Expansion of *Phragmites australis* in a Mississippi Estuary Determined from Aerial Image Data

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I. Introduction: *Phragmites australis* in Mississippi's Coastal Marshes

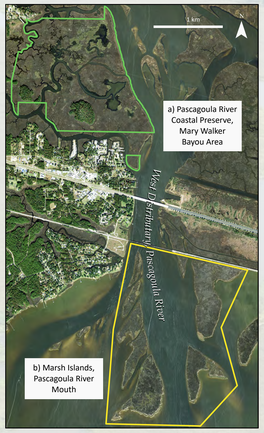

Fig. 1. The Southwest Pascagoula River Estuary. Two sites were examined within the study area: a) the Mary Walker Bayou area, in green (inland, protected from wave action, less saline) and b) the Marsh Islands at the mouth of the Pascagoula River, in yellow (exposed to greater wave action and higher salinities).

Phragmites australis (Cav.) Trin. ex Steud. is a highly competitive native species in Northern Gulf of Mexico coastal marshes [1,2,3]. It is associated with decreased vegetative diversity, but provides habitat for a variety of birds, insects and spiders [1, 4, 5, 6]. In Mississippi's estuaries, it has been previously documented in disturbed areas, along natural levees and at higher elevations in more saline areas [1,7]. The species can exist at wide range of elevations under various salinity and hydrological conditions [8,9]. Recent work suggests it could protect against coastal erosion by facilitating sediment deposition better than other marsh species such as *Spartina alterniflora* Loisel [10]. Our study aims to describe how *P. australis* has responded to recent changes in sea level compared with co-located marsh vegetation in the Pascagoula River Estuary, Mississippi, USA (Fig. 1).

Research Questions

1. How has *P. australis* extent changed over time (1996-2018)?
2. How does this change in extent compare to the change in extent of other co-located marsh species?
3. Is *P. australis* extent changing more rapidly in areas which are more protected and experience lower salinity levels?

II. Methods: Image Classification and Change Detection

Image Data
Color-infrared datasets were obtained December 2018, October 2014, August 2010, February 1996 by the National Agricultural Imagery Program and the National Aerial Photography Program. All analysis was completed at 1m GSD using the near-infrared, green, and blue image bands.

Training Data
Training pixels were selected based on 2002 maps [1] and present-day field photography. Ten total land cover classes were defined to obtain normal distribution of brightness values in each class.

Maximum likelihood classification

Filtering
Each class image was filtered to remove pixel groups of less than three square meters to reduce noise.

Class combinations
Ten classes were reduced to four: Water, P. australis, all other marsh, and woodland.

QAQC
Data gaps were filled using a majority filter and final corrections were made.

Classified land cover maps (Fig. 2)

Change detection analysis

Changes in total class areas (Fig. 3, 4, 5)

Tabulation of class changes (Fig. 6)

III. Results: Land Cover Maps, Areal Class Changes and Land Cover Conversions

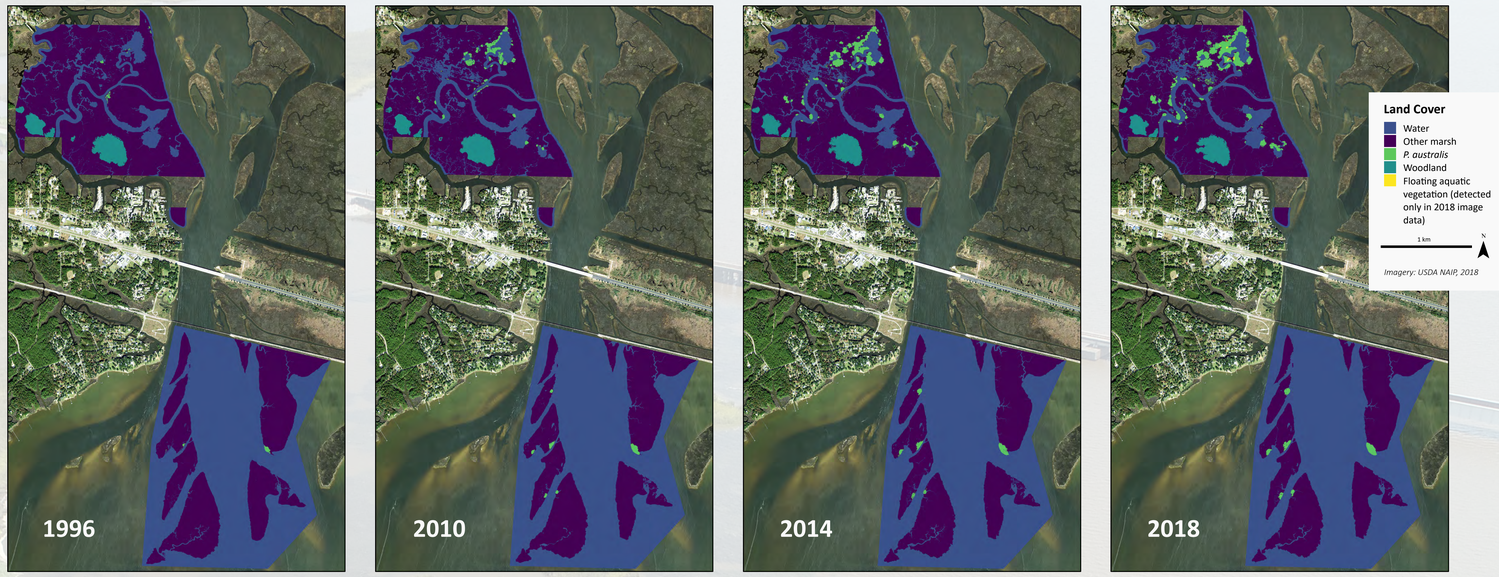

Fig. 2. Classification images for calendar years 1996, 2010, 2014, and 2018.

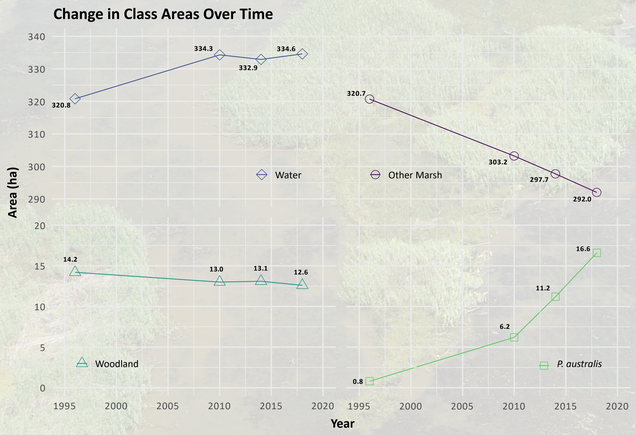

Fig. 3. Areas of each land cover class for each image date (1996, 2010, 2014, 2018).

Fig. 4. Annual rates of change in area (ha/year) of each land cover class for each time interval (1996, 2010, 2014, 2018).

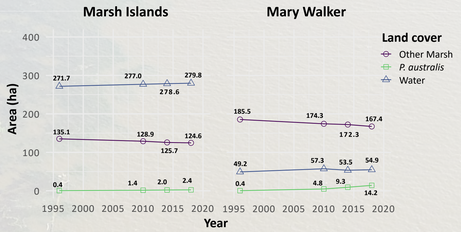

Fig. 5. Comparison of change in area of *P. australis*, Other Marsh, and Water classes over time at each site (Fig. 1).

Key Findings

- *P. australis* extent increased in each year for a total of 15.8 ha, as the area of all other marsh decreased for each image date (Fig. 2, 3, 4).
- Both sites exhibited an increasing trend in *P. australis* extent, with a 13.8 ha increase at the inland, protected, lower salinity site and a smaller 2.0 ha increase at the river mouth (Fig. 1, 5).
- *P. australis* colonized other marsh areas at a rate of 12.4 ha per year overall and open water at a rate of 3.4 ha overall, with lower but still positive rates of colonization at the exposed, higher salinity site (Fig. 6).

Land Cover Class Conversions (1996-2018)

	Mary Walker	*Marsh Islands*	*Total Study Area*
Other marsh to *P. australis*	**10.9 ha** (4955 m^2/yr)	**1.5 ha** (659 m^2/yr)	**12.4 ha** (5616 m^2/yr)
Water to *P. australis*	**2.8 ha** (1268 m^2/yr)	**0.6 ha** (277 m^2/yr)	**3.4 ha** (1544 m^2/yr)
Other marsh to water	**8.5 ha** (3859 m^2/yr)	**8.6 ha** (3923 m^2/yr)	**17.1 ha** (7782 m^2/yr)

Fig. 6. Table of areal conversions between land cover classes (ha, in bold) computed between the 1996 and 2018 images, along with the equivalent annual rates of change (m^2 per year, in parenthesis).

IV. Discussion and Conclusions

Overall, *P. australis* extent increased in each year, with an increasing trend in extent and the rate of spread at both sites (Fig. 1,2,3,4,5). *P. australis* colonized areas previously occupied by both marsh vegetation and open water. When *P. australis* area is combined with other marsh areas, total marsh extent increased between 1996 and 2018 at Mary Walker Bayou area, despite the overall trend of marsh loss exhibited across the estuary (Fig. 3,4,6) [11]. This has both positive and negative implications for the future of Mississippi's coastal marshes in terms of biodiversity, species composition, and ecosystem function. In terms of marsh shoreline movement over time, *P. australis* appears to be mitigating marsh loss due to relative sea level rise. Removal of the species would have detrimental effects, including reduced coastal protection from wave action and storm surge flooding, loss of wildlife habitat, lowered carbon sequestration, and reduced ability to filter pollutants from upland runoff. As we continue the project, we are working to compute shoreline movement over time, expand the studied area to other parts of the Northern Gulf of Mexico Coast to evaluate broader trends, and quantify how certain environmental factors (e.g. wind fetch, salinity) are related to the rate of spread of *P. australis*.

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