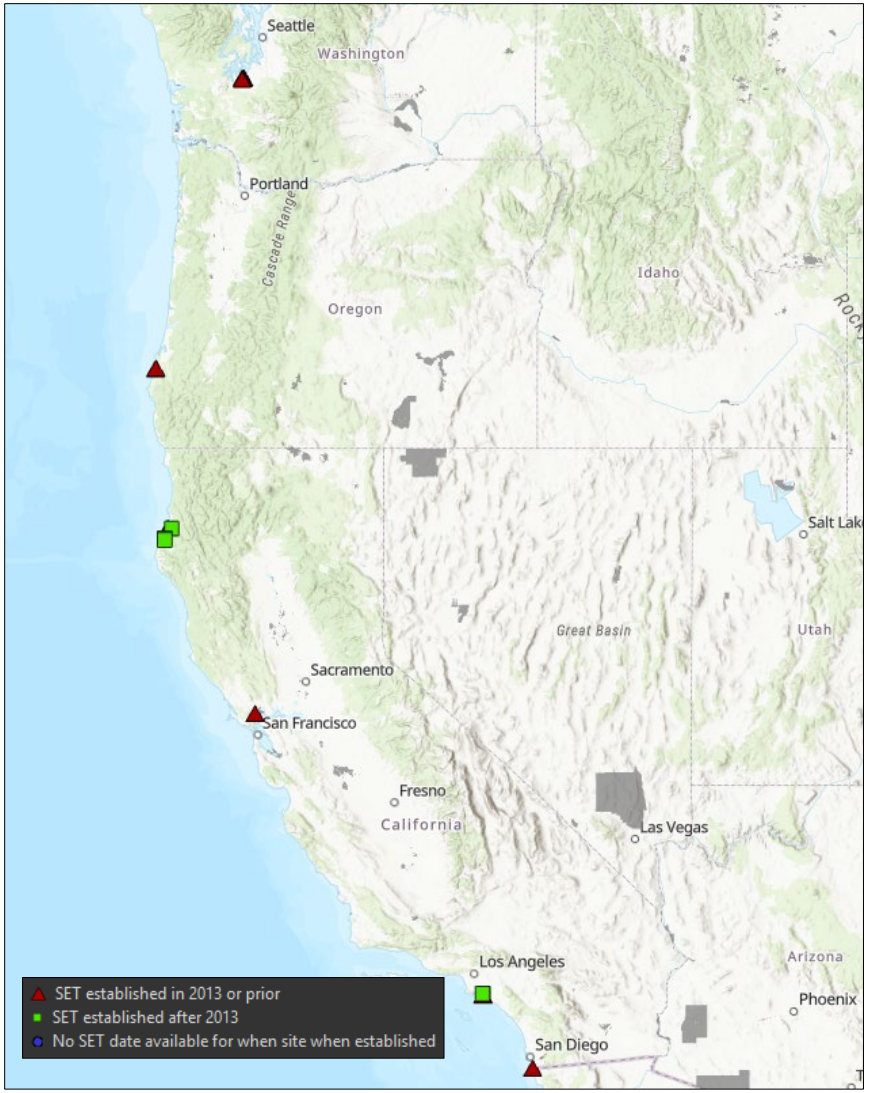

Figure 10. Map of California, Oregon and Washington indicating locations of refuges with Surface Elevation Tables (SET). Due to the scale of the map, individual polygons only reveal the general location of individual SET sites. SETs established in 2013 or prior can be used in trend analysis.

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