Background and Motivation: Changing environmental conditions prompt shifts in coastal vegetation species. The speed of these changes and the resulting vegetation response can be the difference between vegetation death and subsequent land loss or vegetation transition and land maintenance. Since vegetation impacts both sediment and hydrologic processes, including vegetation changes is key to modeling coastal land evolution.

The integrated compartment model (ICM) is used to support the Louisiana Coastal Master Plan (LCMP) project selection process (Coastal Restoration and Protection Authority of Louisiana, 2023). The model contains multiple sub-models that work in coordination to predict the land area, species composition, and suitable habitats across the Louisiana coast decades from now. The vegetation sub-model, LAVegMod, tracks the species composition of each vegetation grid cell (480 m x 480 m) in the ICM based on species specific probability of establishment and mortality (Foster-Martinez et al., 2023; J. Visser & Duke-Sylvester, 2017; J. M. Visser et al., 2013). These probabilities are calculated from the presence/absence of each species at stations in the Coastwide Reference Monitoring System (CRMS) and are a function of the mean annual salinity and water level variability (i.e., the standard deviation of the water level). If conditions are suitable for a particular species and it is present within the surrounding area, that species can then occupy the available space. If that is true for multiple species, then they occupy an amount of space proportional to their suitability.

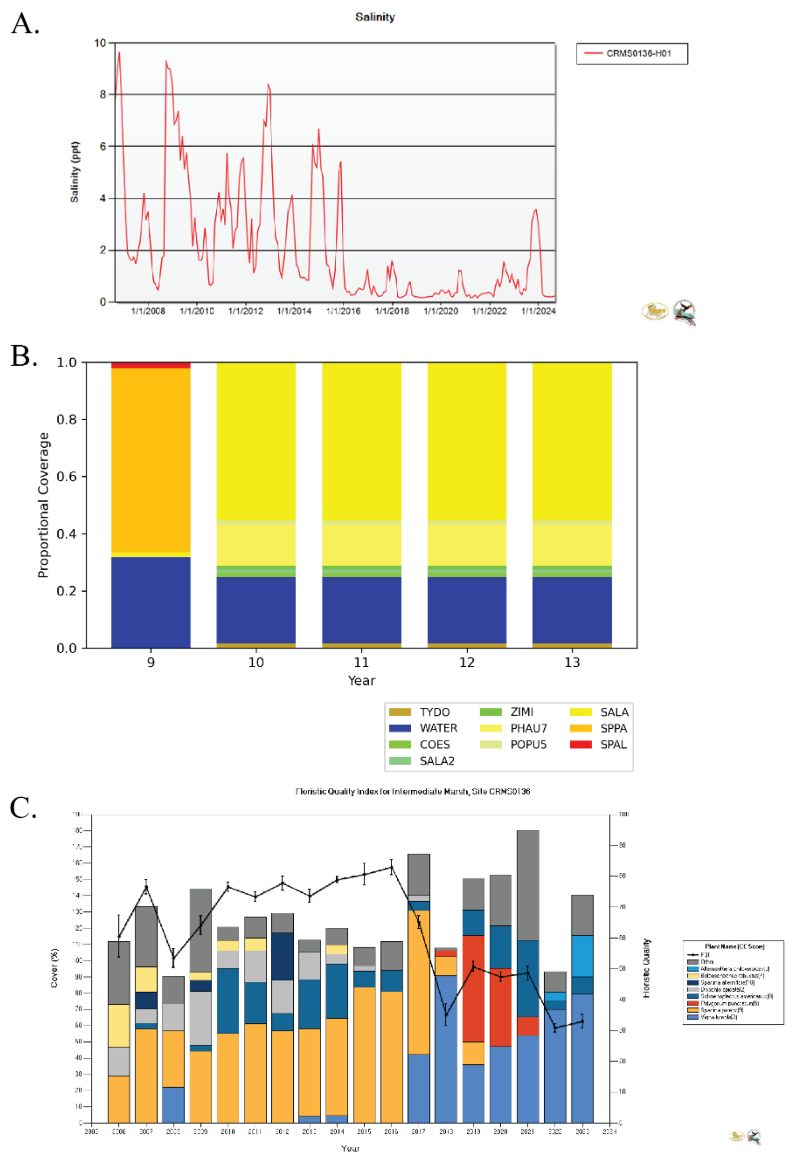

Figure 1: Observations and modeling at CRMS0136 in Breton Sound. A) Daily salinity observations. B) Preliminary LAVegMod output at the grid cell containing CRMS0136; year 10 corresponds to 2016; species are given by USDA symbols. C) Observations of vegetation species coverage from 2016-2023 (CPRA 2024).

When changes in environmental conditions are gradual, this proportional approach works well, allowing species to gradually adjust to shifting estuarine gradients and occupy their species niche. However, when changes are more abrupt, it can lead to abrupt changes in vegetation cover. For example, CRMS0136 freshened considerably in 2016. Salinity had a seasonal maximum greater than 5 ppt until 2016. The salinity then remained lower than 1.5 ppt until 2023 (Figure 1A). LAVegMod results over this time show an abrupt change in species composition at this grid cell (Figure 1B), while *in-situ* observations of vegetation composition at CRMS0136 show a more gradual transition (Figure 1C). With the increasing likelihood of faster transitions in the future decades, it is important to investigate transitions that have been observed and explore alternatives to the niche-approach to vegetation modeling, such as identifying successional patterns and trajectories.

<u>Project Objectives and Methods</u>: The graduate student will utilize the data collected through CRMS to identify vegetation transition patterns. CRMS stations were established in 2006-2007, producing over 18 years of annual vegetation surveys, timeseries of environmental conditions (e.g., water level, salinity, precipitation, temperature), and regular measurement vegetation and soil properties (e.g., above and belowground biomass, accretion, bulk density).

We leverage the work by Snedden (2019) to reduce the complexity of available data. Snedden (2019) trained a self-organizing map (SOM) with the available CRMS data, producing 260 map units that were further classified into 11 vegetation community types (VCT). Rather than having states defined by the percent cover of each species in the surveyed CRMS plots, the student will use the VCT and 260 map units to define each plot through time and will create a framework for tracking transitions through time. Two additional states will be added, unvegetated ground (i.e., baregound) and open water, to account for land building and land loss observed at the sites. Although land building is not currently observed at CRMS sites since all are established within the vegetated wetlands, including that state is important, as it gives the method greater flexibility for future use. Figure 2 A and B show the difference between transitioning between the VCTs (A) and between the map units (B). The VCT data is readily available, and the map units can be calculated from the survey data. Python code for determining the best matching unit (BMU) for LAVegMod results is available on Github (Foster-Martinez, https://github.com/CPRA-MP) and can be adjusted to work with CRMS survey input.

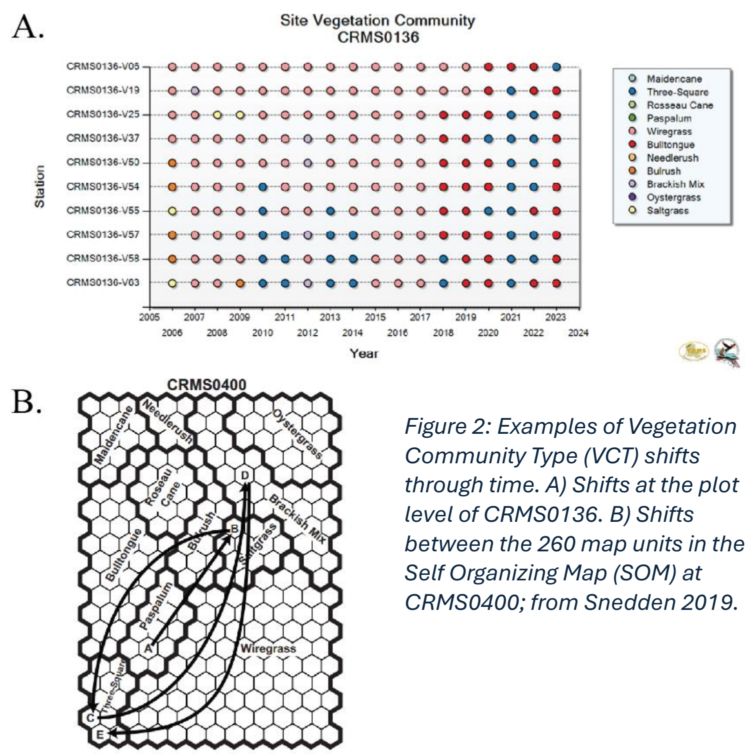

Figure 2: Examples of Vegetation Community Type (VCT) shifts through time. A) Shifts at the plot level of CRMS0136. B) Shifts between the 260 map units in the Self Organizing Map (SOM) at CRMS0400; from Snedden 2019.

Via sequential encoding and a transition matrix, the frequency of transitioning between states will be tracked, allowing for the probabilities of common transitions to be calculated. Perhaps equally as important, trajectories that do not occur will be identified. By grounding the analysis in CRMS observations, ecological functions can influence the results, even if they are not explicitly represented in a mechanistic model. For example, Turner et al. (2004) showed that with healthy below ground biomass, marshes can recover, even if aboveground biomass is reduced. That could manifest in survey data as more consistent vegetation coverage.