Research Application Proposal for: Evaluating impacts of pedestrian traffic on footpaths on resilience of restored and natural sand dunes on Tybee Island, GA

Applicant and Contact Information

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Objectives: Tourism provides significant economic benefits for coastal communities, including Tybee Island, which has nearly two million visitors annually. However, coastal sand dunes–essential for coastal protection from storm surge–are threatened by human disturbance, particularly by trampling that occurs on footpaths when beach-goers travel through the dunes to the beach. In 2019, as a part of their Sea-Level Rise Adaptation Plan, the City of Tybee constructed a new vegetated dune on a half-mile-long section of their beach. Protecting this investment that the City of Tybee has made is essential, and my study will provide guidelines regarding the best practices to protect the dunes while still maintaining the same visitation and tourism rates on the island. Specifically, I will 1) measure characteristics of dune vegetation, soil, and sand accumulation along footpaths of the restored and natural dune in the foredune and interdune and compare them with adjacent undisturbed dune areas, 2) measure rate and extent of recovery of the restored dune following the restriction of pedestrian traffic, 3) measure rate and severity of damage to the restored dune incurred over time after the addition of new footpaths. If the dune is progressively degraded over time as a result of pedestrian traffic, the dune will be less effective in providing ecosystem services such as storm protection, and the City's investment in the dune restoration will be impaired. Dune conservation is not only important for Tybee Island but for all restored coastal sand dune systems across the globe.

Methods: This field study will be divided into three objectives as described above. Objective 1 focuses on comparing characteristics of soil and vegetation along footpaths and adjacent undisturbed dune in the foredune and interdune on the established (E) and restored (i.e., planted) (P) dunes. In previous studies conducted by the Leege Lab on Tybee's sand dunes, the interdune was not included in measurements. However, during storms, the interdune holds overwashed sediment and flood water, protecting the backdune and areas further inland from damage; therefore, it is important to understand the interdune's ability to effectively provide these ecosystem services. For objective 1, 12 footpaths (F) will be used throughout E and P; these footpaths will not be restricted from pedestrian access in any way. 12 transects paired with these footpaths through undisturbed (U) dune areas will be established to assess how the dune naturally

functions with no pedestrian traffic previously present. All transects in this study will be perpendicular to the shoreline and will span from the interdune to the toe of the foredune to evaluate the differences in human impact along the entirety of the dune profile. To evaluate this objective, I will compare EF and EU with PF and PU.

For objective 2, 5 footpaths in P will be closed to evaluate the recovery (R) of a dune after being exposed to long term pedestrian traffic, so that I can compare PR to PF and PU. Lastly, objective 3 entails measuring the rate and severity of impact on dune function following exposure to pedestrian traffic. At 4 locations along the planted dune, transects will be established and opened for scheduled foot traffic (T) by authorized personnel only. A schedule of the frequency of foot traffic will be established with authorized personnel. 4 adjacent transects through undisturbed (TU) dune areas will be paired with the 4 T transects so that I can directly compare PT and PTU transects over time.

For all objectives of this study, at each footpath and/or transect, 3 sets of 3 1x1 meter plots will be established in random locations at the toe, crest, and heel of the foredune, totalling nine plots in the foredune of each transect. Depending on the total width of the interdune at each location, one to three replicate sets of three plots will be established in the interdune of each transect. One of the plots will be located in the center of the footpath, and the other two plots will be located 0.5 meters from each edge of the footpath.

To evaluate the effect of pedestrian traffic on vegetation succession and community composition, in each plot I will determine plant community composition, species richness, and species diversity (Simpson's and Shannon-Weiner diversity indices). In addition, I will visually estimate percent cover for each species, percent cover for each life form (i.e., grass, herb, shrub, and vine), and total percent vegetation cover. These measurements will be taken monthly during the growing season from March 2024 to October 2024. The number of stems per species in each plot will be counted quarterly during the growing season. While plots with higher percent vegetation cover and stem counts may indicate that these areas are more resilient to pedestrian traffic, varying levels of species richness and diversity will provide insight into the vegetation successional stage of an area. As *U. paniculata* was the primary plant planted during dune restoration, *U. paniculata* (one per plot) will be targeted for measurements of height and photosynthetic ability (i.e., chlorophyll levels). Soil temperature, moisture, and salinity will be measured monthly year-round by inserting a digital probe into the soil in each plot. Sand accumulation will be also measured monthly year-round by placing a wooden dowel in each plot, marking a line in permanent marker on the dowel, and measuring the sand increase or decrease from this line. For plots in the center of control footpaths (F), a wooden dowel would be easily kicked over or removed by pedestrians; therefore, we request to place larger, semi-permanent wooden posts extending ~1' above the sand on opposite sides of the path to triangulate sand increase or decrease in these plots.

Synopsis: Recognizing the necessity to optimize protection against increased storm events and sea level rise, the City of Tybee constructed a section of vegetated dune along their beach in 2019. Since 2020, in partnership with Georgia Southern University, the success of the restored dune has been monitored and compared to the natural dune

present on the island. Although human disturbance poses a threat to the resiliency of the dune system, tourism provides a significant economic benefit for Tybee Island, so removing human presence on beaches to reduce impact on sand dunes is not feasible; alternative ways to limit human disturbance to protect the dune system must be considered. In this study, I will evaluate the impact of footpaths on ecosystem services provided by coastal dunes with the goal of suggesting management strategies to protect the investment that the City of Tybee has made in the construction of the restored dune. Additionally, I will obtain informative measurements on the interdune–an area of the dune that supplies protection–because Tybee's interdune has not yet been studied.

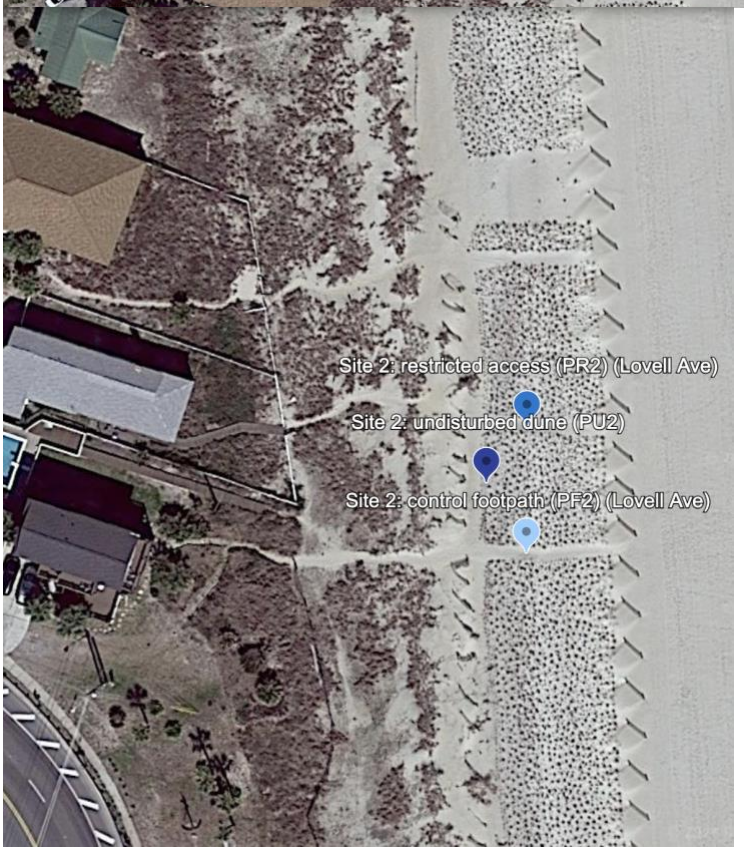
Map: The study site for this project is Tybee Island, Chatham County, Georgia. 17 footpaths total will be used for this study, 11 in the restored (i.e., Planted) (P) sand dune and 6 in the Established (E) dune. 16 additional transects will be established through undisturbed dune sections where no footpath is present (10 in P, 6 in E).

- Objective 1: 12 footpaths (F) will be used (6 in P, 6 in E).12 transects through undisturbed (U) dune areas will be established (6 in P, 6 in E).
- Objective 2: 5 footpaths in P will be closed to eliminate pedestrian traffic to evaluate recovery (R).
- Objective 3: 4 transects in P will be established where scheduled traffic (T) will occur by authorized personnel only. Directly adjacent to the 4 T transects, 4 transects in P through undisturbed (TU) dune areas will be established.

Sites include the following:

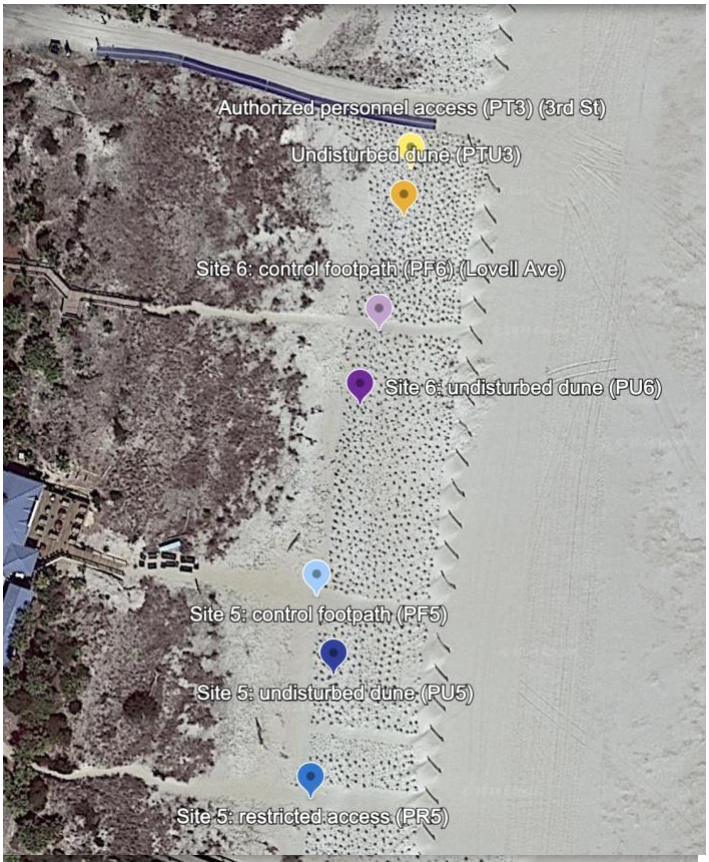
Exact footpaths for use and transects that will be established are marked in the below Google Earth photos. Photos are in order from north to south. If footpaths extend from an identifiable road on Google Earth, road names are stated in parentheses following the point label.

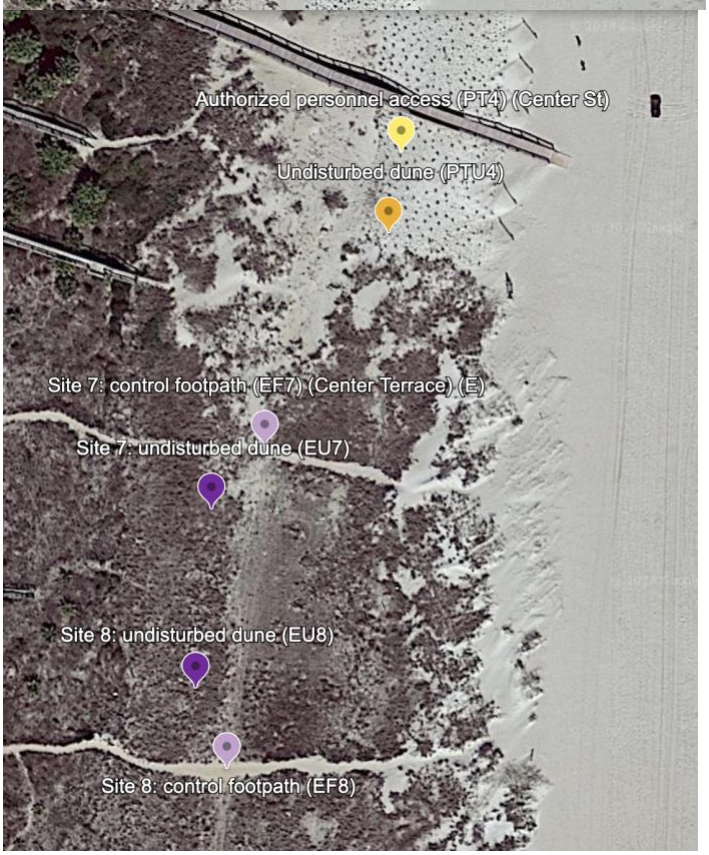

Site 1: restricted access (PR1) (2nd Ave)
Site 1: undisturbed dune (PU1) (2nd Ave)
Site 1: control footpath (PF1) (Lovell Ave)


Site 2: restricted access (PR2) (Lovell Ave)
Site 2: undisturbed dune (PU2)
Site 2: control footpath (PF2) (Lovell Ave)


Site 3: restricted access (PR3)
Site 3: undisturbed dune (PU3)
Site 3: control footpath (PF3)
Site 4: restricted access (PR4)
Site 4: undisturbed dune (PU4)
Site 4: control footpath (PF4)

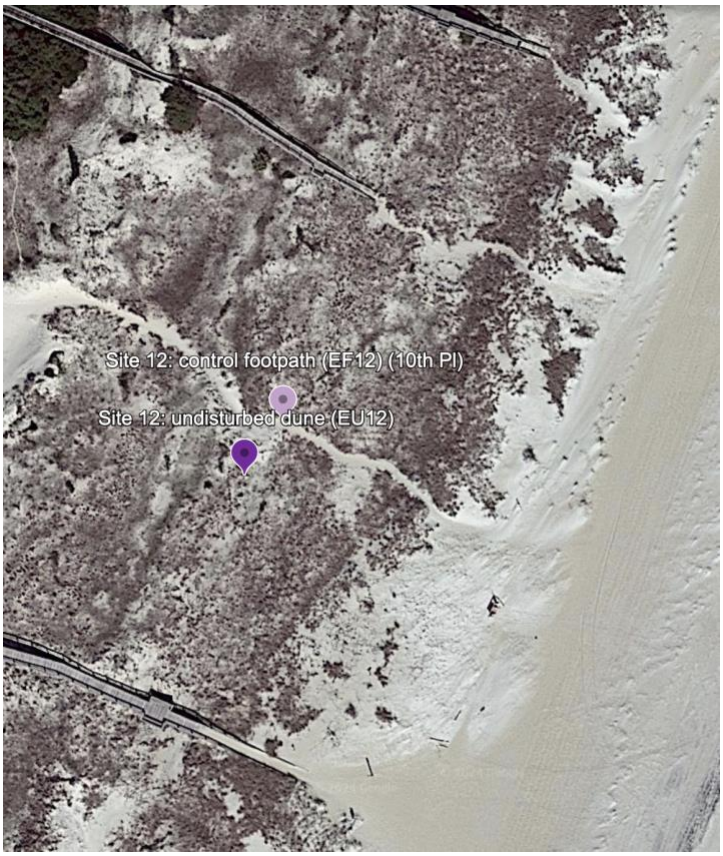

Authorized personnel access (PT1) (2nd St)
Undisturbed dune (PTU1)
Authorized personnel access (PT2)
Undisturbed dune (PTU2)


Authorized personnel access (PT3) (3rd St)
Undisturbed dune (PTU3)
Site 6: control footpath (PF6) (Lovell Ave)
Site 6: undisturbed dune (PU6)
Site 5: control footpath (PF5)
Site 5: undisturbed dune (PU5)
Site 5: restricted access (PR5)


Authorized personnel access (PT4) (Center St)
Undisturbed dune (PTU4)
Site 7: control footpath (EF7) (Center Terrace) (E)
Site 7: undisturbed dune (EU7)
Site 8: undisturbed dune (EU8)
Site 8: control footpath (EF8)


Site 9: control footpath (EF9) (6th Pl)
Site 9: undisturbed dune (EU9)
Site 10: control footpath (EF10) (7th Terrace)
Site 10: undisturbed dune (EU10)


Site 11: control footpath (EF11) (8th Terrace)
Site 11: undisturbed dune (EU11)



The GPS coordinates are as follows:
32°00'50"N 80°50'27"W - northernmost footpath (Site 1: restricted access (PR1) (2nd Ave))
31°59'56"N 80°50'35"W - southernmost footpath (Site 12: control footpath (EF12) (10th Pl))

Funding sources:

- City of Tybee contract with Georgia Southern University ($20,000)
- Georgia Southern University College of Science and Mathematics ($1,000)

Time frame: March 2024 – March 2025 with additional sampling in 2025

Structural components: We request to install one 1’ dowel (½” in diameter) in each plot (inserted ~8” into the ground), against which to measure sand movement. For plots in the center of control footpaths (F), a wooden dowel would be easily kicked over or removed by pedestrians; therefore, we request to place larger, semi-permanent wooden posts extending 1' above the sand on opposite sides of the path to triangulate sand movement in these plots. We also request to install wooden sand fencing around the sections of the footpaths from which we will restrict pedestrian access.

Frequency of access: Plots will be measured monthly. People who will be accessing these plots include the PI and student researcher, as well as possible volunteers. Data

will be collected over the span of four to six days each month during peak growing season and over a span of one to two days during dormant months, as we will be taking limited vegetation measurements during the dormant season.

Likely impacts of the project to the site: Impact will occur along the four dune sections that will be open to be crossed by authorized personnel (objective 3 of study). However, it is important to note that these transects will not be open to the public; this research will preserve the publics' view that dune crossing is not permitted under any circumstances while still providing data regarding how quickly vegetation damage occurs as a result of pedestrian traffic after the opening of a footpath. The data we obtain will also show how resilient Tybee's restored dune is to human disturbance. Other impacts on sites will be minimal, and dune crossing will be avoided as much as possible.

Qualifications of the PI and student researcher: see attached abbreviated PI CV and student CV