Evaluation of Regional SLAMM Results to Establish a Consistent Framework of Data and Models

Prepared for the Gulf Coast Prairie Landscape Conservation Cooperative

June, 2015

Minor Revisions, March 2016

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Executive Summary

In this study, the Sea-Level Affecting Marshes Model (SLAMM) was applied to the entire Gulf Coast of the United States. Several million hectares of the study area had already been examined using SLAMM, but simulation results were not directly comparable due to differences in model domain definitions, accretion modeling approaches, and future sea-level scenarios. This project, funded by the Gulf Coast Prairie Landscape Conservation Cooperative, aimed to generate a seamless set of landcover projections for the Gulf of Mexico coast using SLAMM version 6.5 and conduct a focal species analysis using SLAMM results. This entailed running SLAMM in the gap areas between existing simulations as well as re-running previously simulated project areas to generate results for consistent sea-level rise (SLR) scenarios throughout the Gulf (0 .5, 1, 1.2, 1.5, and 2 m of eustatic SLR by 2100). In order to accurately represent changing marsh elevations due to the accumulation of organic and inorganic matter, mechanistic marsh accretion feedbacks were applied to define relationships between tide ranges, water levels, and accretion rates.

SLAMM model results were used to assess the impact of SLR on focal species through the generation of patch metrics for each species' habitat. The effects of SLR on seaside sparrow, mottled duck, and black skimmer were determined by developing wildlife-habitat-relationship models (WHRM). These models were developed for each species by identifying one or more SLAMM cover categories (patch classes) upon which the species is dependent. Metrics were produced for each WHRM at each time step and for each SLR scenario. SLAMM results indicated losses in the majority of land cover categories, with high marshes and estuarine beaches predicted to be the most vulnerable habitats.

For the seaside sparrow and non-Florida mottled duck focal-species analyses, the trends for key habitat metrics through time were generally negative. The magnitude of these trends increased as the magnitude of the SLR scenarios increased: total patch area decreased, mean patch size decreased, and perimeter-to-area ratios increased. Due to the potential for marsh expansion in Florida, the mottled-duck habitat-metric trends were not always negative. However, WHRM metrics presented here assume that all dry land that is not currently diked will be made available for wetland colonization given sufficient sea-level rise. Due to the likelihood of dry-land protections across the Gulf, this likely makes these results "best-case" scenarios for animal habitat.

Low-quality elevation data sensitivity analyses were run to test the extent of effects of non-LiDAR data on SLAMM predictions. The two primary observations from this analysis were that dry lands and swamps were predicted to be more resilient than when LiDAR data are used, and that coastal marshes were predicted to be less resilient when low-quality elevation data are used.

The SLAMM analyses conducted in this project are a large step forward as they have created seamless Gulf-of-Mexico projections that are consistent in model assumptions and accretion modeling. Results presented herein can stand alone or form the basis for additional study.

Different assumptions about dry-land protections and future development footprints can be examined; the assumption that all dry lands will be made available for wetland colonization likely results in overestimates of future marsh coverage. Alternatively, the current set of model results can be used to address the likelihood of SLR effects on existing development and transportation infrastructure. Other potential model refinements include linkages to salinity models to inform habitat switching, refinements to the erosion and suspended sediment assumptions, and assessments of overall model uncertainty using SLAMM's built-in uncertainty module. Linkages to other models are also possible, such as storm-surge models that utilize future land-cover predictions to more accurately predict the effects of specific large storms.

Background

From 2008 to 2013 the Sea Level Affecting Marshes Model (SLAMM, version 6.5) was applied to more than ten million hectares of the Gulf of Mexico coastline through funding from a variety of sources (e.g. Gulf of Mexico Alliance, National Wildlife Federation, US Fish & Wildlife Service, US Environmental Protection Agency, and the Nature Conservancy). However, simulation results were not directly comparable due to differences in model domain definitions, accretion modeling approaches, and future sea-level scenarios. In addition, several gap areas had not yet been modeled. In 2014, the Gulf Coast Prairie Landscape Conservation Cooperative funded this analysis of the US Gulf of Mexico Coast.in order to establish a consistent framework of data and models. The main objectives of this project were to generate a seamless set of landcover projections for the Gulf of Mexico coast using SLAMM and conduct a focal species analysis using SLAMM results. Additional project goals included deriving and applying mechanistic accretion feedbacks for coastal marshes, analysis of the effects of low-quality (non-LiDAR) elevation data on model results, and posting the SLAMM outputs to SLAMM-View (www.slammview.org) for public access to results.

The study area (Figure 1) includes coastline in the Gulf Coast Prairie, South Atlantic, Gulf Coast Plains and Ozarks, and Peninsular Florida Landscape Conservation Cooperatives. Results of the study will provide a gulf-wide dataset to help identify the most appropriate adaptation strategies for specific areas including land acquisition, marsh restoration, infrastructure development, and other land and facility management actions.

Tidal marshes are dynamic ecosystems that provide significant ecological and economic value. Given that tidal marshes are located at the interface between land and water, they can be among the most susceptible ecosystems to climate change, especially accelerated sea-level rise (SLR). Numerous factors can affect marsh fate including the elevation of marshes relative to the tides, marshes' frequency of inundation, the salinity of flooding waters, the biomass of marsh platforms, land subsidence, marsh substrate, and the settling of suspended sediment into the marshes. Because of these factors, a simple calculation of current marsh elevations as compared to future projections of sea level does not provide an adequate estimation of wetland vulnerability.

Changes in tidal marsh area and habitat type in response to sea-level rise were modeled using the Sea Level Affecting Marshes Model (SLAMM 6). SLAMM is widely recognized as an effective model to study and predict wetland response to long-term sea-level rise (Park et al. 1991) and has been applied in every coastal US state (Craft et al. 2009; Galbraith et al. 2002; Glick et al. 2007, 2011; National Wildlife Federation and Florida Wildlife Federation 2006; Park et al. 1993; Titus et al. 1991).

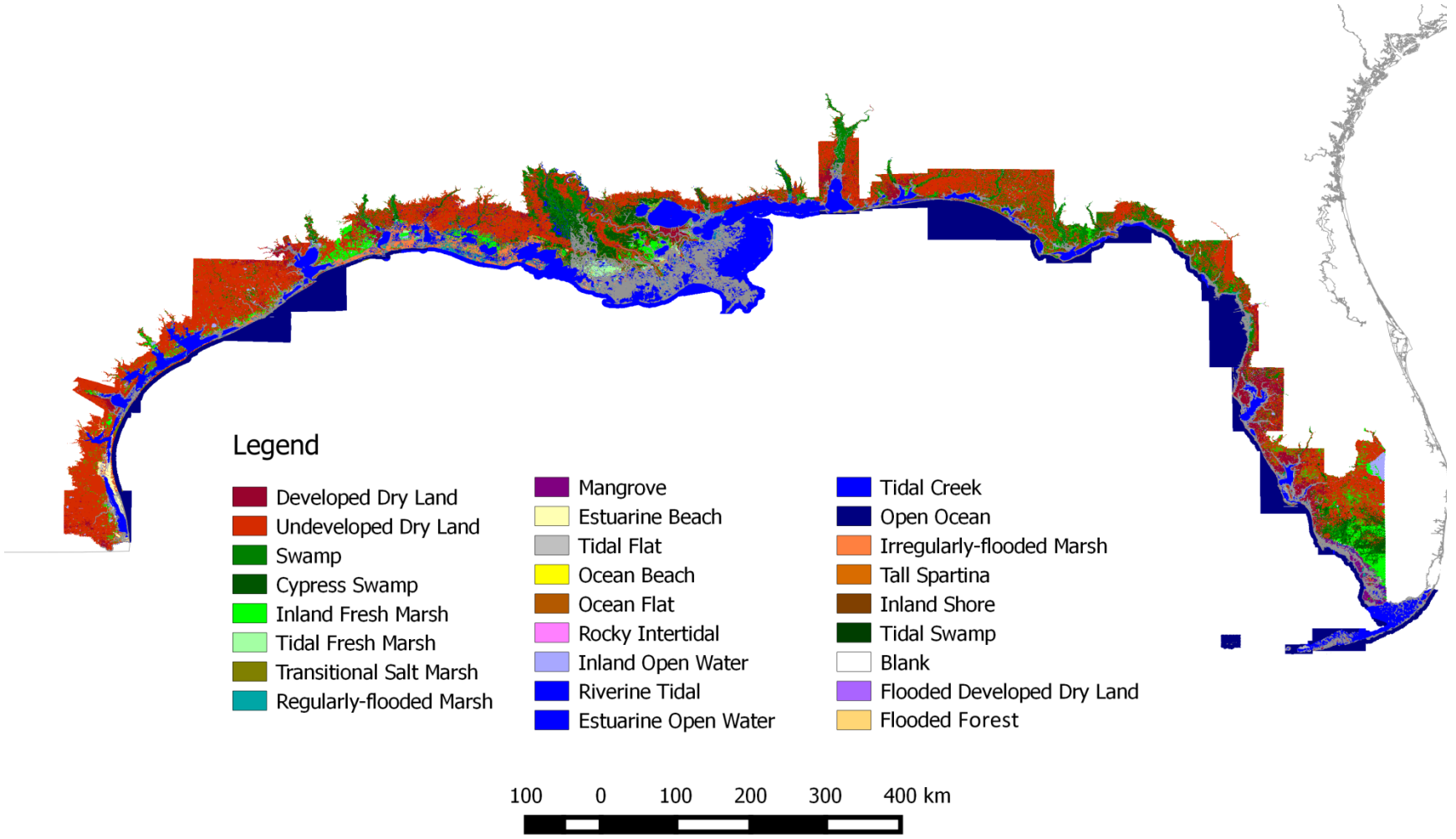

Figure 1. Project Study Area

Model Summary

SLAMM 6.5 predicts when marshes are likely to be vulnerable to SLR and where marshes may migrate upland in response to changes in water levels. The model attempts to simulate the dominant processes that affect shoreline modifications during long-term sea-level rise and uses a complex decision tree incorporating geometric and qualitative relationships to represent transfers among coastal classes. SLAMM is not a hydrodynamic model but long term shoreline and habitat changes are modeled as a succession of equilibrium states with sea level. Model outputs include map distributions of wetlands at different time steps in response to sea level rise changes as well as tabular and graphical data. The model's relative simplicity and modest data requirements allow its application at a reasonable cost. Mcleod and coworkers wrote in their review of sea-level rise impact models that "... the SLAMM model provides useful, high-resolution, insights regarding how sea-level rise may impact coastal habitats" (Mcleod et al. 2010).

SLAMM assumes that wetlands inhabit a range of vertical elevations that is a function of the tide range. Elevation loss relative sea level is computed for each cell in each time step: it is given by the sum of the historic SLR eustatic trend, the site specific or cell specific rate of change of elevation due to subsidence and isostatic adjustment, and the accelerated sea level rise depending on the scenario considered. Sea level rise is offset by sedimentation and accretion.

When the model is applied, each study site is divided into cells of equal area that are treated individually. The conversion from one land cover class to another is computed by considering the new cell elevation at a given time step with respect to the class in that cell and its inundation frequency. Assumed wetland elevation ranges may be estimated as a function of tidal ranges or may be entered by the user if site-specific data are available. The connectivity module determines salt water paths under normal tidal conditions. In general, when a cell's elevation falls below the minimum elevation of the current land cover class and is connected to open water, then the land cover is converted to a new class according to a decision tree.

In addition to the effects of inundation represented by the simple geometric model described above, the model can account for second order effects that may occur due to changes in the spatial relationships among the coastal elements. In particular, SLAMM can account for exposure to wave action and its *erosion* effects, *overwash* of barrier islands where beach migration and transport of sediments are estimated, *saturation* allowing coastal swamps and fresh marshes to migrate onto adjacent uplands as a response of the fresh water table to rising sea level close to the coast, and *marsh accretion*.

Marsh accretion is the process of wetland elevations changing due to the accumulation of organic and inorganic matter. Accretion is one of the most important processes affecting marsh capability to respond to SLR. The SLAMM model was one of the first landscape-scale models to incorporate the effects of vertical marsh accretion rates on predictions of marsh fates, including this process since

the mid-1980s (Park et al. 1989). Since 2010, SLAMM has incorporated dynamic relationships between marsh types, marsh elevations, tide ranges, and predicted accretion rates. The SLAMM application presented here utilizes a mechanistic marsh accretion model (the Marsh Equilibrium Model) to define relationships between tide ranges, water levels, and accretion rates (Morris 2013; Morris et al. 2002).

As with any numerical model, SLAMM has important limitations. As mentioned above, SLAMM is not a hydrodynamic model. Therefore, cell-by-cell water flows are not predicted as a function of topography, diffusion and advection. Furthermore, there are no feedback mechanisms between hydrodynamic and ecological systems. Solids in water are not accounted for via mass balance which may affect accretion (e.g. local bank sloughing does not affect nearby sedimentation rates). The erosion model is also very simple and does not capture more complicated processes such as "nick-point" channel development. A more detailed description of model processes, underlying assumptions, and equations can be found in the SLAMM 6.2 Technical Documentation (available at www.warrenpinnacle.com/prof/SLAMM).

Study Area

The United States coast of the Gulf of Mexico was modeled from Key West, FL to the Mexico border, as shown in Figure 2. This study area was comprised of 25 areas with existing SLAMM simulations and 20 new 'gap' study areas.

Figure 2. Study Area Boundaries

All SLAMM study areas are identified in Figures 3-5, in grey the existing SLAMM simulations while in color all the new project areas. A brief description of the geographic locations is provided in Table 1 and 2.

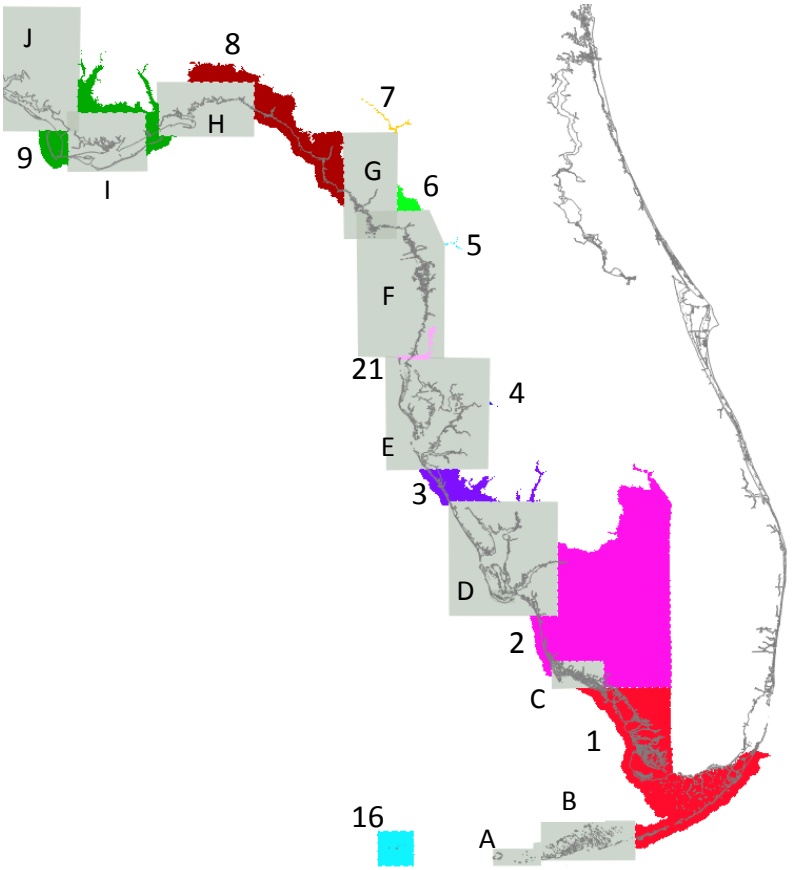

Figure 3. New Study Areas in Florida

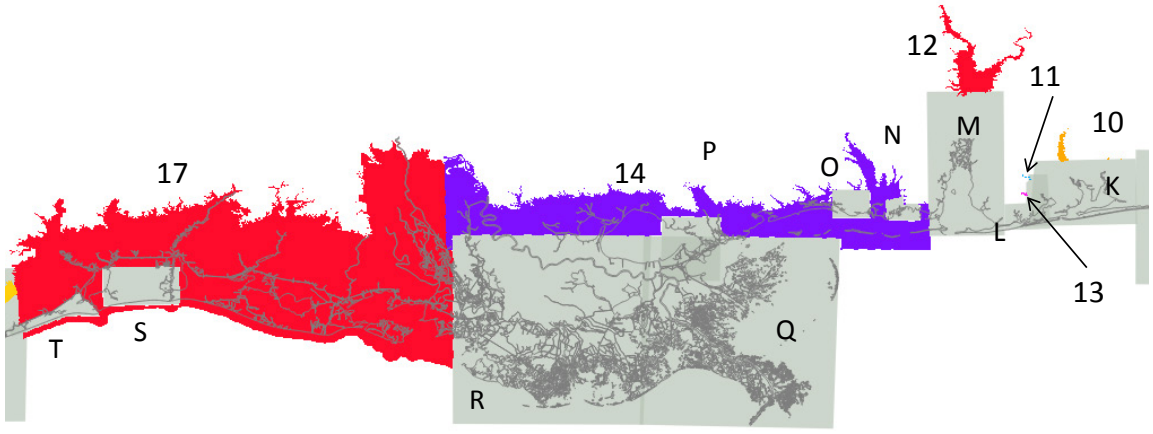

Figure 4. New Study Areas in Northern Florida, Alabama, Mississippi, and Louisiana

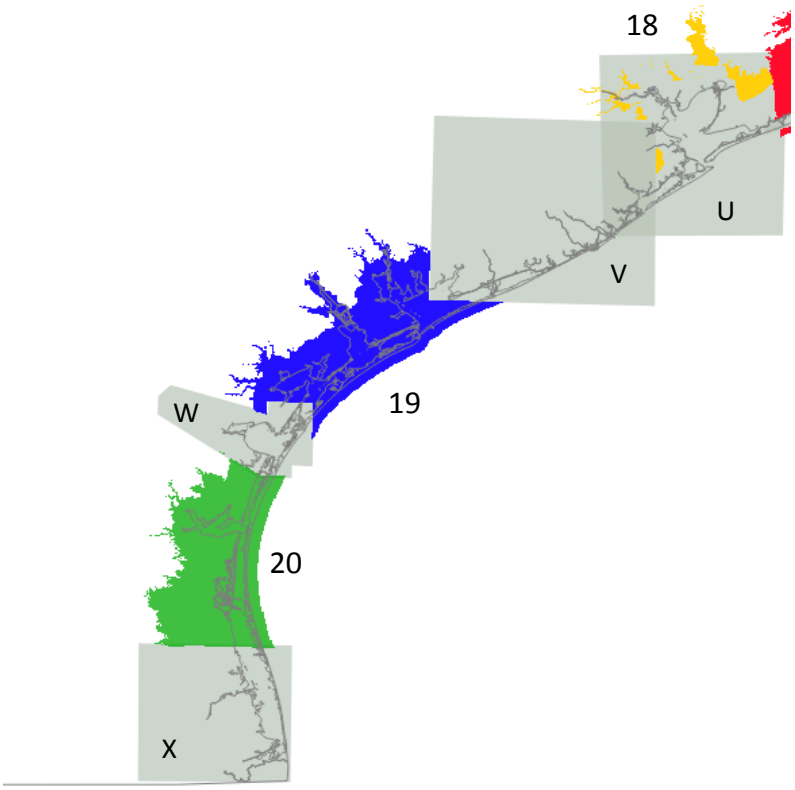

Figure 5. New Study Areas in Texas

Table 1. Existing SLAMM Study Areas.

Site Name	Area ID	State	Cell Size (m)	Original project funder
Key West	A	FL	10	USFWS
Great White Heron	B	FL	10	GOMA
10K Islands	C	FL	10	GOMA
Charlotte Harbor*	D	FL	30	USEPA
Ding Darling	D	FL	5	USFWS
Tampa Bay*	E	FL	15	USEPA
Southern Big Bend*	F	FL	30	USEPA
Lower Suwannee	G	FL	30	USFWS
St. Marks	H	FL	10	USFWS
Apalachicola	I	FL	30	USFWS
Saint Andrew Choctawhatchee	J	FL	10	GOMA
Pensacola Bay*	K	FL	15	USEPA
Perdido Bay*	L	FL	30	USEPA
Mobile Bay*	M	AL	30	USEPA
Grand Bay	N	MS	10	GOMA
Sandhill Crane	O	MS	30	GOMA
Bayou Sauvage/Big Branch Marsh	P	LA	10	USFWS
Southeast Louisiana	Q,R	LA	15	NWF/GOMA
Sabine	S	LA	30	USFWS
Jefferson Co.	T	TX	10	GOMA
Galveston Bay	U	TX	10	GOMA
San Bernard Big Boggy	V	TX	30	GOMA
Freeport*	V	TX	10	TNC
Corpus Christi Bay**	W	TX	15	USEPA
Lower Rio Grande Valley/Laguna Atascosa	X	TX	30	USFWS

* This analysis was done as part of the collaboration between The Nature Conservancy (TNC) and The Dow Chemical Company and was funded by the Dow Chemical Company Foundation.

**SLAMM analysis completed by The Nature Conservancy.

USFWS = United States Fish and Wildlife Service; GOMA = Gulf of Mexico Alliance; USEPA = United States Environmental Protection Agency; NWF= National Wildlife Federation; TNC = The Nature Conservancy

Existing SLAMM projects were run with the input layers used in the original model applications. Information regarding these inputs are available in the original model reports, available at the following URL: http://warrenpinnacle.com/prof/SLAMM/GCPLCC. Existing SLAMM projects were also run with marsh accretion feedbacks, however, to be consistent with new model applications (see the "Accretion" section below).

New model application inputs, summarized in Table 2, were processed as described in the following sections.

Table 2. New SLAMM Study Areas

Area ID	Description
16	Dry Tortugas, Florida
1	Monroe County, FL
2	Naples, FL
3	Sarasota, FL
4	Upstream Tampa, FL
21	South of Tampa, FL
5	Lake Rousseau, FL
6	Near Gainesville, FL
7	Upstream Lower Suwannee River, FL
8	Tallahassee to Steinhatchee, FL
9	St. Joe Bay and Carabelle, Florida
10	Upstream Pensacola, FL
11	Upstream Perdido, FL
13	Upstream Perdido, FL
12	Upstream Mobile River, AL
14	Mississippi and Eastern Louisiana
17	Louisiana Chenier Plain
18	Galveston Bay, Texas
19	Matagorda and San Antonio Bays, Texas
20	Baffin Bay, South Texas

Model Time steps

SLAMM simulations were run from the date of the initial wetland cover layer to 2100 with model-solution time steps of 2025, 2050, 2075, and 2100. Maps and numerical data were output for each of these time steps.

Sea Level Rise Scenarios

Five accelerated sea level rise scenarios were run: 0.5, 1, 1.2, 1.5, and 2 m of eustatic SLR by 2100 as requested by the project advisory group.

Gap Study Area Input Raster Preparation

Understanding the sources and processing of data used to create SLAMM's input rasters is key to understanding how the model's results were produced. This section describes these critical data

sources and the steps used to process the data for analysis of the gap study areas, which were run at a cell size of 15 meters. Data types reviewed here include elevation, wetland land cover, impervious land cover, dikes and impoundments.

Elevation Data

High vertical-resolution elevation data may be the most important SLAMM data requirement. For example, elevation data are used to define the area of saltwater influence that, when combined with tidal data, determine extent and frequency of saltwater inundation.

For the purposes of this project, the coastal study areas are limited to those regions along the Gulf Coast shoreline at elevations less than 10 m above mean tide level (MTL). In order to derive the elevation layers within the study areas, several LiDAR sources were combined. The data used for each new study area are shown in Appendix A. In addition, specific elevation-data processing steps may be found in the metadata associated with each new model input file. The elevation uncertainty of the elevation layers can be estimated as the Root Mean Squared Error (RMSE) provided in the metadata of each LiDAR source data (see Appendix A).

Slope Layer

Slope rasters were derived from the hydro-enforced DEMs described above using ESRI's spatial analyst tool. The "slope tool" was used to create slope with output values in degrees. Accurate slopes of the marsh surface are an important SLAMM consideration as they are used in the calculation of the fraction of a wetland that is lost (transferred to the next class).

Elevation correction

VDATUM versions 3.2 and 3.3 (NOS 2013) were used to convert elevation data from the NAVD88 vertical datum to Mean Tide Level (MTL), the vertical datum used in SLAMM. This is required as coastal wetlands inhabit elevation ranges in terms of tide ranges as opposed to geodetic datums (McKee and Patrick 1988). VDATUM does not provide vertical corrections over dry land. Therefore dry-land elevations were corrected using the VDATUM correction from the nearest open water. The elevation uncertainty associated with the VDATUM transformation in the study area ranges from a minimum of 8 cm in the north part of Florida to up 17 cm in areas of Mississippi and Alabama.

Wetland Layers and translation to SLAMM wetland categories

Wetland rasters were created from a National Wetlands Inventory (NWI), the Florida Natural Areas Inventory (FNAI), and pseudo-NWI wetland layers developed by Brady Couvillion of the USGS (Couvillion et al. 2011). Maps of the data used for each study area are presented in Appendix B, except for site 21, in which FNAI data with a date of 2010 was used. NWI land coverage codes were translated to SLAMM codes using Table 4 of the SLAMM Technical Documentation as produced

with assistance from Bill Wilen of the National Wetlands Inventory (Clough et al. 2012). One important note is that there is one change in wetland categories between SLAMM 6.2 and SLAMM 6.5. The "backshore" category (26) has been replaced with "Flooded Forest" category[1]. The total acreage for each SLAMM category is presented in Table 3.

Since dry land (developed or undeveloped) is not classified by NWI, SLAMM classified cells as dry land if they were initially blank but had a non-negative LiDAR elevation assigned. The resulting raster data were checked visually to make sure the projection information was correct, had a consistent number of rows and columns as the other rasters in the project area, and to ensure that the data looked complete based on the source data.

The initial accuracy of the land cover data derived from NWI sources: smallest wetlands are approximately 0.2 ha (0.5 acres) in size with 98% feature accuracy wetland vs. upland, 85% classification accuracy, 1 m spatial resolution of source imagery and ±5 m horizontal accuracy (http://www.fws.gov/wetlands/Documents/FGDC-Wetlands-Mapping-Standard.pdf). The FNAI inventory has an horizontal accuracy of 2.3 m (http://www.fnai.org/shapefiles/Cooperative_Land_Cover_v2_3_Metadata.html)

Dikes and Impoundments

Dike rasters were created using information from the National Levee Database. Dike-location data were also gathered from the National Wetland Inventory data in which impounded wetlands have an "h" designation. In Louisiana, some diked areas were added in consultation with local experts (see "Area 17" discussion below).

Percent Impervious

Percent Impervious rasters were extracted from the 2006 National Land Cover Dataset (Fry et al. 2011). The cell size was resampled from the original 30 m resolution to 15 m resolution in order to match the cell resolution of the other rasters in the project.

[1] SLAMM 6.5 assumes that permanently flooded cypress swamps become "flooded forest" rather than immediately converting to open water. See Glick et al. (2013) for more information.

Table 3. Land cover categories for entire Gulf of Mexico

Land cover type	Area (acres)	Percentage (%)
Undeveloped Dry Land	15,073,544	32
Estuarine Open Water	9,985,969	21
Open Ocean	7,297,819	15
Swamp	3,885,512	8
Developed Dry Land	2,343,639	5
Inland-Fresh Marsh	2,242,242	5
Cypress Swamp	1,795,686	4
Irreg.-Flooded Marsh	1,580,854	3
Regularly-Flooded Marsh	828,533	2
Inland Open Water	784,694	2
Mangrove	501,051	1
Tidal-Fresh Marsh	333,278	1
Tidal Flat	272,221	1
Estuarine Beach	239,099	1
Tidal Swamp	85,717	< 1
Riverine Tidal	41,487	< 1
Inland Shore	31,420	< 1
Ocean Beach	18,585	< 1
Trans. Salt Marsh	8,106	< 1
Ocean Flat	1,519	< 1
Tidal Creek	1,040	< 1
Rocky Intertidal	484	< 1
Total (incl. water)	**47,352,499**	**100**

Gap Study Areas Parameterization

The full set of parameters applied to each input subsite within each study area is presented in Appendix C. A summary of parameter derivation may be found below.

Erosion Rates

In SLAMM average erosion rates are entered for marshes, swamps and beaches. Horizontal erosion in marshes is only assumed when the wetland is exposed to open water and where considerable wave effects are possible (a 9km fetch). SLAMM models erosion as additive to inundation. In general, SLAMM has been shown to be less sensitive to the marsh erosion parameters than accretion

parameters (Chu-Agor et al. 2010). Erosion parameters were primarily applied from data in the USGS "Coastal Vulnerability to Sea-Level Rise U.S. Gulf Coast" data layer. Using the USGS layer, average erosion rates were derived for each input subsite within a study and when warranted, additional subsites were added to reflect areas of high erosion. In inland study areas, erosion rates applied to adjacent areas were assigned.

Historic sea level rise rates

The most appropriate Historic SLR data from NOAA COOPS was applied to each study area. Figure 6 shows that spatial distribution of average historic SLR trends observed across the Gulf. When the study area fell between two gauges, an average of the two was applied.

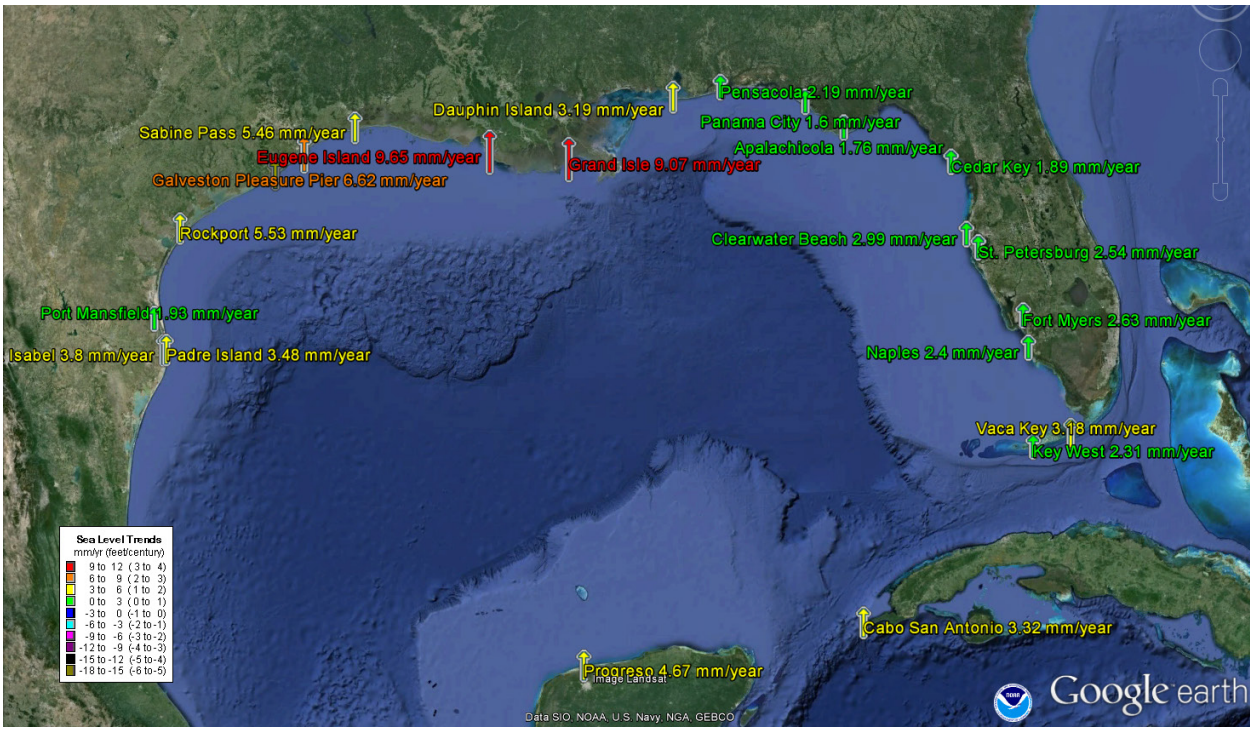

Figure 6. Average historical SLR trends data in the Gulf from NOAA Gauge Station

Tide Ranges

A spatial database of great diurnal tide ranges (GT) from NOAA's tidal datums and 2012 Tide Tables (High and Low water predictions, East Coast of North and South America) was created for the study area. Tide-table data were available as mean higher high water (MHHW) in feet (relative to mean-tide level or MTL), which was multiplied by two to calculate the GT and then converted to meters. These data were used to delineate input subsites with the study areas.

Salt Elevation

Within SLAMM the "salt elevation" (SE) defines the line between saline wetlands and dry land. We have estimated the approximate salt elevation as the height inundated once every 30 days by studying the relationship between land coverage, elevation distributions, and inundation data in several areas around the US.

Unfortunately, time series of inundation data are not recorded at all gauge stations. Therefore, in order to initially determine salt elevations across the study area, several relationships were used to estimate them from tide ranges.

For Florida, frequency-of-inundation analyses were carried out for all of the NOAA verified water level stations. The last five years of data were collected for each site (when available) and the 30-day inundation height (in meters above MTL) was determined using an Excel spreadsheet. Several data points are available in this study area, and were plotted as function of the great diurnal tide range (GT). Regression analysis showed a clear linear relationship between the two variables (R^2 = 0.94, Figure 7). This relationship was used in all new SLAMM simulations in Florida to derive site specific salt elevations.

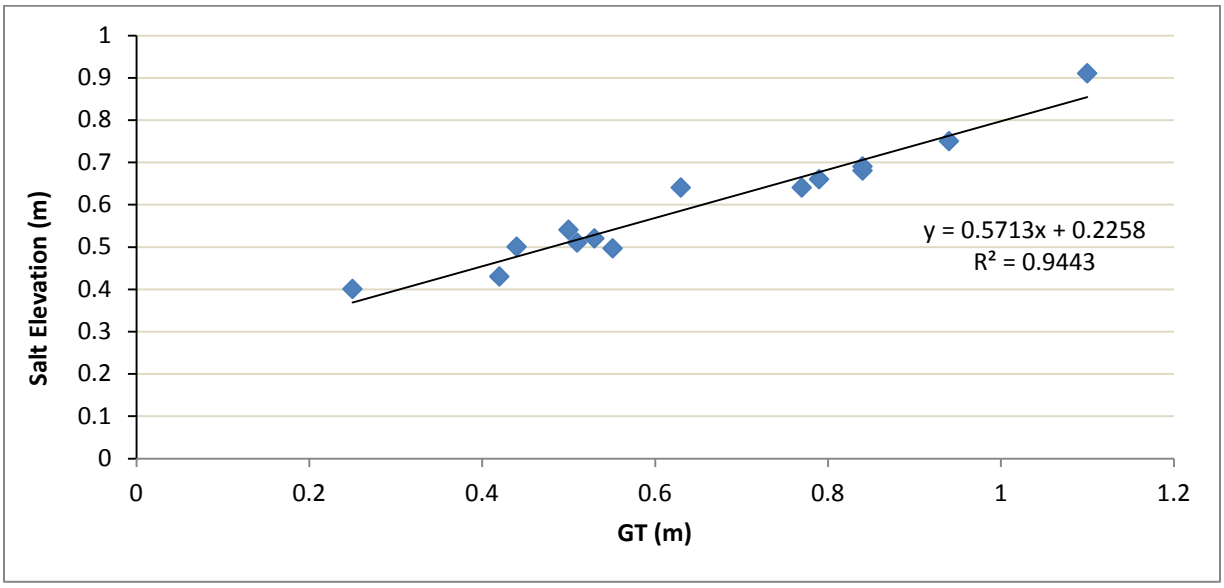

Figure 7. 30-day inundation height vs. great diurnal tide range for Florida

For all other Gulf states, clear relationships could not be derived because available 30-day inundation data were either insufficient or very weakly correlated with GT. Therefore, for study areas with no long-term inundation information, GT and SE were taken from adjacent areas previously modeled and studied. The salt elevation SE was set to $SE=r*GT$ when GT was available and with the coefficient $r=SE/GT$ used in nearby areas.

As discussed in more detail below, the consistency of these parametrizations was then verified, and modified where necessary, by examining the consistency between land cover, elevation data and modeled tidal/inundation heights.

Accretion Rates

SLAMM accepts accretion-rate data for each wetland type modeled. A full literature search was conducted to collect relevant accretion rates. In addition, unpublished data were solicited from the experts in Gulf-bordering states listed at http://www.pwrc.usgs.gov/set/SETusers.html.

Regularly-flooded marsh. This SLAMM application attempts to account for what are potentially critical feedbacks between tidal-marsh accretion rates and SLR (Kirwan et al. 2010). In tidal marshes, increasing inundation can lead to additional deposition of inorganic sediment that can help tidal wetlands keep pace with rising sea levels (Reed 1995). In addition, salt marshes will often grow more rapidly at lower elevations allowing for further inorganic sediment trapping (Morris et al. 2002). In this study, new feedbacks were developed only for regularly-flooded marsh (RFM). Qualitatively, RFM includes low to mid marshes while irregularly-flooded marsh (IFM) includes high marshes. We chose to develop feedback relationships for RFM only due to data availability and also because the impact of inorganic sedimentation, which drives these feedbacks, is significantly less important above the mean higher high water (MHHW) level. Marsh accretion feedbacks were applied to all study areas. If the existing study area was originally run with accretion feedbacks, these were left intact. However, if the original model application did not include accretion feedbacks, they were added as a part of this project.

The best types of data for an accretion-feedback analysis are accretion data points with corresponding elevations relative to tide levels. To meet this requirement, a database of 166 accretion measurements throughout the Gulf of Mexico was derived. One significant problem with this database was the assignment of locations to the various accretion studies. Very few studies report latitude and longitude along with their accretion data and in some cases no maps were included at all. When maps were available, approximate latitude and longitudes were assigned to each accretion study (Figure 8).

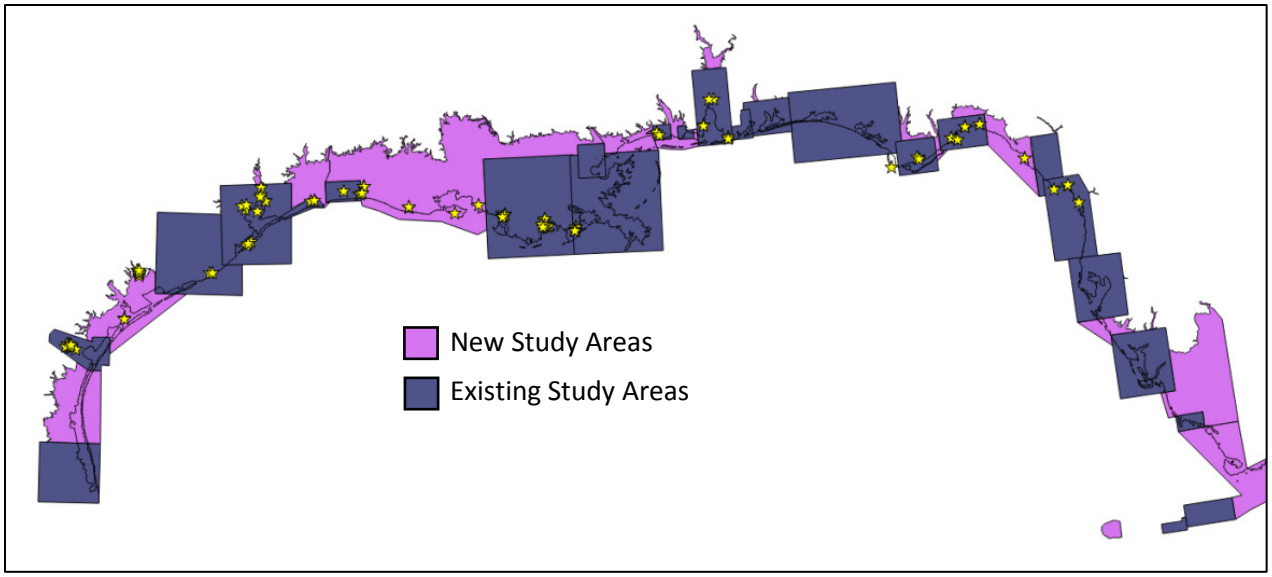

Figure 8. Accretion Locations (yellow stars) in Study Area which could be assigned locations

Elevation data were assigned to accretion data points based on best-available LiDAR data and converted to "mean tide level (MTL) basis" using the NOAA VDATUM product. There is significant uncertainty in assigning elevations to these observed accretion rate study sites, especially when sediment core data were used to derive accretion rates[2]. Whenever possible "elevation change" data were used preferentially to "accretion rate" data to properly account for shallow subsidence effects within the data set. Data from the farthest southeast corner of Louisiana were not included in this dataset as a calibrated accretion feedback model was already developed for this location. Furthermore, data from the Balize ("Bird's Foot") Delta were not assumed to be relevant to other locations in the Gulf of Mexico. When sources did not define the type of marsh being studied, data for RFM vs. IFM were discerned using the NWI wetland layer.

Accretion rates and their relationship with elevation were derived by calibrating the Marsh Equilibrium Model (MEM) (Morris 2013; Morris et al. 2002, 2012) to site-specific data. The MEM model was chosen for several reasons. MEM describes feedbacks in marsh accretion rates, it is backed up by existing data, and it accounts for physical and biological processes that cause these feedbacks. Using a mechanistic model such as MEM helps explain the causes of feedbacks between accretion rates and elevation and therefore can tell a more compelling story. Another important reason to use MEM is that results from this model can be extrapolated to (a) other geographic areas

[2] With core data, assuming that the marsh has maintained a constant equilibrium elevation relative to sea levels, accretion rate best estimate is the average value over the historical period of the core (in the order of hundred years) while the marsh platform elevation (relative to sea level) best estimate is the current elevation. These accretion rate and marsh platform elevation uncertainties should be accounted for in an accretion rate uncertainty analysis.

where there is no accretion data available but when other physical/biological parameters are available (e.g. suspended sediment concentrations or tidal regimes); and (b) to vertical positions in the tidal frame where data do not exist, (e.g. accretion rates of marshes that are drowning and not in equilibrium with sea level).

The key physical input parameters of the MEM model are tide ranges, suspended sediment concentrations, initial sea-level and marsh platform elevations, and the elevation defining the domain of marsh existence within the tidal frame. Biological input parameters are the peak concentration density of standing biomass at the optimum elevation, organic matter decay rates, and parameters determining the contribution to accretion from belowground biomass. Some parameters values can be estimated from available measurements, e.g. tide ranges, initial marsh platform, suspended sediments, etc. However, several others are often unknown (e.g. partition between organic and inorganic components to accretion, peak biomass, settling velocities, trapping coefficients, organic matter decay rate, below ground turnover rate and others). One approach is to determine these unknown parameters by fitting MEM output to observed accretion data.

One important parameter for the MEM model is the average Total Suspended Solids (TSS) concentration. The EPA STORET database was queried to receive these data and a resulting dataset of 117,611 points was derived and spatially characterized throughout the study area.

The vast majority of accretion data with relevant elevations are located in Louisiana and a MEM3 model was derived for this location. A graph of this relationship and the data used to derive it is shown in Figure 9. To achieve this Louisiana-specific MEM3 model, the biomass range was extended to well above Mean Higher High water which is likely reasonable in this microtidal region. The organic matter contribution to accretion also was boosted to support relatively high accretion rates that data show occur at 0.5 m above MTL and higher. The MEM curve in Figure 9 suggests that accretion rates will vary between 7.0 and 16 mm/yr. depending on location in the tidal frame.

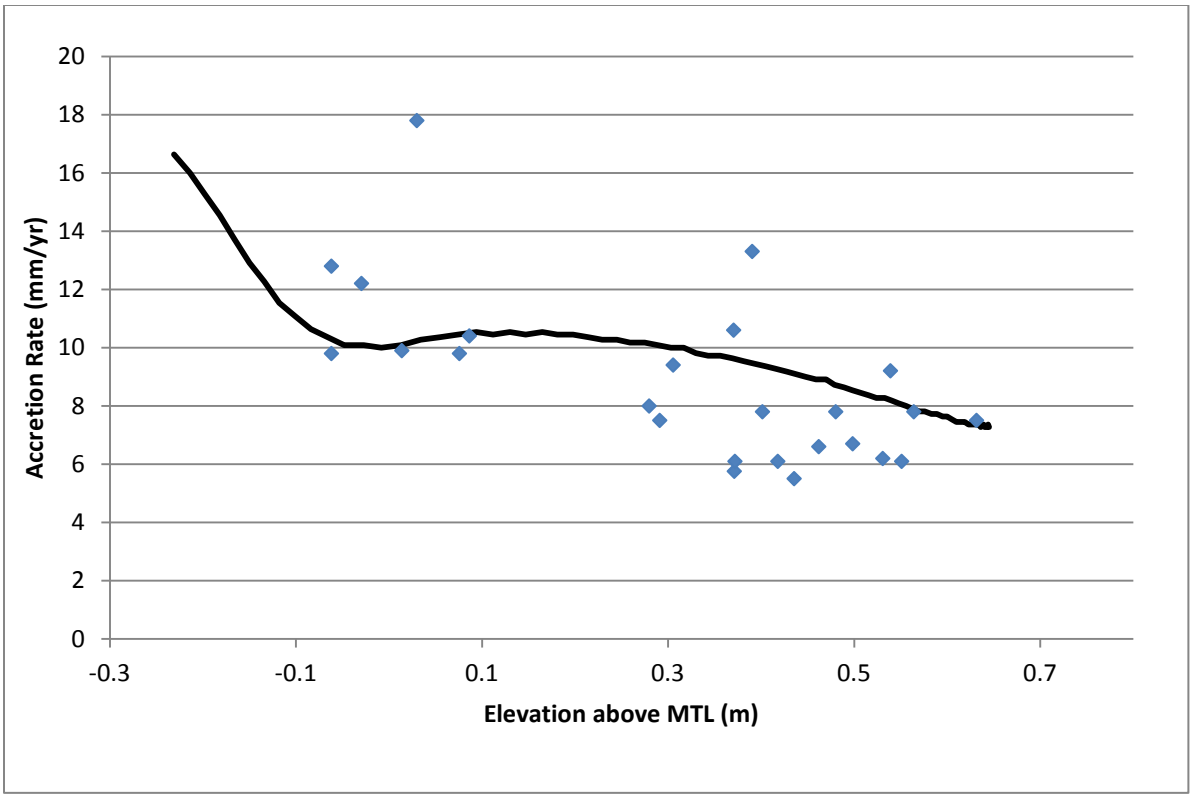

Figure 9. Derived MEM3 model with Louisiana-specific regularly-flooded marsh accretion data

Results from the derived model have a wider range than the calibrated accretion feedback used in SE Louisiana (Glick et al. 2013) in which accretion rates varied between 6 and 11 mm/yr. This MEM model was applied to all regularly-flooded marsh throughout new study areas in Louisiana

For other locations in the study area, accretion data with associated locations and elevations were too sparse to constrain a MEM3 model application. For example, in Florida, for regularly-flooded marsh, only five data points were found, all quite high in the tidal frame and with relatively low accretion rates. This dataset, therefore, did not provide any insight into how accretion rates may increase under accelerated SLR (when the marshes move lower in the tidal frame). One approach used in other studies has been to derive a MEM3 model in a data rich area and then move this calibration into another location, varying only the TSS and tide range. However, here we chose not to apply the calibrated MEM3 model to regions outside of Louisiana; Louisiana has often been considered to be fairly unique in terms of marsh characteristics based on differences in organic matter content, suspended sediment supply, and the presence of floating marshes. For this reason it does not seem appropriate to derive a model with Louisiana-specific data and then apply this model throughout the Gulf of Mexico. Based on these considerations, a "generic" accretion-to-elevation curve has been derived with the MEM3 model, see Figure 10.

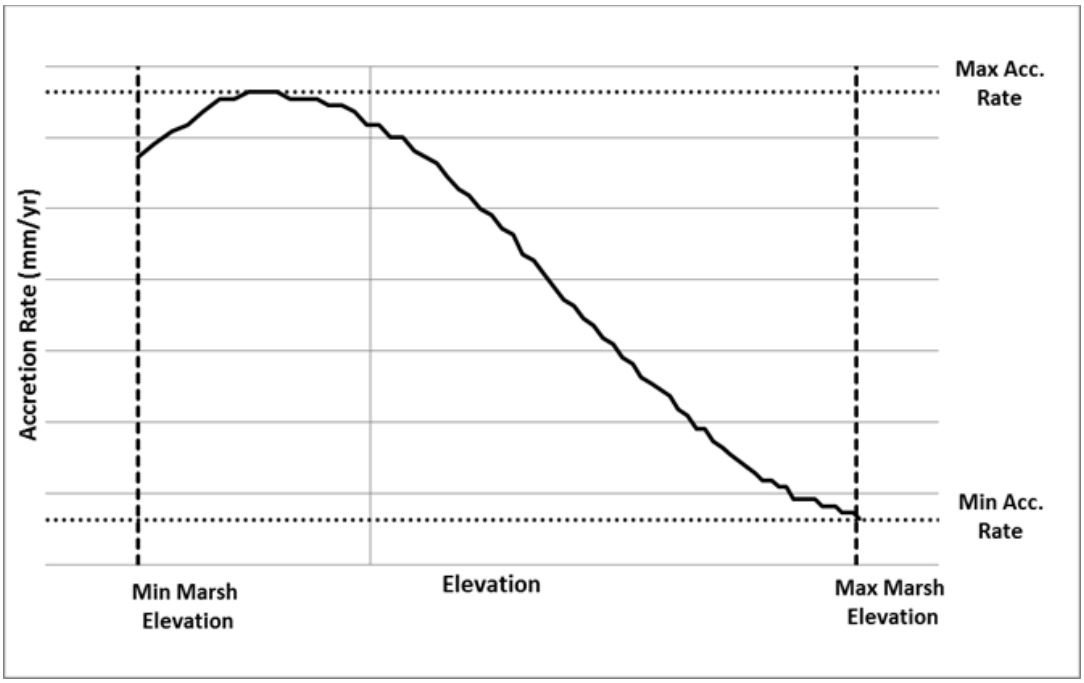

Figure 10. Generic MEM3 curve

Minimum and maximum accretion rates were then modified on the basis of local conditions to account for measured accretion data, spatial variability in TSS data, and professional judgments. The following accretion regions have been defined based on TSS:

- Southern Florida (South of Big Bend study area) - Mean TSS of 8 mg/L
- Northern Florida (Big Bend of Florida north) - Mean TSS of 10 mg/L
- Alabama, excluding Mobile Bay - Mean TSS of 11 mg/L
- Mobile Bay - Higher TSS (16 mg/L) and site-specific accretion data
- Mississippi - Mean TSS of 34 mg/L
- Louisiana - Calibrated accretion feedback in existing study areas and MEM model in non-modeled locations (Chenier Plain), TSS set to 26 mg/L
- Northern Texas (to Freeport) - Calibrated accretion feedbacks in existing study areas and MEM3 for Jefferson County, mean TSS of 30 mg/L
- Freeport, Texas South to Mexican border - mean TSS of 36 mg/L

TSS data presented above were derived first by querying individual data points from EPA STORET and then assigning these points to each defined study area. In order to remove data artifacts and the effects of unique events that may not reflect the average TSS conditions affecting marshes, the top

and bottom 2.5% of TSS data were discarded. Study areas were combined and averaged to obtain a spatially weighted average TSS for each region. These data have been qualitatively considered, as part of the weight of evidence approach in determining reasonable accretion-feedback curves for each region. Accretion models for each region are described below:

Southern Florida. Analysis of the accretion database created for this project indicates a minimum accretion rate of 0.8 mm/year and maximum measured accretion rates of 4.9 mm/yr. This is consistent with regularly-flooded marsh accretion rates applied in Florida given previous SLAMM applications. It is also consistent with observations of TSS that are lowest among the accretion regions defined above. As increased SLR has not started to drown regularly-flooded marshes in this portion of the study area yet (at least in areas that we have accretion data), the upper bound accretion rate is uncertain. However, based on TSS availability it is safe to presume that it should be less than the 16 mm/yr. measured in Louisiana. Constraining the maximum accretion rate to the maximum accretion rate measured in the region seems like a reasonable conjecture. In the future, the uncertainty in the model based on this conjecture can be measured with a SLAMM uncertainty analysis, as done in recent SLAMM applications to New York and Connecticut (Warren Pinnacle Consulting Inc. 2014, 2015). In addition, as will be the case for most study areas, additional observed data regarding marsh accretion rates at elevation (marsh organ studies), marsh biomass densities, and inorganic sediment settling rates can improve the accuracy of future SLR simulations. To summarize, for S. Florida salt marshes were modeled with accretion feedbacks and minimum accretion rates of 0.8 mm/yr. and maximums of 4.9 mm/yr.

Northern Florida. TSS concentrations increase relative to S. Florida as do maximum accretion rates observed. For this reason a similar relationship between accretion rates and elevations is assumed, but with the maximum accretion rate being set to 7.6 mm/yr. (maximum observed in the study area, measured by Leonard et al 1995) and minimum accretion rate set to 0.8 mm/yr. (Cahoon et al. 1995, Hendrickson 1997, net elevation change). Florida is the only portion of the study area with a useful database of elevation change data, measured by SET tables maintained by the Florida Geologic Survey. These data were provided to WPC in 2011 by Joe Donoghue in support of the Saint Andrew's Choctawhatchee modeling effort funded by TNC. These rates cover the same range as previously applied to other SLAMM applications in this region (0.8 mm/yr. in Apalachicola to 7.2 mm/yr. in Southern Big Bend).

Alabama excluding Mobile Bay. A maximum accretion rate of 6.8 mm/yr. was applied based on somewhat lower TSS than Northern Florida and the accretion data of Callaway (1997). In previous SLAMM applications in Mississippi, this value was applied without feedbacks.

Mobile Bay, Alabama. The minimum accretion rate is set to 0.9 mm/yr. and the maximum accretion rate to 11 mm/yr. (Smith et al. 2013) based on the higher TSS observed in this region and observed accretion data cited above. The Smith reference also informed the previous application of SLAMM to Mobile Bay.

Mississippi. With much higher TSS measured than Alabama, an intermediate curve between Alabama and Louisiana was used, with a minimum rate of 3 mm/yr. and a maximum of 11 mm/yr.

Louisiana. For the region modeled by Glick and coworkers (2013), the calibrated accretion feedbacks were maintained as previously applied. For the Chenier Plain of Louisiana, the new MEM3 model derived as part of this project was applied with accretion rates ranging from 7-16 mm/yr. based on measurements by Delaune et al. (1989)and Nyman and coworkers (1993). This range is slightly wider than the 6 to 11 mm/yr. applied in Southeast Louisiana.

Northern Texas down to Freeport. Calibrated accretion feedbacks in existing study areas were applied, ranging from 3.8-10 mm/yr.

Southern Texas (below Freeport TX). The generic MEM curve was adapted to the area based on a minimum accretion of 4.6 mm/yr. (White et al. 2002) and a maximum of 8.4 mm/yr (Callaway et al. 1997).

Figure 11 shows the geographic distribution for each MEM model applied while Table 4 summarizes accretion rate ranges applied using the general accretion curve shown in Figure 10.

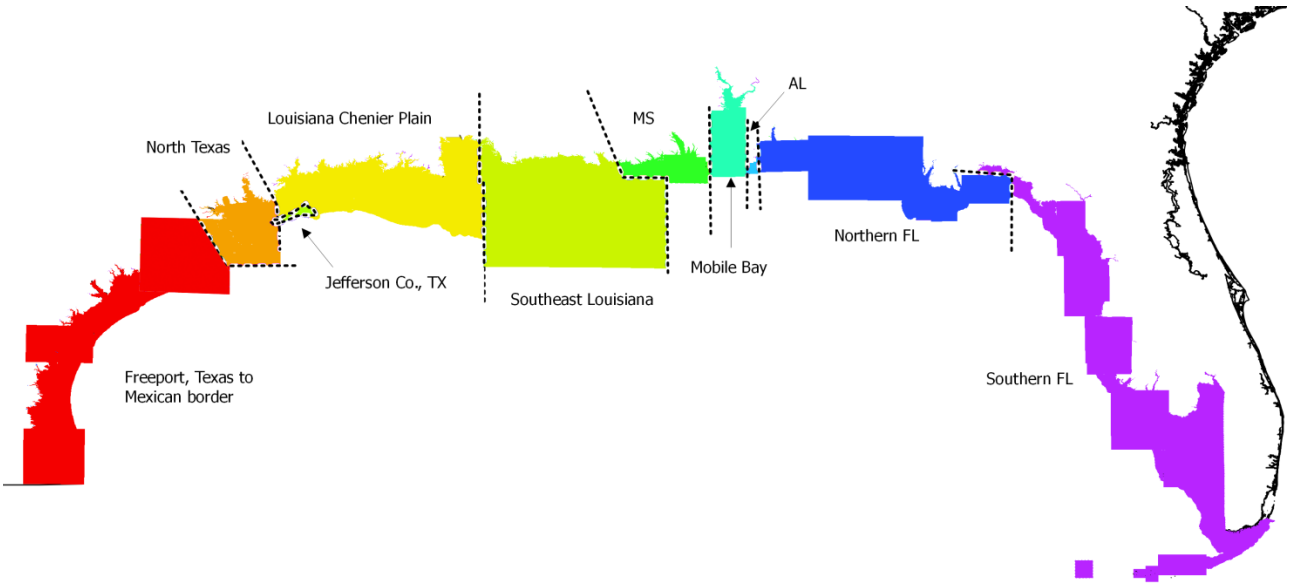

Figure 11. Geographic areas covered by each accretion rate model.

Table 4. Accretion Regions

Location	Minimum Accretion rate (mm/yr.)	Maximum Accretion rate (mm/yr.)	New Study Areas where applied	Notes
Southern FL	0.8	4.9	1-4,16,21	Lowest TSS region and measured accretion.
Northern FL	0.8	7.6	5-10	Higher TSS and measured accretion.
AL	1	6.8	11,13,14	Slightly lower TSS than N. FL. and observed.
Mobile Bay	3	11	12	Higher TSS and measured accretion
MS	3	11	14	Similar to non-Bird's Foot LA
Southeast LA	6	11	---	Calibrated, varies spatially
LA Chenier Plain	7	16	17	MEM3 calibration (Figure 9)
Jefferson Co. TX	6	12	---	Intermediate between LA and Galveston
North TX/Galveston Bay	3.8	10	18	Calibrated previously
Freeport to MX	4.6	8.4	19,20	Lower TSS, and based on Callaway (1997)

Irregularly-flooded marshes. For this marsh type, a mechanistic model may provide fewer insights as the effect of inorganic sedimentation, so important to MEM3 predictions, is relatively unimportant above the mean higher high water (MHHW) level. It may be assumed that the feedback between irregularly-flooded marshes and their elevations is less important because the tidal flooding which drives this process is much less regular. For this reason, and also based on data limitations, the accretion of irregularly-flooded marshes was not modeled using MEM3. A constant accretion rate was instead applied as done in previous model applications.

Mangrove. Elevation change data collected in Florida suggests an accretion rate of 2 mm/yr. (Cahoon and Lynch 1997; Donoghue 2011; McKee 2011) This is lower than the rates of 7 mm/yr. and 3.3 mm/yr. previously applied in the Gulf; however, it is more appropriate since SLAMM tracks elevation change.

Regarding mangrove distribution, mangroves in Florida up to Tampa Bay were modeled based on previous SLAMM applications and the findings of Osland and coworkers (2013). When the SLAMM model finds adequate mangrove coverage in a site, it designates that site as "tropical" and all wetland to wetland or dry land to wetland conversions become mangroves. Therefore, mangroves tend to dominate these sites under conditions of SLR. In Florida, north of the Tampa Bay study area, previous SLAMM applications were not designated as "tropical." It is certainly possible that mangroves will continue to migrate further north in the next 85 years and this is not represented by these simulations. The northern boundary of mangrove habitat tends to be driven by the "hard freeze" line and air temperature is not a driving variable within SLAMM applications. Furthermore, the boundary of mangrove habitat is patchy and uncertain and can be variable from year to year. No mangrove expansions in Texas, Louisiana, MS, or AL are predicted by this

modeling exercise, either, consistent with previous applications of SLAMM in those states, however, the model accounts for the effects of SLR on the substantial existing acreage of mangroves in these areas.

Tidal and Inland Fresh Marsh. A gap analysis was used to apply accretion rates to unmodeled areas: The values applied to adjacent areas were extrapolated based on site characteristics and professional judgment.

Swamp and Tidal Swamp. For all previous Gulf SLAMM analyses, excluding the Atchafalaya Basin, swamp and tidal swamp accretion rates were set to 0.3 and 1.1 mm/yr., respectively. Based on information received from Brady Couvillion (personal communication, 2011) the swamp and tidal swamp accretion rates in the Atchafalaya river basin were increased to 8.2 mm/yr since these areas directly receive increased sediment loads from the river. Due to a lack of data to determine more appropriate site-specific rates, and to maintain consistency with previous model applications, these rates were applied throughout the entire Gulf.

Model Calibration

Once a SLAMM project is set up with all raster layers and initial parameterization, SLAMM is run at "time zero." At this time step only the tides are applied to the study area while no SLR, accretion or erosion is considered. These "time zero projections" allow model users to assess the consistency between elevation data, the current land coverage, modeled tidal ranges and hydraulic connectivity. Generally, due to local factors, DEM and NWI uncertainty, and simplifications within the SLAMM conceptual model, some cells will initially be below their lowest allowable elevation category and are immediately converted by the model to a different land cover category. For example, an area categorized in the wetland layer as fresh-water swamp but which is subject to regular saline tides, according to its elevation and tidal information, is converted by SLAMM to a tidal marsh at time zero. Or initially areas identified as marsh are not regularly inundated because either the tidal ranges are not correct or there are impediments in the elevation layer that require to be removed to further hydro-enforce the DEM's.

Where significant land cover changes occur, additional investigation may be required to confirm that the current land cover of a particular area is correctly represented. If not, it is sometimes necessary to better calibrate data layers and model inputs to the actual observed conditions. The general rule of thumb is that if 95% of a major land cover category (one covering ≥ 5% of the study area) is not converted at time zero, then the model set-up is considered acceptable. However, land coverage conversion maps at time zero are always reviewed to identify initial problems, if any, and necessary adjustments to correct them.

In some cases the initial land cover re-categorization by SLAMM better describes the current coverage of a given area. For example, the high horizontal resolution of the elevation data can allow

for a more refined wetland map than the original NWI-generated shapefiles used in this project. Therefore, if time zero maps include changes that are supported by satellite imagery or local knowledge of wetland types, then these types of land cover conversion are then accepted without further investigation.

Elevation Pre-processor

SLAMM can model areas with lower-quality elevation data by applying the "elevation pre-processor" module. When required, SLAMM estimates coastal-wetland elevation ranges as a function of tide ranges and known relationships between wetland types and tide ranges. However, this method is subject to error and uncertainty. As a rough estimate, areas where the pre-processor was applied have an elevation variability that can be conservatively estimated as the elevation change between two contour lines (which is often around 20 feet).

Fortunately the vast majority of the GCPLCC study area is covered with high-resolution LiDAR data. In terms of new study areas, the exceptions were some inland areas in South Florida (small inland portions of study areas 1, 2, & 3), Area 16 (the Dry Tortugas, Florida), and far inland north of Mobile Bay (portions of study area 12). With regards to existing model results, the sole exception was the Key West National Wildlife Refuge study area.

The elevation pre-processor works by processing wetland elevations unidirectionally away from open water. The front edge of each wetland type is assigned a minimum elevation, specific to the wetland category that it falls into. The back edge of each wetland type is given the maximum elevation for that category. The slope and elevations of intermediate cells are interpolated between these two points. The model assumes that wetland elevations are uniformly distributed over their feasible vertical elevation ranges or "tidal frames"—an assumption that may not reflect reality. If wetlands elevations are actually clustered high in the tidal frame they would be less vulnerable to SLR and if elevations are towards the bottom, they would be more vulnerable. LiDAR data for any site assists in reducing model uncertainty by characterizing where these marshes exist in their expected range.

As a test of how the elevation pre-processor may change model predictions, we performed an analysis of low-quality elevation data effects in this project. We chose two model domains with high-quality data, converted these data to "contour equivalent" elevations, and then ran the model with the elevation pre-processor. These results were compared with model results based on LiDAR. The results of this analysis may be found in the "Results and Discussion" section.

Freshwater Flow Polygons

Within SLAMM, a polygon may be defined as having freshwater-flow influence without explicitly modeling salinity—this modifies the habitat-switching flow chart. This is often done along large

rivers and their tributaries. In this modified flow chart Dry Land or Swamp converts to Tidal Swamp, Tidal Swamp converts to Tidal Fresh Marsh, and Tidal Fresh Marsh then converts to Irregularly-Flooded Marsh. In comparison, when no freshwater influence is defined, Swamp converts directly to Irregularly-Flooded Marsh and dry lands convert to transitional salt marsh.

Flooded Swamp

Several areas along the Gulf coast are populated by cypress swamps. For the NWF-funded application of SLAMM to Southeast LA, SLAMM was adjusted to predict that cypress swamps convert to permanently "flooded swamp" when their elevations falls to a level below which non-flooded land will rarely be exposed. This designation was added to denote swamps that may still include live plants but which are not expected to remain viable for long as they are not able to germinate.

Cypress swamps often occur at elevations of 2m above mean sea level or less (Allen et al. 1996) and may be regularly inundated with standing water. Bald cypress has been found to be highly tolerant of flooding, though germination is not possible under permanent flooding conditions (Allen et al. 1996). In a study of wetland tree growth-response to flooding, Keeland and coworkers found permanent shallow flooding of approximately 25 cm occurred in the area of the Barataria basin swamp under examination (1997). In addition, site-specific data suggest that this elevation is the lowest elevation inhabited by this wetland type.

The addition of "flooded swamp" is a bit of a departure from SLAMM conventions. Generally, SLAMM estimates what will happen if a given habitat comes to equilibrium with the water levels predicted a given time step. However, given the length of time that cypress trees can remain alive within flooded swamps, assuming immediate conversion to open water may provide misleading model results.

Considerations for individual study areas

This section provides a brief description of the distinguishing characteristics, if any, of each of the new study sites, refers Figure 3-5 for their exact location.

Study Area 1 – Monroe County, FL

The US Army Corps of Engineers National Levee Database (NLD) indicates large leveed area but is not indicated along the coast in the elevation layer or satellite imagery. NLD "dike protection" area is likely indicating protected areas from freshwater flooding. Production simulations for this study were run without including the dike layer.

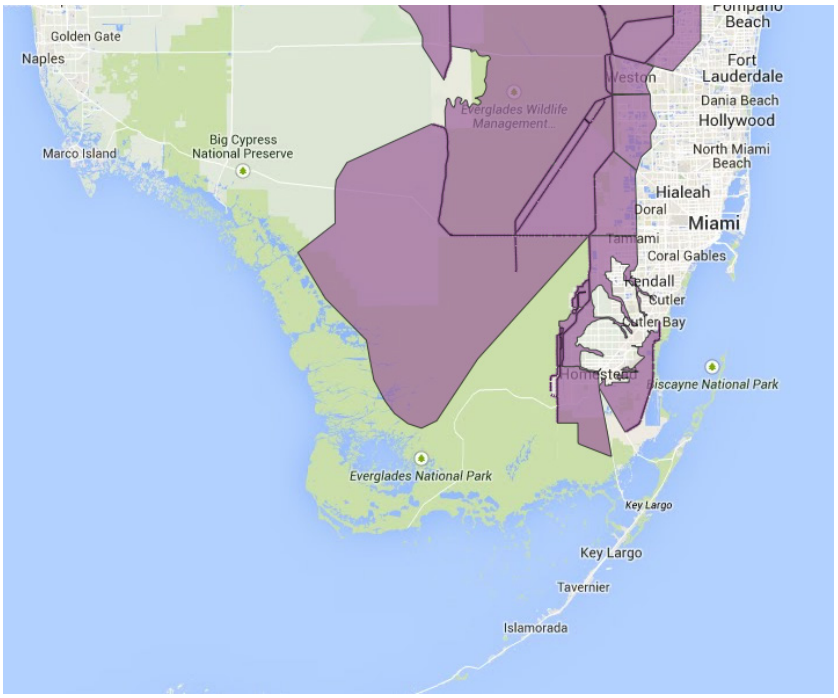

Figure 12. National Levee Database information for South Florida

Study Area 2 – Naples, FL

Extensive calibration was carried out for this study area. In order to account for tidal muting which appeared to present throughout the study area, several subsites were added that assumed tide ranges were reduced due to flow restrictions caused by roads.

Study Area 3 – Sarasota, FL

In this study area the assumption of a tropical area, which is usually applied when an area is > 5% mangrove, was forced so mangrove expansion would be compatible with surrounding regions.

Study Area 4 – Upstream Tampa, FL

This study area is composed of upstream areas adjacent to Tampa Bay.

Study Area 5 – Lake Rousseau, FL

This study area is composed of upstream areas adjacent to Southern Big Bend.

Study Area 6 – Near Gainesville, FL

This is an inland area adjacent to Southern Big Bend and Lower Suwanee.

Study Area 7 – Upstream Lower Suwannee River, FL

This study area upstream of the Lower Suwannee River

Study Area 8 – Tallahassee to Steinhatchee, FL

Muted tide ranges were applied to the NW corner of the study area.

Study Area 9 – St. Joe Bay and Carabelle, Florida

In this study area some wetland areas were edited. In south St. Joseph's Bay, inland fresh marshes that, according to aerial photography, should have been beach were converted to estuarine beach.

Study Area 10 – Upstream Pensacola, FL

This study area is located upstream of the Pensacola study area. SLAMM input parameters were taken from an adjacent subsite area in the older Pensacola study.

Study Areas 11 and 13 – Upstream Perdido, FL

This study area is composed of upstream areas adjacent to Perdido Bay. SLAMM input parameters were taken from an adjacent subsite area in the older Perdido Bay study.

Study Area 12 – Upstream Mobile River, AL

This study is located upstream of the Mobile Bay study area. A freshwater flow polygon was added to the entire study area. SLAMM input parameters were taken from an adjacent subsite area in the older Mobile Bay study.

Study Area 14 – Mississippi and Eastern Louisiana

SLAMM input parameters were taken from an adjacent subsite areas in older studies. Subsidence was added by adjusting historic SLR rate and applying the average rate for the area based on the data of Shinkle and Dokka (2004). Input data were divided based on the rates for each state, LA in the west and MS in the east. In addition, a freshwater flow polygon was added to northern Bayou Sauvage to match the freshwater extent applied in the Bayou Sauvage study area.

(Study Area 15 does not exist in this study-- it was possible to include this area in an adjacent study area.)

Study Area 16 – Dry Tortugas, Florida

Due to low-quality elevation data the elevation pre-processor was used for the entirety extent of this study area.

Study Area 17 – Louisiana Chenier Plain

In Louisiana, since the input wetland data from Couvillion (2011) does not include tidal fresh marsh, it was necessary to add this wetland type where tidal fresh was classified simply as inland fresh. This approach was also used in the previous applications of SLAMM to Southeast Louisiana (Glick et al. 2013). Subsidence was added by adjusting historic SLR rate and applying the average rate for the area based on the data of Shinkle and Dokka (2004)

One of the difficulties in modeling this area was the lack of knowledge regarding levees, many of which are private and are not always apparent in the elevation layer due to averaging within a cell. Despite our best efforts to procure a detailed levee database, the simulation run does not account for all the existing flood control structures within the study area. In setting up this site we were able to add levees based on a conversation with Schuyler Dartez at White Lake Wetlands Conservation Area (WCA), the entirety of the WCA is impounded/leveed and all water levels are controlled by rainfall, not tides. Therefore we designated the entire area as diked.

To improve the initial model calibration several steps were taken, including adjusting the tide range based on CRMS tide data at station CRMS0567 and adding two freshwater flow polygons (one around the Atchafalaya River and another around the Sabine River). In addition, it is important to note horizontal linear artifacts in elevation data north of Maurepas show up in the time-zero (calibration step) and some future predictions, increasing uncertainty in the model predictions in these regions.

Study Area 18 – Galveston Bay, Texas

Subsite parameters for this site were added from adjacent Galveston subsites.

Study Area 19 – Matagorda and San Antonio Bays, Texas

Though the majority of the subsites in this study area were added to reflect differences in tide ranges, some input subsites were added based on erosion data. In particular, subsites were added around the Matagorda Ship Channel and Pass Cavallo to reflect the high rates of erosion observed in those areas.

Study Area 20 – Baffin Bay, South Texas

Radosavljevic and coworkers have suggested a historic SLR in the Mustang Island area ranged between 3.4-5.2 mm yr. for the past fifty to sixty years (2012). In comparison, we applied a Historic Trend of 3.17mm/yr. to the area, which was the average of the values applied in the existing Lower Rio Grande and Corpus Christi project areas.

Study Area 21 – South of Tampa, FL

This area closes a small gap between Tampa Bay and Southern Big Bend study areas.

Focal Species Approach

As part of this project, an analysis was performed to assess the impact of SLR on focal species through the generation of patch metrics for each species' habitat. The GCPLCC technical team provided the focal species choices which were all avian species: seaside sparrow, mottled duck, and black skimmer. One or more wildlife habitat relationship models (WHRM) were developed for each species by identifying one or more SLAMM cover categories (patch classes) upon which the species is dependent. In some cases, queries were developed that required spatial (patch size) constraints.

Table 5. Models specified by GCPLCC staff and their partners

Species Name	Species Code	SLAMM Category Code – Name	Spatial Query / Note
Seaside sparrow	SESA	8 – Regularly Flooded Marsh 20 – Irregularly Flooded Marsh	Number and proportion of polygons $\geq$ 10,000 acres
Mottled duck*	MODU	6 – Tidal Fresh Marsh 7 – Transitional Marsh / Scrub Shrub 20 – Irregularly Flooded Marsh	
Mottled duck*	MODU	17 – Estuarine Open Water	Number and proportion of polygons $\leq$ 640 acres (=1 mile^2)
Black skimmer	BLSK	10 – Estuarine Beach 12 – Ocean Beach	Note that polygons were generated from an aggregation of both SLAMM categories.
Black skimmer	BLSK	10 – Estuarine Beach	
Black skimmer	BLSK	12 – Ocean Beach	

*Note that, for the mottled duck analysis, the analysis was performed separately for the state of Florida, and for rest of the study area (the states of TX, LA, MS, and AL) and inland fresh marsh and inland open water SLAMM classes were not included in the mottled duck focal species analysis.

A number of summary metrics were produced for each WHRM at each time step in each scenario. This resulted in 150 unique combinations (6 WHRMs × 5 scenarios × 5 time steps). Summary metrics include:

- The number of patches (when combined with total raw area, can calculate mean patch size);
- The mean patch area;
- The P/A ratio (best measure of shape complexity that can be generated with tools identified at present).

In addition, the Patch Data Table data product (.dbf format; 150 unique files, zipped together for a project deliverable) was produced for each WHRM at each time step in each scenario, so patch distributions can be developed as needed in the future.

The specific processing steps used to generate the summary patch metric statistics for each WHRM at each time step for each scenario are as follows:

1. Create a new raster output in Project projection (Albers_USGS, NAD83) with15m resolution, snapped to project grid, for all output from existing studies.
2. Mosaic all new study area output and that from existing studies into single rasters (5 scenarios X 5 time steps = 25 unique rasters). For existing studies, all base years merged to same "base" condition.
3. Reclassify mosaicked rasters to these 6 species-specific habitat rasters (6 X 25 scenario-time steps = 150 unique rasters), utilizing the WHRMs presented above.
4. Convert 150 species-specific habitat rasters to polygons (no polygon simplification / generalization)
5. Add area (Area_m2), perimeter (Perimeterm), and P/A ratio (P2A_ratio) attributes
6. Calculate geometry for area and perimeter attributes, and then calculate P/A ratio attribute.
7. Generate summary (patch metric) statistics and compile into single tables for each WHRM.

Finally, the WHRM tables (spreadsheets) were compiled into an Excel workbook as a project deliverable.

Results and Discussion

In this section SLAMM results are presented for the entire study area, which comprised more than 47 million acres. This is followed by a graphical presentation and discussion of the focal species analysis . Tables of land-cover acreage at each time step for each SLR scenario simulated are included, as well as summary tables showing the percentage loss and acreage gain for selected land-cover types. It is important to note that changes presented in the summary tables are calculated starting from the time-zero result and represent projected land-cover changes as a result of sea-level rise excluding any predicted changes that occur when the model is applied to initial-condition data (as discussed the Model Calibration section).

Table 6 presents Gulf-wide results of the percentage change in each land cover category for each SLR scenario simulated. Irregularly-flooded (high) marsh and estuarine beach are both extremely vulnerable habitats, with near complete losses predicted under the 2m by 2100 scenario. Even under the "more likely" scenario of 1m, significant losses are observed in these categories. However, as there is uncertainty in model predictions between high marshes and "transitional salt marshes," some irregularly-flooded marsh loss may be offset by the increases predicted in the transitional salt marsh category.

Cypress swamp is particularly vulnerable, with losses that do not appear to vary widely as a function of SLR. 46% loss is predicted under 0.5m of SLR by 2100 while 57% is predicted under 2m of SLR. Inland fresh marsh appears fairly resilient while tidal fresh marsh is less so, with losses peaking at 1.2m of SLR. (Some tidal-fresh marsh may be created under higher SLR scenarios when tidal swamps are predicted to succumb.) Finally, mangroves appear resilient under the lowest scenario but have serious losses predicted when SLR exceeds 1m by 2100. However, mangrove losses with SLAMM are hard to predict since important factors that influence their potential for expansion, such as air temperature, are not considered.

Overall, these results indicate losses in the majority of land cover categories. However, in certain categories, such as estuarine open water, tidal flat, transitional marsh, and ocean beach, gains occur. Gains in SLAMM can occur when landcover from a higher-elevation landcover type are converted to a lower habitat (such as regularly-flooded marsh being converted to tidal flat), or when dry land becomes marshy due to increasing inundation (e.eg, gains in transitional marsh), and when land is lost to open water (gains in estuarine open water). Because gains are not well-represented by percentages (in particular for flooded forest which does not occur in the initial wetland layers), Table 7 provides the changes in acreage in these categories. Despite observed gains in some land cover categories, the overall trend is one of a loss of habitat richness with increasing rates of accelerated SLR.

Table 8 to Table 12 present acreages of each land-cover category at each time step for each SLR scenario simulated

Table 6. Predicted percentage changes in land covers from time zero to 2100 for the entire study area. Negative values represent losses while positive values are gains.

Land cover category	Acres at Time Zero	Percentage Land cover change for different SLR scenarios				
		0.5m	1m	1.2m	1.5m	2m
Undeveloped Dry Land	14,976,368	-5	-7	-8	-10	-13
Estuarine Open Water	10,101,098	15	31	36	42	47
Swamp	3,809,911	-13	-20	-22	-24	-30
Developed Dry Land	2,335,070	-3	-6	-8	-11	-15
Inland-Fresh Marsh	2,131,645	-14	-26	-29	-33	-39
Cypress Swamp	1,782,028	-46	-52	-53	-55	-57
Irreg.-Flooded Marsh	1,310,526	-63	-87	-92	-95	-96
Regularly-Flooded Marsh	1,084,884	45	-5	-11	-13	-8
Inland Open Water	715,540	-12	-15	-16	-17	-19
Mangrove	488,353	-10	-39	-50	-62	-64
Tidal Flat	319,694	133	284	282	279	274
Tidal-Fresh Marsh	314,107	-12	-59	-71	-68	-63
Trans. Salt Marsh	242,876	134	136	158	196	279
Estuarine Beach	235,574	-39	-78	-86	-92	-95
Tidal Swamp	109,123	-14	-27	-21	-25	1
Inland Shore	31,231	-4	-10	-12	-15	-19
Riverine Tidal	28,667	-69	-79	-81	-84	-86
Ocean Beach	20,842	14	50	59	57	29
Ocean Flat	1,517	-41	-61	-68	-79	-84
Rocky Intertidal	425	-43	-95	-98	-100	-100

Table 7. Landcover change in acres for categories predicted to increase (gains are represented by positive numbers)

Land cover category	Time Zero (acres)	Land cover change for different SLR scenarios				
		0.5m	1m	1.2m	1.5m	2m
Estuarine Open Water	**10,101,098**	1,464,830	3,149,515	3,684,317	4,208,187	4,758,215
Open Ocean	**7,298,321**	13,474	21,712	26,122	35,348	51,919
Regularly-Flooded Marsh	**1,084,884**	485,722	-54,762	-124,424	-146,253	-82,836
Tidal Flat	**319,694**	424,702	914,753	910,239	902,303	891,708
Trans. Salt Marsh	**242,876**	326,166	333,788	390,422	489,316	709,165
Ocean Beach	**20,842**	2,975	10,377	12,363	11,923	6,080
Flooded Forest	**13,660**	823,842	919,337	941,920	972,056	1,019,467

Table 8. Gulf of Mexico SLAMM predictions for 0.5m SLR by 2100 scenario (acres).

		Time Zero	2025	2050	2075	2100
	Undeveloped Dry Land	14,976,368	14,900,438	14,733,636	14,530,181	14,267,948
	Estuarine Open Water	10,101,098	10,226,614	10,456,046	10,889,717	11,565,929
	Open Ocean	7,298,321	7,300,223	7,303,010	7,306,784	7,311,795
	Swamp	3,809,911	3,751,446	3,601,518	3,457,104	3,301,153
	Developed Dry Land	2,335,070	2,332,315	2,320,548	2,298,659	2,262,719
	Inland-Fresh Marsh	2,131,645	2,099,638	2,019,436	1,921,310	1,828,235
	Cypress Swamp	1,782,028	1,654,297	1,369,506	1,118,148	958,226
	Irreg.-Flooded Marsh	1,310,526	1,209,073	984,639	675,011	487,830
	Regularly-Flooded Marsh	1,084,884	1,234,457	1,416,782	1,646,427	1,570,606
	Inland Open Water	715,540	679,347	656,794	640,068	627,931
	Mangrove	488,353	487,462	479,416	464,691	439,532
	Tidal Flat	319,694	389,412	471,561	613,979	744,396
	Tidal-Fresh Marsh	314,107	319,158	295,376	271,001	276,544
	Trans. Salt Marsh	242,876	213,214	400,589	463,709	569,042
	Estuarine Beach	235,574	230,594	221,291	178,287	143,852
	Tidal Swamp	109,123	110,720	126,102	132,891	94,352
	Inland Shore	31,231	31,180	31,104	30,876	30,118
	Riverine Tidal	28,667	18,875	15,696	11,439	8,802
	Ocean Beach	20,842	19,656	20,387	21,896	23,818
	Flooded Forest	13,660	141,409	426,208	677,577	837,502
	Ocean Flat	1,517	1,513	1,417	1,348	890
	Tidal Creek	1,040	1,040	1,040	1,040	1,040
	Rocky Intertidal	425	419	396	355	241
	Total (incl. water)	47,352,499	47,352,499	47,352,499	47,352,499	47,352,499

Table 9. Gulf of Mexico SLAMM predictions for 1m SLR by 2100 scenario (acres).

		TimeZero	2025	2050	2075	2100
	Undeveloped Dry Land	14,975,734	14,875,495	14,623,215	14,263,507	13,899,386
	Estuarine Open Water	10,105,826	10,267,089	10,729,052	11,766,755	13,255,341
	Open Ocean	7,298,329	7,300,494	7,304,944	7,311,675	7,320,041
	Swamp	3,807,645	3,709,778	3,456,383	3,245,112	3,062,487
	Developed Dry Land	2,335,027	2,330,514	2,307,353	2,255,830	2,186,791
	Inland-Fresh Marsh	2,129,137	2,063,207	1,879,999	1,688,803	1,581,418
	Cypress Swamp	1,781,976	1,604,312	1,194,973	941,480	862,687
	Irreg.-Flooded Marsh	1,307,105	1,124,080	653,331	311,561	168,863
	Regularly-Flooded Marsh	1,085,862	1,300,535	1,508,647	1,317,683	1,031,100
	Inland Open Water	715,370	673,964	648,168	626,062	607,209
	Mangrove	485,132	480,423	449,446	385,094	296,802
	Tidal Flat	321,884	425,115	731,416	1,193,127	1,236,637
	Tidal-Fresh Marsh	314,245	316,359	272,095	234,640	130,408
	Trans. Salt Marsh	245,878	264,986	613,583	709,968	579,667
	Estuarine Beach	235,191	227,277	172,461	102,929	52,720
	Tidal Swamp	110,698	124,782	136,875	75,514	80,969
	Inland Shore	31,225	31,159	30,354	29,868	28,012
	Riverine Tidal	28,649	18,631	15,082	9,588	5,987
	Ocean Beach	20,894	19,947	21,928	27,028	31,270
	Flooded Forest	13,712	191,401	600,748	854,254	933,049
	Ocean Flat	1,516	1,499	1,128	767	595
	Tidal Creek	1,040	1,040	1,040	1,040	1,040
	Rocky Intertidal	425	412	278	215	20
	Total (incl. water)	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**

Table 10. Gulf of Mexico SLAMM predictions for 1.2m SLR by 2100 scenario (acres).

		TimeZero	2025	2050	2075	2100
	Undeveloped Dry Land	14,975,463	14,865,476	14,579,200	14,163,233	13,738,203
	Estuarine Open Water	10,107,676	10,285,789	10,862,007	12,138,180	13,791,993
	Open Ocean	7,298,332	7,300,689	7,305,983	7,313,482	7,324,454
	Swamp	3,806,853	3,689,388	3,414,283	3,184,879	2,985,933
	Developed Dry Land	2,335,005	2,329,737	2,301,465	2,235,567	2,148,788
	Inland-Fresh Marsh	2,128,032	2,047,888	1,816,376	1,619,805	1,508,624
	Cypress Swamp	1,781,949	1,583,487	1,134,867	911,799	840,079
	Irreg.-Flooded Marsh	1,305,780	1,086,558	543,390	228,277	103,821
	Regularly-Flooded Marsh	1,086,700	1,329,734	1,467,028	1,200,971	962,275
	Inland Open Water	715,233	672,513	645,222	622,243	600,826
	Mangrove	483,978	477,764	428,503	345,776	243,040
	Tidal Flat	322,283	441,112	879,410	1,338,601	1,232,522
	Tidal-Fresh Marsh	314,301	314,649	260,988	188,123	91,754
	Trans. Salt Marsh	247,202	289,725	697,108	758,357	637,624
	Estuarine Beach	235,059	223,769	155,693	77,216	31,753
	Tidal Swamp	111,156	129,369	129,996	73,011	87,695
	Inland Shore	31,224	31,146	30,307	28,870	27,340
	Riverine Tidal	28,643	18,538	14,858	9,097	5,310
	Ocean Beach	20,912	20,048	22,738	29,286	33,275
	Flooded Forest	13,738	212,228	660,859	883,936	955,658
	Ocean Flat	1,516	1,443	918	710	482
	Tidal Creek	1,040	1,040	1,040	1,040	1,040
	Rocky Intertidal	424	408	258	40	10
	Total (incl. water)	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**

Table 11. Gulf of Mexico SLAMM predictions for 1.5m SLR by 2100 scenario (acres).

		TimeZero	2025	2050	2075	2100
	Undeveloped Dry Land	14,974,980	14,848,880	14,509,006	14,006,439	13,506,422
	Estuarine Open Water	10,110,515	10,345,832	11,082,044	12,658,142	14,318,701
	Open Ocean	7,298,312	7,300,940	7,307,053	7,316,737	7,333,660
	Swamp	3,805,638	3,660,612	3,357,186	3,088,564	2,877,650
	Developed Dry Land	2,334,979	2,328,465	2,291,097	2,201,268	2,085,236
	Inland-Fresh Marsh	2,126,252	2,021,636	1,734,566	1,536,682	1,424,412
	Cypress Swamp	1,781,892	1,549,566	1,058,716	880,374	809,894
	Irreg.-Flooded Marsh	1,303,828	1,025,028	410,817	135,143	63,882
	Regularly-Flooded Marsh	1,087,854	1,371,972	1,359,096	1,156,545	941,601
	Inland Open Water	715,138	669,811	641,607	614,358	592,562
	Mangrove	482,126	472,600	397,001	275,018	181,170
	Tidal Flat	322,919	457,108	1,110,626	1,379,767	1,225,221
	Tidal-Fresh Marsh	314,380	311,144	236,888	127,720	99,468
	Trans. Salt Marsh	249,547	330,251	807,487	844,504	738,863
	Estuarine Beach	234,812	203,032	128,691	49,363	18,238
	Tidal Swamp	111,730	136,818	112,017	95,917	84,185
	Inland Shore	31,219	31,134	30,196	28,064	26,689
	Riverine Tidal	28,634	18,407	14,559	8,394	4,541
	Ocean Beach	20,971	20,258	24,689	32,466	32,894
	Flooded Forest	13,795	246,148	737,017	915,367	985,852
	Ocean Flat	1,515	1,413	861	609	316
	Tidal Creek	1,040	1,040	1,040	1,040	1,040
	Rocky Intertidal	424	402	241	21	1
	Total (incl. water)	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**

Table 12. Gulf of Mexico SLAMM predictions for 2m SLR by 2100 scenario (acres).

		TimeZero	2025	2050	2075	2100
	Undeveloped Dry Land	14,973,911	14,812,985	14,364,358	13,734,202	13,093,216
	Estuarine Open Water	10,115,535	10,412,046	11,398,666	13,260,103	14,873,750
	Open Ocean	7,298,348	7,301,467	7,308,881	7,324,355	7,350,266
	Swamp	3,803,806	3,603,456	3,266,428	2,960,946	2,663,394
	Developed Dry Land	2,334,925	2,325,928	2,266,481	2,134,371	1,985,388
	Inland-Fresh Marsh	2,122,330	1,961,401	1,632,450	1,437,617	1,304,195
	Cypress Swamp	1,781,754	1,481,480	975,854	843,553	762,330
	Irreg.-Flooded Marsh	1,300,247	915,180	263,452	73,062	48,772
	Regularly-Flooded Marsh	1,088,783	1,428,181	1,293,010	1,154,506	1,005,947
	Inland Open Water	715,010	666,056	636,602	607,110	581,424
	Mangrove	478,942	462,590	340,181	215,181	170,292
	Tidal Flat	325,275	520,265	1,387,239	1,355,324	1,216,983
	Tidal-Fresh Marsh	314,501	301,665	171,926	106,048	117,170
	Trans. Salt Marsh	254,526	435,217	961,658	985,375	963,691
	Estuarine Beach	234,341	190,598	86,215	22,290	11,327
	Tidal Swamp	112,527	147,109	105,701	115,052	113,395
	Inland Shore	31,215	31,014	29,217	27,041	25,290
	Riverine Tidal	28,619	18,226	14,141	7,499	3,913
	Ocean Beach	20,997	20,607	28,161	35,222	27,076
	Flooded Forest	13,934	314,232	819,877	952,180	1,033,401
	Ocean Flat	1,512	1,363	750	417	239
	Tidal Creek	1,040	1,040	1,040	1,040	1,040
	Rocky Intertidal	424	392	211	6	-
	Total (incl. water)	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**	**47,352,499**

Re-Run of Existing Study Areas

Within this study, existing study areas were re-run to ensure that all study areas were run with the same SLR scenarios. Areas that were not run with regularly-flooded-marsh accretion feedbacks had accretion feedbacks added in based on their region as described above in this document. In study areas that were run with dry land assumed to remain protected, this assumption was removed for consistency across the entire model domain.

After each existing study area was run, the model results were compared with the previous model runs to discern the extent of the differences from the previous analysis. A short set of notes about each of the existing study areas and differences from previous model applications follows:

- **Apalachicola, FL –** We ran this model with a "freshwater flow polygon" resulting in similar susceptibility to the previous project, but with different future wetland categories predicted.
- **Bayou Sauvage/Big Branch Marsh, LA—** Model results were similar to those run previously. The old model simulations assumed dike failure at 2 meters of SLR while the new model does not make this assumption. Model results won't be perfectly seamless with the surrounding regions due to differences in wetland cover class (NWI data vs. the Couvillion 2011 wetland data).
- **Charlotte Harbor, FL—**There was no previous report to compare results to. However, the results look reasonable and consistent with surrounding regions.
- **Corpus Christi Bay, TX--** Marshes are predicted to be more resilient than in previous simulations due to regularly-flooded marsh accretion feedbacks. The TNC project assumed that developed lands were protected which was not assumed in this project.
- **Ding Darling, FL –** The results are essentially identical; there is very little salt marsh in this region.
- **Freeport, TX—**The new model results are essentially identical. We maintained the accretion feedbacks that were used in the previous set of runs.
- **Galveston Bay, TX—**Results are nearly identical to the previous project.
- **Grand Bay, MS –** Model results are similar, but marshes are predicted to be more resilient due to regularly-flooded marsh accretion feedbacks. Current results assume that flooded cypress swamps become "flooded forest" rather than open water.
- **Great White Heron, FL –** Model results were nearly identical to previous model runs. To fill in a few minor data gaps in beaches and tidal flats, we used the elevation pre-processor for wetlands with no elevation data.

- **Jefferson County, TX—**Model results are quite similar: Regularly-flooded marsh was actually slightly more resilient before the feedbacks were added due to the very high constant accretion rate assumed (>10mm/yr.). Barrier-island overwash was turned off due to excessive streaking – the current version of the overwash module cannot be effectively run at a cell size below 30 meters.

- **Key West, FL –** The results were identical to those previously derived. No LiDAR data for this site results in significant model uncertainty.

- **Lower Rio Grande Valley/Laguna Atascosa, TX-- Results** are very similar. Most regularly-flooded marsh in this site is created due to upland flooding which doesn't change much. Accretion feedbacks do result in some additional low marsh resilience however, (e.g. in the 1 m by 2100 scenario).

- **Lower Suwannee, FL—**Low marshes are predicted to be slightly more resilient due to regularly-flooded marsh accretion feedbacks. The output maps are quite identical otherwise.

- **Mobile Bay, AL--** We ran this model with a "freshwater flow polygon" resulting in similar susceptibility to the previous project, but different future wetland categories predicted. The TNC project assumed that developed lands were protected which was not assumed in this project.

- **Pensacola Bay, FL—**The TNC results predicted more regularly-flooded marsh due to being run on an older version of the model. (Tidal-fresh marsh will now convert directly to tidal-flat or open water depending on its elevation. Previous model versions forced succession through the regularly-flooded marsh category.) The previous model results protected developed-dry land.

- **Perdido Bay, FL –** In previous model runs, developed dry land was protected. Otherwise results are quite similar. However, low marshes are more resilient in current predictions due to accretion feedbacks.

- **Sabine, TX –** Model results suggest that this study area is slightly more vulnerable than the previous USFWS-funded simulation. This is likely due to differences in accretion assumptions and lower accretion rates for higher-elevation marshes.

- **Saint Andrew Choctawhatchee, FL—**The new results are essentially identical to previous model runs when comparing maps and tables. All future predicted regularly-flooded marshes are created from marsh migration to uplands. Therefore the predicted acreage of marshes is more a function of dry-land elevations than accretion rates.

- **San Bernard Big Boggy, TX—**Results are a very close match to previous results. There are slight differences in regularly-flooded marsh fate due to the new feedback curve vs. the previously assumed constant accretion of 8.2 mm/year.

- **Sandhill Crane, MS –** Regularly-flooded marshes are predicted to be considerably more resilient based on accretion feedbacks. Furthermore, the new model was more carefully parameterized and calibrated in non-refuge locations.
- **Southeast Louisiana, Right and Left** – There were no notable differences from the previous model application.
- **Southern Big Bend, FL –** A higher accretion rate had been used by TNC than was derived regionally for this area. Therefore salt marshes are more vulnerable to intermediate SLR scenarios. The TNC project assumed that developed lands were protected which was not assumed in this project.
- **St. Marks, FL –** Model results are quite similar, but marshes are predicted to be slightly more resilient due to regularly-flooded marsh accretion feedbacks.
- **Tampa Bay, FL –** Quite similar overall. However, the TNC project assumed that developed lands were protected which was not assumed in this project. Simulations in the current study show mangroves extending onto developed lands.
- **Ten Thousand Islands, FL—** Model results are very similar, except the new model runs assume that permanently flooded cypress swamps become "flooded forest" rather than open water. To fill in a few minor data gaps in beaches and tidal flats, this project used the elevation pre-processor for any wetlands with no elevation data.

Focal Species Analysis Results

The statistics resulting from the analysis performed for the focal species is presented in its entirety in Appendix D. One useful tool to discern trends through time for the focal species WHRM metrics, is stacked line graphs – with one line per sea level rise (SLR) scenario. A series of these graphs are presented for the primary focal species analysis metrics stated in the Methods section. Because there are few generalizations that can be made about the trends among all of the various WHRMs metrics through time, the results will be presented in this section on a species-by-species basis.

There are several considerations for understanding and interpreting the focal species analysis results. First, it is assumed that reader is either familiar with the overall trends through time and among SLR scenarios for the individual SLAMM classes, and their relative magnitudes, or can reference Tables 8-12 as necessary for those details. Second, for those WHRMs which contain more than one SLAMM class (or "land cover category"; see Table 3), the aggregation differentially affects the metrics that result from the analysis.

The "total patch area" corresponds directly to the area values presented in Tables 8-12. For WRHMs with a single SLAMM class as the habitat, e.g., the mottled duck's Estuarine Open Water habitat, the values are equivalent to those in Tables 8-12. But for WRHMs with two or more

SLAMM classes as the habitat, e.g., the seaside sparrow's combined Regularly Flooded Marsh and Irregularly Flooded Marsh habitats, the "total patch area" metric values are equivalent to the simple sum of the values of the individual SLAMM classes. These classes, however, do typically trend differently, both through time and among scenarios, as is evident in Tables 8-12.

Another important characteristic of the aggregation is that it is spatially-explicit. The direct adjacency of individual patches from two of the different SLAMM classes in the raw SLAMM output affects the aggregated patch size in a WHRM that includes those two classes. Thus, the landscape configuration, or mosaic pattern, of the different SLAMM classes affects any of the other metrics that are not the simple sum of the area. Thus, for "patch count", "mean patch area", and "P/A ratio" metrics, the changes in adjacency of patches belonging to different (individual) SLAMM classes may greatly influence the WHRM metrics. This would be particularly true in cases where one or more of the individual SLAMM classes becomes more fragmented, and loses area around its edges where the lost area is not converted to another one individual SLAMM classes of the WHRM.

Finally, WHRM metrics presented here assume that all dry land that is not currently diked will be made available for wetland colonization given sufficient sea-level rise, as is the consistent assumption within this Gulf-wide analysis. Due to the likelihood of dry-land protections across the Gulf, this likely makes these results "best-case" scenarios for animal habitat.

Seaside Sparrow

As presented in Table 5, metrics were generated for the seaside sparrow's habitat of combined Regularly Flooded Marsh and Irregularly Flooded Marsh areas, and specifically for those patches that were 10,000 acres or more in areal extent. Trends in metrics for this habitat type are presented in Figures 13 -18.

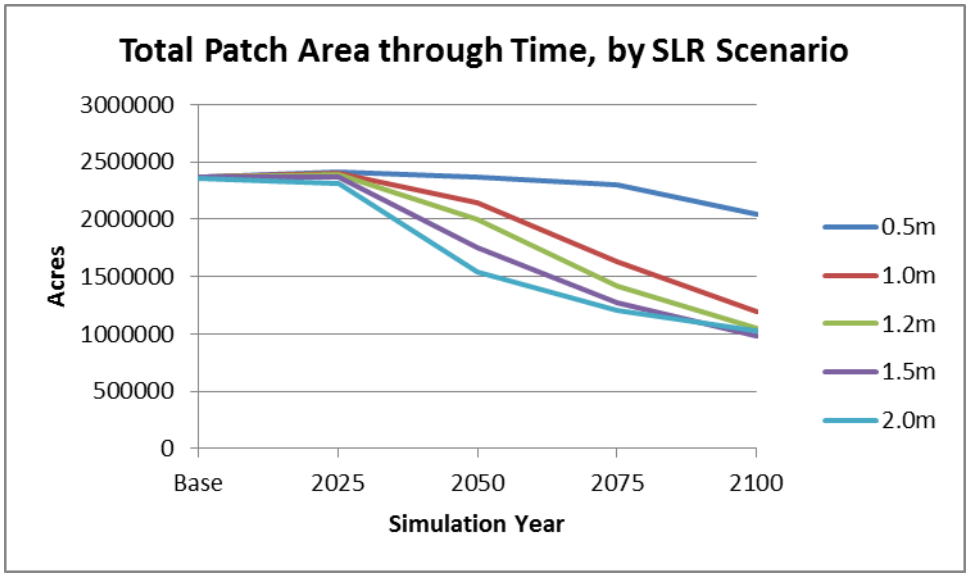

Figure 13. Trends in total area of all seaside sparrow habitat patches through time, by sea level rise scenario.

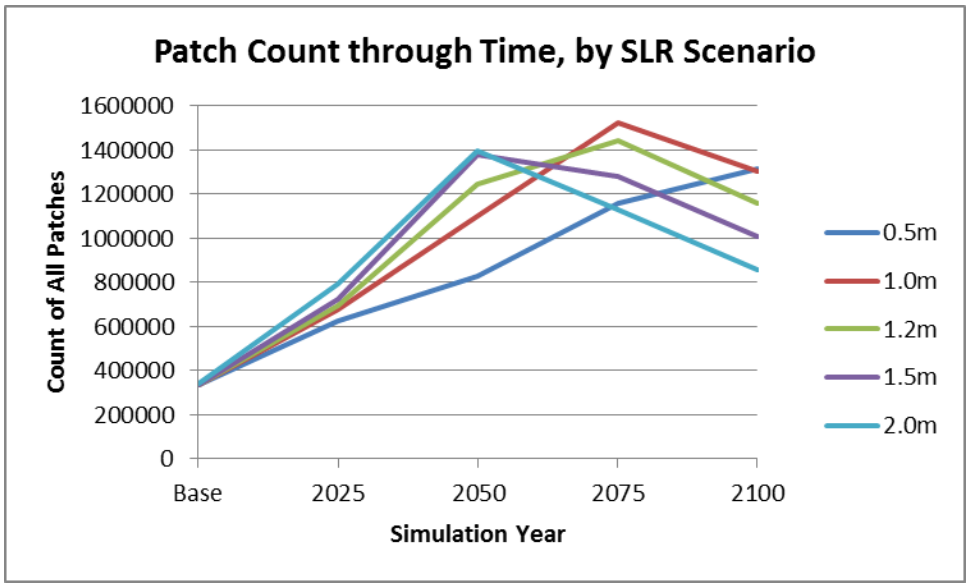

Figure 14. Trends in count of all seaside sparrow patches through time, by sea level rise scenario.

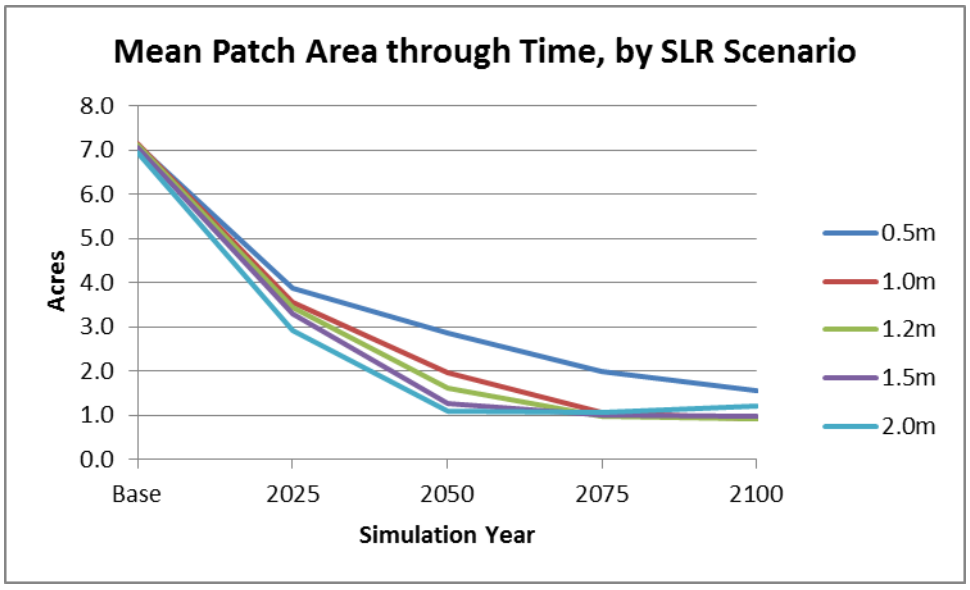

Figure 15. Trends in mean area of all seaside sparrow habitat patches through time, by sea level rise scenario.

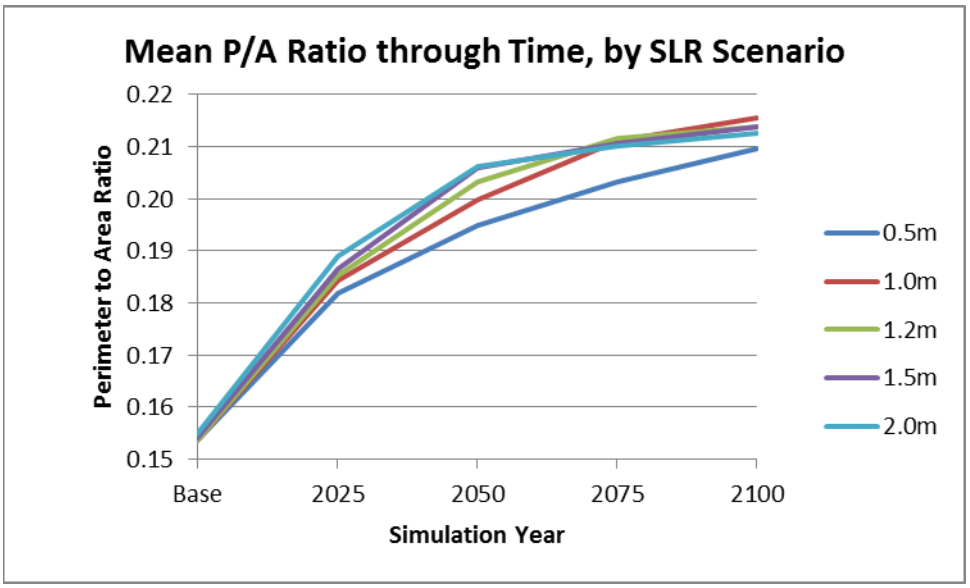

Figure 16. Trends in mean perimeter to area (P/A) ratio of all seaside sparrow habitat patches through time, by sea level rise scenario.

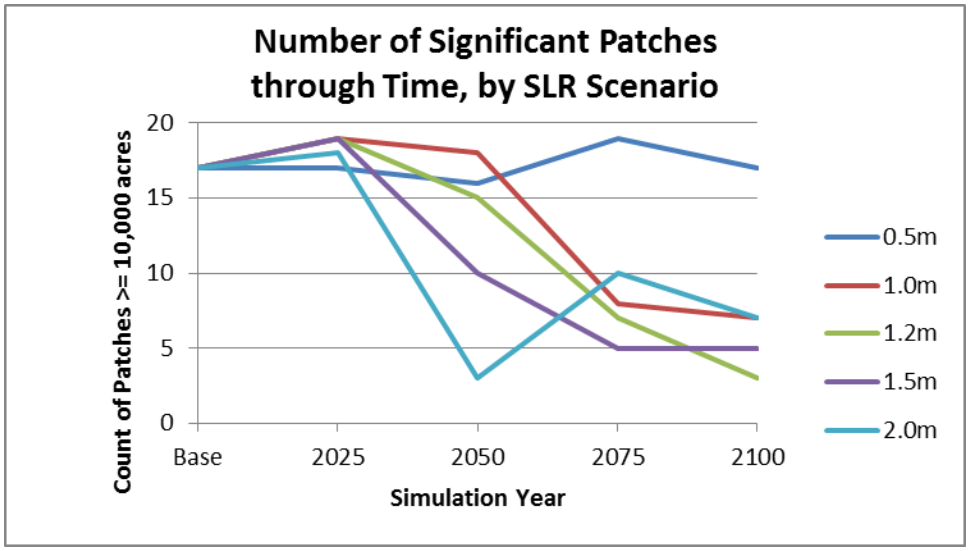

Figure 17. Trends in number of significant seaside sparrow habitat patches (those at least 10,000 acres) through time, by sea level rise scenario.

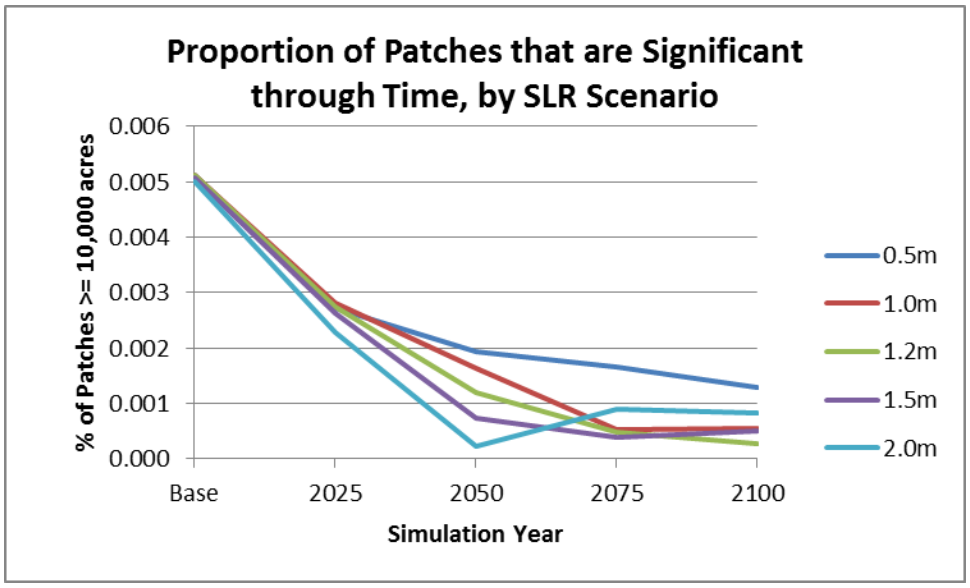

Figure 18. Trends in proportion of seaside sparrow habitat patches that are significant (those at least 10,000 acres) through time, by sea level rise scenario.

As mentioned above, Figure 13 represents the summed areal values for the SLAMM classes in this WHRM: Regularly Flooded Marsh and Irregularly Flooded Marsh. While the magnitude of total area for these two habitats at baseline ("time zero") conditions are relatively similar, the results through time and among SLR scenarios differ greatly. The area of Irregularly Flooded Marsh dramatically decreases, especially for the larger SLR scenarios, and the Regularly Flooded Marsh area increases through time until 2050 (2075, for the 0.5m scenario), then decreases through the 2100 endpoint to a level near the baseline condition (50% increase for 0.5m scenario). Note that some regions, like the Big Bend of Florida (Area 8), actually see a large expansion of Regularly Flooded Marsh by the year 2100 under the 1m SLR scenario (see Figure 45).

There are several noteworthy results for the changes in seaside sparrow WHRM metric:

- Overall, the total combined habitat patch area (Figure 13) decreases for all scenarios by year 2025, and incurs dramatic reductions (~50%) for all but the 0.5m SLR scenario. The increases or small decreases for the Regularly Flooded Marsh are negatively offset by the huge loss in Irregularly Flooded Marsh by year 2100, which is at a maximum (96% decrease) for the 2m SLR scenario.
- The patch count (Figure 14) peaks by about a factor of 4 for all SLR scenarios: by 2050 for two highest SLR scenarios, by 2075 for 1.0 and 1.2m SLR, and by 2100 for the 0.5m SLR scenario. For all but the latter scenario, the count value drops down from the peak at a consistent rate to the year 2100 condition.
- For all SLR scenarios, mean patch area (Figure 15) was reduced from about 7.1 acres at time zero to about 1.1 acres at year 2100.

- For all SLR scenarios and especially those 1m or greater, there is very close correspondence among trend patterns for mean patch area, and mean P/A ratio (Figure 16) trends, with a 84% decrease and a 38% increase on average, respectively. Also noteworthy is the convergence of final (year 2100) values of both metrics.
- There is a threshold of SLR magnitude between 0.5 and 1.0m (by 2100) for impact on total patch area through time.
- This threshold was also evident for the number of patches attributed to have special significance to the seaside sparrow (Figure 17), those with an extent of at least 10,000 acres.
- Starting with a baseline of 17 significant patches for all SLR scenarios, by 2100 the number is reduced for SLR scenarios 1m or greater to 5.5 on average, i.e., a 2/3 reduction. However, the count for the 0.5m SLR scenario remains close to the baseline condition of 17 for the duration of the simulation.

Mottled Duck

As mentioned in the Focal Species Approach, metrics for the two mottled duck WHRM were generated separately for the state of Florida, and for rest of the study area (the states of Texas, Louisiana, Mississippi, and Alabama). In addition, it is important to note that the inland fresh marsh and inland open water SLAMM cover classes were not included in the mottled duck focal species analysis. While these cover classes do provide valuable habitat for mottled ducks, the GCPLCC technical team chose to restrict the analysis to only tidally-influenced classes because they were anticipated to experience the greatest impacts due to projected SLR.

Before presenting the separate regional results, some Gulf-wide patterns are worth mentioning. At the baseline ("time zero") condition, the total area for Irregularly Flooded Marsh is about two and a half times greater than the combined area of the two other marsh types relevant to this WHRM (Tidal Fresh Marsh and Transitional Marsh / Scrub Shrub). The pattern of trends in total area for the Tidal Fresh Marsh mimics that of Irregularly Flooded Marsh, as noted above in the discussion of results for the seaside sparrow. Given its characteristic of gaining in area as dry land becomes marshy due to increasing inundation, the pattern for Transitional Salt Marsh is quite different, exhibiting substantial gains for all five SLR scenarios. Under the 0.5m scenario, a peak of twice the baseline area is reached by 2100. For all other scenarios, the peak area is reached by 2075, with a magnitude of 3x baseline for the 1.0m scenario, to a maximum of 4x baseline for the 2.0m scenario.

Mottled Duck in Florida

As presented in Table 5, metrics were generated for the mottled duck's habitat of combined Tidal Fresh Marsh, Transitional Marsh / Scrub Shrub, and Irregularly Flooded Marsh areas. For brevity, this WHRM will be referred to as "non-salt estuarine" marsh in Figure captions. Trends in metrics for this habitat type for the Florida portion of the Gulf study area are presented in Figures 19- 22.

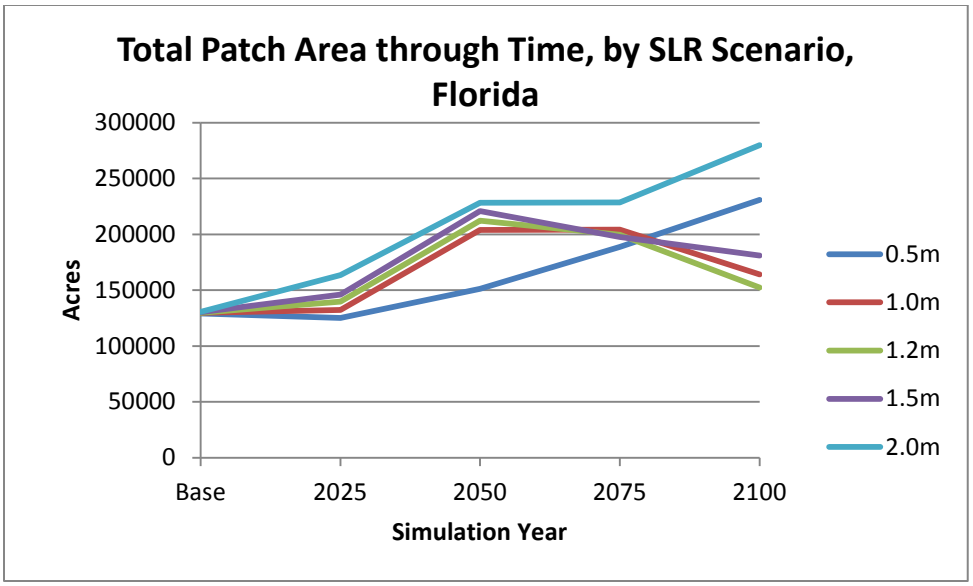

Figure 19. Trends in total area of mottled duck non-salt estuarine marsh habitat patches in Florida through time, by sea level rise scenario.

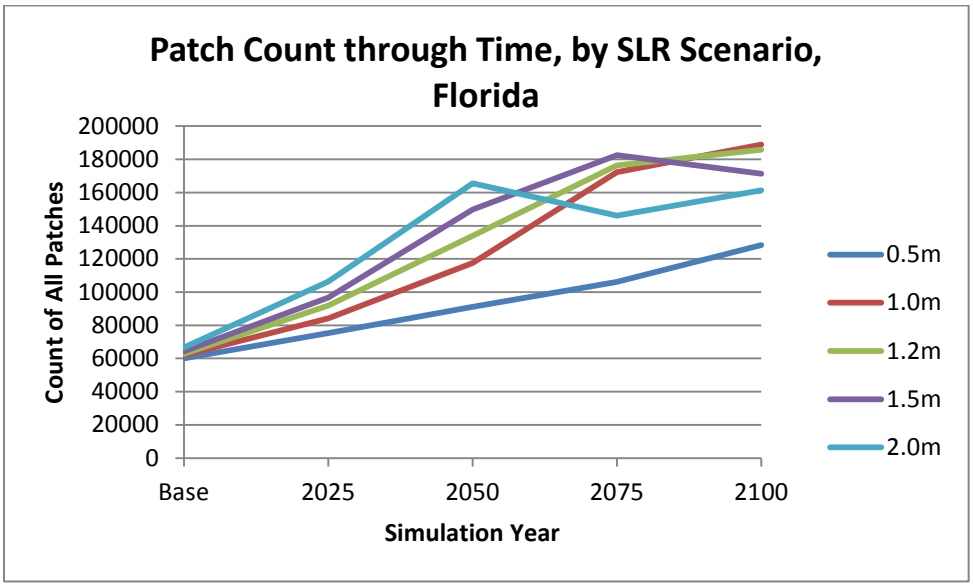

Figure 20. Trends in count of all mottled duck non-salt estuarine marsh habitat patches in Florida through time, by sea level rise scenario.

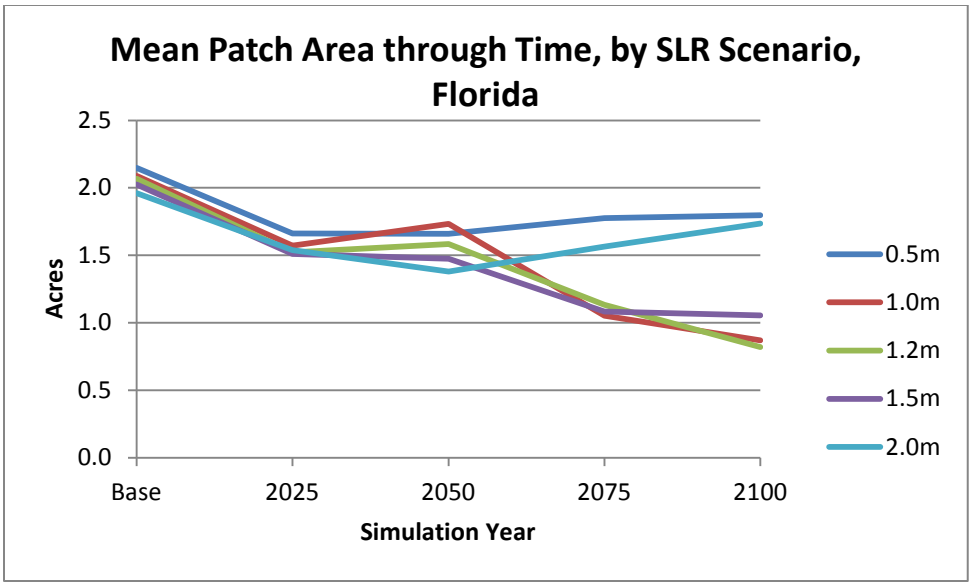

Figure 21. Trends in mean area of all mottled duck non-salt estuarine marsh habitat patches in Florida through time, by sea level rise scenario.

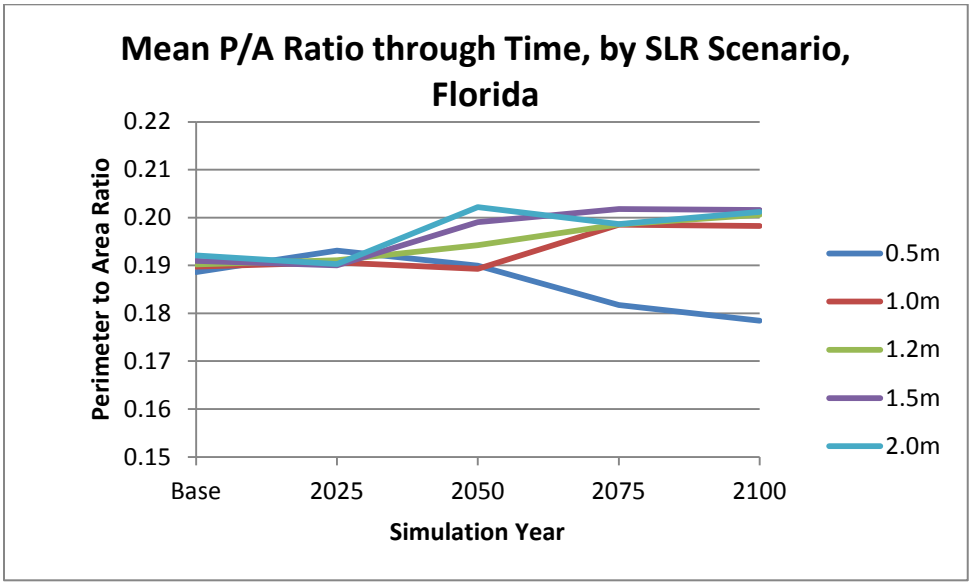

Figure 22. Trends in mean perimeter to area (P/A) ratio of all mottled duck non-salt estuarine marsh habitat patches in Florida through time, by sea level rise scenario.

For the Florida study area, there are several noteworthy results for the mottled duck's WHRM estuarine marsh habitat metrics:

- Overall, patch counts (Figure 20) rapidly increase to year 2050, and generally continue to increase to the year 2100 across all but the largest SLR scenarios. For the 2.0m scenario,

patch counts drop from 2050 to 2075, and then the number of patches increases again by 2100. The 1.5m scenario shows the same pattern as the 2.0m rise, though with a 25 year lag.

- As with patch counts, the total patch area (Figure 19) increases substantially across all scenarios to the year 2050. From that point in time, patch areas, for all but the smallest SLR scenario, level off for the next 25 years. In the 2075 to 2100 time period, the total patch area of the 0.5m SLR continues on its upward trend, reaching a level approximately equivalent to the values of the other SLRs at 2050. For other scenarios, all but the 2.0m SLR show decreases in total patch area by 2100. Notably, the endpoint of total patch area for the 2.0m SLR is substantially higher than that of the other scenarios, nearly doubling that of the 1.2m scenario at year 2100.
- There is very close correspondence among the trends in mean patch area (Figure 21) for all of the scenarios through the year 2050. From that point forward the largest and smallest SLR scenarios exhibit modest increases in mean patch area, while the other three scenarios show continued, and overall dramatic, declines. This is expected given the pattern of total patch area among SLRs and through time.
- For mean P/A ratio (Figure 22), for all but the 0.5m SLR scenario, the uniformity in trends and final convergence at a 5% average increase over baseline ratios is also noteworthy.

In addition, metrics were generated for the mottled duck's Estuarine Open Water habitat in Florida and specifically for those patches that were less than 640 acres in areal extent. Trends in metrics for the Estuarine Open Water habitat types are presented in the graphs included in Figures 23-28.

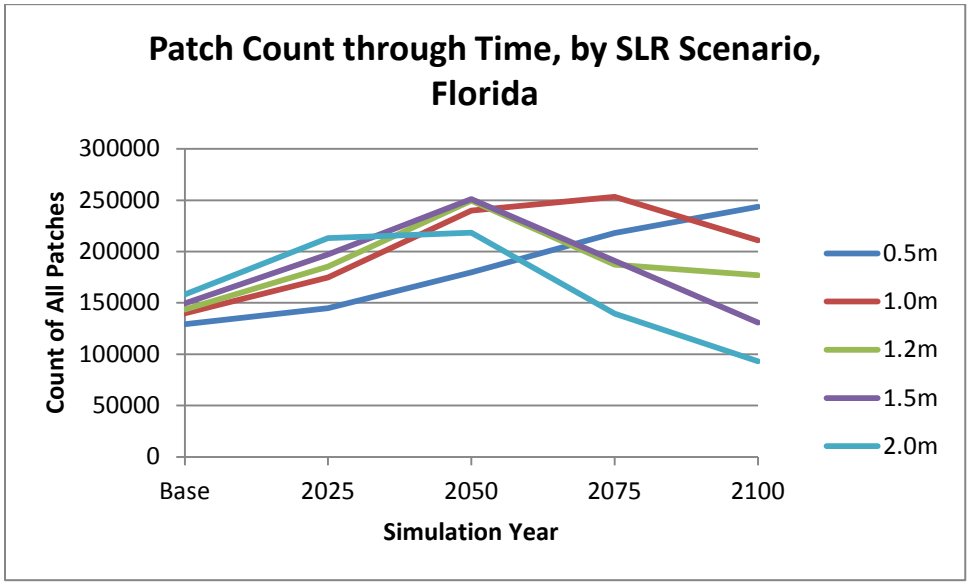

Figure 23. Trends in count of all mottled duck Estuarine Open Water habitat patches in Florida through time, by sea level rise scenario.

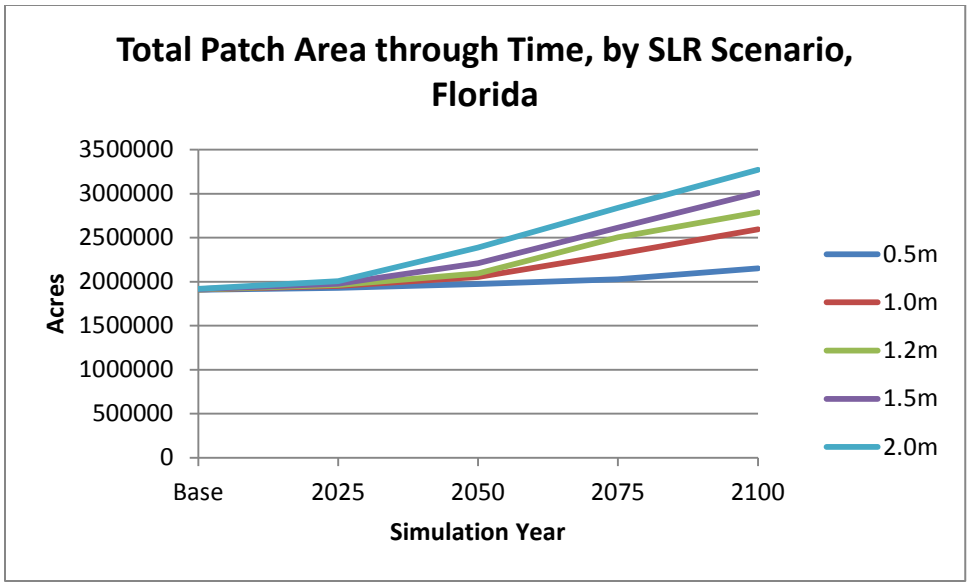

Figure 24. Trends in total area of mottled duck Estuarine Open Water habitat patches in Florida through time, by sea level rise scenario.

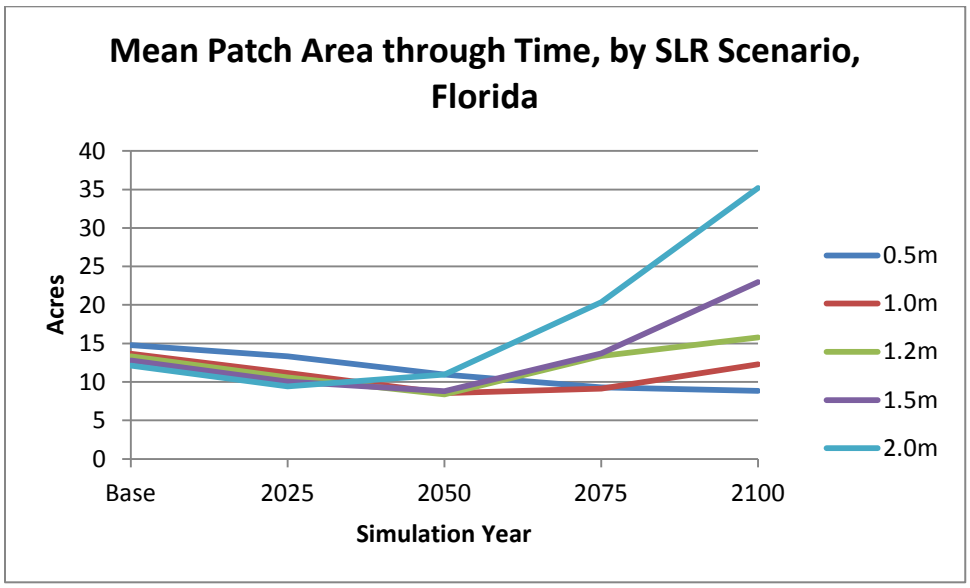

Figure 25. Trends in mean area of all mottled duck Estuarine Open Water habitat patches in Florida through time, by sea level rise scenario.

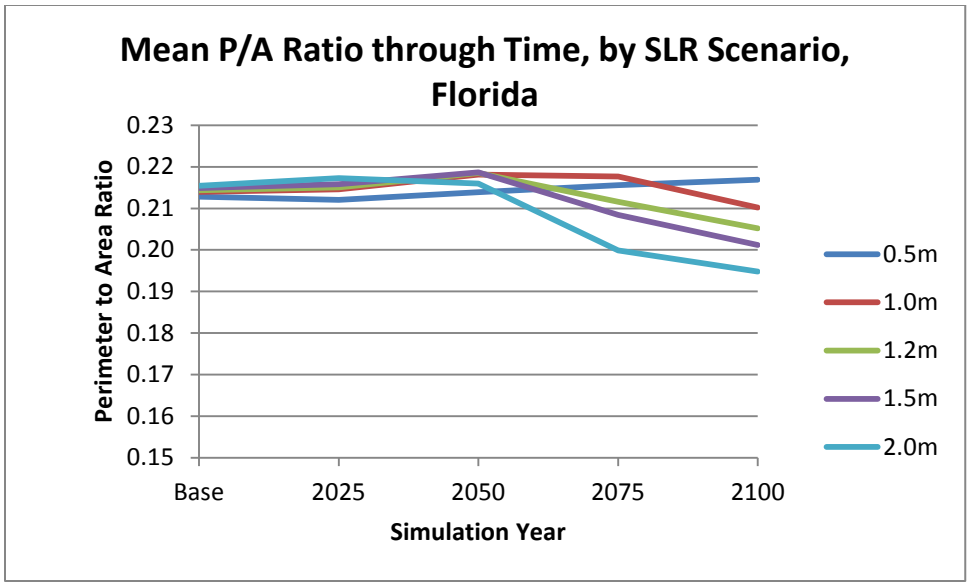

Figure 26. Trends in mean perimeter to area (P/A) ratio of all mottled duck Estuarine Open Water habitat patches in Florida through time, by sea level rise scenario.

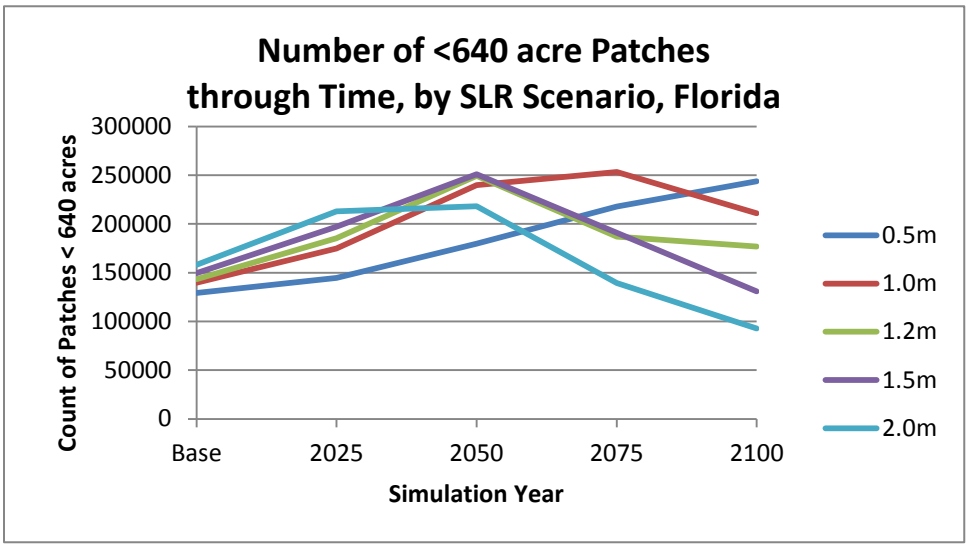

Figure 27. Trends in number of significant mottled duck Estuarine Open Water habitat patches (those less than 640 acres) in Florida through time, by sea level rise scenario.

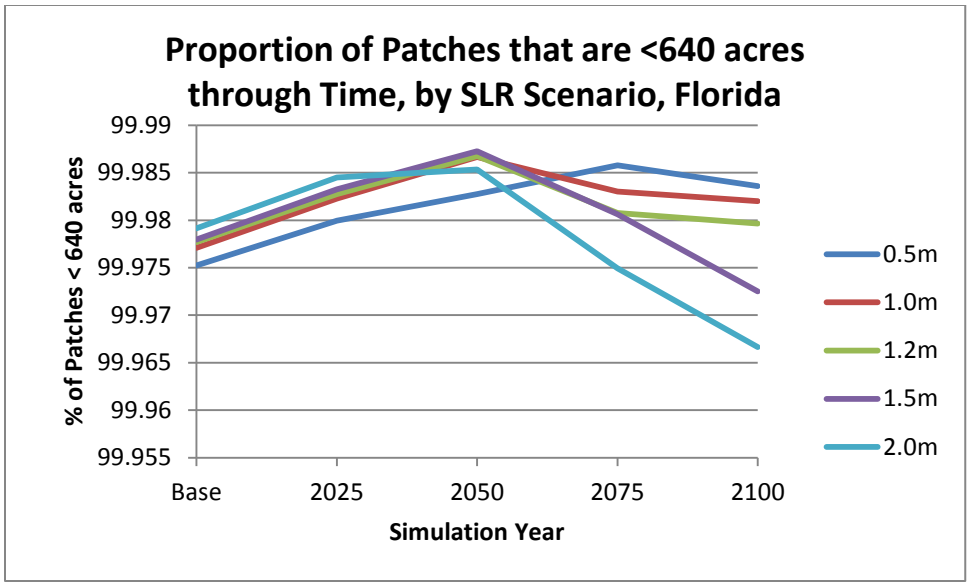

Figure 28. Trends in proportion of mottled duck Estuarine Open Water habitat patches that are significant (those less than 640 acres) in Florida through time, by sea level rise scenario.

Unlike SLAMM classes that generally lose area under SLR scenarios, Estuarine Open Water typically gains area due to losses in Estuarine Beach, Tidal Flat and tidal marsh at lower elevations. Thus, the trends predicted for the mottled duck Estuarine Open Water WHRM metrics are much different than those presented for its estuarine marsh habitat, or that of the seaside sparrow.

There are several noteworthy results for the changes in mottled duck's WHRM Estuarine Open Water habitat metrics in Florida:

- The patch count (Figure 23) at 2050 for all SLR scenarios is higher than baseline conditions. For the 0.5m SLR scenario, the increase in patch count is relatively steady, with a 2100 endpoint approximately 2x the baseline level. For the 1.0m, 1.2m, and 1.5m scenarios, the peak is predicted to occur at year 2050 or 2075, with an average increase exceeding 70% of the baseline levels. For 2m scenario, although the patch count also peaks at the year 2050, there is no substantial increase over the next 25 years, followed by a roughly 50% loss relative to baseline levels. The other scenarios show a similar pattern, though lagged in time due to the less rapid SLR. By 2100, the relative numbers of patches are inversely proportional to the magnitude of the SLR scenario.
- The total patch area (Figure 24) show a highly regular pattern, with minor to major increases in total patch area in directly proportional to the SLR magnitude. Given the impetus for gains in Estuarine Open Water, the increases are, not surprisingly, directly proportional to the magnitude of the SLR scenario, with the smallest (13%) for the 0.5m scenario, and the largest (70%) for the 2.0m scenario.
- This pattern in patch count trends can be explained by the initial creation of many non-contiguous pockets of Estuarine Open Water, which later become connected. This

phenomenon is evident in the mean patch area (Figure 25) trends, which are the converse of the patch count trends: by 2100 the relative areal size of patches is directly proportional to the magnitude of the SLR scenario. Thus, while the magnitude of change in total patch area is not huge, there are obviously large changes in the spatial configuration of these patches across the estuarine landscape.

- The trends in mean P/A ratio among SLR scenarios (Figure 26) exhibit a pattern that is also consistent with the hypothesized changes in patch size distribution and configuration. The trend pattern is very similar to that of the patch count, and opposite that of the mean patch area.
- Patches of estuarine open water less than 640 acres (1 square mile) in areal extent are considered significant habitat for mottled duck (Figure 27). Because the vast majority of estuarine-open-water patches are smaller than 640 acres, trends through time are nearly identical to those in Figure 23. The hypothesis of "increased connectivity of Estuarine Open Water patches through time and with increased SLR" explains this pattern as well, and is evident in the final graph (Figure 28) which exhibits the general pattern seen for mean patch area.

Mottled Duck in Texas, Louisiana, Mississippi, and Alabama (TX, LA, MS, & AL)

As presented in Table 5, metrics were generated for the mottled duck's habitat of combined Tidal Fresh Marsh, Transitional Marsh / Scrub Shrub, and Irregularly Flooded Marsh areas. For brevity, this WHRM will be referred to as "non-salt estuarine" marsh in Figure captions. Trends in metrics for this habitat type for the *non*-Florida (TX, LA, MS, & AL) portion of the Gulf study area are presented in Figures 29- 32. For brevity, the Texas, Louisiana, Mississippi, and Alabama region of the study area will be referred to as the "TX-LA-MS-AL region" in Figure captions.

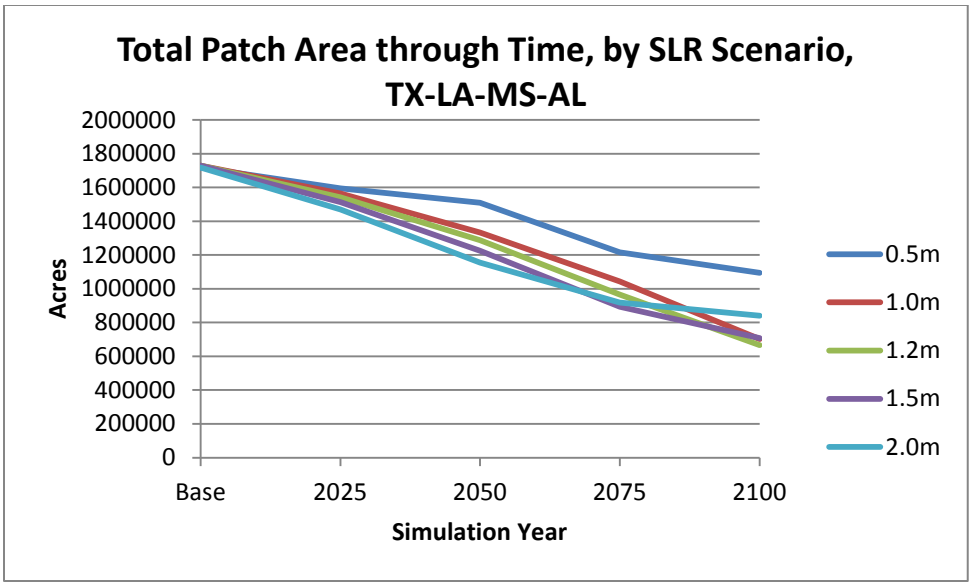

Figure 29. Trends in total area of mottled duck non-salt estuarine marsh habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

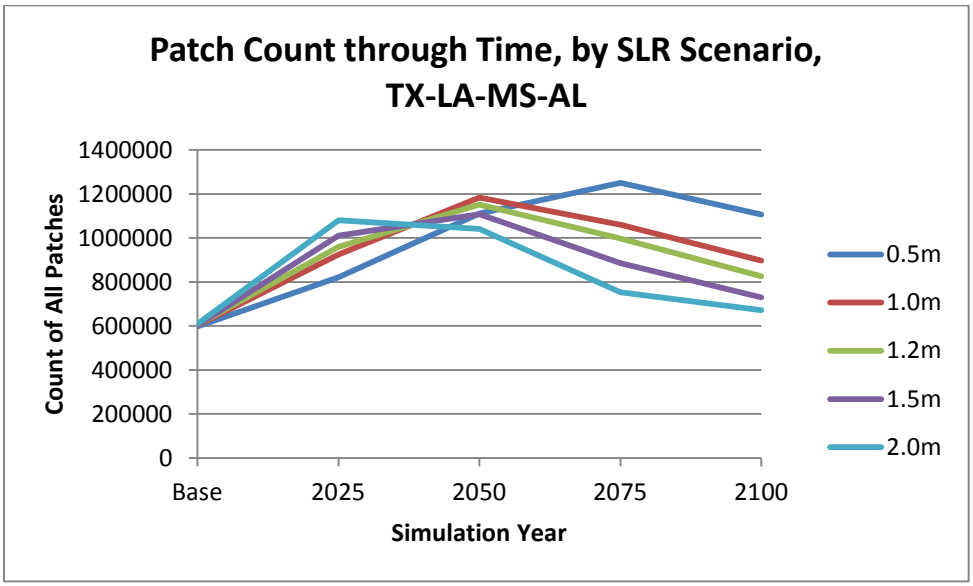

Figure 30. Trends in count of all mottled duck non-salt estuarine marsh habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

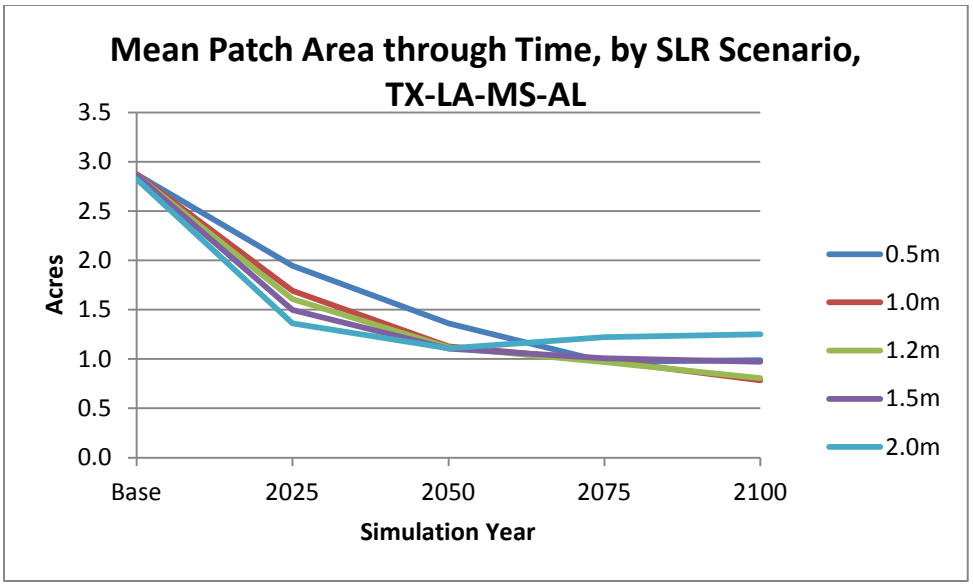

Figure 31. Trends in mean area of all mottled duck non-salt estuarine marsh habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

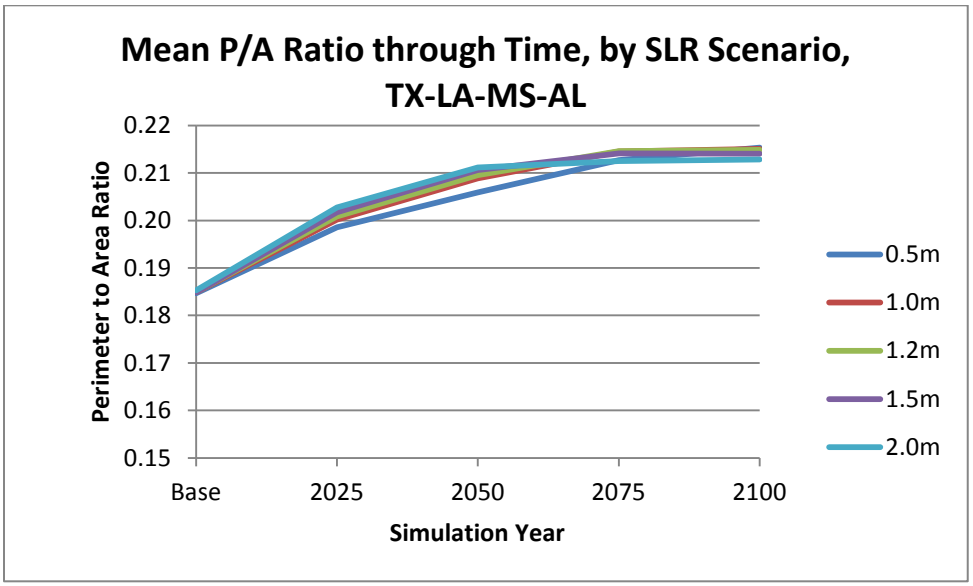

Figure 32. Trends in mean perimeter to area (P/A) ratio of all mottled duck non-salt estuarine marsh habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

There are several noteworthy results for the changes in mottled duck's WHRM non-salt estuarine marsh habitat metrics for the TX-LA-MS-AL region of the study area, which differ markedly from those of the Florida region:

- Overall, non-salt estuarine marsh patch counts (Figure 30) increase through time to year 2100 across all SLR scenarios, but only after large increases followed by decreases. The rise and fall pattern takes place earliest for the most severe SLR scenario, and not until 50 years later for the 0.5m SLR – peaking at 2075. The intermediate SLR scenarios all peak at the year 2050, exhibiting only a 25-year lag from the 2.0m scenario.
- For all but the 0.5m SLR scenario, total patch area (Figure 31) decreases to a consistent value that is roughly half of the baseline condition. Again, a threshold is evident between the 0.5m and 1.0m condition, with a loss of only 36% of the mottled duck's estuarine non-salt marsh habitat under the 0.5m scenario.
- There is close correspondence among the trends in mean patch area (Figure 31) and mean P/A ratio (Figure 32). For P/A ratio, the uniformity in trends and final convergence at about 21% over baseline ratios is noteworthy.
- For all SLR scenarios, there is also a close correspondence among scenarios for mean patch area, with a large (66%) decrease, on average.

In addition, metrics were generated for the mottled duck's Estuarine Open Water habitat in the TX-LA-MS-AL region of the study area, and specifically for those patches that were less than 640 acres in areal extent. Trends in metrics for the Estuarine Open Water habitat types are presented in the graphs included in Figures 33-38.

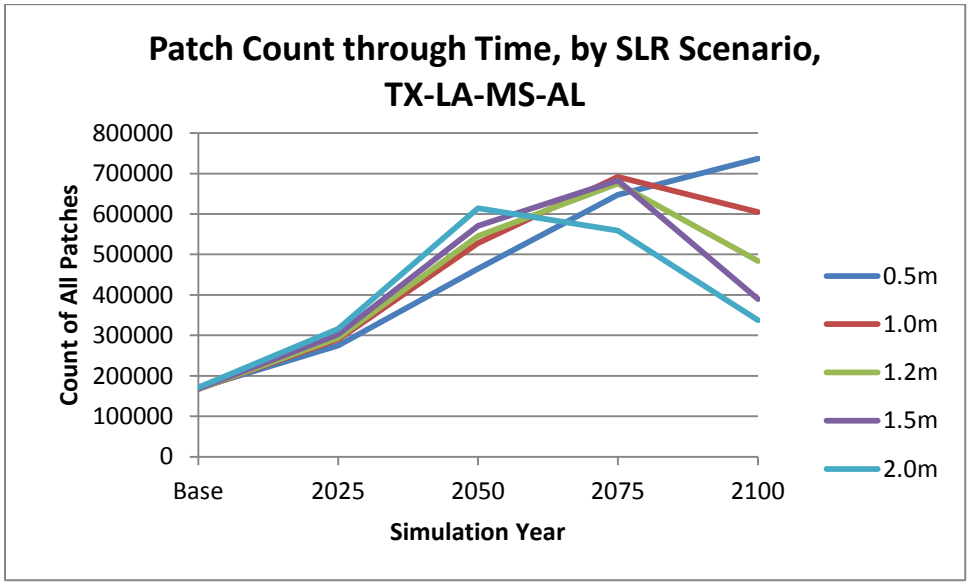

Figure 33. Trends in count of all mottled duck Estuarine Open Water habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

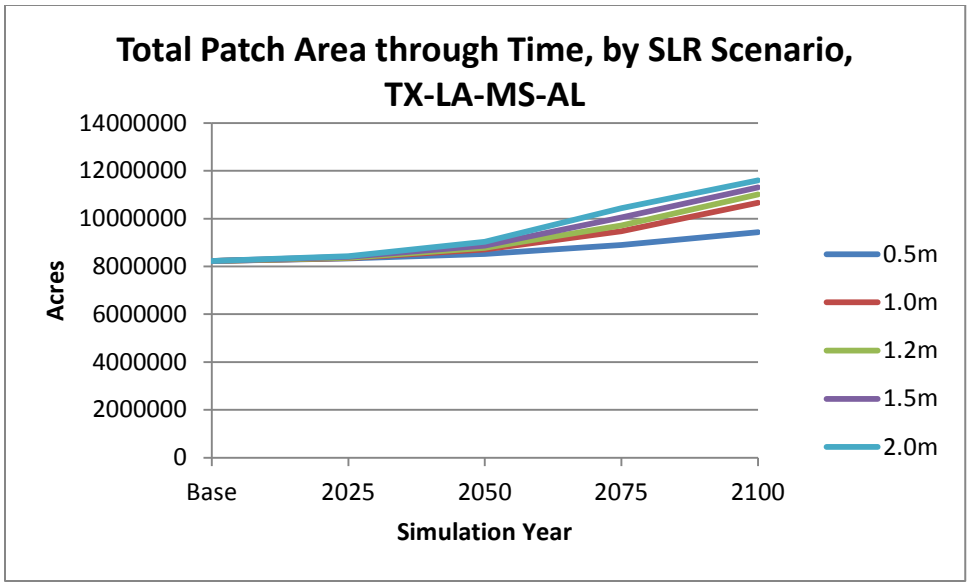

Figure 34. Trends in total area of mottled duck Estuarine Open Water habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

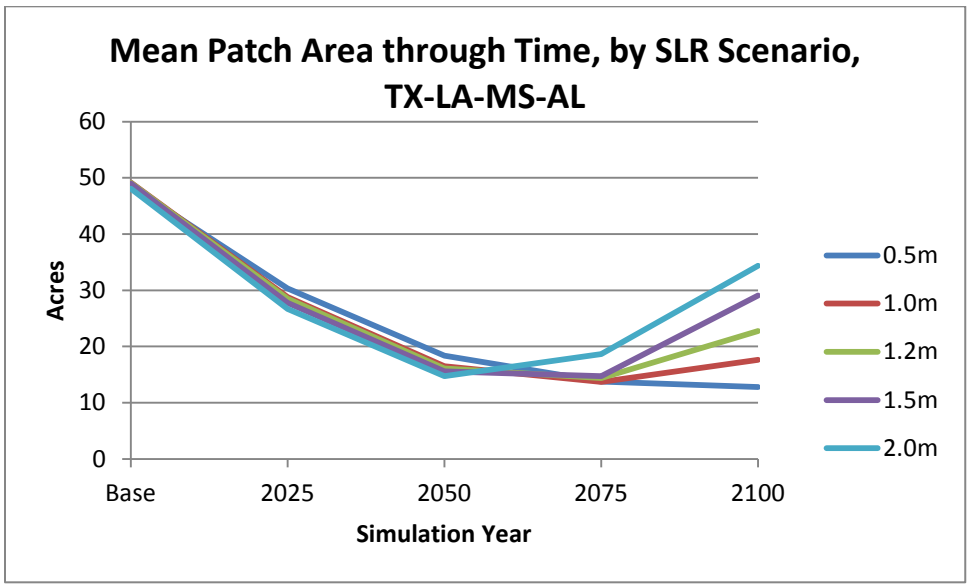

Figure 35. Trends in mean area of all mottled duck Estuarine Open Water habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

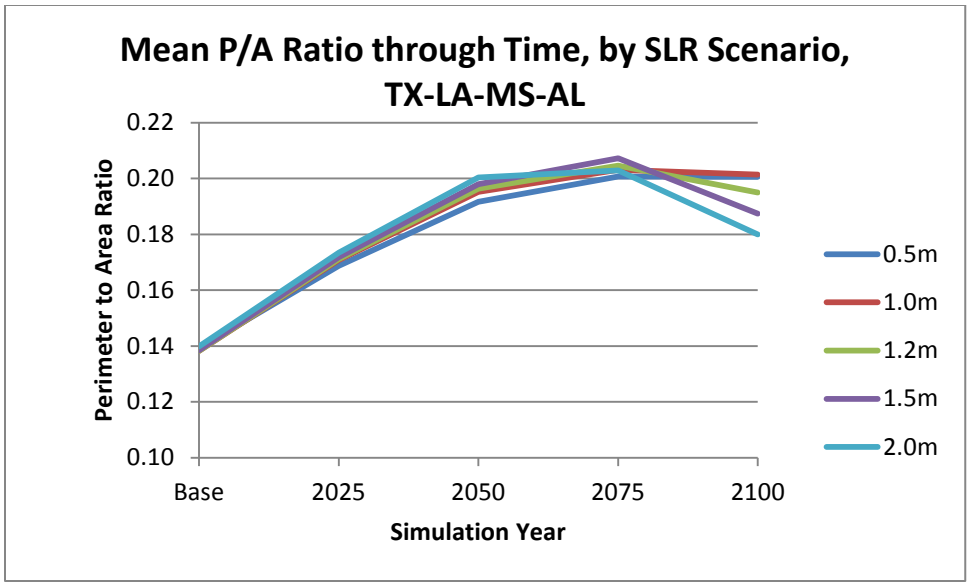

Figure 36. Trends in mean perimeter to area (P/A) ratio of all mottled duck Estuarine Open Water habitat patches in the TX-LA-MS-AL region through time, by sea level rise scenario.

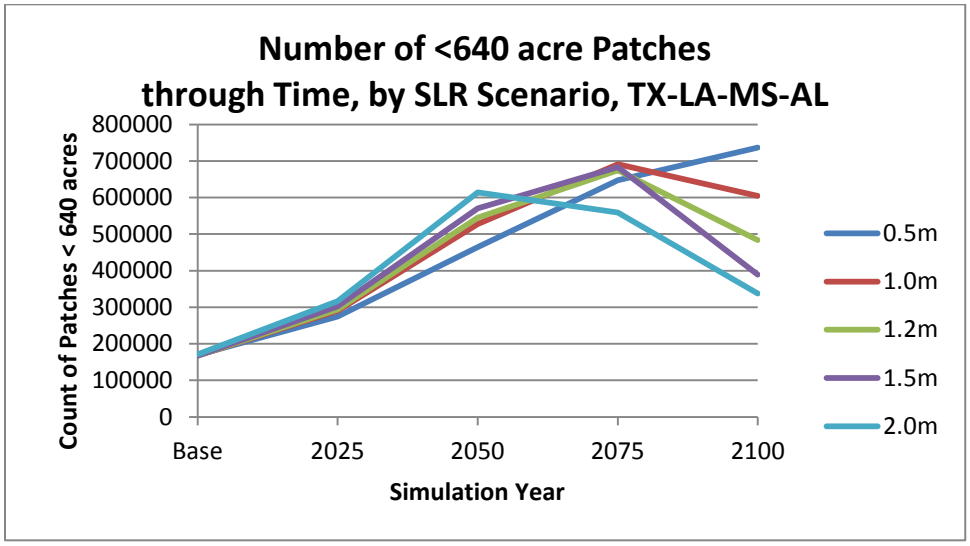

Figure 37. Trends in number of significant mottled duck Estuarine Open Water habitat patches (those less than 640 acres) in the TX-LA-MS-AL region through time, by sea level rise scenario.

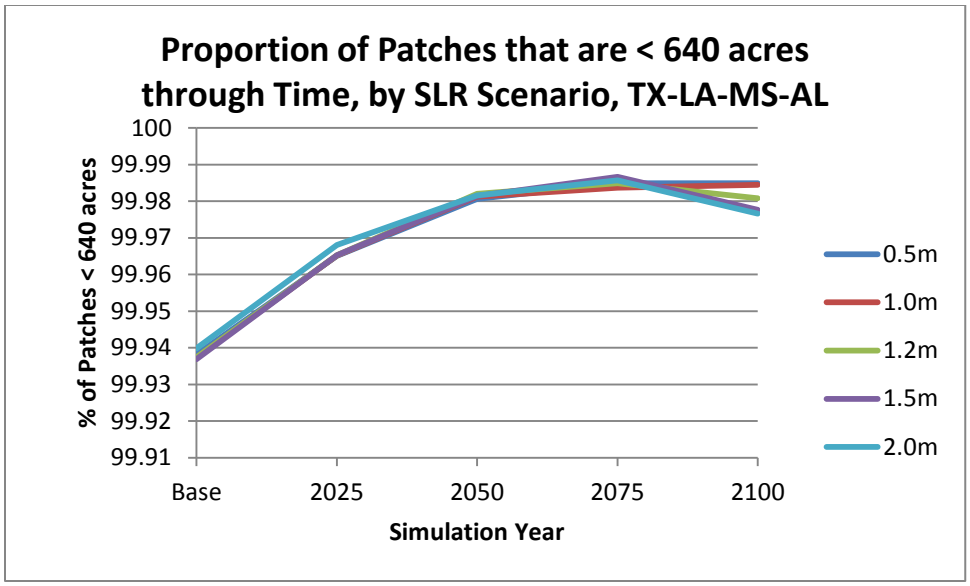

Figure 38. Trends in proportion of mottled duck Estuarine Open Water habitat patches that are significant (those less than 640 acres) in the TX-LA-MS-AL region through time, by sea level rise scenario.

Unlike SLAMM classes that generally lose area under SLR scenarios, Estuarine Open Water typically gains area due to losses in Estuarine Beach, Tidal Flat and tidal marsh at lower elevations (levels in the tidal frame). Thus, the trends predicted for the mottled duck Estuarine Open Water WHRM metrics are much different than those presented for its estuarine marsh habitat, or that of the seaside sparrow.

Several observations follow about the changes in mottled duck's WHRM Estuarine Open Water habitat metrics in the TX-LA-MS-AL region of the study area:

- The patch count (Figure 33) at 2100 is considerably higher than baseline conditions, for all SLR scenarios. For the 0.5m SLR scenario, the increase in patch count is relatively steady, with a 2100 endpoint well over 3x baseline level. For the 1.0m, 1.2m, and 1.5m scenarios, the peak is predicted to occur at year 2075 at about 3x of baseline, on average. For 2m scenario, the patch count peak occurs earliest, by year 2050. By 2100, the relative numbers of patches are inversely proportional to the magnitude of the SLR scenario.
- The total patch area (Figure 34) show modest increases through time, relative to trends in total patch count. Given the impetus for gains in Estuarine Open Water, the increases are, not surprisingly, directly proportional to the magnitude of the SLR scenario, with the smallest (15%) for the 0.5m scenario, and the largest (41%) for the 2.0m scenario.
- As explained above, for the Florida region of the study area, this pattern in patch count trends can be explained by the initial creation of many non-contiguous pockets of Estuarine Open Water, which later become connected. This phenomenon is evident in the mean patch area (Figure 35) trends, which are the converse of the patch count trends: by 2100 the

relative areal size of patches is directly proportional to the magnitude of the SLR scenario. Thus, while the magnitude of change in total patch area is not huge, there are obviously large changes in the spatial configuration of these patches across the estuarine landscape, as with the Florida region.

- The trends in mean P/A ratio among SLR scenarios (Figure 36) exhibit a pattern that is also consistent with the hypothesized changes in patch size distribution and configuration. The trend pattern is almost identical to that of the patch count, and opposite that of the mean patch area.
- The magnitudes and trends in significant-habitat (<640 acre) patch count among scenarios through time is nearly identical to that of Figure 37 Again, the hypothesis of "increased connectivity of Estuarine Open Water patches through time and with increased SLR" explains this pattern, and is evident in the final graph (Figure 38) which exhibits the general pattern seen for mean patch area.

Black Skimmer

As presented in Table 5, metrics were generated for the black skimmer's habitat of combined Estuarine Beach and Ocean Beach areas. Trends in metrics for this habitat type are presented in the following series of graphs, Figures 39-42.

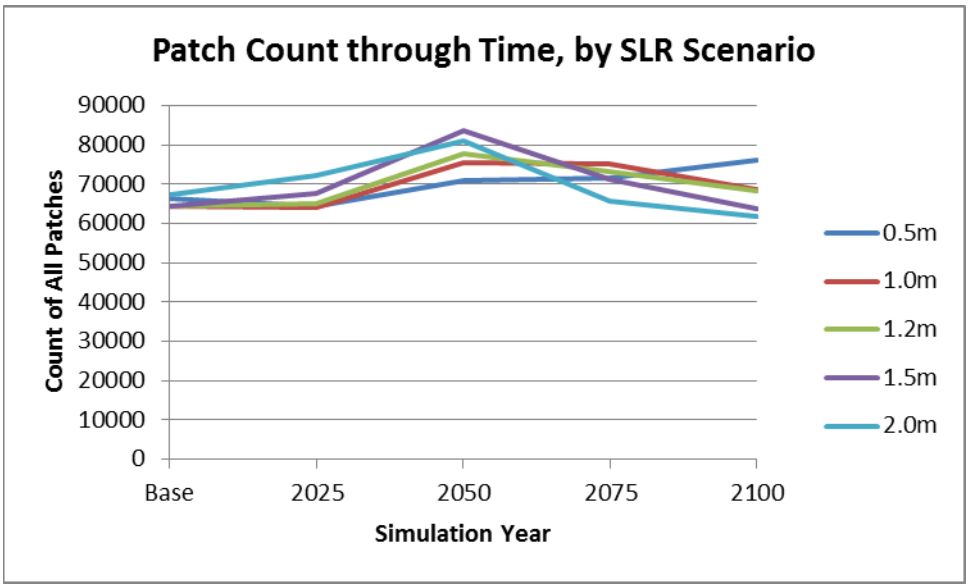

Figure 39. Trends in count of all black skimmer beach habitat patches through time, by sea level rise scenario.

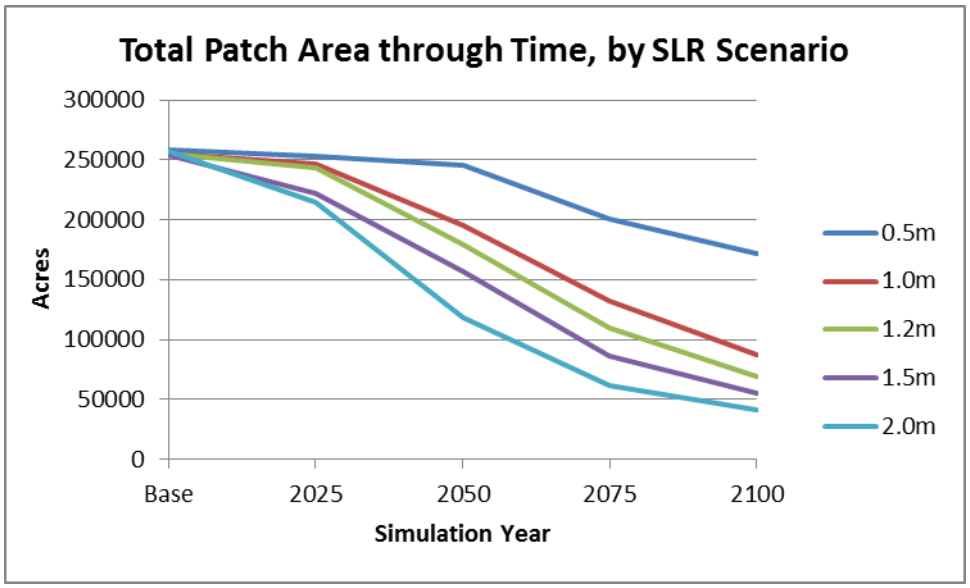

Figure 40. Trends in total area of all black skimmer beach habitat patches through time, by sea level rise scenario.

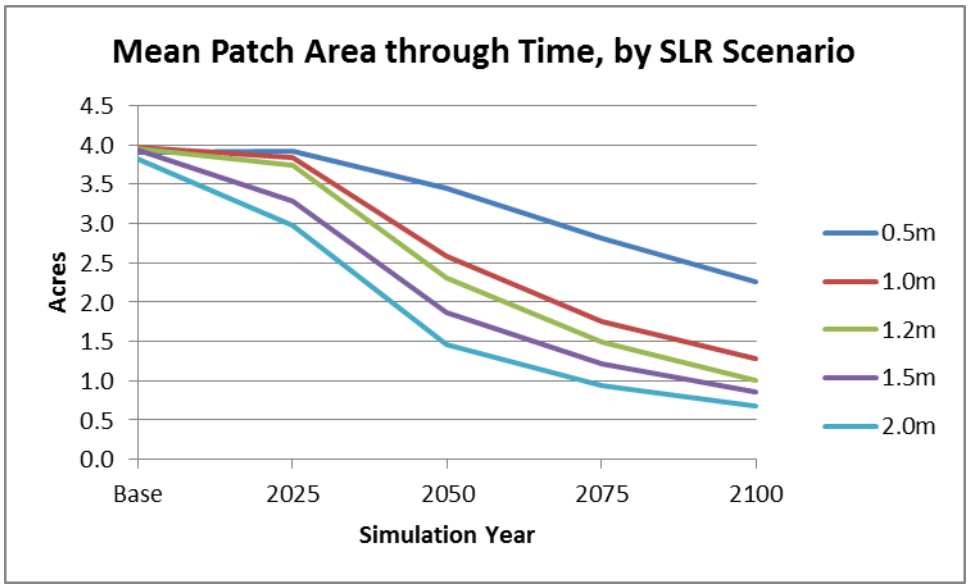

Figure 41. Trends in mean area of all black skimmer beach habitat patches through time, by sea level rise scenario.

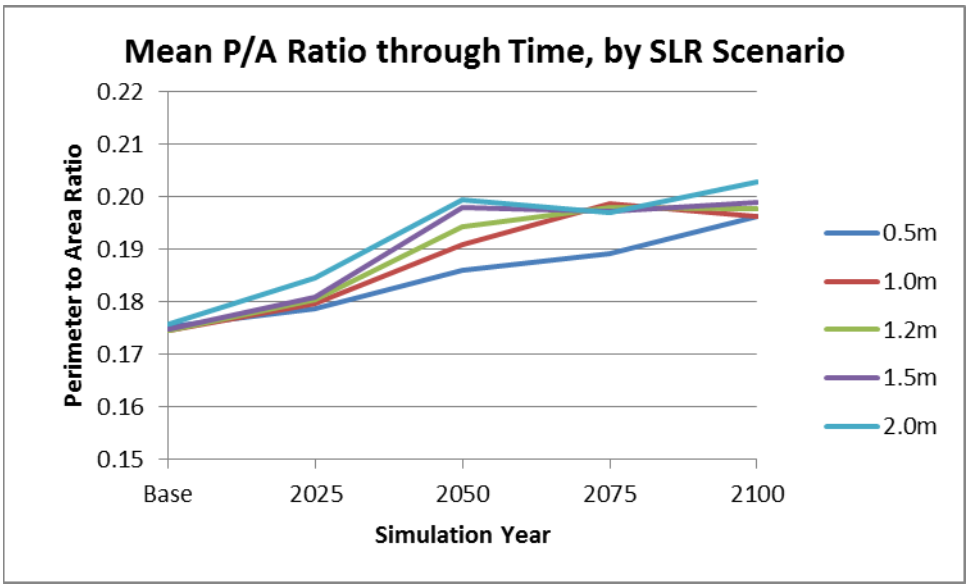

Figure 42. Trends in mean perimeter to area (P/A) ratio of all black skimmer beach habitat patches through time, by sea level rise scenario.

As evident in Tables 8-12, the magnitude of the total area of Estuarine Beach is over eleven times that of Ocean Beach at the simulation baseline (time zero). Thus, the overall patterns in trends that are presented here for the black skimmer "beach" WHRM metrics, with the two SLAMM classes combined, closely resemble those of the Estuarine Beach class.

The noteworthy results for the changes in black skimmer WHRM metrics are as follows:

- The trends in patch count among all SLR scenarios (Figure 39) over the entire simulation period are similar and, on average, increase less than 4%.
- The trends in total patch area through time (Figure 40) are all negative and substantial, and correspond in magnitude with the amount of SLR. Considering all but the smallest SLR scenario, losses range from 66% for the 1.0m to 84% for the 2m SLR scenario. There appears to be a threshold after the 0.5m SLR scenario, as its loss is only 34%.
- The pattern of trends in mean patch area through time (Figure 41) very closely corresponds to that of total patch area, with the very similar percentagewise losses. The one major difference is the sharp decline across all SLR scenarios from year 2025 to 2050, save the 0.5m scenario.
- The trends in patch count among SLR scenarios (Figure 39) help explain this sharp decline. For all scenarios, between years 2025 and 2050, there is a noticeable increase in (17%, on average) in the number of patches, which is the denominator in the mean patch area metric. The reason for this change is likely the fragmentation of larger beach patches, separated at points that are lower in elevation. The increase in patch count within the 2025-2050 period is followed by either a stabilization of patch count for the three smaller SLR scenarios, or a

sharp decrease for the 1.5m and 2.0m scenarios. It is likely that the fragmentation is followed by the inundation of a number of smaller patches of relatively low elevation.

- The above hypothesis is supported by the trends evident in the mean P/A ratios among SLR scenarios (Figure 42). Note the peaks in patch count occurring at the 2050 condition for the 1.5m and 2.0m scenarios, and the direct correlation for all scenarios between the magnitude of SLR and the patch count (save for the 2m scenario, which likely peaked at some point in time between 2025 and 2050). These same patterns are apparent in the P/A ratios, and would also be explained by a fragmentation/inundation process. Fragmentation would increase the patch count (more small patches with relatively high P/A ratios), then inundation would remove a substantial number of the smaller patches. While the results consistent with this hypothesized process are fully evident for only the 1.5m and 2.0m scenarios, the process does appear to be present, though logically lagged and more muted for the 1.0m and 1.2m scenarios. It is possible that (1) the process started under the 0.5m scenario, with evidence for fragmentation occurring during the 2075-2100 period, and (2) a further cycle could occur in later (post-2100) years.

Analysis of Low-quality Elevation Data Effects

The vast majority of the GCPLCC study area is covered with high-resolution LiDAR data, the exception being some inland regions in Florida and Alabama and the Dry Tortugas, FL. To test the extents of effects of non-LiDAR data on model predictions, tests were performed in two study areas. These tests have limited relevance to the current study but may be used to inform the interpretation of older analyses or studies in different regions that do not have LiDAR data available.

Low-elevation sensitivity tests were run on one site in Florida (Site 8) and one site in Texas (Site 19). In these locations LiDAR data were rounded to the nearest 3-meter elevations to reflect "simulated 10-foot contour data." For the Florida site, the LiDAR data were also rounded to the nearest 1.5 meter elevation to reflect "simulated 5-foot contour data," as most Florida contour maps have a 5-foot resolution. As DEMs derived from contour maps usually interpolate between the contours this artificial data set is likely somewhat worse than true contour-generated elevation data. Model results using the pre-processor were then compared to model results derived using LiDAR data.

The two primary observations from this analysis were that dry lands and swamps were predicted to be more resilient than when LiDAR data is used and that coastal marshes were predicted to be less resilient (Figure 43). These two observations are related because, in the low-quality analysis, the errantly high-elevations of dry lands do not permit the inland migration of coastal marshes. Additionally, the elevation pre-processor assigned regularly-flooded marshes to lower elevations than was measured by their LiDAR data. This indicates that the low marshes in these study areas had considerably more "elevation capital" (height relative to MTL) than would be predicted based on a strict assignment to tide ranges from McKee and Patrick (1988). The SLAMM pre-processor assumes that low marsh extends to 120% of the high-tide level (Figure 44).

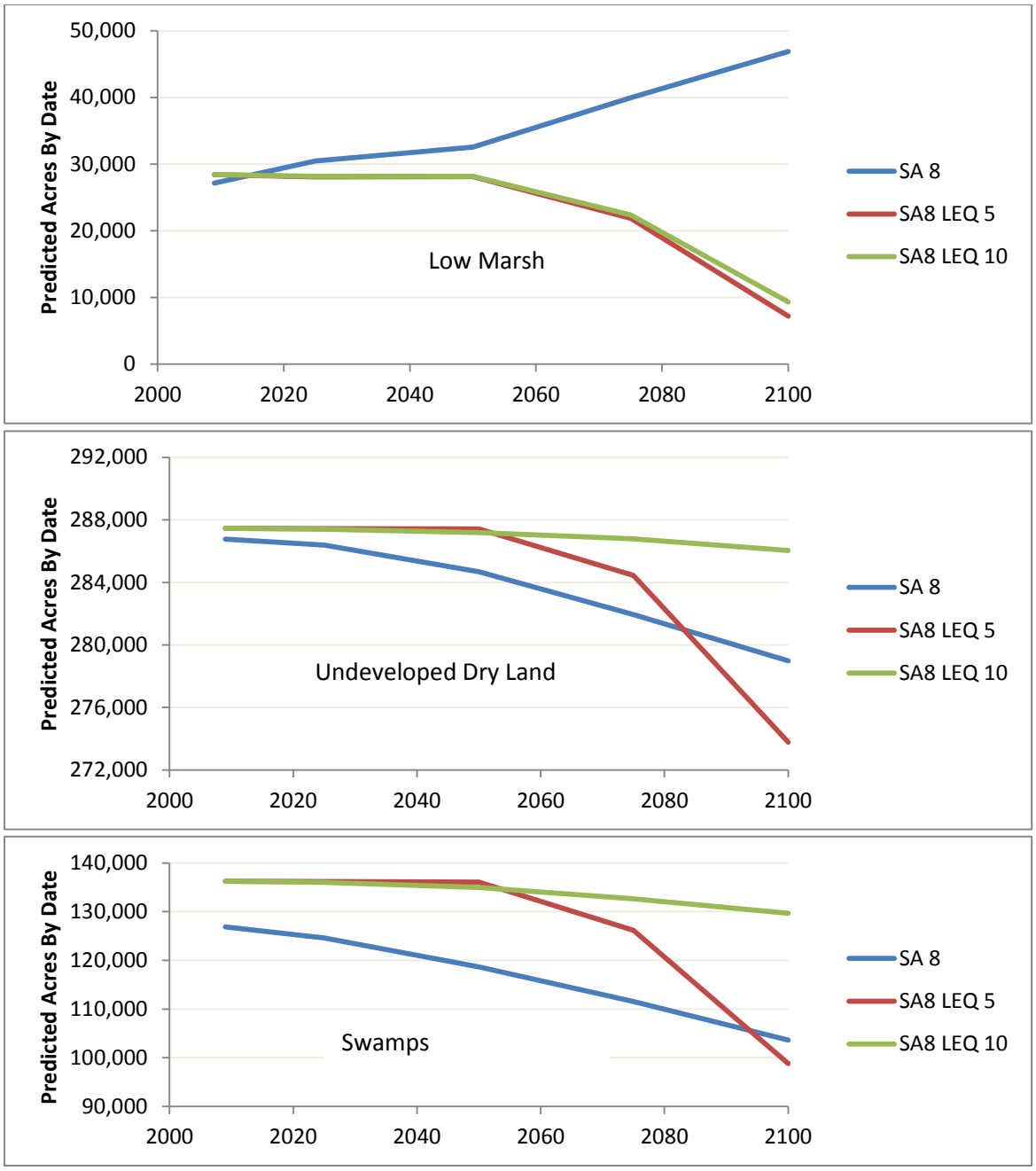

Figure 43. Predicted Low-Marsh, Dry-Land, and Swamp Fate for the 1-Meter Base Simulation (SA 8) vs Low Elevation Quality Analyses assuming 5- and 10-foot contours (LEQ 5 and LEQ 10).

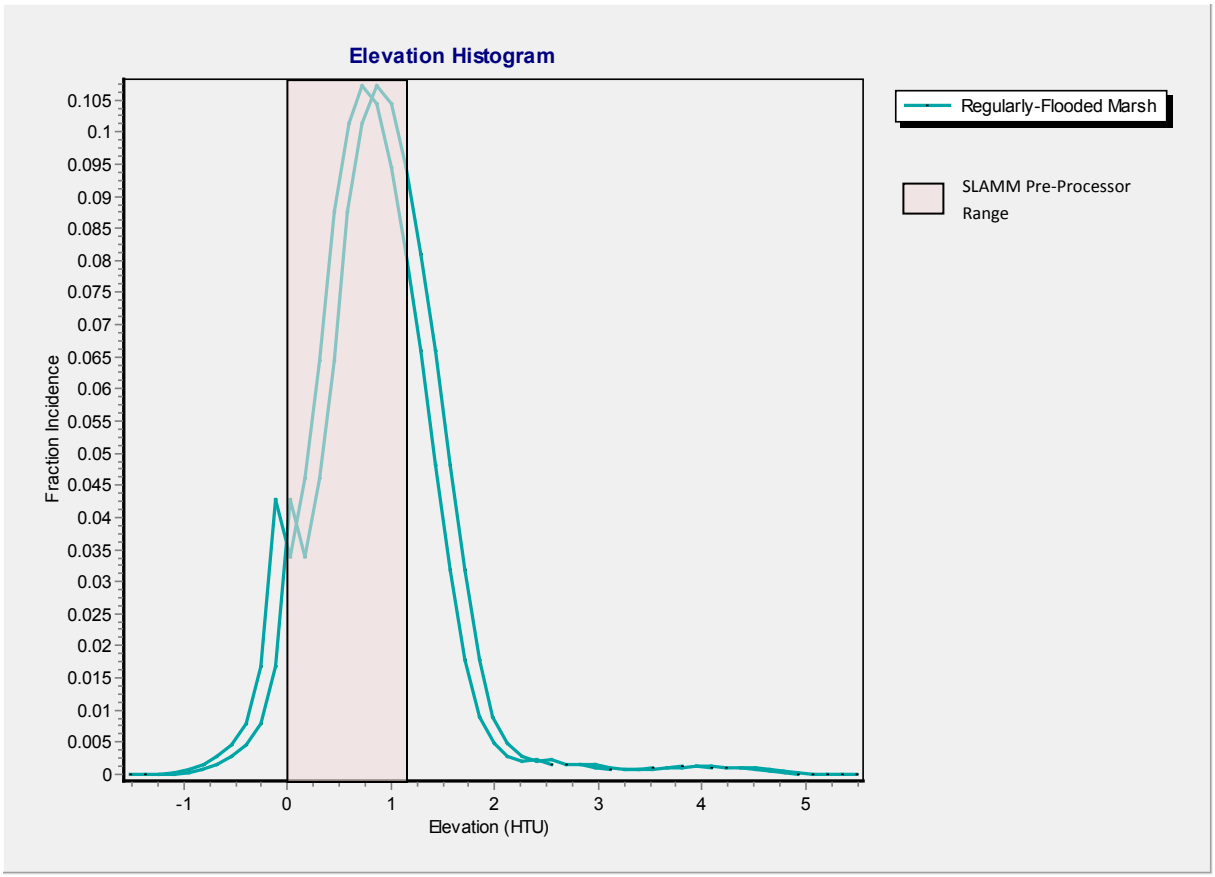

Figure 44. Comparison of SLAMM Elevation Pre-processor Assumption to Low Marsh LiDAR data for Florida Site 8

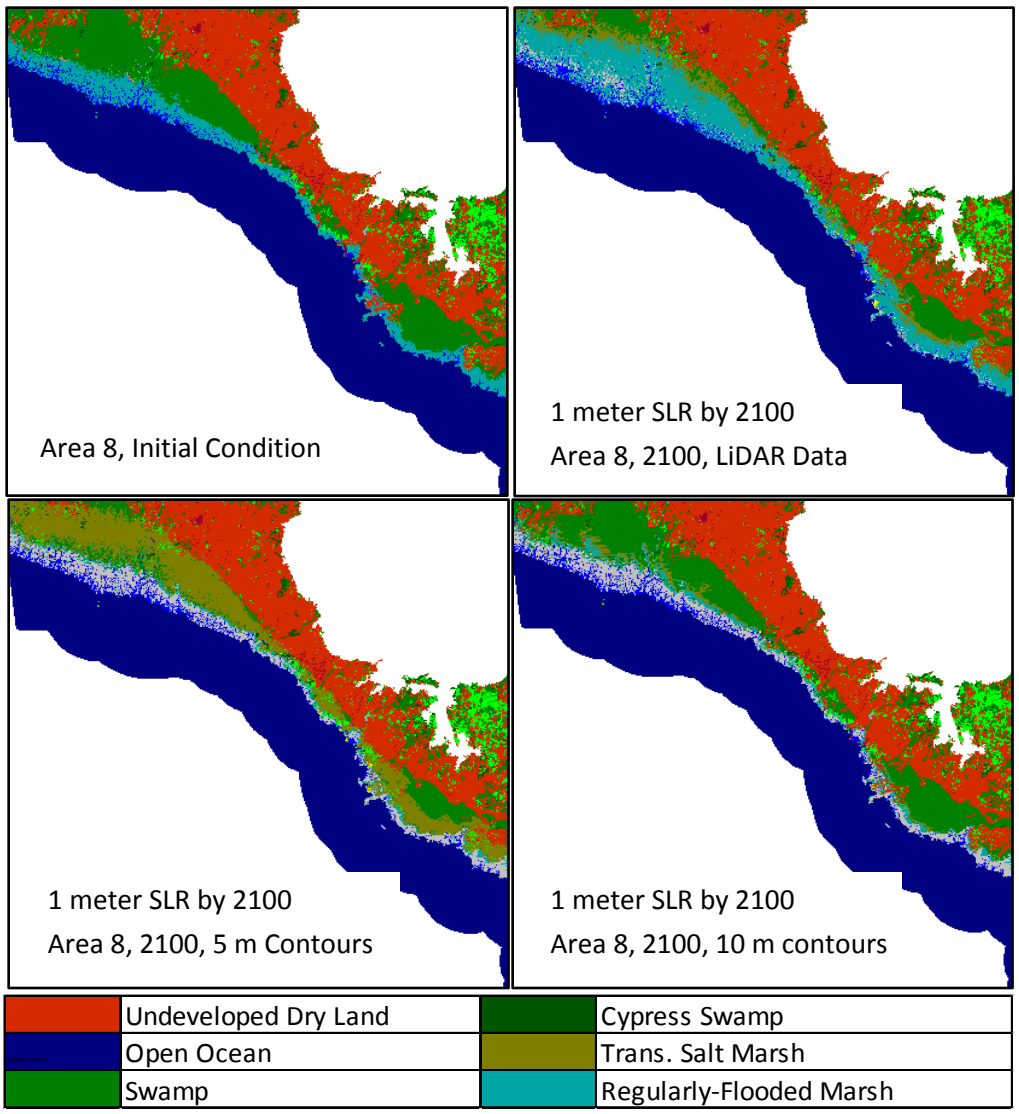

Figure 45. Comparison of Florida Site 8 (detail) Given Three Different Elevation Assumptions

Figure 45 shows an example of model predictions given the three different elevation data sets. These maps illustrate predictions in 2100 assuming 1-meter of SLR by that date. With LiDAR Data, currently-existing regularly-flooded marsh is expected to mostly persist and extensive migration into swamp lands is predicted. With 5-foot contours, most regularly-flooded marsh is predicted to be lost. Neighboring swamps have converted to transitional salt marsh but have not yet completed a transition to low marsh. With 10-foot contours, minimal conversion of neighboring swamp is predicted and nearly all regularly-flooded marsh is lost.

Results for the Texas site were similar if not more severe (Figure 46) as 5-meter contour data were generally not available in Texas, so this test was not run. However, the entire GCPLCC study area in Texas was covered with LiDAR making this exercise largely academic and ultimately unimportant

for the final results of this study. Nonetheless, it is important to notice how land cover projections under long term SLR are very sensitive to the quality of elevation data.

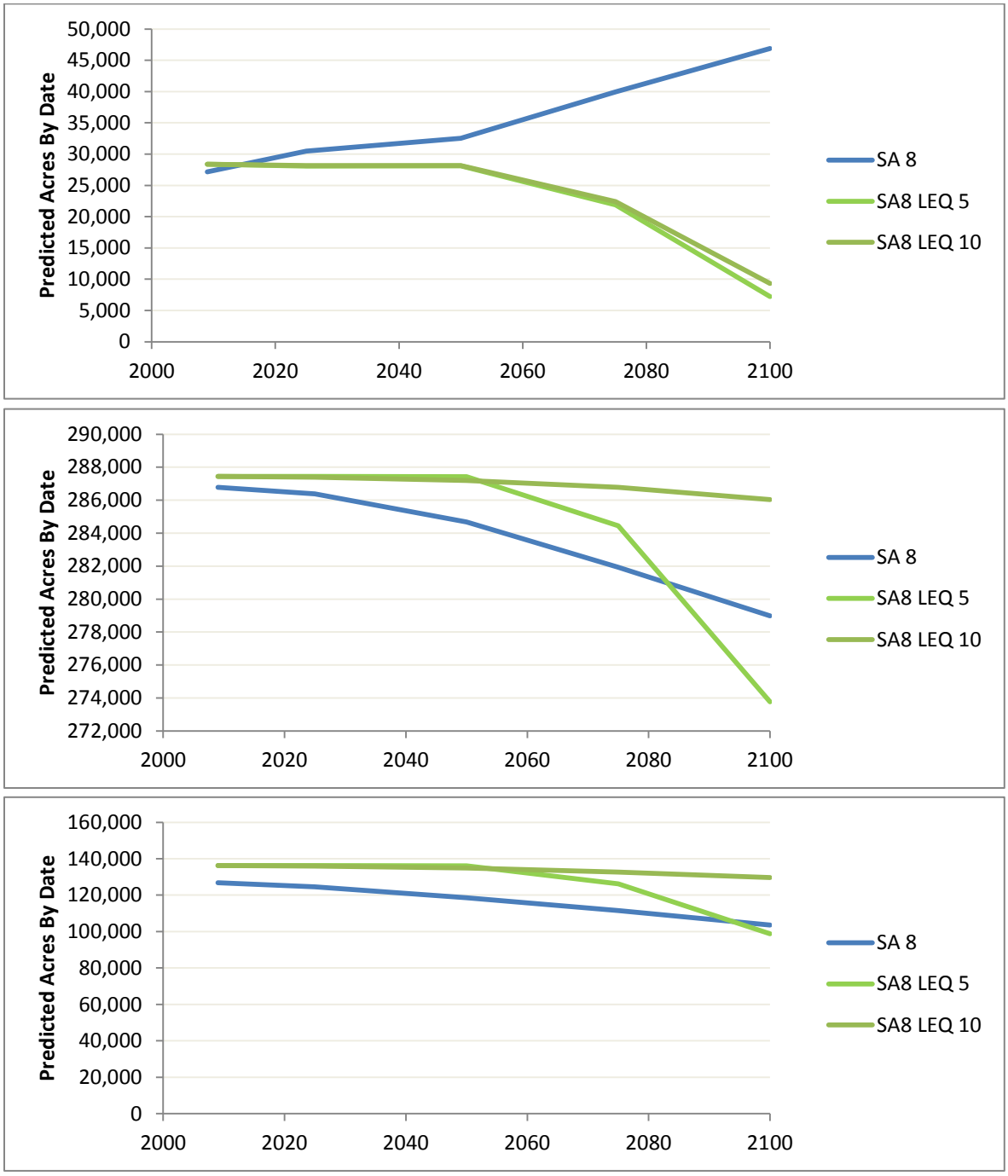

Figure 46. Predicted Low-Marsh, Dry-Land, and Swamp Fate for the 1-Meter Base Simulation (SA 19) vs Low Elevation Quality Analysis 10-foot contours (LEQ 10).

Conclusions and Perspectives

This application of the SLAMM model and its associated focal-species analysis provides a Gulf-wide dataset to support conservation and adaptation strategies in the face of accelerated sea-level rise. This modeling effort used the best currently-available input data for both spatial and parametric inputs. However, results reported herein possess a level of uncertainty that must be kept in mind when interpreting them. Uncertainty in future rates of sea-level rise has been well addressed by considering a range of different scenarios. However, the uncertainty associated with the spatial and parametric data inputs have not been incorporated and the robustness of the predictions has not been assessed with respect to these uncertainties.

The current Gulf-wide model application assumes that marshes will successfully migrate into all (non-diked) dry lands regardless of their current use, development status, or likely future protection. As such, the model is informative in terms of potential future marsh habitats, but likely overstates future marsh resilience to sea-level rise, numerically. Evaluation of marsh-migration pathways in conjunction with likely future developed-land footprints (or a public vs. private-land overlay) may help to constrain model predictions. This analysis is a large step forward in creating a seamless model that is consistent in model assumptions and accretion-feedback modeling. It is anticipated that this work will provide useful data for policymakers and planners for years to come, based both on current model outputs and through additional derived products.

Recommended Data Uses and Caveats

The Sea-Level Affecting Marshes Model (SLAMM) is a valuable tool to quantify the potential changes in marsh communities under the stress of accelerated SLR. Because coastal wetlands provide a natural buffer against sea-level rise and its associated impacts, this project can constitute the basis to determine proper adaptation strategies for marsh conservation. Results can be analyzed spatially to identify areas in which proper land-use management can assist marsh maintenance and migration in order to maintain the ecological functions and buffering capacity wetlands provide. As an example, the following areas could be worth identifying:

- upland areas that are predicted to become wetland by 2100;
- large wetlands that are predicted to remain intact in 2100;
- wetlands that are predicted to be inundated (to prioritize available resources);
- marsh-migration pathways (to avoid in future development).

While the quality of data-layers used by SLAMM have considerably improved in recent years, input layers, parameter inputs, and the conceptual model continue to have uncertainties that should be kept in mind when interpreting these results. Perhaps most importantly, the extent of future sea-level rise is unknown, as are the drivers of climate change used by scientists when projecting SLR rates. Future levels of economic activity, fuel type (e.g., fossil or renewable, etc.), fuel consumption,

and greenhouse gas emissions are unknown and estimates of these driving variables are speculative. To account for these uncertainties, results presented here investigated effects for a wide range of possible sea level rise scenarios, from a more conservative rise (0.5 m by 2100) to a more accelerated process (2 m by 2100). However, to better support managers and decision-makers, the results presented here could also be studied as a function of input-data uncertainty to provide a range of possible outcomes and their likelihood. SLAMM includes a stochastic uncertainty analysis module that has been applied in New York and Connecticut, providing planners there a robust way to present and prioritize coastal flooding risks, marsh migration pathways, and marsh restoration projects (Warren Pinnacle Consulting, Inc. 2014, 2015). An analysis of this kind on the Gulf coast would leverage the existing SLAMM projects and deliver results that account for site-specific parameter data uncertainty, as well as the uncertainty associated with the spatial layers (DEM and VDATUM), and perhaps most importantly, the uncertainty in future SLR rates.

Another potential line of research would be to characterize the effects of SLR on road infrastructure and the effects that road barriers have on wetland migration. The SLAMM roads module, funded by USFWS, can clarify road and infrastructure effects on potential marsh migration pathways and the potential costs of infrastructure losses.

SLAMM results should be integrated with decision-making and decision-support tools that allow stakeholders to plan adaptation strategies for marsh conservation and coastal community resiliency. When integrated with time-varying model results, these tools can provide methods to aggregate stakeholder values in a meaningful and simple way and can explicitly include model uncertainty as part of the decision-making process.

Finally, the SLAMM model itself can provide a cost-effective means to evaluate the long-term effectiveness of proposed restoration activities under accelerated SLR conditions. Alternative management scenarios to enhance the adaptability of marshes and surrounding areas can be developed and evaluated. In particular, SLAMM projections can be produced for areas that would be restored through excavation and/or changes of hydraulic connectivity (such as building levees, raising roads, removing ditches, adding culverts, or restoring marshes). These projections can be used to examine the viability of these marshes under multiple scenarios of accelerated SLR.

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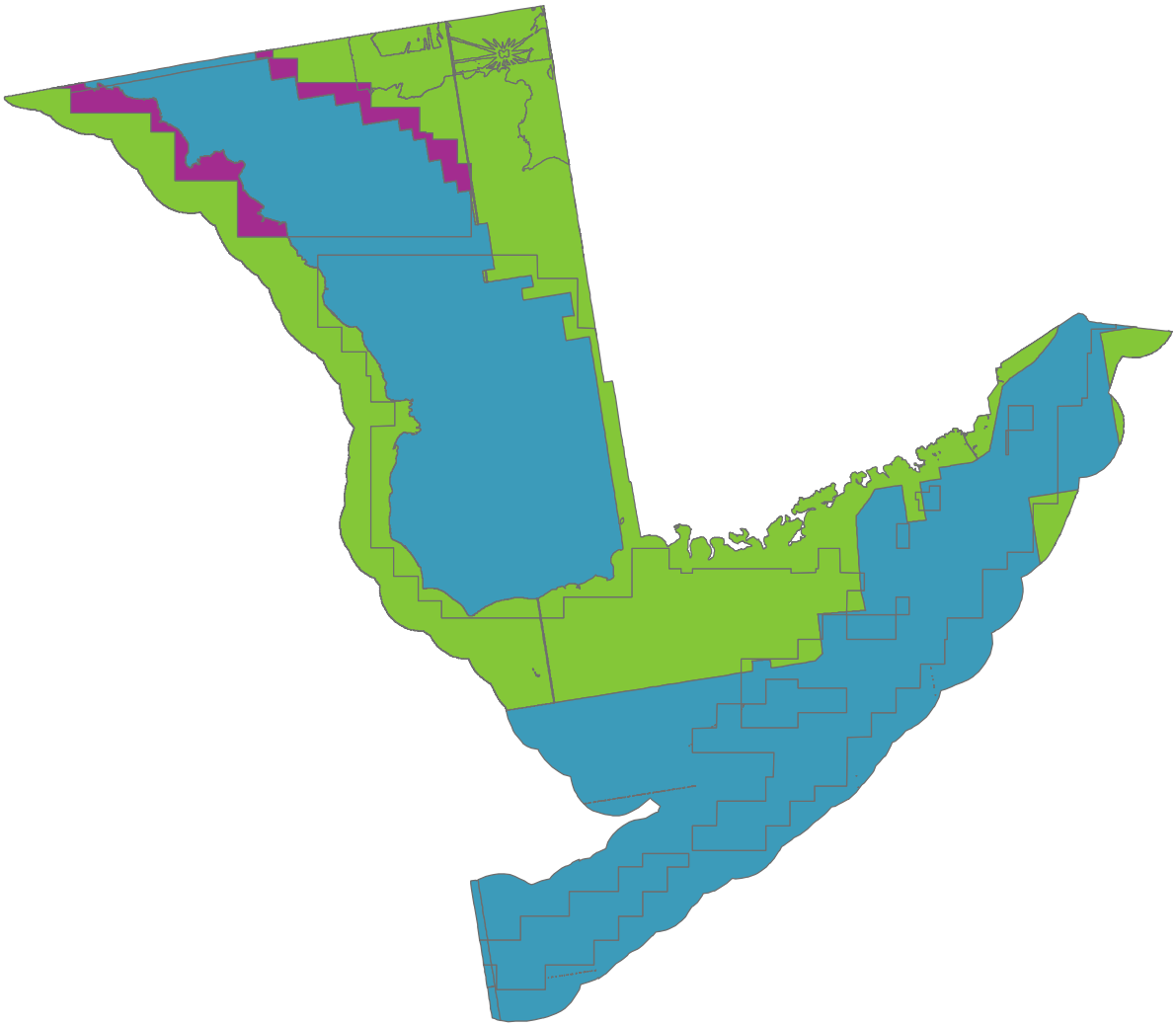
Appendix A – Elevation Data Sources

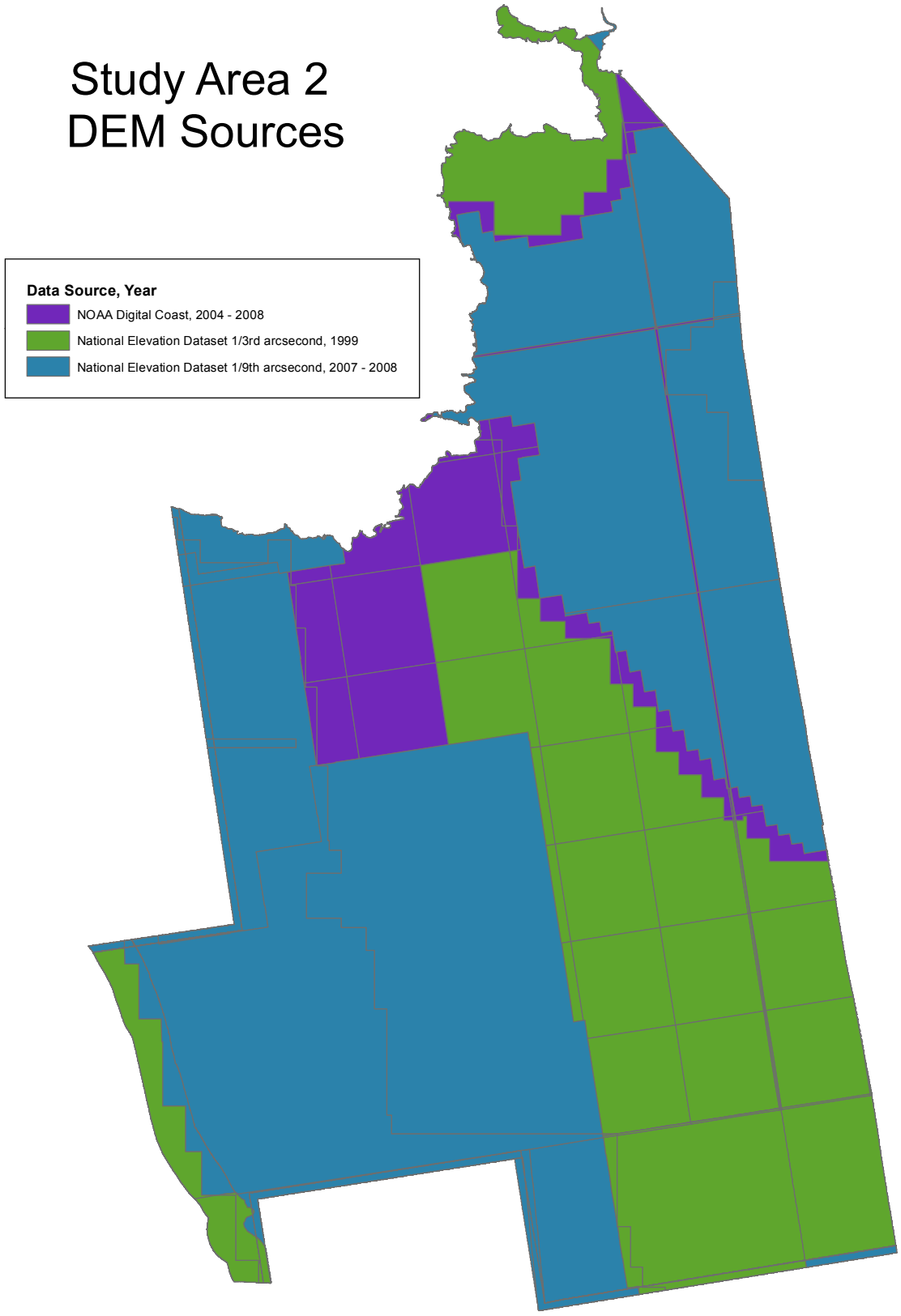
Study Area 1 DEM Sources



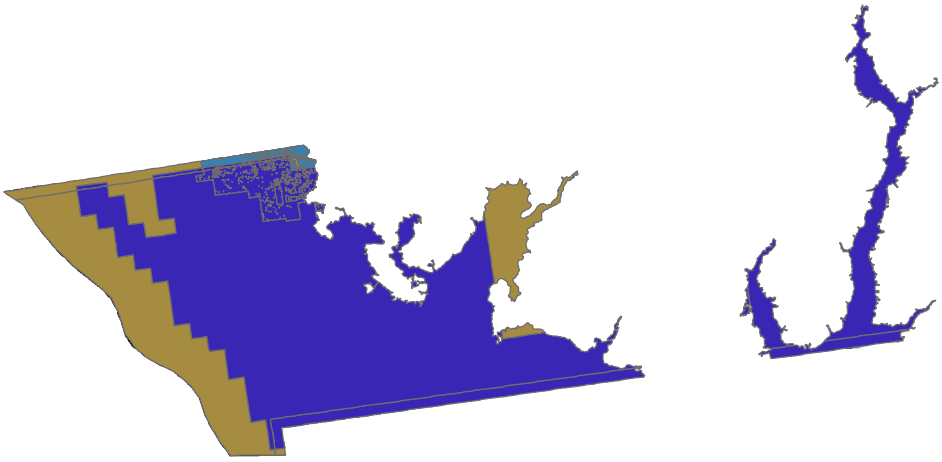
Data Source, Year

- NOAA Digital Coast, 2004 - 2008
- National Elevation Data Set 1/3rd arc second data, 1999
- National Elevation Dataset 1/9th arcsecond, 2007

Study Area 2
DEM Sources



Study Area 3 DEM Sources

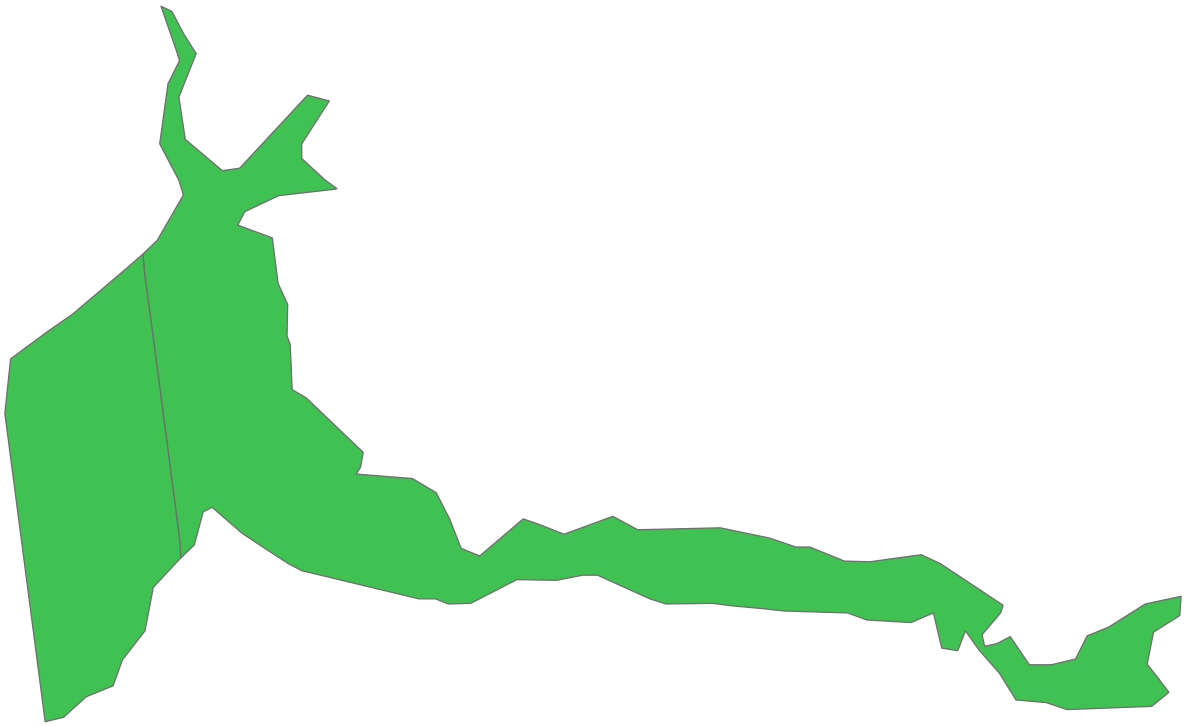


Legend

Data Source, Year

- NED 1/3rd Arc Second, 1999
- NED 1/9th Arc Second, 2008
- NOAA Digital Coast, 2007

Study Area 4, Elevation Data Sources



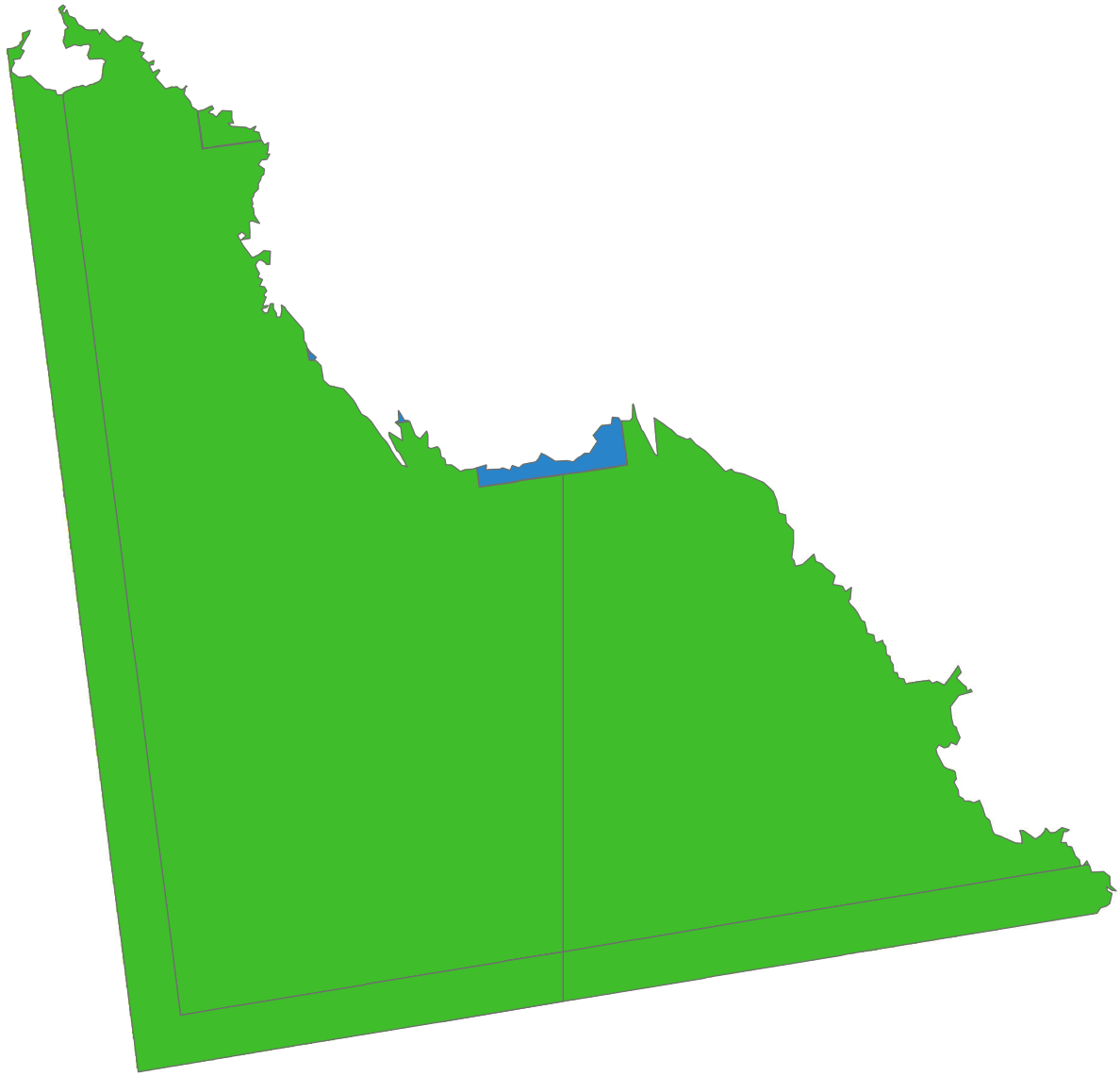
Data Source

National Elevation Dataset 1/9th arcsecond, 2007

Study Area 5 DEM Sources

National Elevation Dataset 1/9th arcsecond, 2009

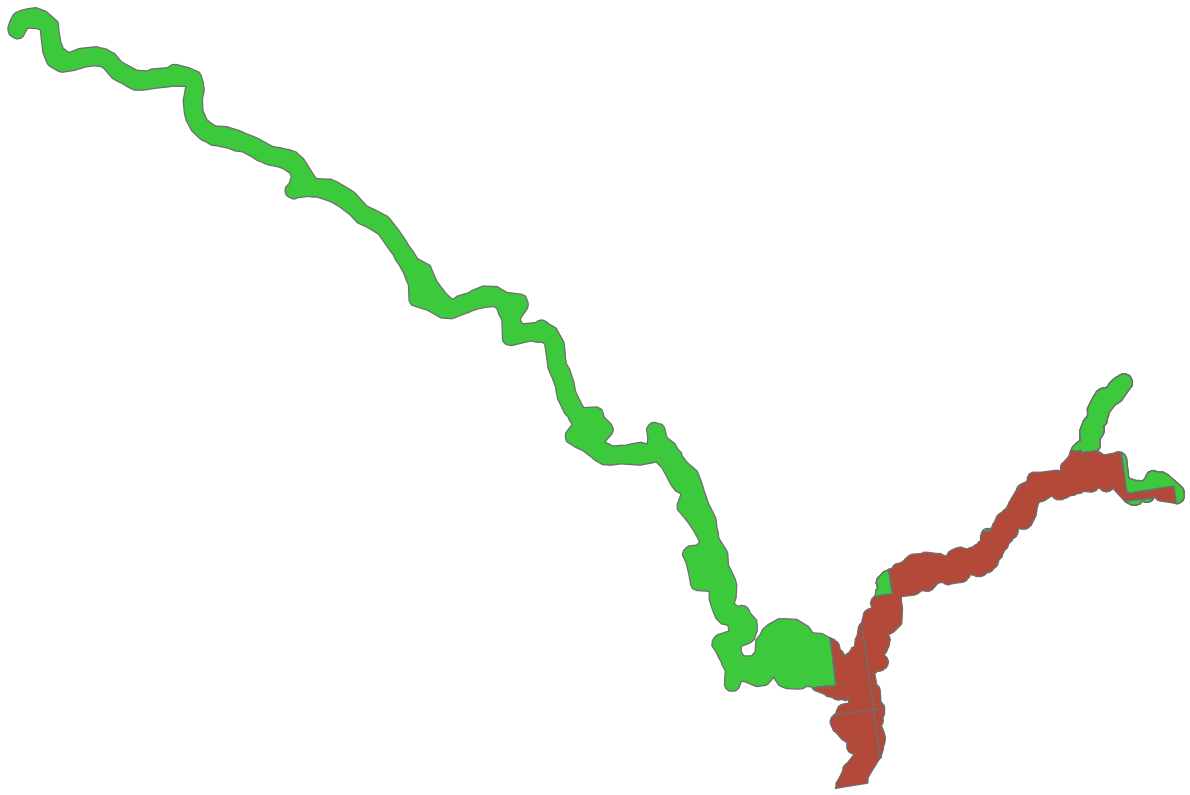
Study Area 6 DEM Sources



Data Source, Year

- National Elevation Dataset 1/3rd arcsecond, 1999
- National Elevation Dataset 1/9th arcsecond, 2007 - 2009

Study Area 7 DEM Sources

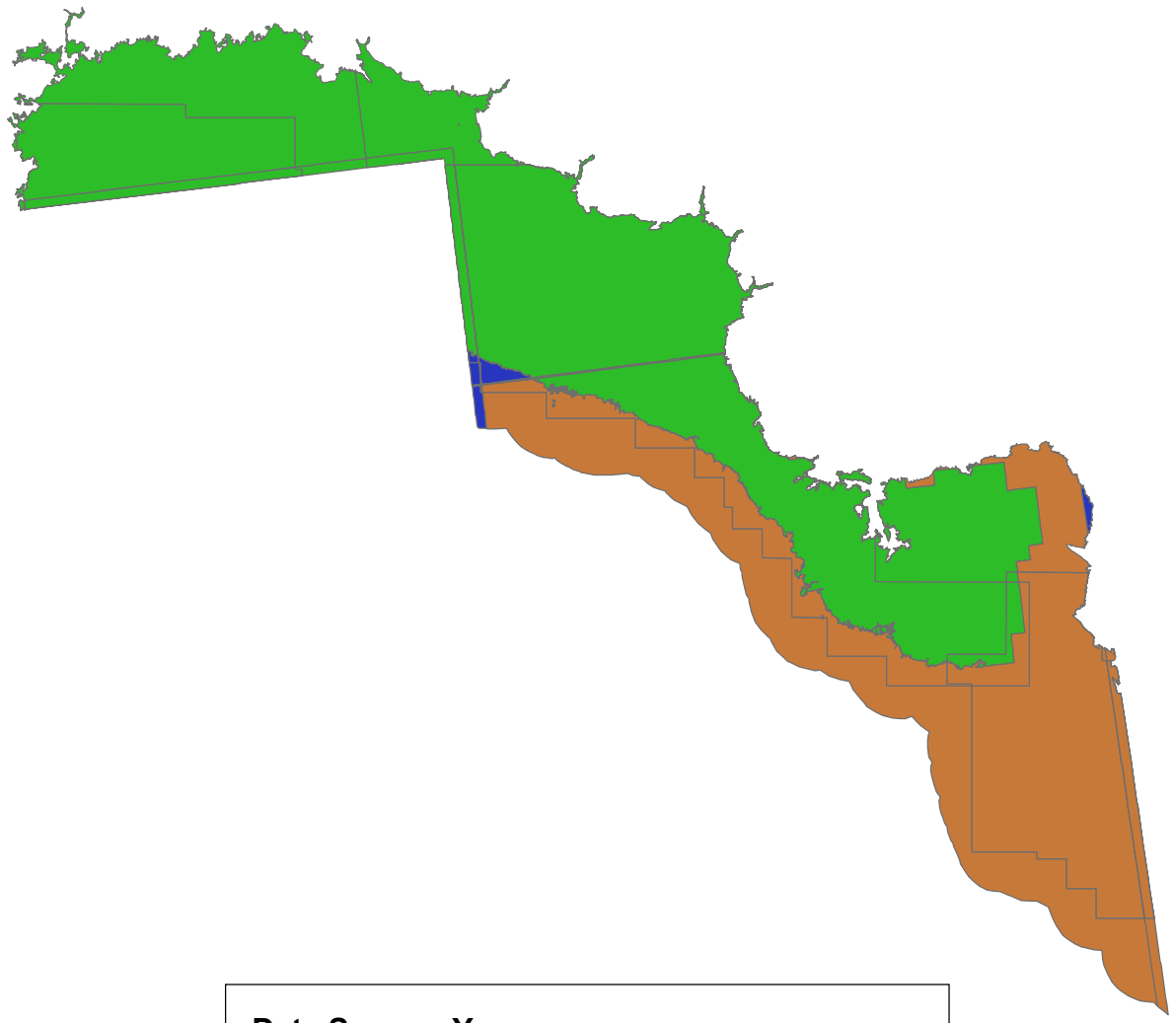


Data Source

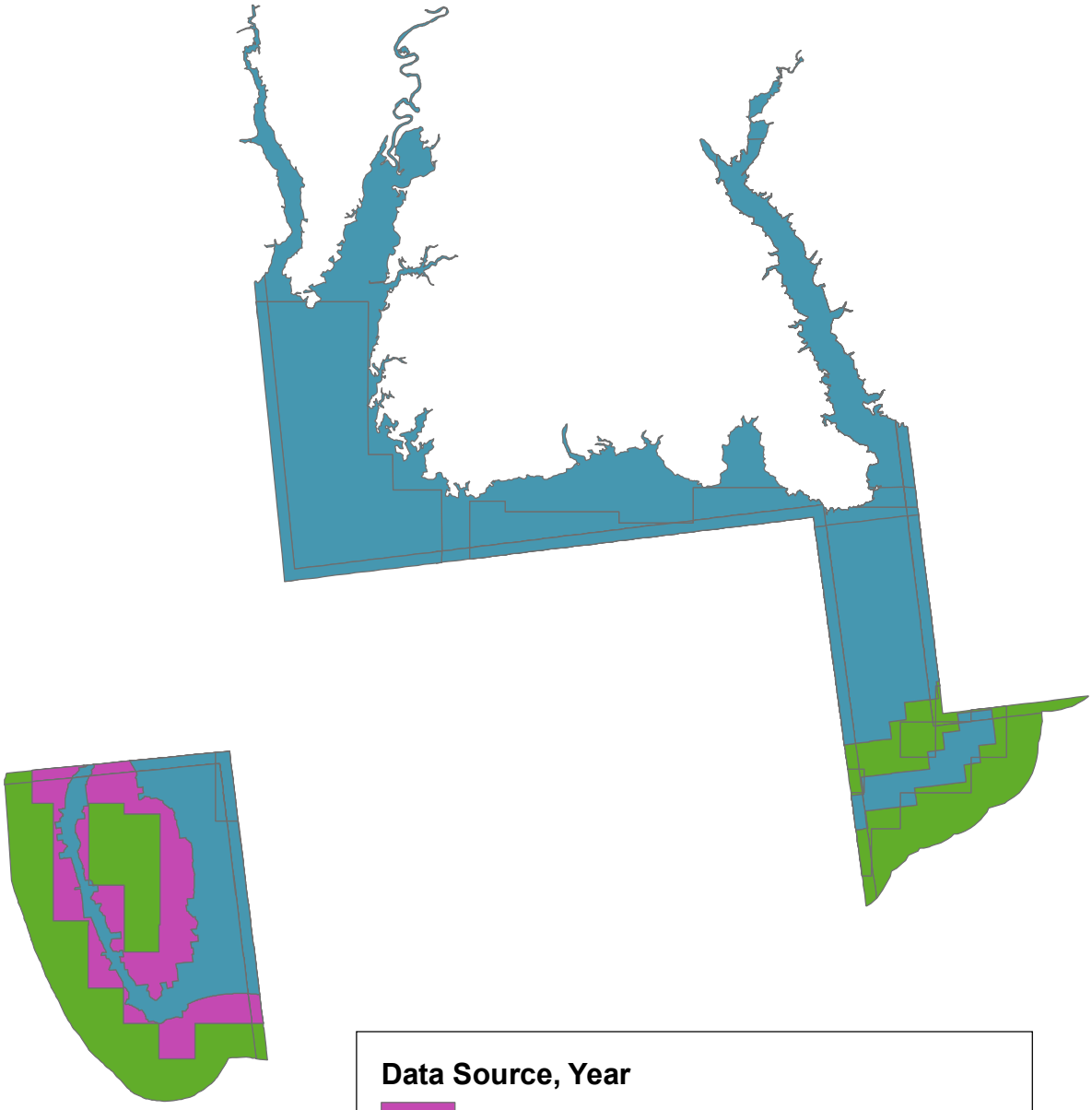
NOAA Digital Coast, 2008

National Elevation Dataset 1/9th arcsecond, 2008

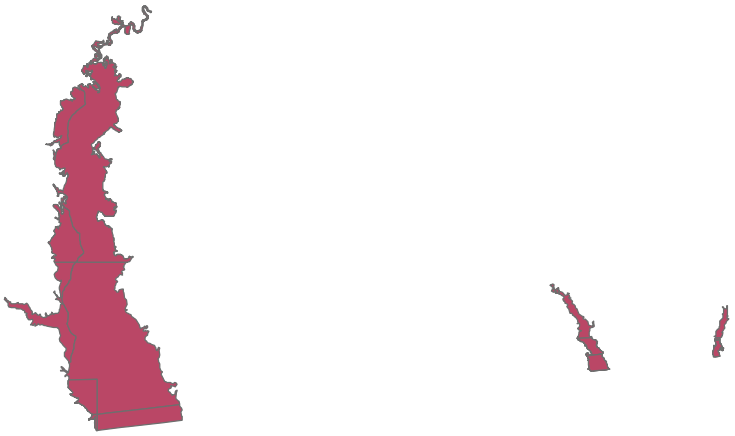
Study Area 8
DEM Sources



Study Area 9 DEM Sources



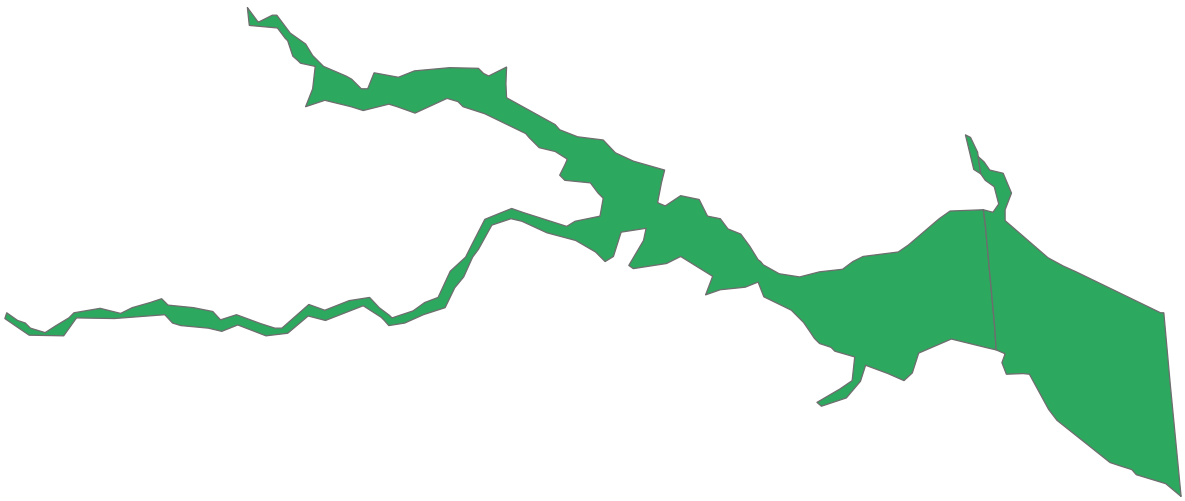
Study Area 10 DEM Sources



Data Source, Year

National Elevation Dataset 1/9th arcsecond, 2007 - 2009

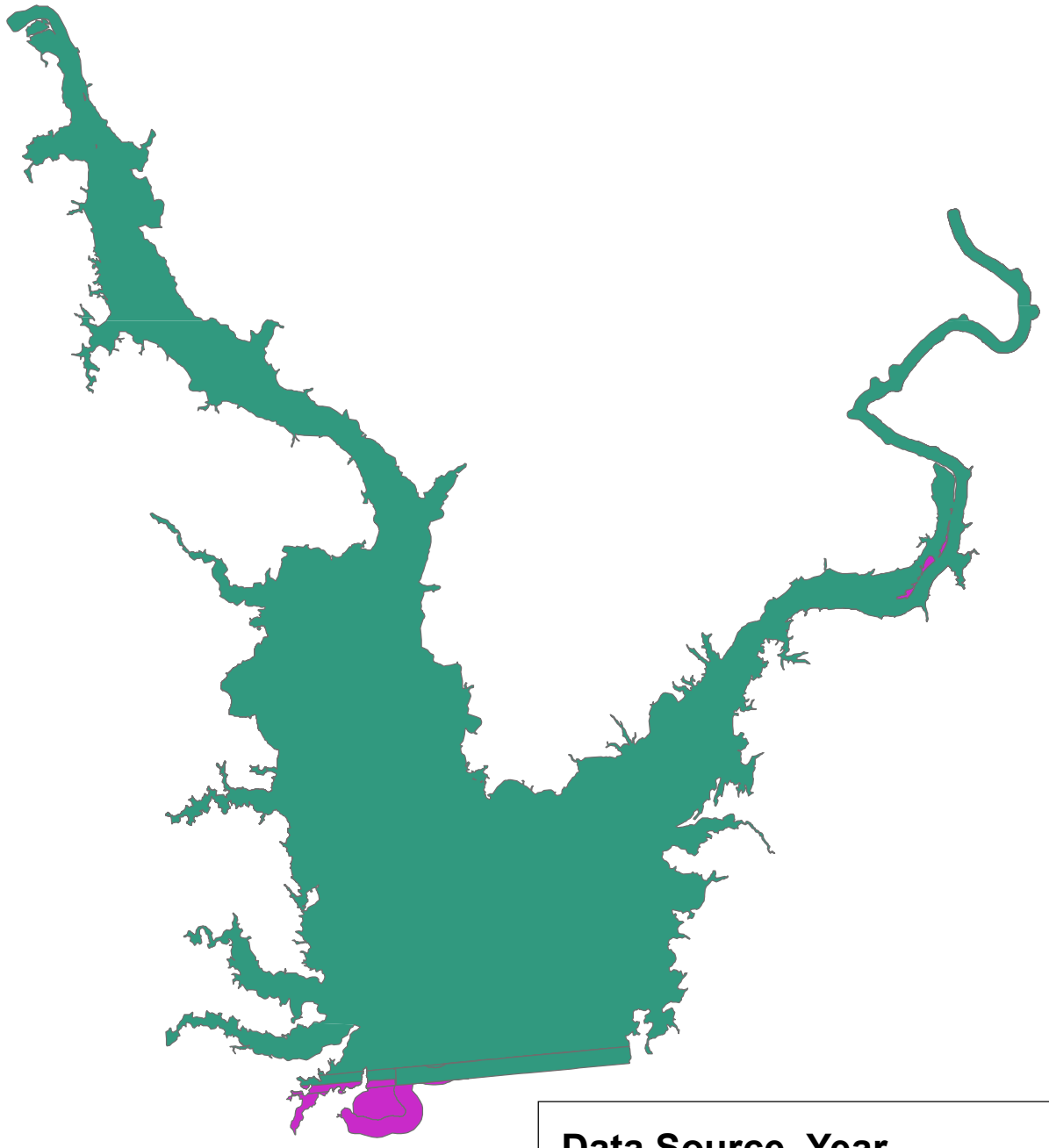
Study Area 11 DEM Sources



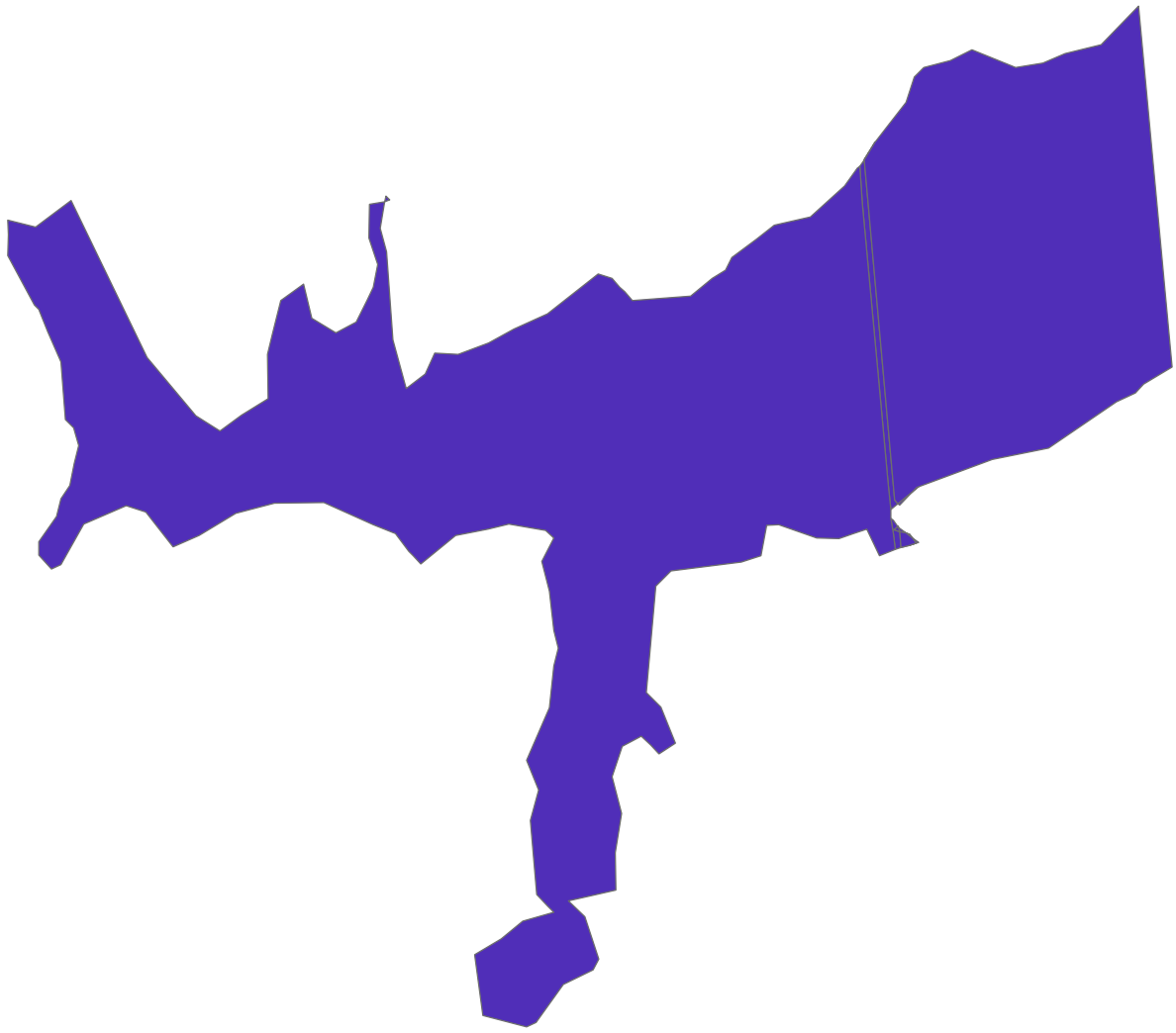
Data Source, Year

NED 1/9th ArcSecond, 2009

Study Area 12 DEM Sources



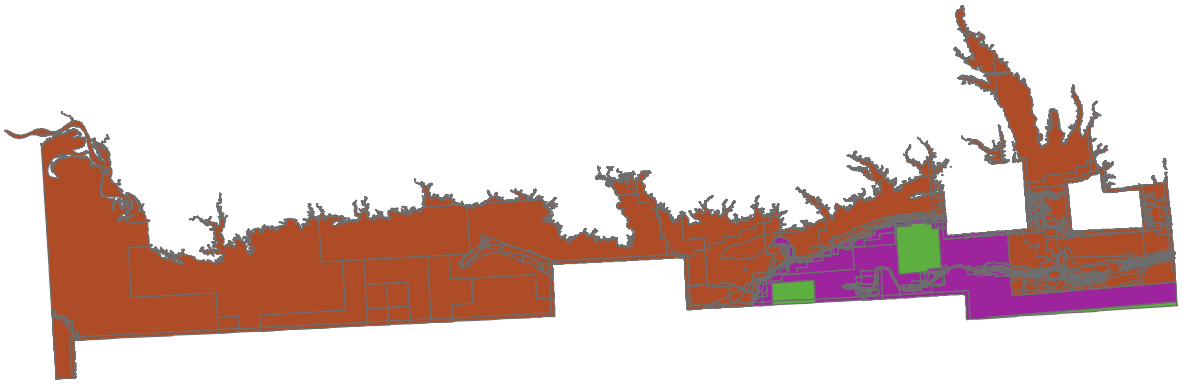
Study Area 13 DEM Sources



Data Source, Year

NED 1/9th ArcSecond, 2009

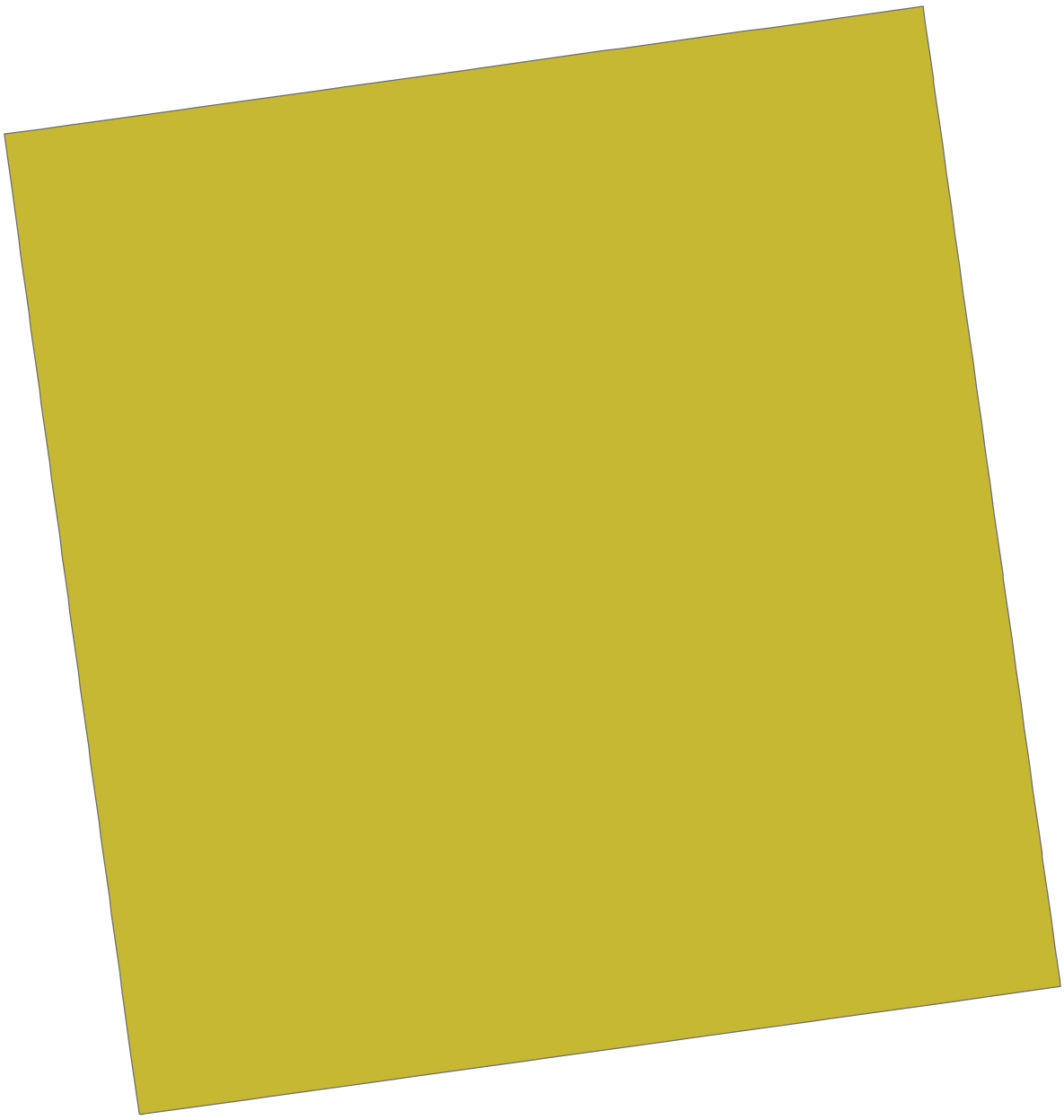
Study Area 14 DEM Sources



Data Sources, Year

- NED 1/3rd ArcSecond, 1999
- NED 1/9th ArcSecond, 2007 - 2009
- NOAA Digital Coast, 2004 - 2008

Study Area 16, Elevation Source Date



Data Source

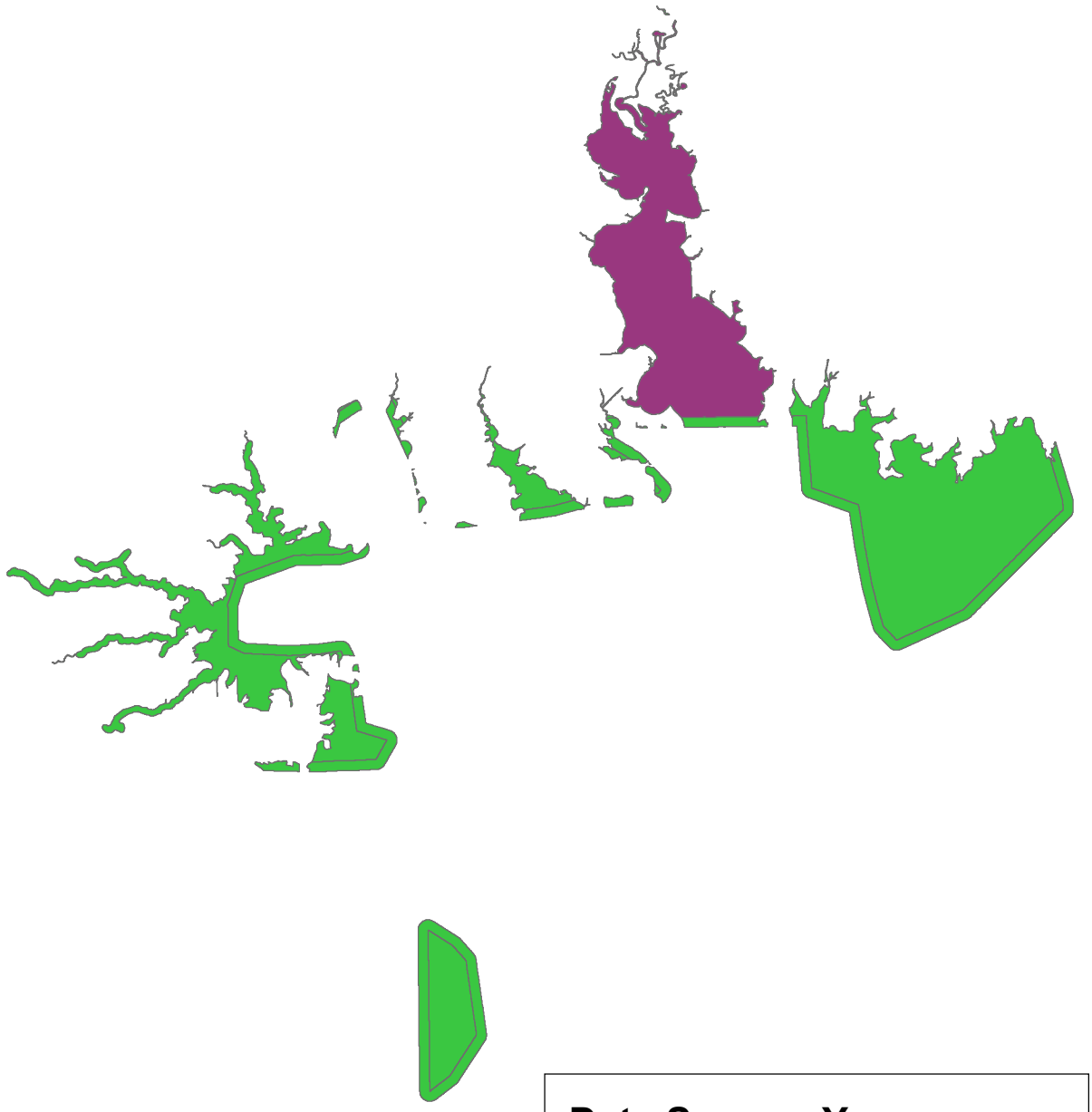
National Elevation Dataset 1/3rd arcsecond, 1999

Study Area 17 DEM Sources

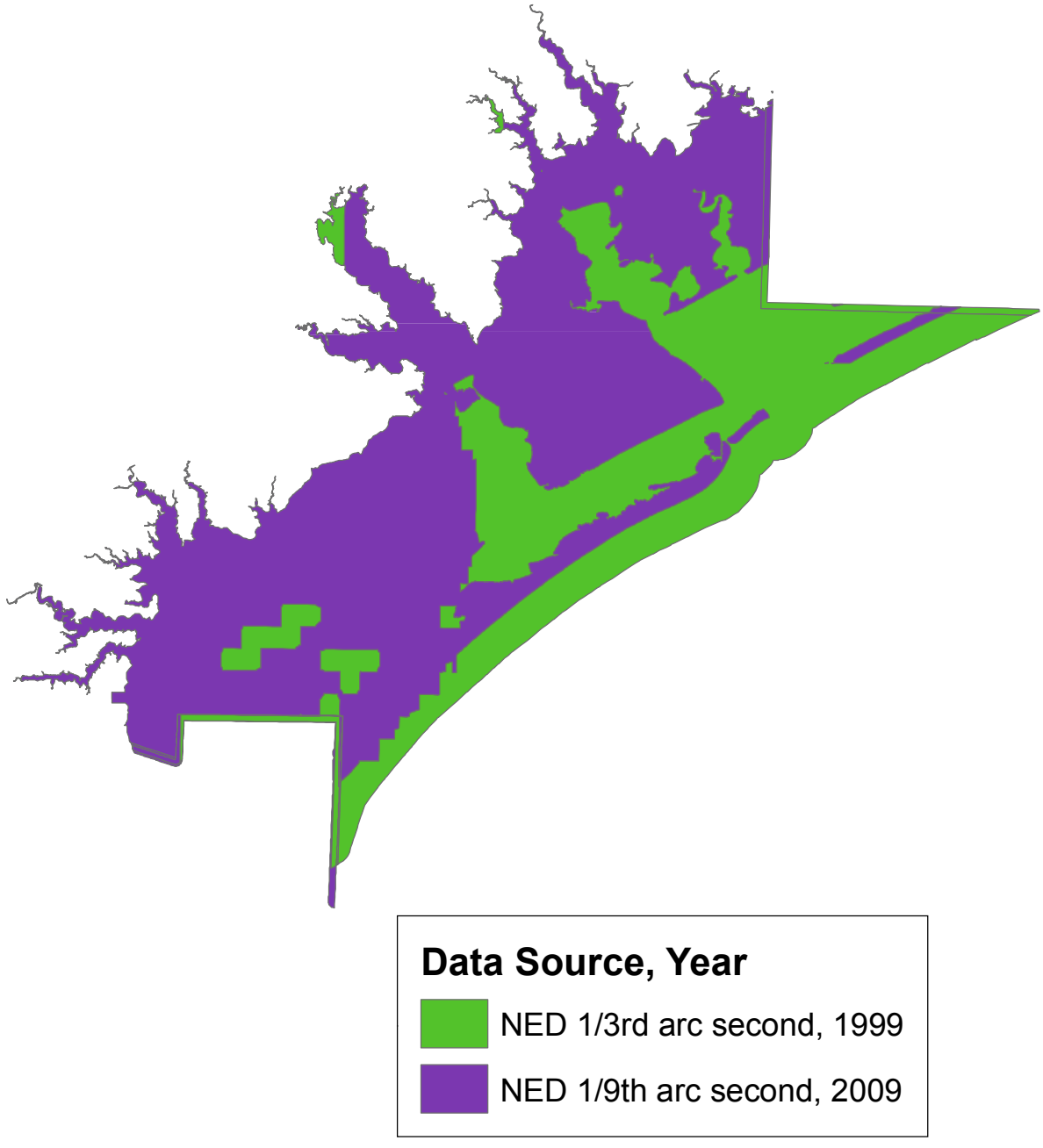
Data Source, Year

- NED 1/3rd ArcSecond, 1999
- NED 1/9th ArcSecond, 2007

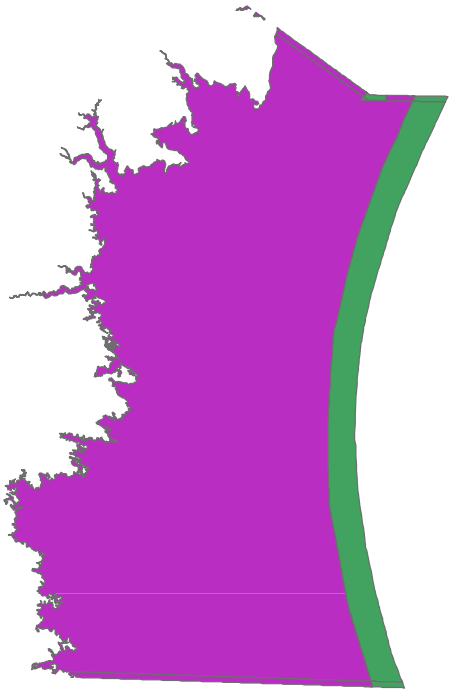
Study Area 18 DEM Sources



Study Area 19 DEM Sources



Study Area 20, Elevation Data Sources

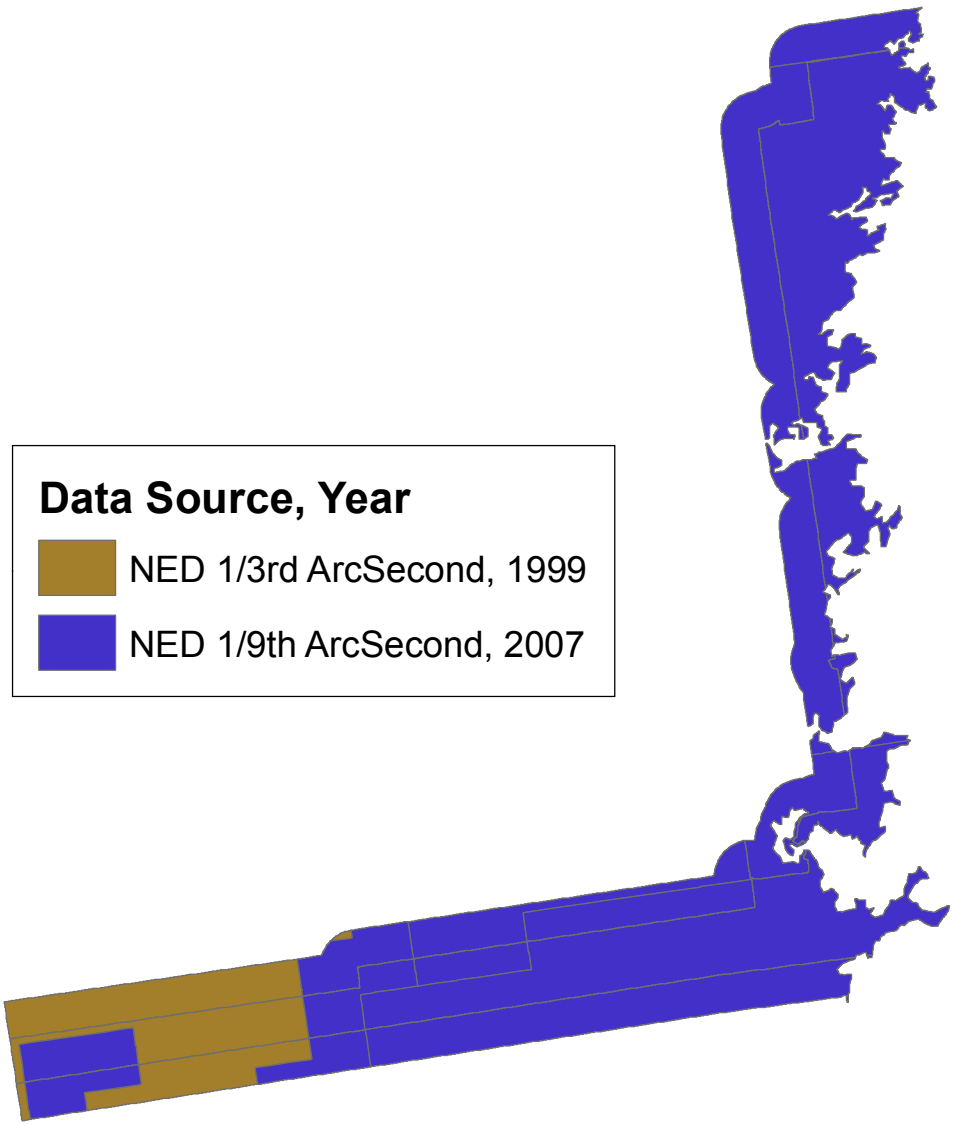


Data Source

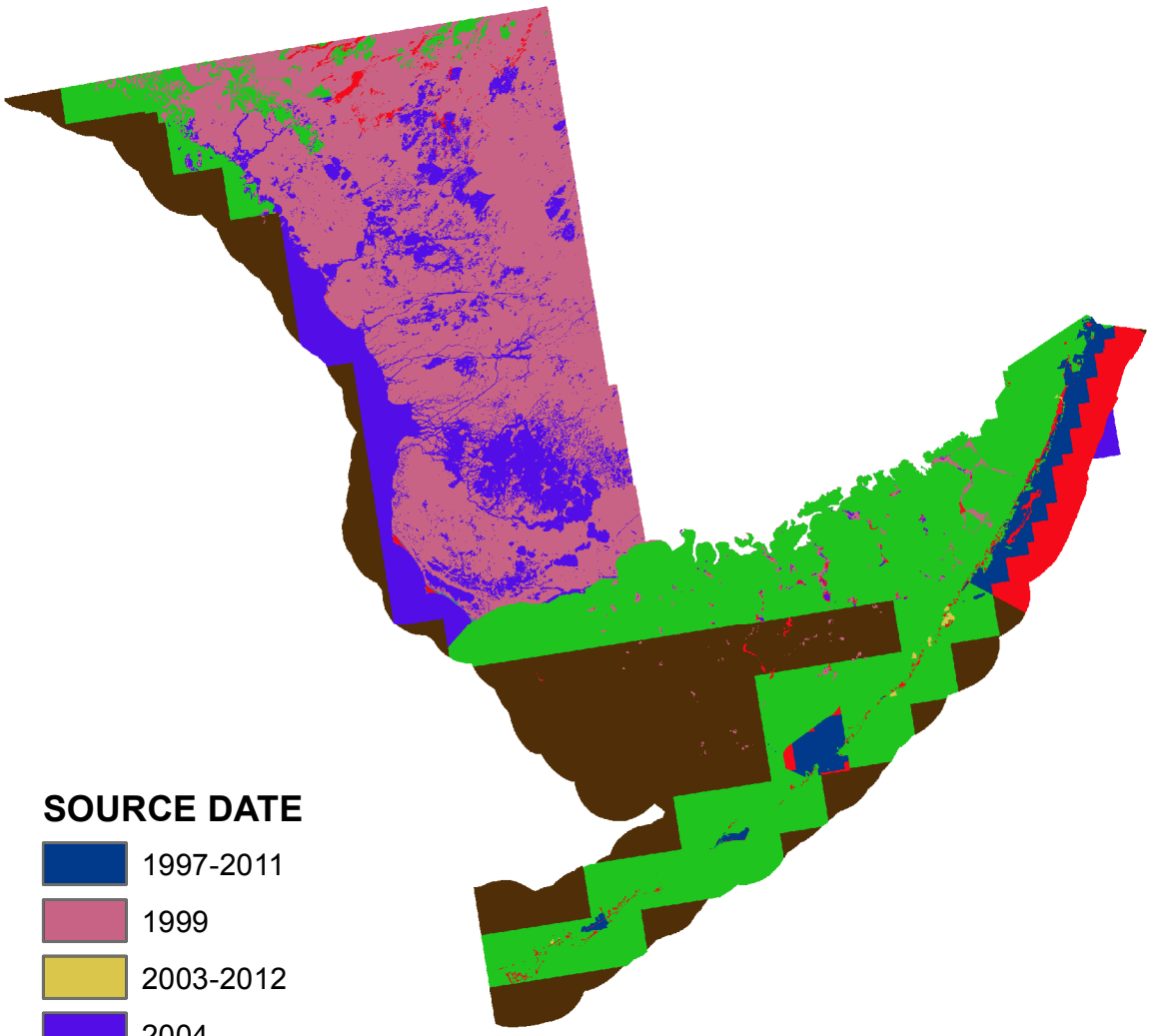
NED 1/3rd arc second, 1999

NED 1/9th arc second, 2008-2011

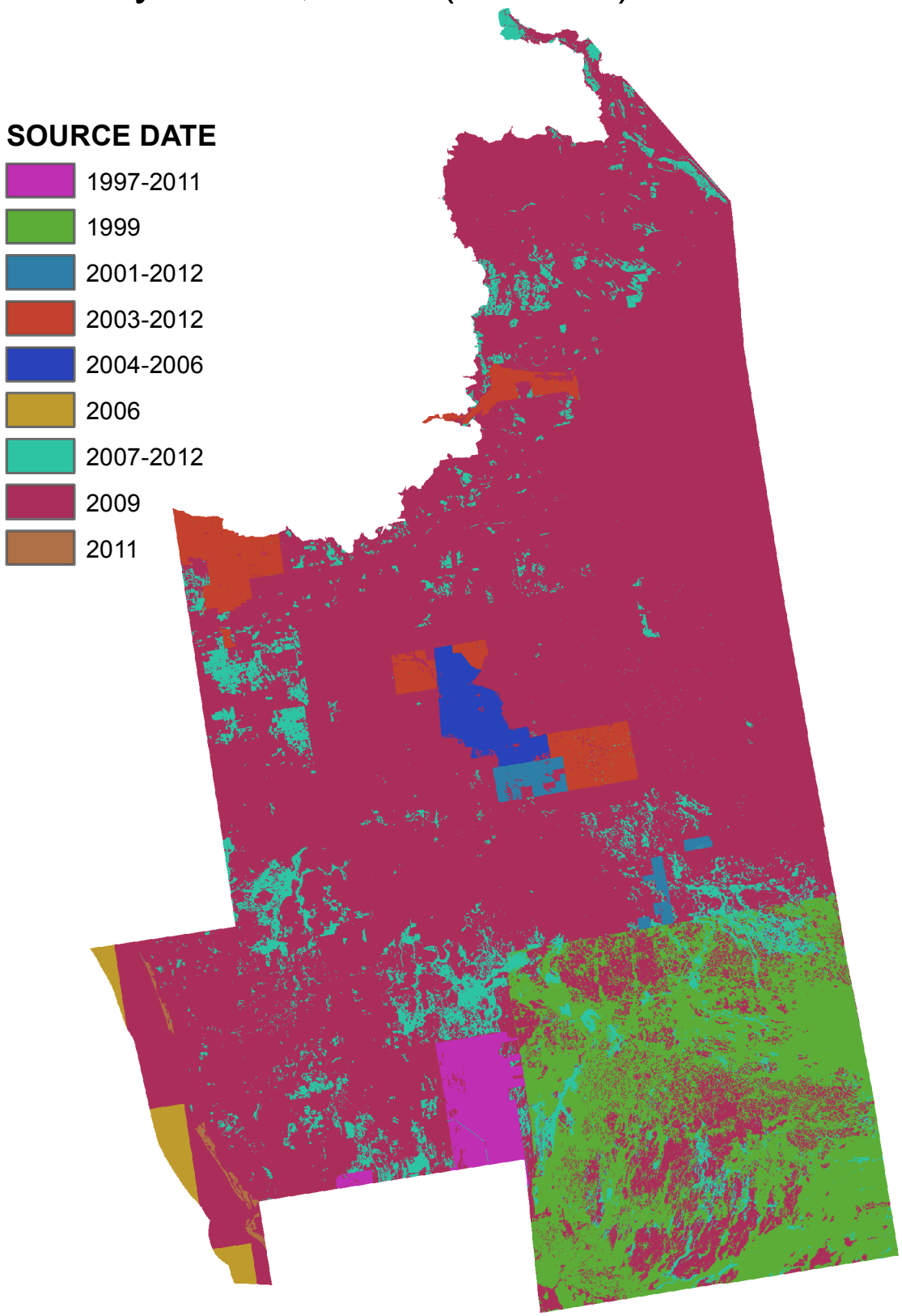
Study Area 21 DEM Sources



Study Area 1, FNAI (SLAMM) Source Date



Study Area 2, FNAI (SLAMM) Source Date



Study Area 3, FNAI (SLAMM) Source Date

SOURCE DATE

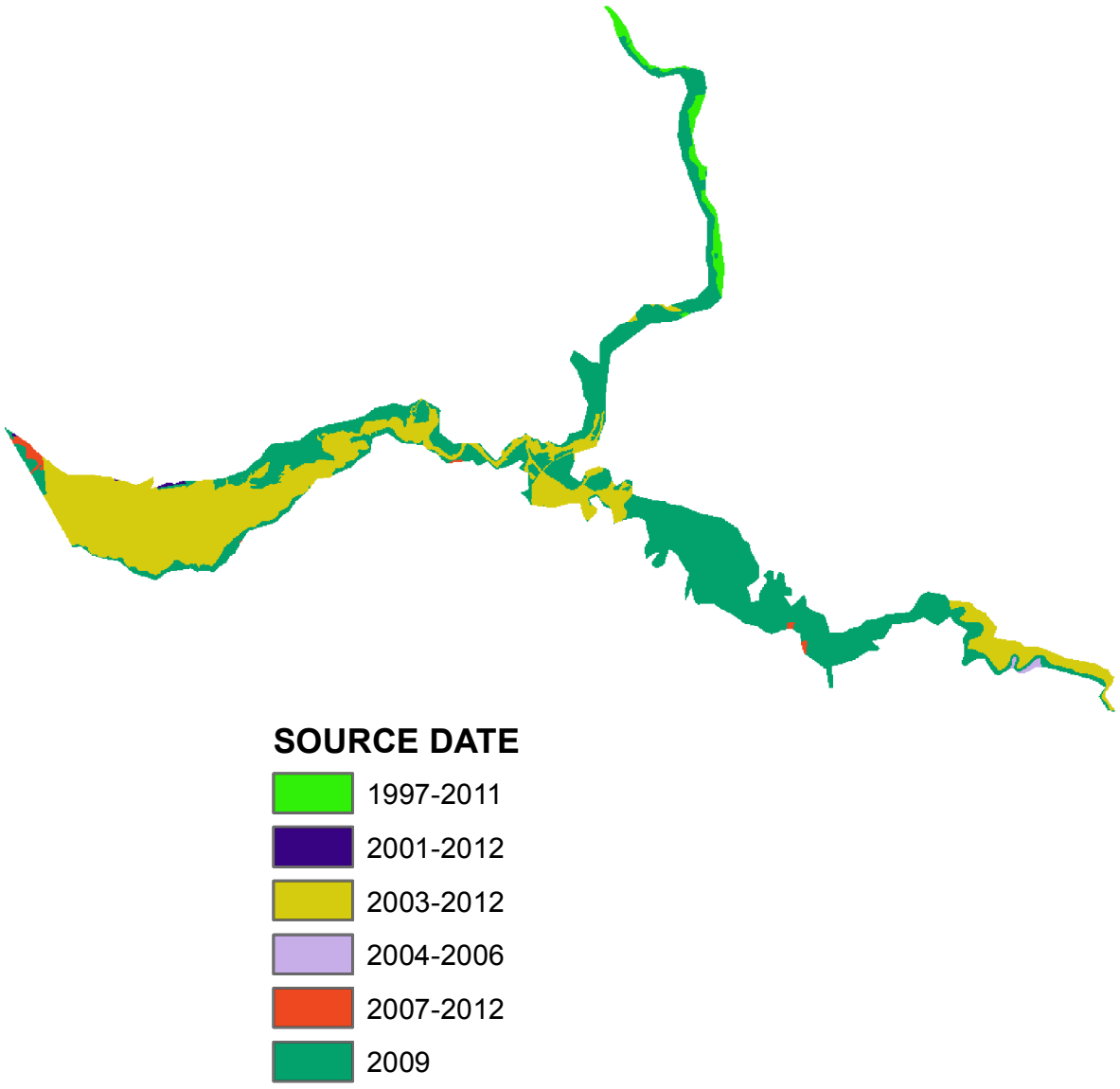
- 1997-2011
- 2001-2011
- 2001-2012
- 2003-2012
- 2006
- 2007-2012
- 2009
- 2011

Study Area 4, FNAI (SLAMM) Source Date

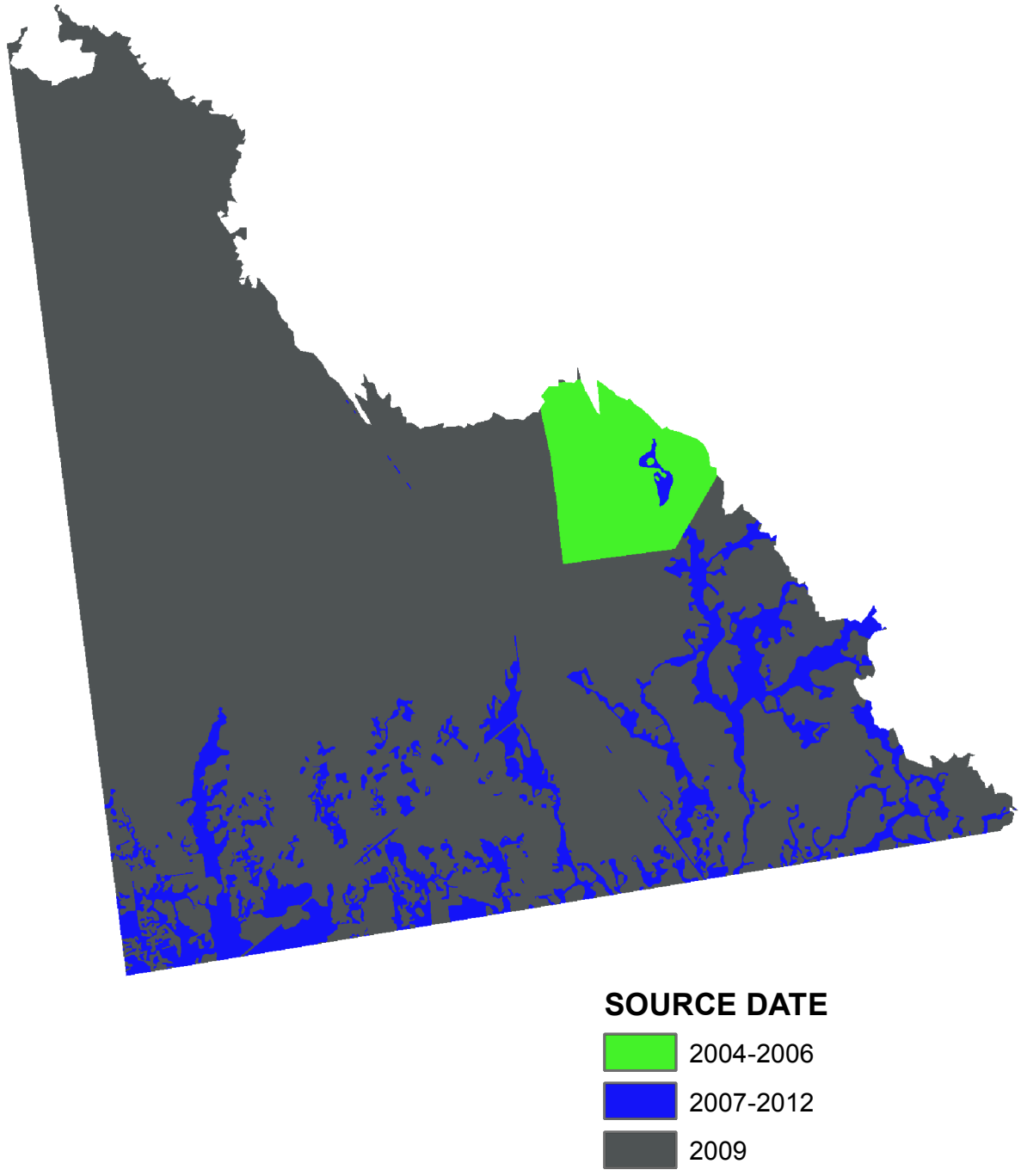
SOURCE DATE

2009

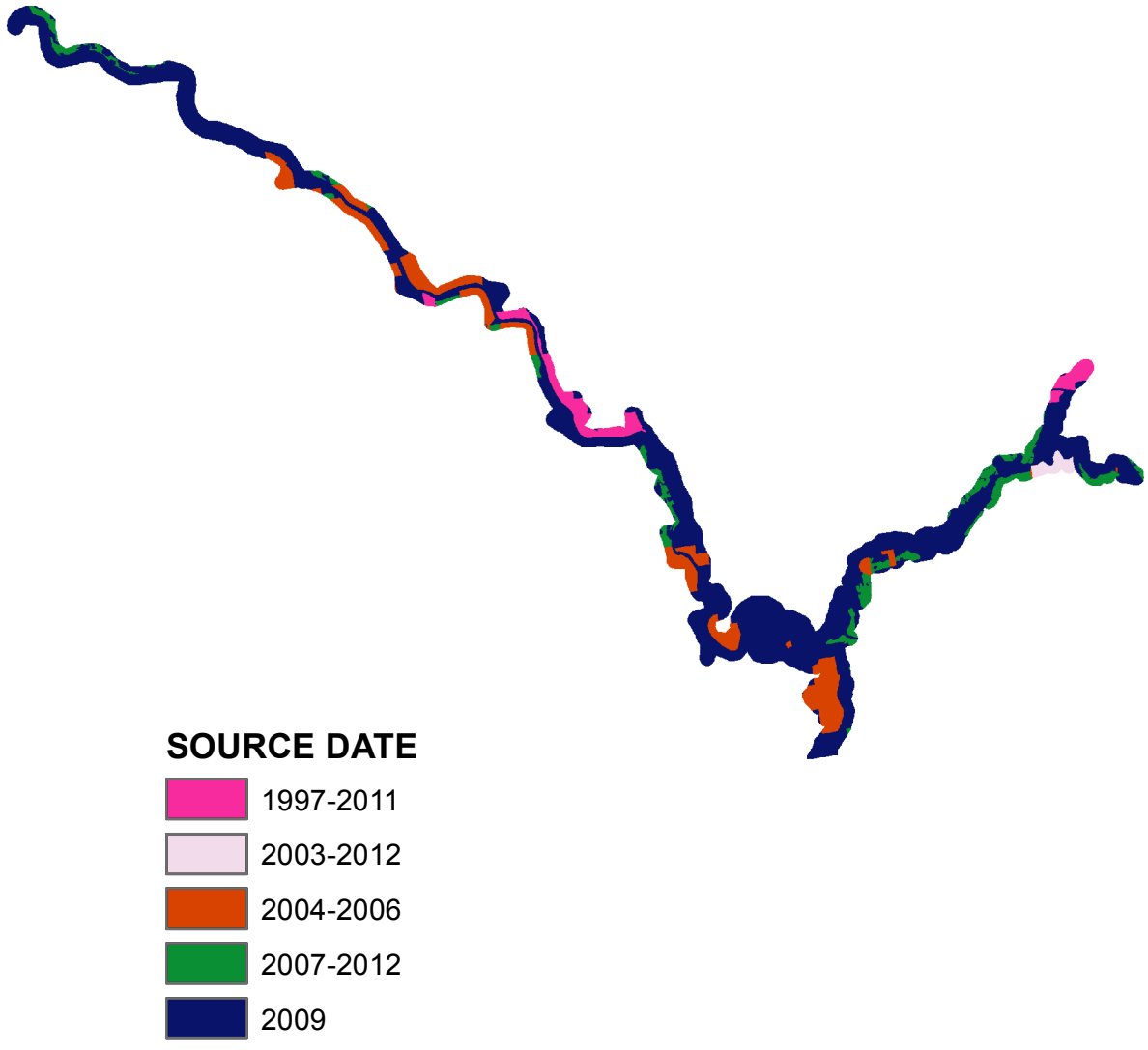
Study Area 5, FNAI (SLAMM) Source Date



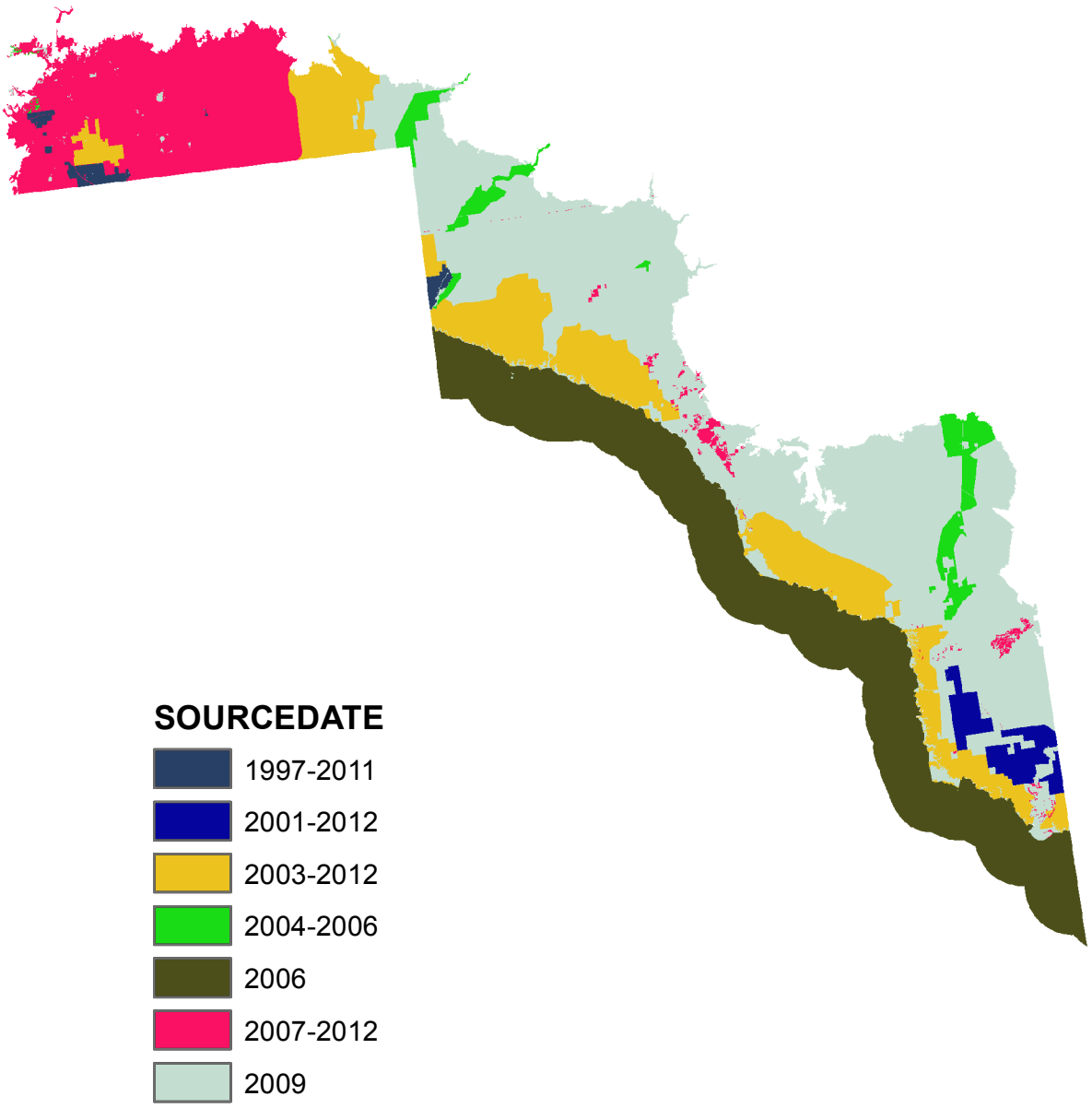
Study Area 6, FNAI (SLAMM) Source Date



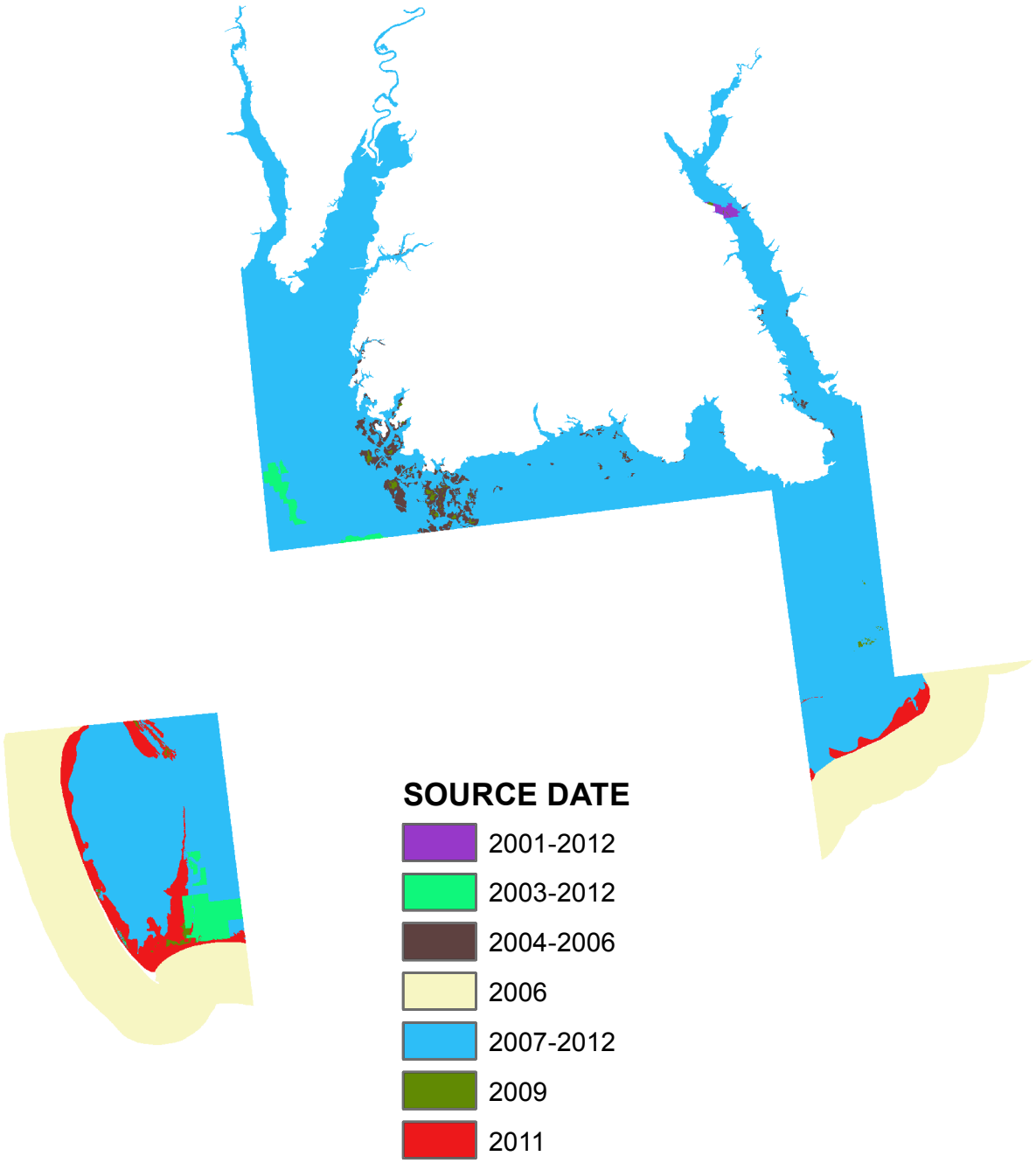
Study Area 7, FNAI (SLAMM) Source Date



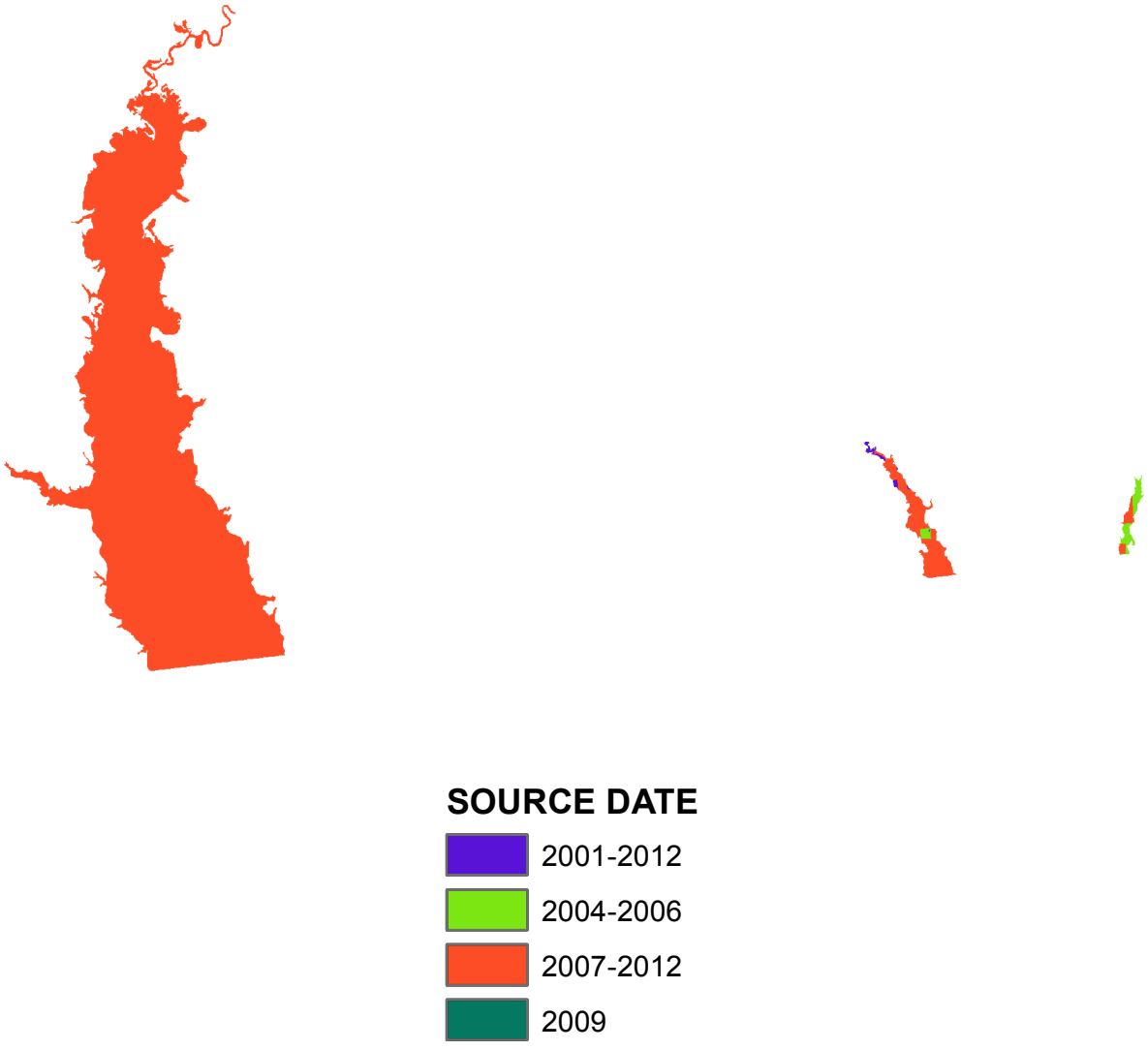
Study Area 8, FNAI (SLAMM) Source Date



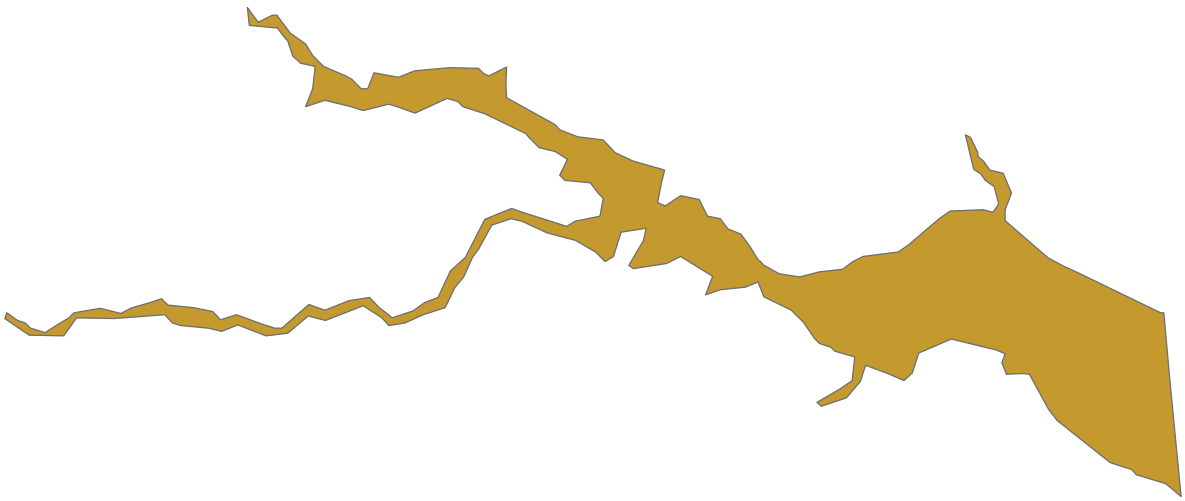
Study Area 9, FNAI (SLAMM) Source Date



Study Area 10, FNAI (SLAMM) Source Date



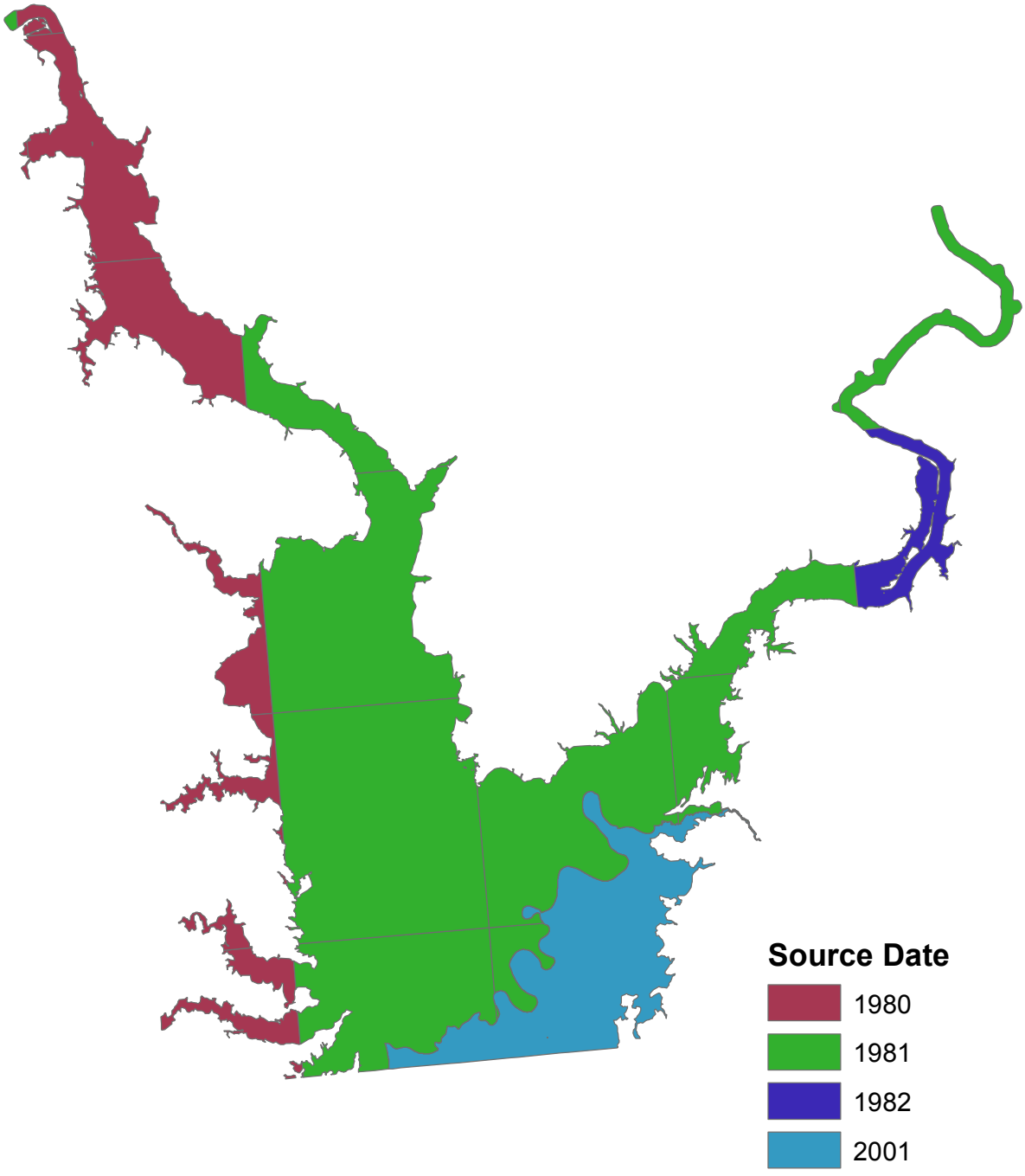
Study Area 11, NWI (SLAMM) Source Date



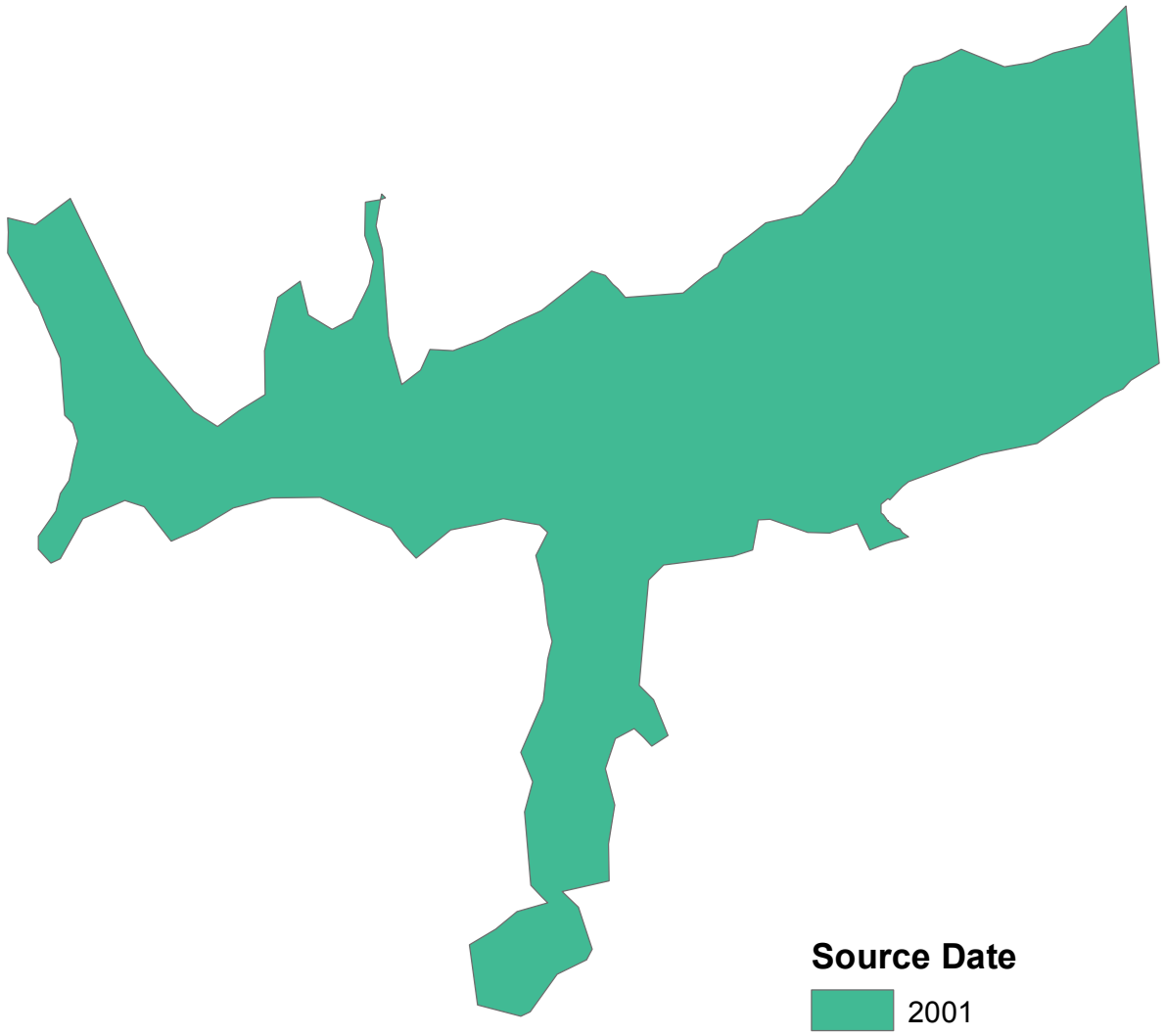
Source Date

2001

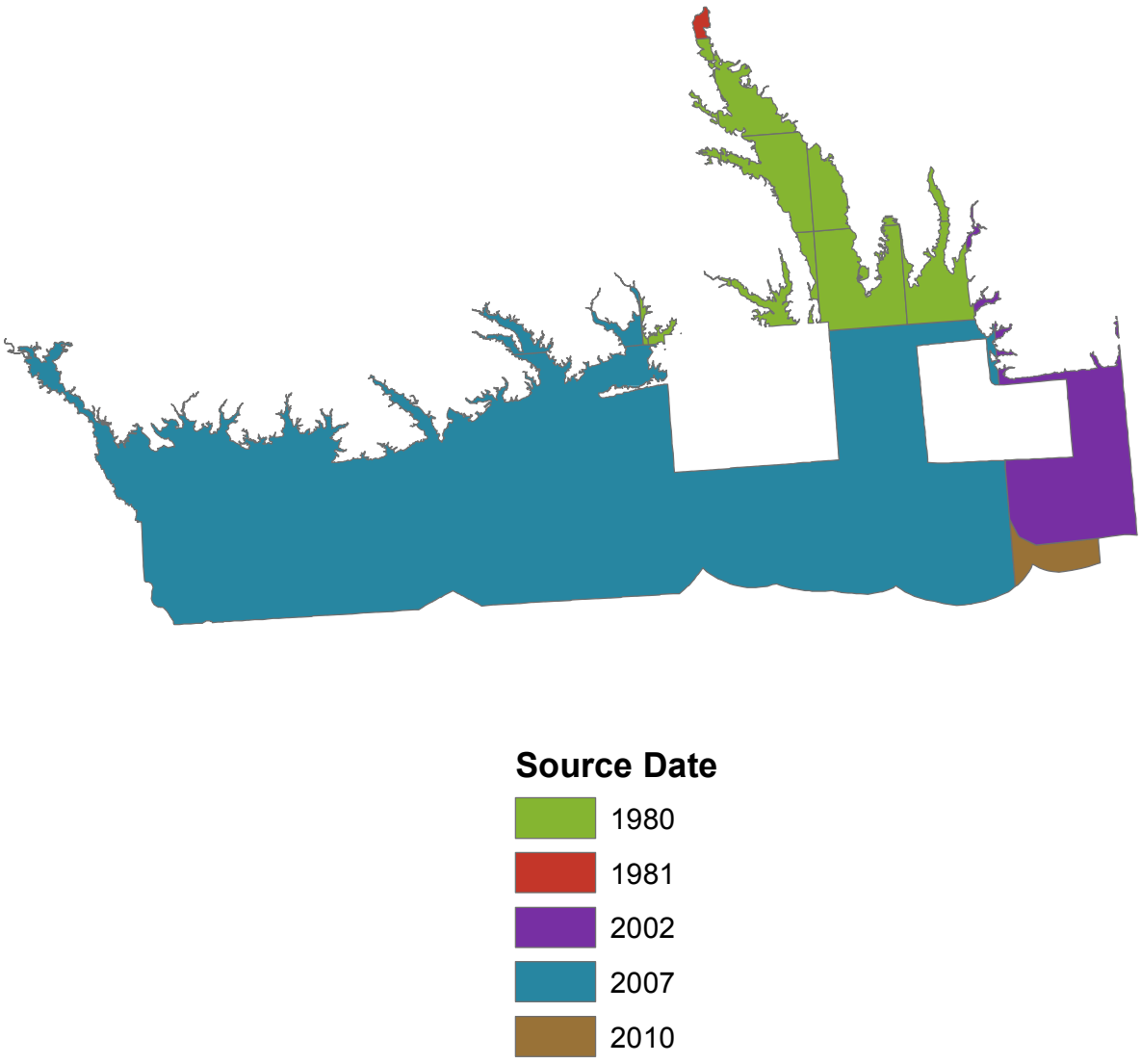
Study Area 12, NWI (SLAMM) Source Date



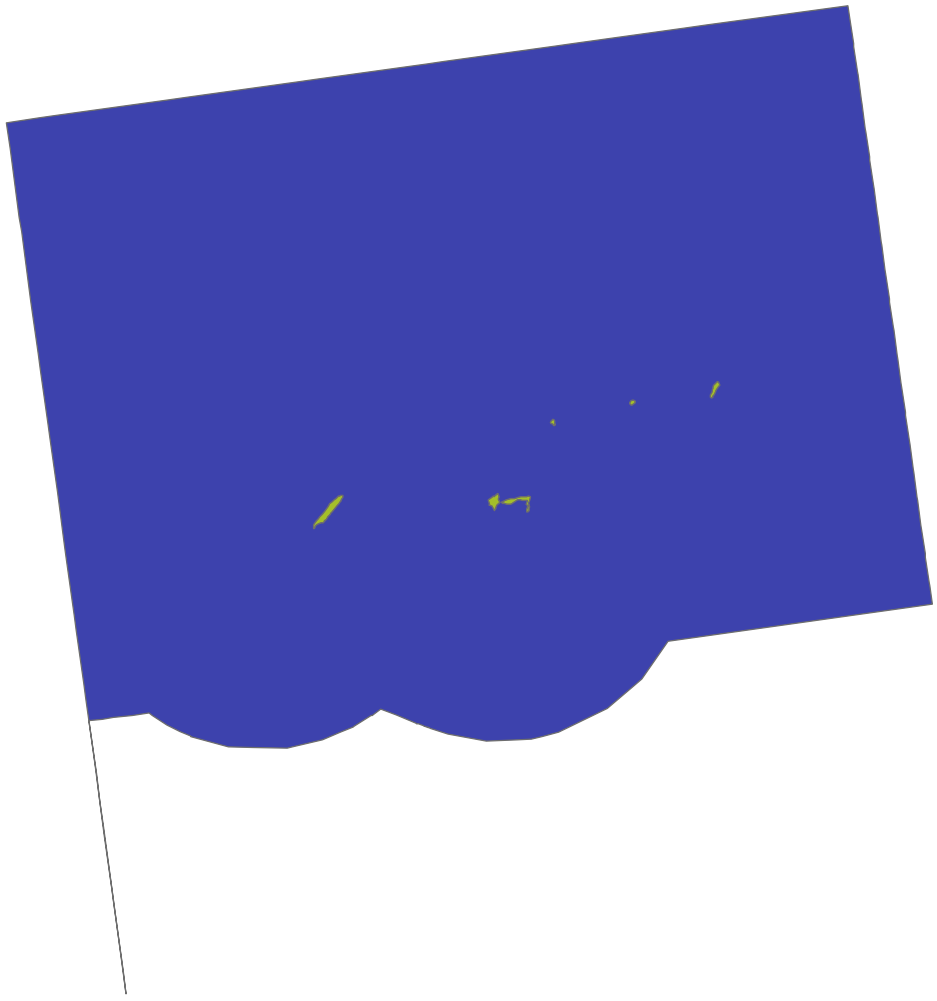
Study Area 13, NWI (SLAMM) Source Date



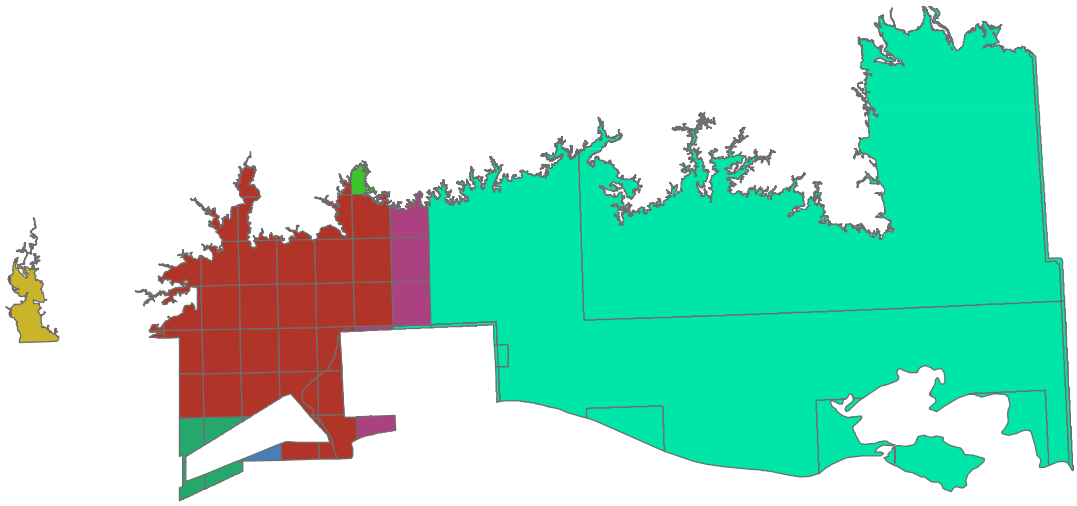
Study Area 14, NWI (SLAMM) Source Date



Study Area 16, FNAI (SLAMM) Source Date



Study Area 17, NWI/NGOM (SLAMM) Source Date



NGOM

Source Date

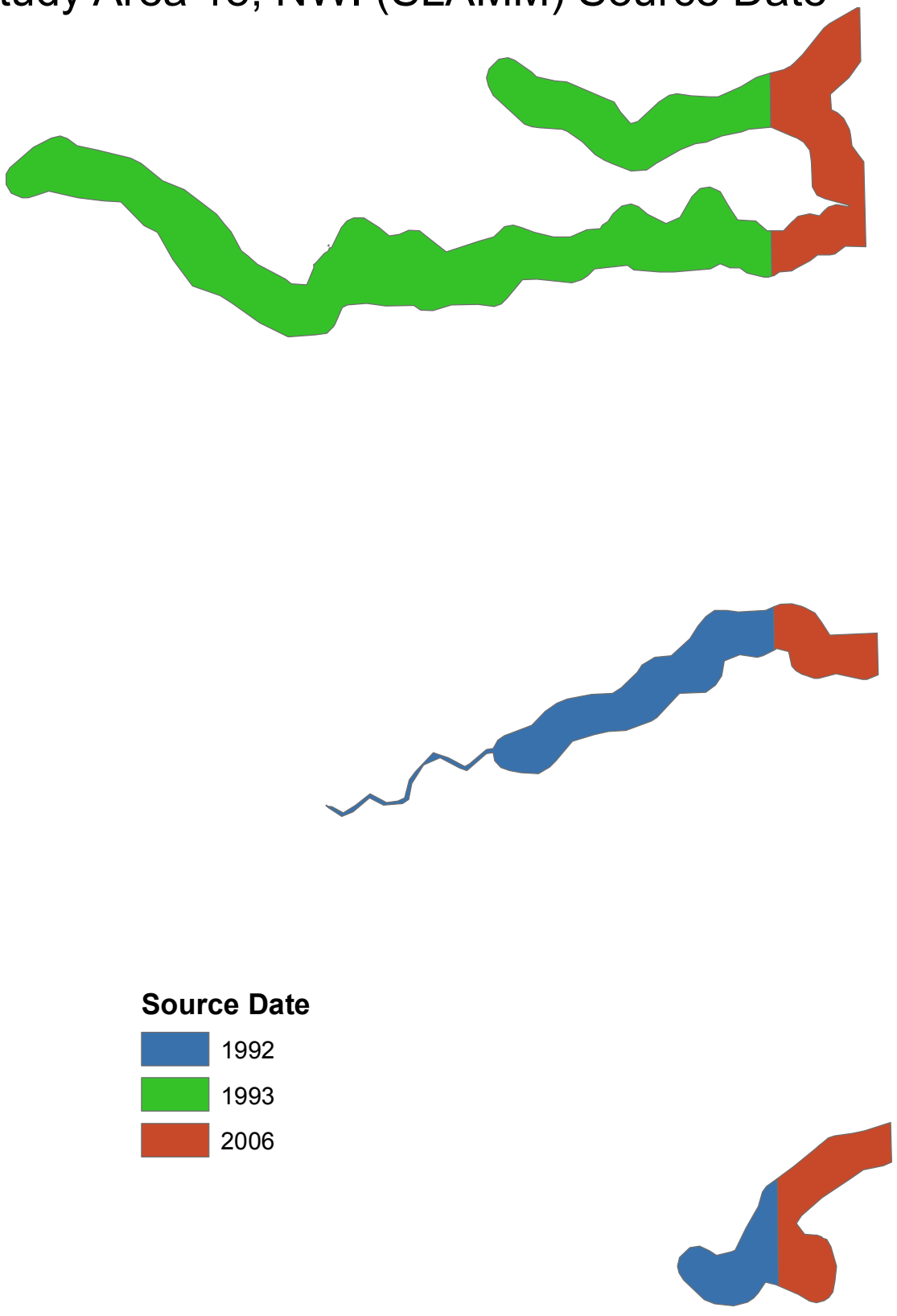
- 2008

NWI

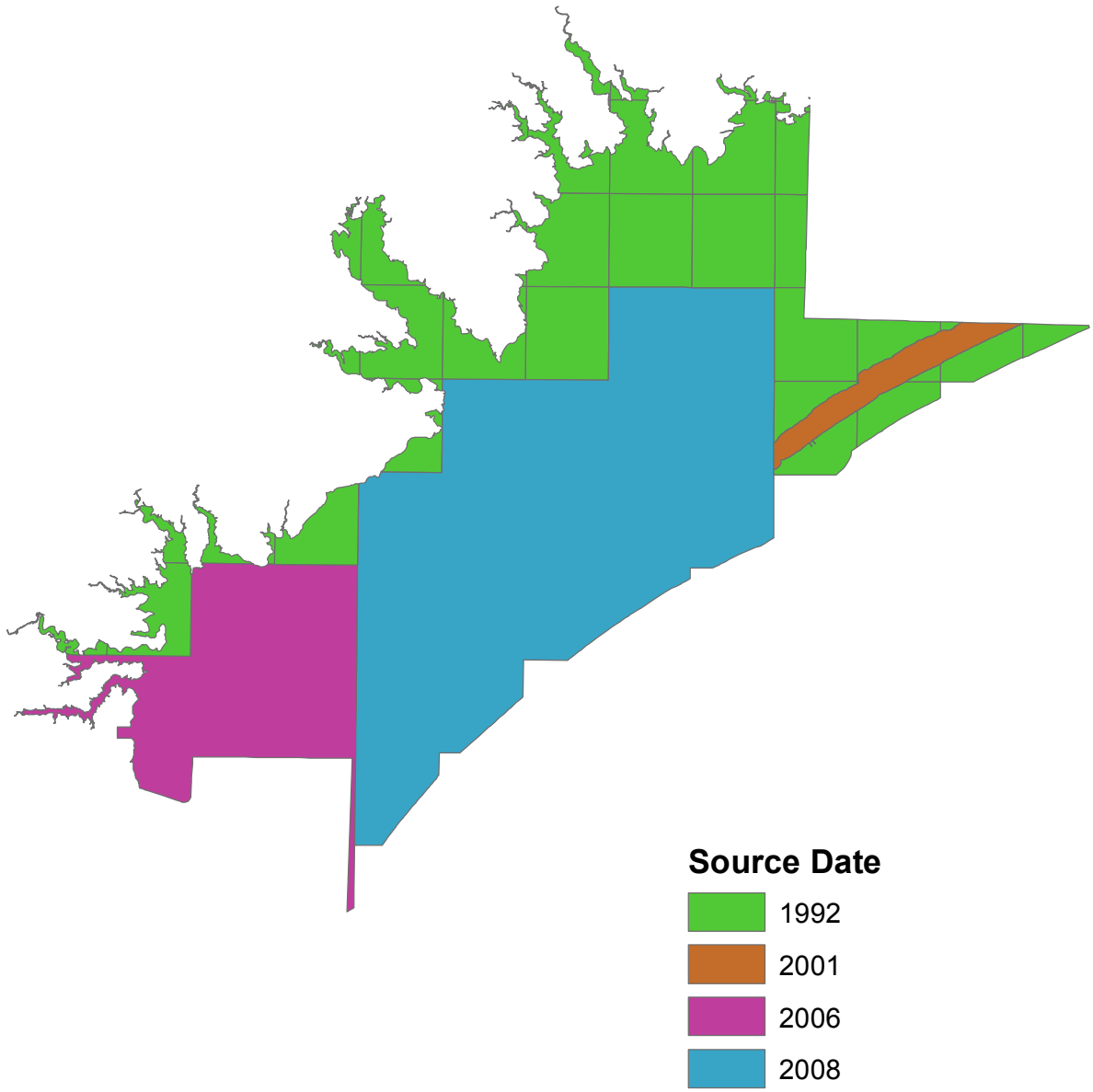
Source Date

- 1982
- 1988
- 1989
- 1992
- 1993
- 1994
- 2006

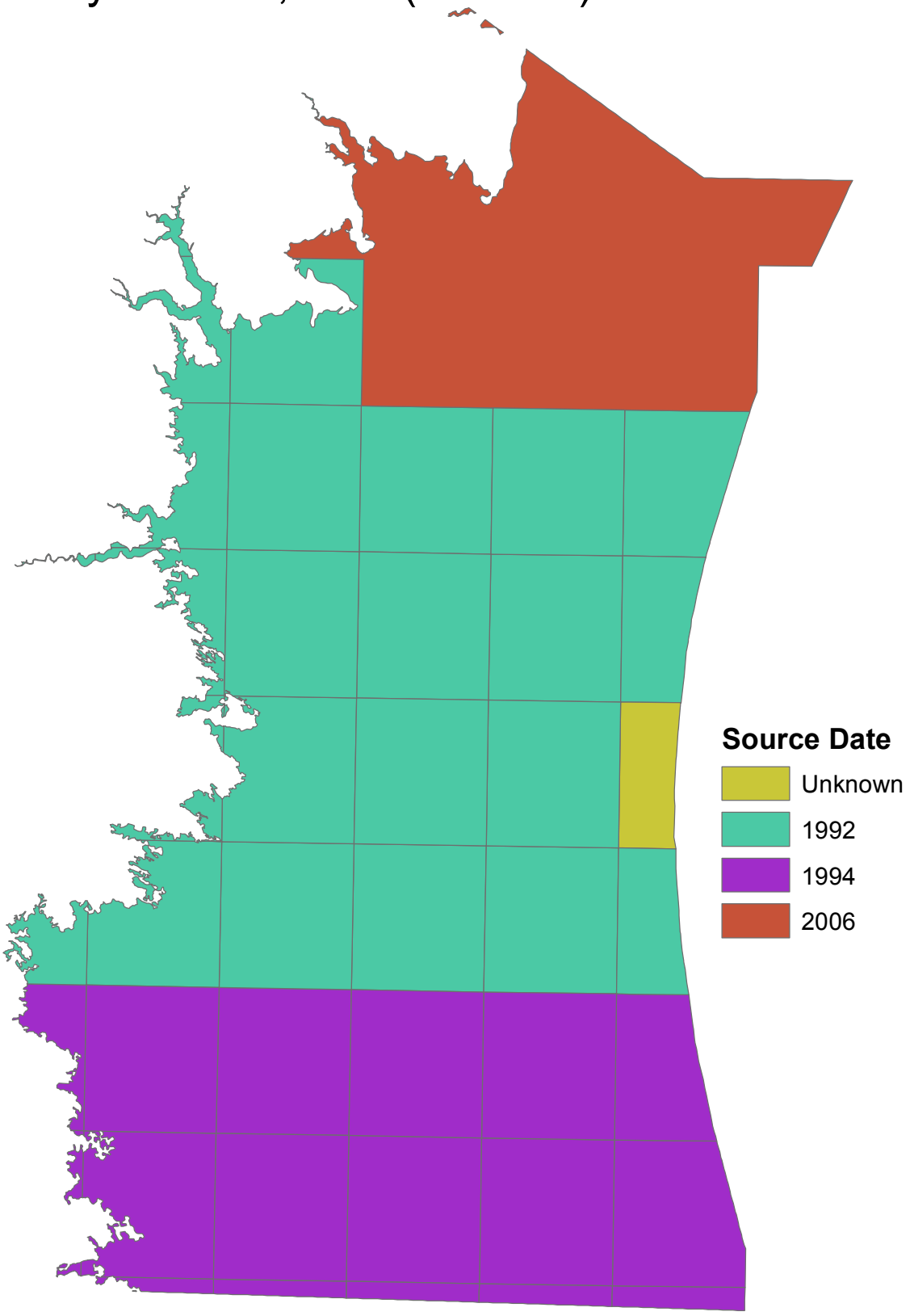
Study Area 18, NWI (SLAMM) Source Date



Study Area 19, NWI (SLAMM) Source Date



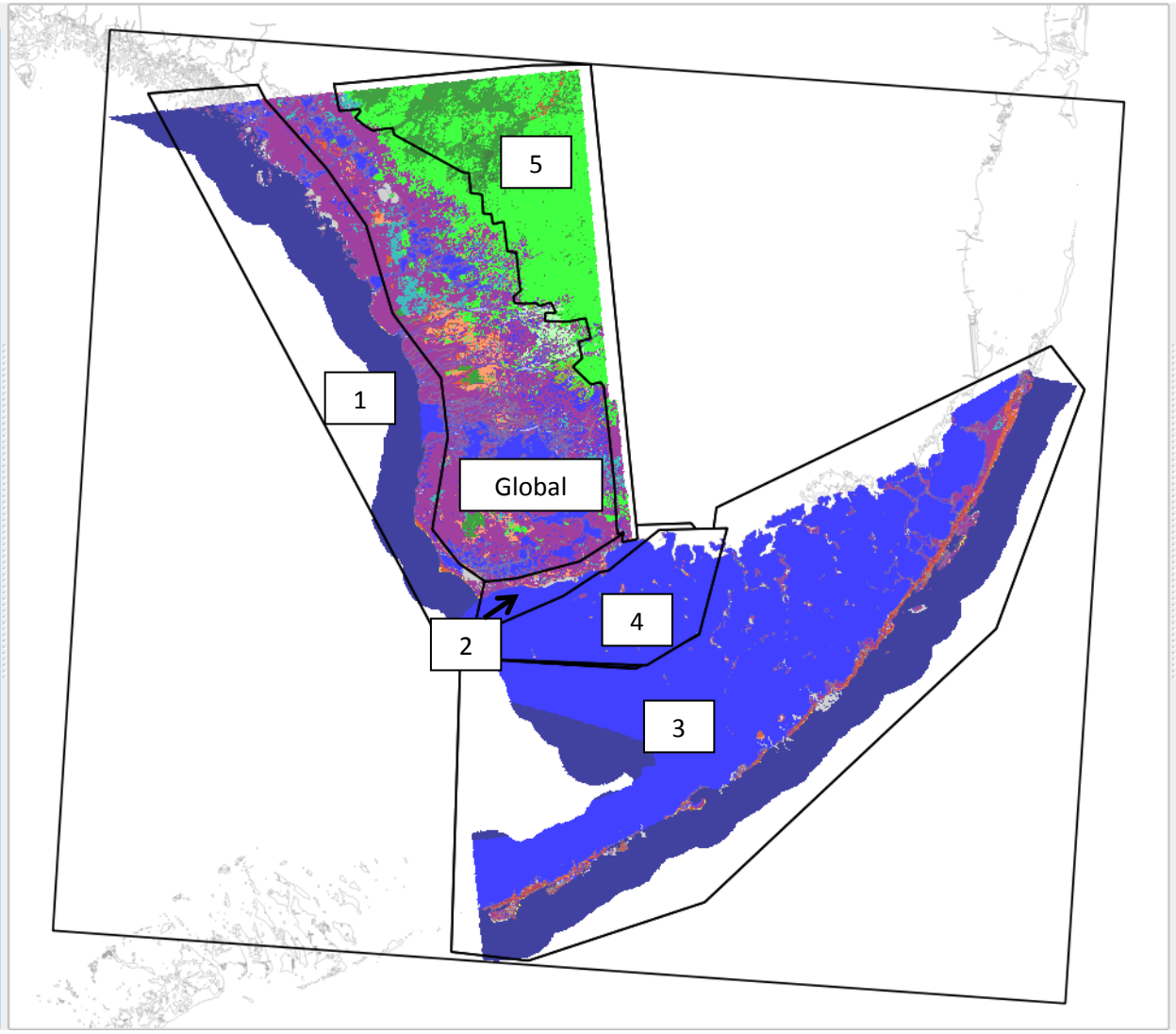
Study Area 20, NWI (SLAMM) Source Date



Appendix C – Parameters for New Study Areas

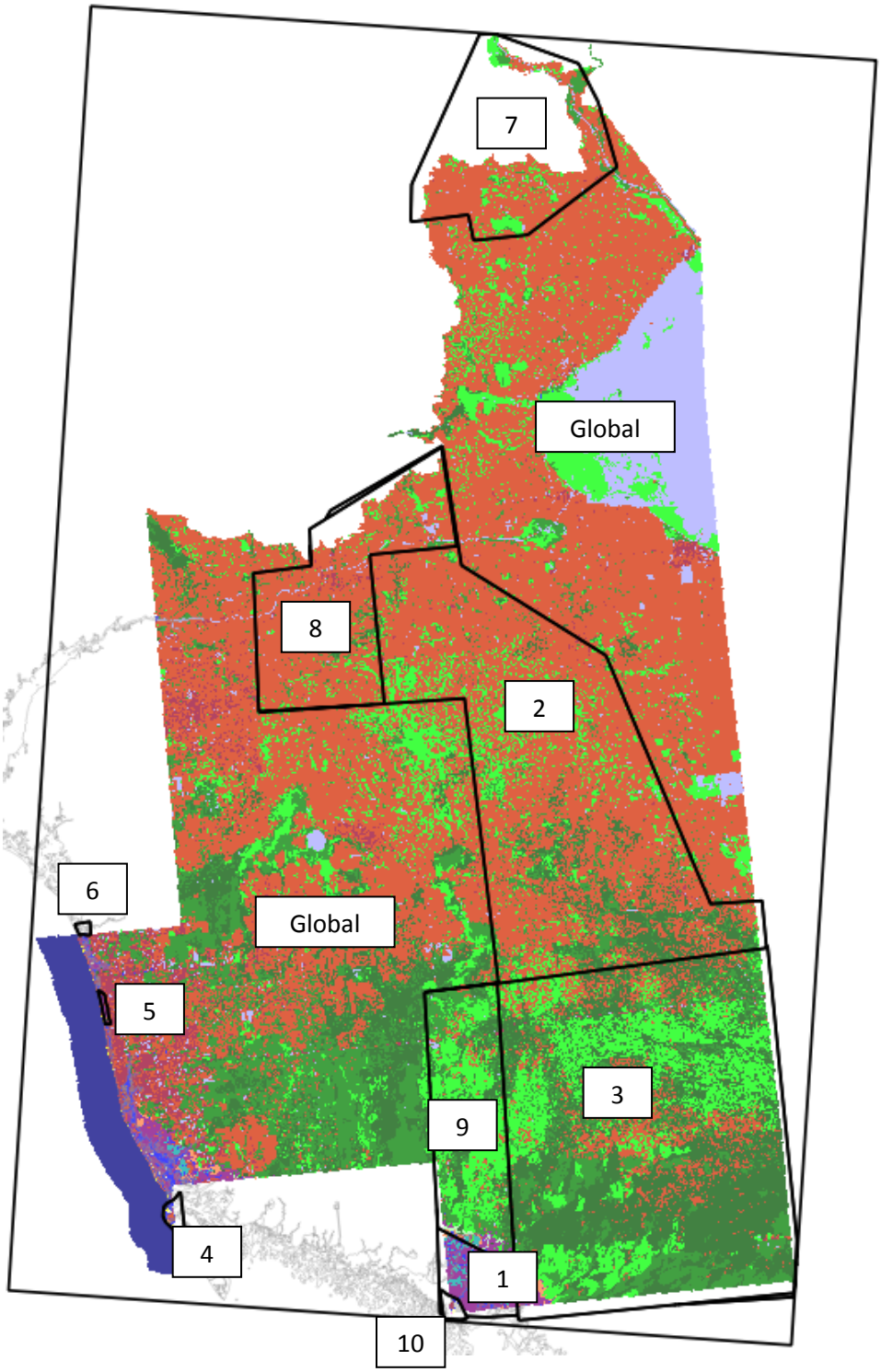
Parameter	Unit/Format
NWI Photo Date	YYYY
DEM Date	YYYY
Direction Offshore	n,s,e,w
Historic Trend	mm/yr
Historic Eustatic Trend	mm/yr
MTL-NAVD88	m
GT - Great Diurnal Tide Range	m
Salt Elev.	m above MTL
Marsh Erosion	horz. m /yr
Swamp Erosion	horz. m /yr
T.Flat Erosion	horz. m /yr
Reg.-Flood Marsh Accr	mm/yr
Irreg.-Flood Marsh Accr	mm/yr
Tidal-Fresh Marsh Accr	mm/yr
Inland-Fresh Marsh Accr	mm/yr
Mangrove Accr	mm/yr
Tidal Swamp Accr	mm/yr
Swamp Accretion	mm/yr
Beach Sed. Rate	mm/yr
Freq. Overwash	years
Use Elev Pre-processor	True,False
Reg Flood Max. Accr.	mm/yr
Reg Flood Min. Accr.	mm/yr
Reg Flood Elev a	mm/year*HTU^3
Reg Flood Elev b	mm/year*HTU^2
Reg Flood Elev c	mm/year*HTU
Reg Flood Elev d	mm/yr

Study Area 1



Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
Description	Interior tides	Gulf tides	South Gulf Tides	Keys	South Gulf Tides 2009	Interior tides DEM 1999
NWI Photo Date	1999	1999	1999	2009	2009	1999
DEM Date	2007	2007	2007	2007	1999	1999
Direction Offshore	West	West	South	South	West	West
Historic Trend	2.4	2.4	2.78	2.78	2.78	2.4
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	0	0	0	0	0	0
GT	0.244	1.3	0.77	0.44	0.77	0.244
Salt Elev.	0.371	0.967	0.668	0.48	0.668	0.371
Marsh Erosion	0	0	0	0	0	0
Swamp Erosion	0	0	0	0	0	0
T.Flat Erosion	0	0	0	0	0	0
Reg.-Flood Marsh Accr	0	0	0	0	0	0
Irreg.-Flood Marsh Accr	4.7	4.7	4.7	4.7	4.7	4.7
Tidal-Fresh Marsh Accr	5.9	5.9	5.9	5.9	5.9	5.9
Inland-Fresh Marsh Accr	5.9	5.9	5.9	5.9	5.9	5.9
Mangrove Accr	2	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.75	0.75	0.75	0.75	0.75	0.75
Freq. Overwash	0	0	0	0	0	0
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE
Reg Flood Max. Accr.	4.9	4.9	4.9	4.9	4.9	4.9
Reg Flood Min. Accr.	0.8	0.8	0.8	0.8	0.8	0.8
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377	6.54377

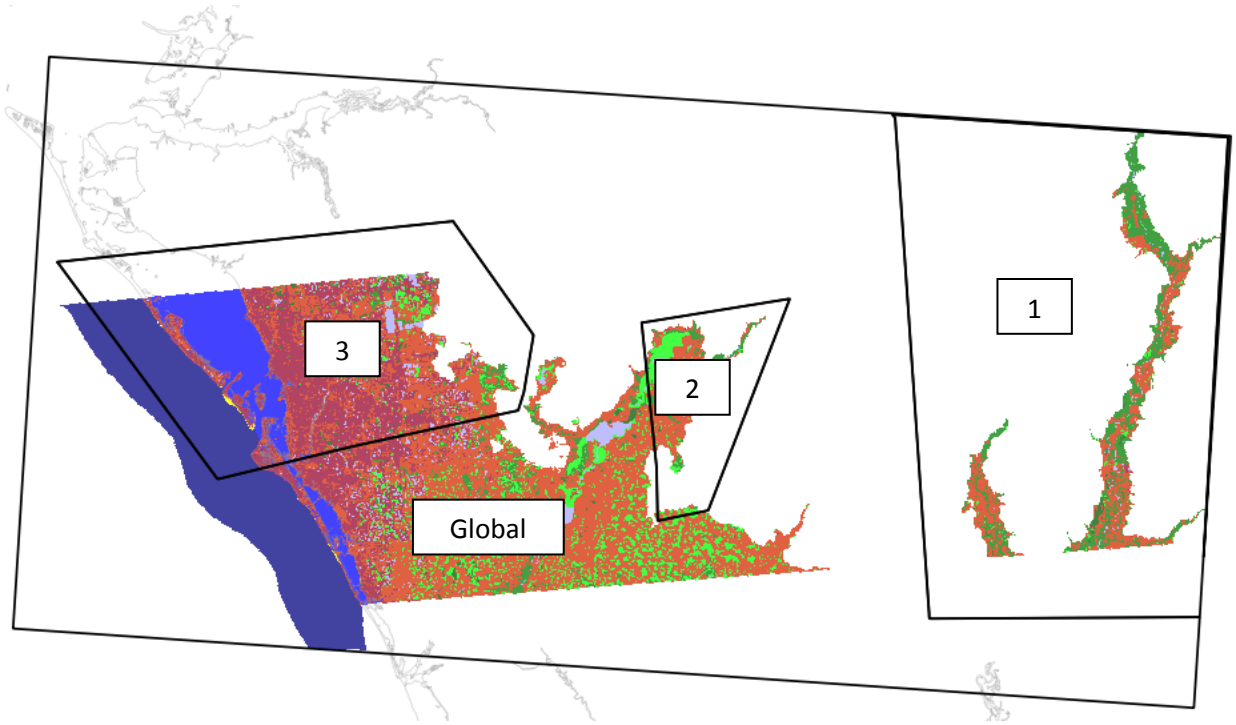
Study Area 2



Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
Description		FNAI 1999-2	NED 1999	FNAI & NED 1999	Marco Island	Outer Clam Bay
NWI Photo Date	2009	1999	2009	1999	2009	2009
DEM Date	2008	2008	1999	1999	2008	2008
Direction Offshore	West	West	West	West	West	West
Historic Trend	2.02	2.02	2.02	2.02	2.02	2.02
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	0	0	0	0	0	0
GT	0.8	0.86	0.8	0.96	0.93	0.37
Salt Elev.	0.6853	0.71917	0.6853	0.77562	0.758685	0.442565
Marsh Erosion	1.17	1.17	1.17	1.17	1.17	1.17
Swamp Erosion	1.17	1.17	1.17	1.17	1.17	1.17
T.Flat Erosion	1.17	1.17	1.17	1.17	1.17	1.17
Reg.-Flood Marsh Accr	0	0	0	0	0	0
Irreg.-Flood Marsh Accr	4.2	4.2	4.2	4.2	4.2	4.2
Tidal-Fresh Marsh Accr	4.95	4.95	4.95	4.95	4.95	4.95
Inland-Fresh Marsh Accr	4.95	4.95	4.95	4.95	4.95	4.95
Mangrove Accr	2	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.4	0.4	0.4	0.4	0.4	0.4
Freq. Overwash	0	0	0	0	0	0
Use Elev Pre-processor	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
Reg Flood Max. Accr.	4.9	4.9	4.9	4.9	4.9	4.9
Reg Flood Min. Accr.	0.8	0.8	0.8	0.8	0.8	0.8
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377	6.54377

Parameter	SubSite 6	SubSite 7	SubSite 8	SubSite 9	SubSite 10
Description	little Hickory Bay	SubSite 7	SubSite 8	FNAI 1999 muted tide	FNAI 1999-1
NWI Photo Date	2009	2009	2009	1999	2009
DEM Date	2008	1999	2008	2008	2008
Direction Offshore	West	West	West	West	West
Historic Trend	2.02	2.02	2.02	2.02	2.02
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	0	0	0	0	0
GT	0.28	0.8	0.8	0.4	0.96
Salt Elev.	0.39176	0.6853	0.6853	0.4595	0.77562
Marsh Erosion	1.17	1.17	1.17	1.17	1.17
Swamp Erosion	1.17	1.17	1.17	1.17	1.17
T.Flat Erosion	1.17	1.17	1.17	1.17	1.17
Reg.-Flood Marsh Accr	0	0	0	0	0
Irreg.-Flood Marsh Accr	4.2	4.2	4.2	4.2	4.2
Tidal-Fresh Marsh Accr	4.95	4.95	4.95	4.95	4.95
Inland-Fresh Marsh Accr	4.95	4.95	4.95	4.95	4.95
Mangrove Accr	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.4	0.4	0.4	0.4	0.4
Freq. Overwash	0	0	0	0	0
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	4.9	4.9	4.9	4.9	4.9
Reg Flood Min. Accr.	0.8	0.8	0.8	0.8	0.8
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377

Study Area 3

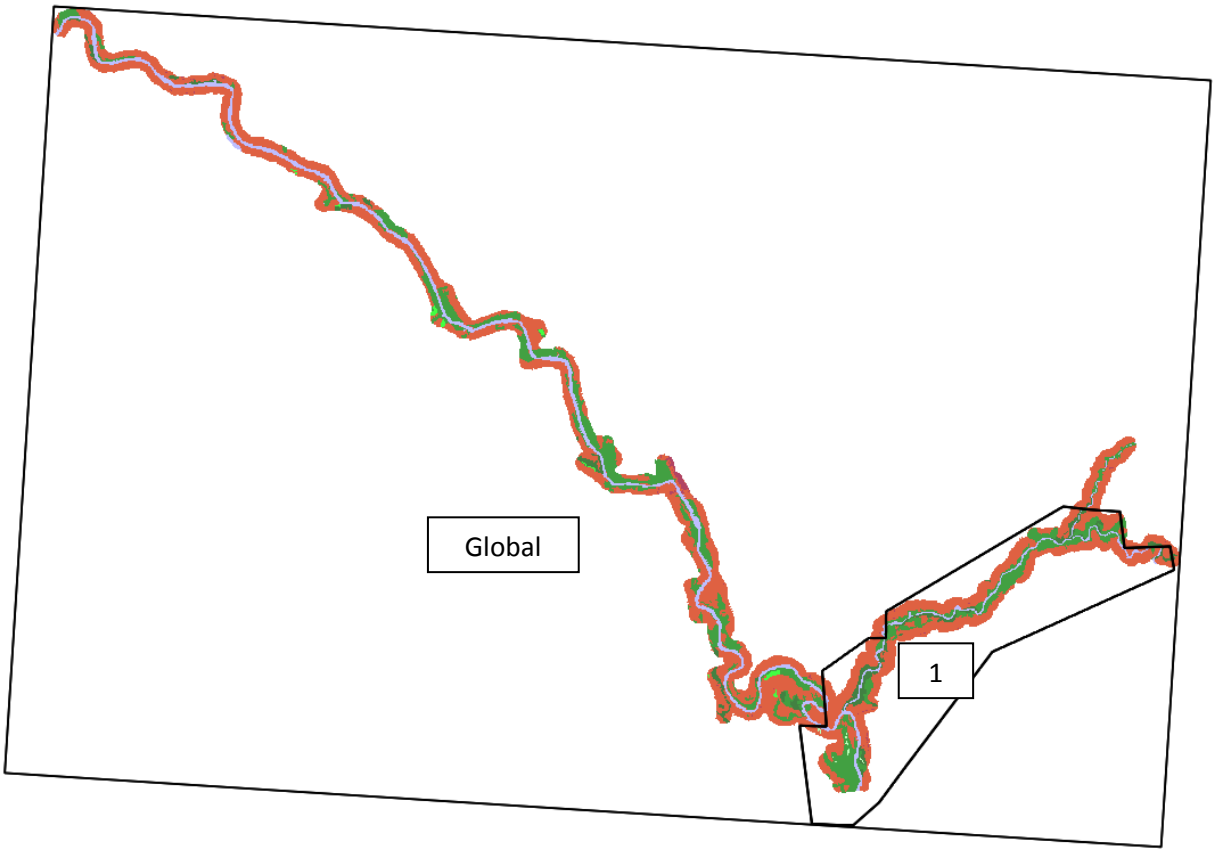


Parameter	Global	SubSite 1	SubSite 2	SubSite 3
Description		SubSite 1	SubSite 2	Global North
NWI Photo Date	2009	2009	2009	2009
DEM Date	2008	2008	1999	2008
Direction Offshore	East	South	East	East
Historic Trend	2.4	2.4	2.4	2.4
Historic Eustatic Trend	1.7	1.7	1.7	1.7
MTL-NAVD88	0	-0.14	0	0
GT	0.53	0.66	0.63	0.63
Salt Elev.	0.533	0.606	0.589	0.589
Marsh Erosion	1	1	1	1
Swamp Erosion	1	1	1	1
T.Flat Erosion	1	1	1	1
Reg.-Flood Marsh Accr	0	0	0	0
Irreg.-Flood Marsh Accr	3.75	3.75	3.75	3.75
Tidal-Fresh Marsh Accr	4	4	4	4
Inland-Fresh Marsh Accr	4	4	4	4
Mangrove Accr	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.5	0.5	0.5	0.5
Freq. Overwash	25	25	25	25
Use Elev Pre-processor	FALSE	FALSE	TRUE	FALSE
Reg Flood Max. Accr.	4.9	4.9	4.9	4.9
Reg Flood Min. Accr.	0.8	0.8	0.8	0.8
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377

Site 4 – 6, 10-11, 13 and 16 had no subsites

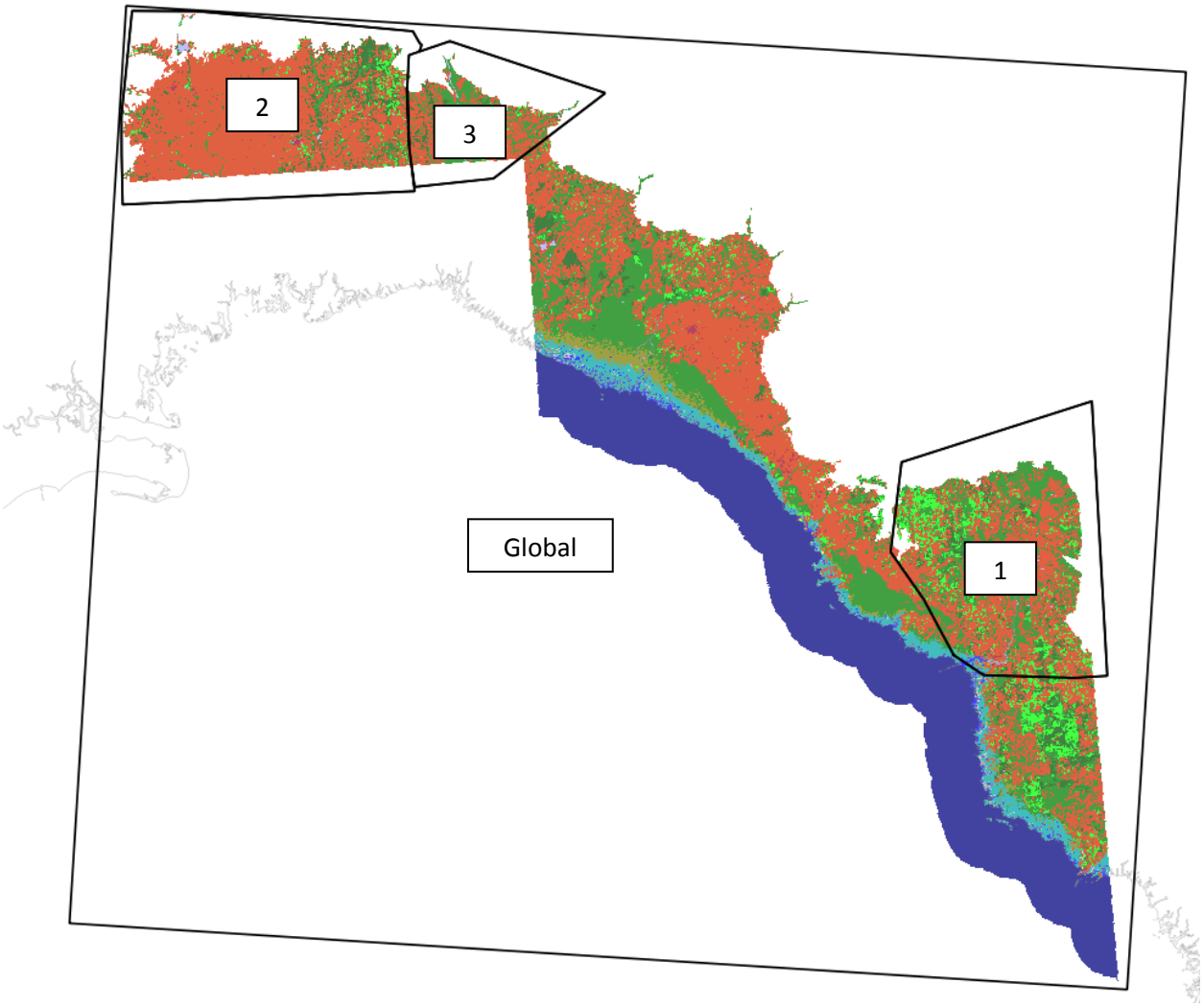
Parameter	Study Area 4	Study Area 5	Study Area 6	Study Area 10	Study Area 11	Study Area 13	Study Area 16	Study Area 21
Description	Global	Global	Global	Global	Global	Global	Global	Global
NWI Photo Date	2009	2006	2009	2010	2001	2001	2010	2010
DEM Date	2007	2009	2008	2009	2009	2009	1999	2007
Direction Offshore	West	West	West	South	East	East	East	East
Historic Trend	2.36	1.8	1.8	2.1	2.1	2.1	2.24	2.4
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	-0.08	-0.06	-0.06	0.11	0.13	0.13	0	0
GT	0.79	1.19	0.66	0.465	0.255	0.255	0.51	1
Salt Elev.	0.65	0.9	0.53	0.57	0.467	0.467	0.52	0.7982
Marsh Erosion	2	0.32	1.8	2	2	2	1.8	2
Swamp Erosion	1	0.32	1	1	1	1	1	2
T.Flat Erosion	0.5	0.32	0.5	0.5	0.5	0.5	0.1	2
Reg.-Flood Marsh Accr	0	0	0	0	2.25	2.25	0	0
Irreg.-Flood Marsh Accr	3.75	7.2	4.7	3.75	3.75	3.75	4.7	3.75
Tidal-Fresh Marsh Accr	4	7.2	5.9	4	4	4	5.9	4
Inland-Fresh Marsh Accr	4	7.2	5.9	4	4	4	0	4
Mangrove Accr	2	2	2	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1	1.1	0	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3	0.3	0	0.3
Beach Sed. Rate	2.7	0.5	0.5	0.5	0.5	0.5	1	1.6
Freq. Overwash	0	0	100	0	25	25	0	25
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Reg Flood Max. Accr.	4.9	7.6	7.6	7.6	0	0	4.9	4.9
Reg Flood Min. Accr.	0.8	0.8	0.8	0.8	0	0	0.8	0.8
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	0	0	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	0	0	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	0	0	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	0	0	6.54377	6.54377

Study Area 7



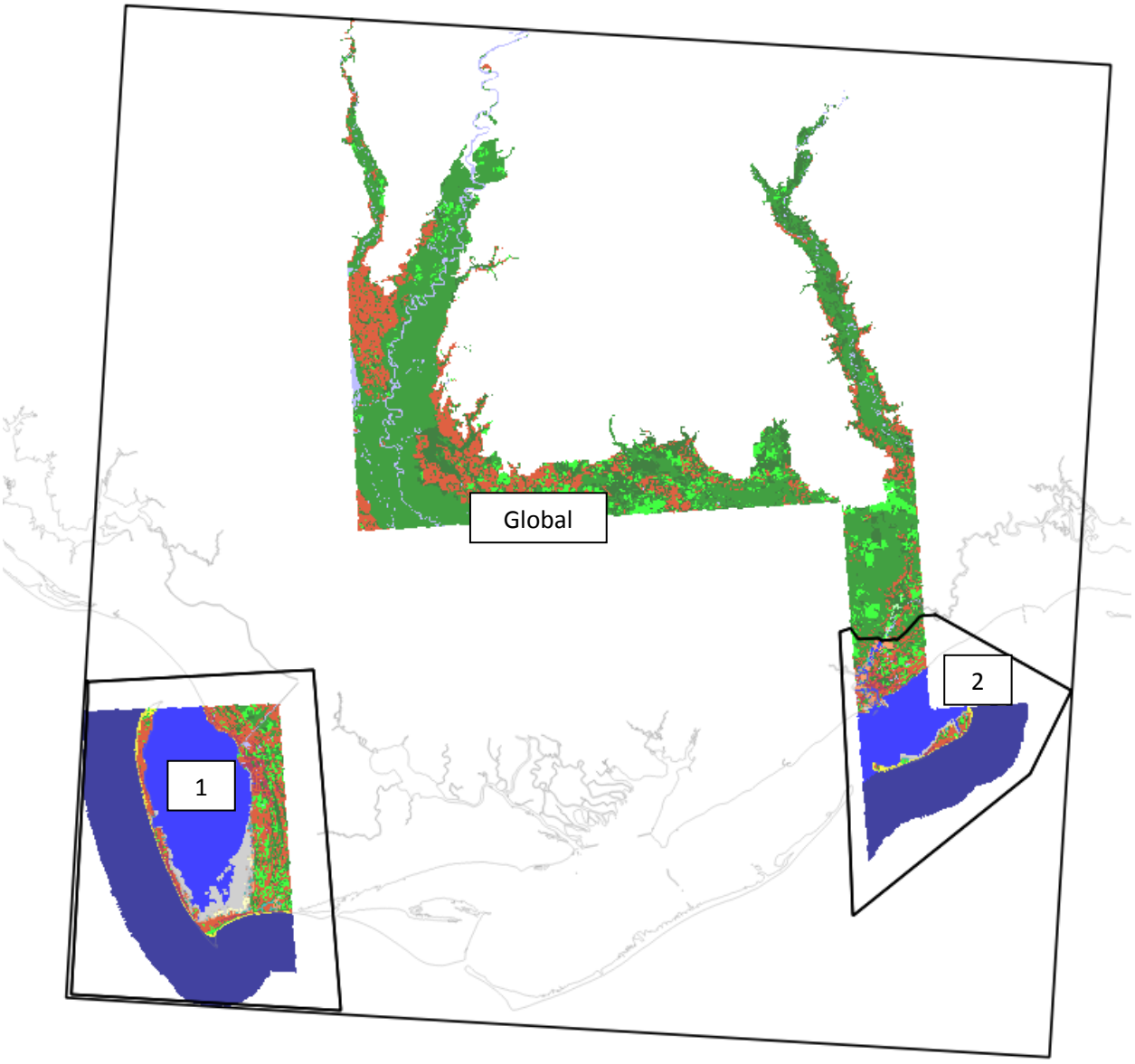
Parameter	Global	SubSite 1
Description		1/3 arcsecond
NWI Photo Date	2007	2007
DEM Date	2009	2009
Direction Offshore	South	South
Historic Trend	1.8	1.8
Historic Eustatic Trend	1.7	1.7
MTL-NAVD88	0.18	0.18
GT	0.6584	0.6584
Salt Elev.	0.5334	0.5334
Marsh Erosion	1.8	1.8
Swamp Erosion	1	1
T.Flat Erosion	0.5	0.5
Reg.-Flood Marsh Accr	0	0
Irreg.-Flood Marsh Accr	4.7	4.7
Tidal-Fresh Marsh Accr	5.9	5.9
Inland-Fresh Marsh Accr	5.9	5.9
Mangrove Accr	2	2
Tidal Swamp Accr	1.1	1.1
Swamp Accretion	0.3	0.3
Beach Sed. Rate	0.5	0.5
Freq. Overwash	0	0
Use Elev Pre-processor	FALSE	FALSE
Reg Flood Max. Accr.	7.6	7.6
Reg Flood Min. Accr.	0.8	0.8
Reg Flood Elev a	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377

Study Area 8



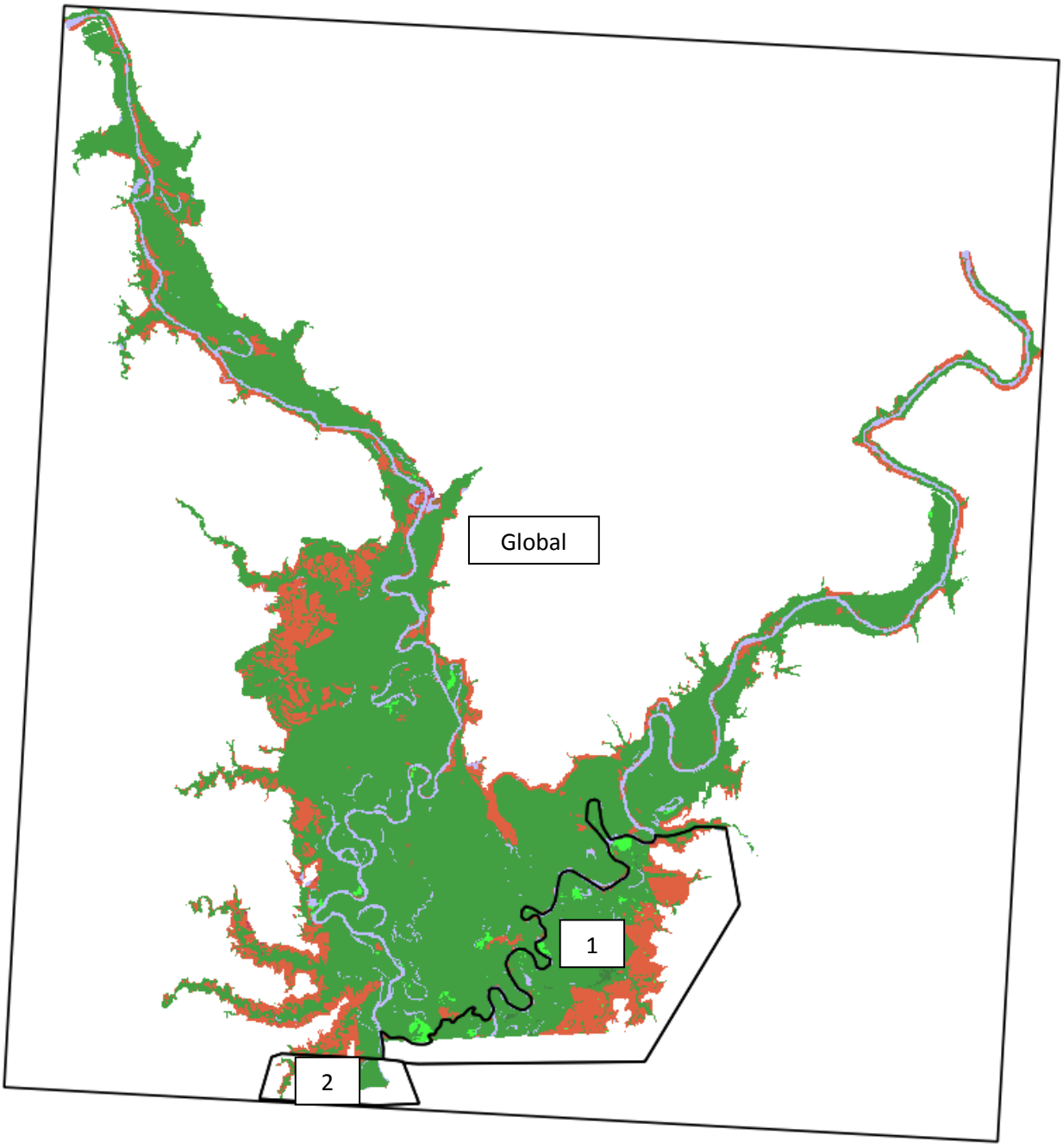
Parameter	Global	SubSite 1	SubSite 2	SubSite 3
Description		SubSite 1	SubSite 2	SubSite 3
NWI Photo Date	2009	2009	2009	2009
DEM Date	2009	2009	2009	2009
Direction Offshore	West	West	West	West
Historic Trend	1.6	1.6	1.6	1.6
Historic Eustatic Trend	1.7	1.7	1.7	1.7
MTL-NAVD88	0	0	0	0
GT	1.1	1.17	0.344	0.75
Salt Elev.	0.855	0.894	0.428	0.657
Marsh Erosion	2	2	2	2
Swamp Erosion	2	2	2	2
T.Flat Erosion	2	2	2	2
Reg.-Flood Marsh Accr	0	0	0	0
Irreg.-Flood Marsh Accr	4.8	4.8	4.8	4.8
Tidal-Fresh Marsh Accr	5.9	5.9	5.9	5.9
Inland-Fresh Marsh Accr	5.9	5.9	5.9	5.9
Mangrove Accr	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.5	0.5	0.5	0.5
Freq. Overwash	0	0	0	0
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	7.6	7.6	7.6	7.6
Reg Flood Min. Accr.	0.8	0.8	0.8	0.8
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377

Study Area 9



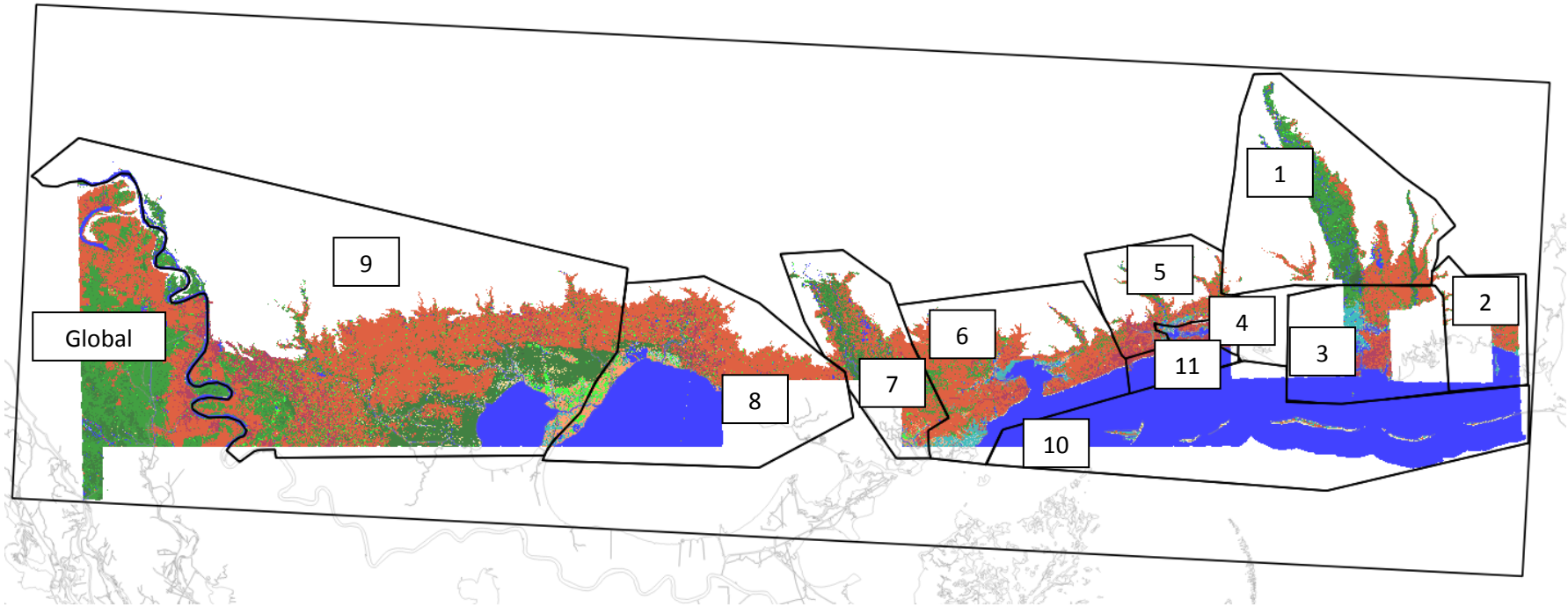
Parameter	Global	SubSite 1	SubSite 2
Description		St. Joseph Bay	SubSite 2
NWI Photo Date	2010	2010	2010
DEM Date	2009	2009	2009
Direction Offshore	South	West	South
Historic Trend	1.38	1.38	1.38
Historic Eustatic Trend	1.7	1.7	1.7
MTL-NAVD88	0	0	0
GT	0.5	0.49	0.75
Salt Elev.	0.51	0.51	0.75
Marsh Erosion	2	1.27	1.27
Swamp Erosion	2	1.27	1.27
T.Flat Erosion	2	1.27	1.27
Reg.-Flood Marsh Accr	0	0	0
Irreg.-Flood Marsh Accr	4.8	4.8	4.8
Tidal-Fresh Marsh Accr	5.9	5.9	5.9
Inland-Fresh Marsh Accr	5.9	5.9	5.9
Mangrove Accr	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3
Beach Sed. Rate	0.5	0.5	0.5
Freq. Overwash	0	25	0
Use Elev Pre-processor	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	7.6	7.6	7.6
Reg Flood Min. Accr.	0.8	0.8	0.8
Reg Flood Elev a	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377

Study Area 12



Parameter	Global	SubSite 1	SubSite 2
Description		SubSite 1	SubSite 2
NWI Photo Date	1981	2001	1981
DEM Date	1999	1999	2009
Direction Offshore	South	South	South
Historic Trend	2.98	2.98	2.98
Historic Eustatic Trend	1.7	1.7	1.7
MTL-NAVD88	0.18	0.18	0.18
GT	0.471	0.471	0.471
Salt Elev.	0.385	0.385	0.385
Marsh Erosion	1.5	1.5	1.5
Swamp Erosion	1	1	1
T.Flat Erosion	0.8	0.8	0.8
Reg.-Flood Marsh Accr	0	0	0
Irreg.-Flood Marsh Accr	4.4	4.4	4.4
Tidal-Fresh Marsh Accr	9	9	9
Inland-Fresh Marsh Accr	9	9	9
Mangrove Accr	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3
Beach Sed. Rate	4.45	4.45	4.45
Freq. Overwash	25	25	25
Use Elev Pre-processor	TRUE	TRUE	FALSE
Reg Flood Max. Accr.	11	11	11
Reg Flood Min. Accr.	3	3	3
Reg Flood Elev a	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377

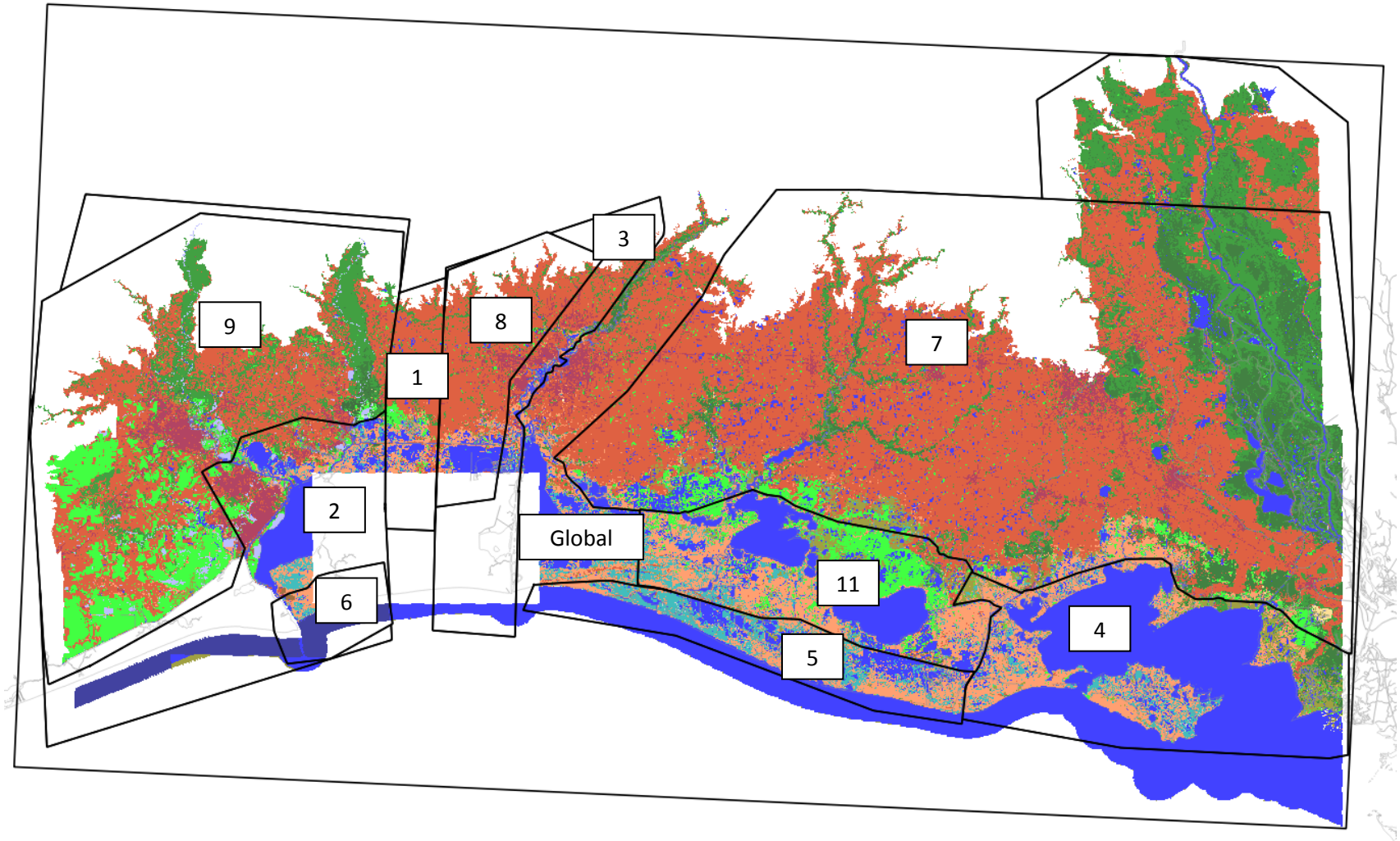
Study Area 14



Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
Description	LA Left Global	MSSC 3	NWI 2002	MSSC 3B	MSSC GL	GT 0.61
NWI Photo Date	2007	1980	2002	2007	2007	2007
DEM Date	2008	2008	2008	2008	2008	2008
Direction Offshore	South	South	South	South	South	South
Historic Trend	10.06	2.98	2.98	2.98	3	3
Historic Eustatic Trend	0	1.7	1.7	1.7	0	0
MTL-NAVD88	0	0	0	0	0	0
GT	0.015	0.47	0.48	0.47	0.54	0.61
Salt Elev.	0.016	0.53	0.53	0.53	0.61	0.69
Marsh Erosion	3	1.8	2.14	1.22	1.8	1.8
Swamp Erosion	3	1	2.14	1.22	1.8	1
T.Flat Erosion	3	0.5	0.5	0.5	0.5	0.5
Reg.-Flood Marsh Accr	3	4.7	4.7	4.7	4.7	4.7
Irreg.-Flood Marsh Accr	8.5	4.7	4.7	4.7	4.7	4.7
Tidal-Fresh Marsh Accr	9.8	5.9	5.9	5.9	5.9	5.9
Inland-Fresh Marsh Accr	9.8	5.9	5.9	5.9	5.9	5.9
Mangrove Accr	2	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	1	0.5	0.5	0.5	0.5	0.5
Freq. Overwash	25	25	25	25	25	25
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	16	11	11	11	11	11
Reg Flood Min. Accr.	7	3	3	3	3	3
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377	6.54377

Parameter	SubSite 6	SubSite 7	SubSite 8	SubSite 9	SubSite 10	SubSite 11
Description	SubSite 6	SubSite 7	GL BS	LA LEFT 11	Islands	6B
NWI Photo Date	2007	2007	2007	2007	2007	2007
DEM Date	2008	2008	2008	2008	2008	2008
Direction Offshore	South	South	South	South	South	South
Historic Trend	5	9.44	9.44	9.44	2.98	3
Historic Eustatic Trend	0	1.7	1.7	1.7	1.7	0
MTL-NAVD88	0	0	0	0	0	0
GT	0.52	0.375	0.155	0.155	0.475	0.52
Salt Elev.	0.57	0.32	0.13175	0.13175	0.53	0.57
Marsh Erosion	2.2	0	1.8	1.8	3	2.4
Swamp Erosion	2.2	0	1	1	3	2.4
T.Flat Erosion	0.5	2	2	2	0.5	0.5
Reg.-Flood Marsh Accr	4.7	8.5	8.5	8.5	4.7	4.7
Irreg.-Flood Marsh Accr	4.7	8.5	8.5	8.5	4.7	4.7
Tidal-Fresh Marsh Accr	5.9	9.8	9.8	9.8	5.9	5.9
Inland-Fresh Marsh Accr	5.9	9.8	9.8	9.8	5.9	5.9
Mangrove Accr	2	2	2	2	2	2
Tidal Swamp Accr	1.1	8.2	8.2	8.2	1.1	1.1
Swamp Accretion	0.3	8.2	8.2	8.2	0.3	0.3
Beach Sed. Rate	0.5	1	1	1	0.5	0.5
Freq. Overwash	25	25	25	25	25	25
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	11	16	16	16	11	11
Reg Flood Min. Accr.	3	6	6	6	3	3
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377	6.54377

Study Area 17

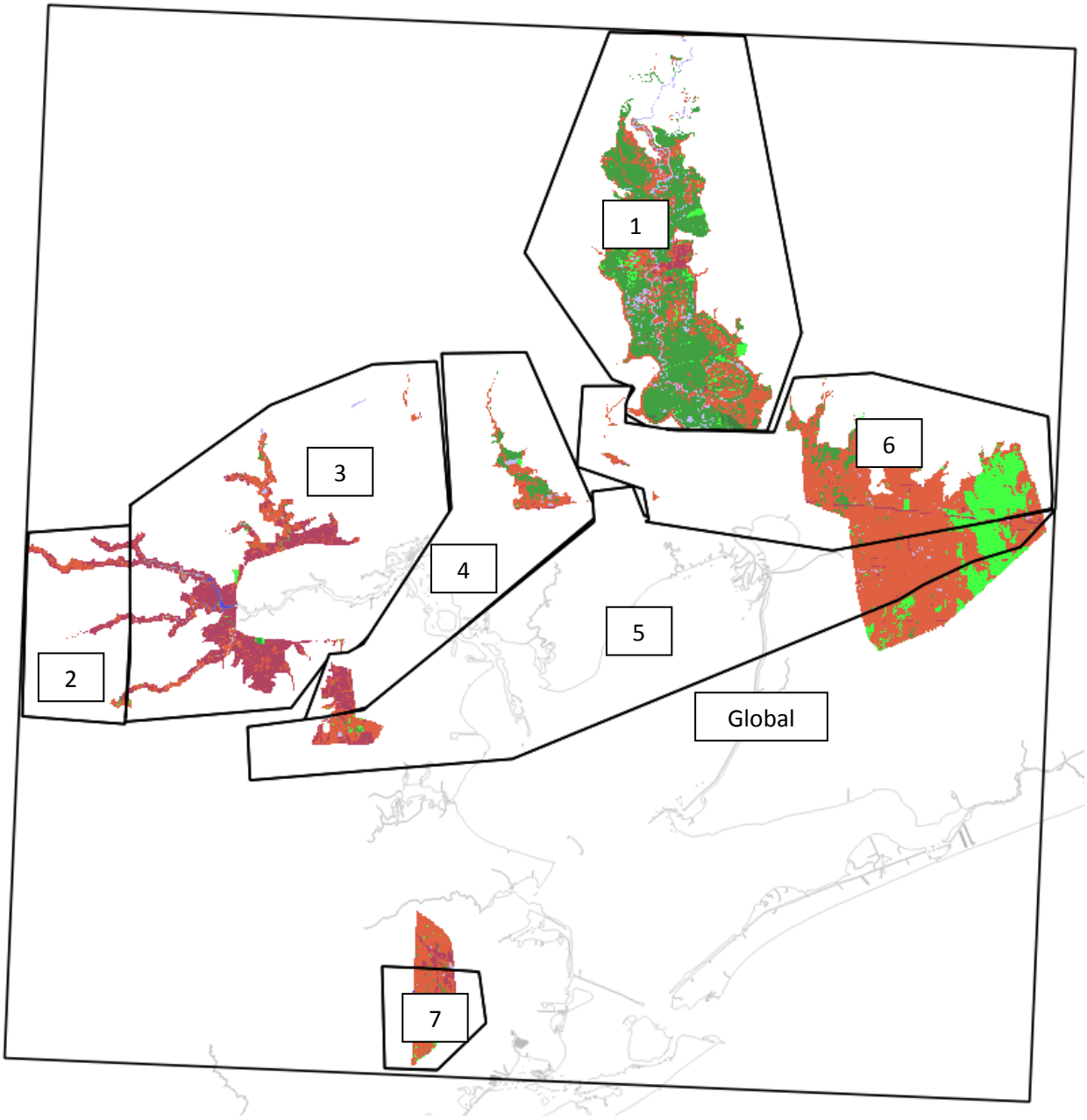


Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
Description		Muted 1	SubSite 2	SubSite 3	Vermillion Bay	Open Ocean5
NWI Photo Date	2008	1988	1993	2008	2008	2008
DEM Date	2007	2007	2007	2007	2007	2007
Direction Offshore	South	South	South	South	South	South
Historic Trend	10.06	10.06	10.06	10.06	10.06	10.06
Historic Eustatic Trend	0	0	0	0	0	0
MTL-NAVD88	0	0	0	0	0	0
GT	0.42	0.284	0.42	0.42	0.52	0.61
Salt Elev.	0.45	0.189	0.45	0.45	0.56	0.66
Marsh Erosion	3	3	3	3	2	9
Swamp Erosion	3	3	3	3	2	9
T.Flat Erosion	3	3	3	3	2	9
Reg.-Flood Marsh Accr	3	3	3	3	2	9
Irreg.-Flood Marsh Accr	8.5	8.5	8.5	8.5	8.5	8.5
Tidal-Fresh Marsh Accr	9.8	9.8	9.8	9.8	9.8	9.8
Inland-Fresh Marsh Accr	9.8	9.8	9.8	9.8	9.8	9.8
Mangrove Accr	2	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	1	1	1	1	1	1
Freq. Overwash	0	0	0	0	0	0
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	16	16	16	16	16	16
Reg Flood Min. Accr.	7	7	7	7	7	7
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377	6.54377

Parameter	SubSite 6	SubSite 7	SubSite 8	SubSite 9	SubSite 11
Description	Open Ocean	Muted 2	Muted 3	Muted 4	Muted 5
NWI Photo Date	1993	2008	2008	1993	2008
DEM Date	2007	2007	2007	2007	2007
Direction Offshore	South	South	South	South	South
Historic Trend	10.06	10.06	10.06	10.06	10.06
Historic Eustatic Trend	0	0	0	0	0
MTL-NAVD88	0	0	0	0	0
GT	0.61	0.015	0.32	0.2	0.05
Salt Elev.	0.66	0.016	0.27	0.17	0.054
Marsh Erosion	9	3	3	3	3
Swamp Erosion	9	3	3	3	3
T.Flat Erosion	9	3	3	3	3
Reg.-Flood Marsh Accr	9	3	3	3	3
Irreg.-Flood Marsh Accr	8.5	8.5	8.5	8.5	8.5
Tidal-Fresh Marsh Accr	9.8	9.8	9.8	9.8	9.8
Inland-Fresh Marsh Accr	9.8	9.8	9.8	9.8	9.8
Mangrove Accr	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	1	1	1	1	1
Freq. Overwash	0	0	0	0	0
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	16	16	16	16	16
Reg Flood Min. Accr.	7	7	7	7	7
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377

Subsite 10 was superseded

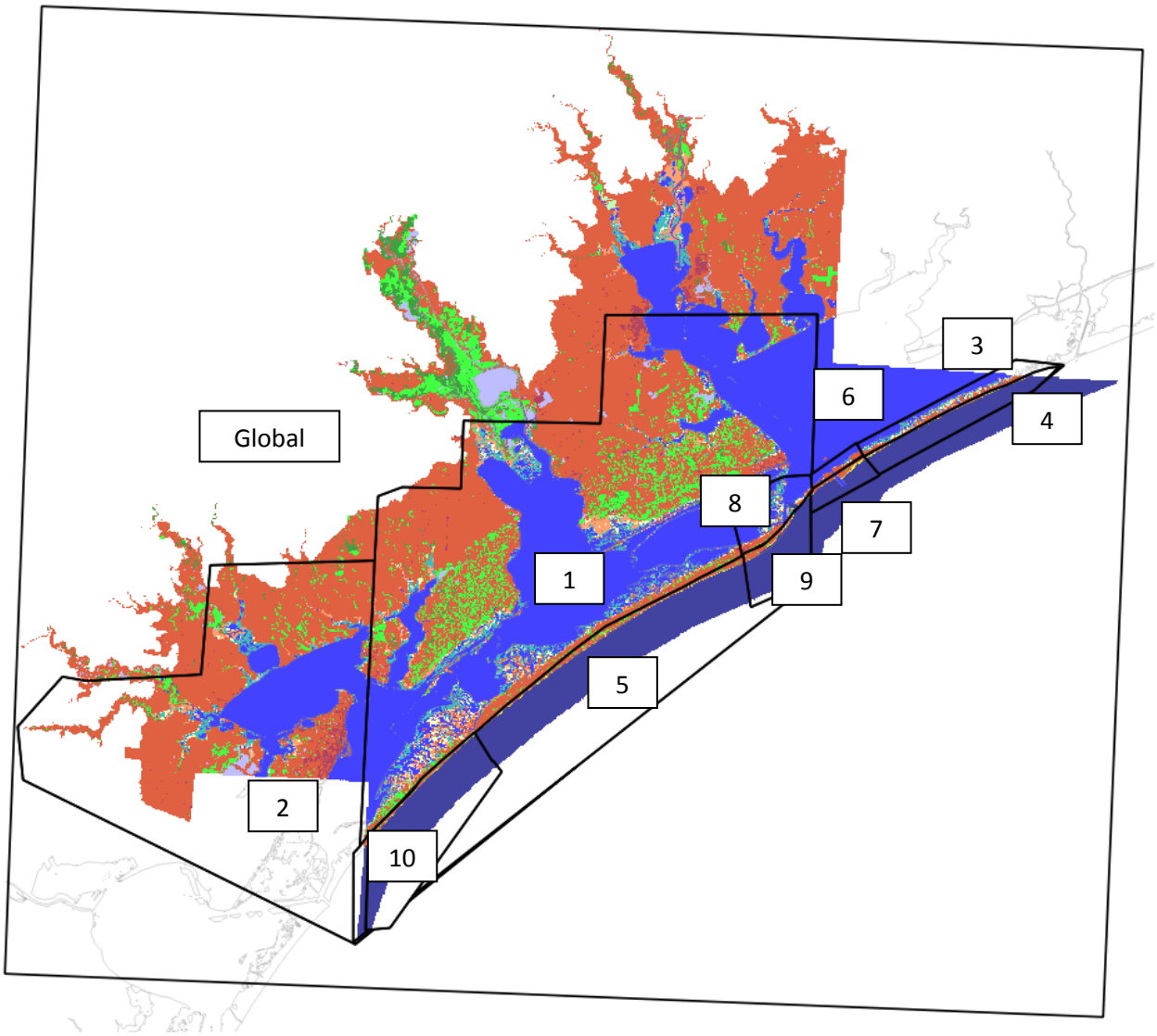
Study Area 18



Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4
Description		DEM 2008 Trinity Delta	SubSite 2	Urban Tribs	HSC
NWI Photo Date	2006	2006	1992	2006	2006
DEM Date	2009	2008	2009	2009	2009
Direction Offshore	East	South	East	East	East
Historic Trend	4.75	4.75	4.75	4.75	4.75
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	0.1224	0.1224	0.1224	0.1224	0.1224
GT	0.3444	0.3	0.4998	0.4998	0.4511
Salt Elev.	0.3508	0.38357	0.4324	0.4324	0.4068
Marsh Erosion	1	1	2.44	2.44	1
Swamp Erosion	1	1	2.44	2.44	1
T.Flat Erosion	1	1	2.44	2.44	1
Reg.-Flood Marsh Accr	7.75	7.75	7.75	7.75	7.75
Irreg.-Flood Marsh Accr	7.75	7.75	7.75	7.75	7.75
Tidal-Fresh Marsh Accr	2.9	2.9	2.9	2.9	2.9
Inland-Fresh Marsh Accr	2.9	2.9	2.9	2.9	2.9
Mangrove Accr	7	7	7	7	7
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	1	1	3	3	1
Freq. Overwash	30	30	30	30	30
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	10	10	10	10	10
Reg Flood Min. Accr.	3.8	3.8	3.8	3.8	3.8
Reg Flood Elev a	4.977941	4.977941	4.977941	4.977941	4.977941
Reg Flood Elev b	-13.3409	-13.3409	-13.3409	-13.3409	-13.3409
Reg Flood Elev c	3.930084	3.930084	3.930084	3.930084	3.930084
Reg Flood Elev d	9.692886	9.692886	9.692886	9.692886	9.692886

Parameter	SubSite 5	SubSite 6	SubSite 7
Description	Northern Bay	Trinity Delta	West Bay
NWI Photo Date	2006	2006	2006
DEM Date	2009	2009	2009
Direction Offshore	South	South	East
Historic Trend	4.75	4.75	4.75
Historic Eustatic Trend	1.7	1.7	1.7
MTL-NAVD88	0.1224	0.1224	0.1224
GT	0.415	0.3	0.32
Salt Elev.	0.37137	0.38357	0.40121
Marsh Erosion	1	1	0.77
Swamp Erosion	1	1	0.77
T.Flat Erosion	1	1	0.77
Reg.-Flood Marsh Accr	7.75	7.75	4.7
Irreg.-Flood Marsh Accr	7.75	7.75	4.7
Tidal-Fresh Marsh Accr	2.9	2.9	2.9
Inland-Fresh Marsh Accr	2.9	2.9	2.9
Mangrove Accr	7	7	7
Tidal Swamp Accr	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3
Beach Sed. Rate	1	1	1
Freq. Overwash	30	30	30
Use Elev Pre-processor	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	10	10	4
Reg Flood Min. Accr.	3.8	3.8	1.6
Reg Flood Elev a	4.977941	4.977941	4.977941
Reg Flood Elev b	-13.3409	-13.3409	-13.3409
Reg Flood Elev c	3.930084	3.930084	3.930084
Reg Flood Elev d	9.692886	9.692886	9.692886

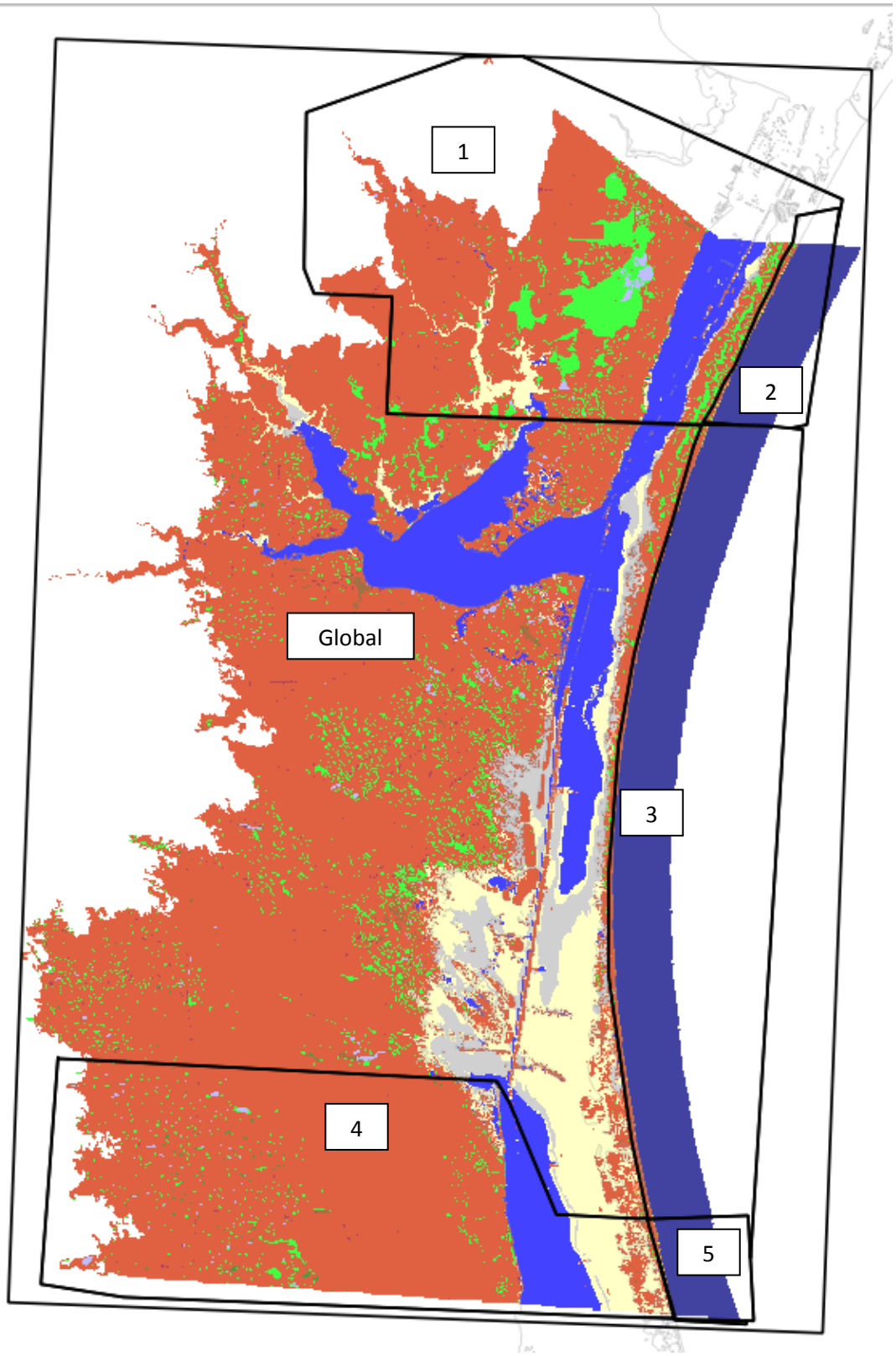
Study Area 19



Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
Description		SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
NWI Photo Date	1992	2008	2006	2001	2001	2008
DEM Date	2009	2009	2009	2009	2009	2009
Direction Offshore	East	East	East	East	East	East
Historic Trend	5.16	5.16	5.16	5.16	5.16	5.16
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	0	0	0	0	0	0
GT	0.12	0.12	0.12	0.12	0.53	0.53
Salt Elev.	0.09	0.09	0.09	0.09	0.52	0.52
Marsh Erosion	0.8	0.25	0	1	1	0
Swamp Erosion	0.8	0.25	0	1	1	0
T.Flat Erosion	0.8	0.25	0	1	1	0
Reg.-Flood Marsh Accr	0	0	0	0	0	0
Irreg.-Flood Marsh Accr	3	3	3	3	3	3
Tidal-Fresh Marsh Accr	5.4	5.4	5.4	5.4	5.4	5.4
Inland-Fresh Marsh Accr	4.4	4.4	4.4	4.4	4.4	4.4
Mangrove Accr	2	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.69	0.69	0.69	0.69	0.69	0.69
Freq. Overwash	36	36	36	36	36	36
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	8.4	8.4	8.4	8.4	8.4	8.4
Reg Flood Min. Accr.	4.6	4.6	4.6	4.6	4.6	4.6
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377	6.54377

Parameter	SubSite 6	SubSite 7	SubSite 8	SubSite 9	SubSite 10
Description	SubSite 6	SubSite 7	SubSite 8	SubSite 9	SubSite 10
NWI Photo Date	2001	2001	2008	2008	2008
DEM Date	2009	2009	2009	2009	2009
Direction Offshore	East	East	East	East	East
Historic Trend	5.16	5.16	5.16	5.16	5.16
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	0	0	0	0	0
GT	0.12	0.53	0.12	0.53	0.53
Salt Elev.	0.09	0.52	0.09	0.52	0.52
Marsh Erosion	7	7	7	7	1.5
Swamp Erosion	7	7	7	7	1.5
T.Flat Erosion	7	7	7	7	1.5
Reg.-Flood Marsh Accr	0	0	0	0	0
Irreg.-Flood Marsh Accr	3	3	3	3	3
Tidal-Fresh Marsh Accr	5.4	5.4	5.4	5.4	5.4
Inland-Fresh Marsh Accr	4.4	4.4	4.4	4.4	4.4
Mangrove Accr	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.69	0.69	0.69	0.69	0.69
Freq. Overwash	36	36	36	36	36
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	8.4	8.4	8.4	8.4	8.4
Reg Flood Min. Accr.	4.6	4.6	4.6	4.6	4.6
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377

Study Area 20



Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
Description		SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5
NWI Photo Date	1993	2006	2006	1993	1993	1993
DEM Date	2010	2010	2010	2010	2010	2010
Direction Offshore	East	East	East	East	East	East
Historic Trend	1.93	1.93	1.93	1.93	1.93	1.93
Historic Eustatic Trend	1.7	1.7	1.7	1.7	1.7	1.7
MTL-NAVD88	0	0	0	0	0	0
GT	0.06	0.06	0.56	0.56	0.06	0.56
Salt Elev.	0.045	0.045	0.55	0.55	0.045	0.55
Marsh Erosion	0	1.3	1.3	0	1.5	1.5
Swamp Erosion	0	1.3	1.3	0	1.5	1.5
T.Flat Erosion	0	1.3	1.3	0	1.5	1.5
Reg.-Flood Marsh Accr	0	0	0	0	0	0
Irreg.-Flood Marsh Accr	3	3	3	3	3	3
Tidal-Fresh Marsh Accr	5.38	5.38	5.38	5.38	5.38	5.38
Inland-Fresh Marsh Accr	4.4	4.4	4.4	4.4	4.4	4.4
Mangrove Accr	2	2	2	2	2	2
Tidal Swamp Accr	1.1	1.1	1.1	1.1	1.1	1.1
Swamp Accretion	0.3	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate	0.69	0.69	0.69	0.69	0.69	0.69
Freq. Overwash	50	50	50	50	50	50
Use Elev Pre-processor	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Reg Flood Max. Accr.	8.4	8.4	8.4	8.4	8.4	8.4
Reg Flood Min. Accr.	4.6	4.6	4.6	4.6	4.6	4.6
Reg Flood Elev a	4.905004	4.905004	4.905004	4.905004	4.905004	4.905004
Reg Flood Elev b	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954	-8.36954
Reg Flood Elev c	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503	-1.88503
Reg Flood Elev d	6.54377	6.54377	6.54377	6.54377	6.54377	6.54377

Appendix D. Focal Species Analysis Results

Results for Seaside Sparrow: Aggregated Regularly Flooded Marsh and Irregularly Flooded Marsh Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m^2)	STD Area (m^2)	MIN Area (m^2)	MAX Area (m^2)	RANGE Area (m^2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio	COUNT Patches >= 10,000 acres	Proportion (%) of Patches >= 10,000 acres
0.5 m	Base	332546	9561065175	28751.1	1883108.8	225	665797500	665797275	0.1536	0.0702	0.0034	0.2667	0.2632	17	0.0051
0.5 m	2025	623039	9754362450	15656.1	1093797.1	225	454503825	454503600	0.1818	0.0717	0.0034	0.2667	0.2632	17	0.0027
0.5 m	2050	825372	9583785450	11611.5	923300.6	225	617628825	617628600	0.1950	0.0702	0.0034	0.2667	0.2632	16	0.0019
0.5 m	2075	1155601	9327193200	8071.3	602054.7	225	366077700	366077475	0.2034	0.0673	0.0035	0.2667	0.2632	19	0.0016
0.5 m	2100	1312520	8293682250	6318.9	482371.9	225	273084525	273084300	0.2096	0.0649	0.0021	0.2667	0.2646	17	0.0013
1.0 m	Base	331720	9575949375	28867.6	1886783.4	225	665797500	665797275	0.1535	0.0702	0.0034	0.2667	0.2633	17	0.0051
1.0 m	2025	673774	9697107150	14392.2	910709.5	225	434749275	434749050	0.1844	0.0713	0.0034	0.2667	0.2632	19	0.0028
1.0 m	2050	1101309	8686391625	7887.3	473349.6	225	224565525	224565300	0.1998	0.0683	0.0035	0.2667	0.2632	18	0.0016
1.0 m	2075	1521085	6575247225	4322.7	277677.9	225	235789200	235788975	0.2111	0.0637	0.0028	0.2667	0.2639	8	0.0005
1.0 m	2100	1300364	4810550400	3699.4	265128.5	225	142279200	142278975	0.2155	0.0615	0.0041	0.2667	0.2626	7	0.0005
1.2 m	Base	332359	9574043400	28806.3	1884940.0	225	665797500	665797275	0.1536	0.0702	0.0034	0.2667	0.2633	17	0.0051
1.2 m	2025	693715	9669201075	13938.3	885978.3	225	424721925	424721700	0.1853	0.0712	0.0034	0.2667	0.2632	19	0.0027
1.2 m	2050	1245512	8093781225	6498.4	371199.1	225	222136200	222135975	0.2034	0.0670	0.0037	0.2667	0.2630	15	0.0012
1.2 m	2075	1438147	5720964975	3978.0	300707.2	225	219518550	219518325	0.2115	0.0635	0.0028	0.2667	0.2639	7	0.0005
1.2 m	2100	1157472	4243113225	3665.8	268595.7	225	176160600	176160375	0.2139	0.0621	0.0038	0.2667	0.2629	3	0.0003
1.5 m	Base	334707	9570116025	28592.5	1878300.8	225	665797500	665797275	0.1541	0.0703	0.0034	0.2667	0.2633	17	0.0051
1.5 m	2025	723973	9602931150	13264.2	818056.5	225	367240275	367240050	0.1865	0.0710	0.0034	0.2667	0.2632	19	0.0026
1.5 m	2050	1378821	7097601825	5147.6	275142.0	225	218426400	218426175	0.2059	0.0661	0.0036	0.2667	0.2631	10	0.0007
1.5 m	2075	1278588	5156737650	4033.2	351014.2	225	315399600	315399375	0.2106	0.0637	0.0027	0.2667	0.2640	5	0.0004
1.5 m	2100	1005334	3988305675	3967.1	288287.9	225	186153525	186153300	0.2137	0.0622	0.0035	0.2667	0.2632	5	0.0005
2.0 m	Base	338912	9535277025	28135.0	1865388.5	225	665797500	665797275	0.1549	0.0705	0.0034	0.2667	0.2633	17	0.0050
2.0 m	2025	791194	9376210800	11850.7	681744.1	225	226217925	226217700	0.1890	0.0706	0.0035	0.2667	0.2632	18	0.0023
2.0 m	2050	1396299	6218387325	4453.5	233913.9	225	213073875	213073650	0.2063	0.0658	0.0037	0.2667	0.2630	3	0.0002
2.0 m	2075	1130440	4879271250	4316.3	269685.3	225	140800950	140800725	0.2103	0.0637	0.0023	0.2667	0.2643	10	0.0009
2.0 m	2100	856471	4174103250	4873.6	326473.2	225	208072350	208072125	0.2126	0.0629	0.0031	0.2667	0.2636	7	0.0008

Results for Mottled Duck in TX, LA, MS, and AL: Aggregated Tidal Fresh Marsh, Transitional Marsh / Scrub Shrub, and Irregularly Flooded Marsh Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	base	597898	6953433525	11630	679317	225	215240850	215240625	0.1847	0.0702	0.0034	0.2667	0.2633
0.5 m	2025	820740	6457717800	7868	480868	225	215311500	215311275	0.1986	0.0684	0.0034	0.2667	0.2633
0.5 m	2050	1110286	6111402975	5504	341326	225	215237475	215237250	0.2059	0.0657	0.0036	0.2667	0.2631
0.5 m	2075	1250357	4920007950	3935	297159	225	237370050	237369825	0.2127	0.0629	0.0021	0.2667	0.2646
0.5 m	2100	1106143	4426663050	4002	355671	225	232464375	232464150	0.2153	0.0617	0.0044	0.2667	0.2623
1.0 m	base	601990	6998474025	11626	676331	225	215240850	215240625	0.1848	0.0702	0.0034	0.2667	0.2632
1.0 m	2025	924742	6329576925	6845	404685	225	214807050	214806825	0.2002	0.0676	0.0035	0.2667	0.2631
1.0 m	2050	1183102	5392326825	4558	310412	225	230365350	230365125	0.2089	0.0645	0.0028	0.2667	0.2639
1.0 m	2075	1060596	4224665250	3983	271299	225	142383825	142383600	0.2146	0.0617	0.0041	0.2667	0.2625
1.0 m	2100	897268	2842425675	3168	120884	225	47080125	47079900	0.2151	0.0616	0.0046	0.2667	0.2621
1.2 m	base	603994	6998433975	11587	672732	225	215240850	215240625	0.1850	0.0702	0.0034	0.2667	0.2632
1.2 m	2025	960310	6242911200	6501	383193	225	214388775	214388550	0.2009	0.0674	0.0035	0.2667	0.2631
1.2 m	2050	1151782	5210313975	4524	338410	225	218353725	218353500	0.2095	0.0642	0.0028	0.2667	0.2639
1.2 m	2075	997967	3906730800	3915	280604	225	176168250	176168025	0.2146	0.0616	0.0038	0.2667	0.2628
1.2 m	2100	826208	2696790600	3264	133349	225	57352050	57351825	0.2148	0.0616	0.0025	0.2667	0.2641
1.5 m	base	603693	6998126400	11592	674318	225	215240850	215240625	0.1849	0.0702	0.0034	0.2667	0.2632
1.5 m	2025	1009978	6121036125	6061	357159	225	213511725	213511500	0.2017	0.0670	0.0036	0.2667	0.2631
1.5 m	2050	1107484	4956516900	4475	376056	225	315399825	315399600	0.2106	0.0636	0.0027	0.2667	0.2640
1.5 m	2075	886096	3615898050	4081	299710	225	186156900	186156675	0.2141	0.0619	0.0035	0.2667	0.2631
1.5 m	2100	730387	2868264450	3927	167516	225	47650275	47650050	0.2140	0.0622	0.0024	0.2667	0.2643
2.0 m	base	608722	6955184475	11426	665848	225	215240850	215240625	0.1853	0.0702	0.0034	0.2667	0.2632
2.0 m	2025	1081015	5951111175	5505	311503	225	210757725	210757500	0.2028	0.0667	0.0037	0.2667	0.2630
2.0 m	2050	1041368	4672102725	4487	277781	225	142299675	142299450	0.2112	0.0631	0.0023	0.2667	0.2643
2.0 m	2075	752469	3717985275	4941	339925	225	208072350	208072125	0.2125	0.0628	0.0031	0.2667	0.2636
2.0 m	2100	671719	3400265475	5062	210942	225	52970625	52970400	0.2128	0.0628	0.0055	0.2667	0.2612

Results for Mottled Duck in Florida: Aggregated Tidal Fresh Marsh, Transitional Marsh / Scrub Shrub, and Irregularly Flooded Marsh Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	base	60072	522503100	8697.9	149255.5	225	17012025	17011800	0.1886	0.0723	0.0055	0.2667	0.2612
0.5 m	2025	75232	506061675	6726.7	115519.1	225	10911150	10910925	0.1931	0.0711	0.0055	0.2667	0.2612
0.5 m	2050	91132	611911125	6714.6	126190.9	225	11941650	11941425	0.1900	0.0707	0.0056	0.2667	0.2611
0.5 m	2075	106217	763668000	7189.7	149076.0	225	22676400	22676175	0.1817	0.0720	0.0077	0.2667	0.2590
0.5 m	2100	128359	933684300	7274.0	206184.0	225	47194650	47194425	0.1785	0.0714	0.0073	0.2667	0.2594
1.0 m	base	62052	524740275	8456.5	146288.2	225	17062200	17061975	0.1898	0.0722	0.0055	0.2667	0.2612
1.0 m	2025	84149	535344975	6361.9	109211.6	225	10771875	10771650	0.1906	0.0708	0.0055	0.2667	0.2612
1.0 m	2050	117584	824630400	7013.1	180664.0	225	45746550	45746325	0.1893	0.0715	0.0056	0.2667	0.2611
1.0 m	2075	321590	1368646650	4255.9	98890.8	225	23336325	23336100	0.1985	0.0692	0.0024	0.2667	0.2643
1.0 m	2100	188822	663922575	3516.1	67419.3	225	15434775	15434550	0.1983	0.0686	0.0042	0.2667	0.2625
1.2 m	base	62771	525183300	8366.7	145385.2	225	17065800	17065575	0.1902	0.0721	0.0055	0.2667	0.2612
1.2 m	2025	91821	565524450	6159.0	108939.2	225	10631475	10631250	0.1911	0.0704	0.0056	0.2667	0.2611
1.2 m	2050	133996	858162600	6404.4	174554.7	225	48069000	48068775	0.1942	0.0705	0.0061	0.2667	0.2606
1.2 m	2075	176296	808088625	4583.7	114172.2	225	17752725	17752500	0.1986	0.0693	0.0039	0.2667	0.2627
1.2 m	2100	185763	616608900	3319.3	70258.6	225	17446500	17446275	0.2006	0.0681	0.0046	0.2667	0.2621
1.5 m	base	64330	526958100	8191.5	143688.1	225	17073225	17073000	0.1909	0.0720	0.0055	0.2667	0.2612
1.5 m	2025	96647	590668425	6111.6	108380.3	225	10611675	10611450	0.1900	0.0707	0.0064	0.2667	0.2603
1.5 m	2050	149740	893661300	5968.1	179081.6	225	50494275	50494050	0.1991	0.0696	0.0045	0.2667	0.2622
1.5 m	2075	182449	800102925	4385.4	143223.0	225	27387450	27387225	0.2018	0.0681	0.0039	0.2667	0.2628
1.5 m	2100	171412	731722725	4268.8	141447.6	225	42205050	42204825	0.2016	0.0679	0.0044	0.2667	0.2623
2.0 m	base	66626	528355575	7930.2	141199.6	225	17084250	17084025	0.1921	0.0717	0.0055	0.2667	0.2612
2.0 m	2025	106313	661561650	6222.8	116411.7	225	17114850	17114625	0.1903	0.0708	0.0055	0.2667	0.2612
2.0 m	2050	165505	923969700	5582.7	167186.6	225	39761100	39760875	0.2022	0.0687	0.0042	0.2667	0.2625
2.0 m	2075	146006	924967800	6335.1	230110.3	225	48782700	48782475	0.1986	0.0695	0.0036	0.2667	0.2631
2.0 m	2100	161326	1132211025	7018.2	320101.4	225	100716300	100716075	0.2012	0.0690	0.0029	0.2667	0.2638

Results for Mottled Duck in TX, LA, MS, and AL: Estuarine Open Water

SLR Scenario	Simul -ation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio	COUNT Patches < 640 acres	SUM Area of Patches < 640 acres (m^2)	Proportion (%) of Total Area in Patches < 640 acres
0.5 m	base	169807	33322817925	196239	61256783	225	24823711575	24823711350	0.1393	0.0672	0.0016	0.2667	0.2651	169736	1409940450	4.23
0.5 m	2025	274968	33725751300	122653	52748514	225	27380171475	27380171250	0.1687	0.0751	0.0016	0.2667	0.2651	274900	1611623700	4.78
0.5 m	2050	464588	34491129975	74240	41591246	225	28071126450	28071126225	0.1917	0.0724	0.0016	0.2667	0.2651	464528	1797346350	5.21
0.5 m	2075	647650	36036651600	55642	36593186	225	29121284025	29121283800	0.2007	0.0692	0.0022	0.2667	0.2644	647582	2011992975	5.58
0.5 m	2100	736757	38196975150	51845	36457597	225	30954695400	30954695175	0.2005	0.0684	0.0022	0.2667	0.2644	736685	2092491450	5.48
1.0 m	base	167475	33330071025	199015	61673118	225	24820752150	24820751925	0.1382	0.0669	0.0016	0.2667	0.2651	167401	1415919600	4.25
1.0 m	2025	290071	33809695200	116557	51395682	225	27399354525	27399354300	0.1707	0.0751	0.0016	0.2667	0.2651	290000	1634189400	4.83
1.0 m	2050	527619	35265057975	66838	39490695	225	28369166850	28369166625	0.1952	0.0713	0.0016	0.2667	0.2651	527551	1913949225	5.43
1.0 m	2075	691573	38343540600	55444	37699546	225	30973293225	30973293000	0.2031	0.0678	0.0022	0.2667	0.2644	691502	1976368050	5.15
1.0 m	2100	604630	43189571025	71431	46419761	225	35696457000	35696456775	0.2014	0.0679	0.0022	0.2667	0.2644	604573	1643000850	3.80
1.2 m	base	167618	33331308525	198853	61646878	225	24820752375	24820752150	0.1383	0.0669	0.0016	0.2667	0.2651	167544	1416896550	4.25
1.2 m	2025	293498	33843977550	115312	51122142	225	27412612425	27412612200	0.1711	0.0751	0.0016	0.2667	0.2651	293427	1640352600	4.85
1.2 m	2050	545145	35538618375	65191	39048914	225	28501194600	28501194375	0.1963	0.0710	0.0016	0.2667	0.2651	545079	1940487750	5.46
1.2 m	2075	675133	39318895350	58239	39275232	225	31875862275	31875862050	0.2046	0.0675	0.0022	0.2667	0.2644	675066	1853722800	4.71
1.2 m	2100	483602	44587558350	92199	53812495	225	36997378875	36997378650	0.1950	0.0695	0.0022	0.2667	0.2644	483544	1484419500	3.33
1.5 m	base	167984	33331706325	198422	61579746	225	24820753950	24820753725	0.1385	0.0670	0.0016	0.2667	0.2651	167910	1417134825	4.25
1.5 m	2025	302453	34022872575	112490	50412152	225	27427316625	27427316400	0.1718	0.0750	0.0016	0.2667	0.2651	302380	1678322925	4.93
1.5 m	2050	570607	35933575275	62974	38432529	225	28681523325	28681523100	0.1980	0.0707	0.0016	0.2667	0.2651	570532	1965156975	5.47
1.5 m	2075	683345	40708497600	59572	40698729	225	33219105525	33219105300	0.2072	0.0665	0.0022	0.2667	0.2644	683290	1728715725	4.25
1.5 m	2100	389406	45810131400	117641	61856878	225	38158870725	38158870500	0.1874	0.0704	0.0022	0.2667	0.2644	389354	1348771275	2.94
2.0 m	base	171289	33328309950	194574	60990512	225	24823210275	24823210050	0.1399	0.0675	0.0016	0.2667	0.2651	171218	1414190475	4.24
2.0 m	2025	316244	34151039550	107990	49389154	225	27464183100	27464182875	0.1735	0.0749	0.0016	0.2667	0.2651	316175	1686756150	4.94
2.0 m	2050	614321	36556035075	59506	37462117	225	28983459825	28983459600	0.2004	0.0699	0.0016	0.2667	0.2651	614239	1991208600	5.45
2.0 m	2075	559096	42236084475	75544	47056344	225	34739103600	34739103375	0.2029	0.0680	0.0022	0.2667	0.2644	559050	1544091975	3.66
2.0 m	2100	337731	46994190525	139147	68233906	225	39201381225	39201381000	0.1799	0.0706	0.0022	0.2667	0.2644	337683	1317585375	2.80

Results for Mottled Duck in Florida: Estuarine Open Water

SLR Scenario	Simul-ation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio	COUNT Patches < 640 acres	SUM Area of Patches < 640 acres (m^2)	Proportion (%) of Total Area in Patches < 640 acres
0.5 m	base	129200	7718527800	59740.9	9862270.2	225	3006385200	3006384975	0.2128	0.0636	0.0007	0.2667	0.2660	129168	309998475	4.02
0.5 m	2025	144752	7813586250	53979.1	9382301.2	225	3023569350	3023569125	0.2120	0.0636	0.0007	0.2667	0.2660	144723	347743350	4.45
0.5 m	2050	179775	7982420850	44402.3	8569910.8	225	3091625550	3091625325	0.2139	0.0627	0.0008	0.2667	0.2659	179744	391685400	4.91
0.5 m	2075	217972	8205578550	37645.1	8355929.4	225	3401359200	3401358975	0.2156	0.0622	0.0011	0.2667	0.2656	217941	458578800	5.59
0.5 m	2100	243768	8710859475	35734.2	8329152.4	225	3534026175	3534025950	0.2169	0.0614	0.0010	0.2667	0.2656	243728	512451900	5.88
1.0 m	base	139706	7732750275	55350.2	9484609.1	225	3006435600	3006435375	0.2140	0.0630	0.0007	0.2667	0.2660	139674	321844725	4.16
1.0 m	2025	174870	7904363175	45201.4	8593005.2	225	3050483400	3050483175	0.2145	0.0625	0.0007	0.2667	0.2660	174839	384090300	4.86
1.0 m	2050	240039	8306169750	34603.4	8084639.9	225	3471591600	3471591375	0.2181	0.0608	0.0010	0.2667	0.2657	240007	484911225	5.84
1.0 m	2075	253358	9369360900	36980.7	8896437.7	225	3906723825	3906723600	0.2177	0.0614	0.0010	0.2667	0.2657	253315	515822850	5.51
1.0 m	2100	211052	10506027375	49779.3	12406912.5	225	5232995775	5232995550	0.2102	0.0651	0.0015	0.2667	0.2652	211014	457149150	4.35
1.2 m	base	143518	7738637400	53921.0	9358022.6	225	3006482400	3006482175	0.2144	0.0628	0.0007	0.2667	0.2660	143486	326840400	4.22
1.2 m	2025	185360	7943662125	42855.3	8372499.0	225	3063163500	3063163275	0.2150	0.0621	0.0007	0.2667	0.2660	185328	397836000	5.01
1.2 m	2050	249498	8478974025	33984.1	8159397.3	225	3602701125	3602700900	0.2185	0.0607	0.0010	0.2667	0.2657	249465	500484825	5.90
1.2 m	2075	187163	10132816050	54139.0	12919128.5	225	5135631975	5135631750	0.2116	0.0647	0.0010	0.2667	0.2656	187127	426298950	4.21
1.2 m	2100	176845	11288057400	63830.2	14724800.4	225	5693350275	5693350050	0.2051	0.0670	0.0015	0.2667	0.2652	176809	422523900	3.74
1.5 m	base	149652	7748159175	51774.5	9164509.4	225	3006494325	3006494100	0.2149	0.0625	0.0007	0.2667	0.2660	149619	330579675	4.27
1.5 m	2025	197120	8007499800	40622.5	8164727.1	225	3083200425	3083200200	0.2158	0.0618	0.0007	0.2667	0.2660	197087	409698225	5.12
1.5 m	2050	251198	8937127800	35578.0	8579790.7	225	3774986550	3774986325	0.2187	0.0606	0.0010	0.2667	0.2657	251166	501656850	5.61
1.5 m	2075	191025	10580386725	55387.4	13377701.0	225	5372455725	5372455500	0.2084	0.0658	0.0013	0.2667	0.2654	190988	428911425	4.05
1.5 m	2100	130958	12179707200	93004.7	18450904.2	225	6051105900	6051105675	0.2012	0.0684	0.0015	0.2667	0.2652	130922	346079250	2.84
2.0 m	base	158116	7764982425	49109.4	8916597.4	225	3006514125	3006513900	0.2155	0.0622	0.0007	0.2667	0.2660	158083	341422875	4.40
2.0 m	2025	213129	8124122475	38118.3	7904453.6	225	3105759825	3105759600	0.2173	0.0612	0.0007	0.2667	0.2660	213096	436163625	5.37
2.0 m	2050	218289	9663529725	44269.4	11165000.0	225	4728199950	4728199725	0.2160	0.0623	0.0010	0.2667	0.2657	218257	435702600	4.51
2.0 m	2075	139553	11492903475	82355.1	17146878.5	225	5829090300	5829090075	0.1999	0.0686	0.0014	0.2667	0.2653	139518	393721425	3.43
2.0 m	2100	92935	13238026875	142443.9	23196514.9	225	6319778175	6319777950	0.1948	0.0700	0.0014	0.2667	0.2653	92904	290195775	2.19

Results for Black Skimmer: Aggregated Ocean Beach and Estuarine Beach Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m^2)	STD Area (m^2)	MIN Area (m^2)	MAX Area (m^2)	RANGE Area (m^2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	Base	66238	1046707425	15802.2	1059771.0	225	248687775	248687550	0.1754	0.0718	0.0032	0.2667	0.2635
0.5 m	2025	64302	1022148000	15896.1	1074770.9	225	248613075	248612850	0.1786	0.0722	0.0032	0.2667	0.2635
0.5 m	2050	70986	992691900	13984.3	1003185.6	225	243086850	243086625	0.1859	0.0718	0.0032	0.2667	0.2635
0.5 m	2075	71626	814160700	11366.8	940047.3	225	234742950	234742725	0.1892	0.0714	0.0045	0.2667	0.2621
0.5 m	2100	76111	695393550	9136.6	830959.3	225	217273050	217272825	0.1962	0.0698	0.0053	0.2667	0.2614
1.0 m	Base	64256	1031222025	16048.6	1075899.9	225	248686875	248686650	0.1746	0.0718	0.0032	0.2667	0.2635
1.0 m	2025	64055	996771375	15561.2	1073521.2	225	247801500	247801275	0.1796	0.0720	0.0032	0.2667	0.2635
1.0 m	2050	75575	789321600	10444.2	891256.4	225	229222125	229221900	0.1909	0.0706	0.0048	0.2667	0.2619
1.0 m	2075	75313	536307525	7121.0	559607.3	225	146756700	146756475	0.1988	0.0693	0.0058	0.2667	0.2609
1.0 m	2100	68536	354686850	5175.2	261806.9	225	64341000	64340775	0.1963	0.0694	0.0058	0.2667	0.2609
1.2 m	Base	64364	1030775850	16014.8	1074990.7	225	248685750	248685525	0.1747	0.0718	0.0032	0.2667	0.2635
1.2 m	2025	64916	983312325	15147.5	1046922.8	225	242814150	242813925	0.1805	0.0719	0.0032	0.2667	0.2635
1.2 m	2050	77690	724630050	9327.2	831167.0	225	218478600	218478375	0.1942	0.0700	0.0048	0.2667	0.2619
1.2 m	2075	73266	444277125	6063.9	407969.8	225	105812550	105812325	0.1981	0.0697	0.0060	0.2667	0.2607
1.2 m	2100	68368	278320950	4070.9	89363.7	225	14279625	14279400	0.1976	0.0688	0.0057	0.2667	0.2610
1.5 m	Base	64532	1030042575	15961.7	1073345.5	225	248619375	248619150	0.1748	0.0718	0.0032	0.2667	0.2635
1.5 m	2025	67689	898278750	13270.7	992259.1	225	238600800	238600575	0.1810	0.0716	0.0034	0.2667	0.2632
1.5 m	2050	83730	634634100	7579.5	602528.0	225	161307900	161307675	0.1979	0.0689	0.0054	0.2667	0.2613
1.5 m	2075	71203	349378200	4906.8	224421.5	225	55613250	55613025	0.1972	0.0694	0.0058	0.2667	0.2609
1.5 m	2100	63662	222137550	3489.3	66037.7	225	12662100	12661875	0.1989	0.0681	0.0098	0.2667	0.2569
2.0 m	Base	67284	1043045550	15502.1	1050141.3	225	248299200	248298975	0.1758	0.0717	0.0032	0.2667	0.2635
2.0 m	2025	72100	866961225	12024.4	938559.8	225	233524125	233523900	0.1845	0.0713	0.0043	0.2667	0.2624
2.0 m	2050	81021	479958075	5923.9	406650.7	225	110559825	110559600	0.1994	0.0685	0.0054	0.2667	0.2613
2.0 m	2075	65650	249861825	3806.0	69384.0	225	11758725	11758500	0.1970	0.0688	0.0057	0.2667	0.2610
2.0 m	2100	61793	169248150	2739.0	39388.9	225	5490000	5489775	0.2029	0.0666	0.0098	0.2667	0.2569

Results for Black Skimmer: Estuarine Beach Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m^2)	STD Area (m^2)	MIN Area (m^2)	MAX Area (m^2)	RANGE Area (m^2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	Base	56805	942601275	16593.6	1141705.2	225	248687775	248687550	0.1722	0.0715	0.0032	0.2667	0.2635
0.5 m	2025	54097	923404275	17069.4	1169039.8	225	248613075	248612850	0.1757	0.0723	0.0032	0.2667	0.2635
0.5 m	2050	54989	889672050	16179.1	1137163.2	225	243068175	243067950	0.1811	0.0726	0.0032	0.2667	0.2635
0.5 m	2075	54059	706487175	13068.8	1079306.0	225	234693450	234693225	0.1864	0.0722	0.0044	0.2667	0.2623
0.5 m	2100	57630	580717125	10076.6	951876.4	225	217097775	217097550	0.1964	0.0701	0.0050	0.2667	0.2617
1.0 m	Base	54328	929416950	17107.5	1167344.6	225	248686875	248686650	0.1708	0.0714	0.0032	0.2667	0.2635
1.0 m	2025	52789	898816500	17026.6	1179690.1	225	247797225	247797000	0.1764	0.0723	0.0032	0.2667	0.2635
1.0 m	2050	57463	682397775	11875.4	1019163.9	225	229146975	229146750	0.1886	0.0715	0.0047	0.2667	0.2620
1.0 m	2075	55335	410195925	7413.0	649174.0	225	146756700	146756475	0.2003	0.0691	0.0058	0.2667	0.2609
1.0 m	2100	47228	214176375	4534.9	307286.8	225	64341000	64340775	0.1969	0.0694	0.0058	0.2667	0.2609
1.2 m	Base	54416	928899675	17070.3	1166393.3	225	248685750	248685525	0.1708	0.0714	0.0032	0.2667	0.2635
1.2 m	2025	53418	885051900	16568.4	1151312.0	225	242797275	242797050	0.1775	0.0722	0.0032	0.2667	0.2635
1.2 m	2050	59300	617172075	10407.6	947914.8	225	218368350	218368125	0.1929	0.0706	0.0045	0.2667	0.2622
1.2 m	2075	53042	309525525	5835.5	474832.6	225	105812550	105812325	0.1998	0.0693	0.0060	0.2667	0.2607
1.2 m	2100	45524	130957425	2876.7	83872.9	225	14279625	14279400	0.1979	0.0683	0.0057	0.2667	0.2610
1.5 m	Base	54553	928003725	17011.0	1164659.9	225	248619375	248619150	0.1709	0.0714	0.0032	0.2667	0.2635
1.5 m	2025	55815	798896700	14313.3	1089978.9	225	238576725	238576500	0.1783	0.0719	0.0034	0.2667	0.2633
1.5 m	2050	64555	518592825	8033.3	682385.4	225	161307900	161307675	0.1983	0.0692	0.0054	0.2667	0.2613
1.5 m	2075	49704	200897550	4041.9	258786.7	225	55613250	55613025	0.1982	0.0690	0.0058	0.2667	0.2609
1.5 m	2100	36641	78437925	2140.7	34308.9	225	5614650	5614425	0.1969	0.0673	0.0098	0.2667	0.2569
2.0 m	Base	57699	938279475	16261.6	1131305.2	225	248299200	248298975	0.1727	0.0714	0.0032	0.2667	0.2635
2.0 m	2025	59874	764210025	12763.6	1027103.5	225	233485650	233485425	0.1831	0.0716	0.0042	0.2667	0.2625
2.0 m	2050	60614	347496300	5732.9	465667.2	225	110559825	110559600	0.2008	0.0686	0.0054	0.2667	0.2613
2.0 m	2075	39595	93336525	2357.3	40750.8	225	6630975	6630750	0.1961	0.0682	0.0057	0.2667	0.2610
2.0 m	2100	28026	55638675	1985.3	25651.1	225	3327975	3327750	0.1977	0.0667	0.0098	0.2667	0.2569

Results for Black Skimmer: Ocean Beach Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m^2)	STD Area (m^2)	MIN Area (m^2)	MAX Area (m^2)	RANGE Area (m^2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	Base	10062	104106150	10346.5	158609.1	225	11527200	11526975	0.1922	0.0719	0.0095	0.2667	0.2572
0.5 m	2025	10961	98743725	9008.6	148932.3	225	11477250	11477025	0.1914	0.0703	0.0094	0.2667	0.2573
0.5 m	2050	17787	103019850	5791.9	102943.8	225	10503450	10503225	0.1998	0.0676	0.0096	0.2667	0.2571
0.5 m	2075	19779	107673525	5443.8	92903.7	225	10294425	10294200	0.1944	0.0697	0.0096	0.2667	0.2571
0.5 m	2100	20904	114676425	5485.9	72685.2	225	6558075	6557850	0.1923	0.0703	0.0094	0.2667	0.2573
1.0 m	Base	10592	101805075	9611.5	154428.7	225	11527200	11526975	0.1932	0.0714	0.0095	0.2667	0.2572
1.0 m	2025	12151	97954875	8061.5	139752.8	225	11466450	11466225	0.1917	0.0700	0.0093	0.2667	0.2573
1.0 m	2050	20249	106923825	5280.4	92764.4	225	10477350	10477125	0.1960	0.0686	0.0096	0.2667	0.2571
1.0 m	2075	22479	126111600	5610.2	81282.4	225	8555175	8554950	0.1925	0.0705	0.0096	0.2667	0.2571
1.0 m	2100	24847	140510475	5655.0	74326.5	225	6518025	6517800	0.1946	0.0695	0.0097	0.2667	0.2569
1.2 m	Base	10611	101876175	9601.0	154301.9	225	11527200	11526975	0.1932	0.0714	0.0095	0.2667	0.2572
1.2 m	2025	12428	98260425	7906.4	132121.1	225	10819800	10819575	0.1914	0.0700	0.0095	0.2667	0.2571
1.2 m	2050	20536	107457975	5232.7	93355.8	225	10463400	10463175	0.1962	0.0690	0.0094	0.2667	0.2573
1.2 m	2075	23048	134751600	5846.6	81448.6	225	8498475	8498250	0.1920	0.0711	0.0098	0.2667	0.2569
1.2 m	2100	26900	147363525	5478.2	69679.6	225	4667850	4667625	0.1977	0.0695	0.0104	0.2667	0.2563
1.5 m	Base	10645	102038850	9585.6	154083.6	225	11527200	11526975	0.1931	0.0715	0.0095	0.2667	0.2572
1.5 m	2025	12848	99382050	7735.2	126233.0	225	10813950	10813725	0.1908	0.0701	0.0098	0.2667	0.2569
1.5 m	2050	21431	116041275	5414.6	91300.4	225	10442025	10441800	0.1948	0.0691	0.0094	0.2667	0.2573
1.5 m	2075	24890	148480650	5965.5	83102.2	225	8423325	8423100	0.1941	0.0706	0.0095	0.2667	0.2572
1.5 m	2100	31359	143699625	4582.4	62860.9	225	5347125	5346900	0.2027	0.0683	0.0119	0.2667	0.2548
2.0 m	Base	10222	104766075	10249.1	159277.8	225	11527200	11526975	0.1918	0.0720	0.0095	0.2667	0.2572
2.0 m	2025	13224	102751200	7770.1	125619.0	225	10800450	10800225	0.1884	0.0707	0.0097	0.2667	0.2570
2.0 m	2050	22951	132461775	5771.5	90920.1	225	10484100	10483875	0.1936	0.0690	0.0097	0.2667	0.2570
2.0 m	2075	29820	156525300	5249.0	72635.8	225	7206525	7206300	0.1984	0.0694	0.0116	0.2667	0.2551
2.0 m	2100	38324	113609475	2964.4	37740.5	225	4175550	4175325	0.2079	0.0659	0.0106	0.2667	0.2561

Results for Mottled Duck in TX, LA, MS, and AL: Aggregated Tidal Fresh Marsh, Transitional Marsh / Scrub Shrub, and Irregularly Flooded Marsh Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	base	597898	6953433525	11630	679317	225	215240850	215240625	0.1847	0.0702	0.0034	0.2667	0.2633
0.5 m	2025	820740	6457717800	7868	480868	225	215311500	215311275	0.1986	0.0684	0.0034	0.2667	0.2633
0.5 m	2050	1110286	6111402975	5504	341326	225	215237475	215237250	0.2059	0.0657	0.0036	0.2667	0.2631
0.5 m	2075	1250357	4920007950	3935	297159	225	237370050	237369825	0.2127	0.0629	0.0021	0.2667	0.2646
0.5 m	2100	1106143	4426663050	4002	355671	225	232464375	232464150	0.2153	0.0617	0.0044	0.2667	0.2623
1.0 m	base	601990	6998474025	11626	676331	225	215240850	215240625	0.1848	0.0702	0.0034	0.2667	0.2632
1.0 m	2025	924742	6329576925	6845	404685	225	214807050	214806825	0.2002	0.0676	0.0035	0.2667	0.2631
1.0 m	2050	1183102	5392326825	4558	310412	225	230365350	230365125	0.2089	0.0645	0.0028	0.2667	0.2639
1.0 m	2075	1060596	4224665250	3983	271299	225	142383825	142383600	0.2146	0.0617	0.0041	0.2667	0.2625
1.0 m	2100	897268	2842425675	3168	120884	225	47080125	47079900	0.2151	0.0616	0.0046	0.2667	0.2621
1.2 m	base	603994	6998433975	11587	672732	225	215240850	215240625	0.1850	0.0702	0.0034	0.2667	0.2632
1.2 m	2025	960310	6242911200	6501	383193	225	214388775	214388550	0.2009	0.0674	0.0035	0.2667	0.2631
1.2 m	2050	1151782	5210313975	4524	338410	225	218353725	218353500	0.2095	0.0642	0.0028	0.2667	0.2639
1.2 m	2075	997967	3906730800	3915	280604	225	176168250	176168025	0.2146	0.0616	0.0038	0.2667	0.2628
1.2 m	2100	826208	2696790600	3264	133349	225	57352050	57351825	0.2148	0.0616	0.0025	0.2667	0.2641
1.5 m	base	603693	6998126400	11592	674318	225	215240850	215240625	0.1849	0.0702	0.0034	0.2667	0.2632
1.5 m	2025	1009978	6121036125	6061	357159	225	213511725	213511500	0.2017	0.0670	0.0036	0.2667	0.2631
1.5 m	2050	1107484	4956516900	4475	376056	225	315399825	315399600	0.2106	0.0636	0.0027	0.2667	0.2640
1.5 m	2075	886096	3615898050	4081	299710	225	186156900	186156675	0.2141	0.0619	0.0035	0.2667	0.2631
1.5 m	2100	730387	2868264450	3927	167516	225	47650275	47650050	0.2140	0.0622	0.0024	0.2667	0.2643
2.0 m	base	608722	6955184475	11426	665848	225	215240850	215240625	0.1853	0.0702	0.0034	0.2667	0.2632
2.0 m	2025	1081015	5951111175	5505	311503	225	210757725	210757500	0.2028	0.0667	0.0037	0.2667	0.2630
2.0 m	2050	1041368	4672102725	4487	277781	225	142299675	142299450	0.2112	0.0631	0.0023	0.2667	0.2643
2.0 m	2075	752469	3717985275	4941	339925	225	208072350	208072125	0.2125	0.0628	0.0031	0.2667	0.2636
2.0 m	2100	671719	3400265475	5062	210942	225	52970625	52970400	0.2128	0.0628	0.0055	0.2667	0.2612

Results for Mottled Duck in Florida: Aggregated Tidal Fresh Marsh, Transitional Marsh / Scrub Shrub, and Irregularly Flooded Marsh Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	base	60072	522503100	8697.9	149255.5	225	17012025	17011800	0.1886	0.0723	0.0055	0.2667	0.2612
0.5 m	2025	75232	506061675	6726.7	115519.1	225	10911150	10910925	0.1931	0.0711	0.0055	0.2667	0.2612
0.5 m	2050	91132	611911125	6714.6	126190.9	225	11941650	11941425	0.1900	0.0707	0.0056	0.2667	0.2611
0.5 m	2075	106217	763668000	7189.7	149076.0	225	22676400	22676175	0.1817	0.0720	0.0077	0.2667	0.2590
0.5 m	2100	128359	933684300	7274.0	206184.0	225	47194650	47194425	0.1785	0.0714	0.0073	0.2667	0.2594
1.0 m	base	62052	524740275	8456.5	146288.2	225	17062200	17061975	0.1898	0.0722	0.0055	0.2667	0.2612
1.0 m	2025	84149	535344975	6361.9	109211.6	225	10771875	10771650	0.1906	0.0708	0.0055	0.2667	0.2612
1.0 m	2050	117584	824630400	7013.1	180664.0	225	45746550	45746325	0.1893	0.0715	0.0056	0.2667	0.2611
1.0 m	2075	321590	1368646650	4255.9	98890.8	225	23336325	23336100	0.1985	0.0692	0.0024	0.2667	0.2643
1.0 m	2100	188822	663922575	3516.1	67419.3	225	15434775	15434550	0.1983	0.0686	0.0042	0.2667	0.2625
1.2 m	base	62771	525183300	8366.7	145385.2	225	17065800	17065575	0.1902	0.0721	0.0055	0.2667	0.2612
1.2 m	2025	91821	565524450	6159.0	108939.2	225	10631475	10631250	0.1911	0.0704	0.0056	0.2667	0.2611
1.2 m	2050	133996	858162600	6404.4	174554.7	225	48069000	48068775	0.1942	0.0705	0.0061	0.2667	0.2606
1.2 m	2075	176296	808088625	4583.7	114172.2	225	17752725	17752500	0.1986	0.0693	0.0039	0.2667	0.2627
1.2 m	2100	185763	616608900	3319.3	70258.6	225	17446500	17446275	0.2006	0.0681	0.0046	0.2667	0.2621
1.5 m	base	64330	526958100	8191.5	143688.1	225	17073225	17073000	0.1909	0.0720	0.0055	0.2667	0.2612
1.5 m	2025	96647	590668425	6111.6	108380.3	225	10611675	10611450	0.1900	0.0707	0.0064	0.2667	0.2603
1.5 m	2050	149740	893661300	5968.1	179081.6	225	50494275	50494050	0.1991	0.0696	0.0045	0.2667	0.2622
1.5 m	2075	182449	800102925	4385.4	143223.0	225	27387450	27387225	0.2018	0.0681	0.0039	0.2667	0.2628
1.5 m	2100	171412	731722725	4268.8	141447.6	225	42205050	42204825	0.2016	0.0679	0.0044	0.2667	0.2623
2.0 m	base	66626	528355575	7930.2	141199.6	225	17084250	17084025	0.1921	0.0717	0.0055	0.2667	0.2612
2.0 m	2025	106313	661561650	6222.8	116411.7	225	17114850	17114625	0.1903	0.0708	0.0055	0.2667	0.2612
2.0 m	2050	165505	923969700	5582.7	167186.6	225	39761100	39760875	0.2022	0.0687	0.0042	0.2667	0.2625
2.0 m	2075	146006	924967800	6335.1	230110.3	225	48782700	48782475	0.1986	0.0695	0.0036	0.2667	0.2631
2.0 m	2100	161326	1132211025	7018.2	320101.4	225	100716300	100716075	0.2012	0.0690	0.0029	0.2667	0.2638

Results for Mottled Duck in TX, LA, MS, and AL: Estuarine Open Water

SLR Scenario	Simul -ation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio	COUNT Patches < 640 acres	SUM Area of Patches < 640 acres (m^2)	Proportion (%) of Total Area in Patches < 640 acres
0.5 m	base	169807	33322817925	196239	61256783	225	24823711575	24823711350	0.1393	0.0672	0.0016	0.2667	0.2651	169736	1409940450	4.23
0.5 m	2025	274968	33725751300	122653	52748514	225	27380171475	27380171250	0.1687	0.0751	0.0016	0.2667	0.2651	274900	1611623700	4.78
0.5 m	2050	464588	34491129975	74240	41591246	225	28071126450	28071126225	0.1917	0.0724	0.0016	0.2667	0.2651	464528	1797346350	5.21
0.5 m	2075	647650	36036651600	55642	36593186	225	29121284025	29121283800	0.2007	0.0692	0.0022	0.2667	0.2644	647582	2011992975	5.58
0.5 m	2100	736757	38196975150	51845	36457597	225	30954695400	30954695175	0.2005	0.0684	0.0022	0.2667	0.2644	736685	2092491450	5.48
1.0 m	base	167475	33330071025	199015	61673118	225	24820752150	24820751925	0.1382	0.0669	0.0016	0.2667	0.2651	167401	1415919600	4.25
1.0 m	2025	290071	33809695200	116557	51395682	225	27399354525	27399354300	0.1707	0.0751	0.0016	0.2667	0.2651	290000	1634189400	4.83
1.0 m	2050	527619	35265057975	66838	39490695	225	28369166850	28369166625	0.1952	0.0713	0.0016	0.2667	0.2651	527551	1913949225	5.43
1.0 m	2075	691573	38343540600	55444	37699546	225	30973293225	30973293000	0.2031	0.0678	0.0022	0.2667	0.2644	691502	1976368050	5.15
1.0 m	2100	604630	43189571025	71431	46419761	225	35696457000	35696456775	0.2014	0.0679	0.0022	0.2667	0.2644	604573	1643000850	3.80
1.2 m	base	167618	33331308525	198853	61646878	225	24820752375	24820752150	0.1383	0.0669	0.0016	0.2667	0.2651	167544	1416896550	4.25
1.2 m	2025	293498	33843977550	115312	51122142	225	27412612425	27412612200	0.1711	0.0751	0.0016	0.2667	0.2651	293427	1640352600	4.85
1.2 m	2050	545145	35538618375	65191	39048914	225	28501194600	28501194375	0.1963	0.0710	0.0016	0.2667	0.2651	545079	1940487750	5.46
1.2 m	2075	675133	39318895350	58239	39275232	225	31875862275	31875862050	0.2046	0.0675	0.0022	0.2667	0.2644	675066	1853722800	4.71
1.2 m	2100	483602	44587558350	92199	53812495	225	36997378875	36997378650	0.1950	0.0695	0.0022	0.2667	0.2644	483544	1484419500	3.33
1.5 m	base	167984	33331706325	198422	61579746	225	24820753950	24820753725	0.1385	0.0670	0.0016	0.2667	0.2651	167910	1417134825	4.25
1.5 m	2025	302453	34022872575	112490	50412152	225	27427316625	27427316400	0.1718	0.0750	0.0016	0.2667	0.2651	302380	1678322925	4.93
1.5 m	2050	570607	35933575275	62974	38432529	225	28681523325	28681523100	0.1980	0.0707	0.0016	0.2667	0.2651	570532	1965156975	5.47
1.5 m	2075	683345	40708497600	59572	40698729	225	33219105525	33219105300	0.2072	0.0665	0.0022	0.2667	0.2644	683290	1728715725	4.25
1.5 m	2100	389406	45810131400	117641	61856878	225	38158870725	38158870500	0.1874	0.0704	0.0022	0.2667	0.2644	389354	1348771275	2.94
2.0 m	base	171289	33328309950	194574	60990512	225	24823210275	24823210050	0.1399	0.0675	0.0016	0.2667	0.2651	171218	1414190475	4.24
2.0 m	2025	316244	34151039550	107990	49389154	225	27464183100	27464182875	0.1735	0.0749	0.0016	0.2667	0.2651	316175	1686756150	4.94
2.0 m	2050	614321	36556035075	59506	37462117	225	28983459825	28983459600	0.2004	0.0699	0.0016	0.2667	0.2651	614239	1991208600	5.45
2.0 m	2075	559096	42236084475	75544	47056344	225	34739103600	34739103375	0.2029	0.0680	0.0022	0.2667	0.2644	559050	1544091975	3.66
2.0 m	2100	337731	46994190525	139147	68233906	225	39201381225	39201381000	0.1799	0.0706	0.0022	0.2667	0.2644	337683	1317585375	2.80

Results for Mottled Duck in Florida: Estuarine Open Water

SLR Scenario	Simul-ation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m2)	STD Area (m2)	MIN Area (m2)	MAX Area (m2)	RANGE Area (m2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio	COUNT Patches < 640 acres	SUM Area of Patches < 640 acres (m^2)	Proportion (%) of Total Area in Patches < 640 acres
0.5 m	base	129200	7718527800	59740.9	9862270.2	225	3006385200	3006384975	0.2128	0.0636	0.0007	0.2667	0.2660	129168	309998475	4.02
0.5 m	2025	144752	7813586250	53979.1	9382301.2	225	3023569350	3023569125	0.2120	0.0636	0.0007	0.2667	0.2660	144723	347743350	4.45
0.5 m	2050	179775	7982420850	44402.3	8569910.8	225	3091625550	3091625325	0.2139	0.0627	0.0008	0.2667	0.2659	179744	391685400	4.91
0.5 m	2075	217972	8205578550	37645.1	8355929.4	225	3401359200	3401358975	0.2156	0.0622	0.0011	0.2667	0.2656	217941	458578800	5.59
0.5 m	2100	243768	8710859475	35734.2	8329152.4	225	3534026175	3534025950	0.2169	0.0614	0.0010	0.2667	0.2656	243728	512451900	5.88
1.0 m	base	139706	7732750275	55350.2	9484609.1	225	3006435600	3006435375	0.2140	0.0630	0.0007	0.2667	0.2660	139674	321844725	4.16
1.0 m	2025	174870	7904363175	45201.4	8593005.2	225	3050483400	3050483175	0.2145	0.0625	0.0007	0.2667	0.2660	174839	384090300	4.86
1.0 m	2050	240039	8306169750	34603.4	8084639.9	225	3471591600	3471591375	0.2181	0.0608	0.0010	0.2667	0.2657	240007	484911225	5.84
1.0 m	2075	253358	9369360900	36980.7	8896437.7	225	3906723825	3906723600	0.2177	0.0614	0.0010	0.2667	0.2657	253315	515822850	5.51
1.0 m	2100	211052	10506027375	49779.3	12406912.5	225	5232995775	5232995550	0.2102	0.0651	0.0015	0.2667	0.2652	211014	457149150	4.35
1.2 m	base	143518	7738637400	53921.0	9358022.6	225	3006482400	3006482175	0.2144	0.0628	0.0007	0.2667	0.2660	143486	326840400	4.22
1.2 m	2025	185360	7943662125	42855.3	8372499.0	225	3063163500	3063163275	0.2150	0.0621	0.0007	0.2667	0.2660	185328	397836000	5.01
1.2 m	2050	249498	8478974025	33984.1	8159397.3	225	3602701125	3602700900	0.2185	0.0607	0.0010	0.2667	0.2657	249465	500484825	5.90
1.2 m	2075	187163	10132816050	54139.0	12919128.5	225	5135631975	5135631750	0.2116	0.0647	0.0010	0.2667	0.2656	187127	426298950	4.21
1.2 m	2100	176845	11288057400	63830.2	14724800.4	225	5693350275	5693350050	0.2051	0.0670	0.0015	0.2667	0.2652	176809	422523900	3.74
1.5 m	base	149652	7748159175	51774.5	9164509.4	225	3006494325	3006494100	0.2149	0.0625	0.0007	0.2667	0.2660	149619	330579675	4.27
1.5 m	2025	197120	8007499800	40622.5	8164727.1	225	3083200425	3083200200	0.2158	0.0618	0.0007	0.2667	0.2660	197087	409698225	5.12
1.5 m	2050	251198	8937127800	35578.0	8579790.7	225	3774986550	3774986325	0.2187	0.0606	0.0010	0.2667	0.2657	251166	501656850	5.61
1.5 m	2075	191025	10580386725	55387.4	13377701.0	225	5372455725	5372455500	0.2084	0.0658	0.0013	0.2667	0.2654	190988	428911425	4.05
1.5 m	2100	130958	12179707200	93004.7	18450904.2	225	6051105900	6051105675	0.2012	0.0684	0.0015	0.2667	0.2652	130922	346079250	2.84
2.0 m	base	158116	7764982425	49109.4	8916597.4	225	3006514125	3006513900	0.2155	0.0622	0.0007	0.2667	0.2660	158083	341422875	4.40
2.0 m	2025	213129	8124122475	38118.3	7904453.6	225	3105759825	3105759600	0.2173	0.0612	0.0007	0.2667	0.2660	213096	436163625	5.37
2.0 m	2050	218289	9663529725	44269.4	11165000.0	225	4728199950	4728199725	0.2160	0.0623	0.0010	0.2667	0.2657	218257	435702600	4.51
2.0 m	2075	139553	11492903475	82355.1	17146878.5	225	5829090300	5829090075	0.1999	0.0686	0.0014	0.2667	0.2653	139518	393721425	3.43
2.0 m	2100	92935	13238026875	142443.9	23196514.9	225	6319778175	6319777950	0.1948	0.0700	0.0014	0.2667	0.2653	92904	290195775	2.19

Results for Black Skimmer: Aggregated Ocean Beach and Estuarine Beach Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m^2)	STD Area (m^2)	MIN Area (m^2)	MAX Area (m^2)	RANGE Area (m^2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	Base	66238	1046707425	15802.2	1059771.0	225	248687775	248687550	0.1754	0.0718	0.0032	0.2667	0.2635
0.5 m	2025	64302	1022148000	15896.1	1074770.9	225	248613075	248612850	0.1786	0.0722	0.0032	0.2667	0.2635
0.5 m	2050	70986	992691900	13984.3	1003185.6	225	243086850	243086625	0.1859	0.0718	0.0032	0.2667	0.2635
0.5 m	2075	71626	814160700	11366.8	940047.3	225	234742950	234742725	0.1892	0.0714	0.0045	0.2667	0.2621
0.5 m	2100	76111	695393550	9136.6	830959.3	225	217273050	217272825	0.1962	0.0698	0.0053	0.2667	0.2614
1.0 m	Base	64256	1031222025	16048.6	1075899.9	225	248686875	248686650	0.1746	0.0718	0.0032	0.2667	0.2635
1.0 m	2025	64055	996771375	15561.2	1073521.2	225	247801500	247801275	0.1796	0.0720	0.0032	0.2667	0.2635
1.0 m	2050	75575	789321600	10444.2	891256.4	225	229222125	229221900	0.1909	0.0706	0.0048	0.2667	0.2619
1.0 m	2075	75313	536307525	7121.0	559607.3	225	146756700	146756475	0.1988	0.0693	0.0058	0.2667	0.2609
1.0 m	2100	68536	354686850	5175.2	261806.9	225	64341000	64340775	0.1963	0.0694	0.0058	0.2667	0.2609
1.2 m	Base	64364	1030775850	16014.8	1074990.7	225	248685750	248685525	0.1747	0.0718	0.0032	0.2667	0.2635
1.2 m	2025	64916	983312325	15147.5	1046922.8	225	242814150	242813925	0.1805	0.0719	0.0032	0.2667	0.2635
1.2 m	2050	77690	724630050	9327.2	831167.0	225	218478600	218478375	0.1942	0.0700	0.0048	0.2667	0.2619
1.2 m	2075	73266	444277125	6063.9	407969.8	225	105812550	105812325	0.1981	0.0697	0.0060	0.2667	0.2607
1.2 m	2100	68368	278320950	4070.9	89363.7	225	14279625	14279400	0.1976	0.0688	0.0057	0.2667	0.2610
1.5 m	Base	64532	1030042575	15961.7	1073345.5	225	248619375	248619150	0.1748	0.0718	0.0032	0.2667	0.2635
1.5 m	2025	67689	898278750	13270.7	992259.1	225	238600800	238600575	0.1810	0.0716	0.0034	0.2667	0.2632
1.5 m	2050	83730	634634100	7579.5	602528.0	225	161307900	161307675	0.1979	0.0689	0.0054	0.2667	0.2613
1.5 m	2075	71203	349378200	4906.8	224421.5	225	55613250	55613025	0.1972	0.0694	0.0058	0.2667	0.2609
1.5 m	2100	63662	222137550	3489.3	66037.7	225	12662100	12661875	0.1989	0.0681	0.0098	0.2667	0.2569
2.0 m	Base	67284	1043045550	15502.1	1050141.3	225	248299200	248298975	0.1758	0.0717	0.0032	0.2667	0.2635
2.0 m	2025	72100	866961225	12024.4	938559.8	225	233524125	233523900	0.1845	0.0713	0.0043	0.2667	0.2624
2.0 m	2050	81021	479958075	5923.9	406650.7	225	110559825	110559600	0.1994	0.0685	0.0054	0.2667	0.2613
2.0 m	2075	65650	249861825	3806.0	69384.0	225	11758725	11758500	0.1970	0.0688	0.0057	0.2667	0.2610
2.0 m	2100	61793	169248150	2739.0	39388.9	225	5490000	5489775	0.2029	0.0666	0.0098	0.2667	0.2569

Results for Black Skimmer: Estuarine Beach Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m^2)	STD Area (m^2)	MIN Area (m^2)	MAX Area (m^2)	RANGE Area (m^2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	Base	56805	942601275	16593.6	1141705.2	225	248687775	248687550	0.1722	0.0715	0.0032	0.2667	0.2635
0.5 m	2025	54097	923404275	17069.4	1169039.8	225	248613075	248612850	0.1757	0.0723	0.0032	0.2667	0.2635
0.5 m	2050	54989	889672050	16179.1	1137163.2	225	243068175	243067950	0.1811	0.0726	0.0032	0.2667	0.2635
0.5 m	2075	54059	706487175	13068.8	1079306.0	225	234693450	234693225	0.1864	0.0722	0.0044	0.2667	0.2623
0.5 m	2100	57630	580717125	10076.6	951876.4	225	217097775	217097550	0.1964	0.0701	0.0050	0.2667	0.2617
1.0 m	Base	54328	929416950	17107.5	1167344.6	225	248686875	248686650	0.1708	0.0714	0.0032	0.2667	0.2635
1.0 m	2025	52789	898816500	17026.6	1179690.1	225	247797225	247797000	0.1764	0.0723	0.0032	0.2667	0.2635
1.0 m	2050	57463	682397775	11875.4	1019163.9	225	229146975	229146750	0.1886	0.0715	0.0047	0.2667	0.2620
1.0 m	2075	55335	410195925	7413.0	649174.0	225	146756700	146756475	0.2003	0.0691	0.0058	0.2667	0.2609
1.0 m	2100	47228	214176375	4534.9	307286.8	225	64341000	64340775	0.1969	0.0694	0.0058	0.2667	0.2609
1.2 m	Base	54416	928899675	17070.3	1166393.3	225	248685750	248685525	0.1708	0.0714	0.0032	0.2667	0.2635
1.2 m	2025	53418	885051900	16568.4	1151312.0	225	242797275	242797050	0.1775	0.0722	0.0032	0.2667	0.2635
1.2 m	2050	59300	617172075	10407.6	947914.8	225	218368350	218368125	0.1929	0.0706	0.0045	0.2667	0.2622
1.2 m	2075	53042	309525525	5835.5	474832.6	225	105812550	105812325	0.1998	0.0693	0.0060	0.2667	0.2607
1.2 m	2100	45524	130957425	2876.7	83872.9	225	14279625	14279400	0.1979	0.0683	0.0057	0.2667	0.2610
1.5 m	Base	54553	928003725	17011.0	1164659.9	225	248619375	248619150	0.1709	0.0714	0.0032	0.2667	0.2635
1.5 m	2025	55815	798896700	14313.3	1089978.9	225	238576725	238576500	0.1783	0.0719	0.0034	0.2667	0.2633
1.5 m	2050	64555	518592825	8033.3	682385.4	225	161307900	161307675	0.1983	0.0692	0.0054	0.2667	0.2613
1.5 m	2075	49704	200897550	4041.9	258786.7	225	55613250	55613025	0.1982	0.0690	0.0058	0.2667	0.2609
1.5 m	2100	36641	78437925	2140.7	34308.9	225	5614650	5614425	0.1969	0.0673	0.0098	0.2667	0.2569
2.0 m	Base	57699	938279475	16261.6	1131305.2	225	248299200	248298975	0.1727	0.0714	0.0032	0.2667	0.2635
2.0 m	2025	59874	764210025	12763.6	1027103.5	225	233485650	233485425	0.1831	0.0716	0.0042	0.2667	0.2625
2.0 m	2050	60614	347496300	5732.9	465667.2	225	110559825	110559600	0.2008	0.0686	0.0054	0.2667	0.2613
2.0 m	2075	39595	93336525	2357.3	40750.8	225	6630975	6630750	0.1961	0.0682	0.0057	0.2667	0.2610
2.0 m	2100	28026	55638675	1985.3	25651.1	225	3327975	3327750	0.1977	0.0667	0.0098	0.2667	0.2569

Results for Black Skimmer: Ocean Beach Areas

SLR Scenario	Simulation Year	COUNT (# polygons)	SUM Area (m^2)	MEAN Area (m^2)	STD Area (m^2)	MIN Area (m^2)	MAX Area (m^2)	RANGE Area (m^2)	MEAN Perimeter to Area Ratio	STD Perimeter to Area Ratio	MIN Perimeter to Area Ratio	MAX Perimeter to Area Ratio	RANGE Perimeter to Area Ratio
0.5 m	Base	10062	104106150	10346.5	158609.1	225	11527200	11526975	0.1922	0.0719	0.0095	0.2667	0.2572
0.5 m	2025	10961	98743725	9008.6	148932.3	225	11477250	11477025	0.1914	0.0703	0.0094	0.2667	0.2573
0.5 m	2050	17787	103019850	5791.9	102943.8	225	10503450	10503225	0.1998	0.0676	0.0096	0.2667	0.2571
0.5 m	2075	19779	107673525	5443.8	92903.7	225	10294425	10294200	0.1944	0.0697	0.0096	0.2667	0.2571
0.5 m	2100	20904	114676425	5485.9	72685.2	225	6558075	6557850	0.1923	0.0703	0.0094	0.2667	0.2573
1.0 m	Base	10592	101805075	9611.5	154428.7	225	11527200	11526975	0.1932	0.0714	0.0095	0.2667	0.2572
1.0 m	2025	12151	97954875	8061.5	139752.8	225	11466450	11466225	0.1917	0.0700	0.0093	0.2667	0.2573
1.0 m	2050	20249	106923825	5280.4	92764.4	225	10477350	10477125	0.1960	0.0686	0.0096	0.2667	0.2571
1.0 m	2075	22479	126111600	5610.2	81282.4	225	8555175	8554950	0.1925	0.0705	0.0096	0.2667	0.2571
1.0 m	2100	24847	140510475	5655.0	74326.5	225	6518025	6517800	0.1946	0.0695	0.0097	0.2667	0.2569
1.2 m	Base	10611	101876175	9601.0	154301.9	225	11527200	11526975	0.1932	0.0714	0.0095	0.2667	0.2572
1.2 m	2025	12428	98260425	7906.4	132121.1	225	10819800	10819575	0.1914	0.0700	0.0095	0.2667	0.2571
1.2 m	2050	20536	107457975	5232.7	93355.8	225	10463400	10463175	0.1962	0.0690	0.0094	0.2667	0.2573
1.2 m	2075	23048	134751600	5846.6	81448.6	225	8498475	8498250	0.1920	0.0711	0.0098	0.2667	0.2569
1.2 m	2100	26900	147363525	5478.2	69679.6	225	4667850	4667625	0.1977	0.0695	0.0104	0.2667	0.2563
1.5 m	Base	10645	102038850	9585.6	154083.6	225	11527200	11526975	0.1931	0.0715	0.0095	0.2667	0.2572
1.5 m	2025	12848	99382050	7735.2	126233.0	225	10813950	10813725	0.1908	0.0701	0.0098	0.2667	0.2569
1.5 m	2050	21431	116041275	5414.6	91300.4	225	10442025	10441800	0.1948	0.0691	0.0094	0.2667	0.2573
1.5 m	2075	24890	148480650	5965.5	83102.2	225	8423325	8423100	0.1941	0.0706	0.0095	0.2667	0.2572
1.5 m	2100	31359	143699625	4582.4	62860.9	225	5347125	5346900	0.2027	0.0683	0.0119	0.2667	0.2548
2.0 m	Base	10222	104766075	10249.1	159277.8	225	11527200	11526975	0.1918	0.0720	0.0095	0.2667	0.2572
2.0 m	2025	13224	102751200	7770.1	125619.0	225	10800450	10800225	0.1884	0.0707	0.0097	0.2667	0.2570
2.0 m	2050	22951	132461775	5771.5	90920.1	225	10484100	10483875	0.1936	0.0690	0.0097	0.2667	0.2570
2.0 m	2075	29820	156525300	5249.0	72635.8	225	7206525	7206300	0.1984	0.0694	0.0116	0.2667	0.2551
2.0 m	2100	38324	113609475	2964.4	37740.5	225	4175550	4175325	0.2079	0.0659	0.0106	0.2667	0.2561