

# Abstract

Biodiversity monitoring is important for understanding ecosystem health in coastline restoration projects that rebuild habitats degraded by storms, erosion, and invasive species. This project analyzes the plant species repopulating the restored and non-restored areas at Edith G. Reed Wildlife Sanctuary to determine whether they are invasive or native. We hypothesized that invasive species are present and have helped restoration efforts. Samples were collected and DNA was extracted, amplified at the rbcL region, and sequenced. Sequences were compared to reference databases in DNA Subway. We found invasive species, which were likely critical in restoring the state of the coastline, but now need to be controlled for biodiversity monitoring. These results will contribute to a better understanding of long-term restoration efforts after hurricanes, provide insights into success of coastal restorations, and demonstrate the usefulness of DNA barcoding as a tool for studying and maintaining shore plant diversity.

# Introduction

## Background

Coastal ecosystems, such as sand dunes, play a crucial role in protecting shorelines from erosion, supporting biodiversity, storing excess carbon dioxide, and keeping our water systems clean and healthy. These environments provide irreplaceable benefits for both humans and wildlife but are increasingly threatened by storm damage, rising sea levels, and the spread of invasive plant species. In 2012, Hurricane Sandy severely damaged many of these coastal and dune ecosystems along the east coast, allowing invasive reeds (*Phragmites australis*) to take over ecosystems once populated by native beach grasses and vegetation. (Long Island Sound Partnership, 2021). *Phragmites australis*, or invasive phragmites, can reach heights of 15 feet or more, and are known to be dense, and strong plants: tolerant to a variety of environmental conditions, leading them to spread quickly throughout coastal ecosystems and replace native phragmites, (*Phragmites americanus*, *P. australis* ssp. *americanus*) causing detrimental cascading effects on the biodiversity and balance of coastal communities. Compared to native phragmites, the invasive species are large and dense, leaving little room for diversity among the shoreline, whereas the native phragmites appear scattered, and allow for a biodiverse coastal community (LIISMA, 2024).

Phragmites are crucial to protecting coastal infrastructure and the stability of marine ecosystems, making removing the invasive species and restoring the shoreline's native species a crucial goal. In hopes of restoring these damaged ecosystems, various restoration projects were established to rehabilitate coastal dunes with native plants to help stabilize shoreline ecosystems, restore biodiversity, and improve coastal resilience to future storms.

Researchers have implemented living shoreline restoration efforts at the Edith G. Reed Wildlife Sanctuary in Rye, New York, an area significantly affected by Hurricane Sandy. As a part of this initiative, native beach grasses, salt tolerant shrubs, and other coastal vegetation were planted along the reconstructed dunes beaches to promote native plant recovery, improve shoreline stability, and enhance habitat diversity for birds, fish and invertebrates in the area. The project aims to increase resilience to sea-level rise and demonstrate sustainable coastal restoration techniques (Long Island Sound Partnership, 2021). Our goal was to determine whether native plants are reestablishing successfully or if invasive species continue to dominate.

## Question & Hypothesis

### QUESTION

Was coastal restoration at the Edith G. Reed Wildlife Sanctuary successful in increasing the abundance and diversity of native plant species compared to unrestored areas?

### HYPOTHESIS

We hypothesize that invasive species may still be present in the restored areas, and while their presence could have contributed to the initial success of the restoration, we expect that the restored sites will ultimately exhibit greater biodiversity and a higher proportion of native reeds, with fewer invasive species compared to unrestored areas.



This restoration provides the foundation for biodiversity recovery, which our DNA analysis helps measure.



# Tracing Biodiversity Recovery Through DNA: Monitoring Coastal Restoration at the Edith Read Wildlife Sanctuary

## Materials and Methods

### Field Sampling

- Materials prepared and transect line established to standardize sampling locations
- Plant samples collected using sterile hole punches, test tubes, and bags along transect line
- Samples stored and labeled for DNA extraction and barcoding analysis (steps shown in Figure 2)

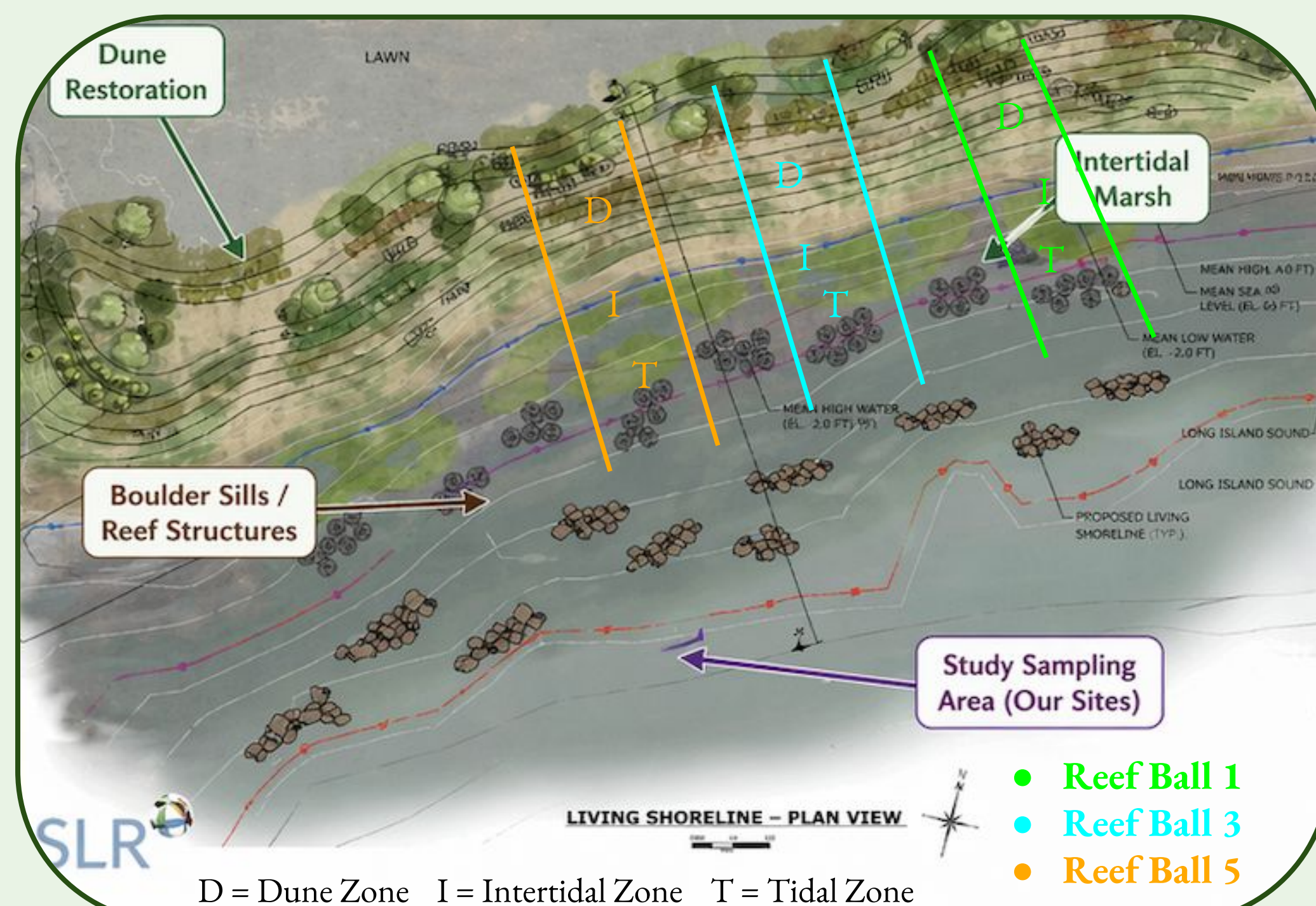


Figure #1: Transect Sampling at Edith Read Wildlife Sanctuary

### I. COLLECT, DOCUMENT, AND IDENTIFY SPECIMENS

- COLLECT specimen
- DOCUMENT plants
- IDENTIFY specimen
- STORE specimen

- ### II. ISOLATE DNA FROM PLANTS
- ADD specimen tissue sample
  - ADD lysis solution
  - GRIND sample in solution
  - INCUBATE 10 min 65°C
  - CENTRIFUGE 1 min
  - TRANSFER supernatant to fresh tube
  - ADD silica resin
  - MIX
  - INCUBATE 5 min 57°C
  - CENTRIFUGE 30 sec

- REMOVE supernatant
- ADD wash buffer
- CENTRIFUGE 30 sec
- REMOVE supernatant
- ADD wash buffer
- MIX
- CENTRIFUGE 30 sec
- REMOVE remaining supernatant
- ADD dH<sub>2</sub>O
- MIX by pipetting in and out
- INCUBATE 5 min 57°C
- CENTRIFUGE 30 sec
- TRANSFER supernatant to fresh tube
- CHILL on ice

- ### III. AMPLIFY DNA BY PCR
- ADD PCR reagents
  - TRANSFER DNA to PCR tube
  - AMPLIFY in thermal cycler
  - CHILL on ice

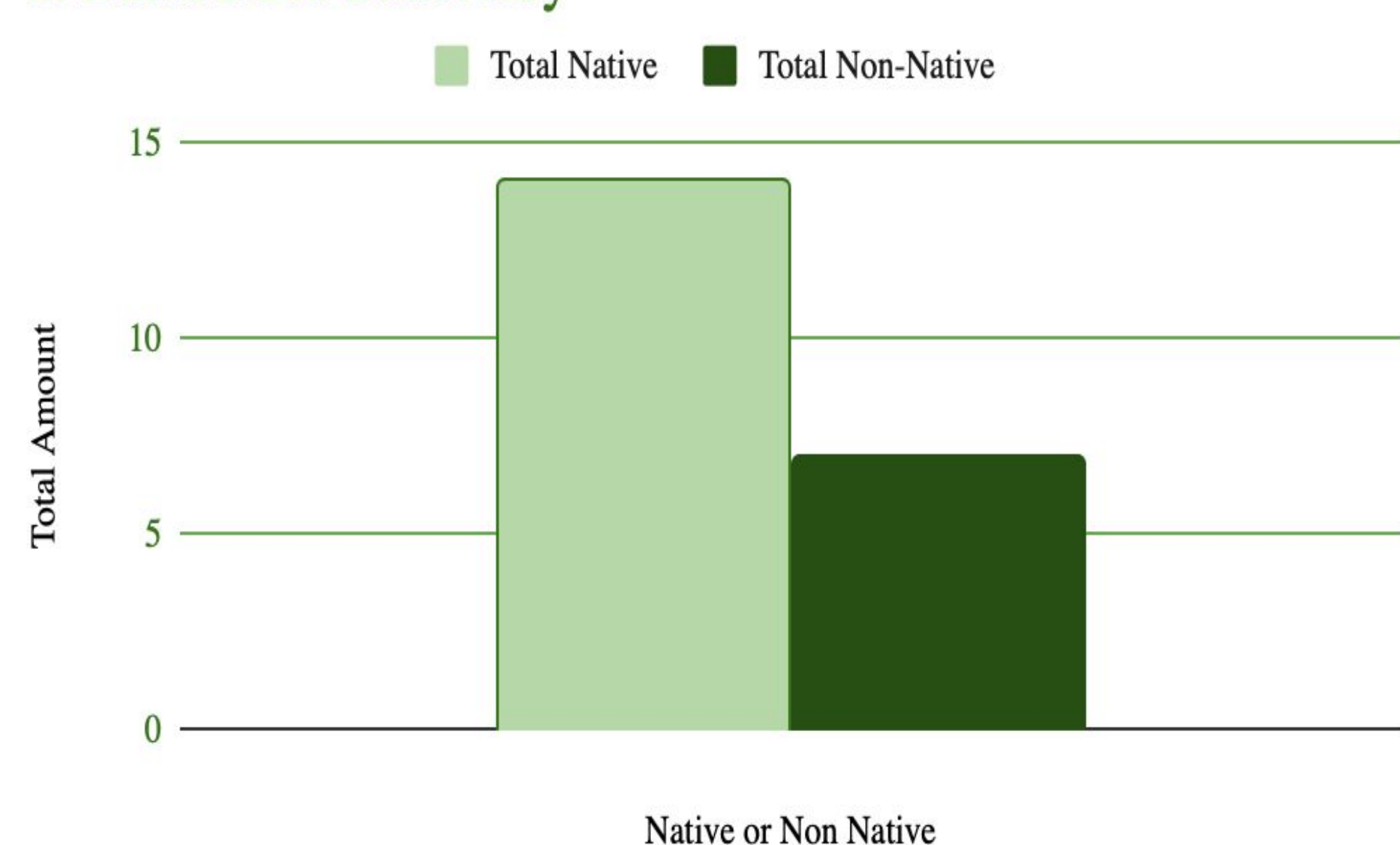
- ### IV. ANALYZE PCR PRODUCTS BY GEL ELECTROPHORESIS
- MELT agarose at 30 sec intervals
  - COOL 5 min
  - POUR gel
  - SET 20 min
  - ADD SYBR Green to fresh tube
  - TRANSFER DNA from PCR tube to SYBR Green tube
  - LOAD gel
  - STAIN PCR tube with remaining 50 µl sample at 4°C overnight or 30°C longer
  - ELECTROPHORESE 130 volts 400 mA 30 min
  - PHOTOGRAPH and upload

- ### V. SEQUENCE PCR PRODUCT AND ANALYZE RESULTS
- SEND sample for sequencing
  - ANALYZE results using bioinformatics

Figure #2: Barcoding Protocol

## Results

### Native vs Non Native Plant Species Present Post Restoration at Edith Reed Sanctuary



- We sought to determine the number of native and non-native plant species currently present in three different zones of Edith Read Sanctuary in order to inform the biodiversity that is present in areas that were restored after Hurricane Sandy.
- We identified 17 native species in our sampling, representing 81% of our samples, and all the remaining four species were invasive.

### Non Native Species Code and Identification

SAMPLE CODE	SPECIES	Image
RB1_2D	<i>Elymus spicatus</i>	
RB5_1D	<i>Helictotrichon sedenense</i>	
RB5_3T	<i>Sporobolus alterniflorus</i>	
RB1_3T-F/R	<i>Sporobolus maritimus</i>	
RB3_2D-F/R	<i>Sporobolus anglicus</i>	
RB5_2I-F/R	<i>Chrysolepis chrysophylla</i>	
RB5_2T-F/R	<i>Sporobolus anglicus</i>	

- Of the 7 non native invasive species identified, a larger total invasive population in dunes and tidal zones (each 3 of 7) and a smaller total invasive population in the intertidal zone (1 of 7).
- All three samples that found in the tidal region (denoted by the T in the sample name) all belong to the same genus: *Sporobolus*. The three invasive species identified in the dunes, which belonged to three different genera: *Elymus*, *Helictotrichon*, and *Sporobolus*. Analysis on genus diversity for the intertidal zone is limited to our one sample, belonging to the genus: *Chrysolepis*.

# Discussion

## Analysis

- Our results showed that the coastal restoration project at Edith G. Reed Wildlife Sanctuary has successfully promoted the recovery of some native plants but some non-natives have moved into the area
- The majority of the samples collected and identified were *Sporobolus alterniflorus*, a perennial deciduous grass which is found in intertidal wetlands and an important native species in coastal ecosystems along Long Island Sound
- The few invasive species we identified suggest that invasive plants are present in the ecosystem, but they were not dominant in our samples
- These findings indicate that the living shoreline restoration efforts are helping restore native coastal vegetation, and improve overall ecosystem health
- This study also demonstrates that DNA barcoding is an effective tool for monitoring biodiversity and should be used when evaluating the success of restoration projects over time

## Limitations and Future

### Limitations

- DNA barcoding only identifies species present in ecosystem, and does not measure abundance or function
- Sampling did not capture all species → limited sample size
- Only one gene region (rbcL) used → may not distinguish closely related species
- Seasonal variation not accounted for (plants change throughout the year)
- Environmental factors (salinity, erosion, wave energy) also influence biodiversity were not directly measured

### Future Steps

- Expand sampling numbers and across multiple seasons for more accurate biodiversity trends
- Use additional genetic markers to improve species identification
- Compare biodiversity over time to track long-term restoration success
- Measure environmental variables (oxygen, salinity, sediment) alongside DNA data
- Apply this method to other Long Island Sound restoration sites
- Use findings to guide removal or control of nonnative invasive species

## References

Cold Spring Harbor Laboratory DNA Learning Center. (n.d.). DNA barcoding: Silica isolation worksheet. <https://dnabarcoding101.org/files/DNA-Barcoding-Silica-Isolation-Worksheet.pdf>

Coastal Invasive Species Committee (Coastal ISC). (2023). Impacts of invasive plants on wetlands. Coastal Invasive Species Committee. <https://www.coastalisc.com/impacts-of-invasive-plants-on-wetlands/>

Long Island Invasive Species Management Area (LIISMA). (n.d.). Common reed (*Phragmites australis*). <https://liisma.org/common-reed-phragmites-australis/>

Long Island Sound Study. (2021). Edith G. Reed living shorelines project. <https://lispartnership.org/wp-content/uploads/2021/08/Edith-Read-Living-Shorelines.pdf>

SLR Consulting, & Westchester County Department of Planning. (2021, May 4). Edith Read Wildlife Sanctuary: Living shoreline feasibility study [PowerPoint slides]. Long Island Sound Study Habitat Restoration and Stewardship Work Group. <https://lispartnership.org/wp-content/uploads/2021/08/Edith-Read-Living-Shorelines.pdf>

U.S. Geological Survey. (2013). Hurricane Sandy: Observations and analysis of coastal change. U.S. Department of the Interior. <https://pubs.usgs.gov/fs/2013/3096/>

**IMAGES OF NON NATIVE SPECIES:**

- Calflora. (n.d.). Occurrence detail for *Sporobolus alterniflorus*. [https://www.calflora.org/entry/occdetail.html?seq\\_num=mu12725](https://www.calflora.org/entry/occdetail.html?seq_num=mu12725) (1)
- Global Biodiversity Information Facility. (n.d.). Occurrence 4994270047: *Sporobolus alterniflorus* (Loisel.) P.M. Peterson & Saarela. <https://www.gbif.org/occurrence/4994270047> (2)
- Wikipedia contributors. (n.d.). *Sporobolus alterniflorus*. In Wikipedia, The Free Encyclopedia. [https://en.wikipedia.org/wiki/Sporobolus\\_alterniflorus](https://en.wikipedia.org/wiki/Sporobolus_alterniflorus) (3)
- Global Biodiversity Information Facility. (n.d.). Occurrence 2550026535: *Sporobolus anglicus* (C.E. Hubb.) P.M. Peterson & Saarela. <https://www.gbif.org/occurrence/2550026535> (4)
- Wikipedia contributors. (n.d.). *Sporobolus anglicus*. In Wikipedia, The Free Encyclopedia. [https://en.wikipedia.org/wiki/Sporobolus\\_anglicus](https://en.wikipedia.org/wiki/Sporobolus_anglicus) (5)
- Halley, M. (n.d.). Giant chinquapin, golden chinquapin (*Chrysolepis chrysophylla* var. *chrysophylla*). Science in the Cascades. <http://science.halleyhosting.com/nature/cascade/shrubs/beech/chrysolepis/chrysophylla.html> (6)