Application of the Sea-Level Affecting Marshes Model (SLAMM 6) to Harris Neck NWR

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Introduction 1
Model Summary 1
Sea Level Rise Scenarios 3
Data Sources and Methods 5
Results 11
Discussion 27
References 28
Appendix A: Contextual Results 30

Introduction

Tidal marshes are among the most susceptible ecosystems to climate change, especially accelerated sea level rise (SLR). The Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) suggested that global sea level will increase by approximately 30 cm to 100 cm by 2100 (IPCC 2001). Rahmstorf (2007) suggests that this range may be too conservative and that the feasible range by 2100 is 50 to 140 cm. Rising sea levels may result in tidal marsh submergence (Moorhead and Brinson 1995) and habitat "migration" as salt marshes transgress landward and replace tidal freshwater and irregularly-flooded marsh (Park et al. 1991).

In an effort to address the potential effects of sea level rise on United States national wildlife refuges, the U. S. Fish and Wildlife Service contracted the application of the SLAMM model for many coastal Region 4 refuges. This analysis is designed to assist in the production of comprehensive conservation plans (CCPs) for each refuge along with other long-term management plans.

This is the second application of SLAMM to Harris Neck NWR; the first analysis of potential sea level rise effects on this refuge was carried out in 2008. The original application used SLAMM 5 and did not include LiDAR-derived elevation data. In addition, refinements to model parameters, accretion and erosion rates in particular, were made. The cell size was reduced to 15 meters from 30 meters. These changes, especially the use of high-resolution elevation data, have resulted in updated habitat projections.

Model Summary

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) that accounts for the dominant processes involved in wetland conversion and shoreline modifications during long-term sea level rise (Park et al. 1989; www.warrenpinnacle.com/prof/SLAMM).

Successive versions of the model have been used to estimate the impacts of sea level rise on the coasts of the U.S. (Titus et al. 1991; Lee et al. 1992; Park et al. 1993; Galbraith et al. 2002; National Wildlife Federation & Florida Wildlife Federation 2006; Glick et al. 2007; Craft et al. 2009).

Within SLAMM, there are five primary processes that affect wetland fate under different scenarios of sea-level rise:

- **Inundation:** The rise of water levels and the salt boundary are tracked by reducing elevations of each cell as sea levels rise, thus keeping mean tide level (MTL) constant at zero. The effects on each cell are calculated based on the minimum elevation and slope of that cell.
- **Erosion:** Erosion is triggered based on a threshold of maximum fetch and the proximity of the marsh to estuarine water or open ocean. When these conditions are met, horizontal erosion occurs at a rate based on site- specific data.

- **Overwash:** Barrier islands of under 500 meters (m) width are assumed to undergo overwash during each specified interval for large storms. Beach migration and transport of sediments are calculated.
- **Saturation:** Coastal swamps and fresh marshes can migrate onto adjacent uplands as a response of the fresh water table to rising sea level close to the coast.
- **Accretion:** Sea level rise is offset by sedimentation and vertical accretion using average or site-specific values for each wetland category. Accretion rates may be spatially variable within a given model domain and can be specified to respond to feedbacks such as frequency of flooding.

SLAMM Version 6.0 was developed in 2008/2009 and is based on SLAMM 5. SLAMM 6.0 provides backwards compatibility to SLAMM 5, that is, SLAMM 5 results can be replicated in SLAMM 6. However, SLAMM 6 also provides several optional capabilities.

- Accretion Feedback Component: Feedbacks based on wetland elevation, distance to channel, and salinity may be specified. Accretion feedbacks were not applied in this simulation due to a lack of adequate data for parameterization.
- Salinity Model: Multiple time-variable freshwater flows may be specified. Salinity is estimated and mapped at MLLW, MHHW, and MTL. Habitat switching may be specified as a function of salinity. This optional sub-model is not utilized in USFWS simulations.
- Integrated Elevation Analysis: SLAMM will summarize site-specific categorized elevation ranges for wetlands as derived from LiDAR data or other high-resolution data sets. This functionality is used in USFWS simulations to test the SLAMM conceptual model at each site. The causes of any discrepancies are then tracked down and reported on within the model application report.
- Flexible Elevation Ranges for land categories: If site-specific data indicate that wetland elevation ranges are outside of SLAMM defaults, a different range may be specified within the interface. In USFWS simulations, the use of values outside of SLAMM defaults is rarely utilized. If such a change is made, the change and the reason for it are fully documented within the model application reports.
- Many other graphic user interface and memory management improvements are also part of the new version including an updated *Technical Documentation*, and context sensitive help files.

For a thorough accounting of SLAMM model processes and the underlying assumptions and equations, please see the SLAMM 6.0 *Technical Documentation* (Clough et al. 2010). This document is available at http://warrenpinnacle.com/prof/SLAMM

All model results are subject to uncertainty due to limitations in input data, incomplete knowledge about factors that control the behavior of the system being modeled, and simplifications of the system (Council for Regulatory Environmental Modeling 2008). Site-specific factors that increase or decrease model uncertainty may be covered in the *Discussion* section of this report.

Sea Level Rise Scenarios

Some SLAMM 6 predictions are obtained using SLR estimates from the Special Report on Emissions Scenarios (SRES) published by the Intergovernmental Panel on Climate Change (IPCC). All IPCC scenarios describe futures that are generally more affluent than today and span a wide range of future levels of economic activity, with gross world product rising to 10 times today's values by 2100 in the lowest, to 26-fold in the highest scenarios (IPCC 2007). Among the IPCC families of scenarios, two approaches were used, one that made harmonized assumptions about global population, economic growth, and final energy use, and those with an alternative approach to quantification. This is important to keep in mind as not all of the IPCC scenarios share common assumptions regarding the driving forces of climate change.

In this model application, the A1B scenario mean and maximum predictions are applied. Important assumptions were made in this scenario: reduction in the dispersion of income levels across economies (i.e. economic convergence), capacity building, increased cultural and social interactions among nations, and a substantial reduction in regional differences in per capita income, primarily from the economic growth of nations with increasing income (Nakicenovic et al. 2000). In addition, the A1 family of scenarios assumes that the future world includes rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Given today's global economic and political climate, as well as environmental and ecological constraints, these may not be feasible assumptions for the future.

In particular, the A1B scenario assumes that energy sources will be balanced across all sources, with an increase in use of renewable energy sources coupled with a reduced reliance on fossil fuels (Nakicenovic et al. 2000). Given this A1B scenario, the IPCC WGI Fourth Assessment Report (IPCC 2007) suggests a likely range of 0.21 m to 0.48 m of SLR by 2090-2099 "excluding future rapid dynamical changes in ice flow." The IPCC-produced A1B-mean scenario that was run as a part of this project falls near the middle of this estimated range, predicting 0.39 m of global SLR by 2100. A1B-maximum predicts 0.69 m of global SLR by 2100. However, other scientists using the same set of economic growth scenarios have estimated much higher estimates of SLR as discussed below.

Recent literature (Chen et al. 2006; Monaghan et al. 2006) indicates that eustatic sea level rise is progressing more rapidly than was previously assumed. This underestimation may be due to the dynamic changes in ice flow omitted within the IPCC report's calculations, and a consequence of overestimating the possibilities for future reductions in greenhouse gas emissions while concurrently striving for economic growth.

A recent paper in the journal *Science* (Rahmstorf 2007) suggests that, taking into account possible model error, a feasible range of 50 to 140 cm by 2100. This work was recently updated and the ranges were increased to 75 to 190 cm (Vermeer and Rahmstorf 2009). Pfeffer et al. (2008) suggests that 2 m by 2100 is at the upper end of plausible scenarios due to physical limitations on glaciological conditions. A recent US intergovernmental report states "Although no ice-sheet model is currently capable of capturing the glacier speedups in Antarctica or Greenland that have been observed over the last decade, including these processes in models will very likely show that IPCC AR4 projected SLRs for the end of the 21st century are too low" (Clark 2009). A recent paper by Grinsted et al. (2009) states that "sea level 2090-2099 is projected to be 0.9 to 1.3 m for the A1B

scenario…" Grinsted also states that there is a "low probability" that SLR will match the lower IPCC estimates.

The variability of SLR predictions presented in the scientific literature illustrates the significant amount of uncertainty in estimating future SLR. Much of the uncertainty may be due to the unknown future of the drivers climate change, such as fossil fuel consumption and the scale of human enterprise. In order to account for these uncertainties, and to better reflect these uncertainties as well as recently published peer-reviewed measurements and projections of SLR as noted above, SLAMM was run not only assuming A1B-mean and A1B-maximum SLR scenarios, but also for 1 m, 1.5 m, and 2 m of eustatic SLR by the year 2100 as shown in Figure 1.

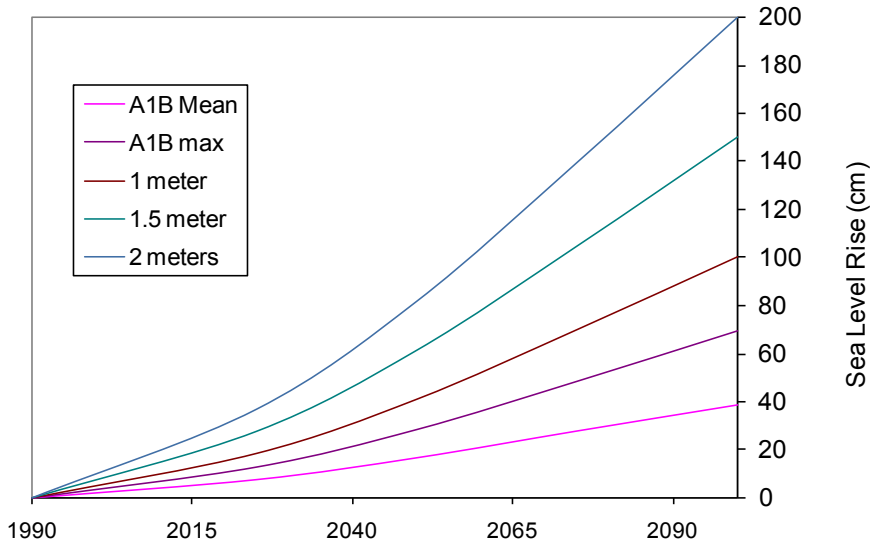


Figure 1. Summary of SLR scenarios utilized

Data Sources and Methods

Elevation Data. The refuge is completely covered by 2010 Coastal Georgia Topographic LiDAR data. However, parts of the surrounding area did not have LiDAR data. For these areas elevations were assigned based on contour maps of the National Elevation Database collected in 1974, as shown in Figure 2. In areas lacking LiDAR data (outside the primary study area) the elevation pre-processor module of SLAMM was then used to assign elevations for wetlands as a function of the local tide range.

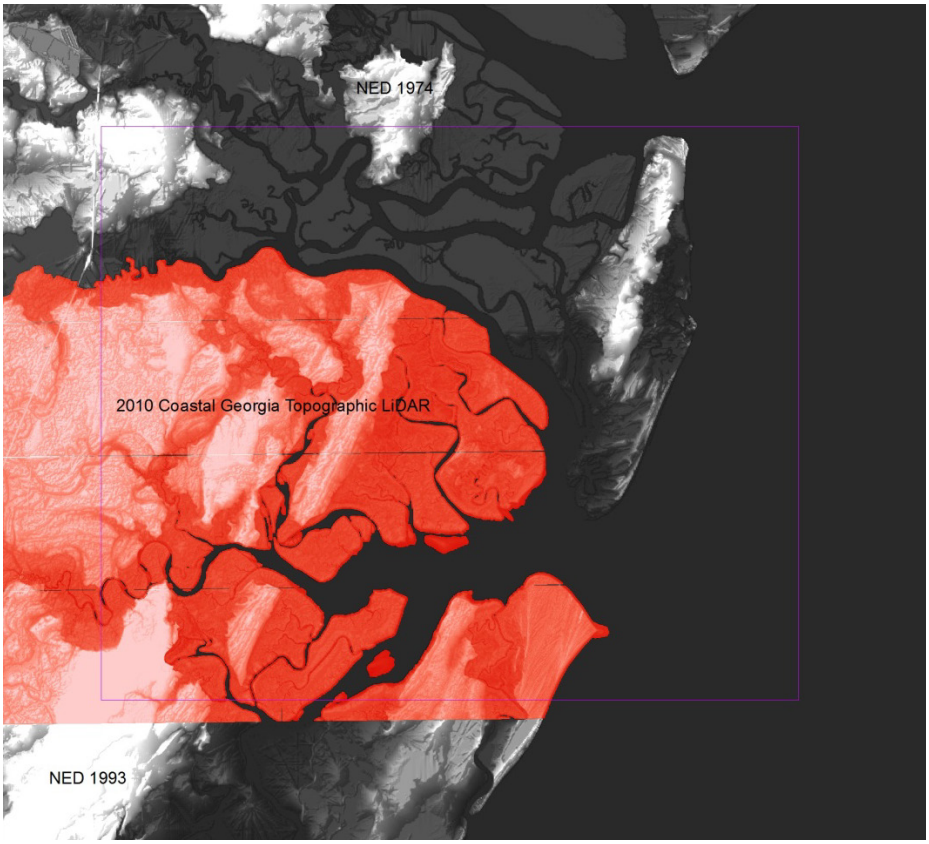


Figure 2. Location of LiDAR (shown in red) and NED-derived elevation data. Study area shown in purple

Wetland layer. Figure 3 shows the most recent available wetlands layer obtained from a National Wetlands Inventory (NWI) photo dated 2007. Converting the NWI survey into 15 m x 15 m cells indicated that the approximately 2,750 acre Harris Neck NWR (approved acquisition boundary including water) is composed of the following categories:

Land cover type		Area (acres)	Percentage (%)
	Undeveloped Dry Land	1473	53
	Regularly Flooded Marsh	910	33
	Irregularly Flooded Marsh	122	4
	Estuarine Open Water	74	3
	Inland Fresh Marsh	53	2
	Inland Open Water	40	1
	Developed Dry Land	28	1
	Swamp	27	< 1
	Transitional Salt Marsh	19	< 1
	Estuarine Beach	9	< 1
	Total (incl. water)	**2754**	**100**

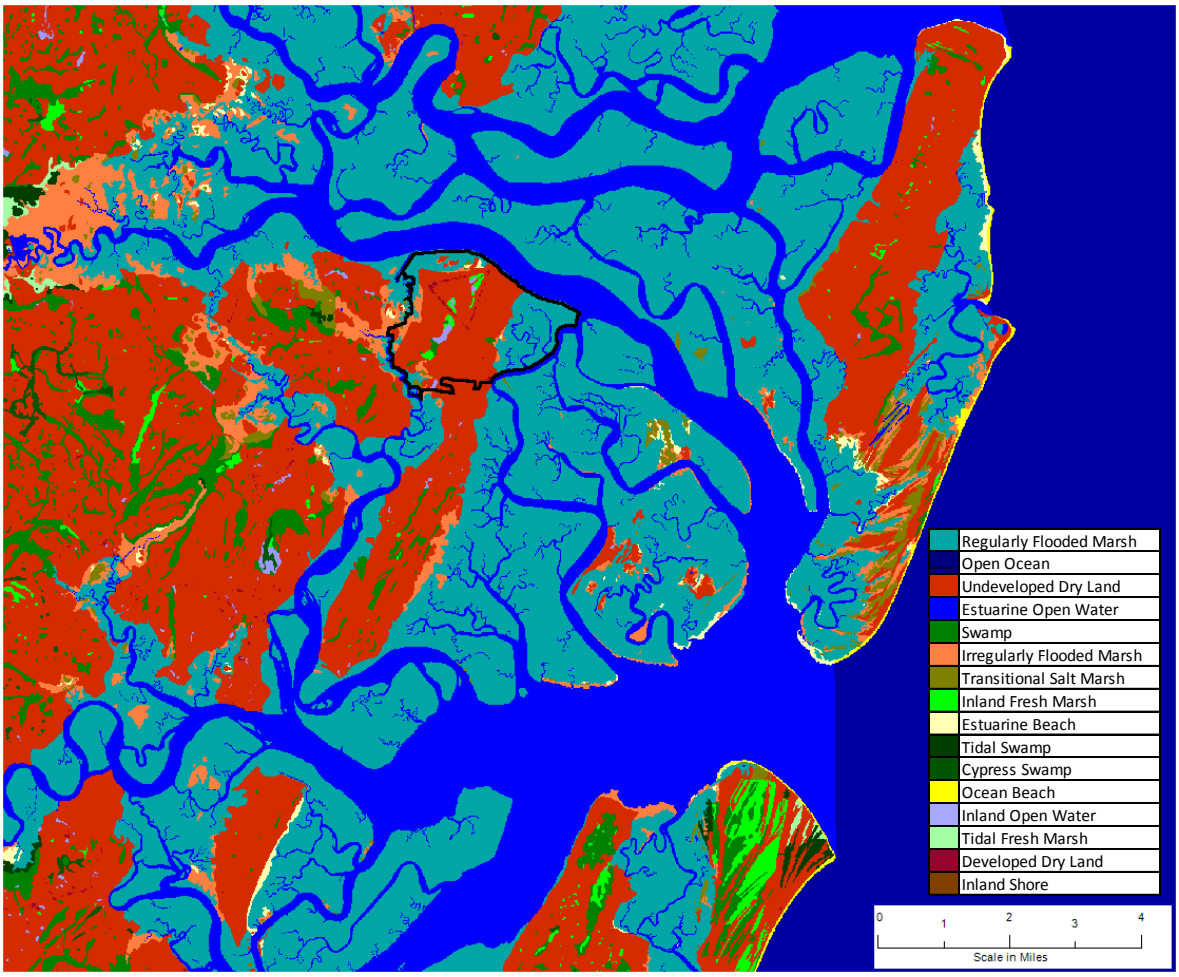


Figure 3. 2007 NWI coverage of the study area. Refuge boundaries are indicated in black

Dikes and Impoundments. According to the National Wetland Inventory, there are areas protected by dikes within the refuge. These are shown in yellow in Figure 4.

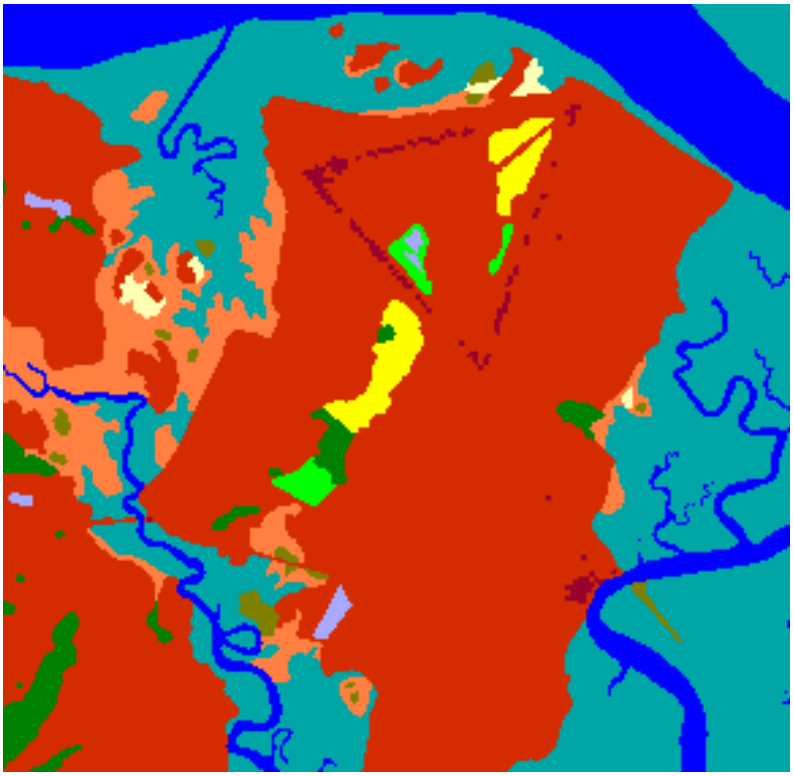


Figure 4. Location of dikes in Harris Neck NWR (shown in yellow)

Model Timesteps. Model forecast data was output for years 2025, 2050, 2075 and 2100 with the initial condition date set to 2007 (the most recent wetland data available). SLAMM uses a built in processor to correct elevations in an attempt to account for any elevation variation due to sea level rise between the wetland photo date and the DEM date.

Historic sea level rise rates. The historic trend for relative sea level rise was estimated at 2.66 mm/yr. using the distance-weighted average of the rate recorded at NOAA gauge stations #8670870 and #8720030 (Fort Pulaski, GA and Fernandina Beach, FL). The rate of sea level rise for this refuge is nearly 1 mm/yr. higher than the global (eustatic) SLR for the last 100 years (approximately 1.7 mm/year), perhaps suggesting some subsidence in this area.

Tide Ranges. The great diurnal range (GT) measured at the NOAA gauge stations present in the area (shown in Figure 5), is between 2.36 m and 2.49 m. For the refuge, a GT of 2.46 m was applied based on NOAA tide table data.

Figure 5. NOAA tide table station locations used for this study (yellow icons with GT in meters). Refuge boundary shown in green

Salt elevation. This parameter within SLAMM designates the boundary between wet lands and dry lands or saline wetlands and fresh water wetlands. For this application, salt elevation was estimated at 1.2 Half Tide Units (HTU), or 1.47 m above MTL, for the refuge.

Accretion rates. Regularly-flooded marsh was assigned an accretion rate of 3.9 mm/yr., based on measured rates of accretion in Georgia Marshes (Craft et. al, 2009).The SLAMM defaults of 3.75 mm/yr. was applied to irregularly-flooded marsh, due to the lack of site-specific data for this marsh type. Likewise, tidal fresh and inland fresh marsh accretion rates were set to 4 mm/yr.

Erosion rates. Horizontal erosion of marshes and swamps occurs only at the wetland-to-open-water interface and only when adequate open water (fetch) exists for wave setup. Due to lack of site-specific values, erosion rates were set to the SLAMM defaults. Tidal flat erosion was set to 0.2 m/yr., marshes were set to 2 m/yr., and a rate of 1 m/yr. was applied to swamps.

Elevation correction. MTL to NAVD88 corrections determined using NOAA's VDATUM software ranged from -0.025 to -0.0545 m and were applied on a subsite-by-subsite basis. A value of -0.025 m was applied to the subsite containing the Harris Neck NWR.

Parameter summary. While Harris Neck refuge is located completely in subsite NWR/SW, the remaining contextual area was divided into several subsites in order to represent differences in tide ranges and elevation data sources. Subsites were defined as shown in Figure 6. The parameters assigned to each subsite are presented in Table 1. Subsites where elevation data was derived from the National Elevation Dataset (NED) were subjected to the SLAMM elevation preprocessor to account for uncertainty associated with contour-based data (Clough et al. 2010). The cell size used for this analysis was 15 meters by 15 meters.

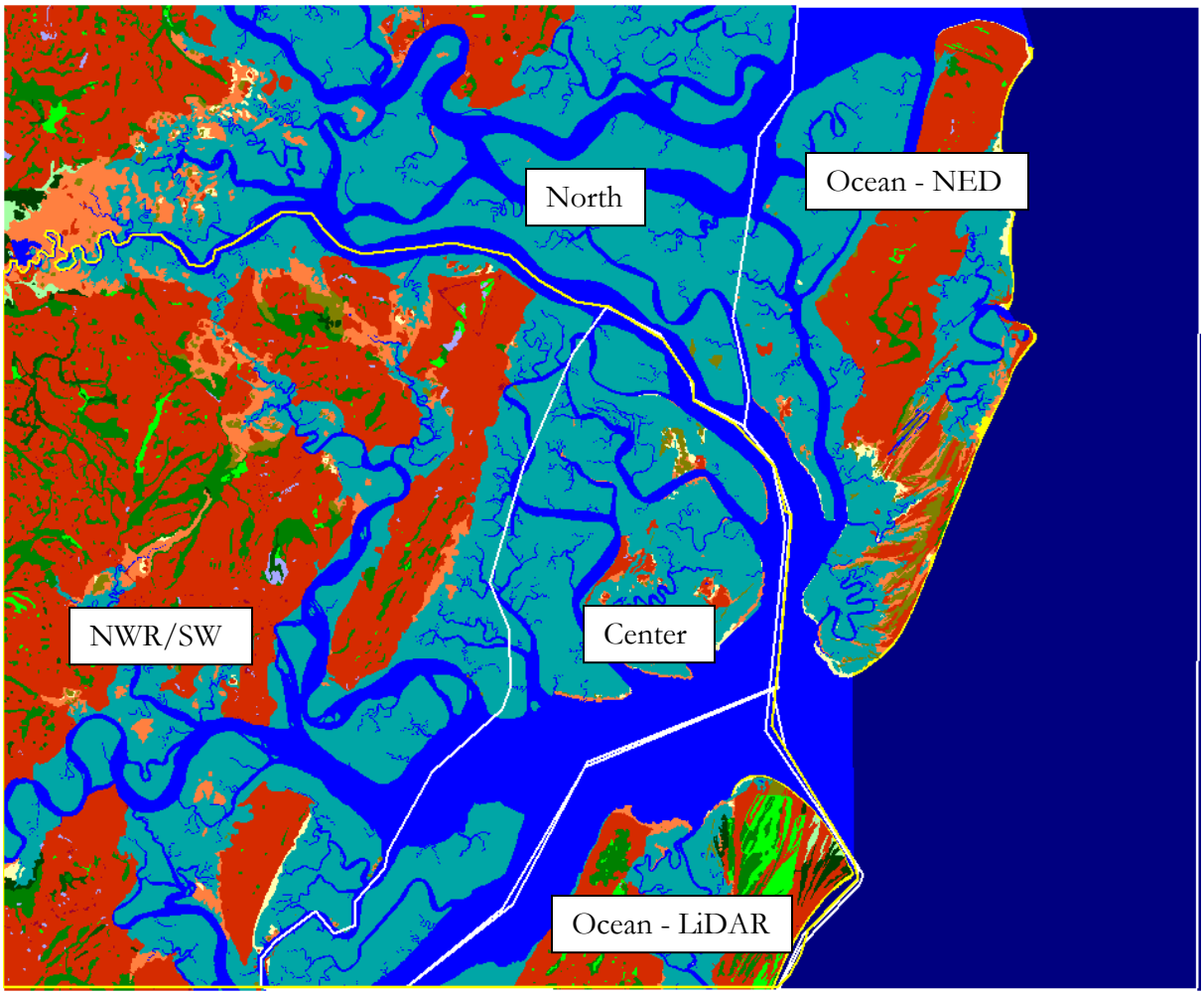


Figure 6. Subsites

Table 1. Summary of SLAMM input parameters for Harris Neck NWR.

Parameter	North	**NWR/SW**	Ocean - NED	Ocean - LiDAR	Center
NWI Photo Date (YYYY)	2007	**2007**	2007	2007	2007
DEM Date (YYYY)	1974	**2010**	1974	2010	2010
Direction Offshore [n,s,e,w]	East	**East**	East	East	East
Historic Trend (mm/yr.)	2.66	**2.66**	2.66	2.66	2.66
MTL-NAVD88 (m)	-0.037	**-0.025**	-0.0545	-0.0545	-0.045
GT Great Diurnal Tide Range (m)	2.49	**2.46**	2.36	2.36	2.41
Salt Elev. (m above MTL)	1.66	**1.47**	1.57	1.57	1.6
Marsh Erosion (horz. m /yr.)	2	**2**	2	2	2
Swamp Erosion (horz. m /yr.)	1	**1**	1	1	1
T.Flat Erosion (horz. m /yr.)	0.2	**0.2**	0.2	0.2	0.2
Reg.-Flood Marsh Accr (mm/yr.)	3.9	**3.9**	3.9	3.9	3.9
Irreg.-Flood Marsh Accr (mm/yr.)	3.75	**3.75**	3.75	3.75	3.75
Tidal-Fresh Marsh Accr (mm/yr.)	4	**4**	4	4	4
Inland-Fresh Marsh Accr (mm/yr.)	4	**4**	4	4	4
Tidal Swamp Accr (mm/yr.)	1.1	**1.1**	1.1	1.1	1.1
Swamp Accretion (mm/yr.)	0.3	**0.3**	0.3	0.3	0.3
Beach Sed. Rate (mm/yr.)	0.5	**0.5**	0.5	0.5	0.5
Freq. Overwash (years)	25	**25**	25	25	25
Use Elev Pre-processor [True,False]	TRUE	**FALSE**	TRUE	FALSE	FALSE

Results

Table 2 presents the predicted losses for each land cover type by 2100 for the total approved acquisition boundary of Harris Neck NWR for each of the five SLR scenarios examined. For this simulation the land-cover losses are calculated in comparison to the 2007 NWI wetland layer.

Table 2. Predicted loss rates of land categories by 2100 given simulated scenarios of eustatic SLR at Harris Neck NWR.
Positive values indicate losses while negative values indicate gains

Land cover category	Land cover change by 2100 for different SLR scenarios (%)				
	0.39 m	0.69 m	1 m	1.5 m	2 m
Undeveloped Dry Land	8	9	10	14	21
Regularly Flooded Marsh	3	-3	14	74	85
Irregularly Flooded Marsh	8	54	89	98	100
Inland Fresh Marsh	0	16	21	23	28
Developed Dry Land	0	0	0	1	7
Swamp	41	63	74	86	95
Transitional Salt Marsh	-381	-155	-45	-220	-617

Undeveloped dry land makes up the majority of the refuge (53%) and this category is predicted to be relatively resilient to SLR. A maximum of 21% loss is predicted to occur under the 2 m SLR by 2100 scenario. Regularly-flooded marsh, which makes up 33% of the refuge area, is predicted to significantly decrease in acreage as sea level increases, culminating in a 85% loss under the 2 m SLR by 2100 scenario. However, under the 1 m of SLR by 2100 scenario, only 14% of regularly-flooded marsh is predicted to be lost. Inland freshwater marshes are also predicted to be somewhat resilient to SLR, with a maximum loss of 28% predicted under the 2 m by 2100 scenario.

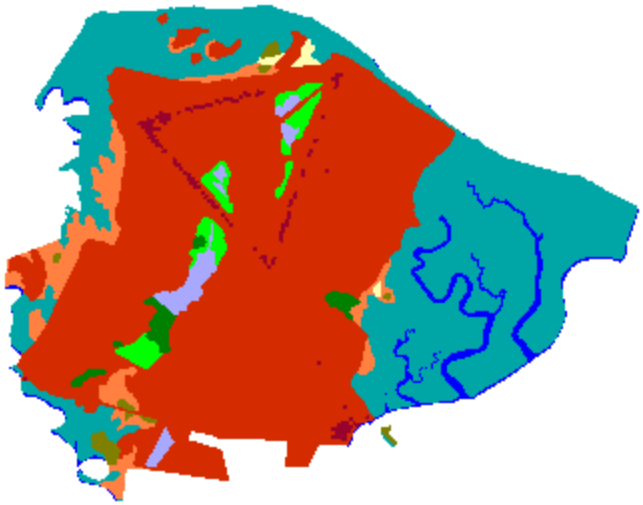
In comparison, irregularly-flooded marsh and swamp appear vulnerable to SLR. Under the 1 m by 2100 SLR scenario, 89% of irregularly-flooded marsh is predicted to be lost. SLR scenarios greater than 1 m by 2100 suggest near complete loss of irregularly-flooded marsh. Swamp losses are also predicted to be extreme. Although only 27 acres of swamp exist in the refuge according to the 2007 NWI data layer, 74% of this habitat is predicted to be lost under the 1 m by 2100 SLR scenario, with a maximum loss of 95% predicted under the 2 m by 2100 scenario.

Only 19 acres of transitional salt marsh are present in the 2007 wetland layer. SLAMM projections indicate increases in this category under each SLR scenario examined, with the greatest increases by 2100 observed under the 0.39 m and 2 m scenarios.

Harris Neck NWR
IPCC Scenario A1B-Mean, 0.39 m SLR eustatic by 2100

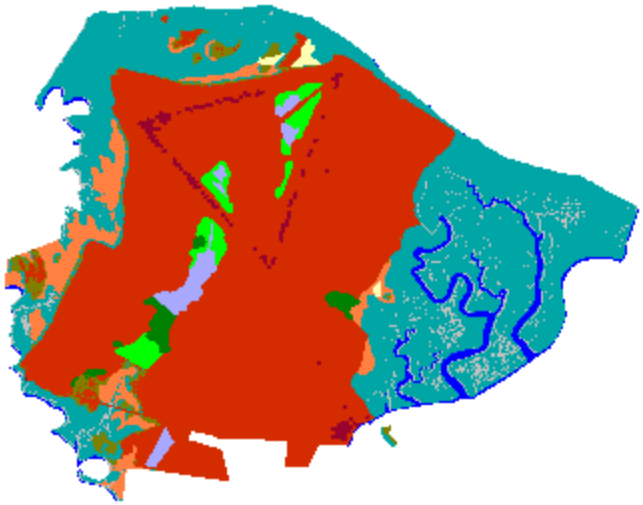
Results in Acres

		Initial	2025	2050	2075	2100
	Undeveloped Dry Land	1473	1405	1391	1374	1362
	Regularly Flooded Marsh	910	881	883	882	882
	Irregularly Flooded Marsh	122	116	115	114	112
	Estuarine Open Water	74	74	75	76	78
	Inland Fresh Marsh	53	53	53	53	53
	Inland Open Water	40	40	40	40	40
	Developed Dry Land	28	28	28	28	28
	Swamp	27	26	26	25	16
	Transitional Salt Marsh	19	50	63	76	93
	Estuarine Beach	9	9	9	9	9
	Tidal Flat	0	72	72	77	82
	Total (incl. water)	**2754**	**2754**	**2754**	**2754**	**2754**

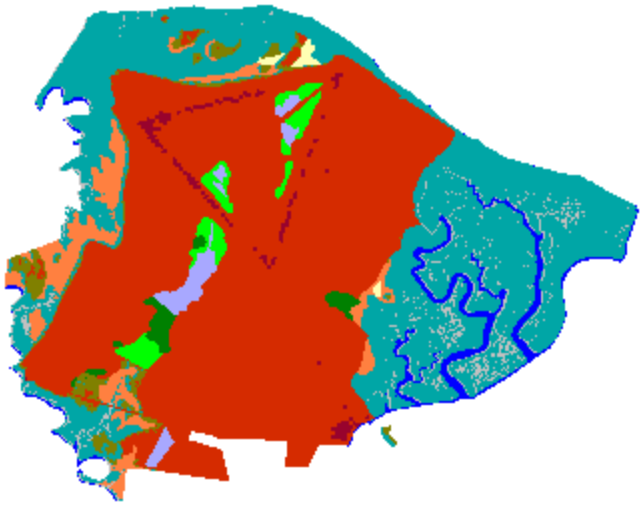


	Undeveloped Dry Land
	Regularly Flooded Marsh
	Irregularly Flooded Marsh
	Estuarine Open Water
	Inland Fresh Marsh
	Inland Open Water
	Developed Dry Land
	Swamp
	Transitional Salt Marsh
	Estuarine Beach
	Tidal Flat

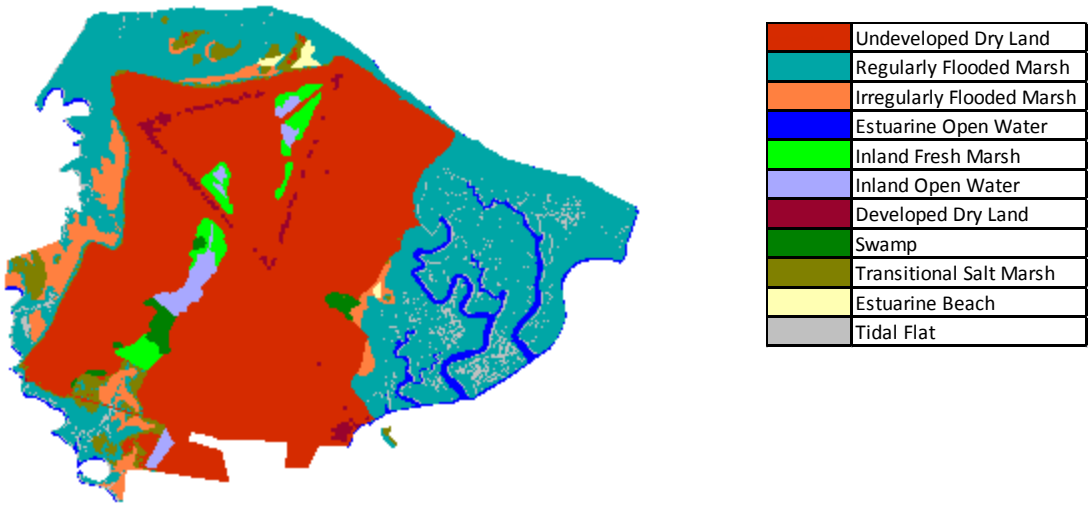
Harris Neck NWR, Initial Condition



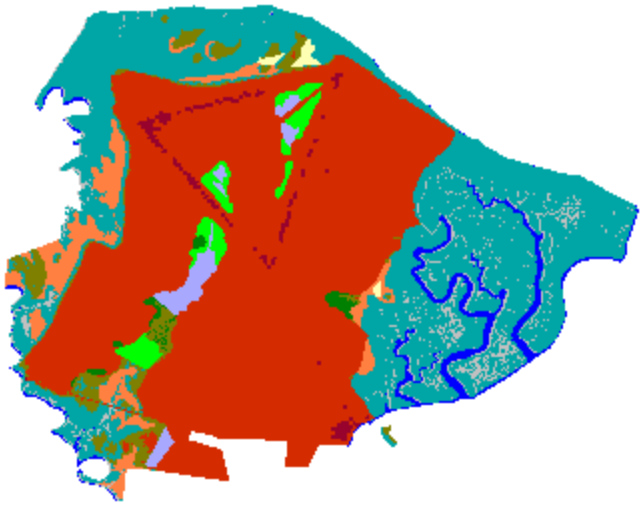
Harris Neck NWR, 2025, Scenario A1B Mean, 0.39 m SLR



Harris Neck NWR, 2050, Scenario A1B Mean, 0.39 m SLR



Harris Neck NWR, 2075, Scenario A1B Mean, 0.39 m SLR

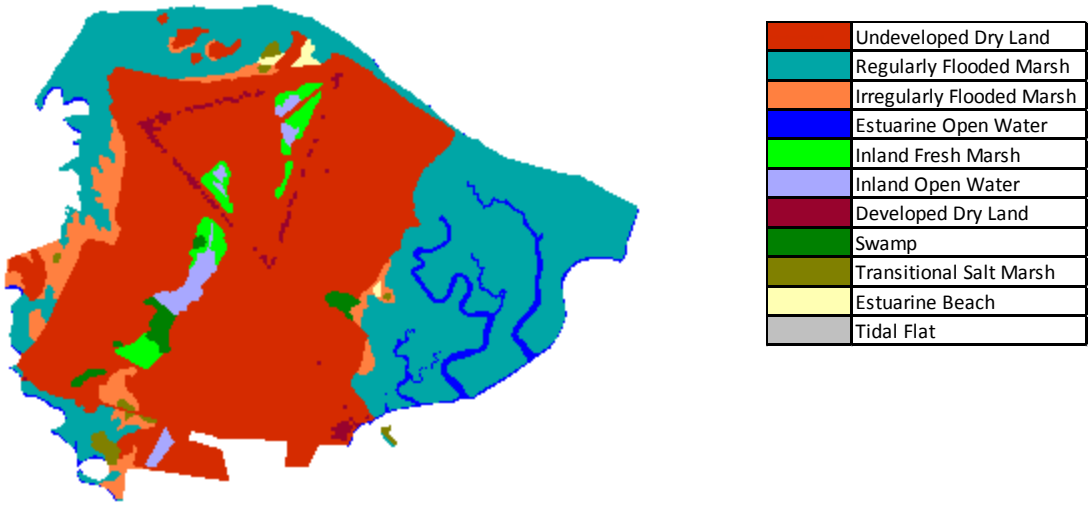


Harris Neck NWR, 2100, Scenario A1B Mean, 0.39 m SLR

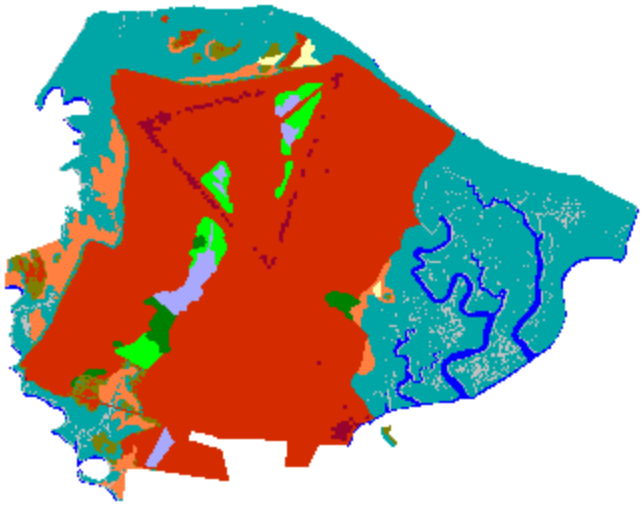
Harris Neck NWR
IPCC Scenario A1B-Max, 0.69 m SLR eustatic by 2100

Results in Acres

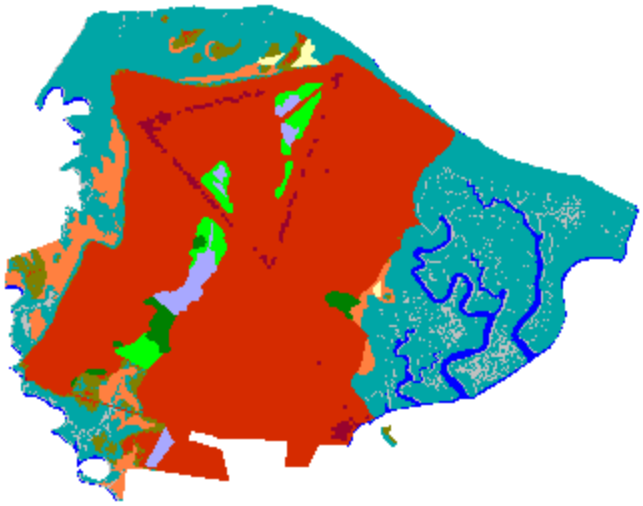
		Initial	2025	2050	2075	2100
	Undeveloped Dry Land	1473	1402	1379	1359	1343
	Regularly Flooded Marsh	910	882	880	897	933
	Irregularly Flooded Marsh	122	115	112	96	57
	Estuarine Open Water	74	74	75	80	98
	Inland Fresh Marsh	53	53	53	49	44
	Inland Open Water	40	40	40	40	36
	Developed Dry Land	28	28	28	28	28
	Swamp	27	26	25	14	10
	Transitional Salt Marsh	19	52	65	68	49
	Estuarine Beach	9	9	9	9	9
	Tidal Flat	0	74	88	114	147
	Total (incl. water)	**2754**	**2754**	**2754**	**2754**	**2754**



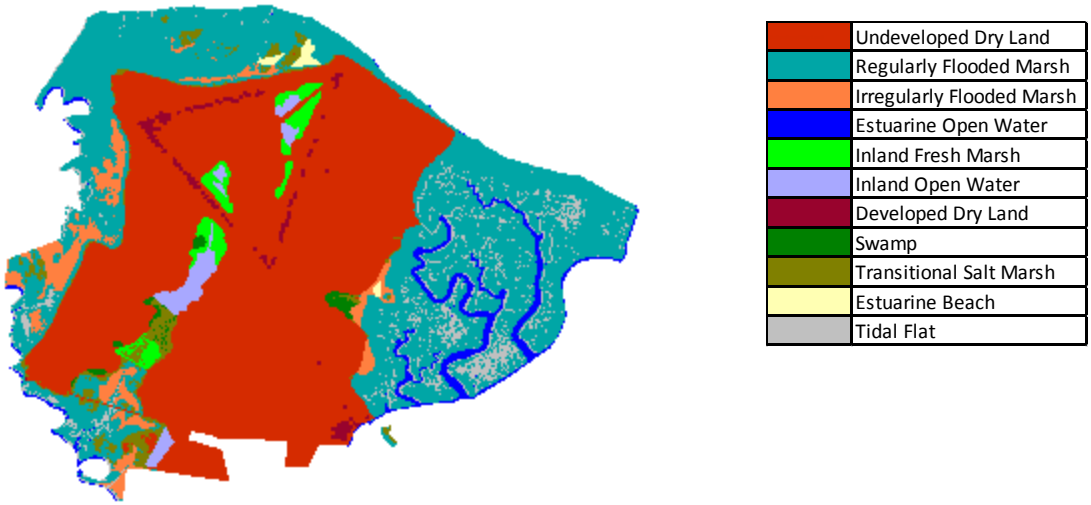
Harris Neck NWR, Initial Condition



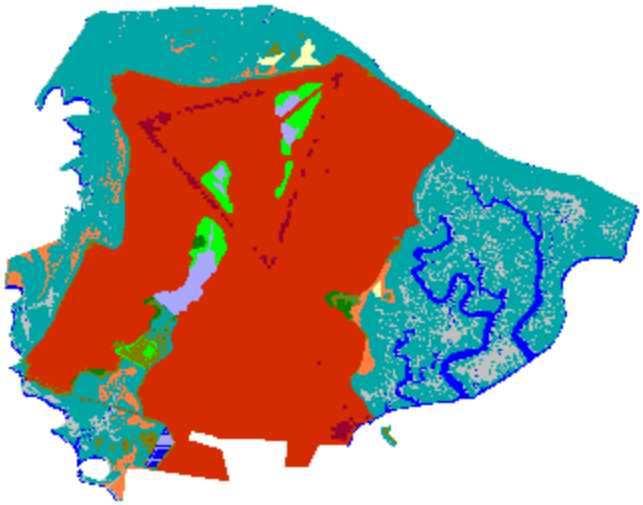
Harris Neck NWR, 2025, Scenario A1B Maximum, 0.69 m SLR



Harris Neck NWR, 2050, Scenario A1B Maximum, 0.69 m SLR



Harris Neck NWR, 2075, Scenario A1B Maximum, 0.69 m SLR

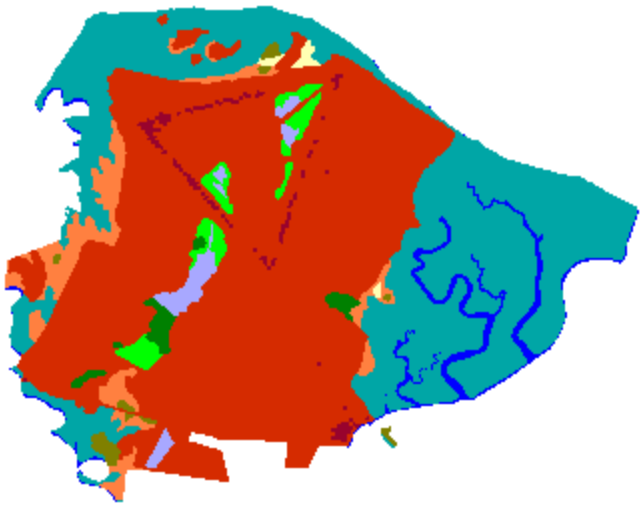


Harris Neck NWR, 2100, Scenario A1B Maximum, 0.69 m SLR

Harris Neck NWR
1 m eustatic SLR by 2100

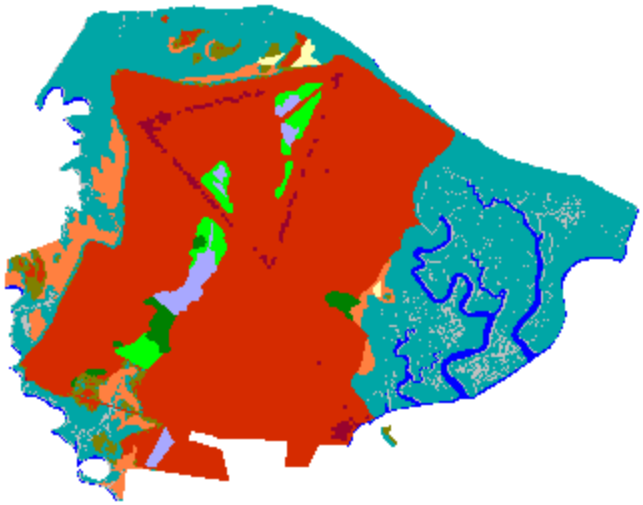
Results in Acres

		Initial	2025	2050	2075	2100
	Undeveloped Dry Land	1473	1398	1368	1346	1326
	Regularly Flooded Marsh	910	882	883	922	785
	Irregularly Flooded Marsh	122	114	102	46	14
	Estuarine Open Water	74	74	77	91	128
	Inland Fresh Marsh	53	53	51	43	42
	Inland Open Water	40	40	40	40	34
	Developed Dry Land	28	28	28	28	28
	Swamp	27	26	19	10	7
	Transitional Salt Marsh	19	53	69	47	28
	Estuarine Beach	9	9	9	9	9
	Tidal Flat	0	79	110	171	353
	Total (incl. water)	**2754**	**2754**	**2754**	**2754**	**2754**

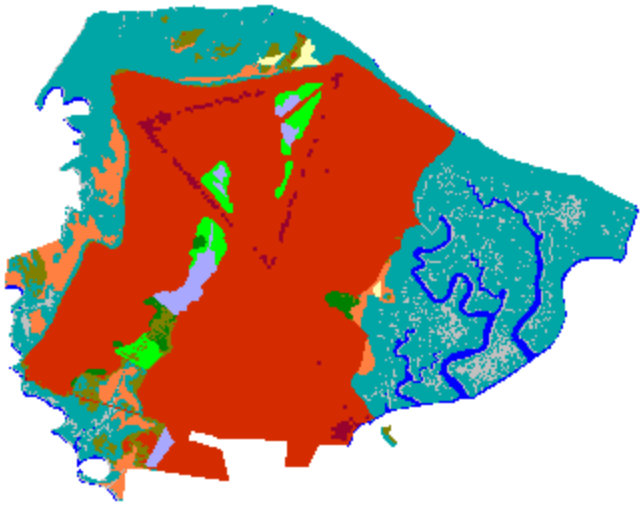


	Undeveloped Dry Land
	Regularly Flooded Marsh
	Irregularly Flooded Marsh
	Estuarine Open Water
	Inland Fresh Marsh
	Inland Open Water
	Developed Dry Land
	Swamp
	Transitional Salt Marsh
	Estuarine Beach
	Tidal Flat

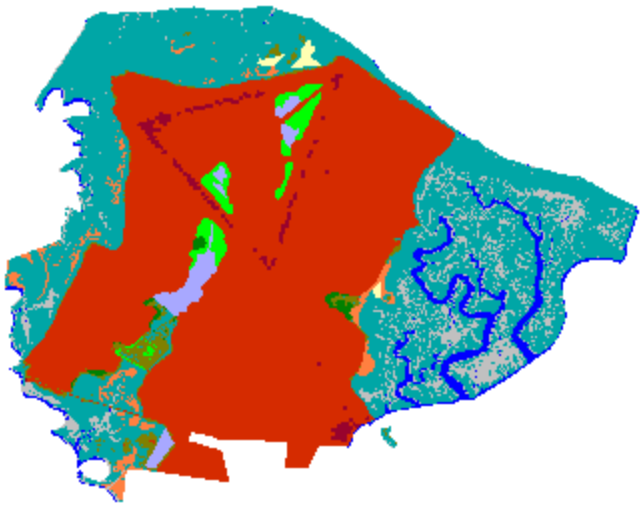
Harris Neck NWR, Initial Condition



Harris Neck NWR, 2025, 1 m SLR

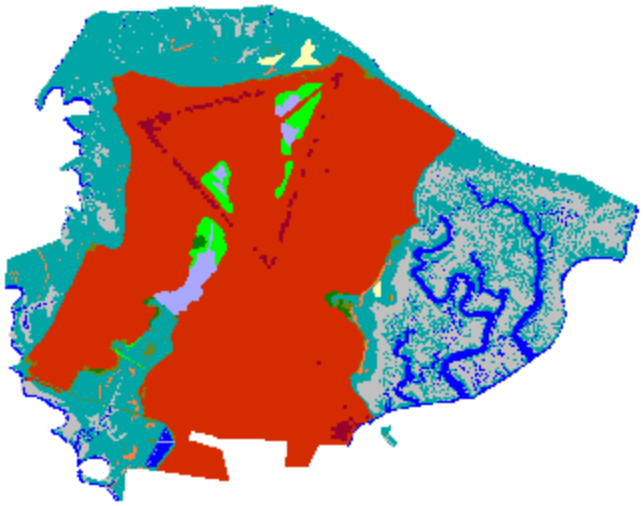


Harris Neck NWR, 2050, 1 m SLR



	Undeveloped Dry Land
	Regularly Flooded Marsh
	Irregularly Flooded Marsh
	Estuarine Open Water
	Inland Fresh Marsh
	Inland Open Water
	Developed Dry Land
	Swamp
	Transitional Salt Marsh
	Estuarine Beach
	Tidal Flat

Harris Neck NWR, 2075, 1 m SLR

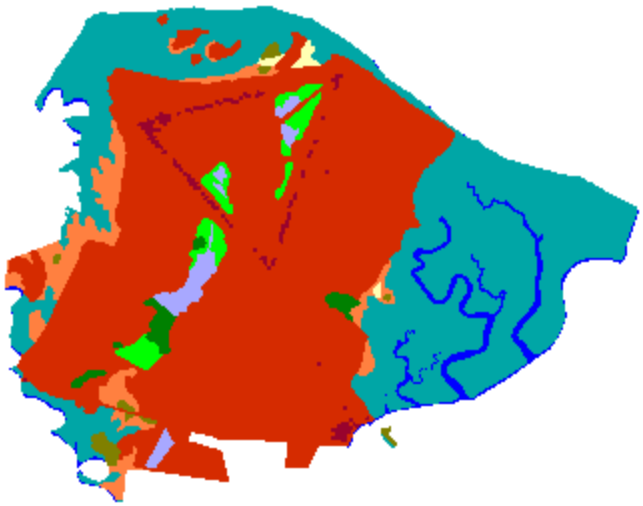


Harris Neck NWR, 2100, 1 m SLR

Harris Neck NWR
1.5 m eustatic SLR by 2100

Results in Acres

		Initial	2025	2050	2075	2100
	Undeveloped Dry Land	1473	1392	1356	1328	1271
	Regularly Flooded Marsh	910	880	902	666	236
	Irregularly Flooded Marsh	122	112	60	10	3
	Estuarine Open Water	74	74	82	126	196
	Inland Fresh Marsh	53	53	44	41	40
	Inland Open Water	40	40	40	34	33
	Developed Dry Land	28	28	28	28	28
	Swamp	27	26	13	7	4
	Transitional Salt Marsh	19	53	63	38	62
	Estuarine Beach	9	9	9	9	9
	Tidal Flat	0	88	157	466	872
	Total (incl. water)	**2754**	**2754**	**2754**	**2754**	**2754**



Undeveloped Dry Land
Regularly Flooded Marsh
Irregularly Flooded Marsh
Estuarine Open Water
Inland Fresh Marsh
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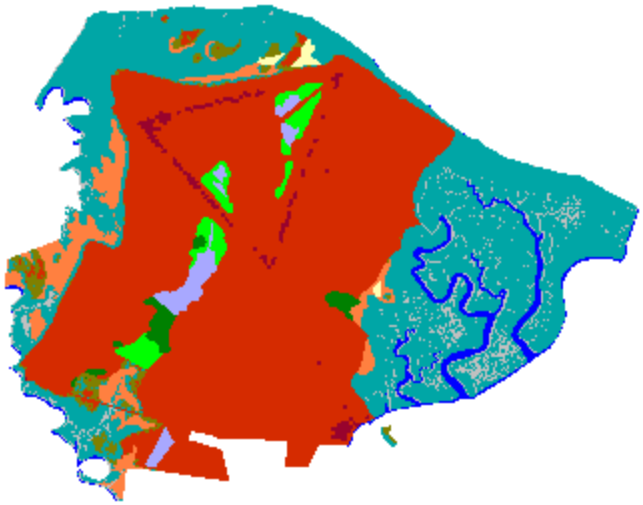
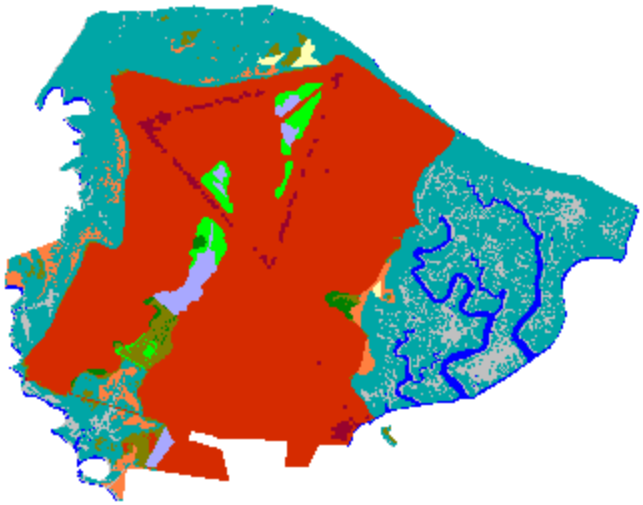
Developed Dry Land
Swamp
Transitional Salt Marsh
Estuarine Beach
Tidal Flat

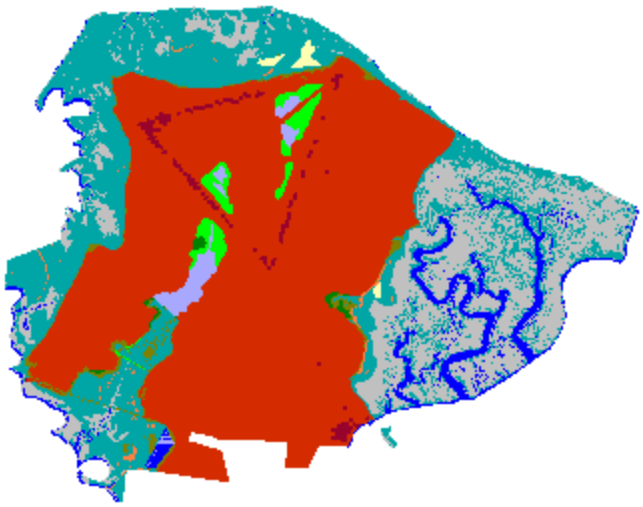
Harris Neck NWR, Initial Condition



Harris Neck NWR, 2025, 1.5 m SLR

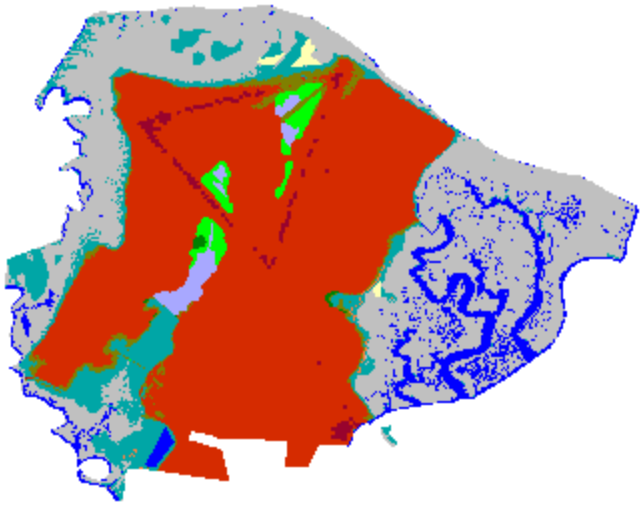


Harris Neck NWR, 2050, 1.5 m SLR



	Undeveloped Dry Land
	Regularly Flooded Marsh
	Irregularly Flooded Marsh
	Estuarine Open Water
	Inland Fresh Marsh
	Inland Open Water
	Developed Dry Land
	Swamp
	Transitional Salt Marsh
	Estuarine Beach
	Tidal Flat

Harris Neck NWR, 2075, 1.5 m SLR

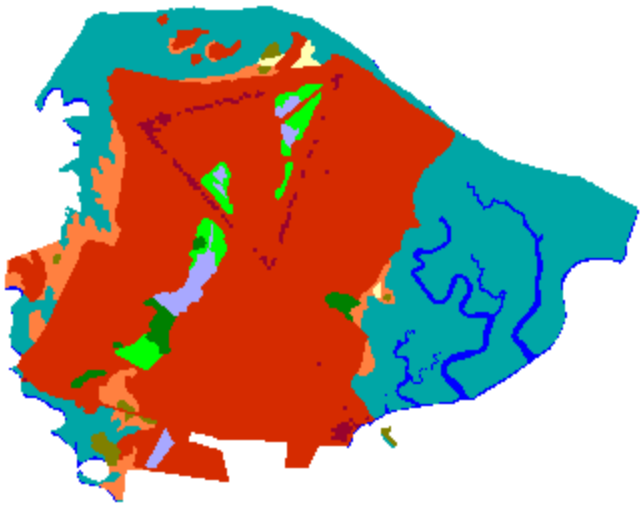


Harris Neck NWR, 2100, 1.5 m SLR

Harris Neck NWR
2 m eustatic SLR by 2100

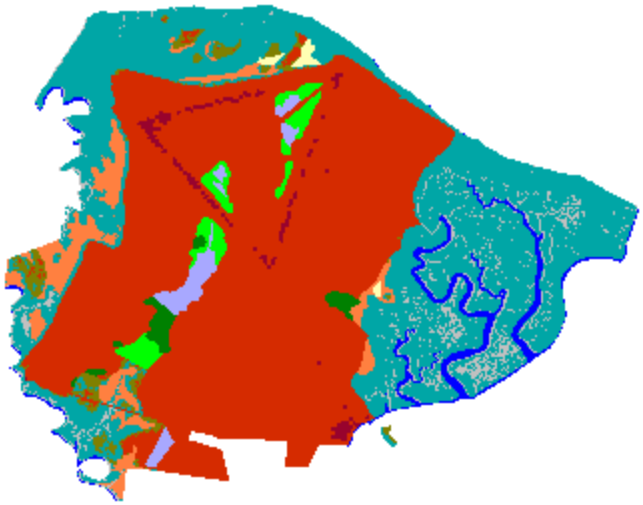
Results in Acres

		Initial	2025	2050	2075	2100
	Undeveloped Dry Land	1473	1387	1346	1299	1169
	Regularly Flooded Marsh	910	879	853	266	138
	Irregularly Flooded Marsh	122	109	27	4	1
	Estuarine Open Water	74	75	93	167	341
	Inland Fresh Marsh	53	52	42	41	38
	Inland Open Water	40	40	40	33	33
	Developed Dry Land	28	28	28	28	26
	Swamp	27	25	10	5	1
	Transitional Salt Marsh	19	53	69	54	138
	Estuarine Beach	9	9	9	9	9
	Tidal Flat	0	98	238	848	860
	Total (incl. water)	**2754**	**2754**	**2754**	**2754**	**2754**

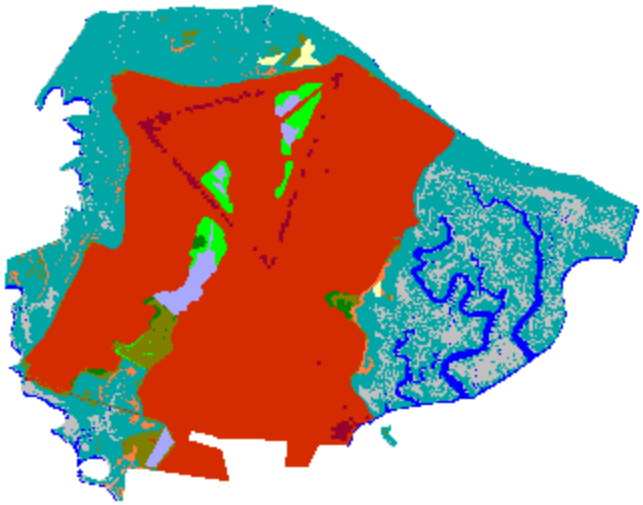


	Undeveloped Dry Land
	Regularly Flooded Marsh
	Irregularly Flooded Marsh
	Estuarine Open Water
	Inland Fresh Marsh
	Inland Open Water
	Developed Dry Land
	Swamp
	Transitional Salt Marsh
	Estuarine Beach
	Tidal Flat

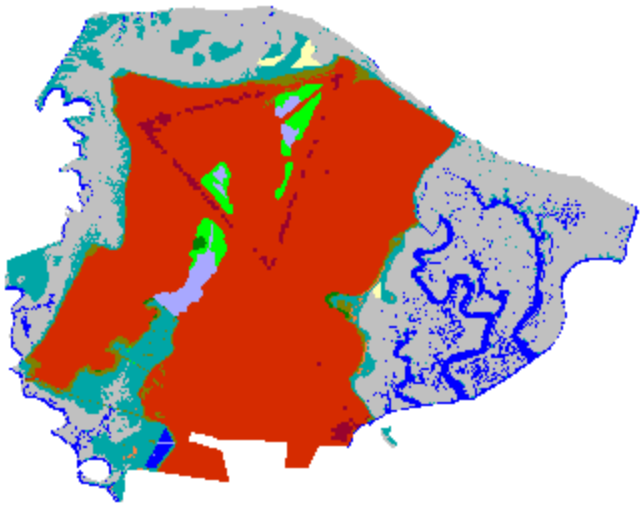
Harris Neck NWR, Initial Condition



Harris Neck NWR, 2025, 2 m SLR

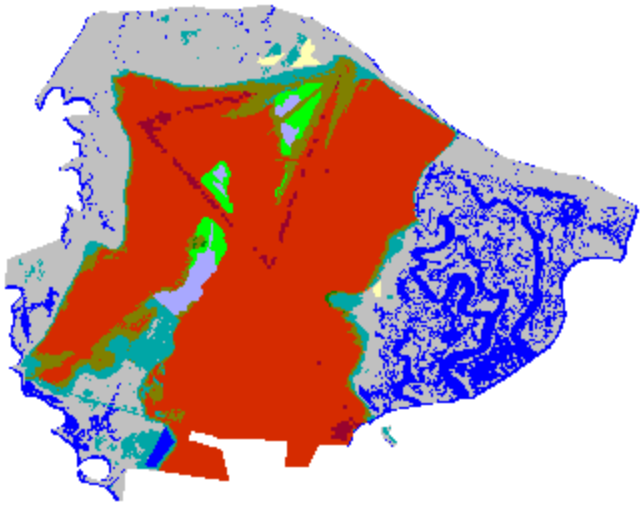


Harris Neck NWR, 2050, 2 m SLR



	Undeveloped Dry Land
	Regularly Flooded Marsh
	Irregularly Flooded Marsh
	Estuarine Open Water
	Inland Fresh Marsh
	Inland Open Water
	Developed Dry Land
	Swamp
	Transitional Salt Marsh
	Estuarine Beach
	Tidal Flat

Harris Neck NWR, 2075, 2 m SLR



Harris Neck NWR, 2100, 2 m SLR

Discussion

In these simulations of Harris Neck NWR, swamp and irregularly-flooded marsh habitats are predicted to be the most impacted by sea-level rise, with more than 50% of each of these wetland types projected to be lost at a SLR of 0.69 m by 2100. However, other habitat types in the refuge appear to be fairly resilient to SLR, especially under scenarios of 1 m by 2100 and less.

As compared to previous simulations of this refuge, which examined only 0.39 m (A1B mean), 0.69 m (A1B maximum), and 1 m SLR by 2100, more loss of irregularly-flooded marsh, inland fresh marsh, and swamp are projected under all scenarios. However, 30 to 70% less loss of regularly flooded marsh is predicted in the updated simulations. Transitional salt marsh and undeveloped dry land loss exhibit similar trends in both model applications. These differences are primarily due to updates to the SLAMM model and input data.

The elevation data used in this analysis are high-quality LiDAR obtained in 2010, which lends an added level of confidence to the results obtained from these SLAMM simulations. However, due to the lack of site-specific data for accretion and erosion, there is significant uncertainty associated with this SLAMM application. In addition, uncertainty in future sea-level rise is important to keep in mind when interpreting these results. Much of this uncertainty is due to assumptions made regarding the drivers of climate change in projecting SLR rates. Future levels of economic activity, fuel type, and fuel consumption 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 (0.39 m by 2100) to a more accelerated process (2 m by 2100).

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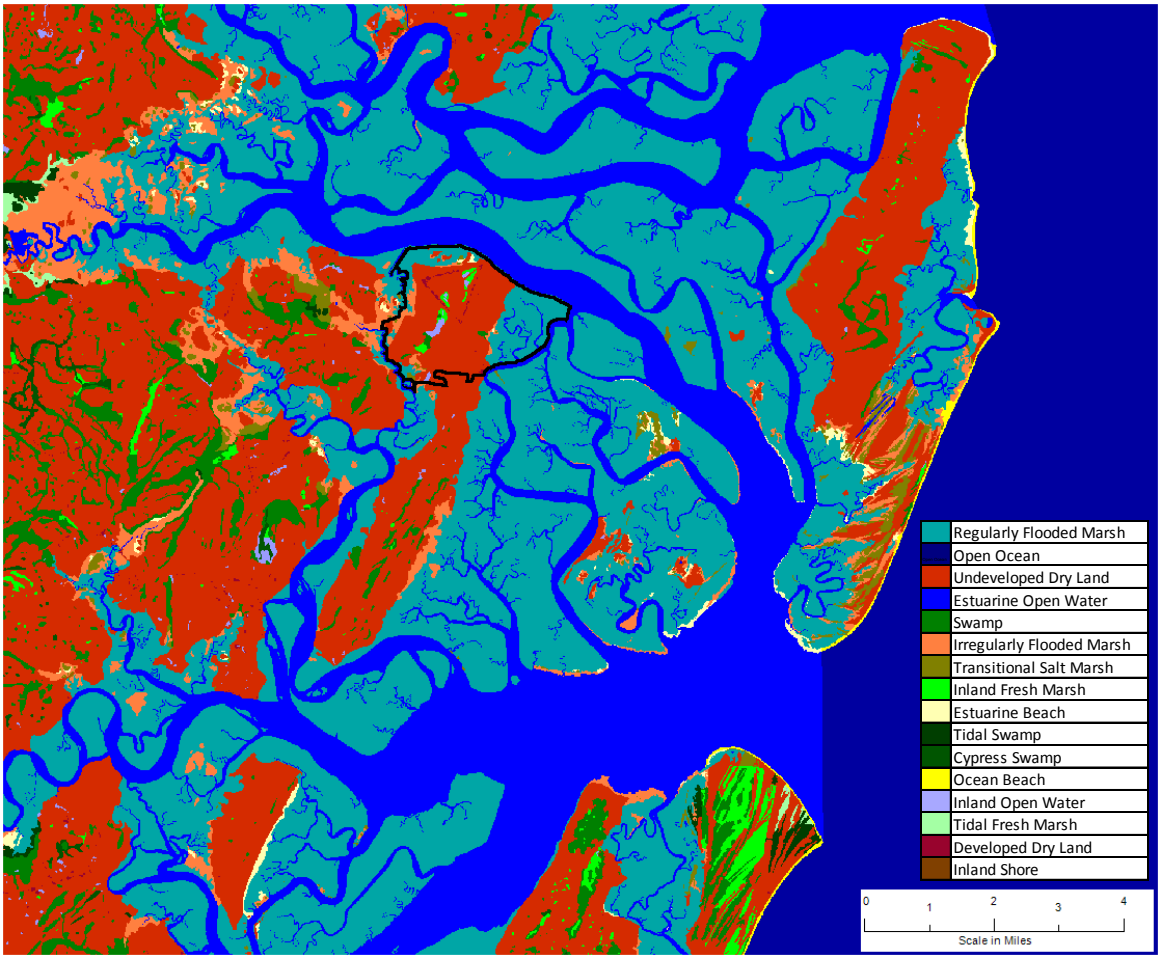
Appendix A: Contextual Results

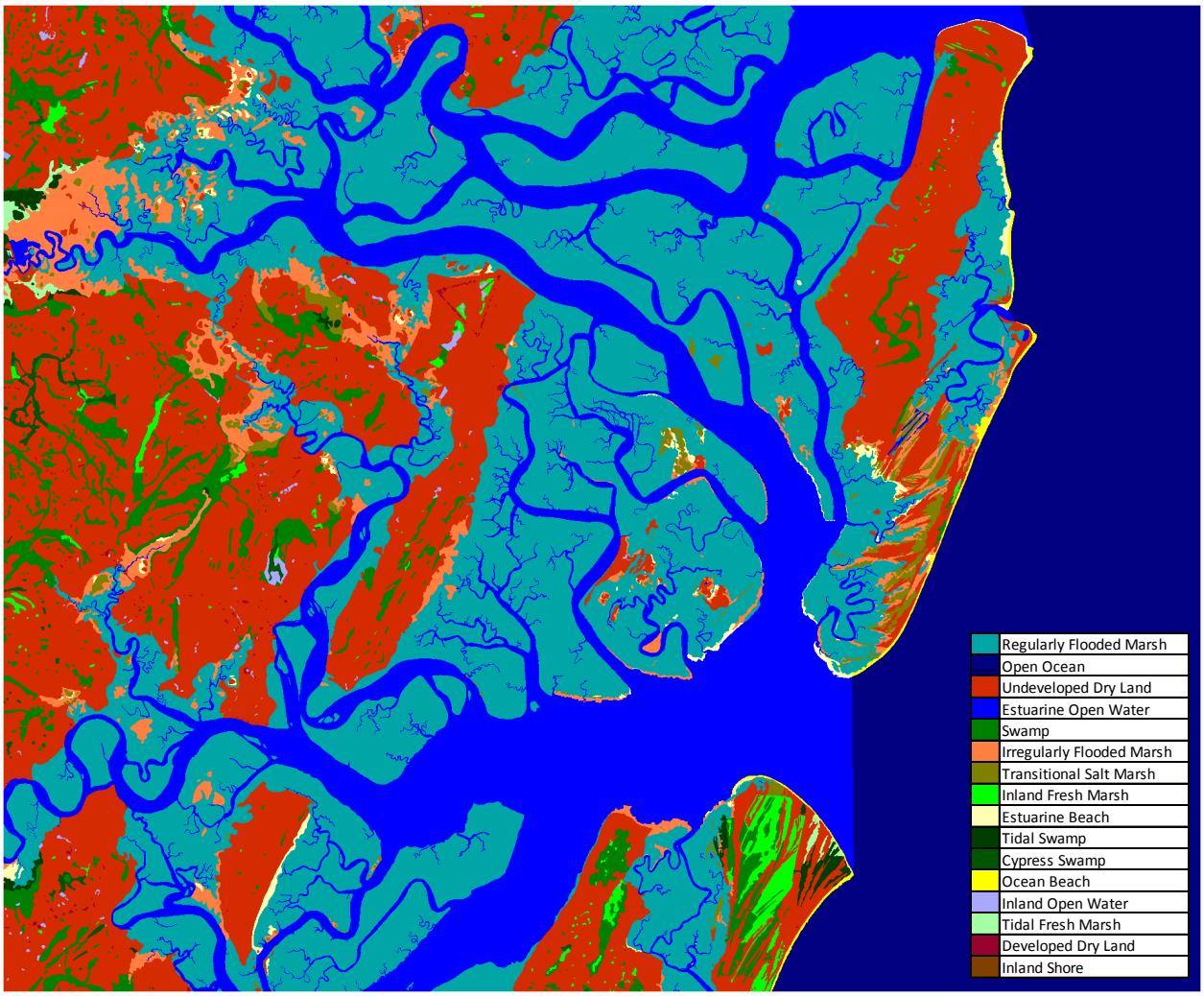
The SLAMM model does take into account the context of the surrounding lands or open water when calculating effects. For example, erosion rates are calculated based on the maximum fetch (wave action) which is estimated by assessing contiguous open water to a given marsh cell. Another example is that inundated dry lands will convert to marshes or ocean beach depending on their proximity to open ocean.

For this reason, an area larger than the boundaries of the USFWS refuge was modeled. Maps of these results are presented here with the following caveats:

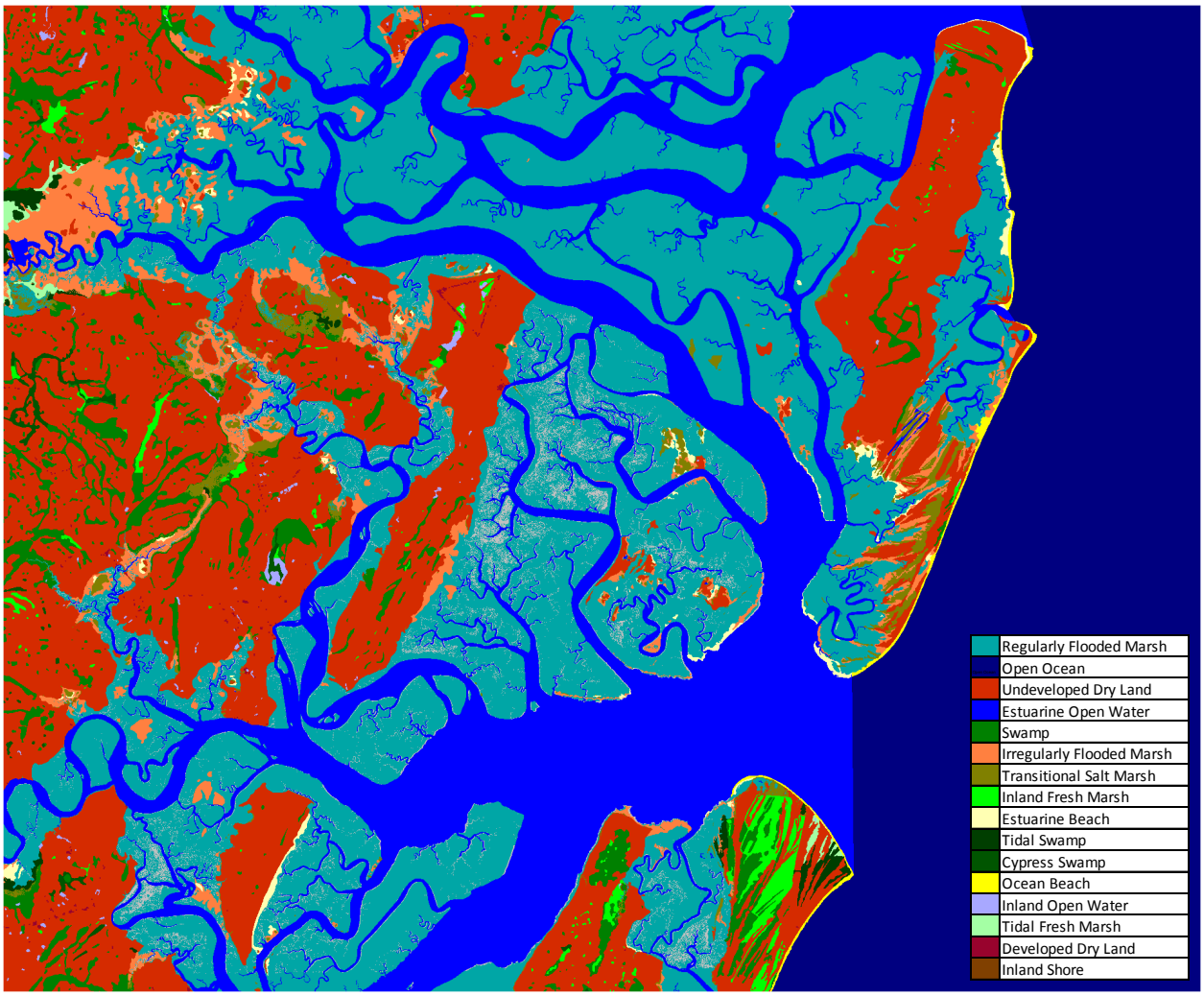
- Results were closely examined within USFWS refuges but not as closely examined for the larger region.
- Site-specific parameters for the model were derived for USFWS refuges whenever possible and may not be regionally applicable.
- Especially in areas where dikes are present, an effort was made to assess the probable location and effects of dikes for USFWS refuges, but this effort was not made for surrounding areas.

Harris Neck National Wildlife Refuge (outlined in black) within simulation context.

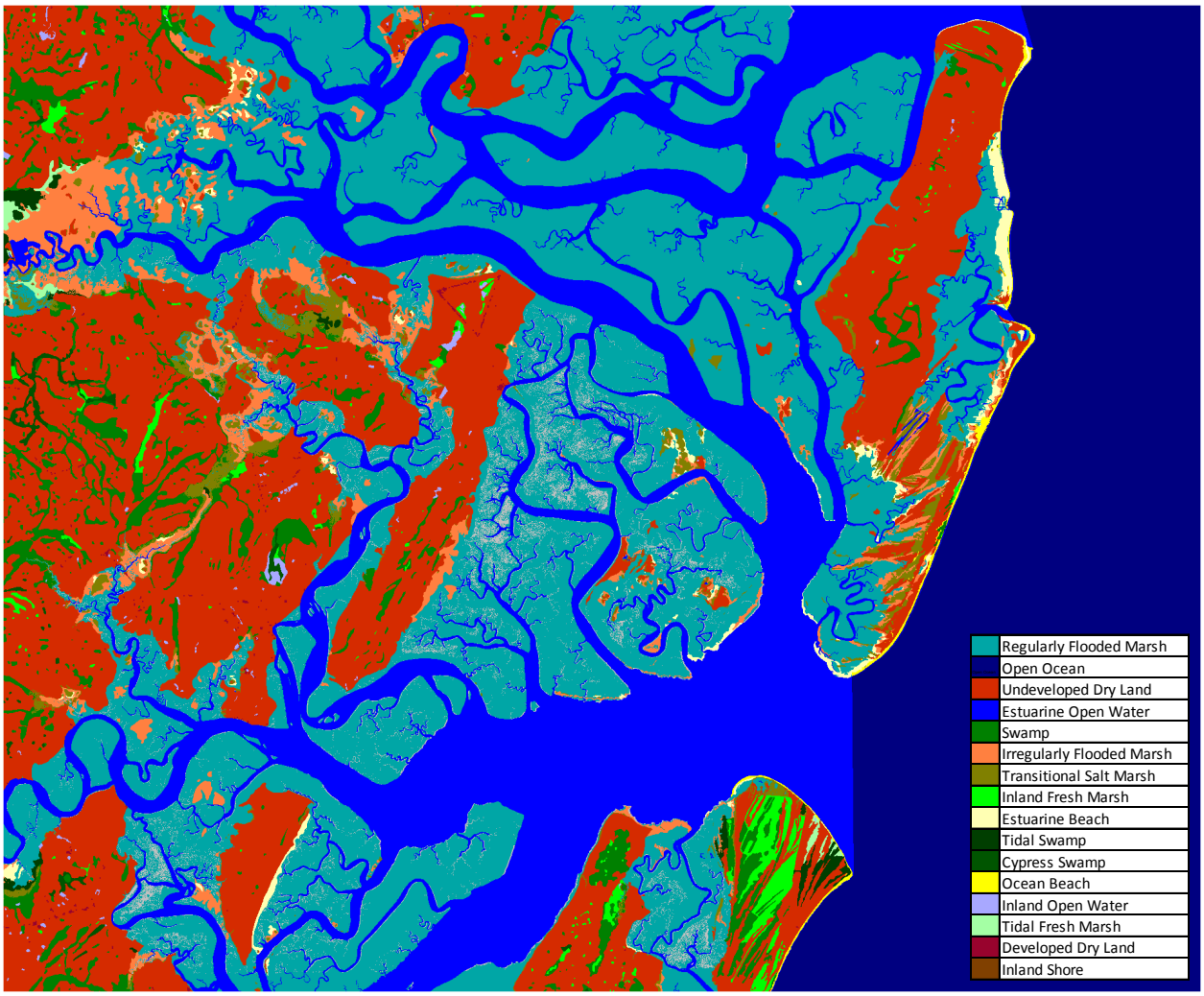




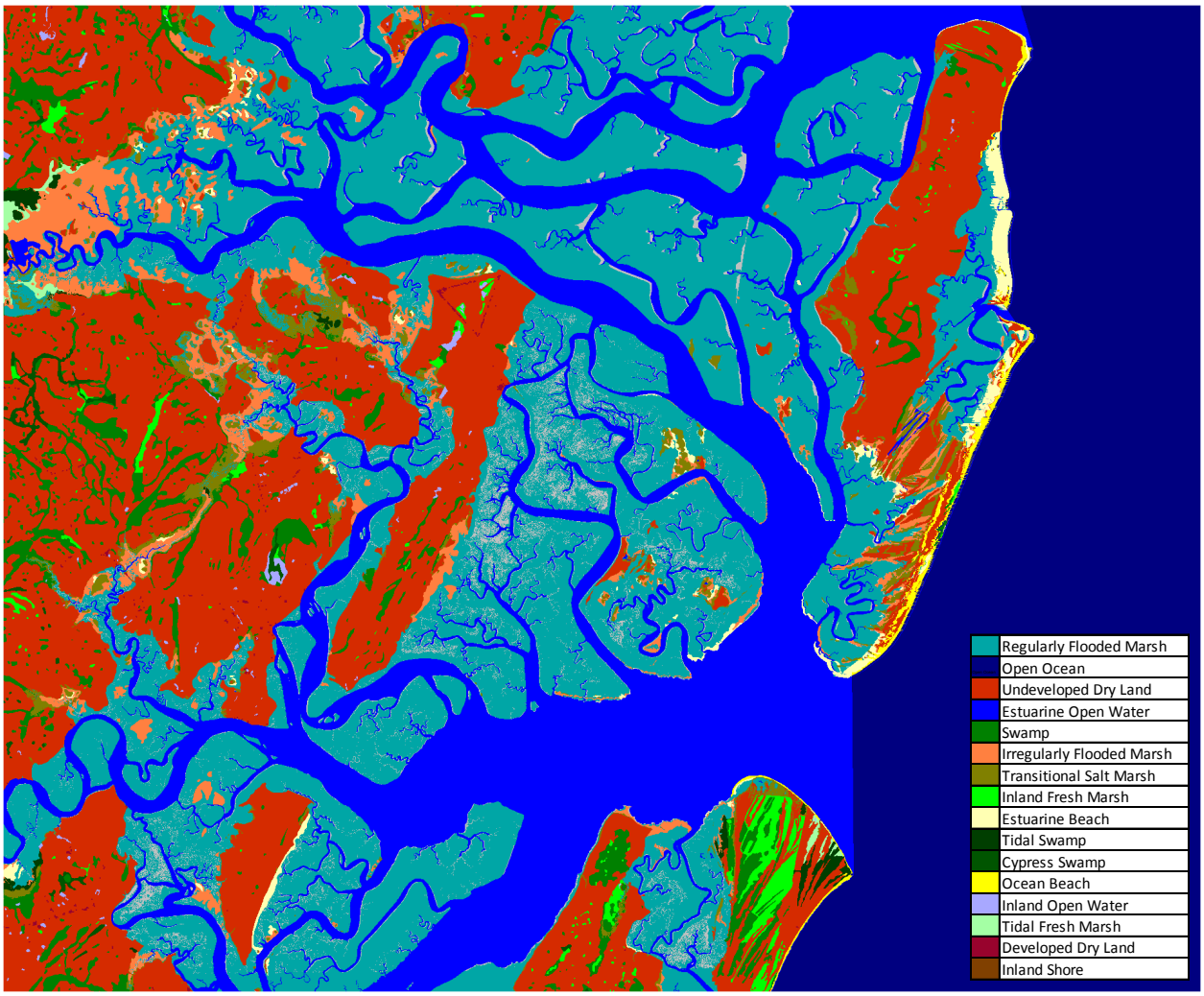
Harris Neck NWR, Initial Condition



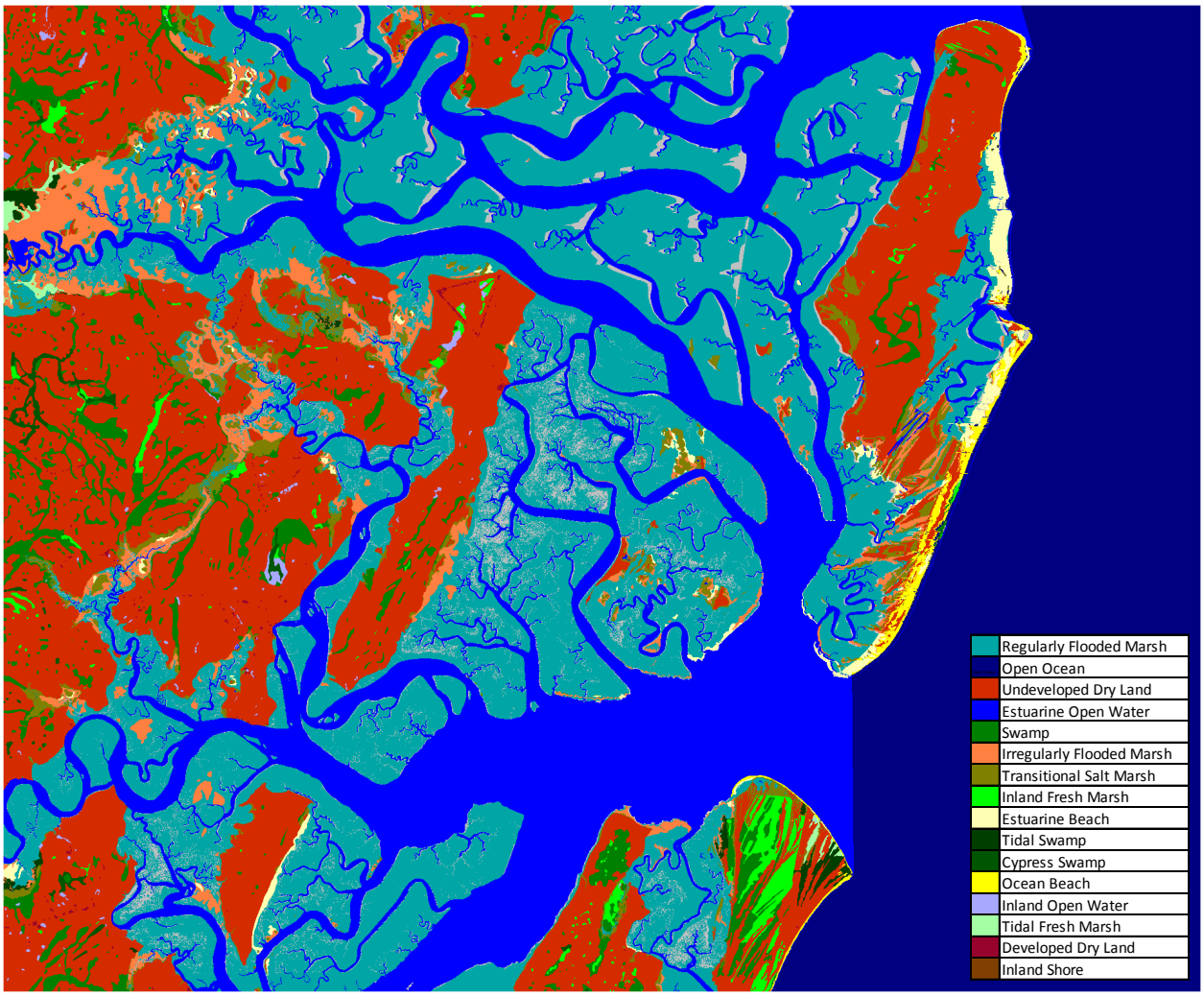
Harris Neck NWR, 2025, Scenario A1B Mean, 0.39 m SLR



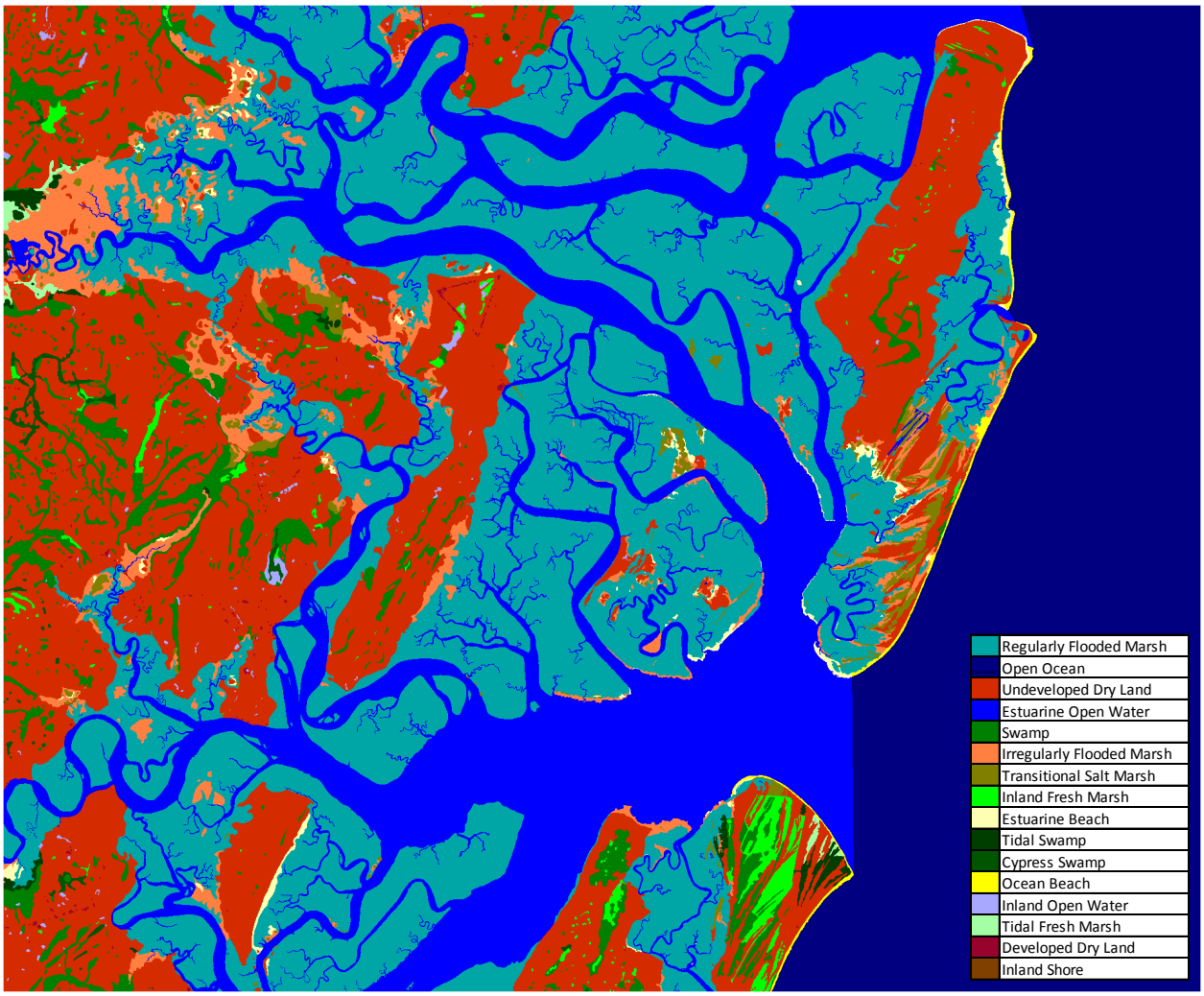
Harris Neck NWR, 2050, Scenario A1B Mean, 0.39 m SLR



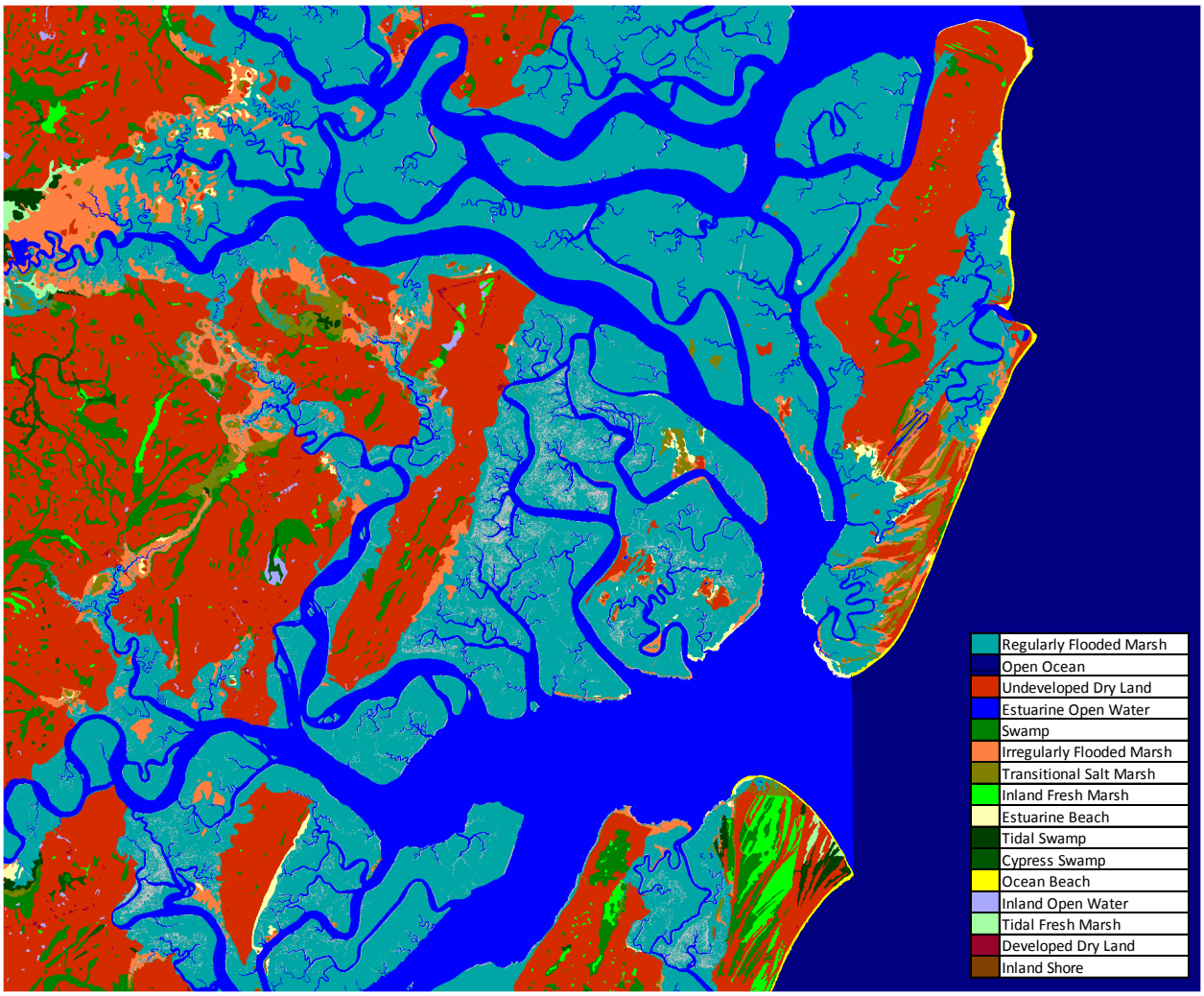
Harris Neck NWR, 2075, Scenario A1B Mean, 0.39 m SLR



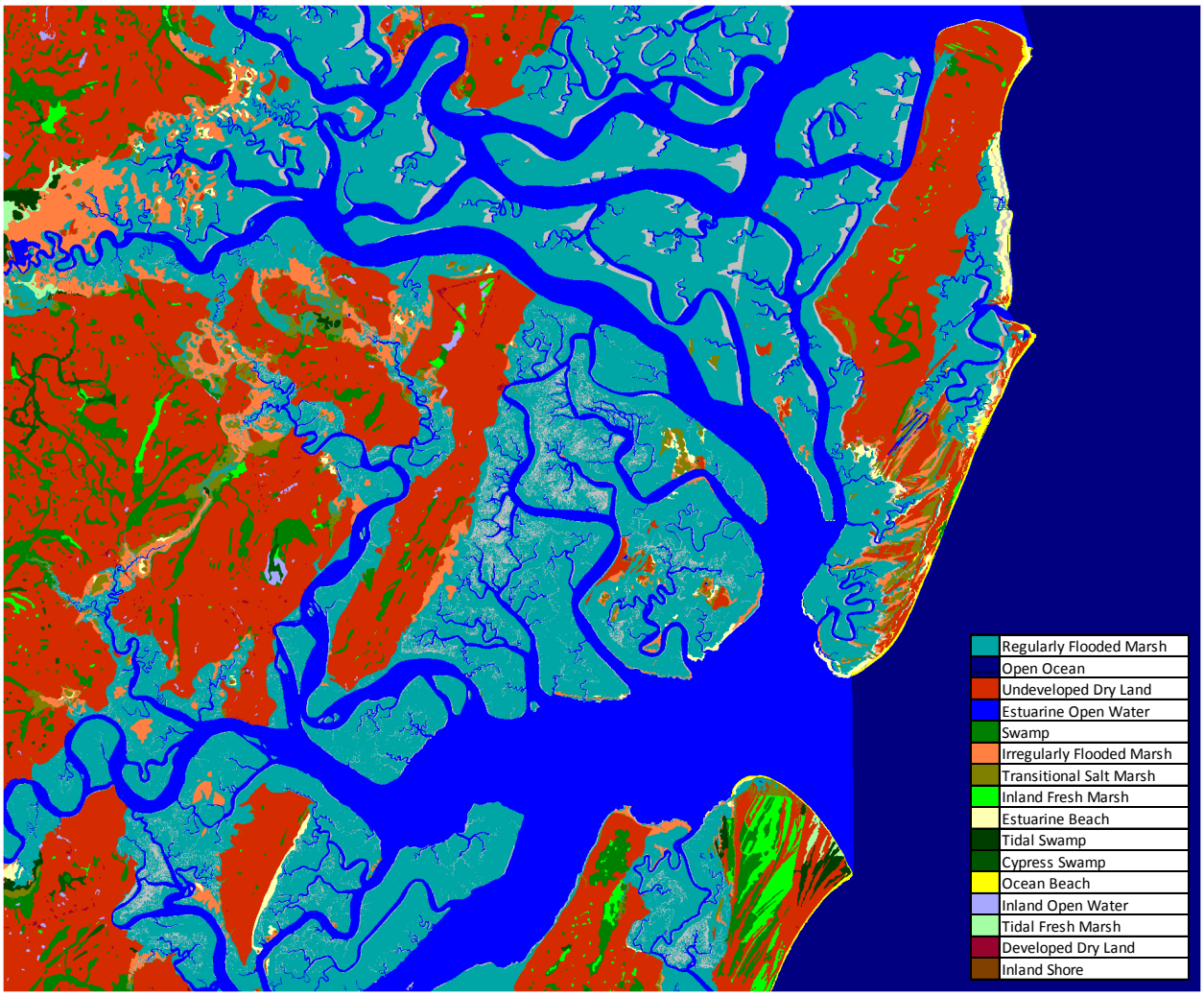
Harris Neck NWR, 2100, Scenario A1B Mean, 0.39 m SLR



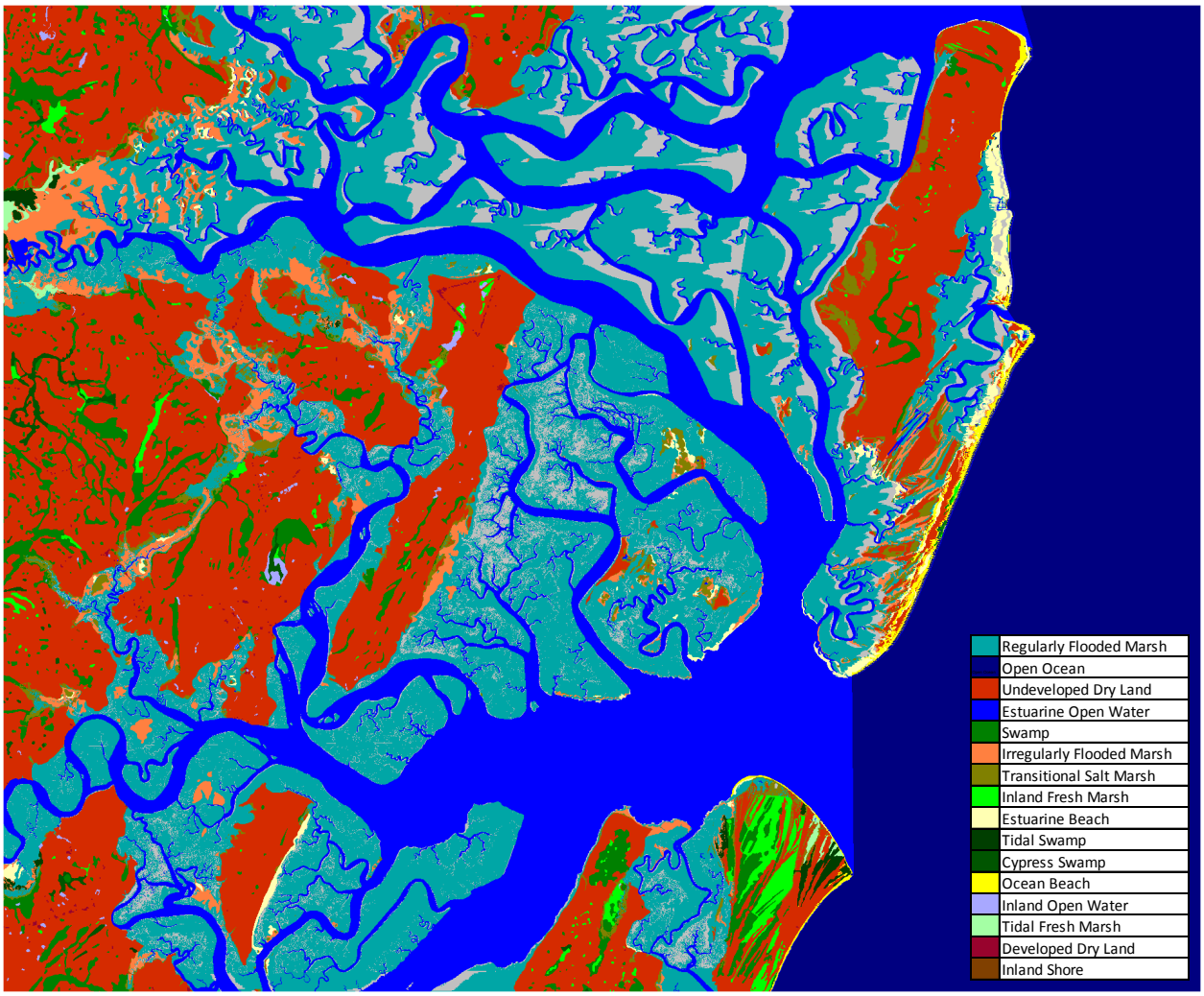
Harris Neck NWR, Initial Condition



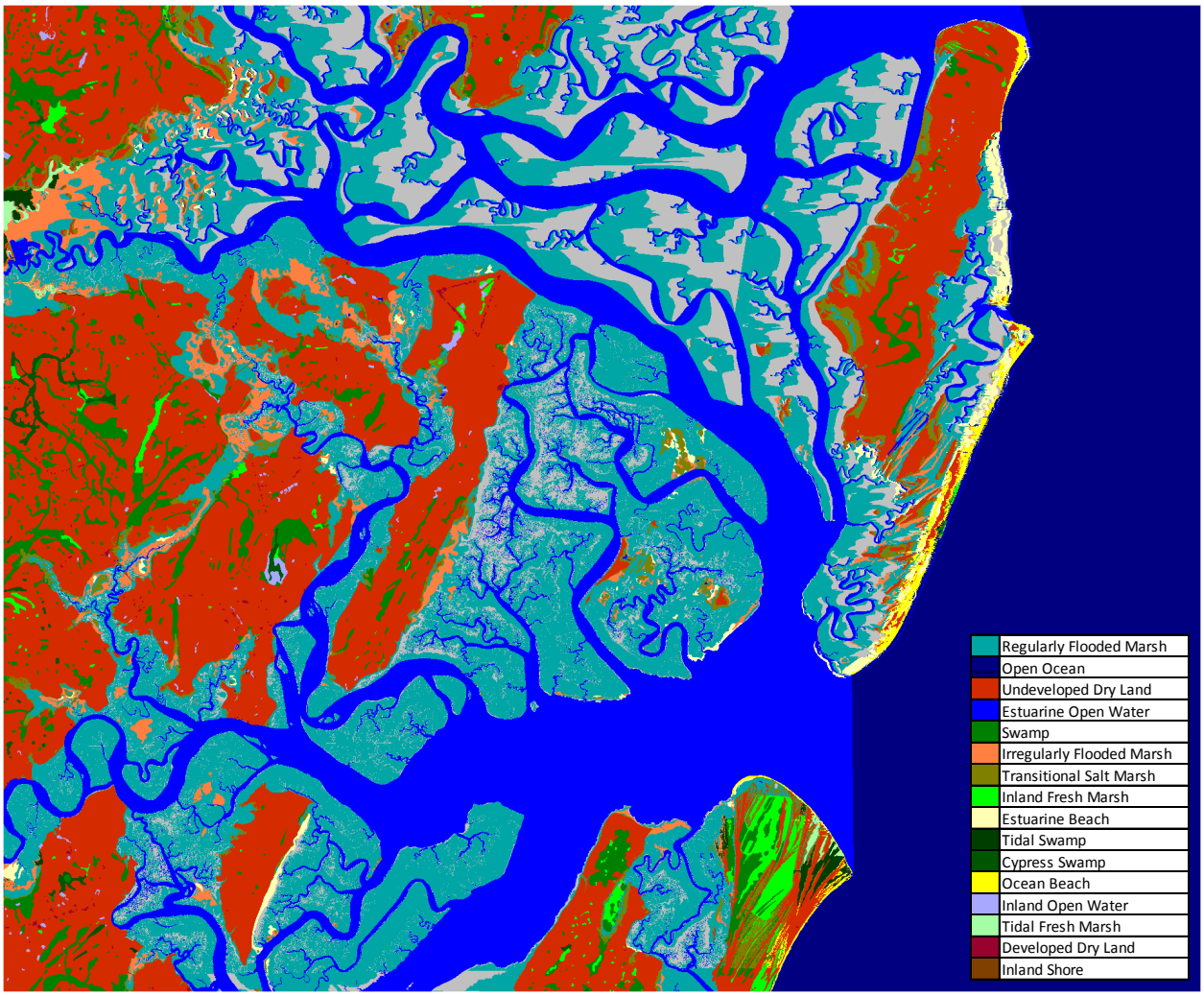
Harris Neck NWR, 2025, Scenario A1B Maximum, 0.69 m SLR



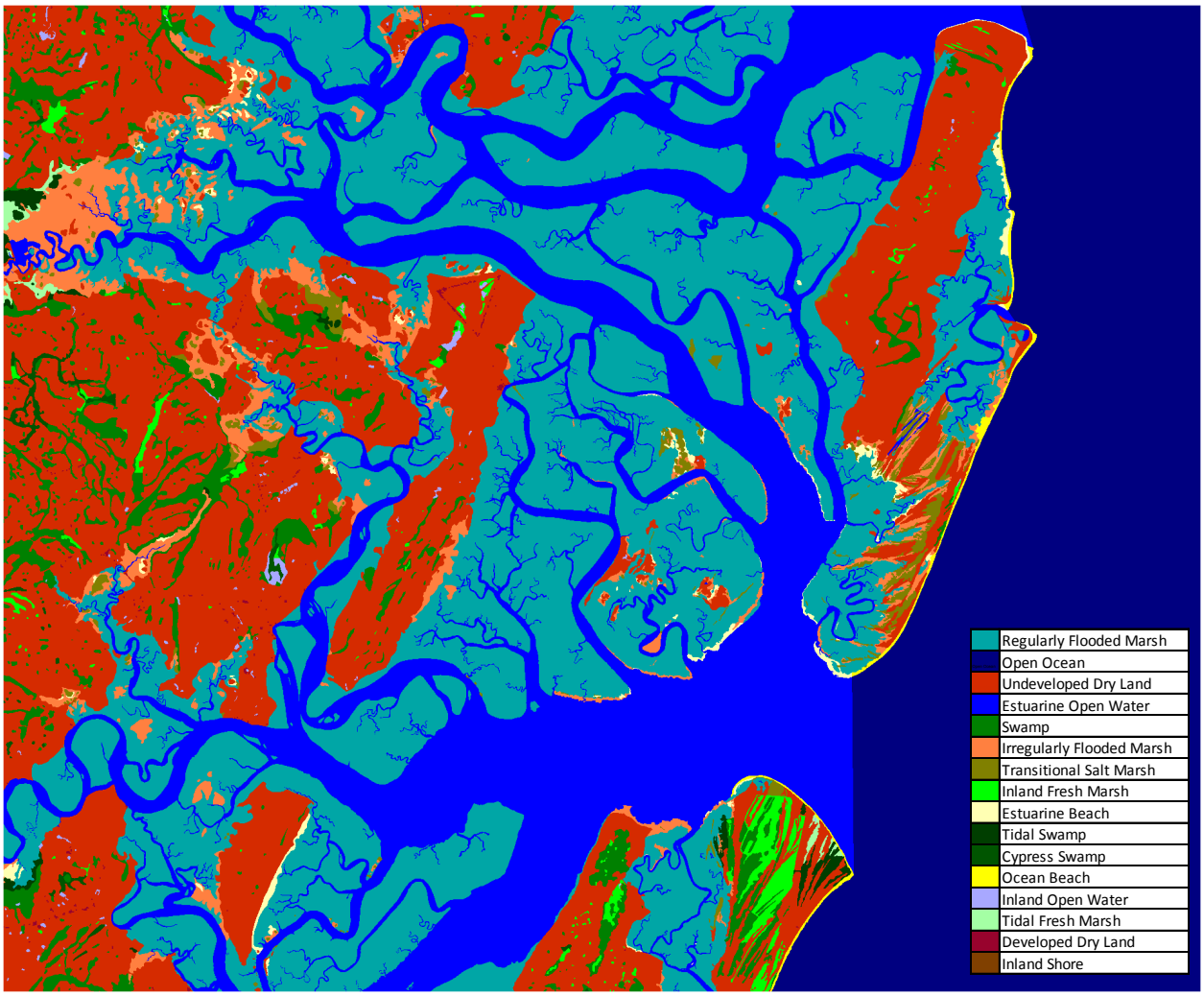
Harris Neck NWR, 2050, Scenario A1B Maximum, 0.69 m SLR



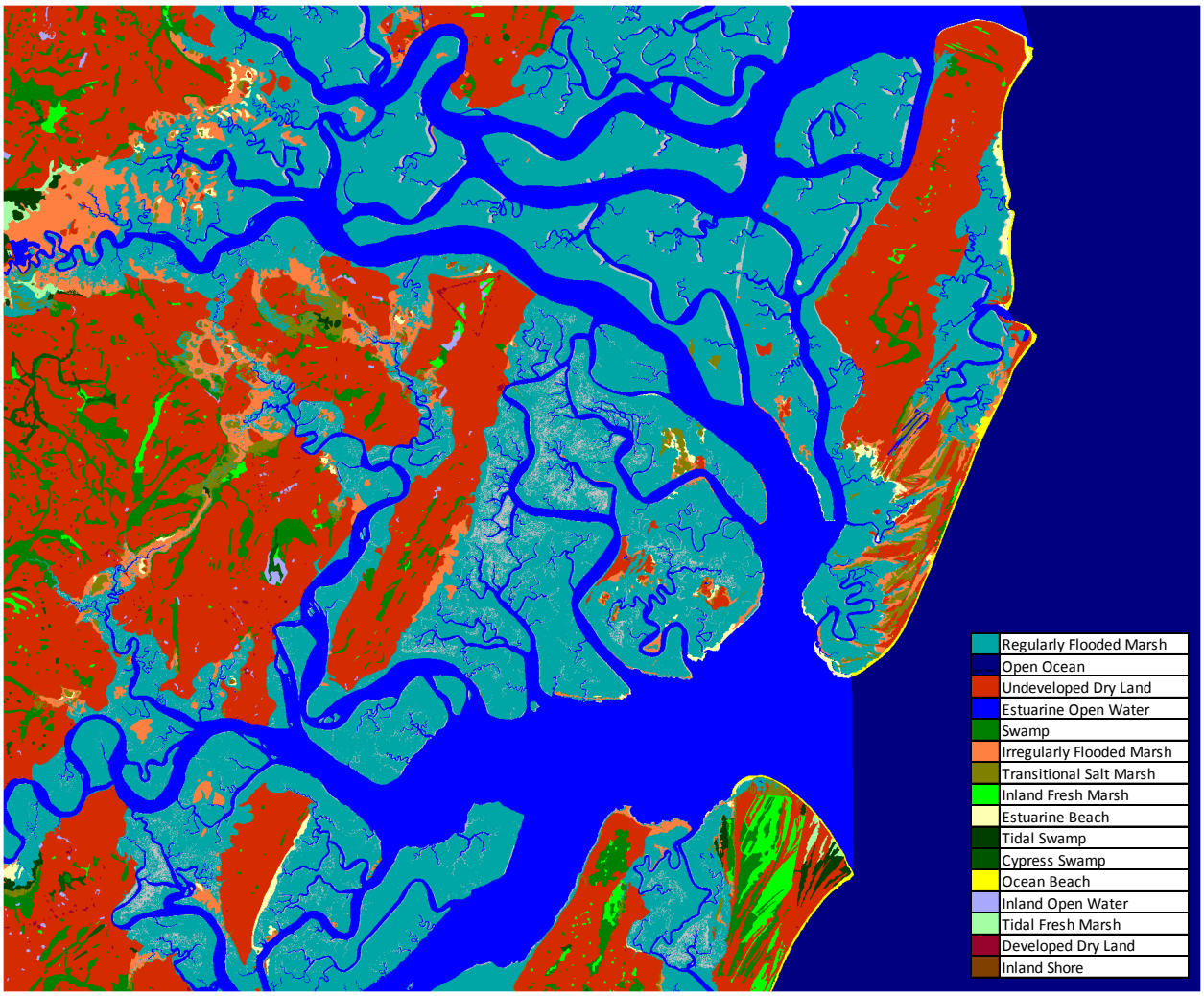
Harris Neck NWR, 2075, Scenario A1B Maximum, 0.69 m SLR



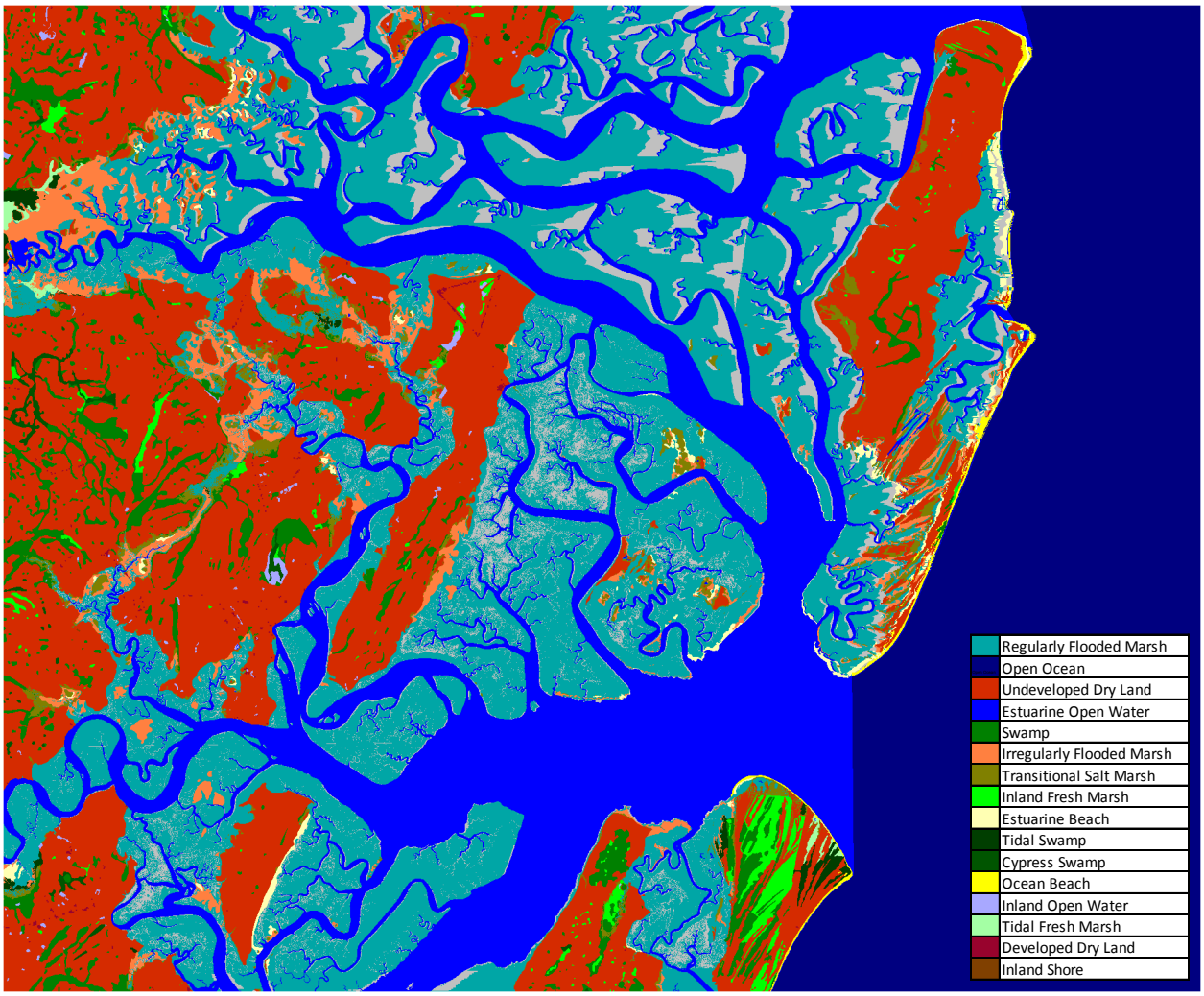
Harris Neck NWR, 2100, Scenario A1B Maximum, 0.69 m SLR



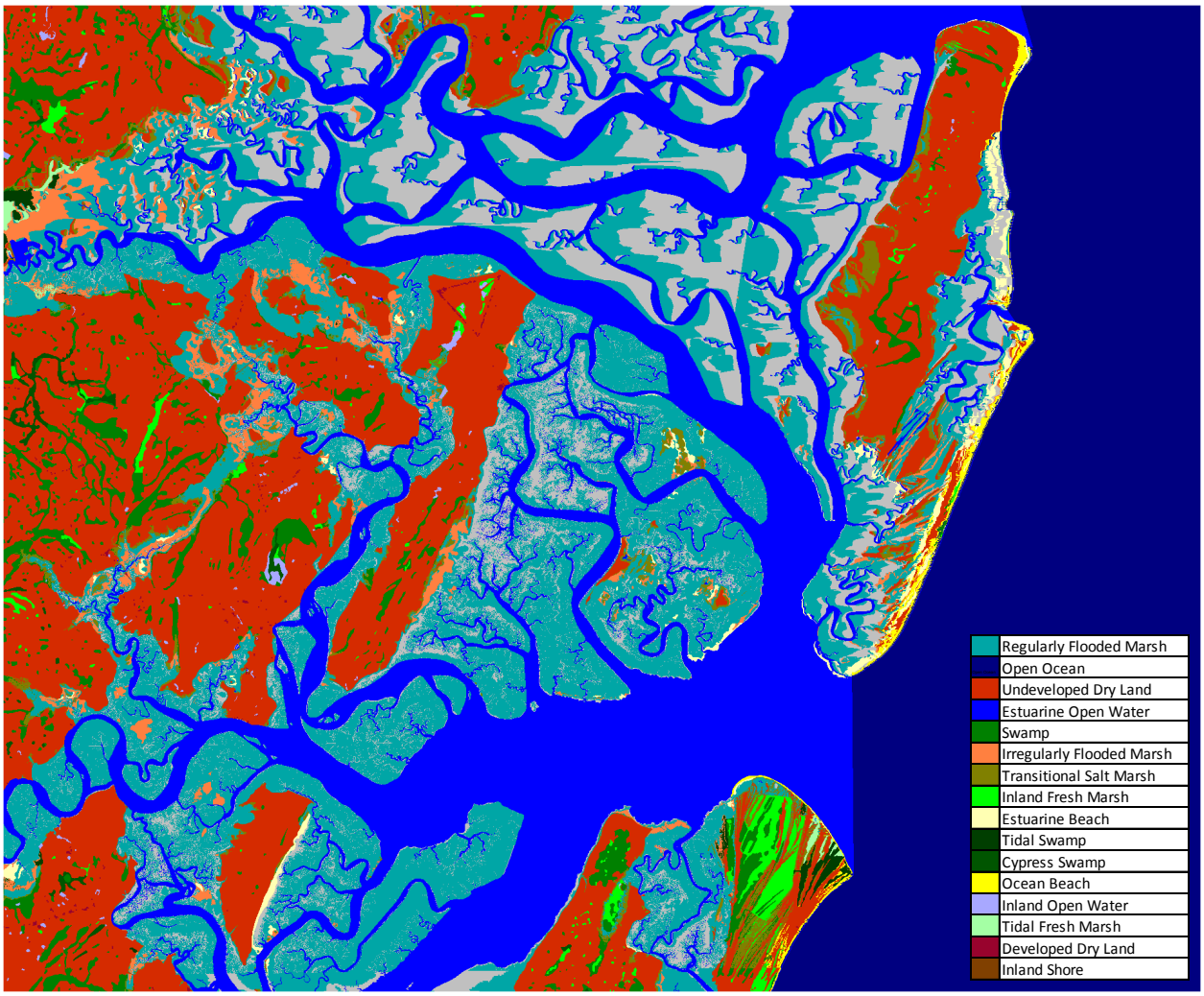
Harris Neck NWR, Initial Condition



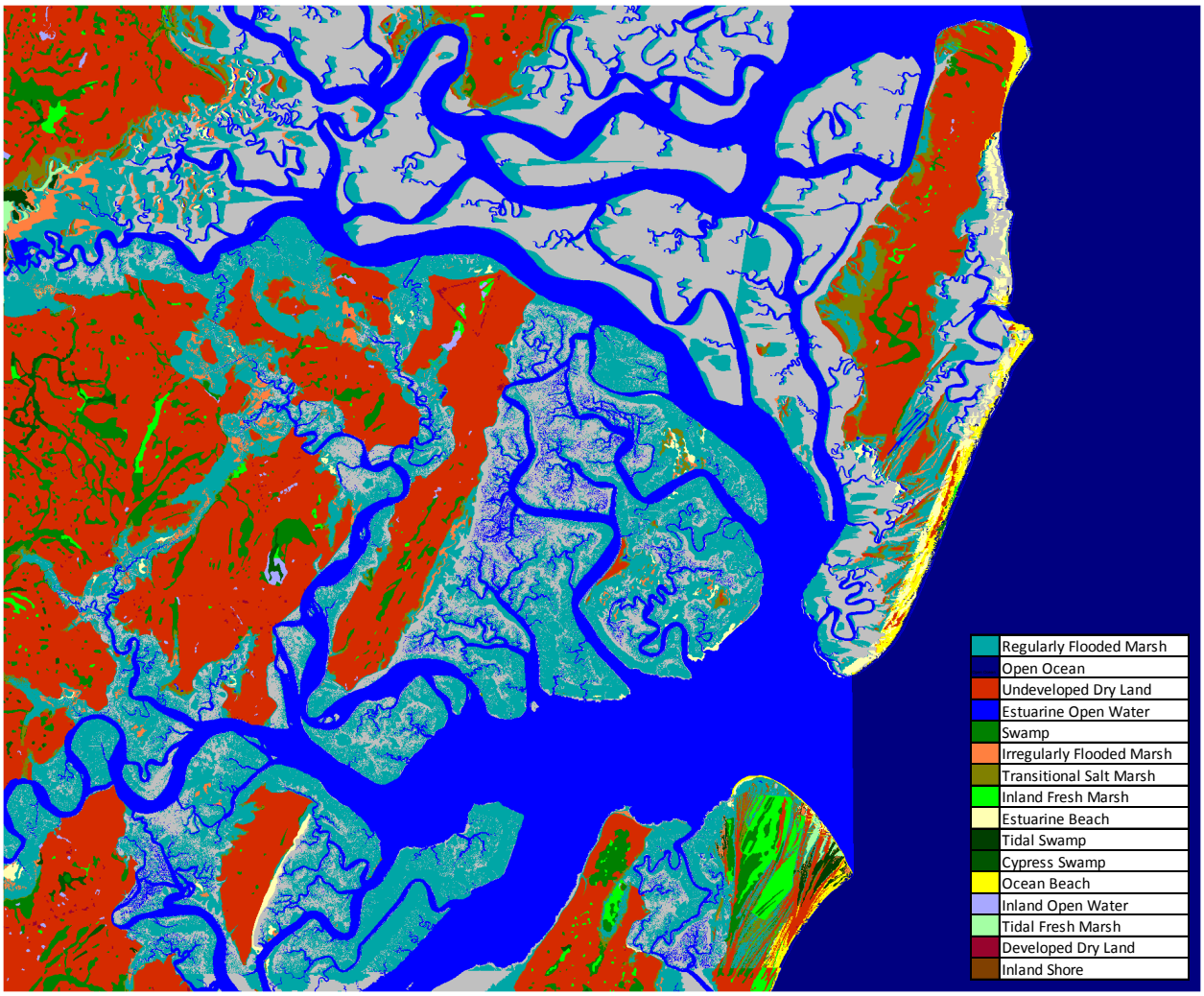
Harris Neck NWR, 2025, 1 m SLR



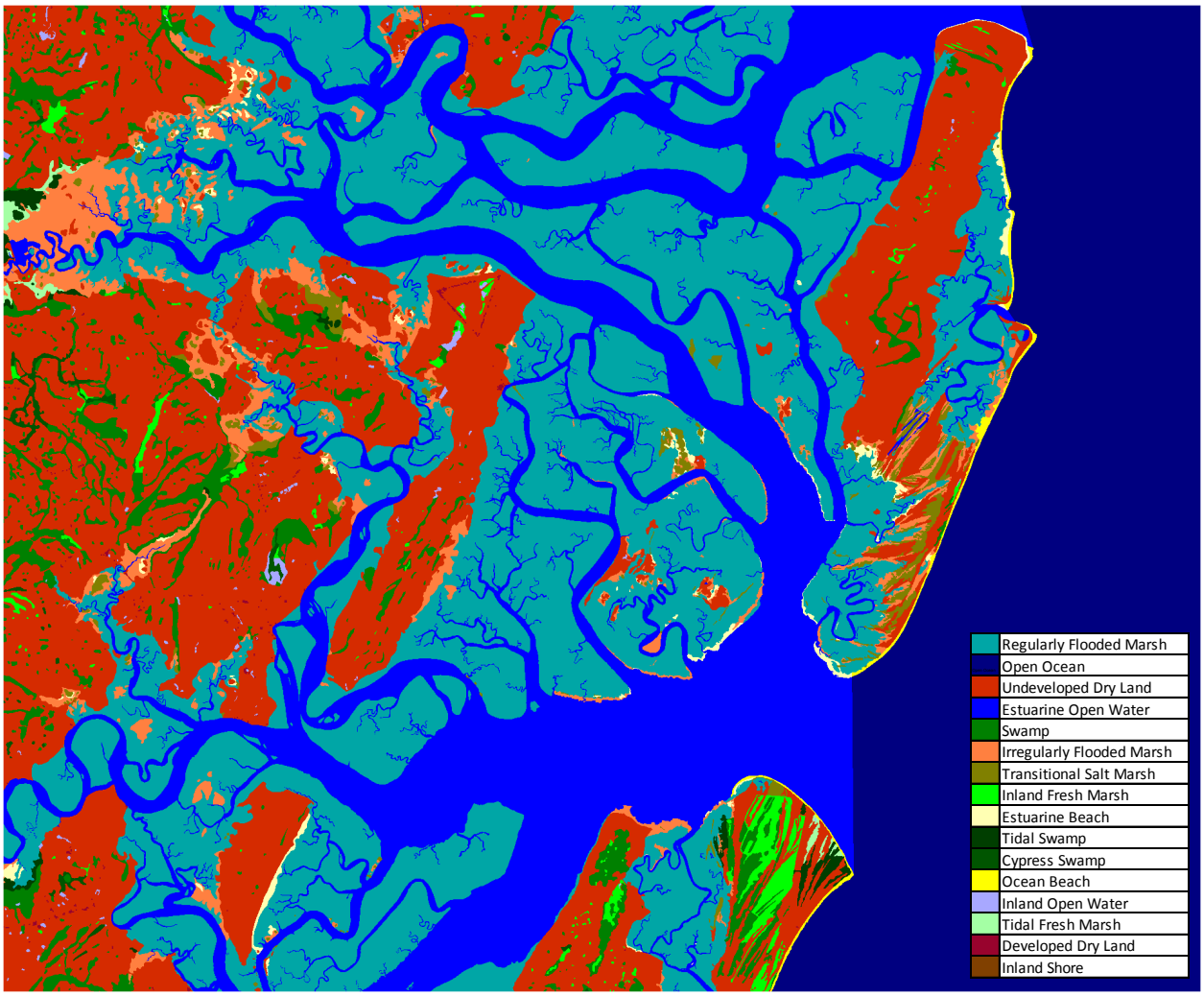
Harris Neck NWR, 2050, 1 m SLR



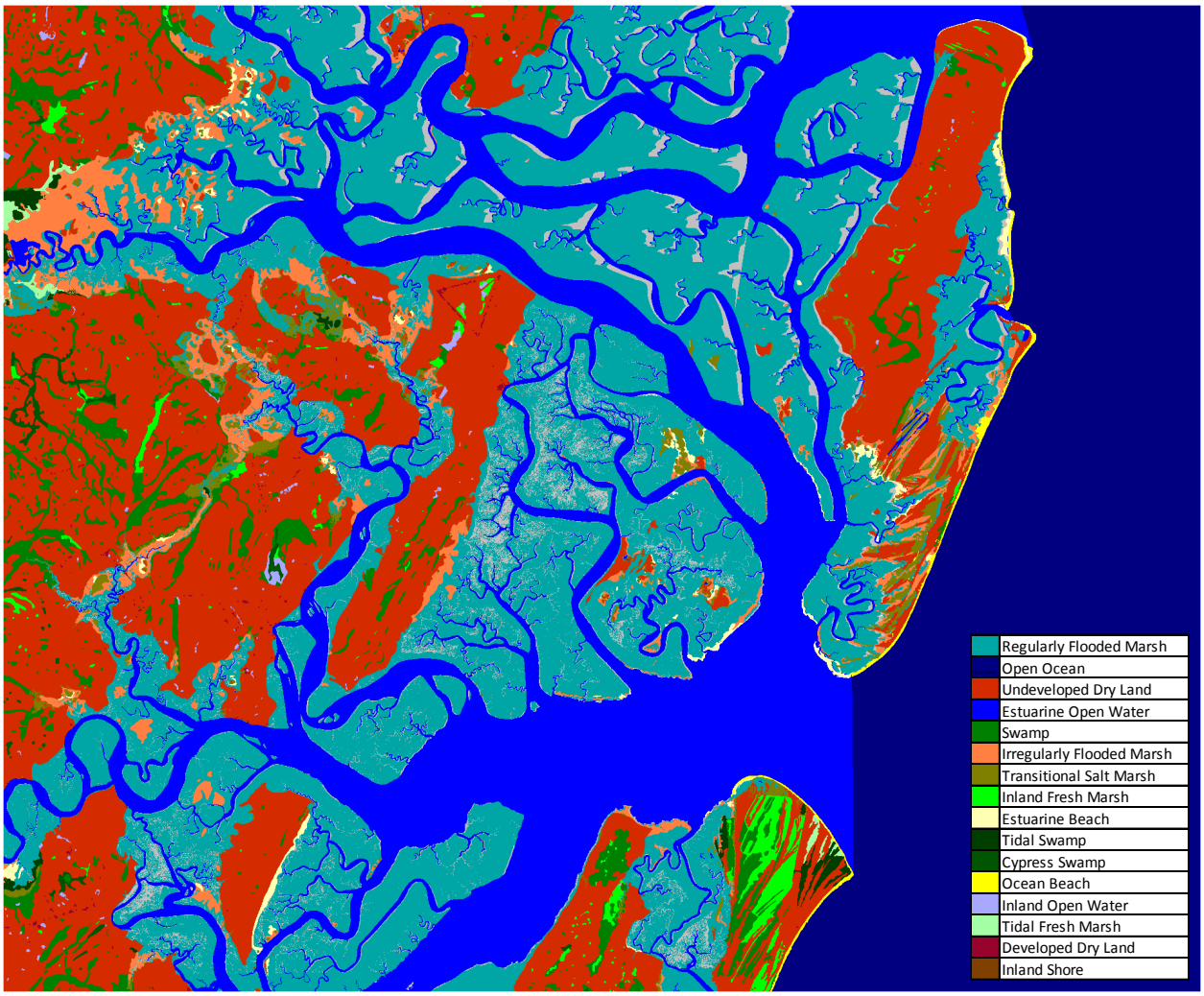
Harris Neck NWR, 2075, 1 meter



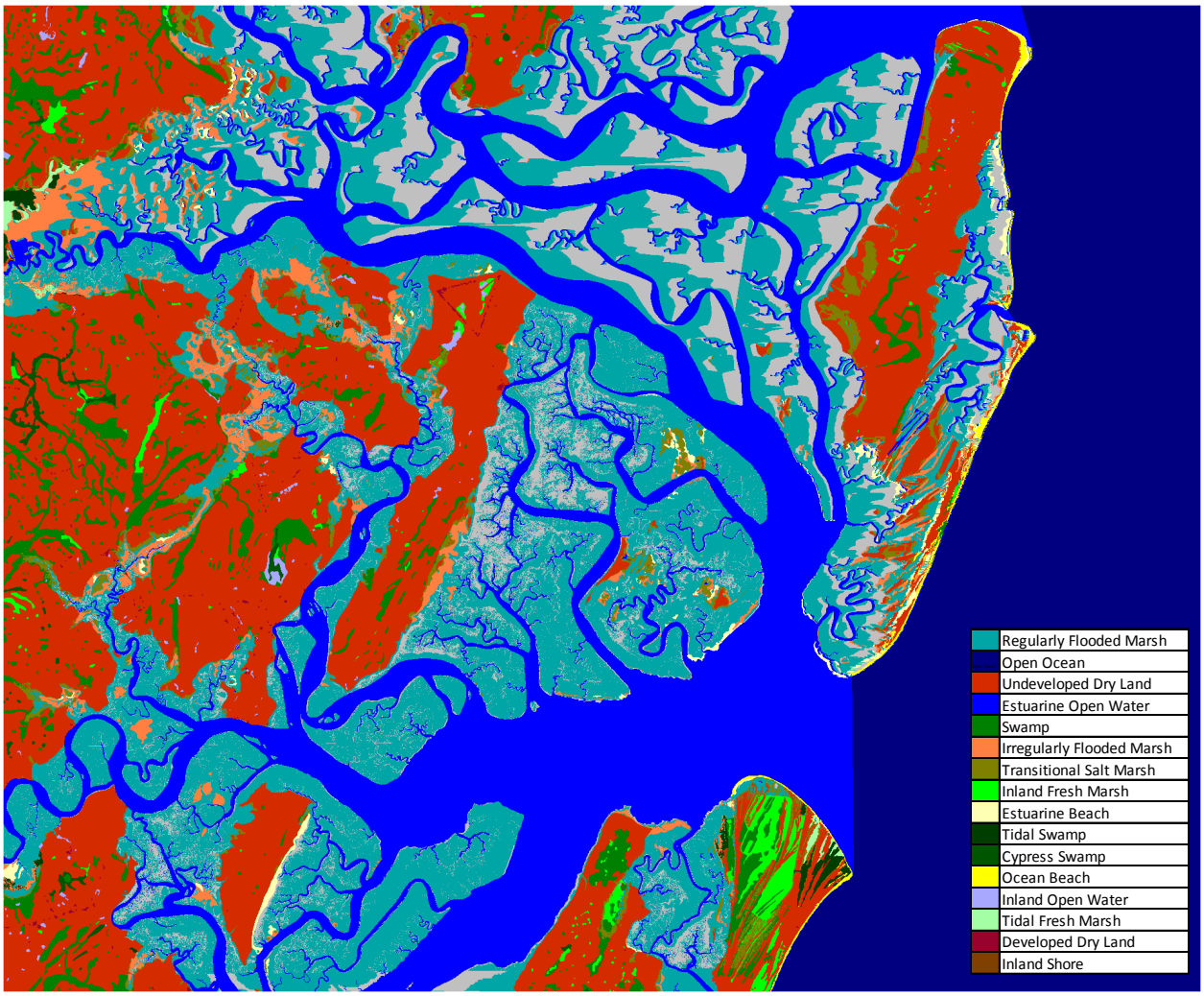
Harris Neck NWR, 2100, 1 m SLR



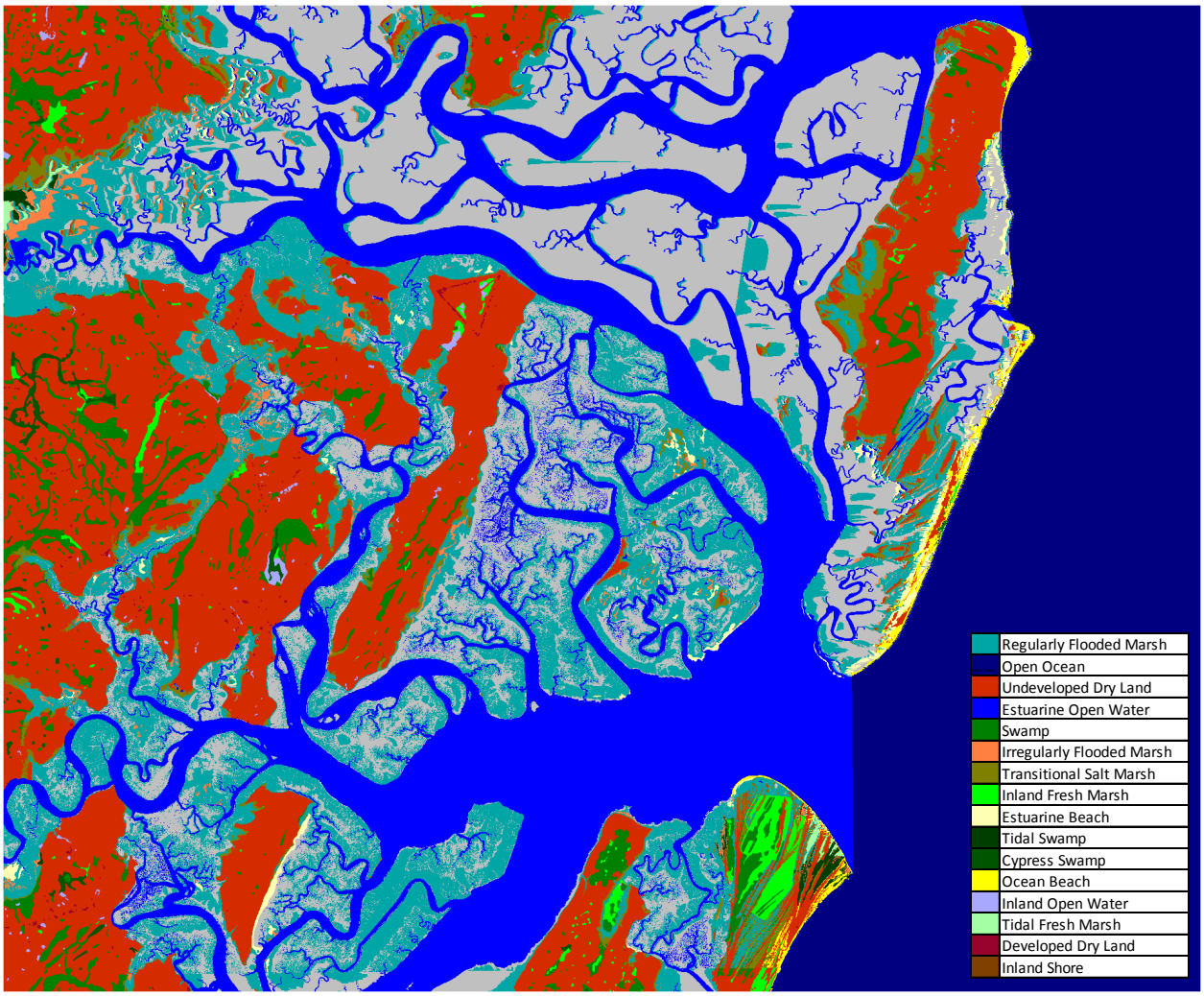
Harris Neck NWR, Initial Condition



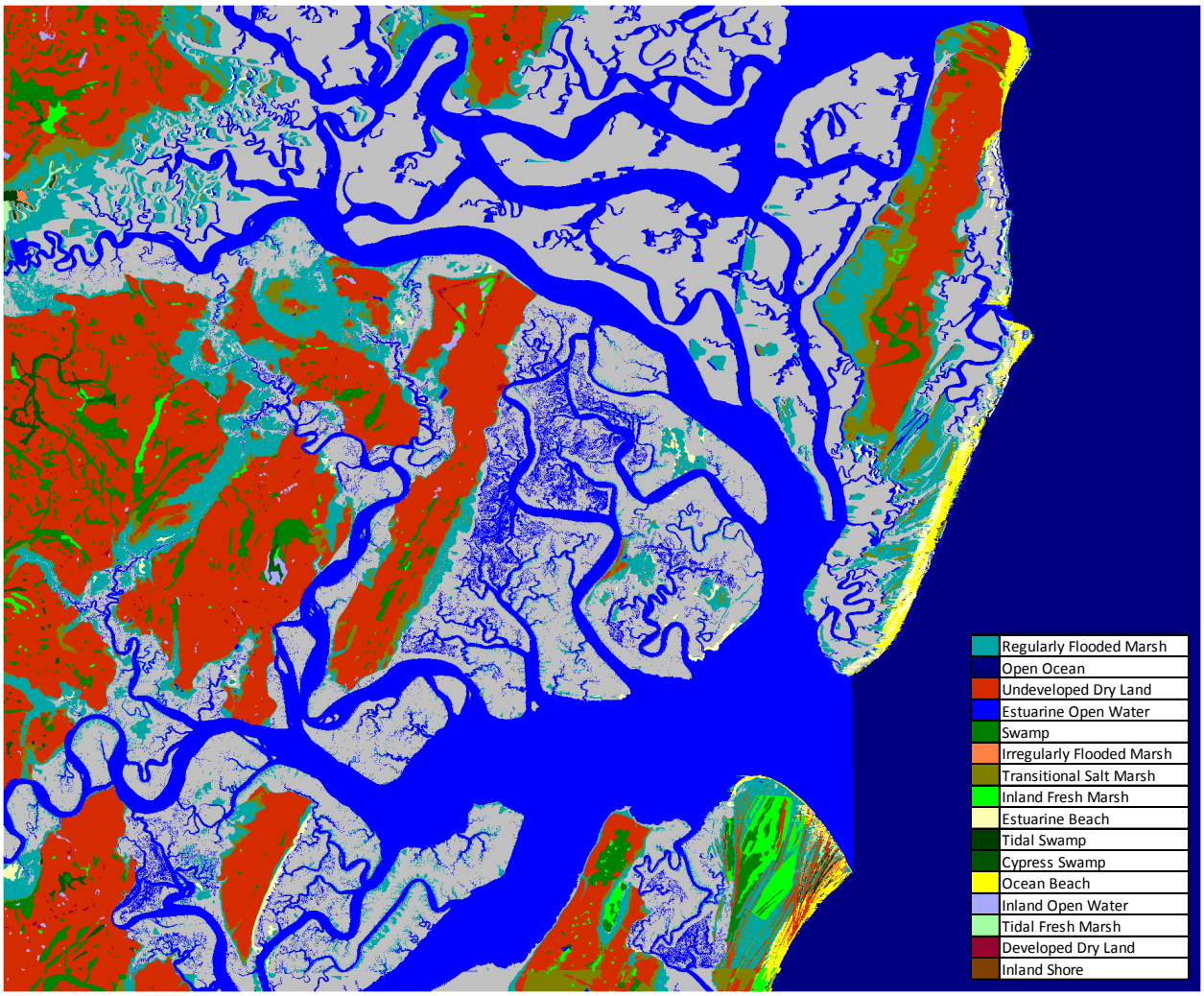
Harris Neck NWR, 2025, 1.5 m SLR



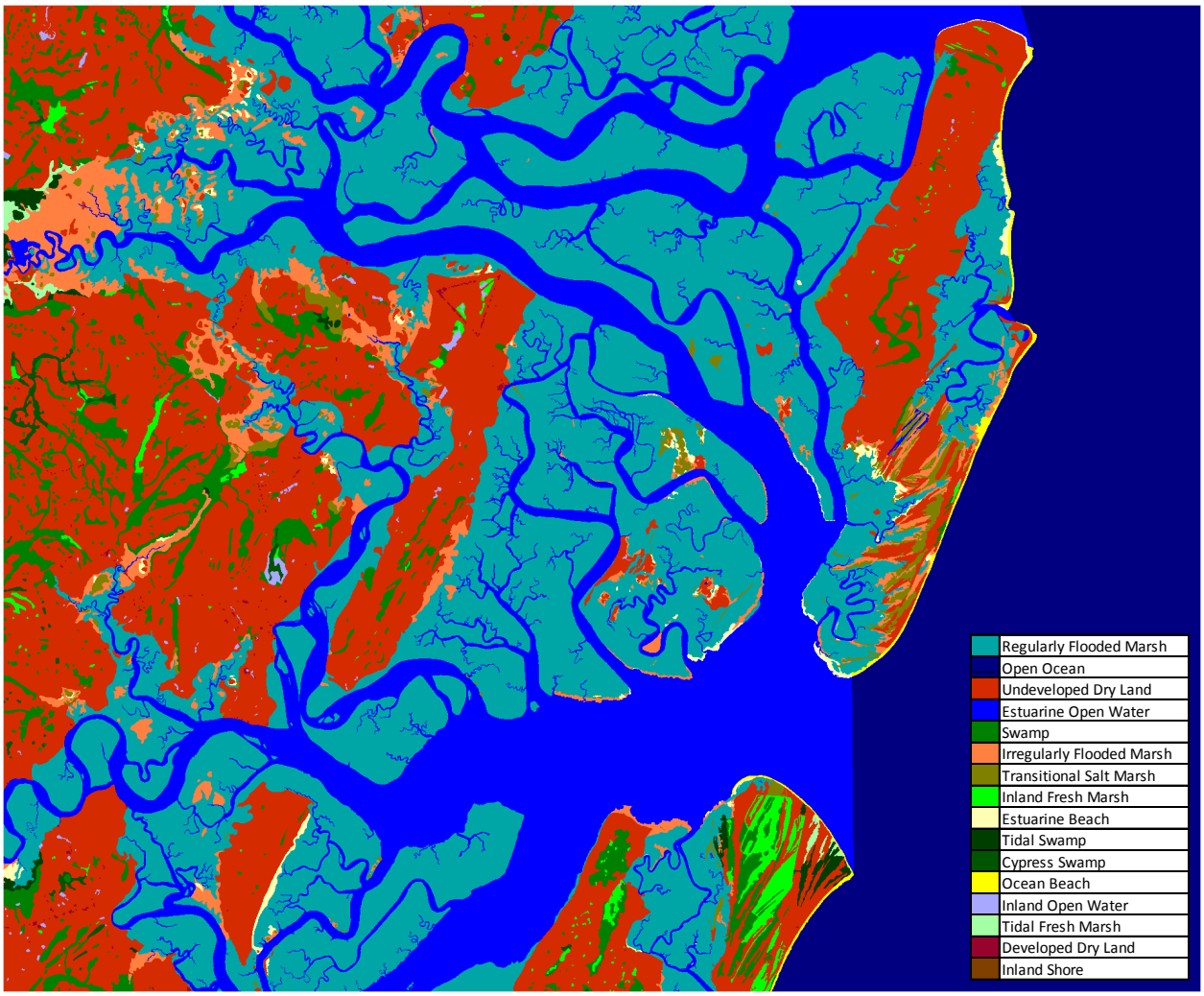
Harris Neck NWR, 2050, 1.5 m SLR



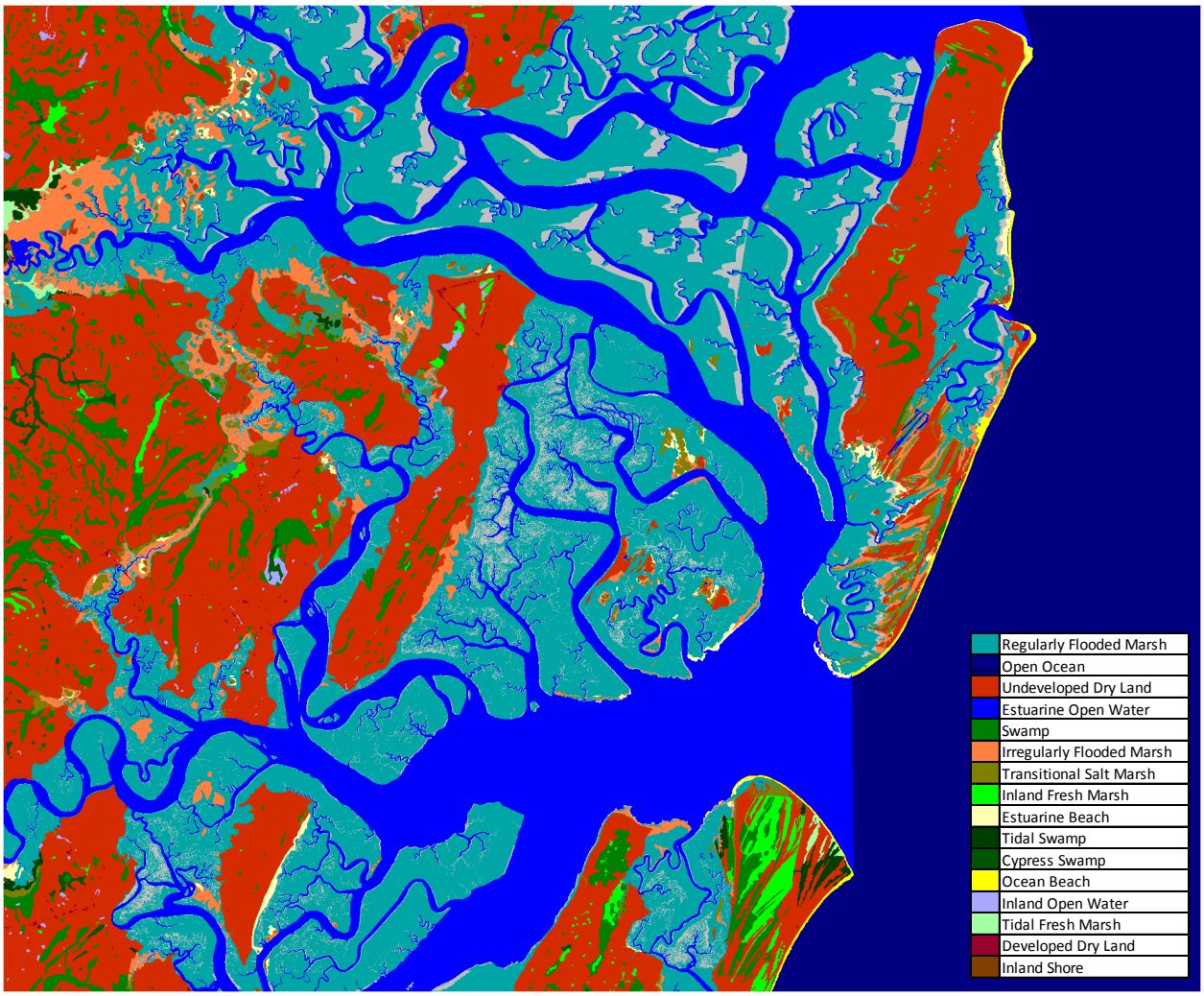
Harris Neck NWR, 2075, 1.5 m SLR



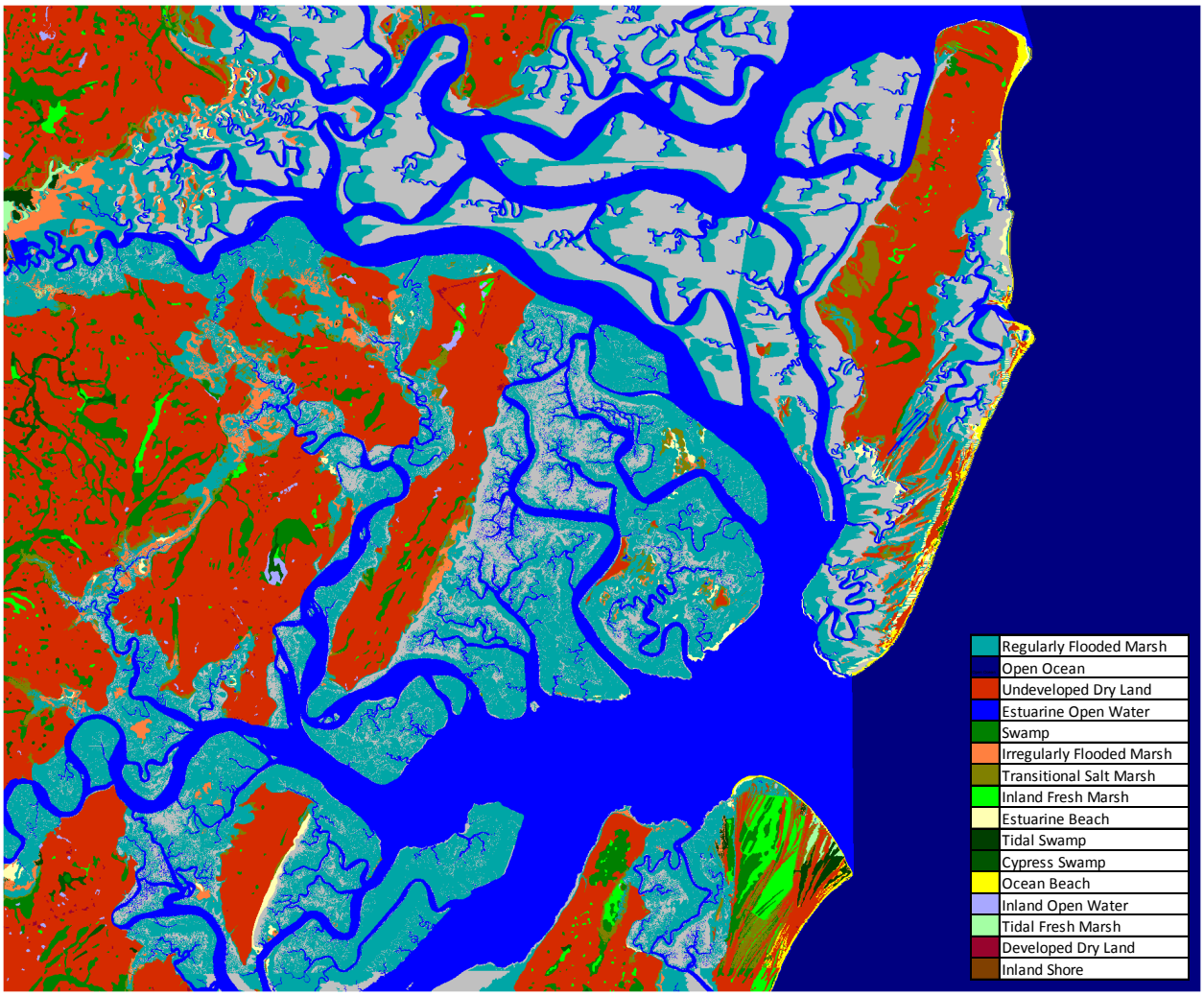
Harris Neck NWR, 2100, 1.5 m SLR



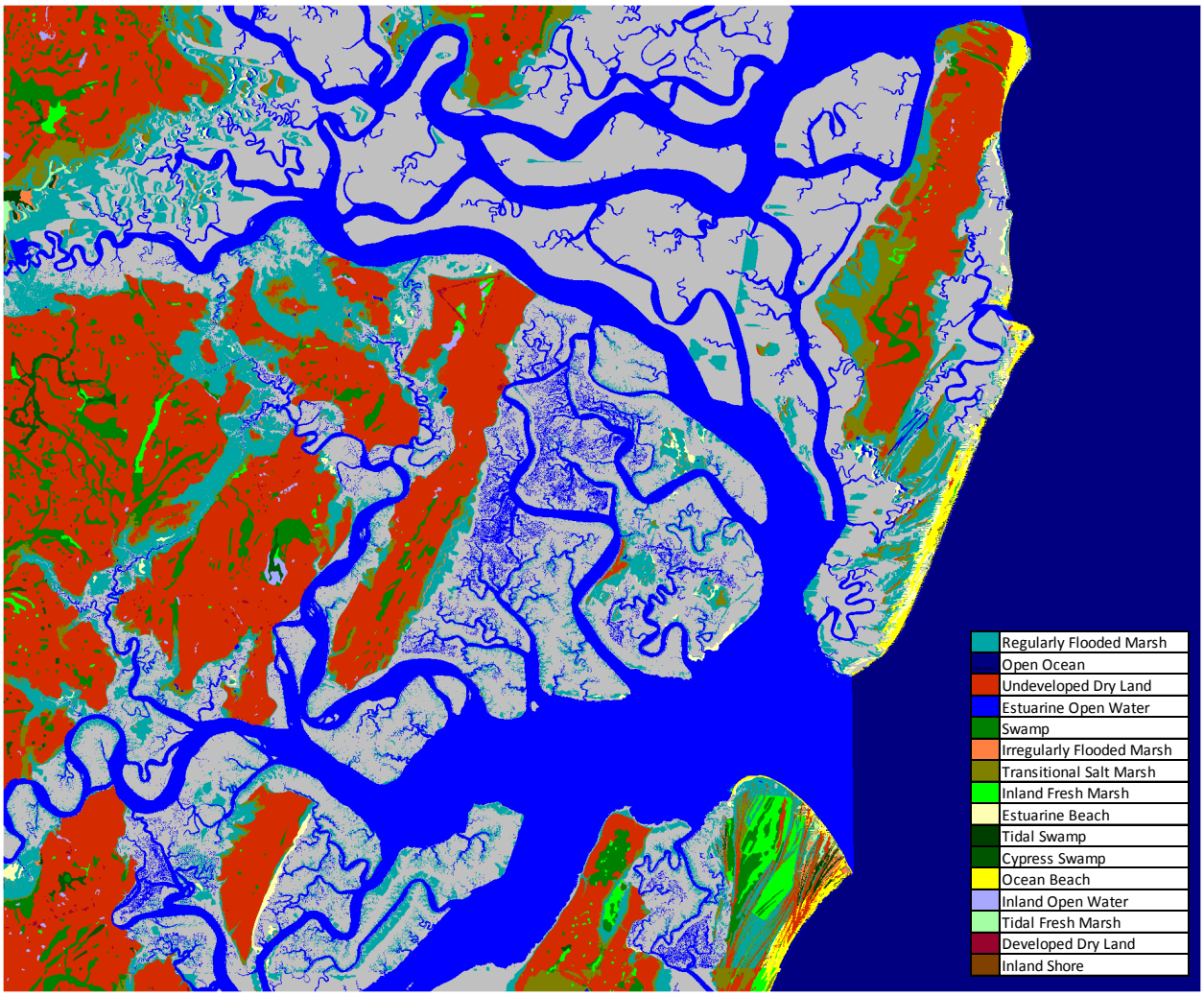
Harris Neck NWR, Initial Condition



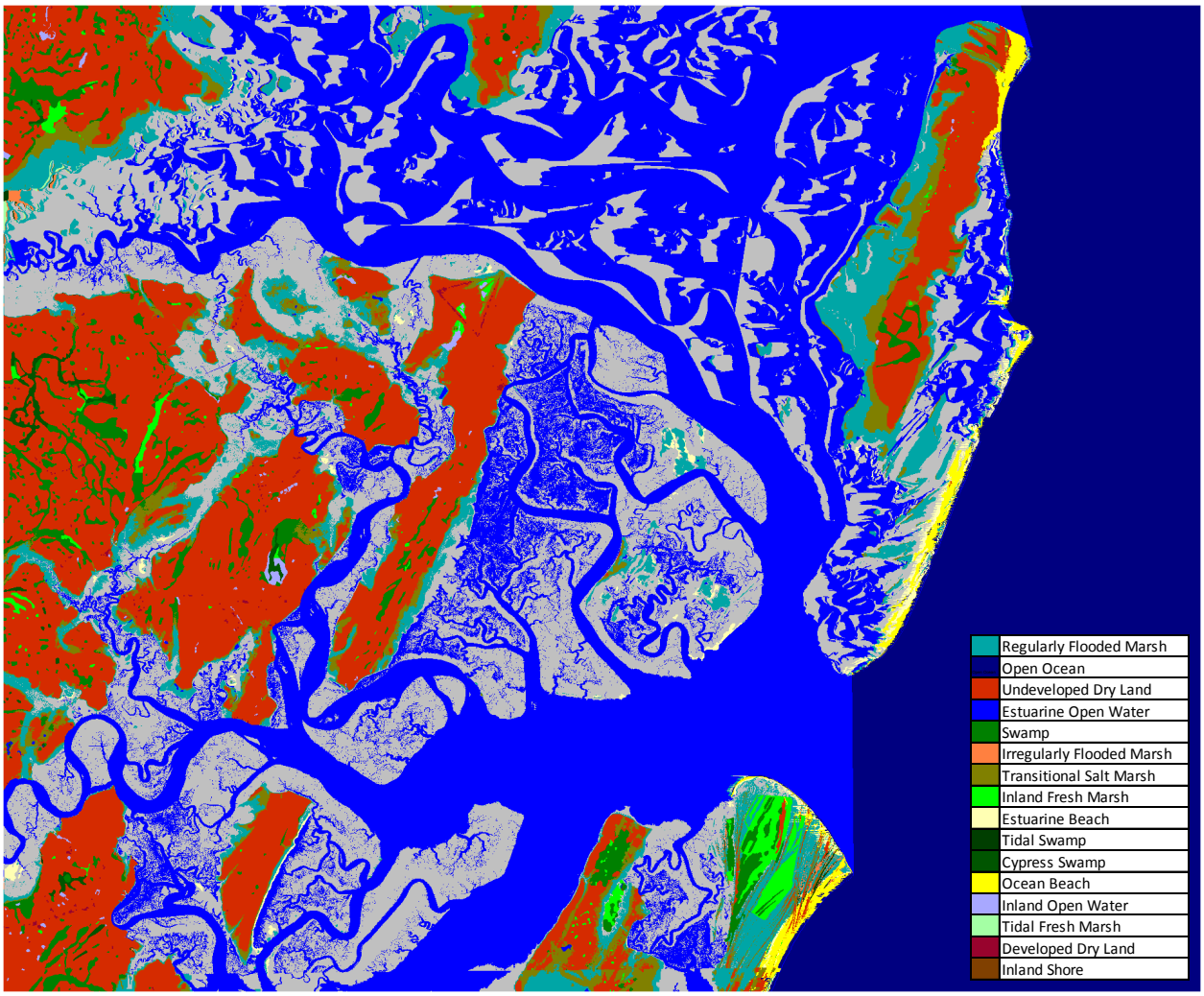
Harris Neck NWR, 2025, 2 m SLR



Harris Neck NWR, 2050, 2 m SLR



Harris Neck NWR, 2075, 2 m SLR



Harris Neck NWR, 2100, 2 m SLR