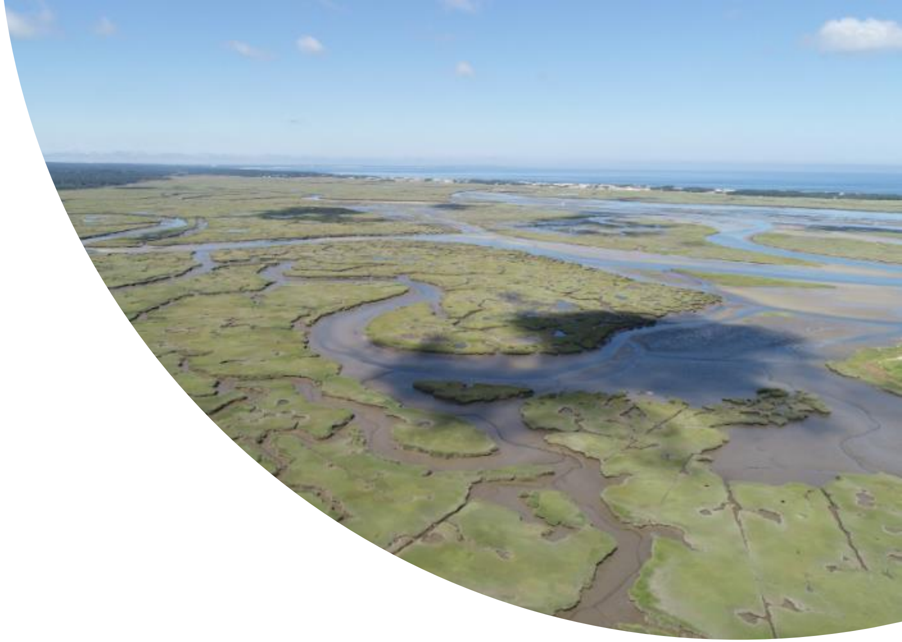
UMass Amherst



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

UMass Personnel:
Scott Jackson, Charlie Schweik, Kate Fickas, Ryan Wicks, Amanda Davis, Josh Ward, Eva Gerstle, and Brett Barnard

MA CZM Personnel: Marc Carullo

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

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

DJI Matrice 600 Pro
(Carries heavier sensor payload)

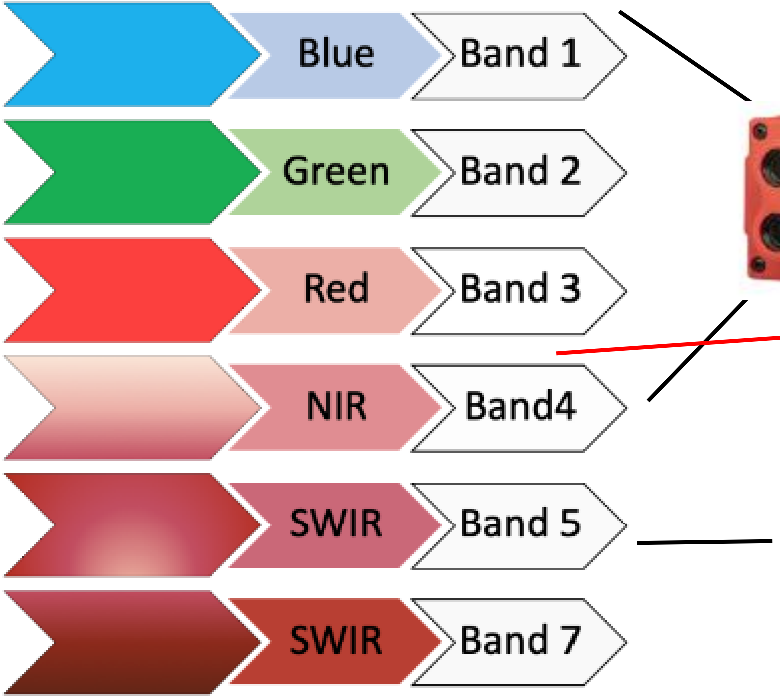
DJI 210
(Carries medium sensor payload)

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

Shortwave Infrared

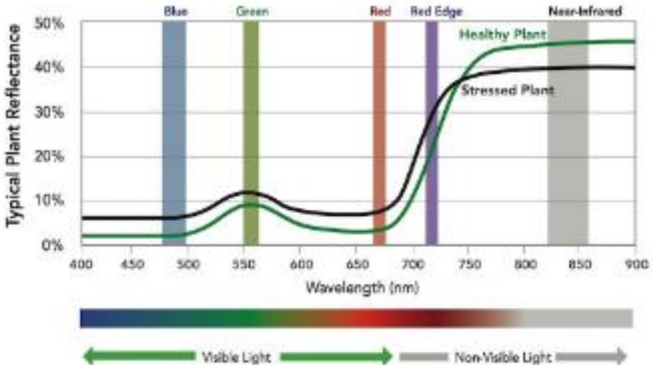
UAS Spectral Resolution

Landsat

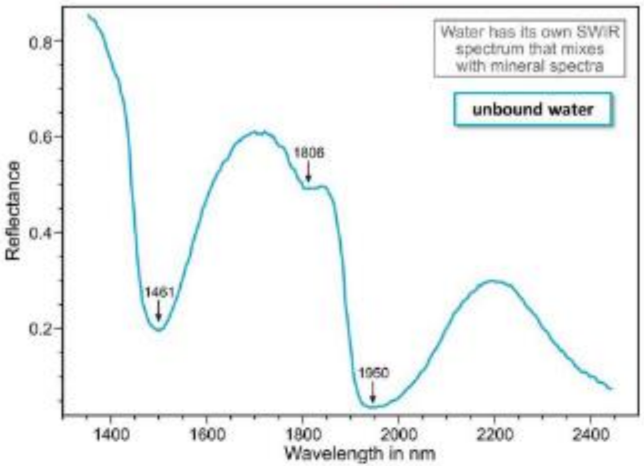


UAS

MicaSense RedEdge

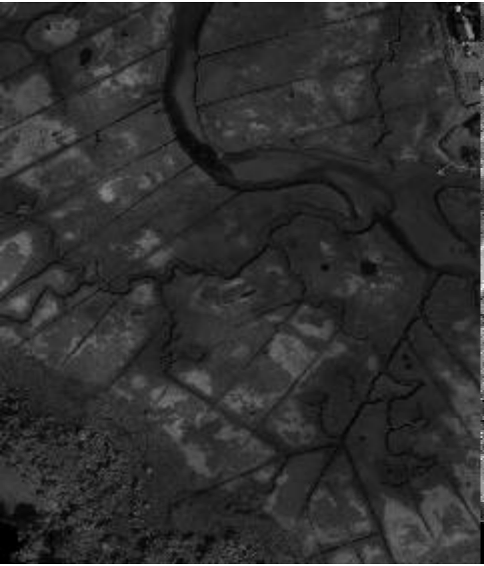


SWIR Water Spectrum



South River

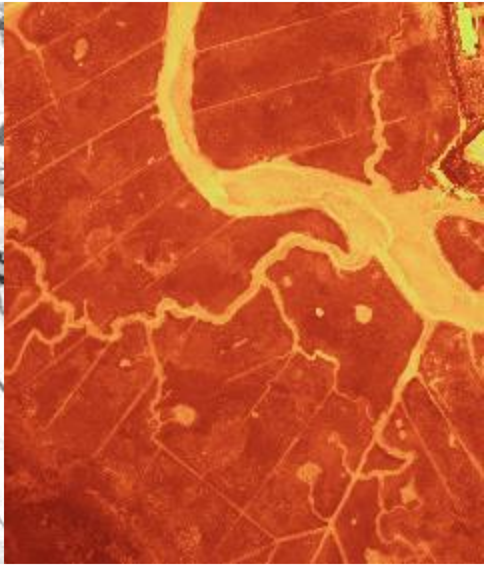
(South Shore)



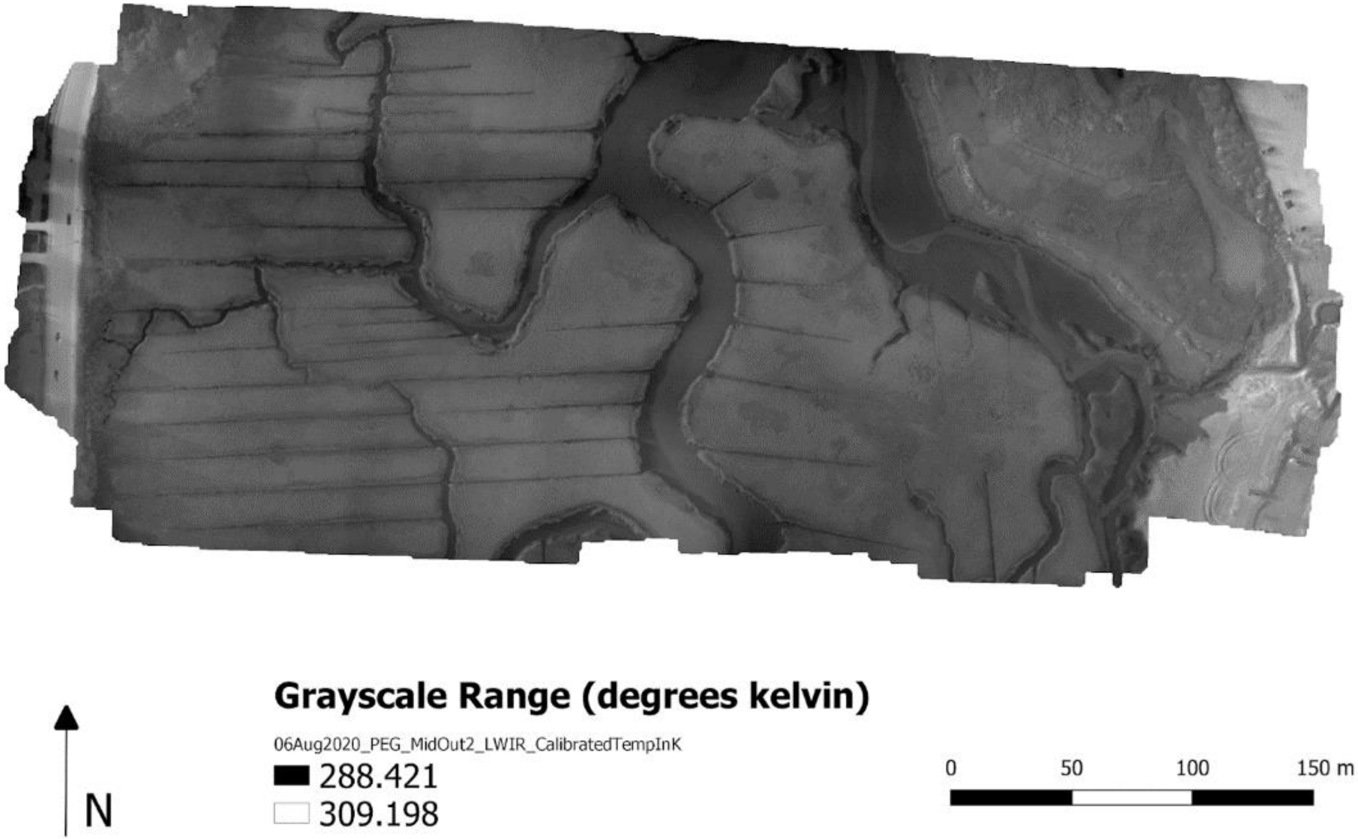
Rededge

NIR

SWIR

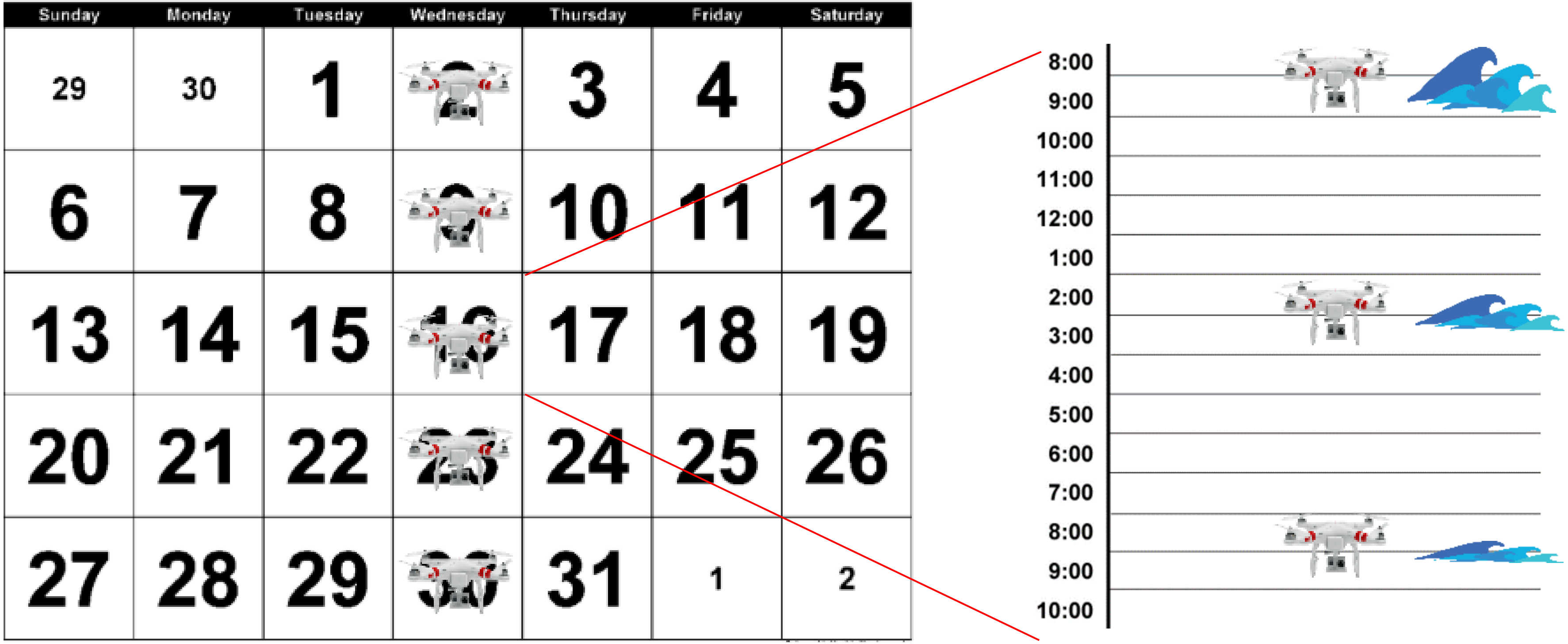


NDVI
(calculated)



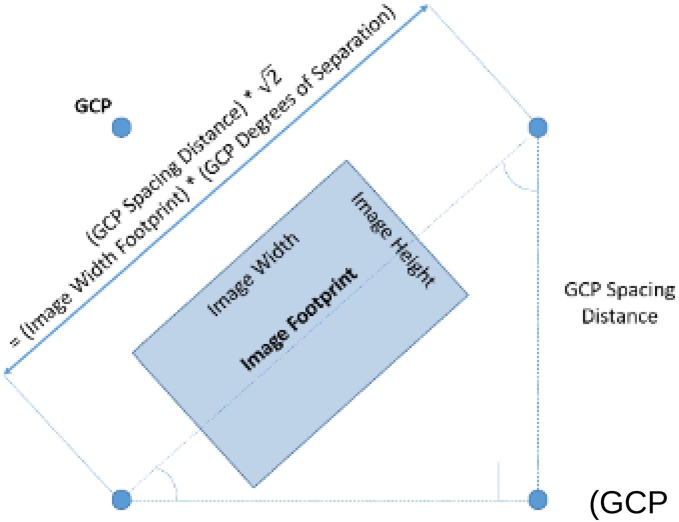
N
Grayscale Range (degrees kelvin)
06Aug2020_PEG_MidOut2_LWIR_CalibratedTempInK
288.421
309.198
0
50
100
150 m

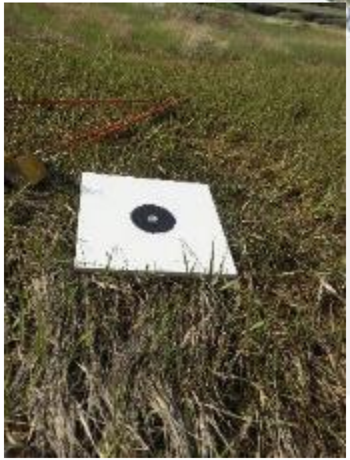
UAS Temporal Resolution



Ground Control Points

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



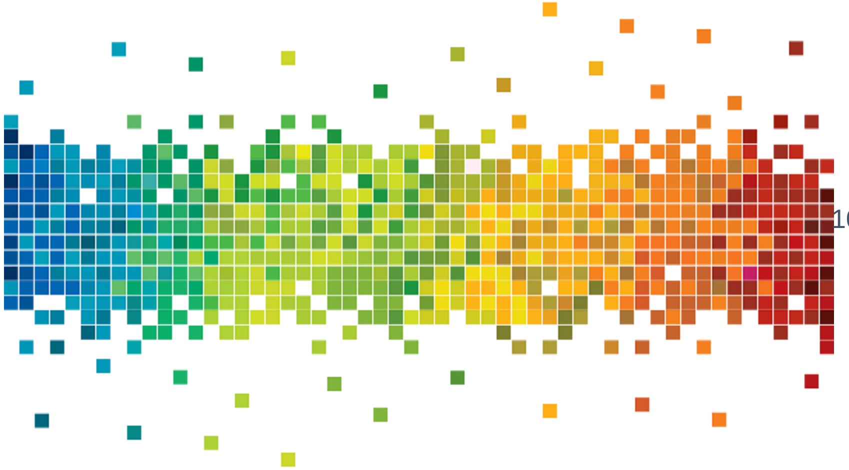


(GCP Spacing [m]) = (camera-GCP degrees of separation) Image Footprint Width m^2

What data do we have, per pixel?

6 bands, 3 points in the tidal cycle =

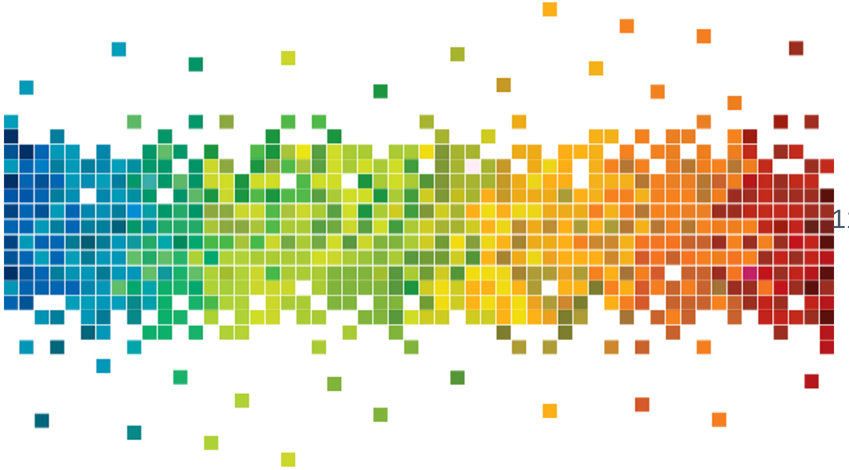
18 features per pixel, per day!



What data do we have, per site?

~810,000 m^2 / (100cm^2) = 81,000,000 pixels

1,458,000,000 data points per site per day!



High performance computing

Introduction to Unity

This introductory tutorial will help you build an understanding of what an HPC, or high performance computing cluster is, and how to most effectively utilize it.

Defining some Terms

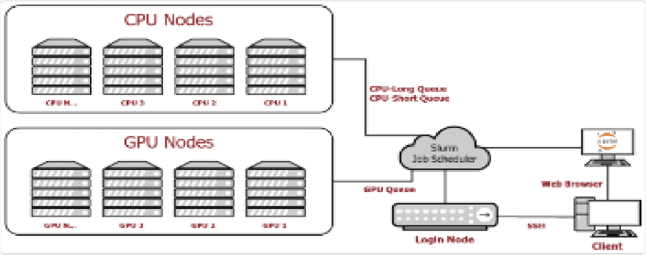
At its most basic level, you are learning how to use a **cluster**. A cluster is many servers (or computers) joined together in an effort to work together, where a single server is known as a **node**. Unity is an **HPC**, or High Performance Computing cluster. This means we focus most on computational power and efficiency, as the name entails. The primary use case of Unity is by researchers wanting more computational power than what is available on their own.

Think about your personal laptop/desktop: when you use your computer, the system decides the resources on your computer to use (cpu, ram, etc.) based on what you are doing at that time. When you scale this process up to a cluster, what is known as a **scheduler** determines what resources to give you, but this time across many computers, not just one. You can picture the cluster as a scaled-up version of a single personal computer. An operation you run on the cluster is referred to as a **job**.

How Unity Works

While you may not need to master every bit of the operation here at the Unity Cluster, it is important that you generally know how the cluster operates, because it can help your troubleshooting in the future. Below is a simplified diagram of the structure of Unity. The process in which you use the cluster: 1. The client connects to Unity using SSH, or the Jupyter portal. 1. Once connected, a job is requested through the scheduler, and your job is placed in the appropriate queue. 1. Once resources are available (cores, gpu, memory, etc.), the scheduler starts your job. 1. Once your job completes, the result returns to the client.

The above process can be viewed below:



1. Connecting to the cluster

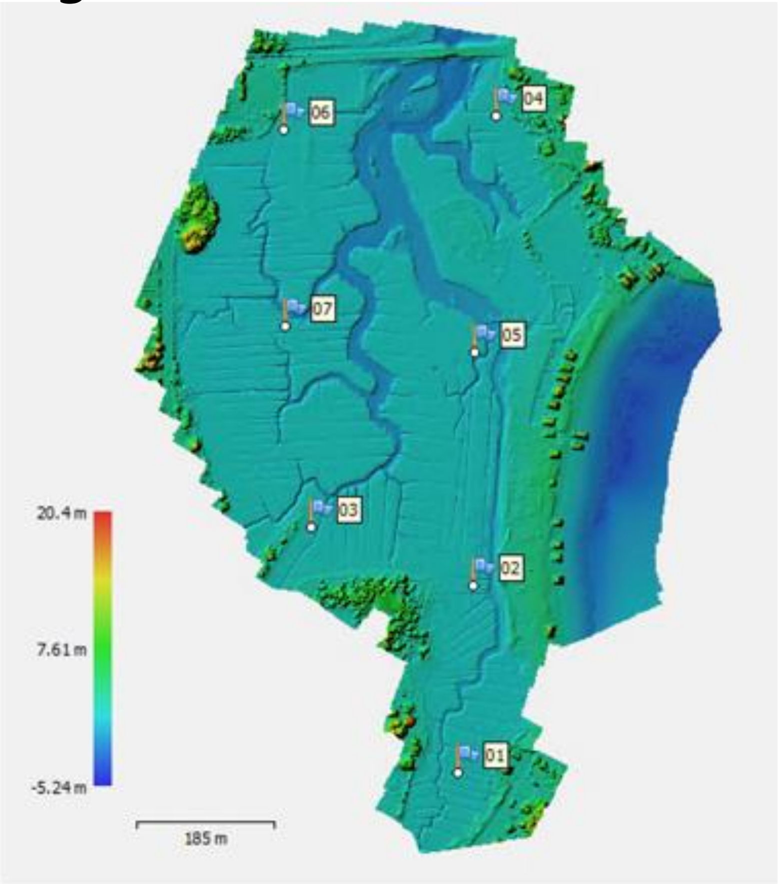
You can connect to Unity in two ways, an SSH connection (the standard linux console), and an instance of JupyterLab. JupyterLab is the easiest to get up and going. When connecting the portal, you will be asked to select one of a few preset resources to allocate for your jupter notebook. Once you attempt to spawn

Data Products

Orthomosaics

Peggotty Beach, Scituate

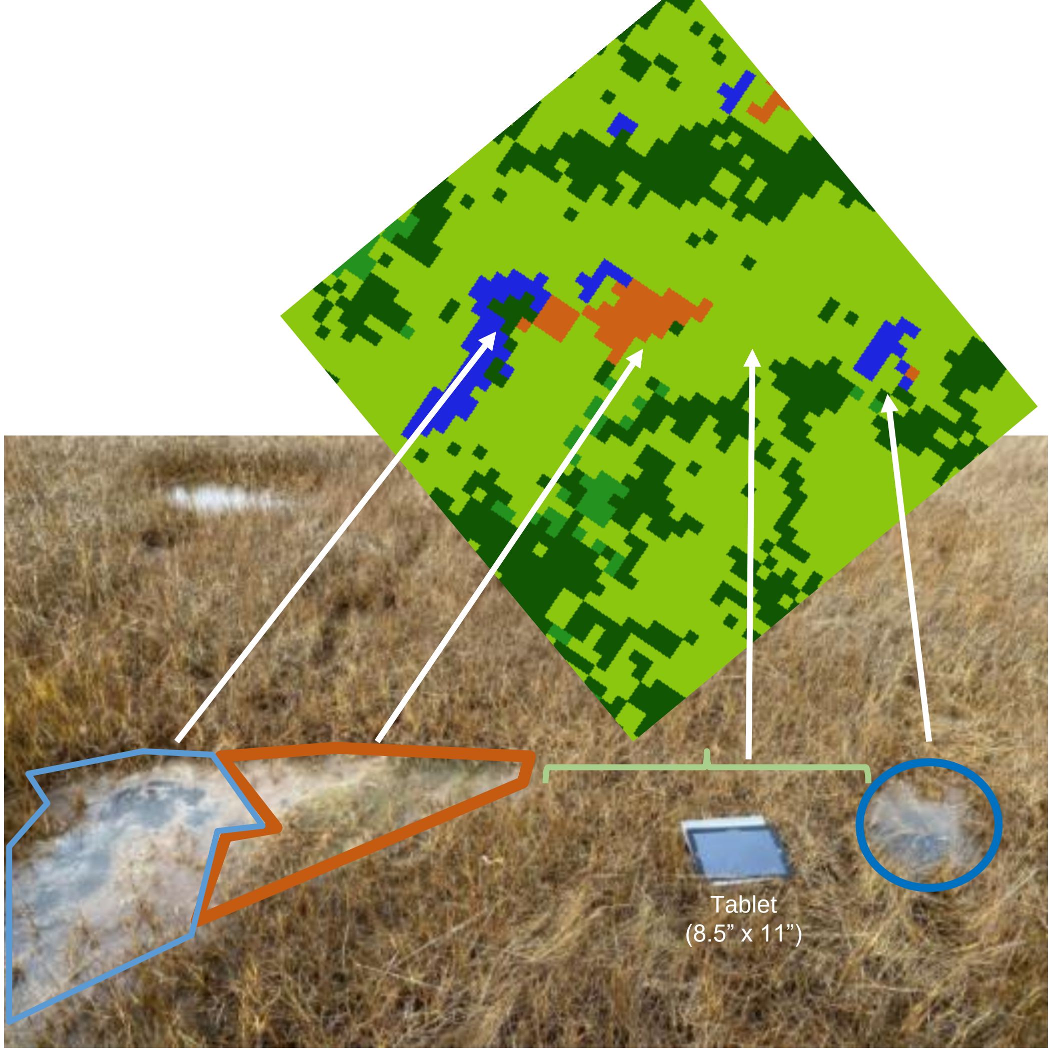
Digital Elevation Models (DEMs)



Primary Findings

- Can access (almost) everywhere when frozen
- Very impressed/amazed with the **detailed** output of bare ground vs water

1 Pixel = 8 cm!



Essex Bay
(North Shore)

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

First Level: Class (first digit - number)

1 - Vegetated: > 30% vegetation cover

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

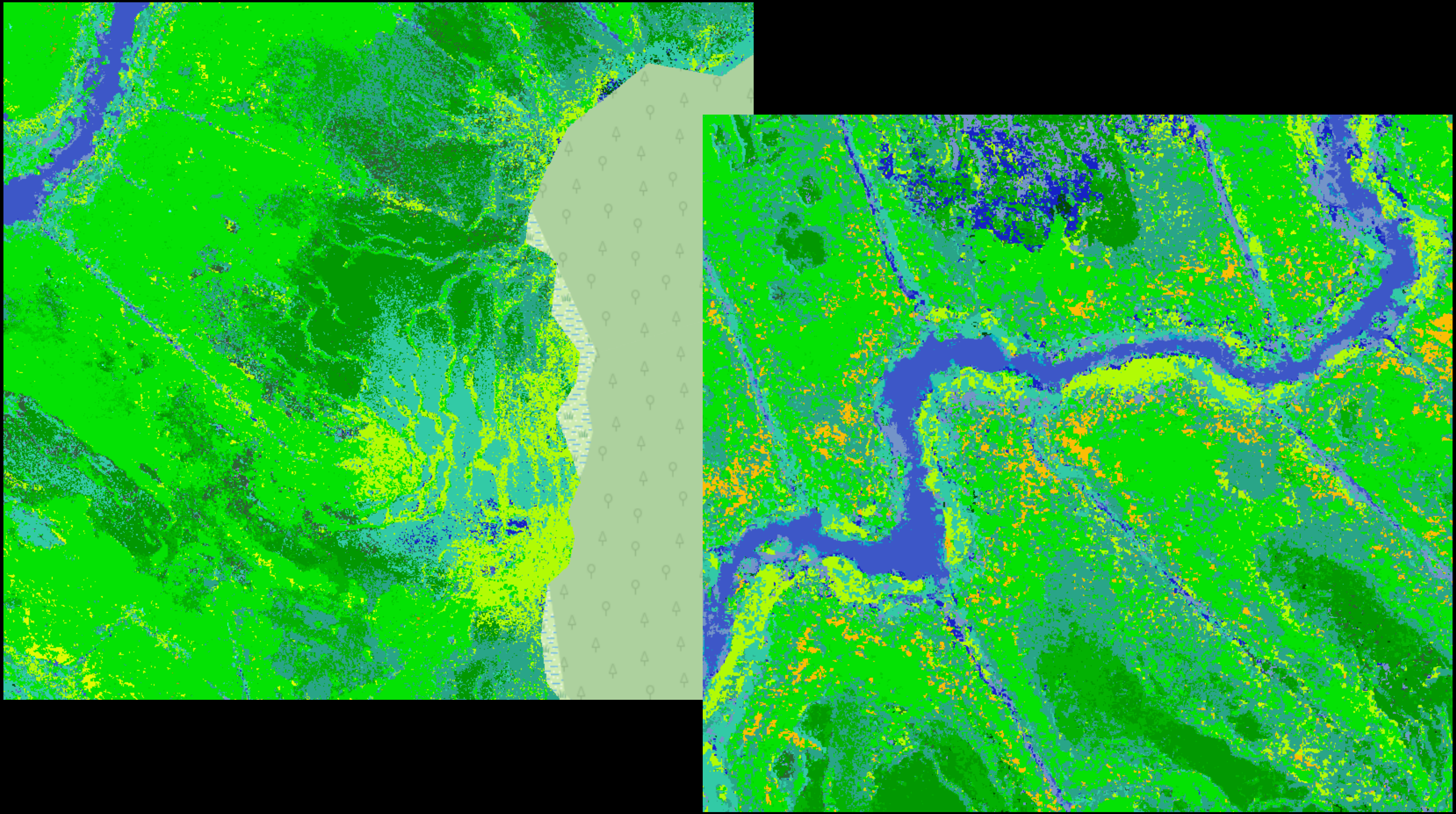
3 - Bare ground: Exposed at typical high tide with < 30% vegetation cover

Salt Marsh Classification
Subclass

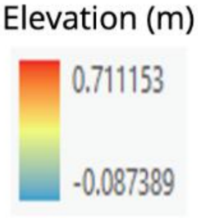
1 - Vegetated: > 30% vegetation cover

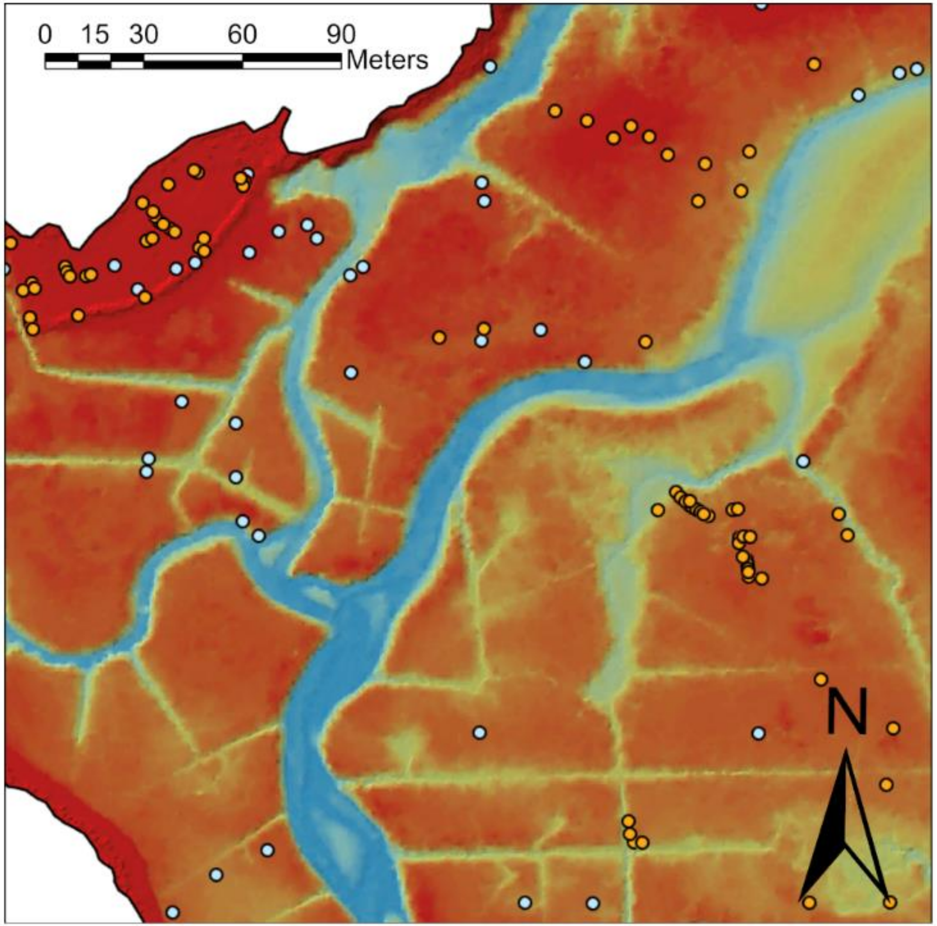
- 01 - Low marsh (tall form *Spartina alterniflora* dominant)
- 02 - Intermediate marsh (mix of high marsh vegetation and tall form *S. alterniflora*)
- 03 - Transitional marsh 1: short form *S. alterniflora* dominant (> 80%) mixed with typical high marsh species
- 04 - Transitional marsh 2: short form *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)

Random Forest Model Classification Updates – Comparing Iterative Classification Schemes (ICSs)

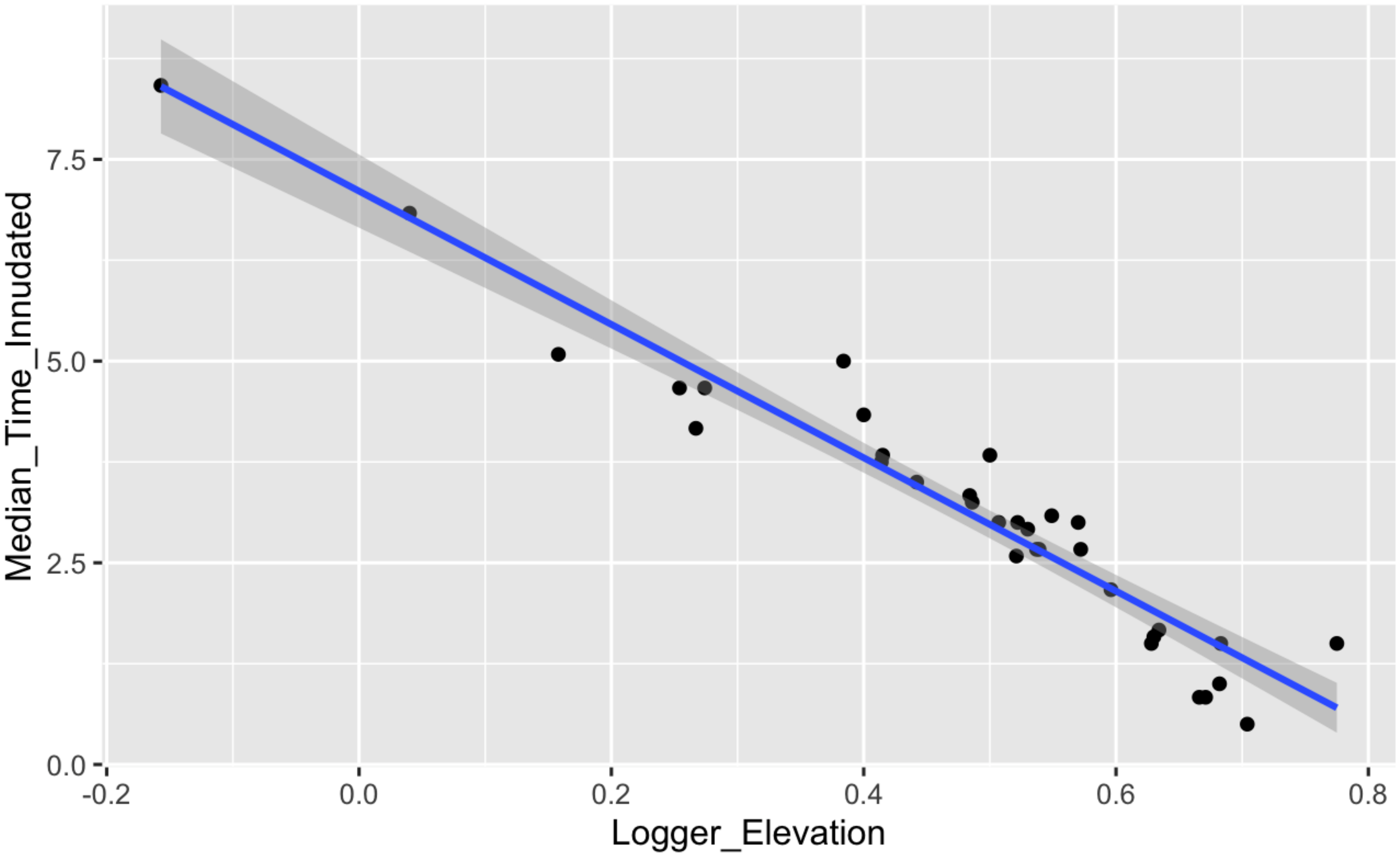


Tidal Flood Routing from LiDAR-Derived High-Resolution Elevation Models

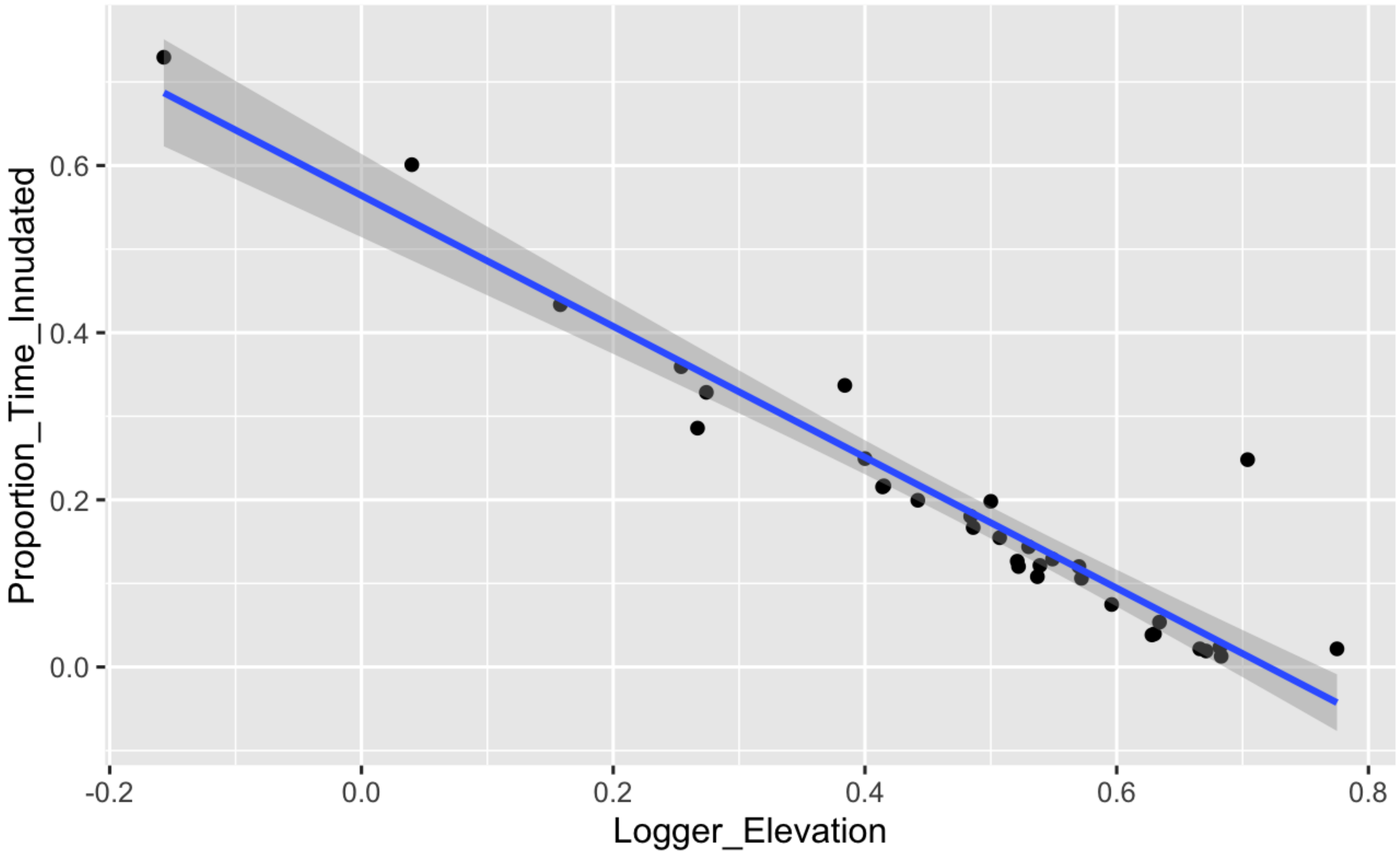




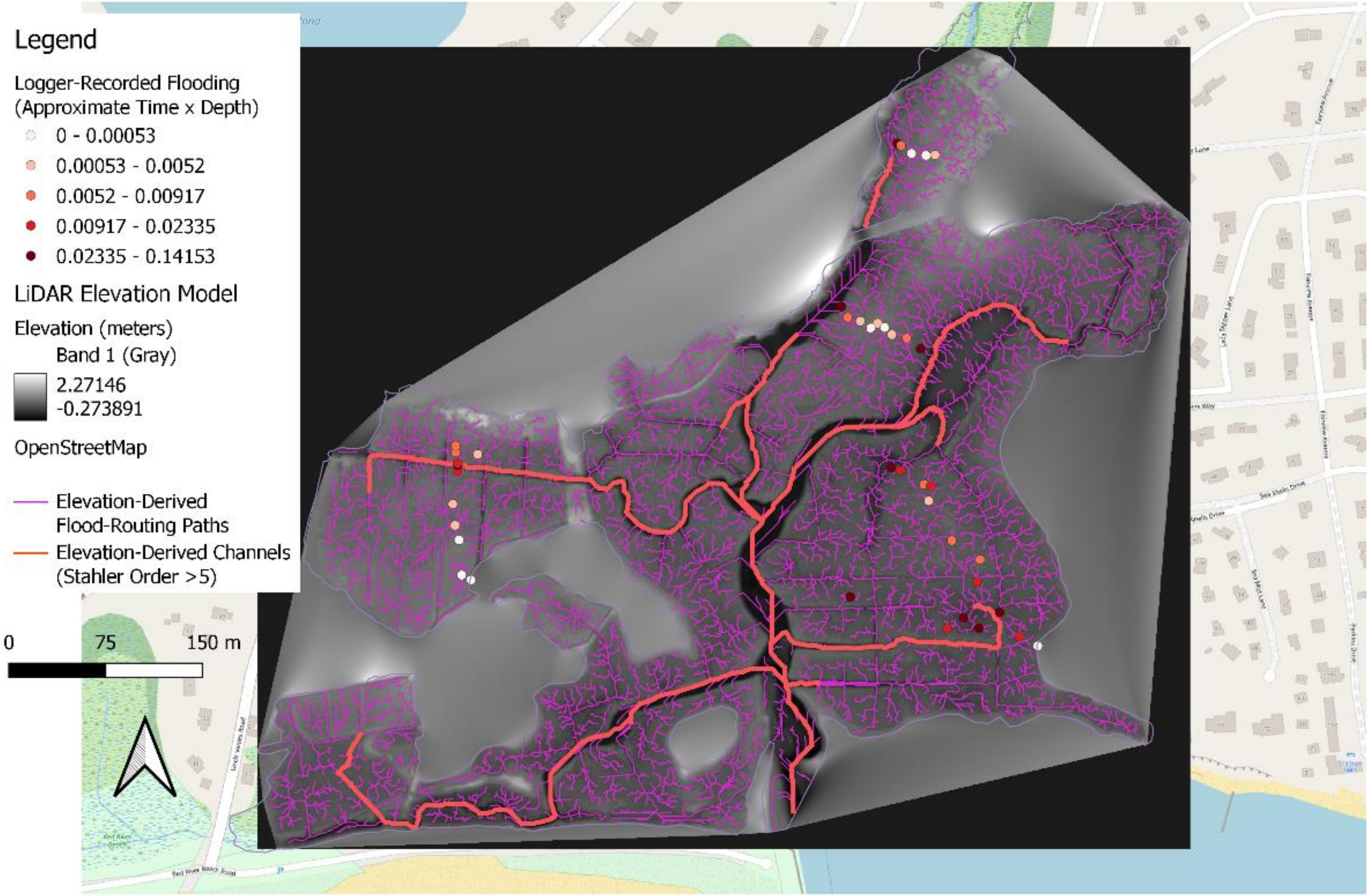
Red River: LiDAR-Derived High-Resolution Elevation Models



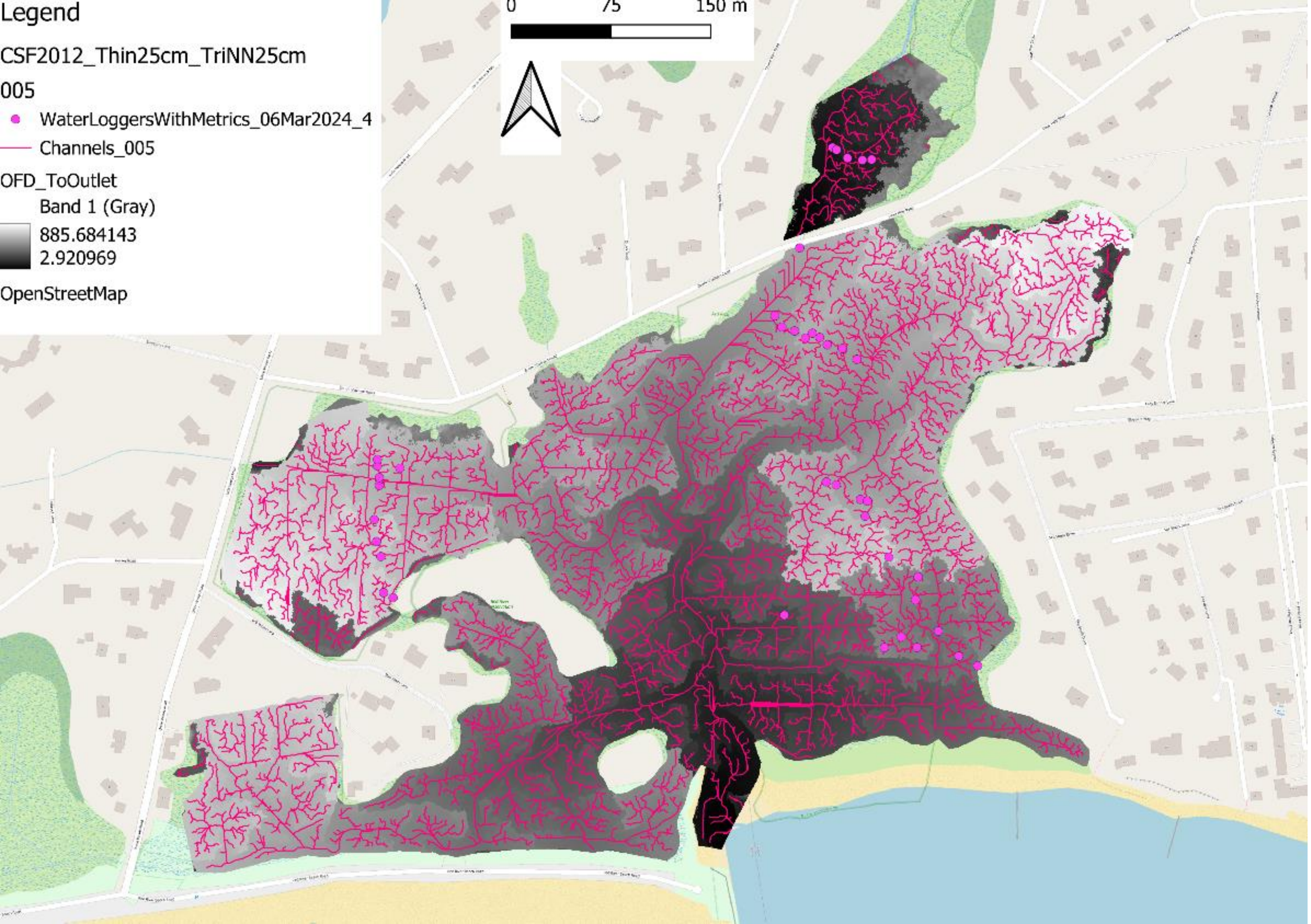
Median_Time_Innudated
7.5
5.0
2.5
0.0
-0.2
0.0
0.2
0.4
0.6
0.8
Logger_Elevation



Proportion_Time_Innudated
0.6
0.4
0.2
0.0
-0.2
0.0
0.2
0.4
0.6
0.8
Logger_Elevation

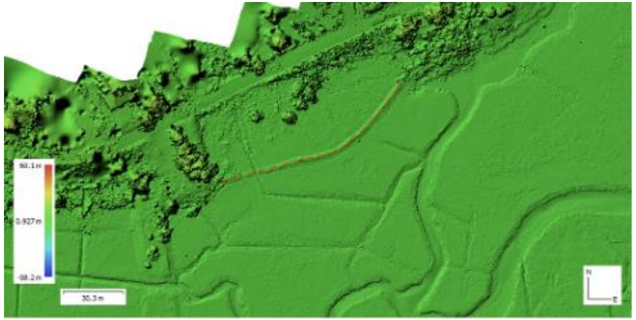


Red River Tidal Flood Routing Model

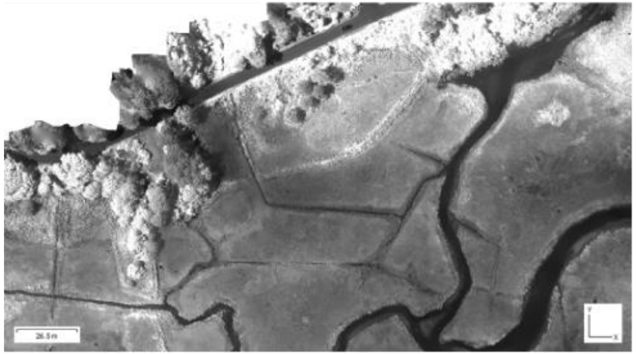


Red River Tidal Flood Overland Flow Distances

Goal: Identify Historical Structures & assess their Impacts

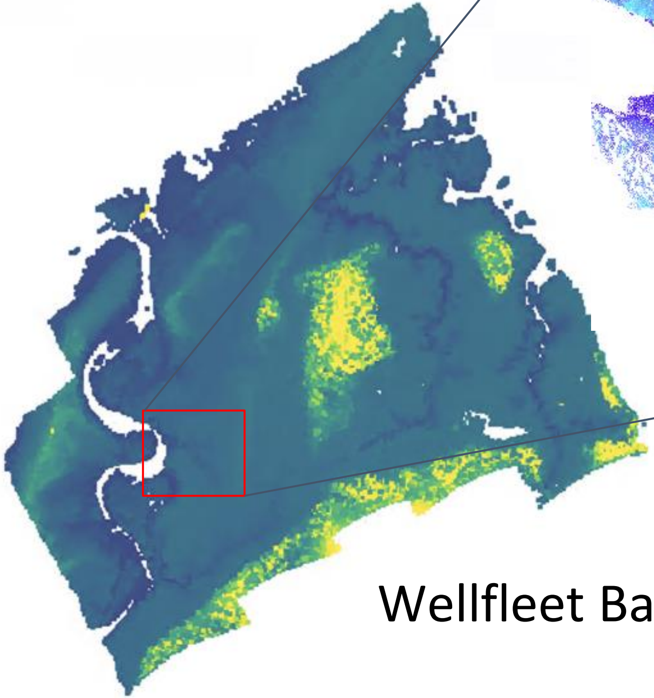


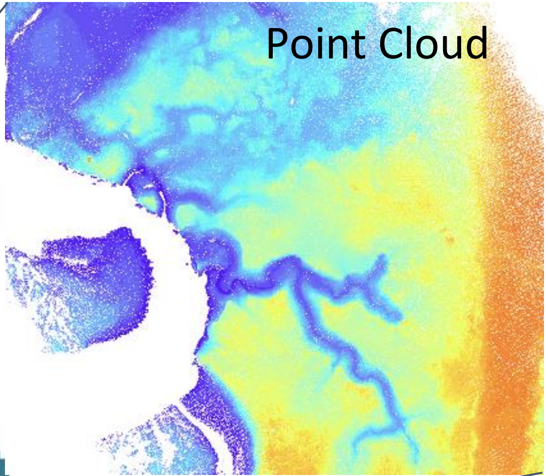
Map Structures

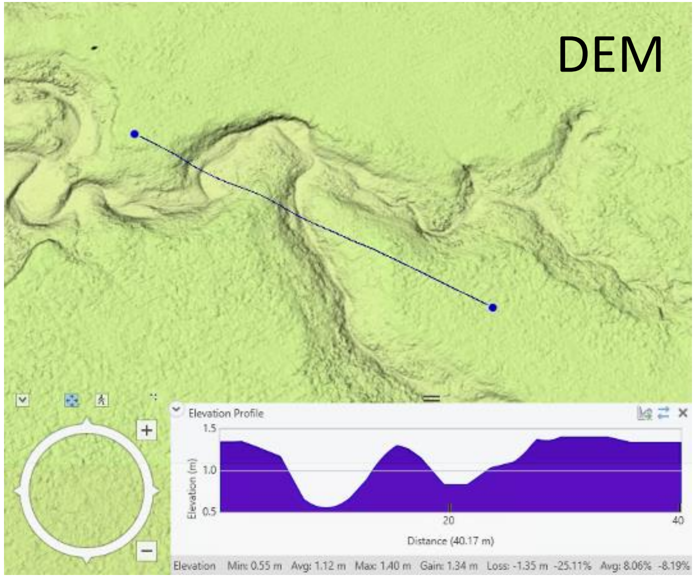


Evaluate Impact (SWIR)

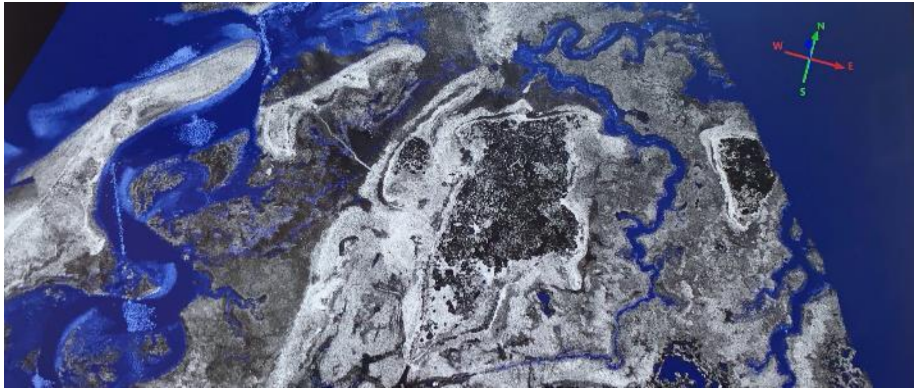
LiDAR





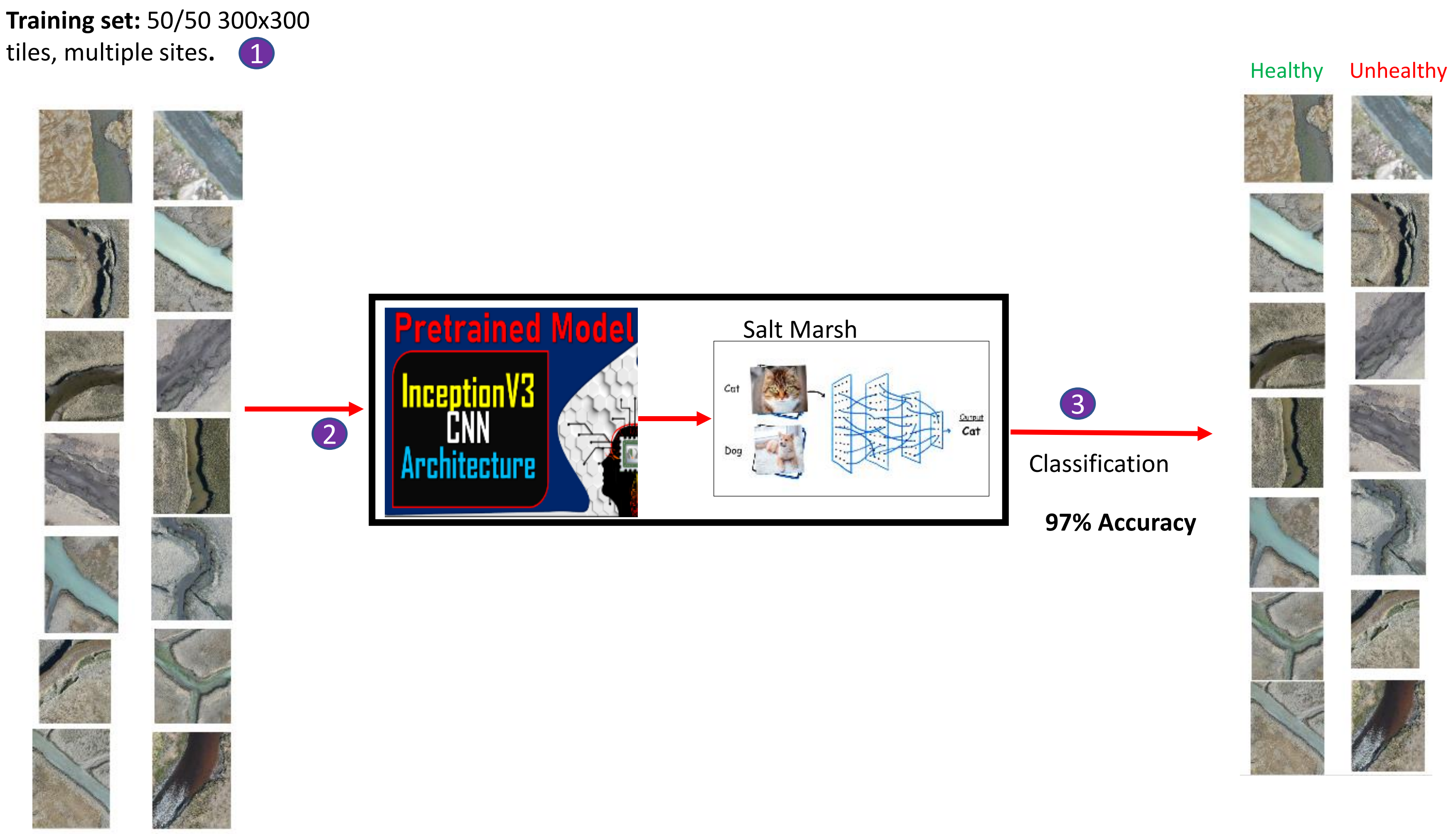


Wellfleet Bay



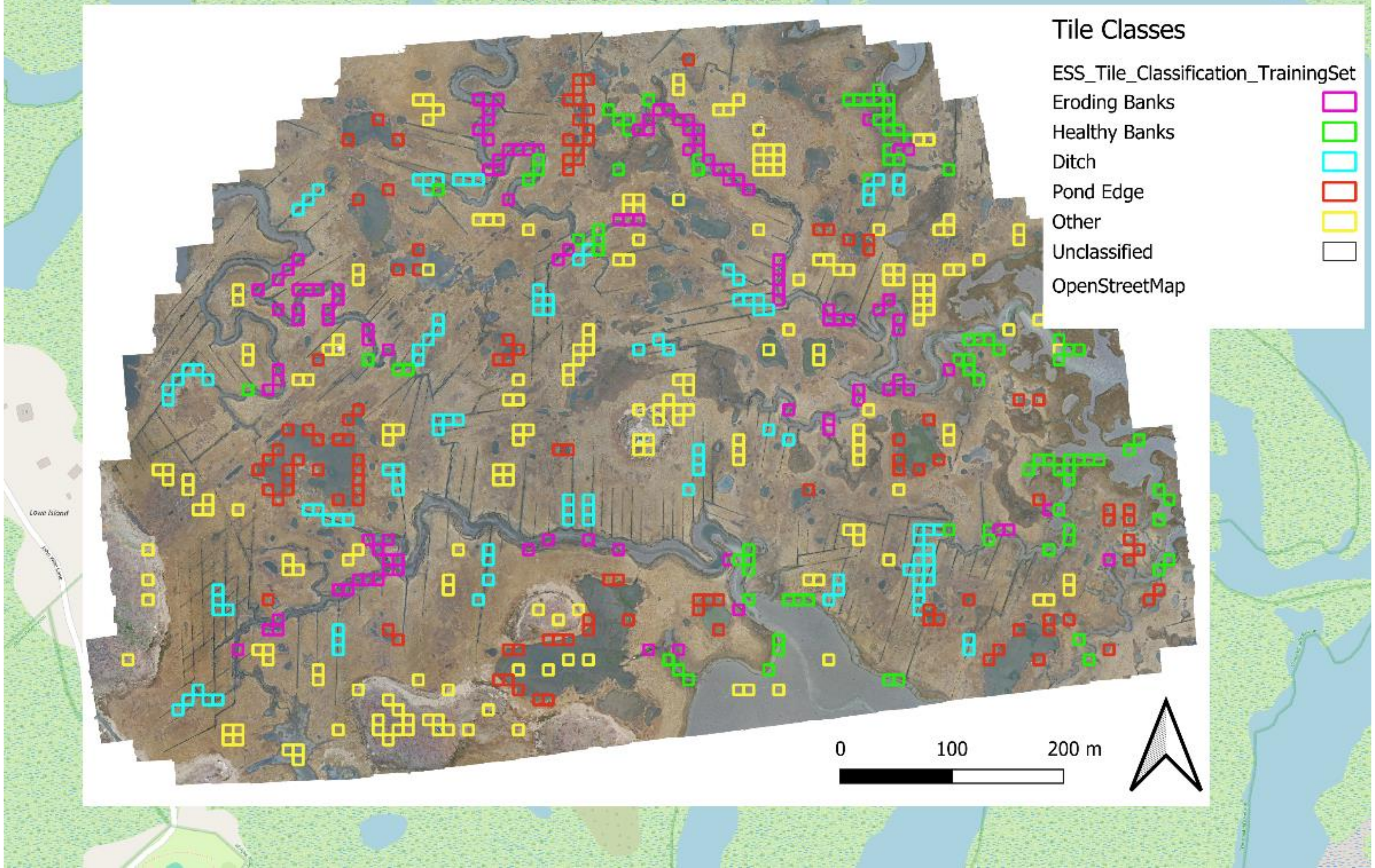
Measuring the health of a salt-marsh through study of creek-bank erosion.

Tiled the site into roughly 3m squares

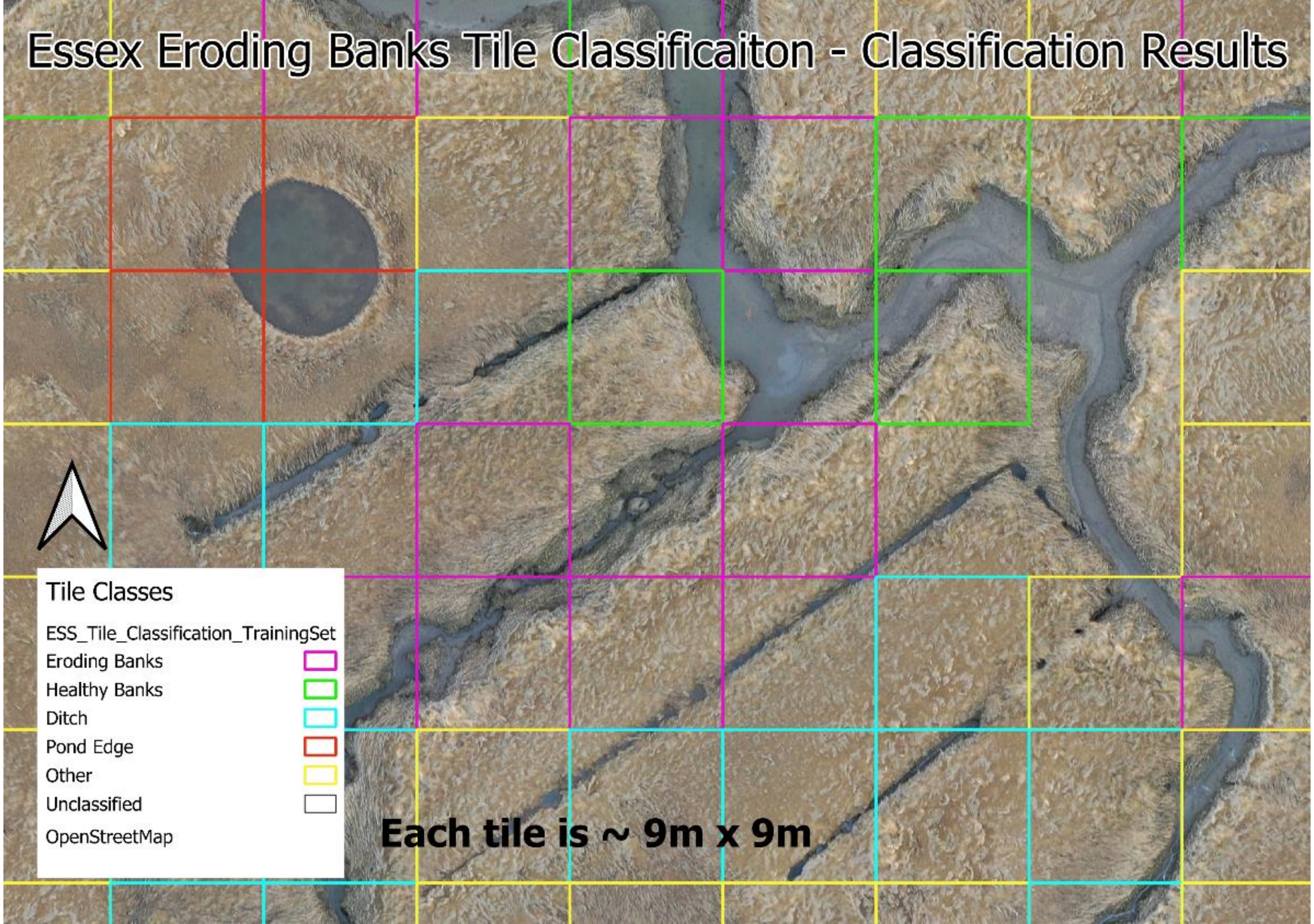


Training set: 50/50 300x300 tiles, multiple sites.
1
2
Pretrained Model
InceptionV3
CNN
Architecture
Salt Marsh
Cat
Dog
Output
Cat
3
Classification
97% Accuracy
Healthy
Unhealthy

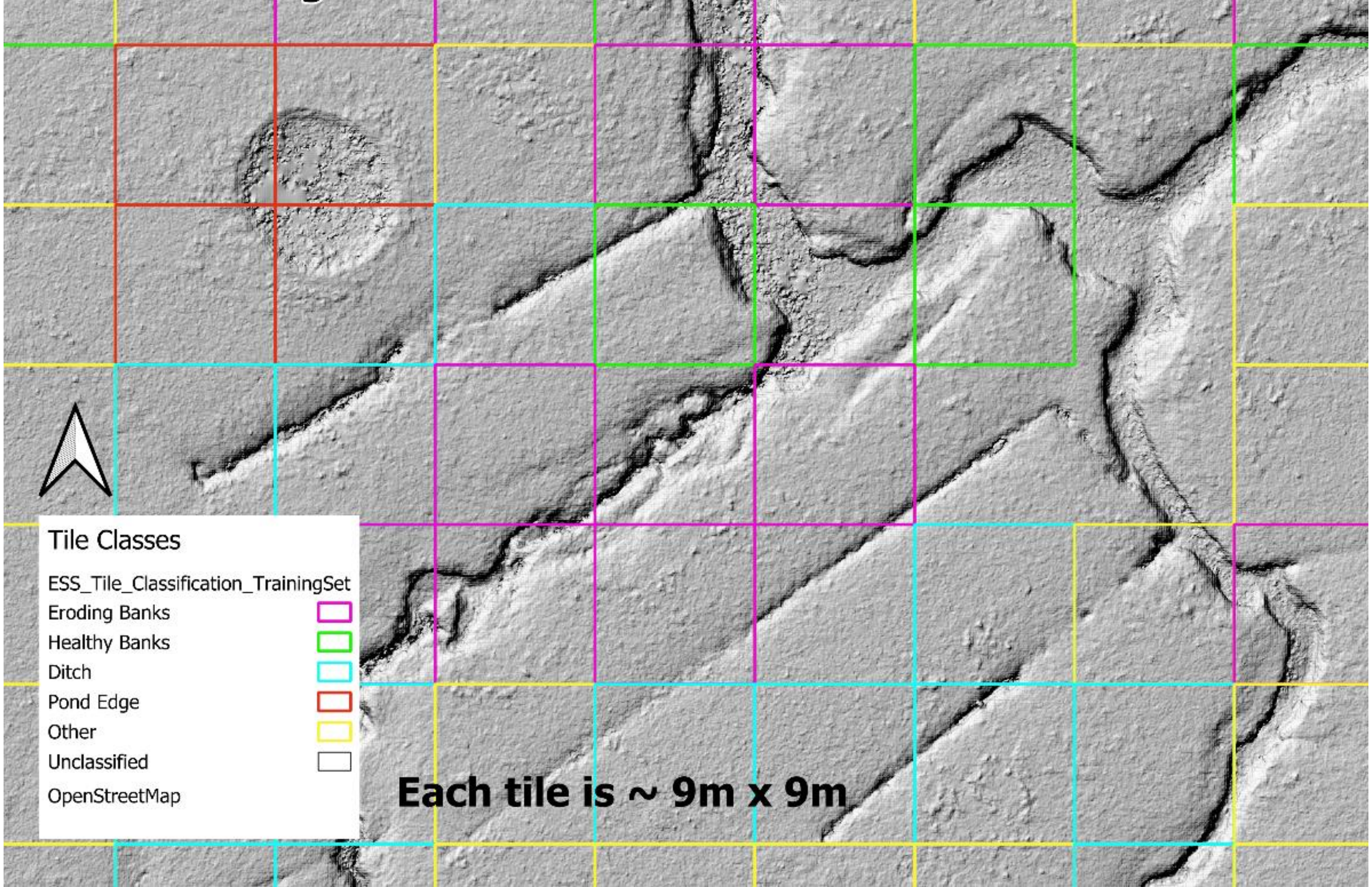
Essex Eroding Banks Tile Classificaiton - Training & Validation Set



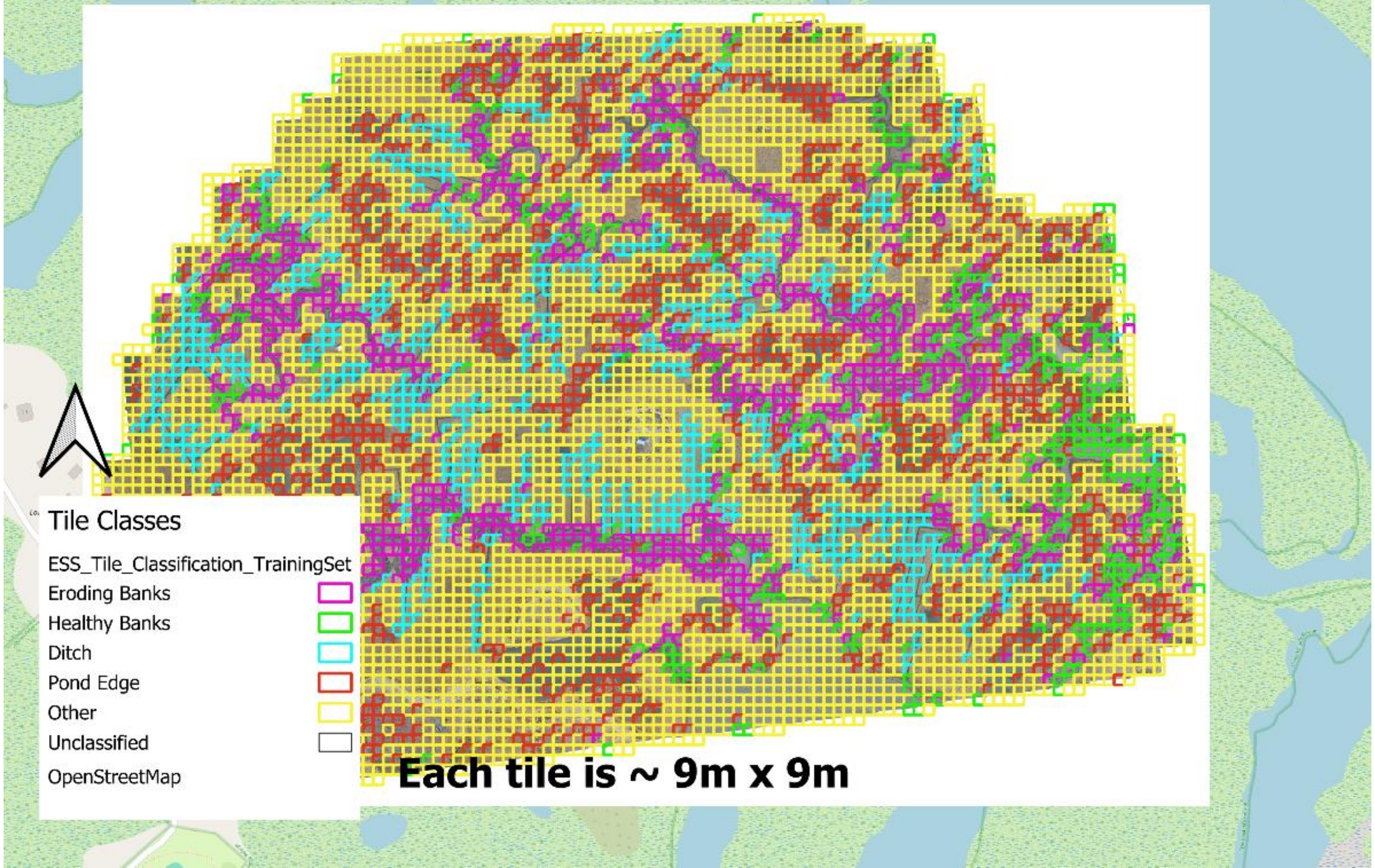
Essex Eroding Banks Tile Classificaiton - Classification Results



Essex Eroding Banks Tile Classificaiton - Classification Results



Essex Eroding Banks Tile Classificaiton - Classification Results



Results to date (Nov 6, 2024)

Site	Precision	Recall	F1	Accuracy
Essex	0.93	0.91	0.92	0.91
Old Town Hill	0.92	0.97	0.94	0.82
North River	0.88	0.74	0.8	0.82
Peggoty Beach	0.81	0.71	0.76	0.75
South River	-	-	-	-
Westport	-	-	-	-
Red River	-	-	-	-

Notes:

- *Precision* measures how often an image classified as eroding-bank is actually an eroding-bank.
- *Recall* measures, out of all eroding-bank images, how many were classified as eroding-banks.
- *F1* is a standard metric for averaging Precision and Recall.
- *Accuracy* measures number of images classified correctly across all 5 classes.

Long-term Salt Marsh Monitoring Program

- Collaborative monitoring
  - Status & Trends
  - Threat monitoring
  - Pre & post project monitoring
- Centralized repository for monitoring data
- Ongoing research and development