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White Paper

MAPPING OF INVASIVE PHRAGMITES IN THE PEARL RIVER COASTAL WETLANDS AND VALIDATION BY ERADICATION

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MAPPING OF INVASIVE PHRAGMITES IN THE PEARL RIVER COASTAL WETLANDS AND THE RESULTS OF ERADICATION EFFORTS

Introduction

Phragmites australis (common reed) is a perennial grass commonly found in brackish and freshwater wetlands. This invasive grass appears to be rapidly outcompeting native species in many areas of the US. At least two subspecies of common reed have been introduced from Eurasia (haplotype M) and Africa (haplotype I) [1-3]. Haplotype I appear to be the predominant subspecies of *Phragmites* invading wetland ecosystems along the Gulf Coast [4]. *Phragmites* seeds abundantly and rapidly spreads vegetatively by stout and creeping rhizomes. Invasion of native ecosystems by *Phragmites* has been shown to have negative impacts on the local ecology, most notably through decreased biodiversity [5]. In highly braided water bodies, like the delta of the Pearl River in southeastern Louisiana, *Phragmites* can also be a navigation hazard to small boats by reducing visibility as the plant regularly reaches heights greater than 15 ft. Once established, *Phragmites* spreads, outcompetes native plants for resources, and can eventually form large monocultures [5]. In this paper, we first discuss our efforts to map *Phragmites* using an unmanned aerial system (UAS) in the Pearl River delta and demonstrate the effectiveness of this approach in-terms of both accuracy and cost. Finally, we provide external, independent validation of our mapping accuracy.

Background

Resource managers currently use a variety of tools including mowing, grazing, burning, and herbicides to control *Phragmites* [6]. All of these methods rely on knowing the location of *Phragmites* before implementing management efforts. The pervasive spread of *Phragmites* in wetlands presents a unique challenge in precise mapping. Mapping is usually achieved through a variety of methods including satellite imagery, manned aircraft, and walking around or through a *Phragmites* stand with a GPS unit [7-10].

The spatial resolution of satellite imagery is not sufficient for the detection of short stands of *Phragmites* (~ 2-6 ft.) or individual plants [9]. Using satellite imagery to determine the location can lead to the reestablishment of a *Phragmites* stand after management efforts have been completed due to undetected individual plants and small stands acting as refugia. The revisit rates of satellites further limit the accessibility of near real-time data. Long wait times associated with satellite imagery can affect management efforts as the plants may have spread beyond the last known border of a stand. Manned aircraft can alleviate the wait time and poor resolution associated with satellite data modalities. However, they are seldom an economically viable. Walking around the *Phragmites* with a GPS unit to manually map a stand involves a lot of man-hours as well as dangers associated with groundwork (i.e. dangerous wildlife or difficult terrain navigation). All of these methods have drawbacks associated with them such as reduced image resolution, long periods between updated photos, cost efficiency, pilot error, and dangers associated with groundwork. These hindrances can often result in an incorrect *Phragmites* stand location which in turn hampers or slows management efforts. To overcome these drawbacks we used a UAS capable of collecting geo-referenced high-resolution visible imagery. In particular, an Altavian Nova UAS with an 18 megapixel Canon EOS Rebel camera. This system negates the low resolution and long update times of satellite imagery, the cost issues and potential pilot error associated with manned aircraft, and the hazards of on-the-ground fieldwork by humans.

The Altavian Nova UAS platform weighs approximately 15 lbs. with payload, with 8.8 ft. wingspan and 4.9 ft. length. It can capture data on flights lasting up to 90 minutes. The Nova is waterproof, enabling water landings in the study area. The camera used was a Canon Rebel EOS SL1 with a payload and lens setup that gave approximately 2x2 inch pixels from an altitude of 750 ft. Images obtained from each flight are mosaicked on a per-flight basis in Agisoft Photoscan Pro [11]. The mosaics produced were typically within meters or better of their true position.

Solution

UAS offers near real-time, low-cost aerial data collection as an alternative to classical manned aerial systems. There are major benefits of employing UAS's, including their ability to fly in inaccessible regions, safety, near real-time or real-time data availability for applications such as disaster response, similar mapping capabilities to a manned aircraft, and the ability to map regions at very high spatial resolutions at low-cost. In short, small UASs can be used as mapping platforms in small scale areas. Figure 1 shows two overlapped image mosaics created from images collected with the visible wavelength camera flown on the NOVA.

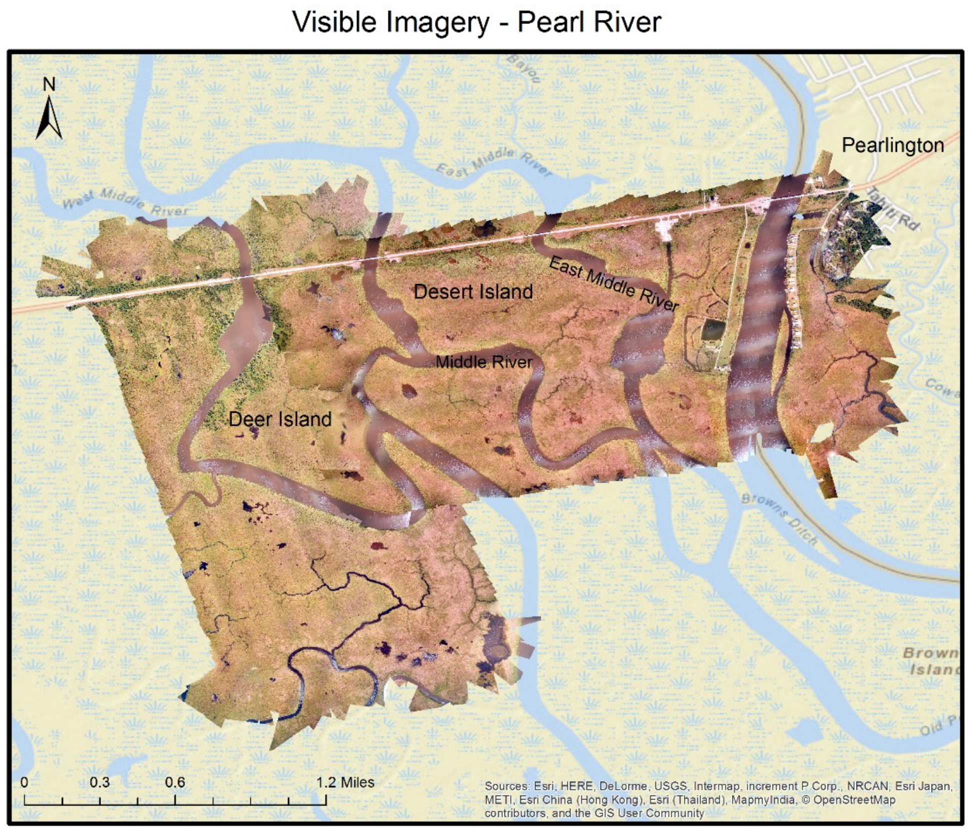

Figure 1. Visible imagery collected near Pearlington, MS on September 23rd , 2014.

The study area was the lower Pearl River basin located in southwest Mississippi and southeast Louisiana (see Figure 2). The region can be classified as a tidal freshwater marsh. Such regions are influenced by the daily influx of tides, yet they have a salinity of less than 0.5 ppt [12]. This region is located in the delta of the Pearl River and drains into the Gulf of Mexico. Due to the heterogeneous habitat, tidal freshwater wetlands harbor diverse communities of plants and animals [12]. This region has one of the healthiest marsh complexes in the Southeast US and supports between 120-140 fish species [13] and approximately 40 species of mussels [14], making it one of the most species-rich river systems in the US. Brackish or mesohaline marsh is found in the lower marsh zone near the mouth of the Pearl River.

Figure 2. Map of the study area. Pearl River delta along the Louisiana and Mississippi state border.

The data used in this study was collected in the lower Pearl River basin west of Pearlington, Mississippi and north and south of U.S. Highway 90, an area totaling over 3,200 acres. Data collected over Desert Island and Deer Island (see Figure 1) on 23 September 2014 were used for creating a map of the *Phragmites* using a texture-based classification scheme.

The texture is a critical feature in imagery; it can compensate for the lack of richness in spectral resolution when seeking to classify land covers. Visible imagery collected from the UAS has a very high spatial resolution, hence texture can be a more meaningful feature for classification of *Phragmites* from other plant species. Visual inspection of the visible imagery revealed unique properties of *Phragmites*; mainly roughness, granulation, and regularity. This observation motivated the use of texture features for *Phragmites* classification. Texture features are extracted to classify the land cover into *Phragmites* and *Non-Phragmites* classes. Small set of *Phragmites* patches were selected to be used as ground truth (GT) patches. These patches were accessed by boat. Once the field crew was on the site a crew member walked around the patches with a handheld GPS unit to record the patch boundary with sub-decimeter accuracy. Navigation to and around patches was difficult due to location, terrain, and vegetation. This further highlights the need for studies of this nature so as to decrease the dangers and costs of fieldwork. After the fieldwork was complete the image mosaic from the UAS flight was loaded into ESRI's ArcMap program. Digitization of the boundaries of the same three patches was done manually by selecting the boundary locations of the patches based on direct visual inspection of the image mosaic in ArcMap. These ground truth patches are for training supervised classification algorithm. Figure 3a shows the area under study (part of the area in Figure 1). In Figure 3b, the automated mapping created from classification using the texture features is shown. The *Phragmites* areas are shown in yellow. The region under study is north of Honey Island and west of Desert Island in the delta of Pearl River.

Validation by Eradication

Mapping and eradication are two non-coordinated independent operations. We returned to the area at a later date (March 2016) to re-image the same area using a Precision Hawk Lancaster UAS [15] with a 5-band Micasense RedEdge sensor [16]. We were seeking to determine how much better of a classification scheme we could develop using more bands albeit with each having a lower spatial resolution. When we examined the collected imagery, we noticed very few areas that looked like *Phragmites*. In fact, it appeared someone had burned (eradicated) almost exactly the areas our texture-based classification scheme had indicated was *Phragmites*! Figure 4a shows the imagery collected after the eradication efforts took place. Figure 4b shows the burned areas. Notice the similarities between Figure 3b and 4b. When comparing the two images, realize the burned areas are larger than the areas containing the invasive to increase the probability of removing all of the invasive.

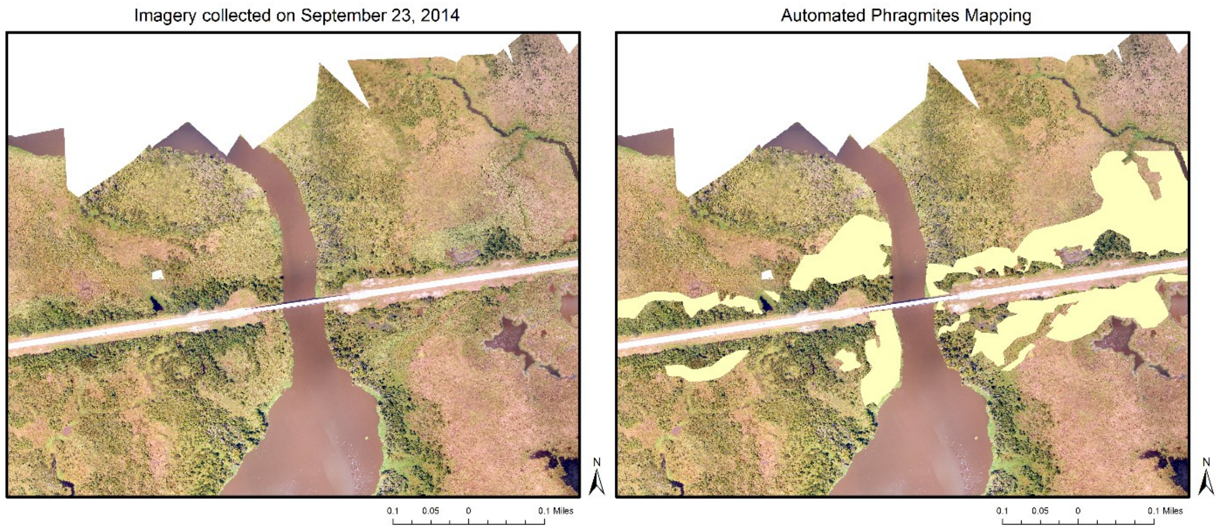

Figure 3. (a) A small region in Upper Bayou cropped from the mosaic shown in Figure 1. The Red-Green-Blue images captured using a Canon EOS Rebel SL1 on an Altavian Nova platform on 23 September 2014. (b) Classification results of Upper Bayou (marked in yellow)

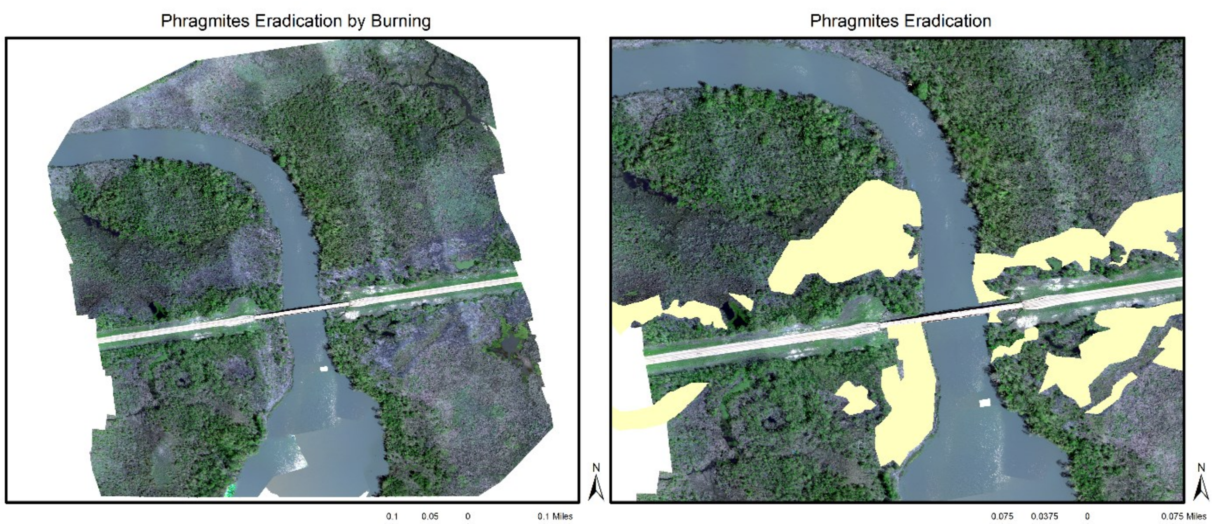

Figure 4. (a) A small region in Upper Bayou (as shown in Figure 1 and Figure 3). The Multispectral (Red, Green, Blue, Red Edge and Near Infrared) images captured using a Mica Sense camera on a Precision Hawk Lancaster platform on 3 March 2016. (b) Burned regions are marked in yellow. Red Green and Blue bands are shown for both (a) and (b).

Discussion

The image classification methods refined in this work using a very high spatial resolution imagery (2x2 inches) allowed for the mapping of small to large stands of invasive *Phragmites* in the Pearl River delta regions. This method is found to be applicable for stands of all heights. However, the classification accuracy for each site is variable, depending on the density of patches. Our study considered the following major questions about the automatic mapping of invasive *Phragmites*: 1) can UASs be used for successful mapping of *Phragmites*, 2) can texture features be used to distinguish *Phragmites* from non-*Phragmites*, and 3) can *Phragmites* be mapped by using only the low altitude high spatial resolution visible imagery. Results suggest each question can be answered with an affirmative. Based on experimental results study and comparing the eradication maps, texture features are able to distinguish *Phragmites* stands.

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