Using Remote Sensing Techniques to Assess and Monitor Salt Marsh Condition in Massachusetts
Threats to Salt Marshes

• Coastal Development
• Invasive species (nutria, green crabs, *Phragmites*)
• Freshwater intrusion
• Tidal restrictions
• Sea level rise
• Nutrient enrichment
• Sediment starvation
• Crab herbivory/trophic cascade
• Salt marsh die back
Assessing Salt Marsh Condition & Vulnerability to SLR

Access is difficult
Difficult to collect data at all stages in the tide cycle
Timing of aerial photos & satellite data
UnVegetated to Vegetated Ratio (UVVR)
Unoccupied Aerial Systems (drones & sensors)
• Subtle changes in vegetative composition
• Water content of marsh peat
• Peat density
• Plant stress
Combination of remote sensing and ground truthing to comprehensively assess salt marsh condition.
Objectives

- Create an automated classification model
  - Vegetation
  - Water features
  - Bare ground

- Assess salt marsh condition
  - Identify areas of degradation
  - Identify areas of stress
  - Characterized tidal hydrology

- Protocol and tools that can used by researchers & practitioners
  - Condition assessment
  - Assist in planning and implementation of conservation action
  - Monitor responses to natural disturbance and ecological restoration
Tools in the toolbox: UAS platforms

Visible Blue, Green, Red
RedEdge
Near Infrared (NIR)

Shortwave Infrared
UAS Spectral Resolution

Landsat

- Blue, Band 1
- Green, Band 2
- Red, Band 3
- NIR, Band 4
- SWIR, Band 5
- SWIR, Band 7

MicaSense RedEdge

SWIR Water Spectrum
South River
(South Shore)

Rededge  NIR  SWIR  NDVI (calculated)
Flight Information

- Receive permissions from nearby airports, land owners, and conservation commissions, MassWildlife & USFWS (for endangered birds)
- Fly at 400 feet
- 70% Overlap
- 100 acre footprints
Ground Control Points

- Strategically placed throughout the salt marsh
- Appear in all bands
- Allows remote sensing data to be accurately stacked

\[(\text{GCP Spacing} [\text{m}]) = (\text{camera-GCP degrees of separation}) \times \text{Image Footprint Width} \text{ m}^2\]
# UAS Temporal Resolution

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Data Products

Orthomosaics

Digital Elevation Models (DEMs)

Peggotty Beach, Scituate
Essex Bay
(North Shore)
6 bands, 3 tidal cycles =

18 features per pixel, per day

1,458,000,000 data points per site per day!
Decision Trees and Machine Learning

Single Decision Tree

Random Forest

Class 1
Class 1
Class 1
Class 2
Class 2
Class 1
Class 1
Class 1
Class 2
Vegetation Classification
Salt Marsh Classification

First Level: Class (first digit - number)

1 - Vegetated: > 30% vegetation cover

2 - Water feature: 100% inundated at typical high tide with < 30% vegetation cover

3 - Bare ground: Exposed at typical high tide with < 30% vegetation cover
Salt Marsh Classification

Subclass

1 - Vegetated: > 30% vegetation cover

01 - Low marsh (tall form *Spartina alterniflora* dominant)
02 - Intermediate marsh (mix of high marsh vegetation and tall form *S. alterniflora*)
03 - Transitional marsh 1: short form *S. alterniflora* dominant (> 80%) mixed with typical high marsh species
04 - Transitional marsh 2: short form *S. alterniflora* common or dominant (30-80%) mixed with typical high marsh species
05 - Transitional marsh 3: *S. patens* & *D. spicata* dominant but mixed with 5-30% short form *S. alterniflora*
06 - High marsh 1: > 90% plant cover in *S. patens* & *D. spicata* and < 5% short form *S. alterniflora*
07 - High marsh 2: < 90% plant cover in *S. patens* & *D. spicata*, mixed with other high marsh species but < 10% shrub species and < 5% short form *S. alterniflora*
08 - *Juncus gerardii* band: > 50% of marsh vegetation is *Juncus gerardii*
09 - Salt-shrub marsh (high marsh vegetation mixed with shrub species)
10 - *Salicornia* or *Suaeda* marsh
11 - Brackish marsh
12 - Brackish marsh - Phragmites: > 30% vegetative cover of *Phragmites australis*
13 - Vegetated ditch edges: mix of high marsh vegetation and intermediate form (neither tall nor short) *Spartina alterniflora* as linear features along the edges of water features (typically along the crown of ditch banks)
Inertial Labs RESEPI with HESAI XT32
LiDAR DTMs

Filtered LiDAR Digital Terrain Model

RGB Orthomosaic
Identification of Historical Embankments

Filtered LiDAR DTMs
HOBO Water Logger Array

Elevation Classification

Land-Cover Classification
Creek Channel Erosion
Zoom in to show extent of 300x300 tiles
Training set: 50/50 300x300 tiles, multiple sites.
Essex Bay with tiling showing unhealthy tiles (purple)
Access and Field Support

Towns: Newbury, Essex, Scituate, Marshfield, Westport, Harwich, Chatham, Barnstable, Wellfleet

Funding

- United States Environmental Protection Agency
- Mass Audubon
- Trustees
- University of New Hampshire
- Building and Construction Technology
- Massachusetts Office of Coastal Zone Management
- The Center for Agriculture, Food and the Environment