Spectral Differences Identified in a P. Australis Monoculture in the Marshlands of the Connecticut River Estuary

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Introduction

- *Phragmites australis* is a facultatively clonal species of wetland grass that is found on every continent except Antarctica, a testament to the highly invasive properties of this grass.
- Remediation of affected areas is often aided by use of remote sensing, which depends on thef the spectral properties of *Phragmites australis*.
- Goose Island in the CT River is dominated by relatively unremediated *Phragmites australis* allowing study of the natural variation differences in the species' spectral properties.
- The color variation comes from cell structure differences that influence near infrared light (NIR) in addition to the leaves' chlorophyll pigments, which influence visible light.
- These varying levels of reflectance can be measured spectrophotometrically via satellite imagery, aerial photographs, or an in situ spectrometry device.
- The mechanisms responsible for the varying spectral signatures of the *P. australis* stands on Goose Island are unknown; however, there are numerous documented factors that can change the cell structure or concentration of chlorophyll pigments in leaves; including elevation, nitrogen (Lippert et al. 2001), salinity (Achenbach et al. 2013), stress (Dykyjova et al. 1979), organics (Posey et al. 2003), and heavy metals (Ayeni et al. 2012).

Research Questions

- Which factors influence the spectral differentiation seen in the *Phragmites australis* found on Goose Island?
- Does the elevation of the plant stands cause enough variation in the soil's constituent contents to influence the cell structure and pigment concentrations of the leaves? Are there other localized factors that could change organic carbon, nitrogen, salinity, heavy metals, and stress from stand to stand?
- How can these spectral differences be incorporated into a remote sensing identification system used to better detect this invasive species?

Methods

Field Study

1. *Phragmites australis* stands on Goose Island are classified by their various spectroscopic properties. Plant material is sampled to determine the nitrogen, carbon, and spectroscopic properties of each respective plant.
2. Five random plant stalks are sampled in each stand, their heights measured, and two healthy leaves removed within highest meter of the stalk. All but two leaves from each stand are set out to air dry once in the lab. The two leaves from each stand are analyzed with a FieldSpec spectrometer as soon as brought back to the lab, yielding reflectance curves representative of each stand.
3. After air drying, the leaves are processed by the Elemental Analyzer, providing the nitrogen and carbon content of each leaf.
4. One soil core is taken and baked at 90 degrees celsius overnight to dry out. The soil is then divided into several subsamples; each sub sample analyzed for its organic matter (Loss on Ignition method), and for its carbon/nitrogen content.

Remote Sensing Analyses

1. The remote sensing was done in Envi Classic and processed in ArcGIS Pro. We performed a Spectral Angle Mapper supervised classification on the aerial imagery (Fig. 1 & 2) taken by USDA FSA's National Agriculture Imagery Program on August 10, 2018. The image utilizes band ranges of; Red: 619-651 nm, Green: 525-585 nm, Blue: 435-495 nm, and Near Infrared: 808-882 nm.
2. Using regions of interest taken from a NIR/green/blue image, we created a spectra classification (Fig. 2) corresponding to the varying colors of plant stands seen on the island. The classification was then used to make an average spectrum of each class.
3. Comparing these profiles to band math conducted with a float NIR/red ratio in addition to LiDAR data produces correlations between elevation, plant health, and reflectance.

Observations

- The spectra of Goose Island displays ten distinct classes (see Fig. 1), despite the monoculture of Phragmites.
- Goose Island has several microhabitats; rivulets, hummocks, and the coastline. A rivulet includes the drainage ditches dug in the 20's that run parallel along the island, as well as the small creeks that flow throughout the island. Hummocks are raised mounds of land, which are generally surrounded by rivulets. Rivulets and coastal microhabitats are exposed to more brackish water throughout the year, as well as having less soil access due to erosion. Hummocks are exposed to less brackish water, thus less salt.
- Laboratory spectra of leaves sampled in July, 2021 correspond well to the profiles obtained via the aerial imagery from August 2018 (see Fig. 3 & 4) the higher values correspond to the brighter colored classes with (orange) having a relatively higher 4/3 ratio than (green) and (maroon). These data would suggest that the healthiest plants would be the brightest color of their class with (orange) being the most prominent.
- Images of Goose Island through a fifteen year span suggest some permanence to certain groups of spectrally distinct *P. australis* stands. The fact that these spectrally differentiable plants remain distinct from their neighbors for such extended periods suggests that the spectral variations are inherent to the clones.

Fig. 1: Color Image of Goose Island taken by the USDA FSA's National Agriculture Imagery Program on August 10, 2018.

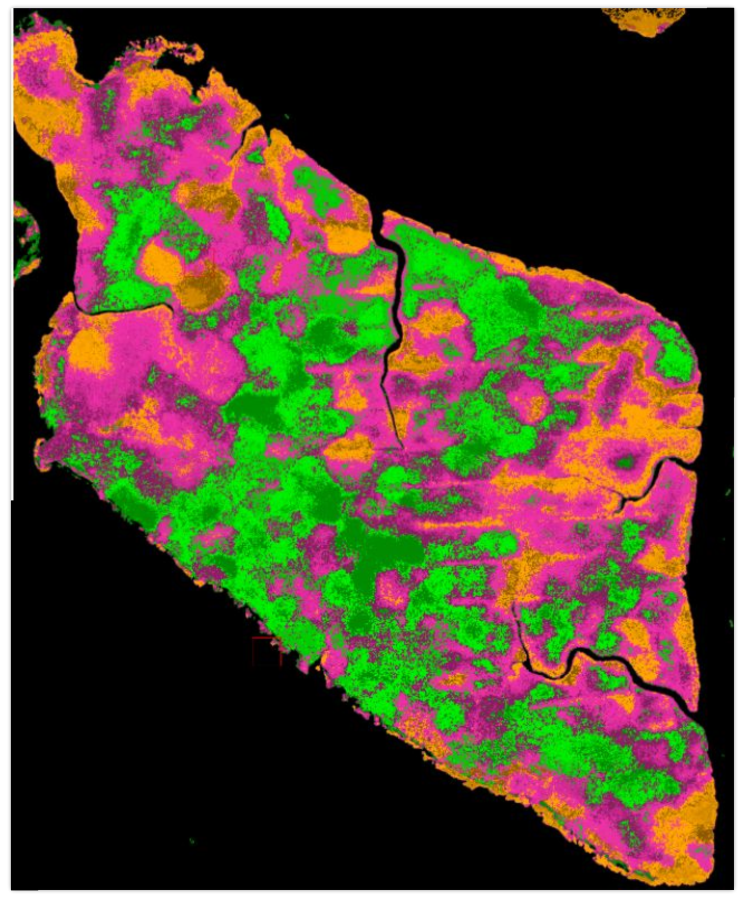


Fig. 2: Supervised classification imagery using a NIR, green, and blue image of the island . The spectral classes correspond to light-dark variations of green, orange, and mixed color stands of *P. australis*.

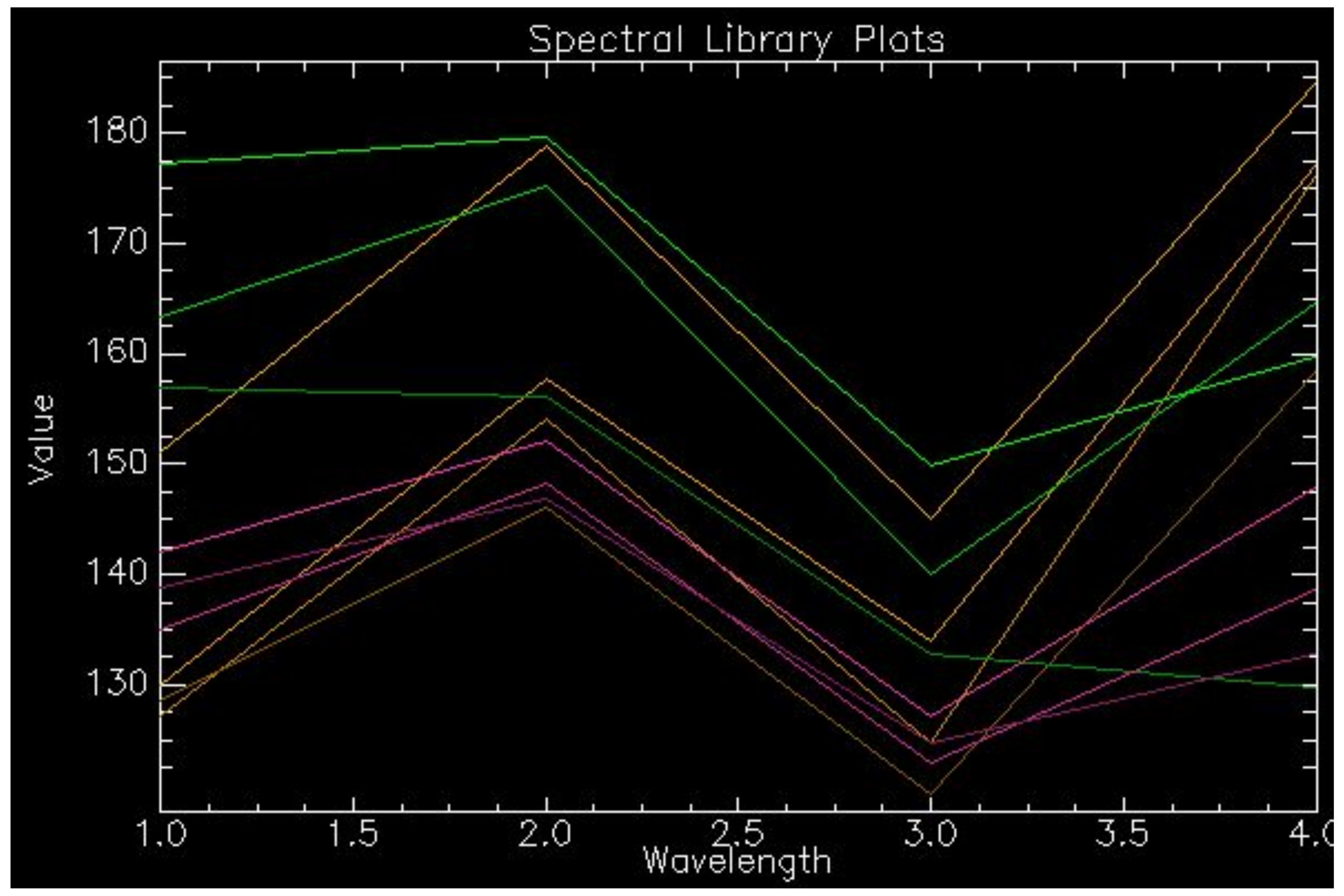


Fig. 3: The average Z profiles of each classification, note the differences in slope between bands 3 (red) and 4

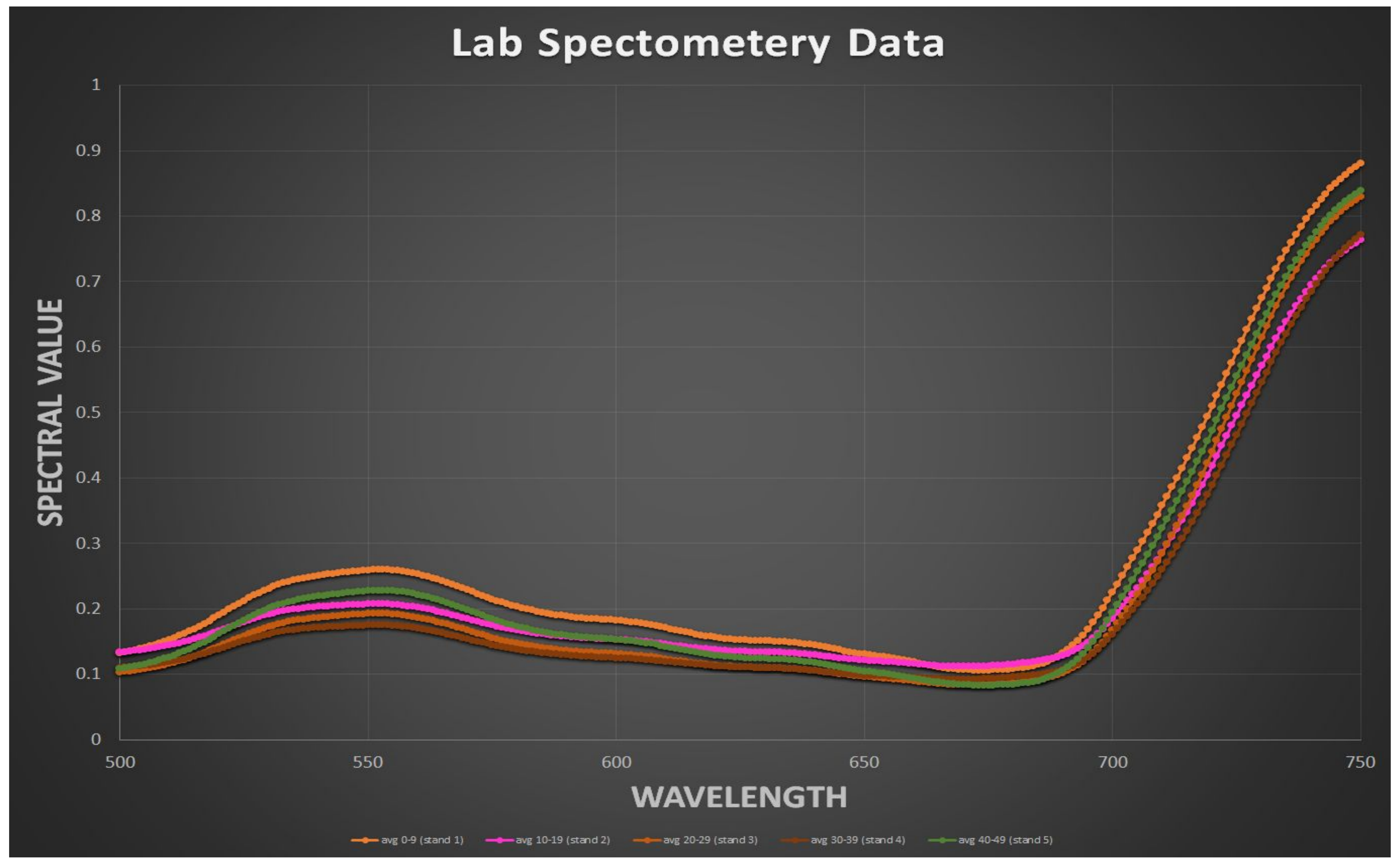
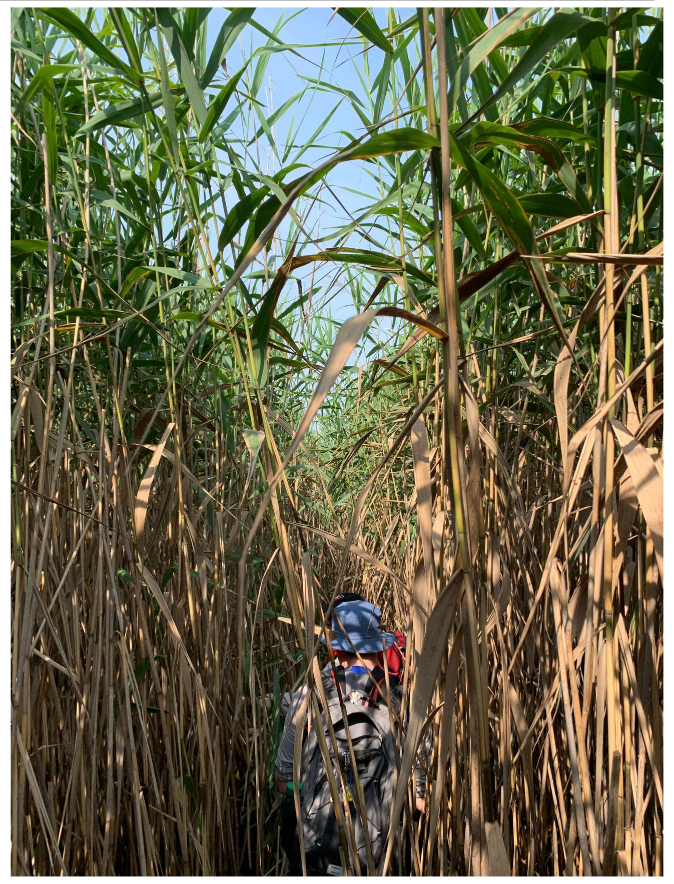


Fig. 4: Spectra of samples taken from the five stands that were analyzed in lab. Colors correspond to the stand's classification in the 2018 aerial image.

Conclusions and Future Work

Visiting the island on multiple occasions, it became apparent that there were many microhabitat variations. Tall versus short grass, dark versus light. Some locations on this island had abrupt changes in phenotypic qualities of the Phrag. When comparing both the remotely sensed image data and the lab spectra, it became apparent that there was a relationship. This is likely due to some small differences in pigment concentrations, which are yet to be ascertained. In the future, we'll have to classify all of the microhabitat variations that we find on the island, and correlate those variations to what we see on images of the island. Additionally, we'd like to incorporate genetic analyses of certain plots to see where these plots vary on a genetic level. It is known that P. australis has a large geospatial range of haplotypes. It is also known that P. australis is an epigenetically active plant, so an epigenetic analysis of Goose Island would be in order (Spens & Douhovnikoff, 2016).



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