Observation of Saltwater Marsh Resiliency to Sea-level Rise in Jamaica Bay, Long Island's Oyster and Great South Bay 1995 to 2020:

Thesis Executive Summary
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Background: Tidal wetlands are resilient environments teaming with diverse flood-preventing flora and fauna. These unique environments typically adapt to environmental changes like sea-level rise (SLR) when changes occur at a pace where wetlands can accrete sediment or biomass, change in elevation, and accrue new vegetation. Historically, all wetland types move upland to high marsh or down to intertidal marsh as a defense to longer or shorter inundation periods brought on by tidal cycles and increased salinity exposure. During this process, marshes inherit new ecological features making small environmental adaptions over time. However, as SLR accelerates, due to climate change, tidal wetlands are threatened. The National Ocean Services states that the rate at which the global sea level has been rising has increased over the past decade to a rate of one-eighth of an inch per year (US Department of Commerce, 2021). Pressure from urban development hinders wetland adaption and restricts the required space needed to move upland as SLR and storms surge flooding becomes more frequent, leading to their disappearance. The Department of Environmental Conservation (DEC) investigated wetlands in Long Island's three estuary complexes: Long Island Sound, Peconic, and South Shore Estuary. Collectively, these estuaries lost approximately 85 acres per year from 1974 to 2008. Specifically, 10 acres per year in Jamaica Bay (Cameron Engineering & Associates, LLP, 2015; DEC, n.d.).

Purpose: Due to the DEC study findings, it is hypothesized that the acceleration of SLR and increased storm frequency are influencing the disappearance of marsh island vegetation in Long Island's South Shore Estuary. Specifically, saltwater marshes that are composed of cord grasses known as *Spartina alterniflora*. Observations regarding Spatio-temporal tidal wetland adaptation have not been observed in this area after 2008. Therefore, this study aims to analyze the impact of mean local sea-level rise (MLSLR) and storm frequency on saltwater marsh vegetation density between the years 1995 to 2020.

Methods: The satellite data used in this study were collected from the USGS Landsat 8 and 5 top of atmosphere (TOA) and surface reflectance (SR) datasets available in Google Earth Engine's Data Catalog(USGS, 2016, 2021). Three normalized difference vegetation index (NDVI) images were created and assigned an RGB band, coloring a 1996 image blue, a 2000 image green, and a 2019 image red. These images were layer stacked to create a single-color image that marked where vegetation had existed in 1996, 2000, and 2019. A calculation was then created in GEE to estimate the vegetation area lost in acres.

MLSLR data were collected from the National Oceanic and Atmospheric Administration's (NOAA) webpage on tides and currents (Center for Operational Oceanographic Products and Services, 2021). A total of 72 SR satellite images from 1995 to 2020 were used in a time-series analysis to investigate temporal changes in vegetation density. Data from the time series analysis were extracted and compared to MLSLR in a correlation analysis in R. The environmental storm data were collected from the NOAA's National Centers for Environmental Information (NCEI) Storm Event Database that receives storm data from the National Weather Service (NWS) to investigate the impact of confounding environmental factors on vegetation density (NOAA, 2021).

Results: A preliminary color image analysis was conducted to visually inspect the Spatio-temporal changes in vegetation density on marsh islands in Google Earth Engine (GEE) through satellite imagery. The final product revealed a decrease in vegetation density throughout Long Island's South Bay from 1996 to 2019. To verify the observations made in the color composite image vegetation area loss was calculated from the color image. It was found that marshes lost vegetation density at a rate of 0.06 km2/year (15 acres/ year) between 1996 and 2000 and .3 km2/ year (74 acres per /year) between 1996 and 2019.

A significant negative correlation was found when comparing MLSLR to marsh vegetation density NDVI values from vegetation existing in 1996 in Jamaica Bay, Queens (spearman's rho, p-value = <0.001, rs = -0.432), and South Oyster Bay, Nassau (spearman's rho, p-value = <0.05, rs = -0.3367741) and in the Great South Bay, Suffolk (spearman's rho, p-value = <0.001, rs = -0.5631231). A significant negative correlation was also found when comparing MLSLR to NDVI values from vegetation existing between the years 1996 to 2000 in the Great South Bay (spearman's rho, p-value = 0.001165, rs = -0.5130808). A multiple linear regression was also conducted to investigate the relationship between vegetation density, MLSLR, and the frequency of storm events. However, no relationship was found.

Conclusion: This analysis revealed that tidal wetlands are losing vegetation at accelerating rates and are not keeping up with climate change-derived SLR. This analysis found that Google Earth Engine facilitates the analysis of large amounts of satellite data. Making it easier to analyze for disappearing coastal habitat without the need to conduct time and resource-intensive field surveys. The use of the methods developed by this study could help provide supplemental decision support to ecological restoration projects. These methods could quickly be used to identify where to reduce coastline urban development and instead rehabilitate marsh landscape. This would give mainland coastlines a better chance to survive erosion and mitigate coastal flooding. There are some limitations of analysis in this study. Future work will include deriving information from Digital Elevation Models (DEM) and land use maps to identify where marsh sediment is eroding, and invasive species are advancing.

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