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

U. S. Fish and Wildlife Service
National Wildlife Refuge System
Division of Natural Resources and Conservation Planning
Conservation Biology Program
4401 N. Fairfax Drive - MS 670
Arlington, VA 22203

August 16, 2011

warren pinnacle consulting, inc.
PO Box 315, Waitsfield VT, 05673
(802)-496-3476

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Information for this project was provided by the Sea-Level Rise and Conservation Project of The Nature Conservancy who also provided GIS processing in support of these analyses. Funding for this project of The Nature Conservancy was provided through a grant from the Gulf of Mexico Foundation, Inc., to support the Gulf of Mexico Alliance.

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 (R. A. 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 2 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. As noted above, this analysis is a summary of model runs produced by The Nature Conservancy through grant from the Gulf of Mexico Foundation, Inc., to support the Gulf of Mexico Alliance (Clough et al. 2011).

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). The first phase of this work was completed using SLAMM 5, while the second phase simulations were run with SLAMM 6.

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 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 or 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. This feedback is used in USFWS simulations where adequate data exist 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 (CREM, 2008). Site-specific factors that increase or decrease model uncertainty may be covered in the *Discussion* section of this report.

Sea Level Rise Scenarios

Forecast simulations used scenario A1B from the Special Report on Emissions Scenarios (SRES) – mean and maximum estimates. 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. In particular, the A1B scenario assumes that energy sources will be balanced across all sources. Under the A1B scenario, the IPCC WGI Fourth Assessment Report (IPCC 2007) suggests a likely range of 0.21 to 0.48 m of sea level rise by 2090-2099 "excluding future rapid dynamical changes in ice flow." The 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 sea level rise by 2100. A1B-maximum predicts 0.69 m of global SLR by 2100.

The latest literature (Chen et al. 2006; Monaghan et al. 2006) indicates that the eustatic rise in sea levels is progressing more rapidly than was previously assumed, perhaps due to the dynamic changes in ice flow omitted within the IPCC report's calculations. A recent paper in the journal *Science* (Rahmstorf 2007) suggests that, taking into account possible model error, a feasible range by 2100 of 50 to 140 cm. 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 sea level rises 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.

To allow for flexibility when interpreting the results, SLAMM was also run assuming 1 m, 1½ m, and 2 m of eustatic sea-level rise by the year 2100. The A1B- maximum scenario was scaled up to produce these bounding scenarios (Figure 1).

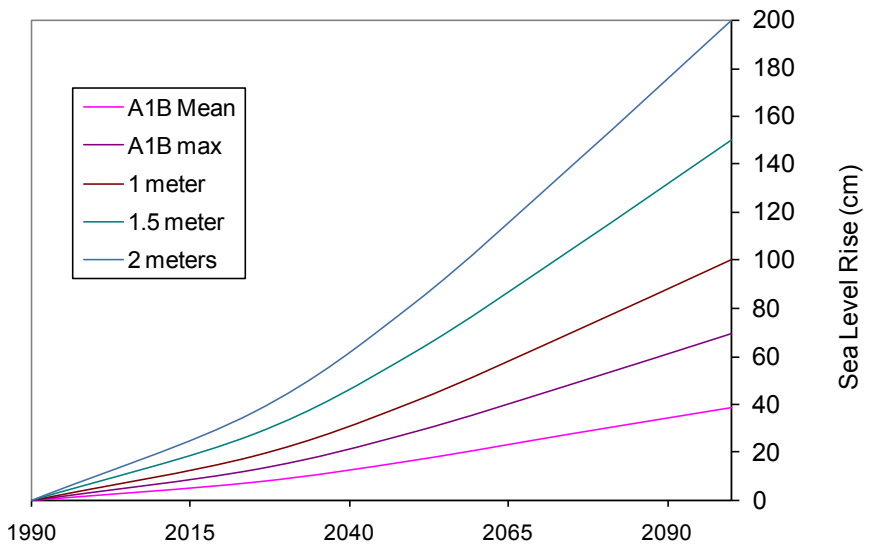


Figure 1: **Summary of SLR scenarios utilized**

Methods and Data Sources

The digital elevation map used in this simulation was derived from Sanborn 2007 and Tropical Storm Allison Recovery Project (TSARP) 2002 LiDAR (received from Harte Research Institute) and 2009 1/9 arc second NED (Figure 2) (Texas Water Development Board 2010).

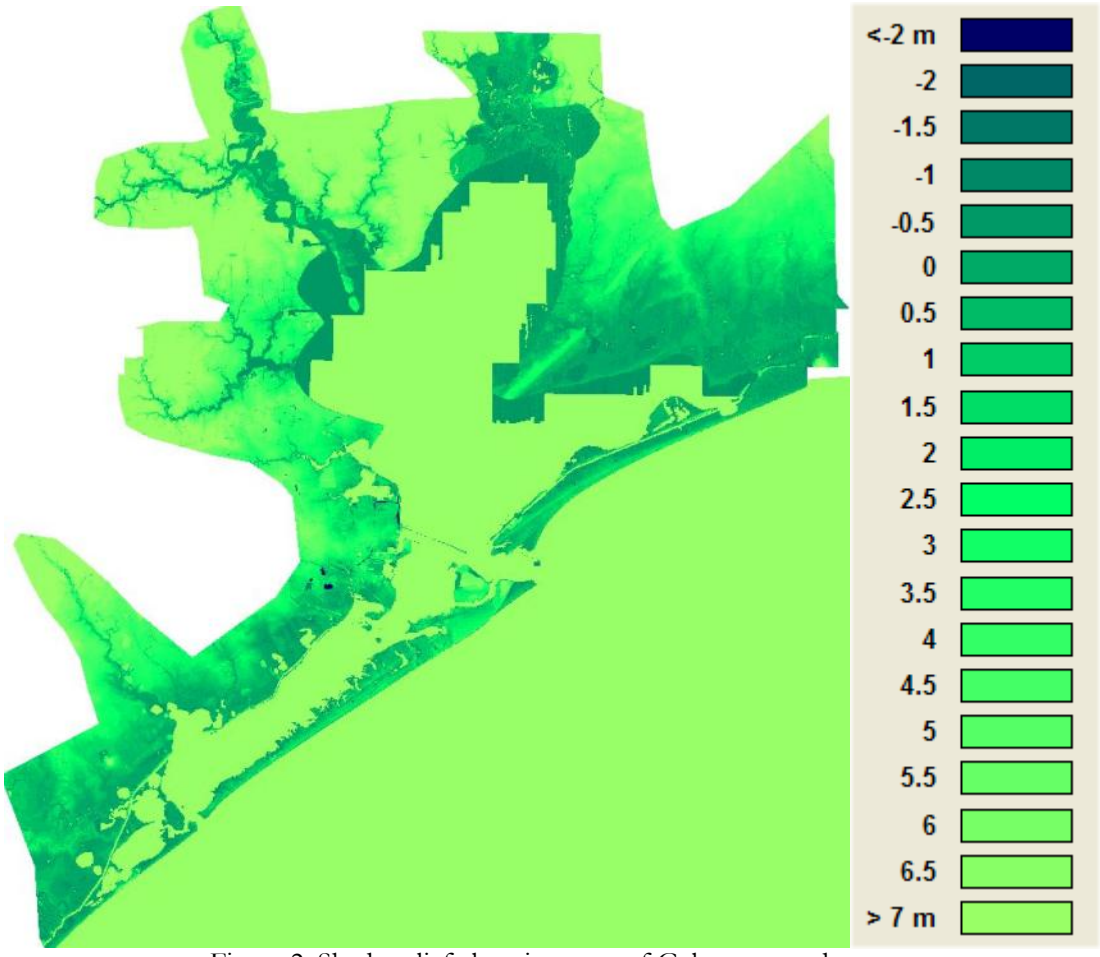


Figure 2. Shade-relief elevation map of Galveston study area

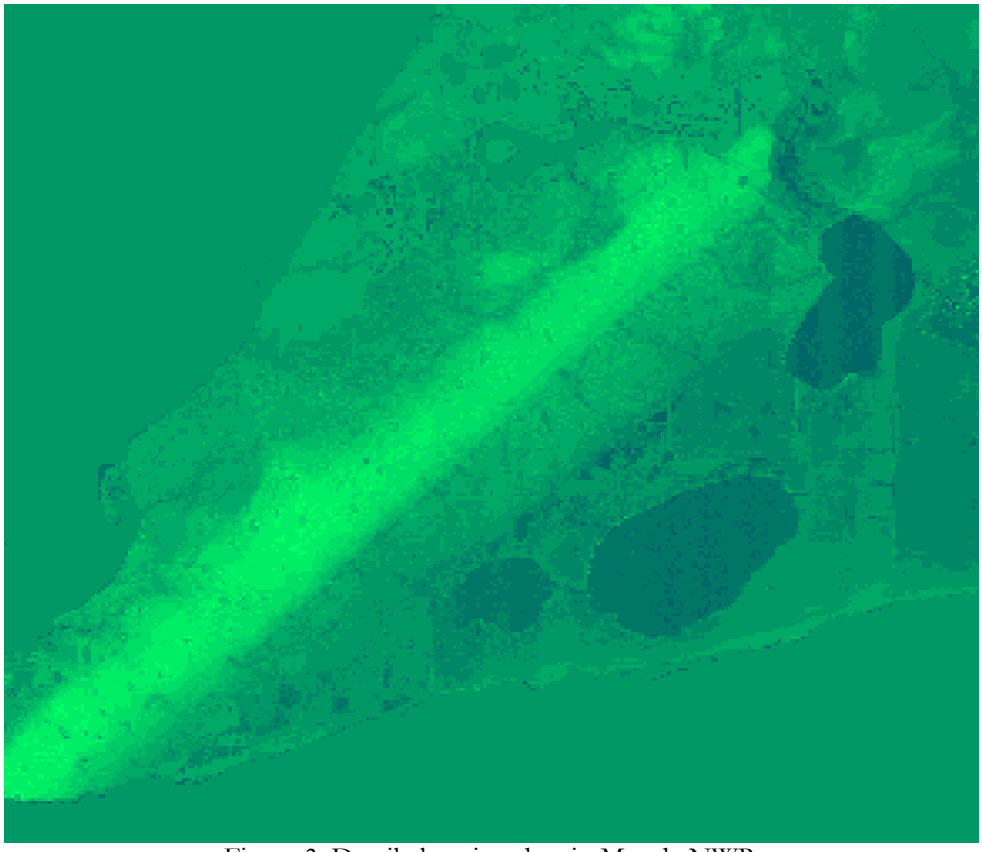


Figure 3. Detail elevation data in Moody NWR

The wetlands layer for the study area was produced in 2009 by the National Wetlands Inventory (Figure 4), but was based on aerial photos taken in August and October of 2004. Therefore, in this report the 2009 NWI layer will be referred to as the 2004 NWI layer. Figure 4 presents the 2004 wetlands data layer.

Converting the NWI survey into 10 m cells indicated that the approximately 11,438 acre refuge (approved acquisition boundary including water) is composed of the following categories:

Land cover type		Area (acres)	Percentage (%)
	Inland Fresh Marsh	5,316	46
	Undeveloped Dry Land	3,342	29
	Inland Open Water	1,812	16
	Irregularly Flooded Marsh	330	3
	Estuarine Open Water	212	2
	Developed Dry Land	199	2
	Swamp	183	2
	Regularly Flooded Marsh	45	< 1
	Total (incl. water)	**11,438**	**100**

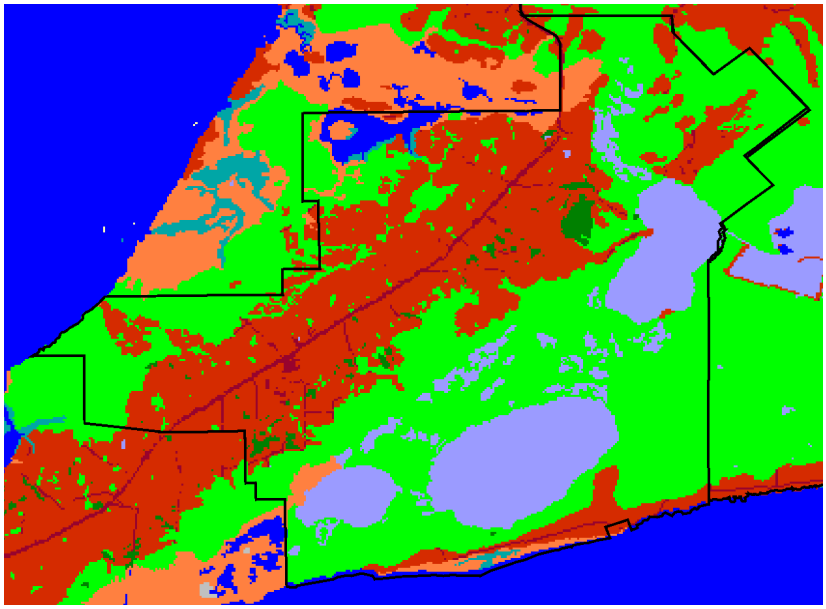


Figure 4. Portion of study area for Moody NWR. White line indicates Refuge boundary

According to the National Wetland Inventory, there are no diked areas within Moody NWR.

Historic SLR trends have been measured at two sites in the study area: Galveston Pier 21 (6.39 ± 0.28 mm/year) on the Bay side of Galveston Island and Galveston Pleasure Pier (6.84 ±0.81 mm/year) on the Ocean side of Galveston Island. The observed rate of SLR at these gauges has been significantly higher than the average for the last 100 years (approximately 1.7 mm/year, IPCC 2007).

This "natural subsidence rate" of 3.05 mm/yr. was applied to the model by modifying the "Historic Trend" parameter for model forecasts (Table 1)[1]. A rate of 3.05 mm/year is lower than subsidence that would be estimated using measured historic SLR trends from Galveston Island (5.1 mm/year at Galveston Pleasure pier and 4.7 mm/yr. at Pier 21)[2]. This discrepancy may be caused by the averaging period for these gauges as they include years prior to 1978, when subsidence in the Houston-Galveston area was more substantial (Buckley et al. 2003; Gabrysch and Coplin 1990; Michel 2010).

The portion of the study area that included Moody NWR included several input subsites. Figure 5 presents the three subsites in the Moody NWR area.

[1] The "Historic Trend" parameter is used to input an estimate of historic local SLR. The difference between this historic local trend and the historic eustatic trend is then used to adjust global estimates of SLR utilized by SLAMM. In model forecasts the "Historic Trend" parameter was set to 4.75 mm/yr., which is equal to the 1.7 mm/year historic eustatic SLR trend plus the 3.05 mm/yr. local subsidence rate. The model then interprets this parameter by applying a subsidence rate of 3.05 mm/year throughout the study area.

[2] For example, at Galveston Pleasure Pier, 6.8 mm/year observed minus 1.7 mm/year of eustatic SLR observed would suggest a rate of 5.1 mm/year due to subsidence.

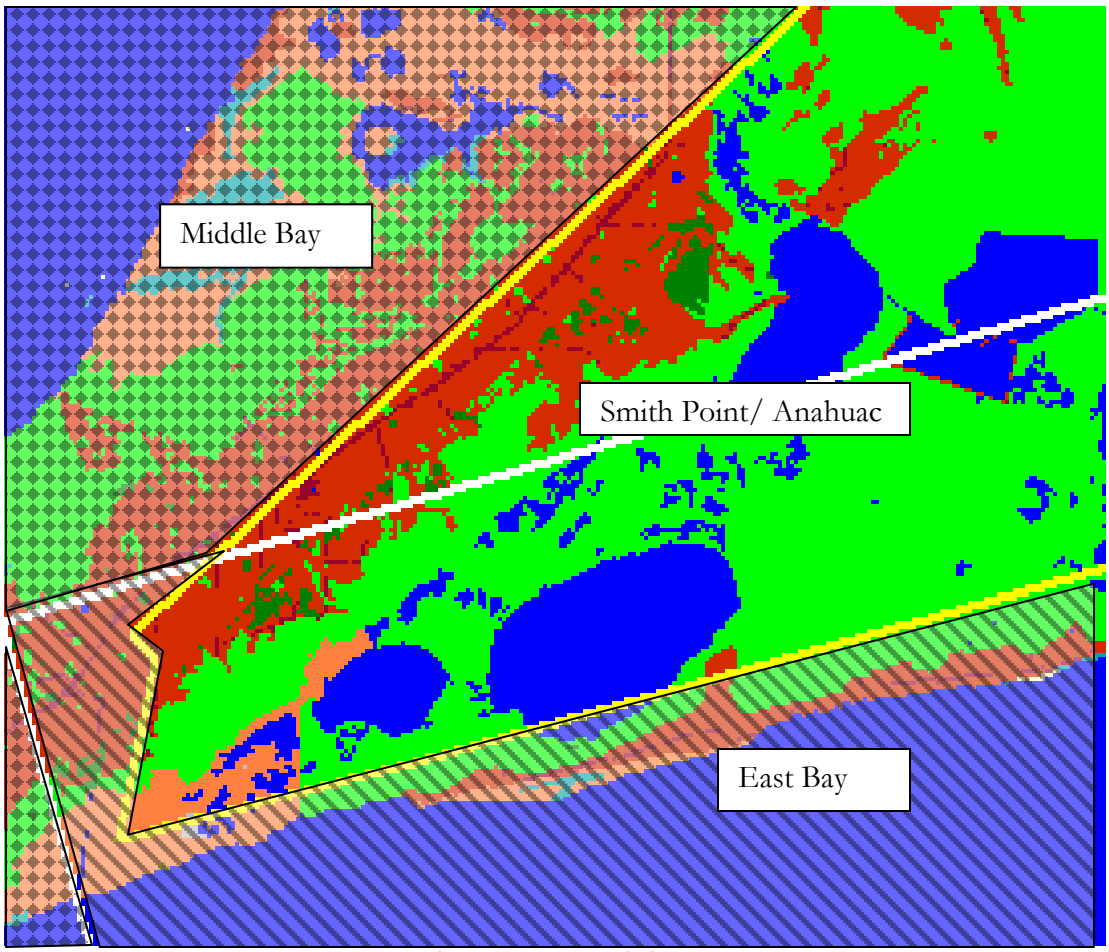


Figure 5. Input subsites

The great diurnal tide range was different for each input subsite. For the Middle Bay and East Bay subsites the great diurnal tide ranges were 0.34 and 0.37 m, respectively, based on NOAA tide tables. In the Smith Point/Anahuac subsite, the tide range was set to 0.25 m in order to simulate reduced tidal influence this area may be exposed to (Walther 2011).

The "salt elevation" parameter within SLAMM designates the boundary between coastal wetlands and dry lands or fresh water wetlands. An estimate of this elevation may be derived by examining historical tide gauge data to determine how frequently different elevations are flooded with ocean water. Within SLAMM modeling simulations this elevation is usually defined as the elevation over which flooding is predicted less than once in every 30 days. Dry lands and fresh-water wetlands are assumed to be located above that elevation. In this study, the value of the salt elevation depended on the subsite as shown in Table 2.

Table 1. Salt Elevations

Input Subsite	Salt Elev. (m above MTL)
Middle Bay	0.35
East Bay	0.35
Smith Point/Anahuac	0.30

The Galveston study area was divided into high and low sediment areas. Moody NWR is located in both high (Middle Bay) and low sediment supply area (East Bay, Smith Point/Anahuac) Accretion rates in salt marshes were subject to feedbacks based on elevation. For the Middle Bay subsite (high-sediment supply area) the maximum accretion rate applied was 10 mm/yr. and minimum was 3.8 mm/yr. resulting in an average rate of 7.7 mm/yr. For the East Bay Smith Point/Anahuac subsites (low sediment supply), the maximum accretion rate applied was 4 mm/yr. and minimum was 1.6 mm/yr., resulting in an average rate of 3.1 mm/yr. Feedbacks for the low sediment-supply areas were based on data reported by Ravens et al. 2009 and for high sediment-supply areas from data collected by Williams (2003).

Tidal Fresh Marsh accretion feedbacks were applied equally to all subsites based on data reported by White and coworkers (2002). This curve resulted in an average accretion rate of 4.86 mm/yr. The accretion rate of 2.9 mm/yr. applied to Inland Fresh Marsh was derived from the average accretion rate of all fresh marsh values reported by White and coworkers (2002; 4.9 mm/yr.) averaged with the rate of 2.5 mm/yr. observed by Williams et al. (2003) and the rate of 1.3 mm/yr. observed by Yeager and coworkers (2007).

Erosion rates observed from 1931-2000 were applied to the SLAMM model based on data from the Texas Hazard Mitigation Package (Texas Geographic Society, http://www.thmp.info/data_layers/coastal-erosion.html).
Rates were determined individually for each input subsite and applied equally to Marsh, Swamp, and Tidal Flat categories. For the Middle Bay subsite an erosion rate of 1 meter per year was applied while the Smith Point/Anahuac and East Bay subsites a rate of 0.77 m/yr. was used.

The MTL to NAVD88 correction was applied the Galveston SLAMM project via input raster. For the Moody NWR area, these correction values were homogeneous (0.17 m).

Modeled U.S. Fish and Wildlife Service refuge boundaries for Texas are based on Approved Acquisition Boundaries as published on the FWS National Wildlife Refuge Data and Metadata website. The cell-size used for this analysis was 10 m by 10 m cells. Note that the SLAMM model will track partial conversion of cells based on elevation and slope.

Table 2. Summary of SLAMM input parameters for Moody NWR

Subsite Description	Middle Bay	Smith Point/ Anahuac	East Bay
NWI Photo Date (YYYY)	2004	2004	2004
DEM Date (YYYY)	2007	2007	2007
Direction Offshore [n,s,e,w]	East	East	West
Historic Trend (mm/yr.)	4.75	4.75	4.75
GT Great Diurnal Tide Range (m)	0.34	0.25	0.37
Salt Elev. (m above MTL)	0.35	0.30	0.35
Marsh Erosion (horz. m /yr)	1	0.77	0.77
Swamp Erosion (horz. m /yr.)	1	0.77	0.77
T.Flat Erosion (horz. m /yr)	1	0.77	0.77
Inland-Fresh Marsh Accr (mm/yr.)	2.9	2.9	2.9
Tidal Swamp Accr (mm/yr.)	1.1	1.1	1.1
Swamp Accretion (mm/yr.)	0.3	0.3	0.3
Beach Sed. Rate (mm/yr.)	1	1	1
Hindcast - Use Elev Pre-processor [True,False]	TRUE	TRUE	TRUE
Forecast - Use Elev Pre-processor [True,False]	FALSE	FALSE	FALSE
Reg Flood Max. Accr. (mm/year)	10	4	4
Reg Flood Min. Accr. (mm/year)	3.8	1.6	1.6
Reg Flood Elev a coeff. (cubic)	-1	-1	-1
Reg Flood Elev b coeff. (square)	0.8	0.8	0.8
Reg Flood Elev c coeff. (linear)	1	1	1
Irreg Flood Max. Accr. (mm/year)	10	4	4
Irreg Flood Min. Accr. (mm/year)	3.8	1.6	1.6
Irreg Flood Elev a coeff. (cubic)	-1	-1	-1
Irreg Flood Elev b coeff. (square)	0.8	0.8	0.8
Irreg Flood Elev c coeff. (linear)	1	1	1
Irreg Flood D.Effect Max (meters)	0	0	0
Irreg Flood D min. (unitless)	1	1	1
Tidal Fresh Max. Accr. (mm/year)	6.5	6.5	6.5
Tidal Fresh Min. Accr. (mm/year)	3.2	3.2	3.2
Tidal Fresh Elev a coeff. (cubic)	0	0	0
Tidal Fresh Elev b coeff. (square)	0	0	0
Tidal Fresh Elev c coeff. (linear)	1	1	1

Results

This simulation of the Moody NWR was completed using a SLAMM model that was calibrated to historical data for a previous project (Clough et al. 2011). This calibrated model predicts that Moody NWR will be severely impacted depending on the SLR scenario and wetland class. Table 3 presents the predicted loss of each wetland category by 2100 for each of the five SLR scenarios examined.

Almost half of the refuge is classified as inland fresh marsh, which is predicted to sustain considerable losses under each SLR scenario examined, as shown in Table 3. This may be explained in part by the uncertainty in the NWI wetland layer used. SLAMM simulates a "time zero" step, in which results for the NWI photo date are estimated. As there is no sea level rise, accretion, or erosion imposed in this time step, conversions in land cover types at "time zero" are based solely on comparisons between land elevations and the SLAMM conceptual model. A large amount of conversion of tidal fresh marsh to transitional marsh was observed at time-zero in the Smith Point area. Discussions with area experts indicated the area around Smith Point is suspected to be under limited tidal influence (Dick 2010) and that the NWI maps of this area do not accurately describe the current salinity of the marshes in this area. In reality the salinity of these marshes is around 10 ppt, making these marshes more likely to be transitional salt marshes rather than inland fresh (Walther 2011).

In general, SLAMM simulations indicate the marshlands in Moody NWR will be severely impacted by sea level rise. The low-lying interior portion of the refuge is predicted to convert to open water by 2100 under all five SLR scenarios examined. While there are significant losses predicted in the inland fresh and irregularly flooded marsh and swamp categories, important gains in regularly flooded marsh are predicted. These increases occur as inland fresh and irregularly flooded marsh convert to regularly flooded marsh due to increased inundation.

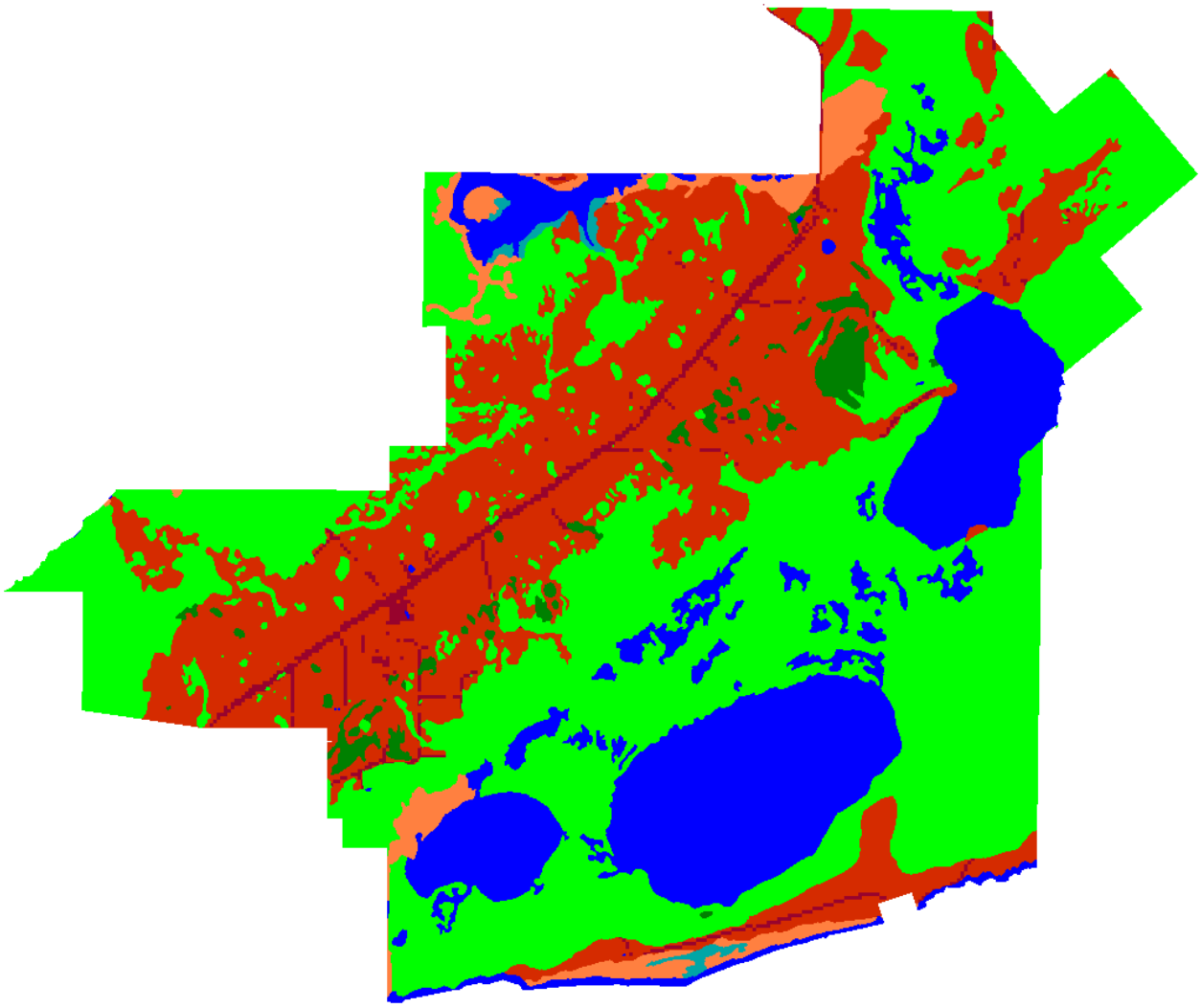
Table 3. Predicted Loss Rates of Land Categories by 2100 Given Simulated Scenarios of Eustatic Sea Level Rise. *Negative values indicate losses and positive indicate gains.*

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
Inland Fresh Marsh	-73	-87	-95	-98	-99
Undeveloped Dry Land	-22	-34	-45	-57	-74
Irregularly Flooded Marsh	-28	-43	-93	-100	-100
Developed Dry Land	-20	-27	-31	-35	-42
Swamp	-51	-71	-84	-95	-98
Regularly Flooded Marsh	2526	3238	3238	3416	3032

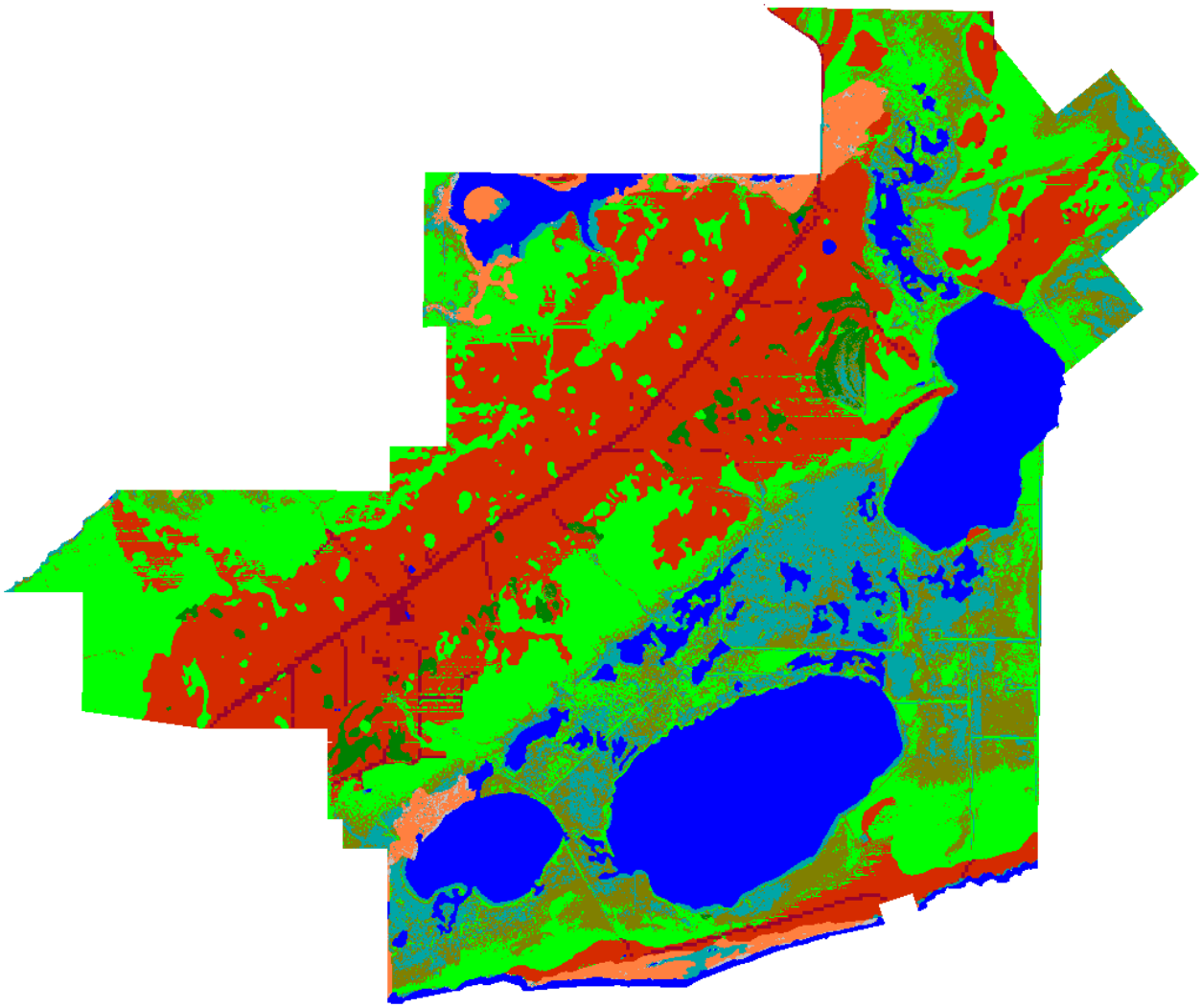
IPCC Scenario A1B-Mean, 0.39 m SLR eustatic by 2100

Results in Acres

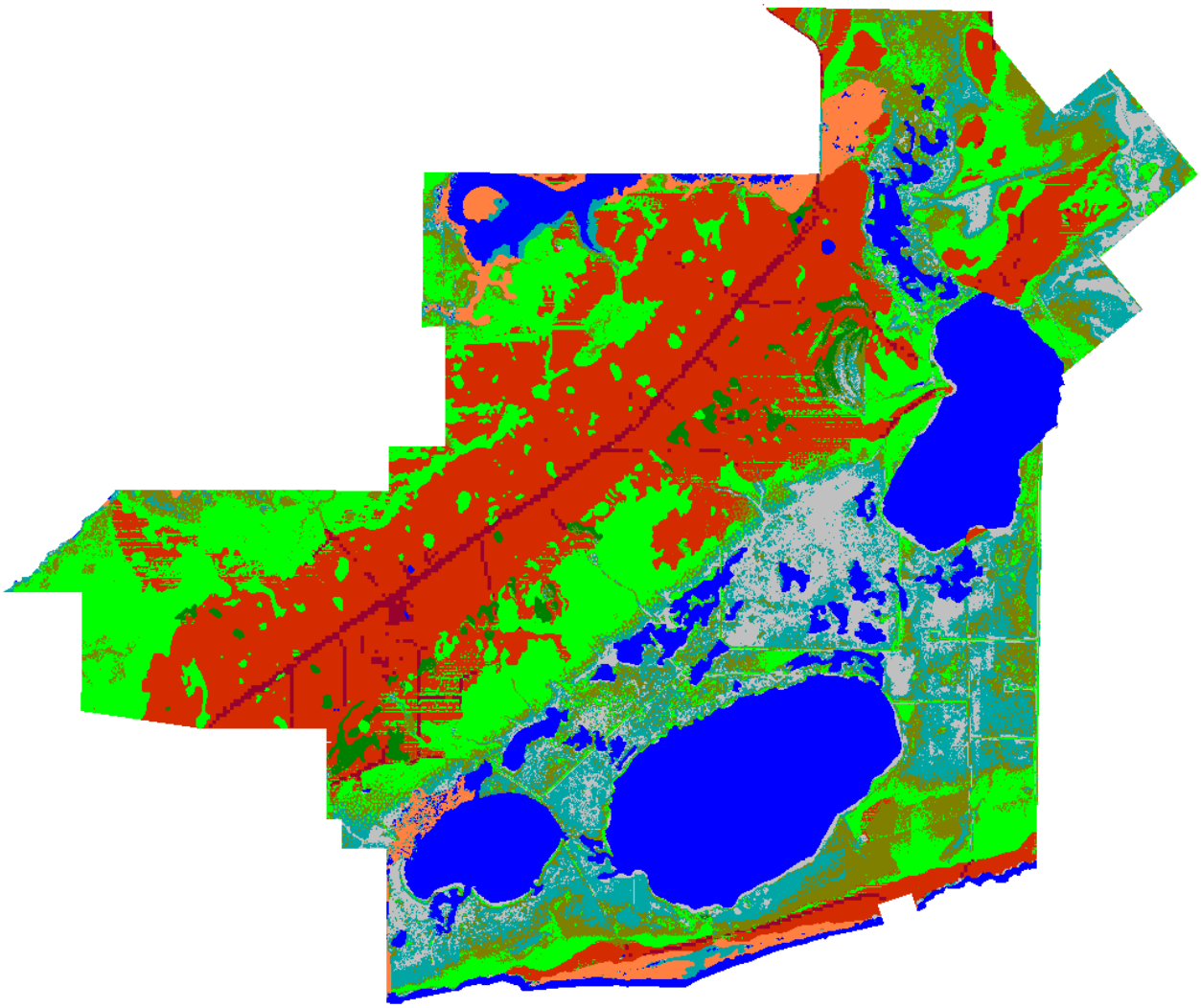
		Initial	2025	2050	2075	2100
	Inland Fresh Marsh	5316	3089	2480	1879	1451
	Undeveloped Dry Land	3342	3170	3029	2833	2597
	Inland Open Water	1812	941	925	908	903
	Irregularly Flooded Marsh	330	291	283	265	237
	Estuarine Open Water	212	1090	1169	1992	3072
	Developed Dry Land	199	196	191	177	159
	Swamp	183	156	138	116	90
	Regularly Flooded Marsh	45	1136	1275	1102	1169
	Tidal Flat	0	29	785	1044	740
	Transitional Salt Marsh	0	1340	1164	1123	1019
	Total (incl. water)	**11438**	**11438**	**11438**	**11438**	**11438**



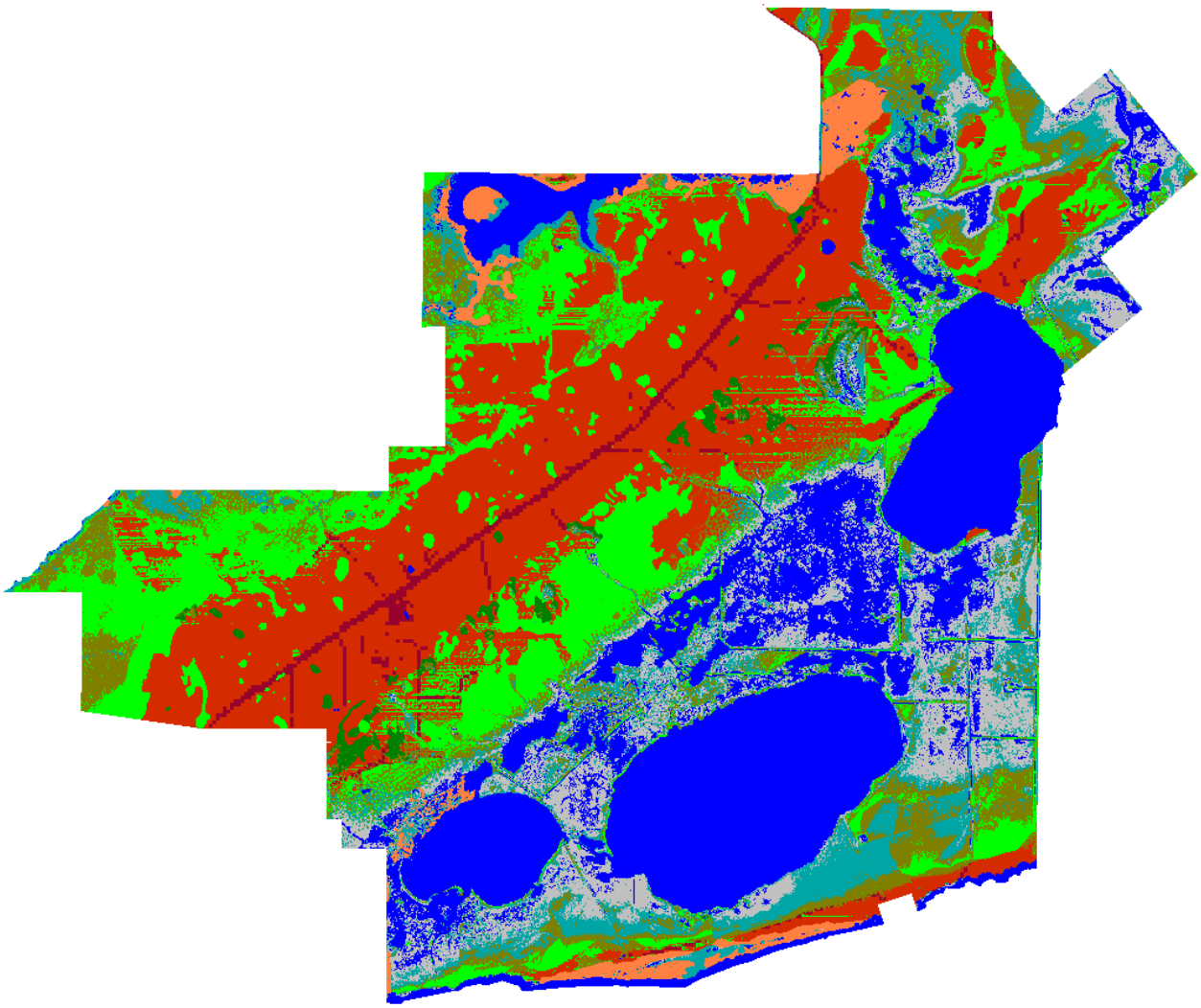
Moody NWR, Initial Condition



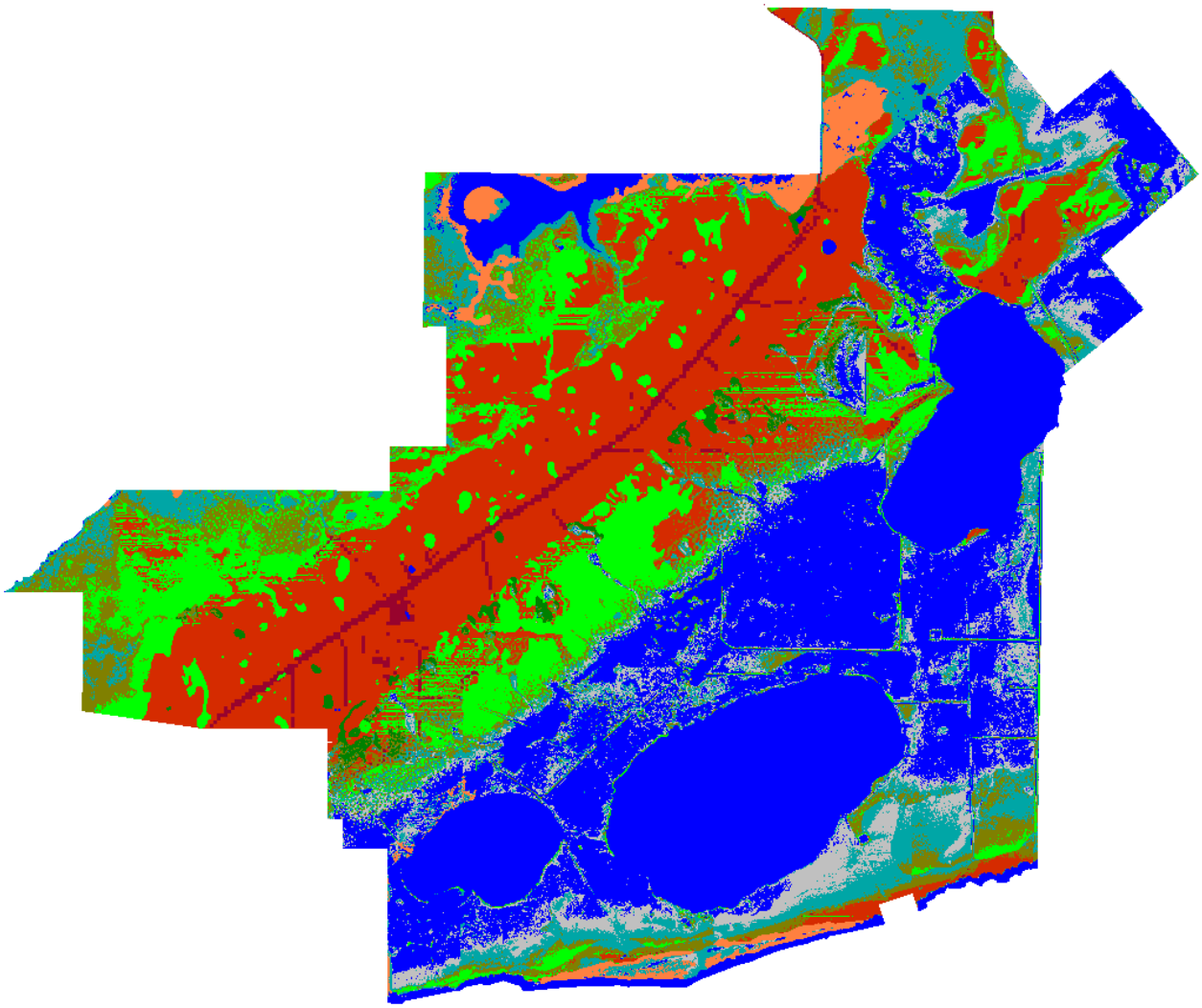
Moody NWR, 2025, Scenario A1B Mean



Moody NWR, 2050, Scenario A1B Mean



Moody NWR, 2075, Scenario A1B Mean

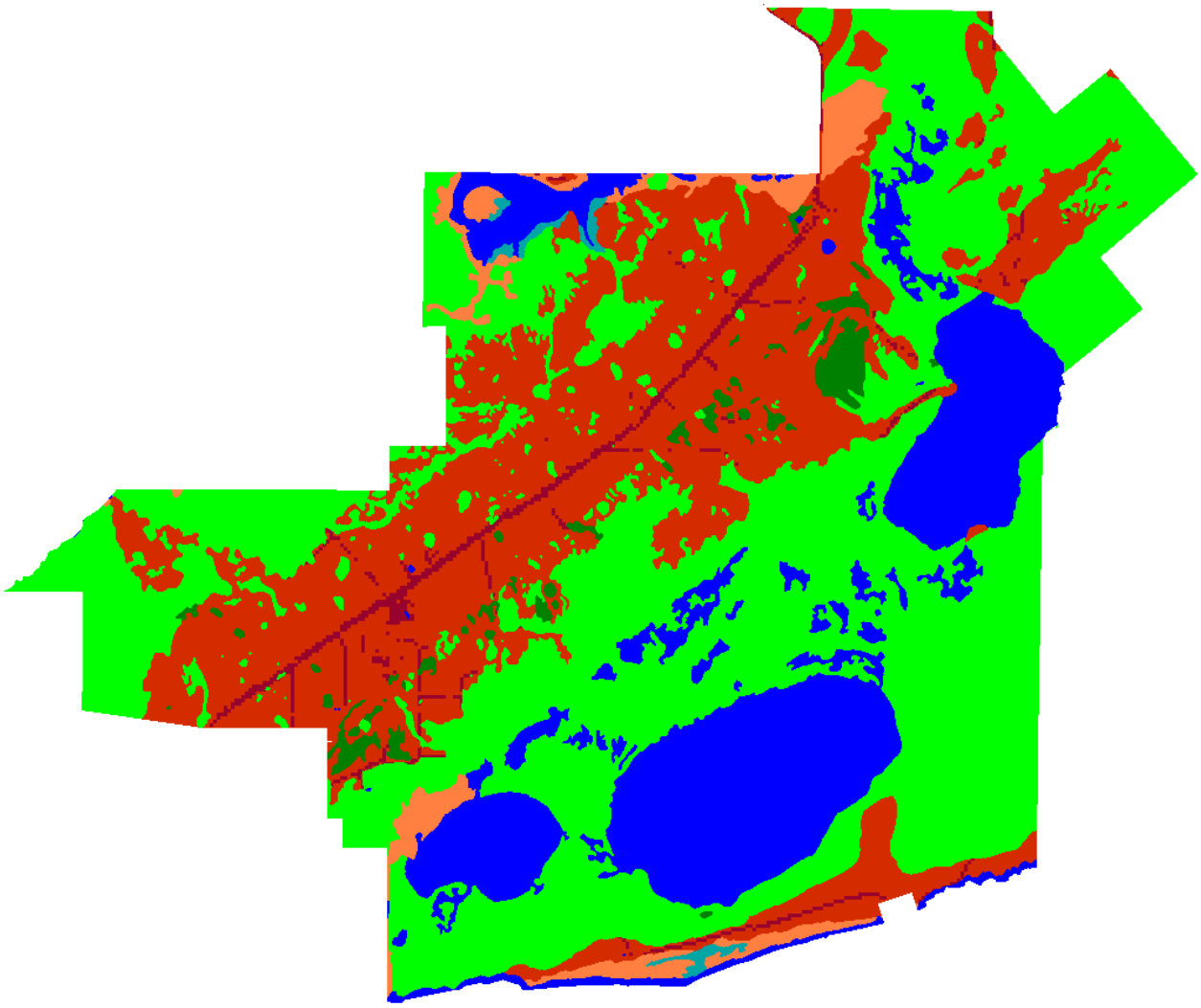


Moody NWR, 2100, Scenario A1B Mean

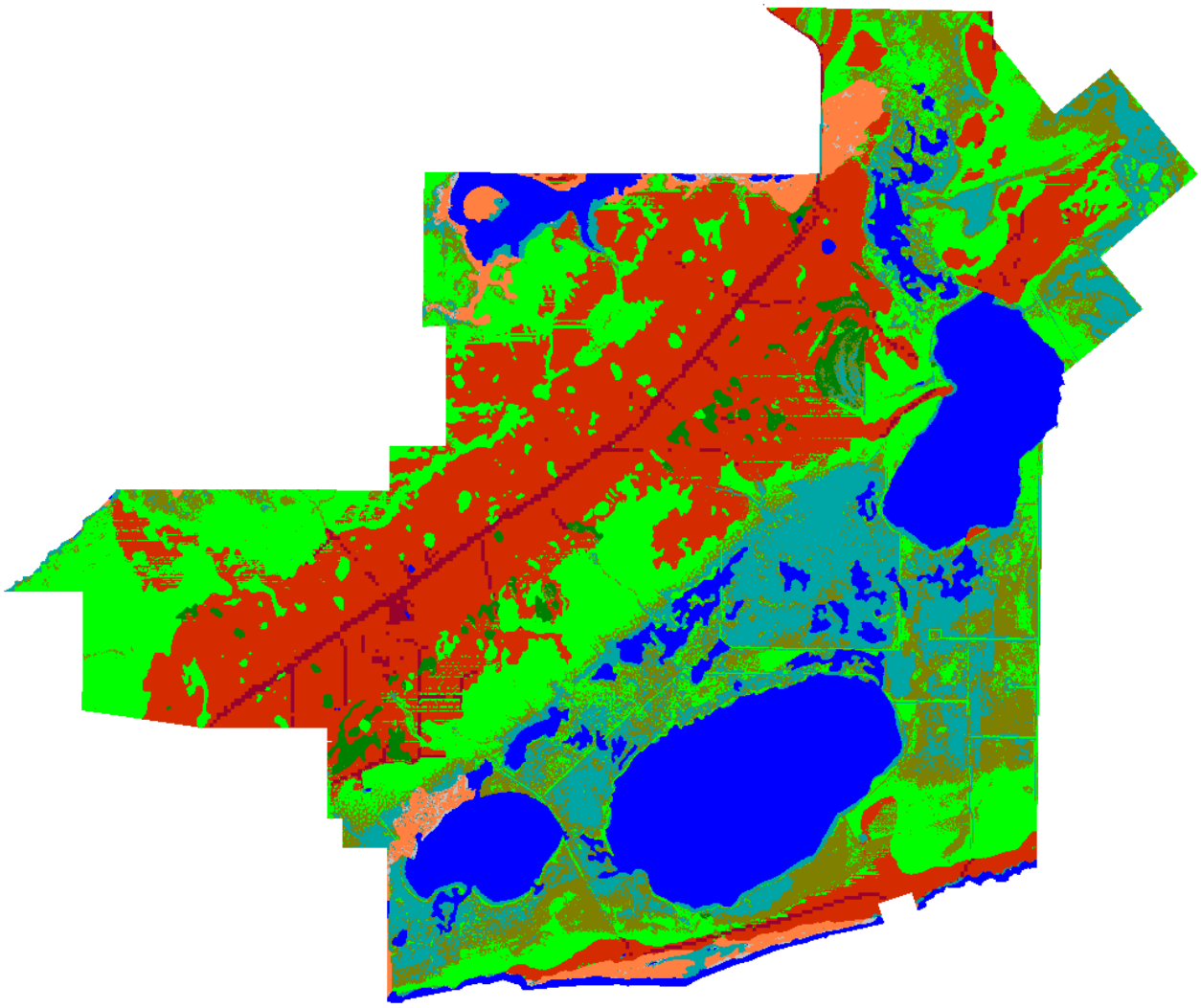
IPCC Scenario A1B-Max, 0.69 m SLR eustatic by 2100

Results in Acres

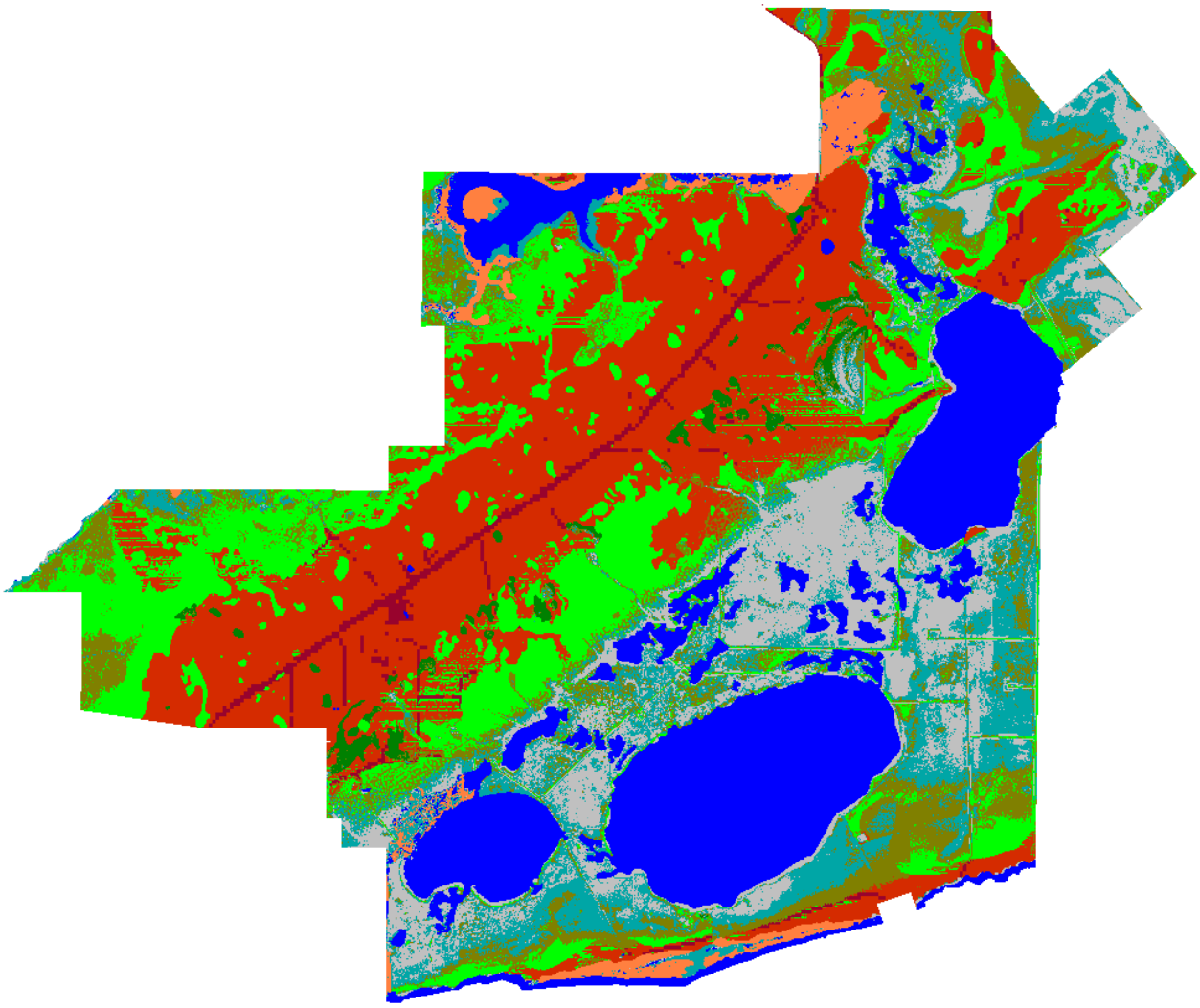
		Initial	2025	2050	2075	2100
	Inland Fresh Marsh	5316	2870	1915	1169	667
	Undeveloped Dry Land	3342	3156	2962	2645	2211
	Inland Open Water	1812	939	917	904	899
	Irregularly Flooded Marsh	330	288	265	212	188
	Estuarine Open Water	212	1093	1187	2488	3736
	Developed Dry Land	199	196	186	159	146
	Swamp	183	152	127	89	54
	Regularly Flooded Marsh	45	1377	1381	1466	1486
	Tidal Flat	0	30	1262	1176	1066
	Estuarine Beach	0	0	0	0	1
	Transitional Salt Marsh	0	1337	1236	1129	985
	Total (incl. water)	**11438**	**11438**	**11438**	**11438**	**11438**



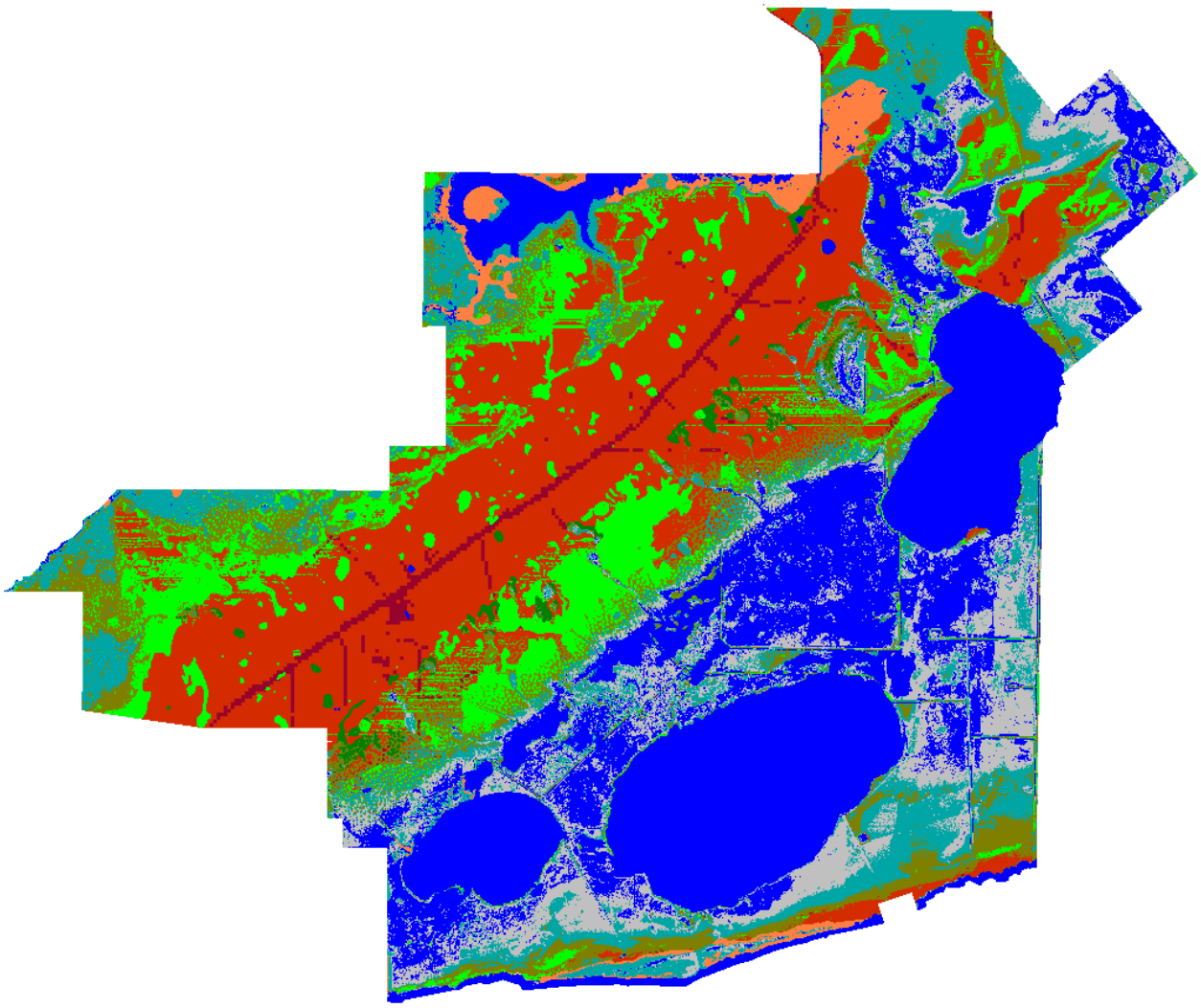
Moody NWR, Initial Condition



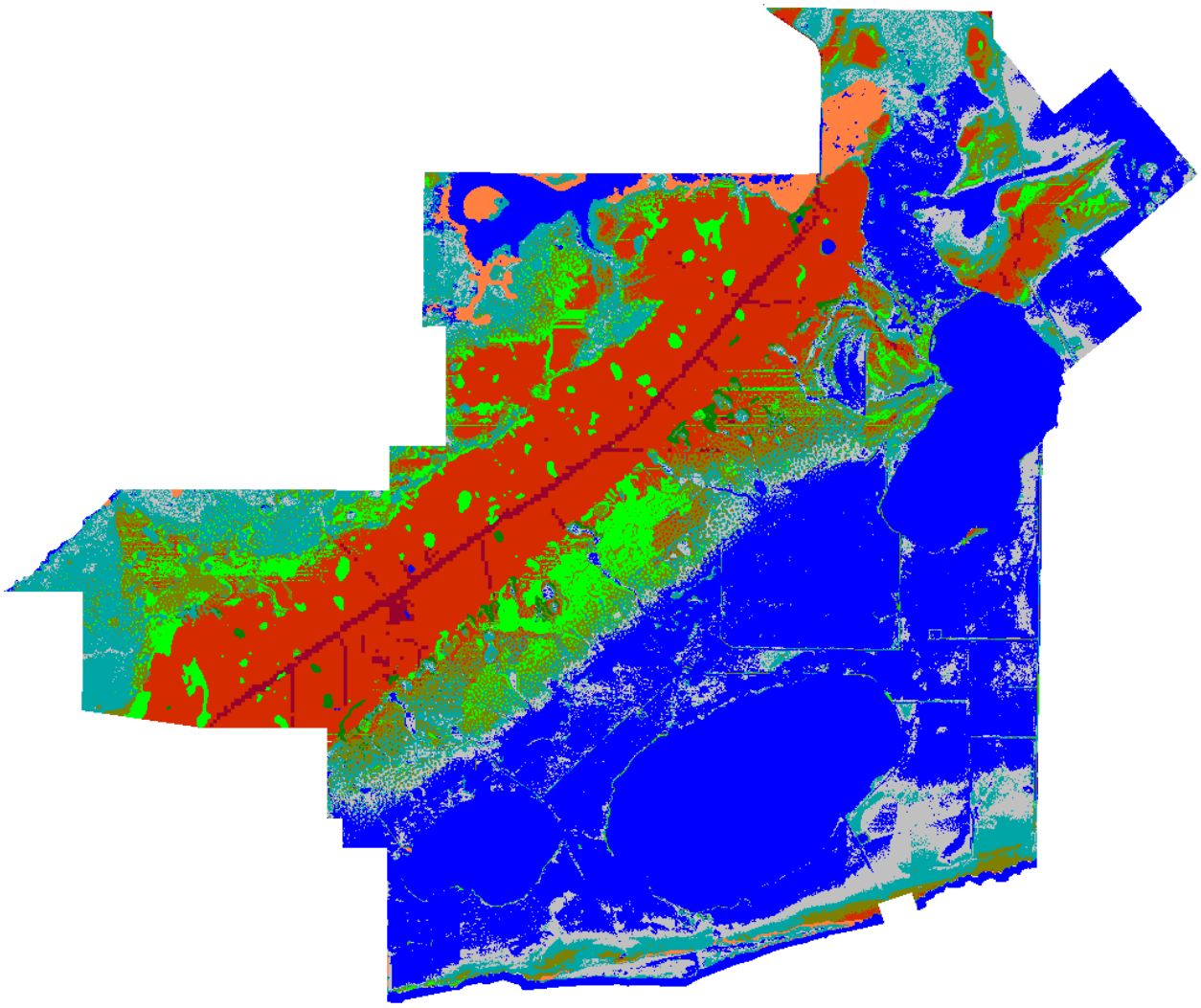
Moody NWR, 2025, Scenario A1B Maximum



Moody NWR, 2050, Scenario A1B Maximum



Moody NWR, 2075, Scenario A1B Maximum

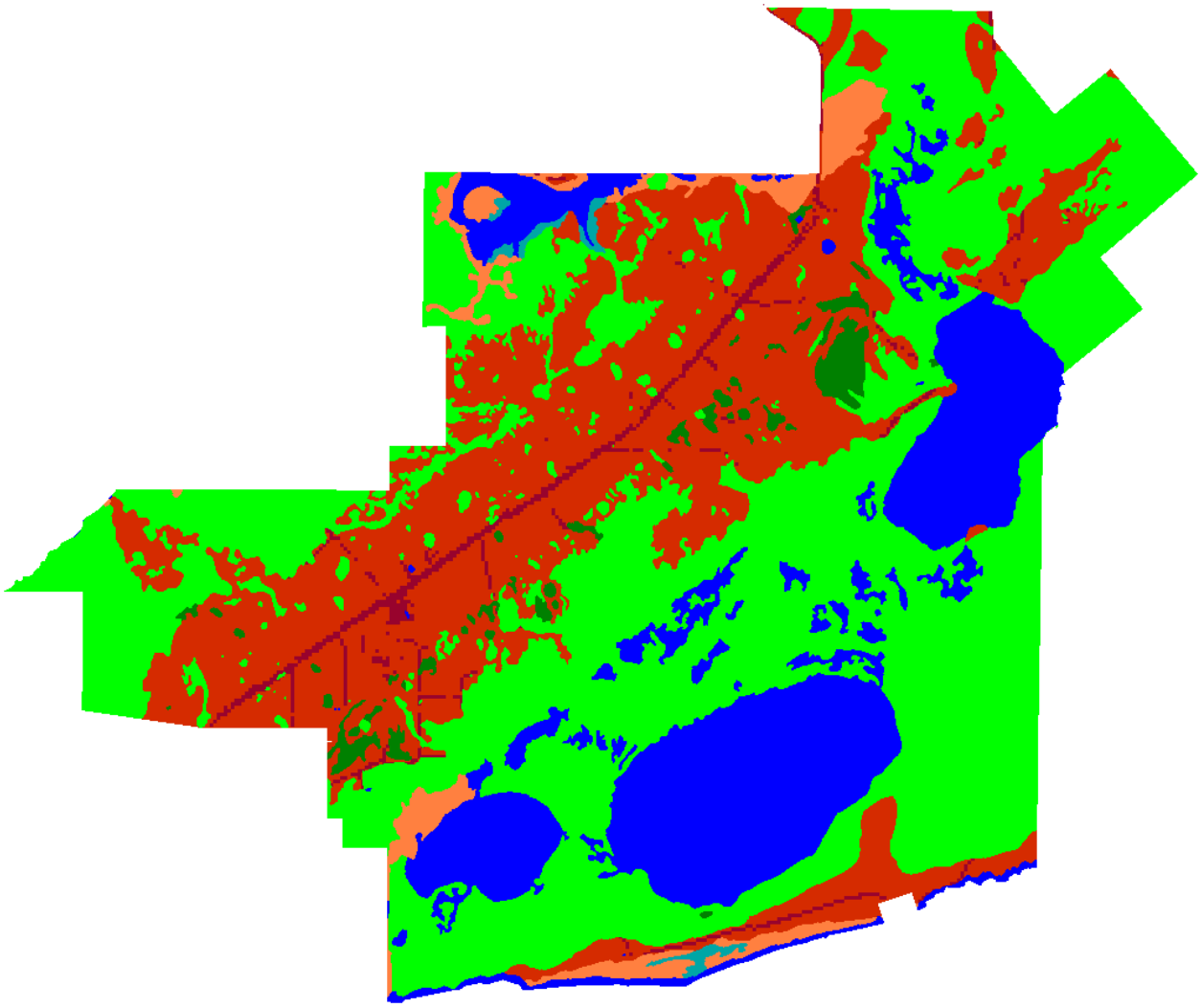


Moody NWR, 2100, Scenario A1B Maximum

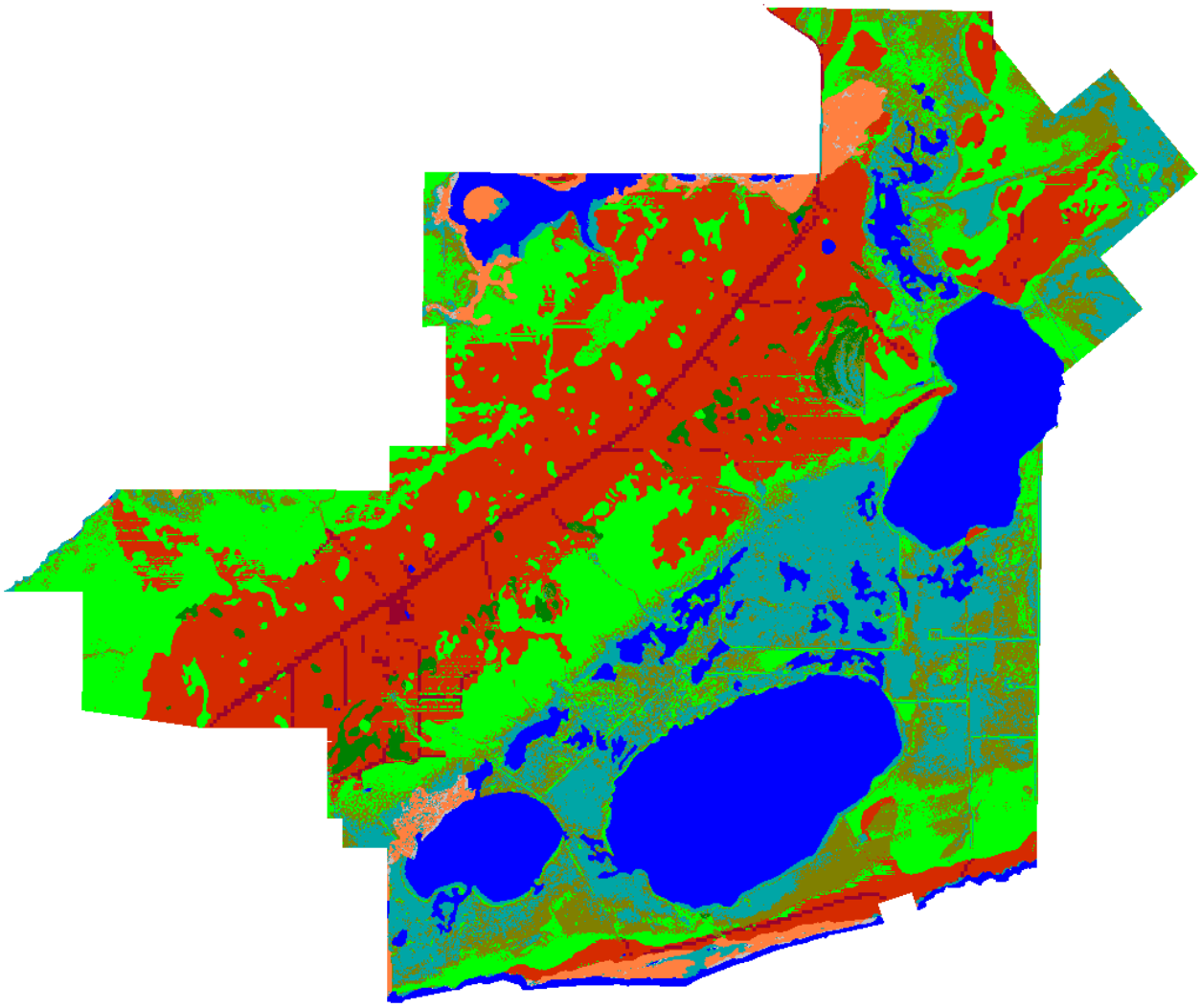
1 m eustatic SLR by 2100

Results in Acres

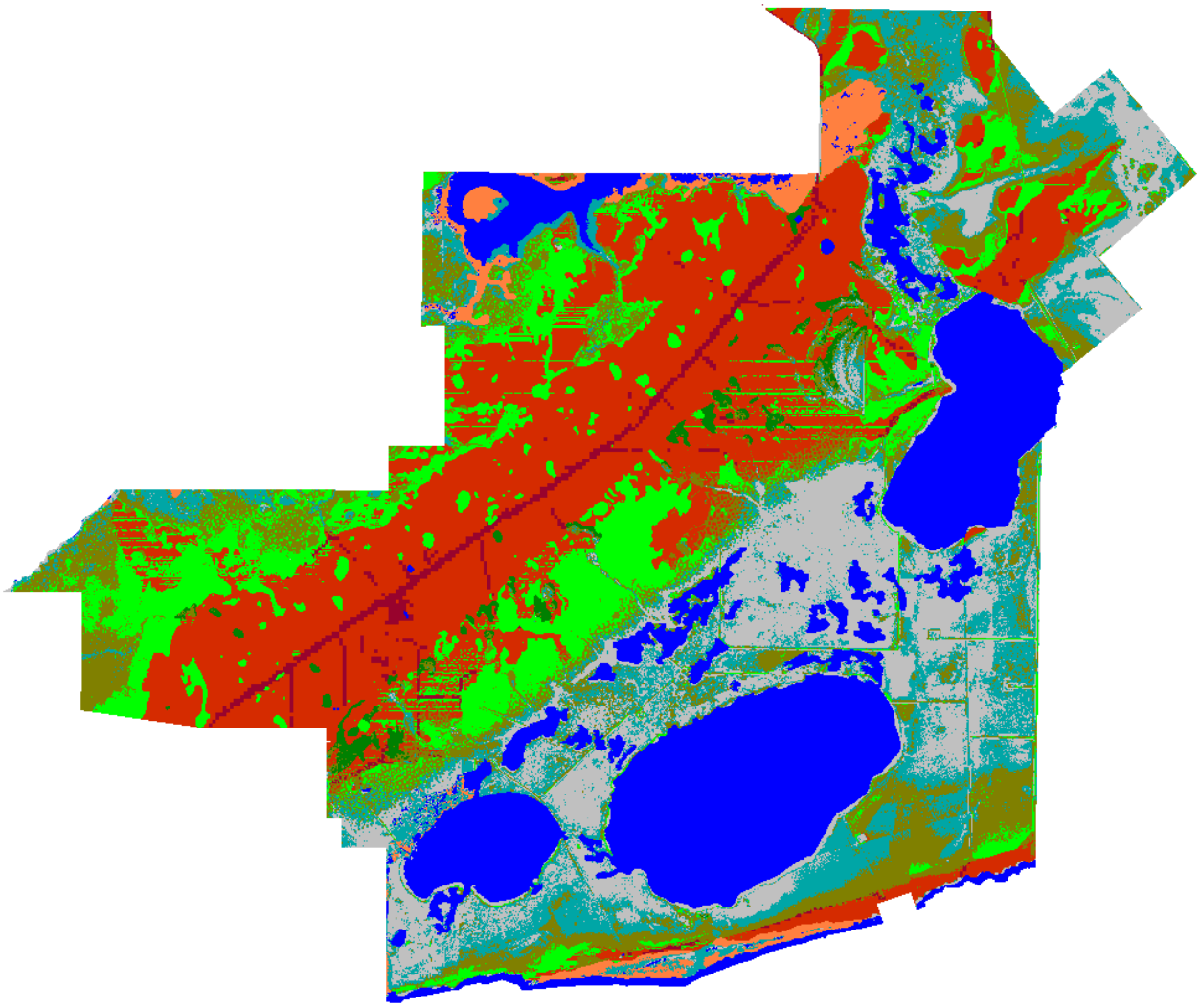
		Initial	2025	2050	2075	2100
	Inland Fresh Marsh	5316	2631	1485	709	267
	Undeveloped Dry Land	3342	3139	2866	2361	1827
	Inland Open Water	1812	937	910	899	898
	Irregularly Flooded Marsh	330	283	239	149	24
	Estuarine Open Water	212	1096	1202	2787	4246
	Developed Dry Land	199	195	175	148	137
	Swamp	183	148	114	64	29
	Regularly Flooded Marsh	45	1657	1428	1580	1485
	Tidal Flat	0	32	1545	1382	1503
	Transitional Salt Marsh	0	1320	1474	1358	1022
	Total (incl. water)	**11438**	**11438**	**11438**	**11438**	**11438**



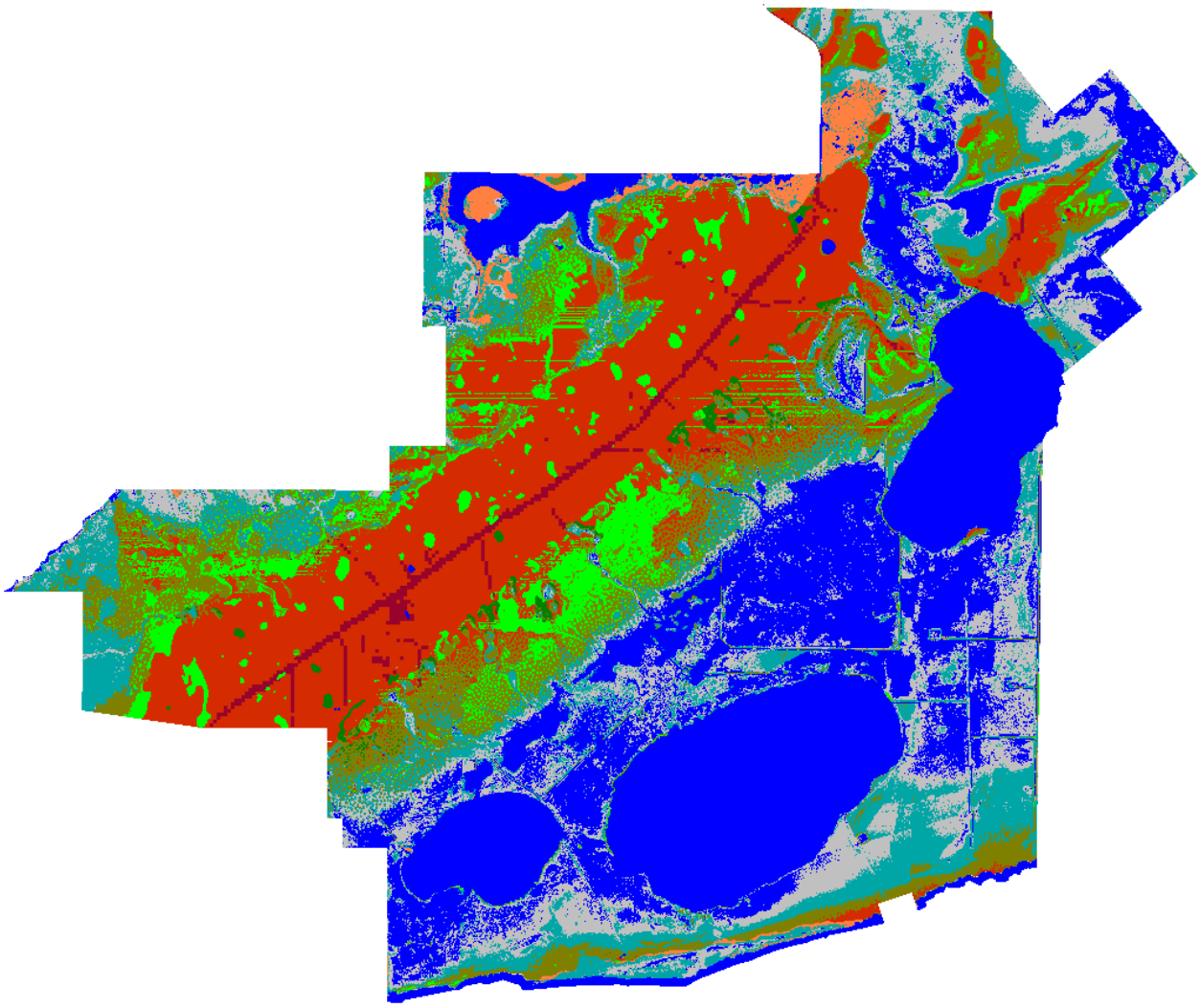
Moody NWR, Initial Condition



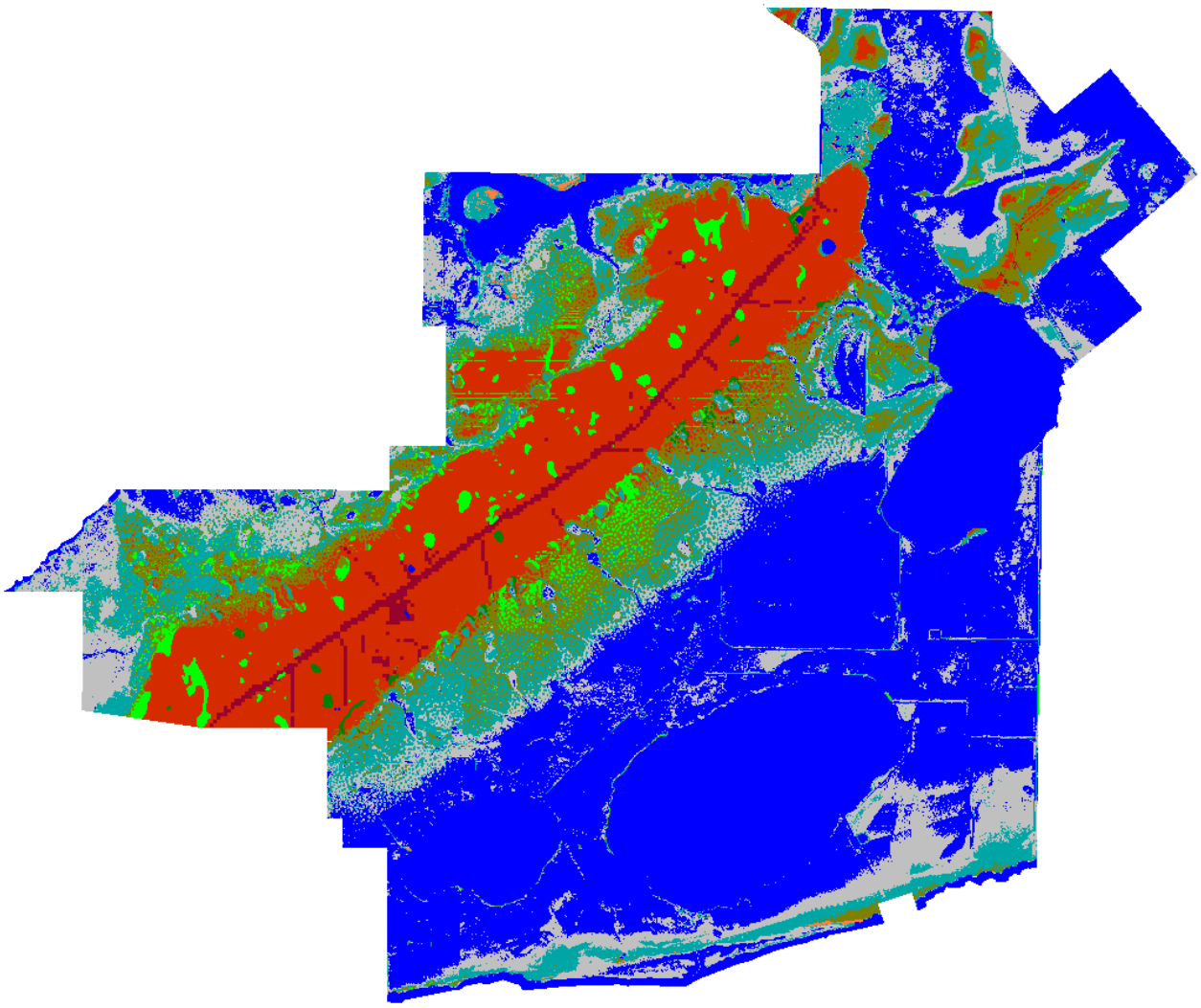
Moody NWR, 2025, 1 Meter



Moody NWR, 2050, 1 Meter



Moody NWR, 2075, 1 Meter

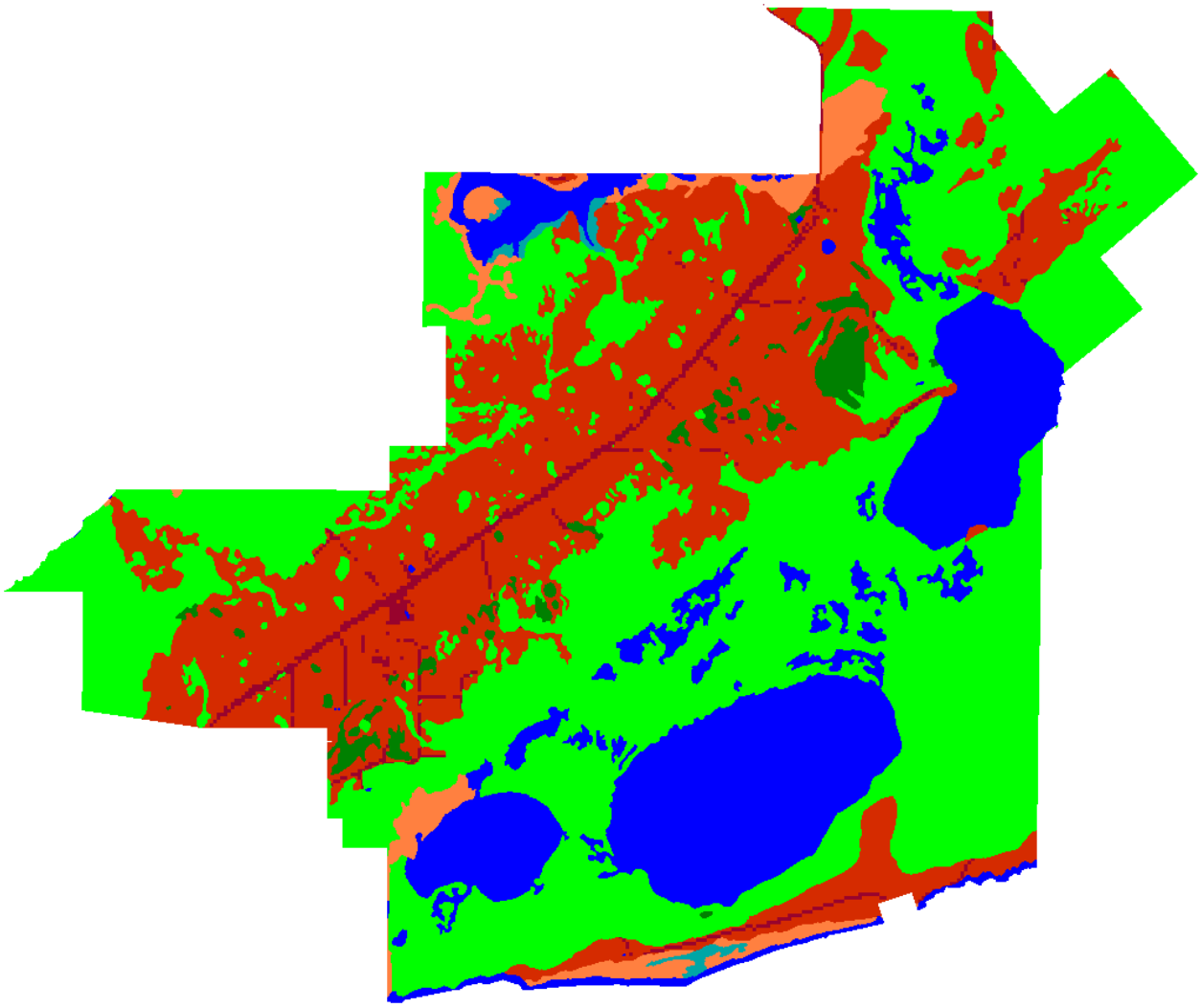


Moody NWR, 2100, 1 Meter

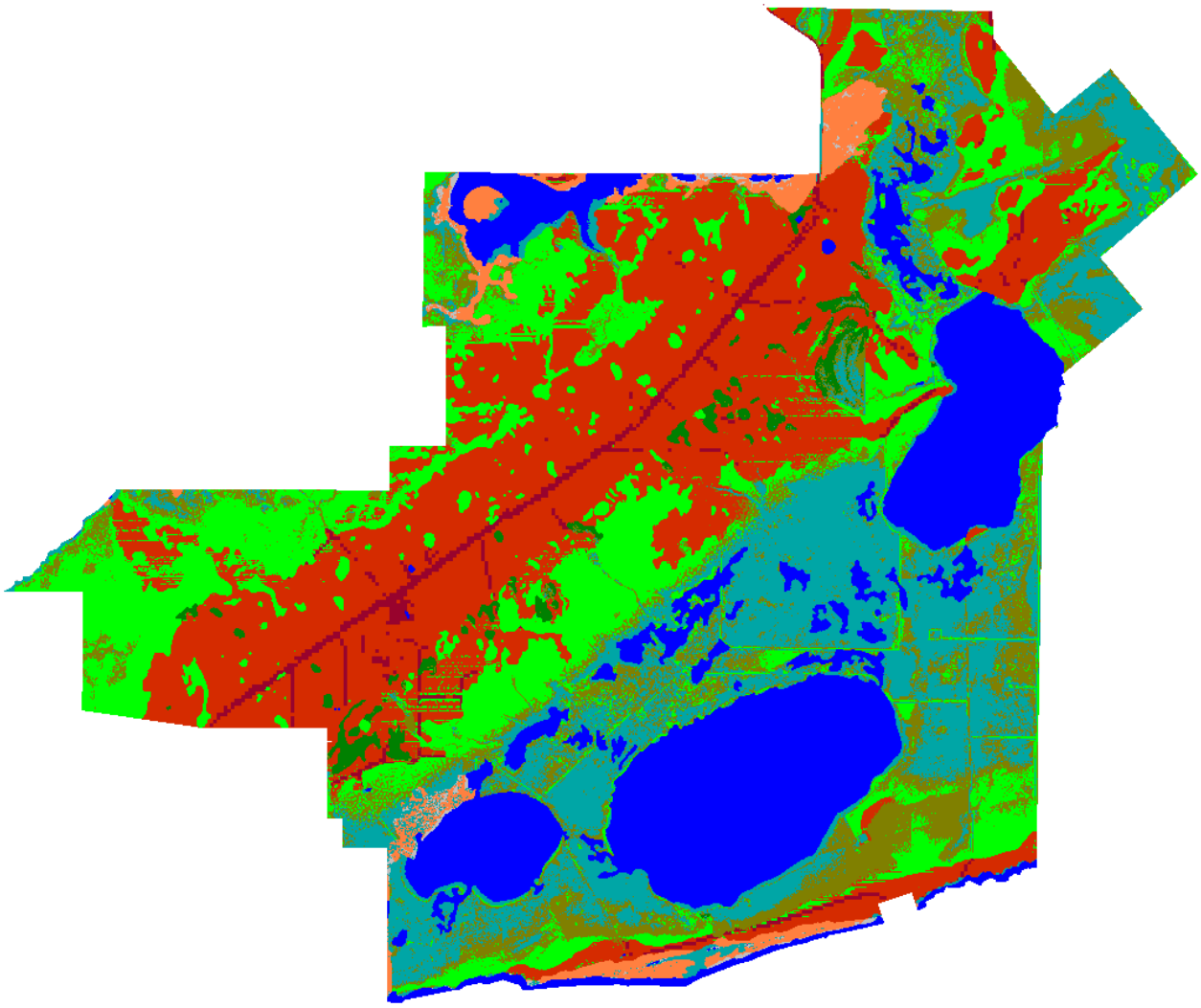
1.5 m eustatic SLR by
2100

Results in Acres

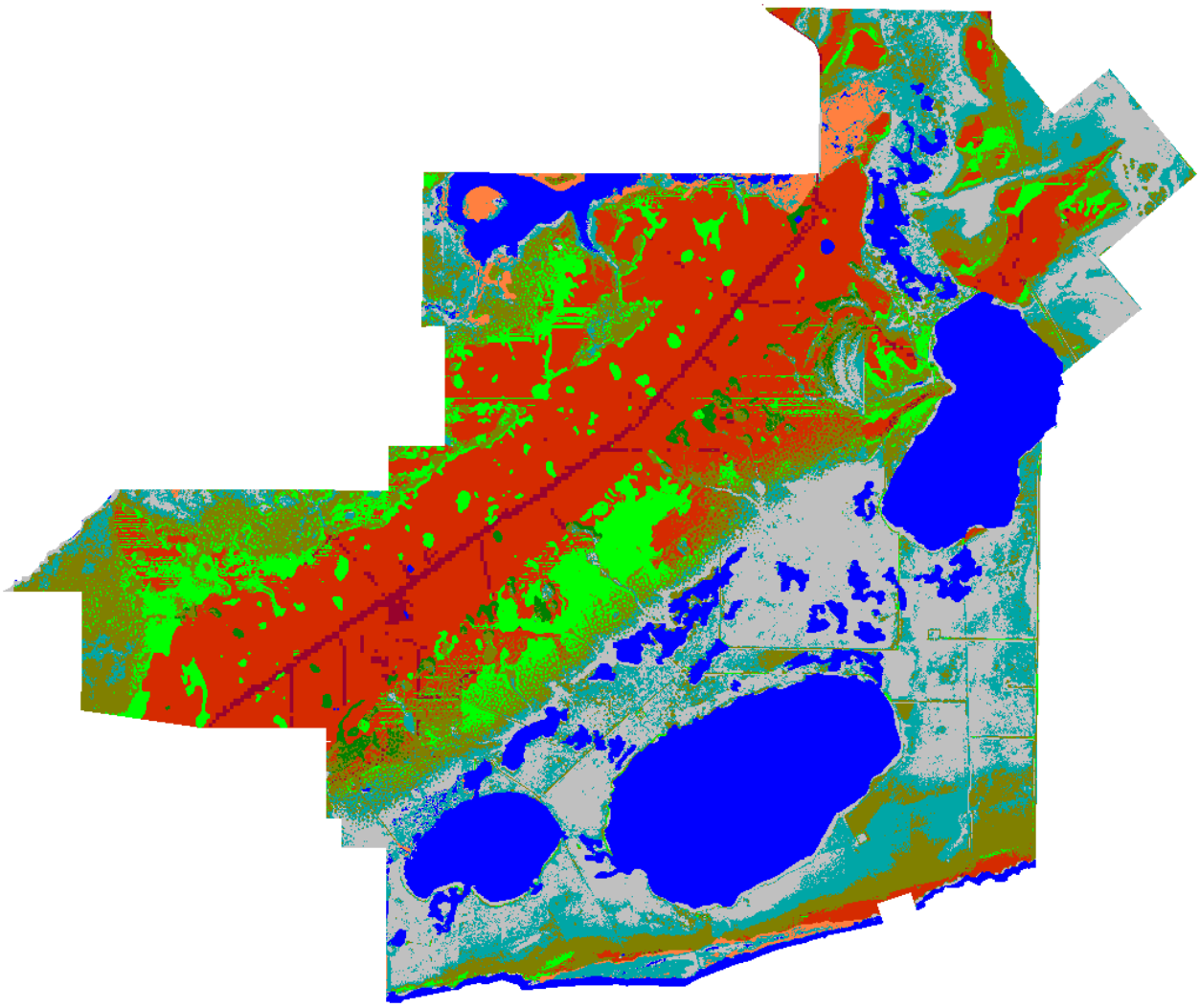
		Initial	2025	2050	2075	2100
	Inland Fresh Marsh	5316	2262	960	256	86
	Undeveloped Dry Land	3342	3110	2688	1913	1422
	Inland Open Water	1812	934	906	898	898
	Irregularly Flooded Marsh	330	273	158	9	1
	Estuarine Open Water	212	1099	1214	3185	4750
	Developed Dry Land	199	193	160	139	130
	Swamp	183	142	89	33	10
	Regularly Flooded Marsh	45	1996	1528	1960	1565
	Tidal Flat	0	34	1925	1490	1885
	Transitional Salt Marsh	0	1395	1810	1556	692
	Total (incl. water)	**11438**	**11438**	**11438**	**11438**	**11438**



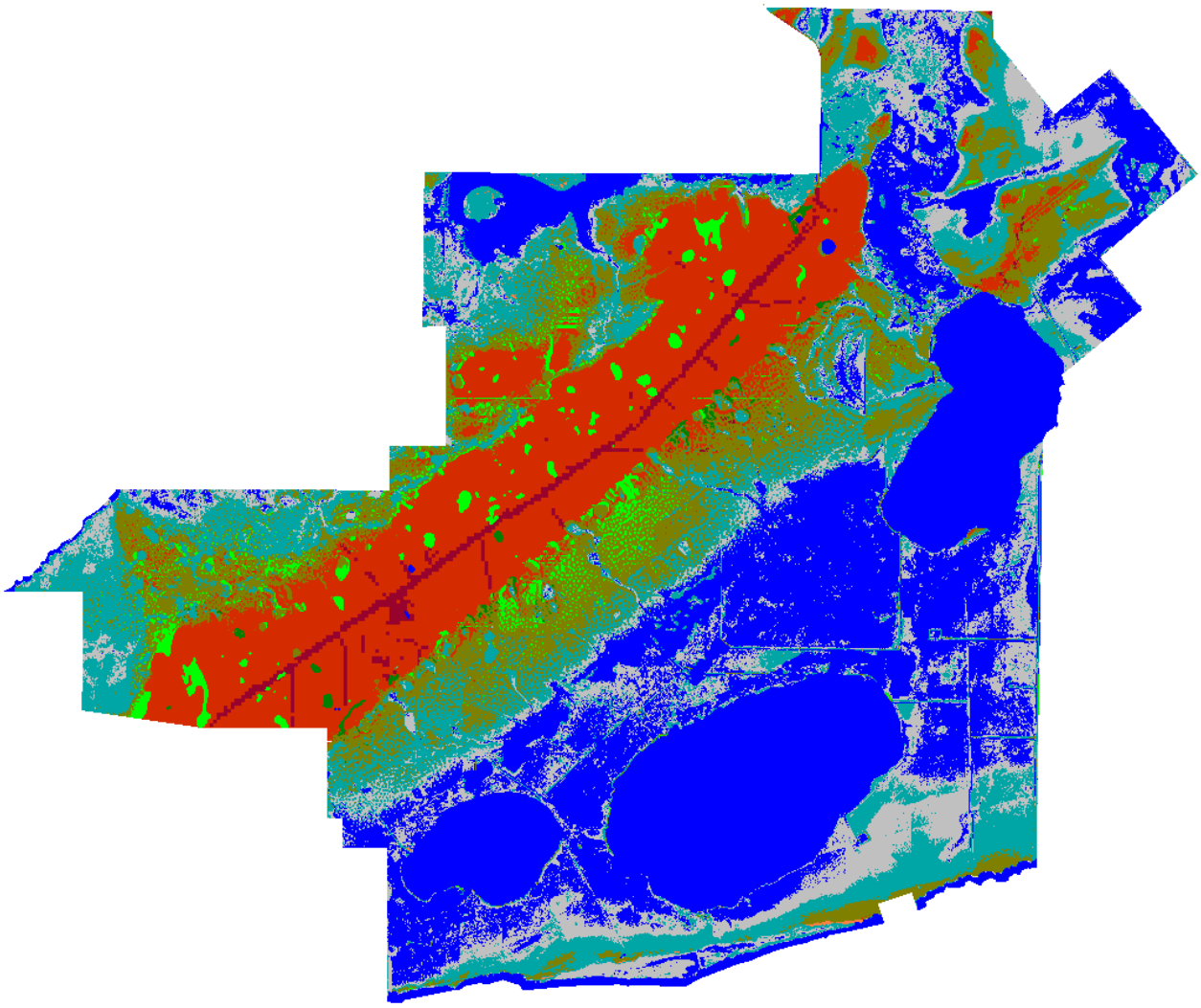
Moody NWR, Initial Condition



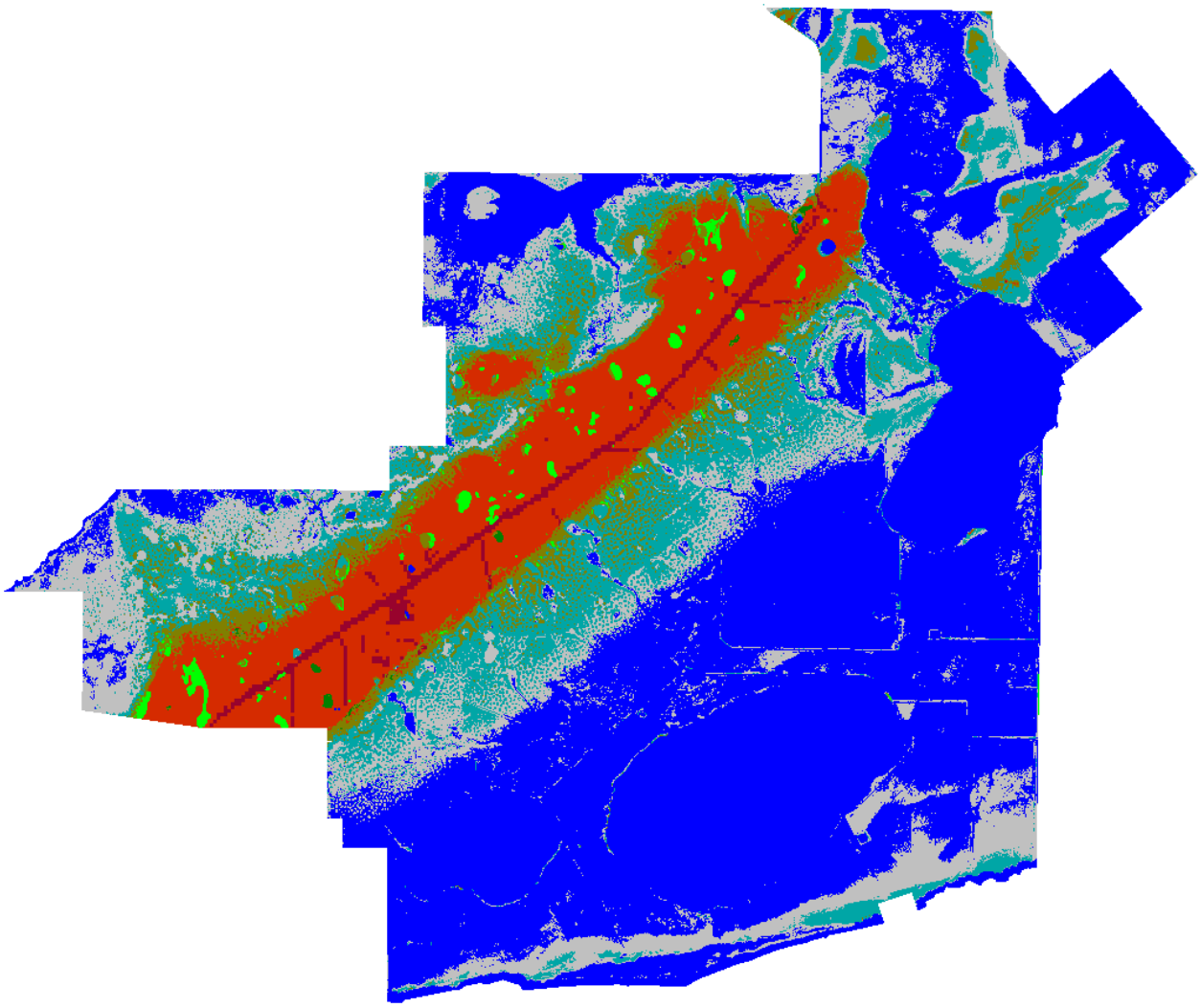
Moody NWR, 2025, 1.5 Meters



Moody NWR, 2050, 1.5 Meters



Moody NWR, 2075, 1.5 Meters

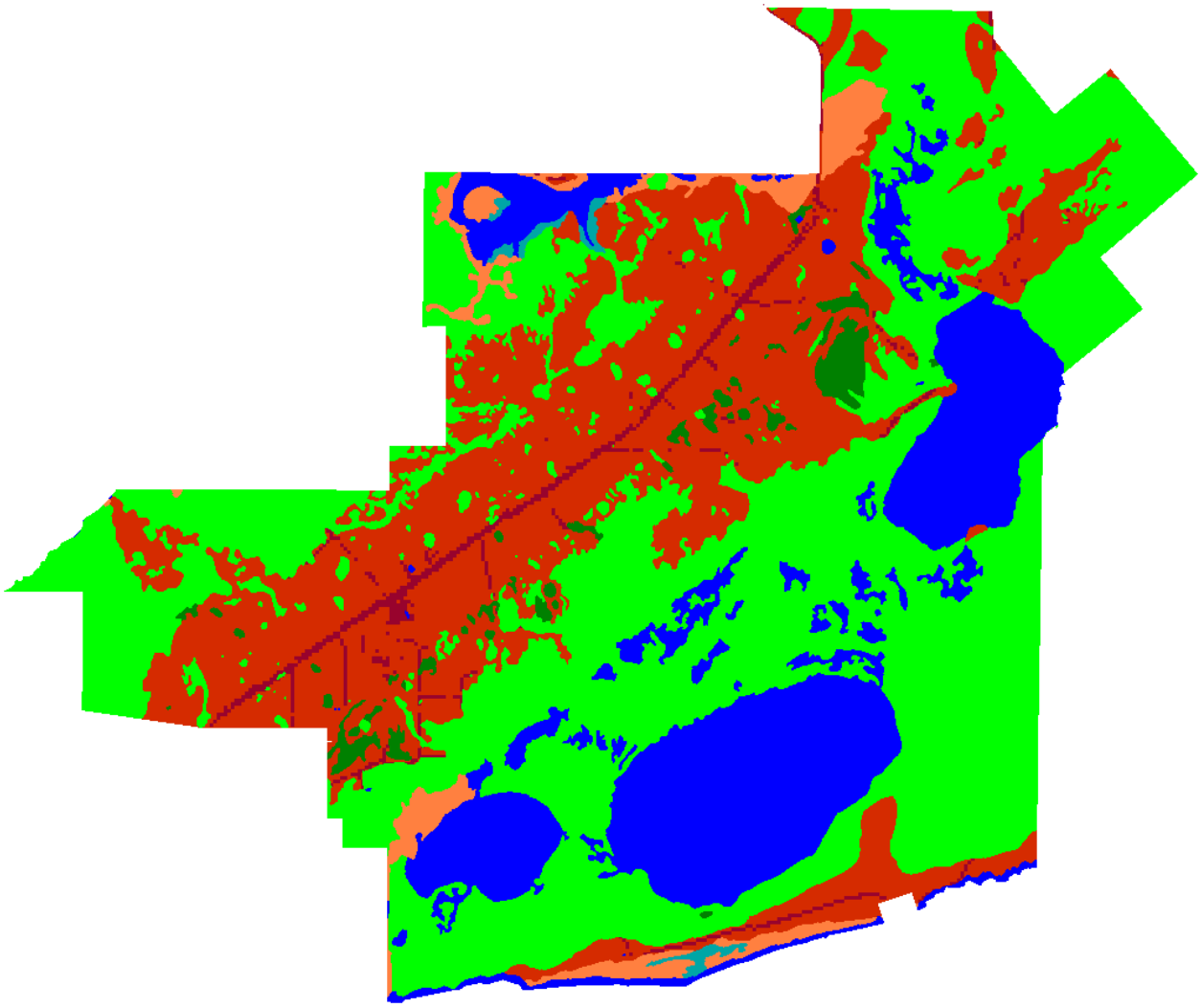


Moody NWR, 2100, 1.5 Meters

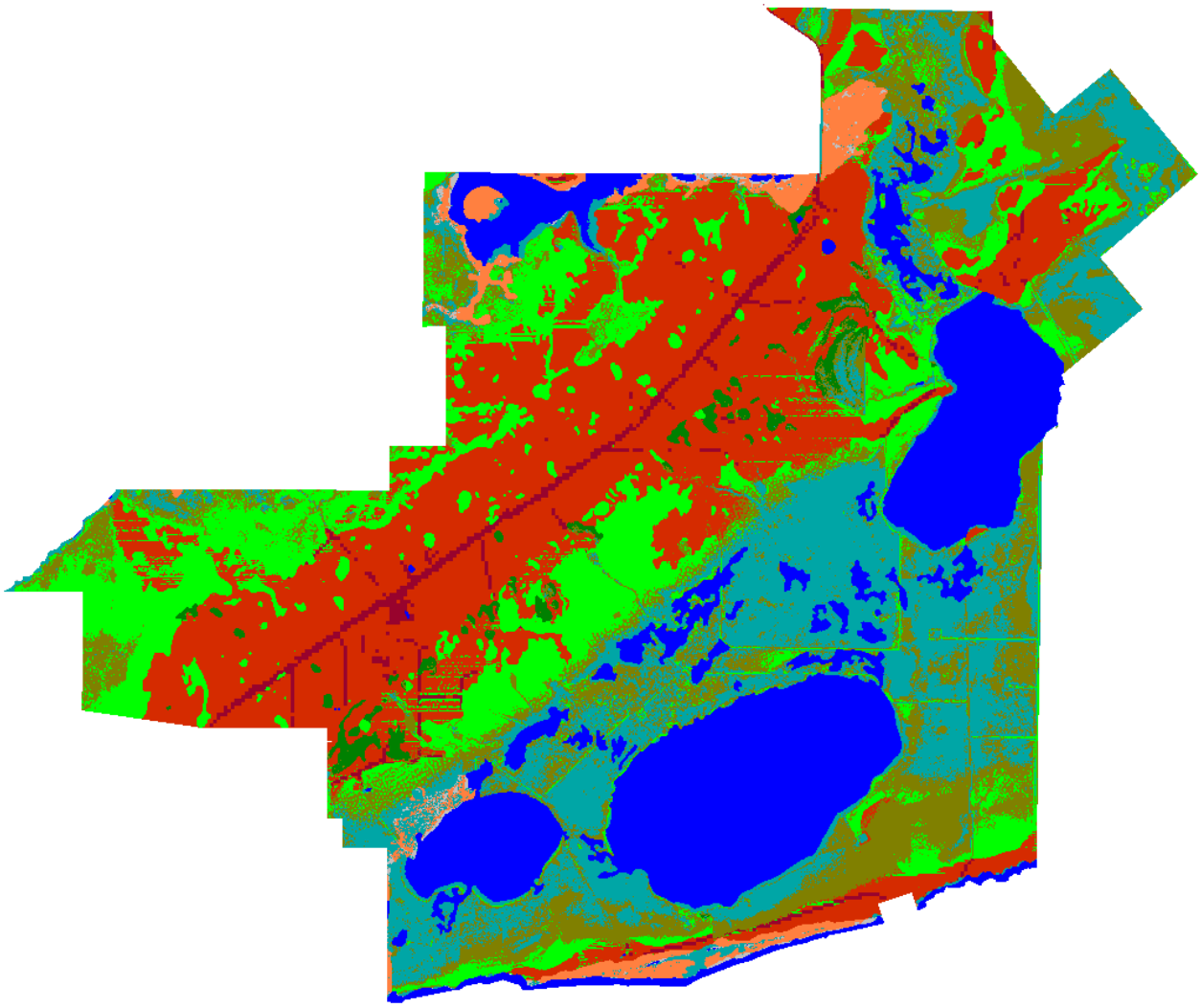
2 m eustatic SLR by 2100

Results in Acres

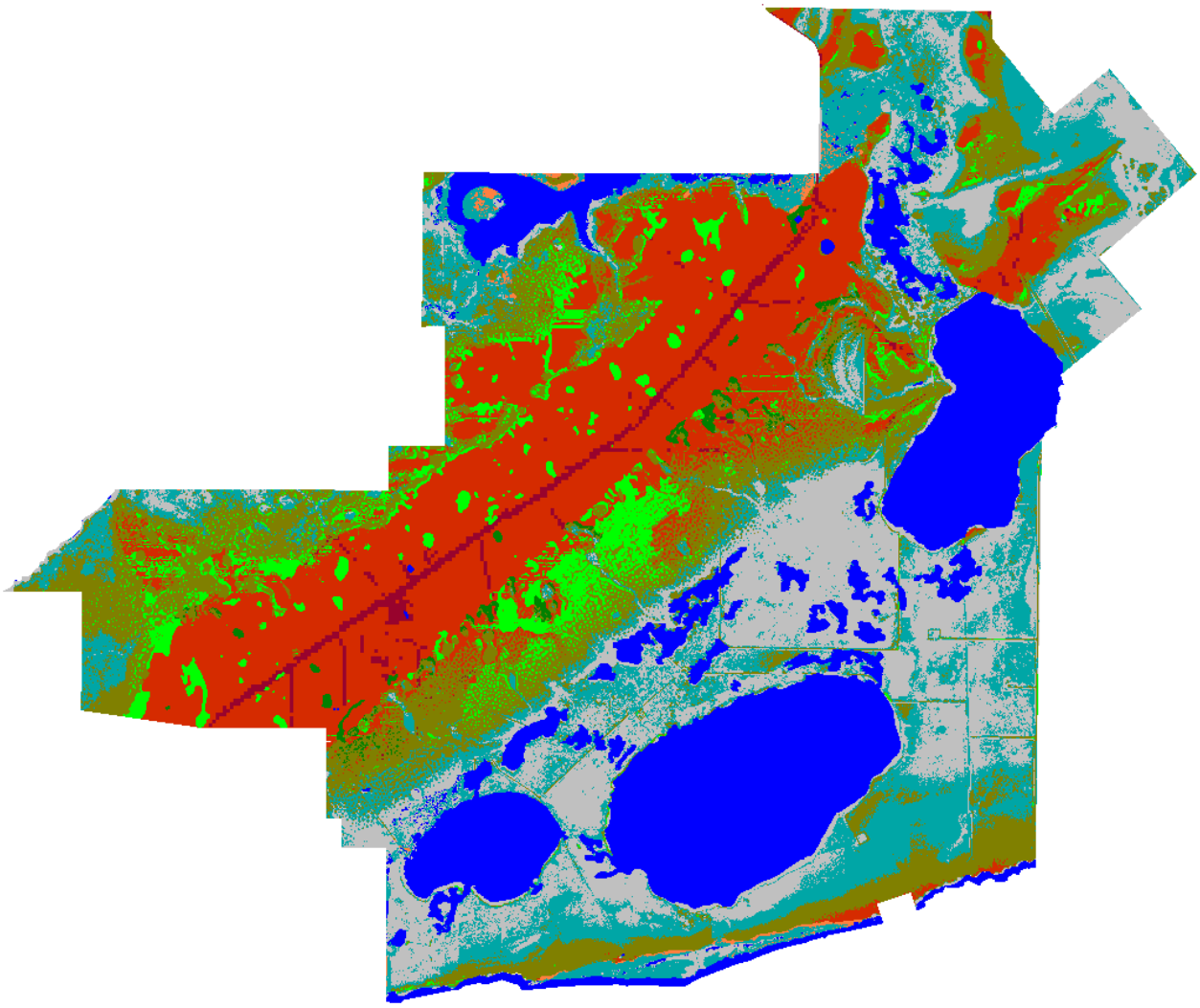
		Initial	2025	2050	2075	2100
	Inland Fresh Marsh	5316	1935	592	110	44
	Undeveloped Dry Land	3342	3084	2444	1599	881
	Inland Open Water	1812	933	903	898	897
	Irregularly Flooded Marsh	330	259	43	1	0
	Estuarine Open Water	212	1100	1219	3241	5206
	Developed Dry Land	199	191	149	133	115
	Swamp	183	136	66	17	4
	Regularly Flooded Marsh	45	2034	1952	2136	1394
	Tidal Flat	0	35	1974	1910	2084
	Transitional Salt Marsh	0	1731	2094	1393	813
	Total (incl. water)	**11438**	**11438**	**11438**	**11438**	**11438**



Moody NWR, Initial Condition



Moody NWR, 2025, 2 Meters



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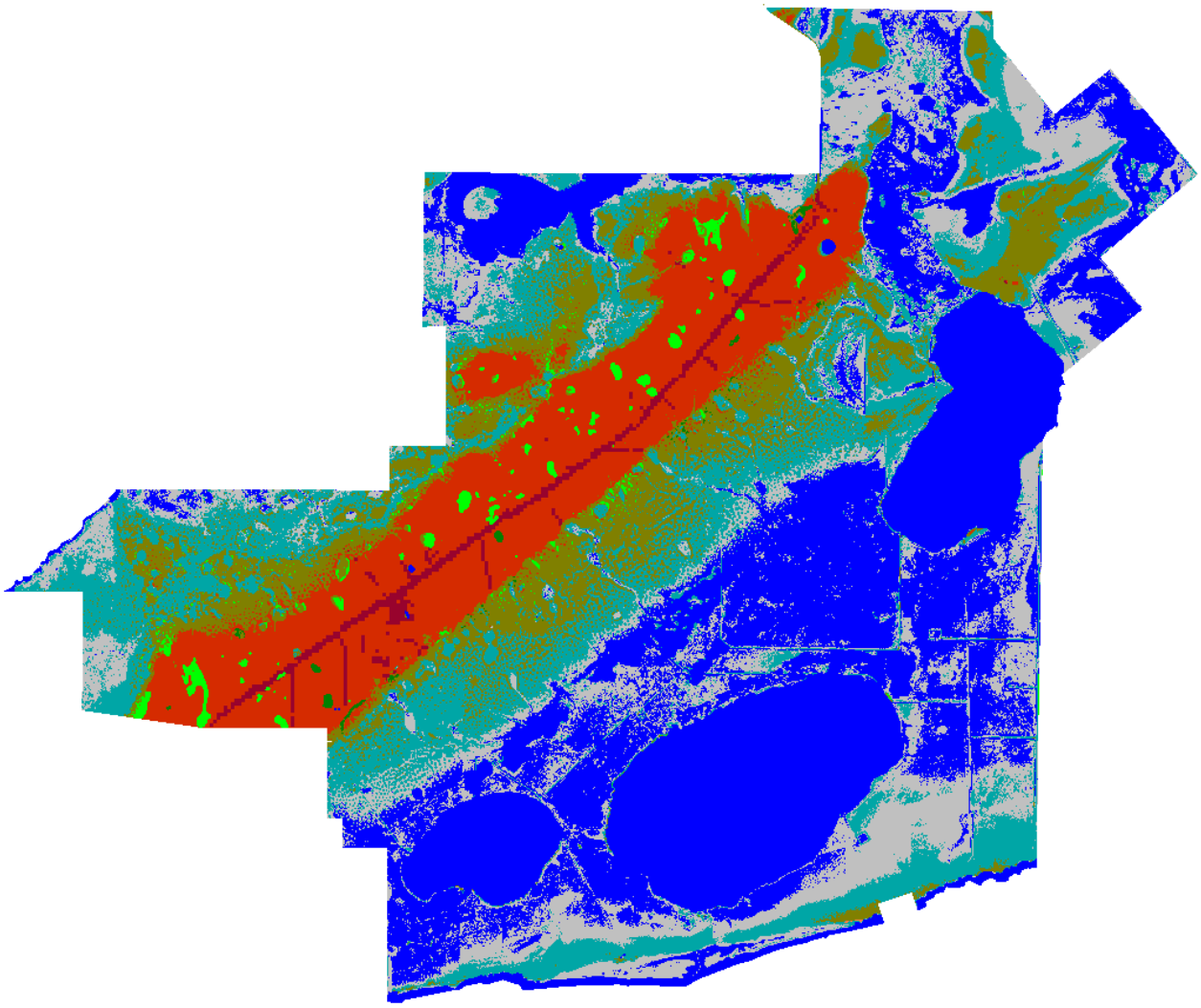

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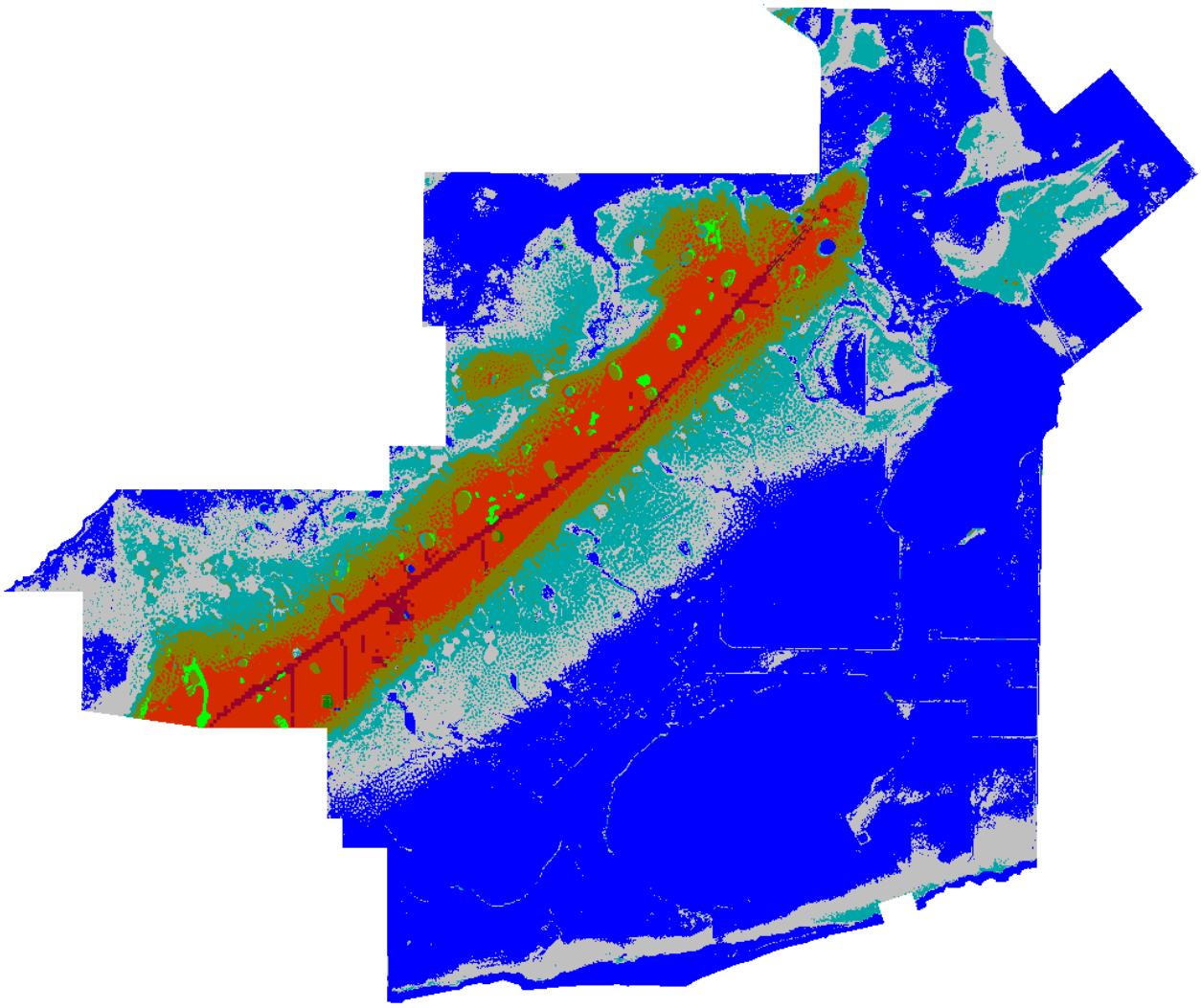

Moody NWR, 2100, 2 Meters

Discussion

Model results for Moody NWR indicate that it is vulnerable to sea level rise under all SLR scenarios examined. The inland-fresh marsh category is predicted by SLAMM to sustain considerable losses under all the SLR scenarios examined. Initially, this may be due to the improper classification of these lands as inland-fresh marsh rather than a more appropriate designation as transitional marsh in the initial wetlands data layer. Regardless of initial classification, the interior low-lying areas of the refuge are predicted to convert to open water in each of the SLR scenarios examined.

Elevation data were based on high-vertical-resolution LiDAR data for the entire refuge, reducing model uncertainty considerably. An elevation uncertainty analysis found minimal variations in model predictions on the basis of elevation-data uncertainty (Warren Pinnacle Consulting, Inc. 2011).

Significant amounts of dry land are predicted to convert to marsh, both due to soil saturation and inundation. Under the 1 m by 2100 SLR scenario (considered by many scientists to be likely, e.g. Vermeer and Rahmstorf 2009), 45% of the dry land in the refuge is predicted to be lost, as is 31% of developed dry land.

The area surrounding Moody was studied in a previous SLAMM analysis funded by The Nature Conservancy (Warren Pinnacle Consulting, Inc. 2011). Maps of results for the larger study area are presented in the "contextual maps" below.

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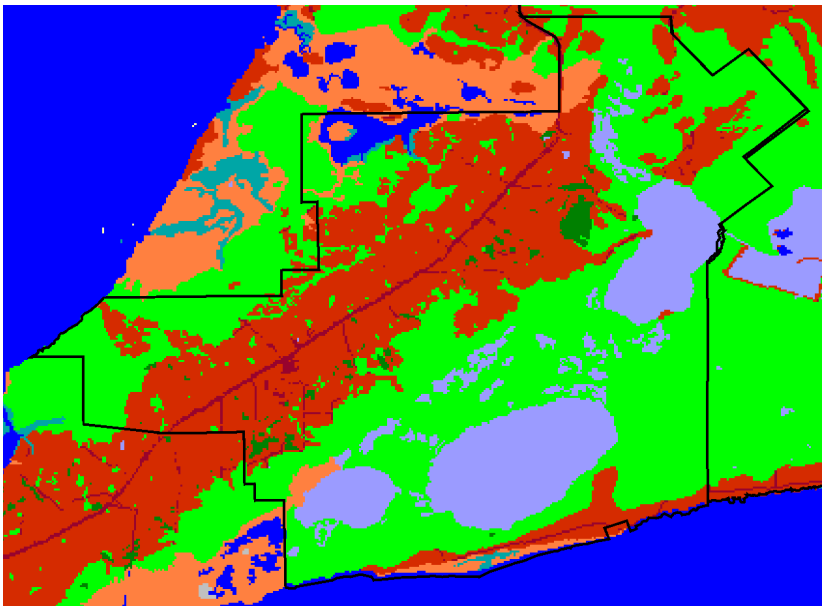
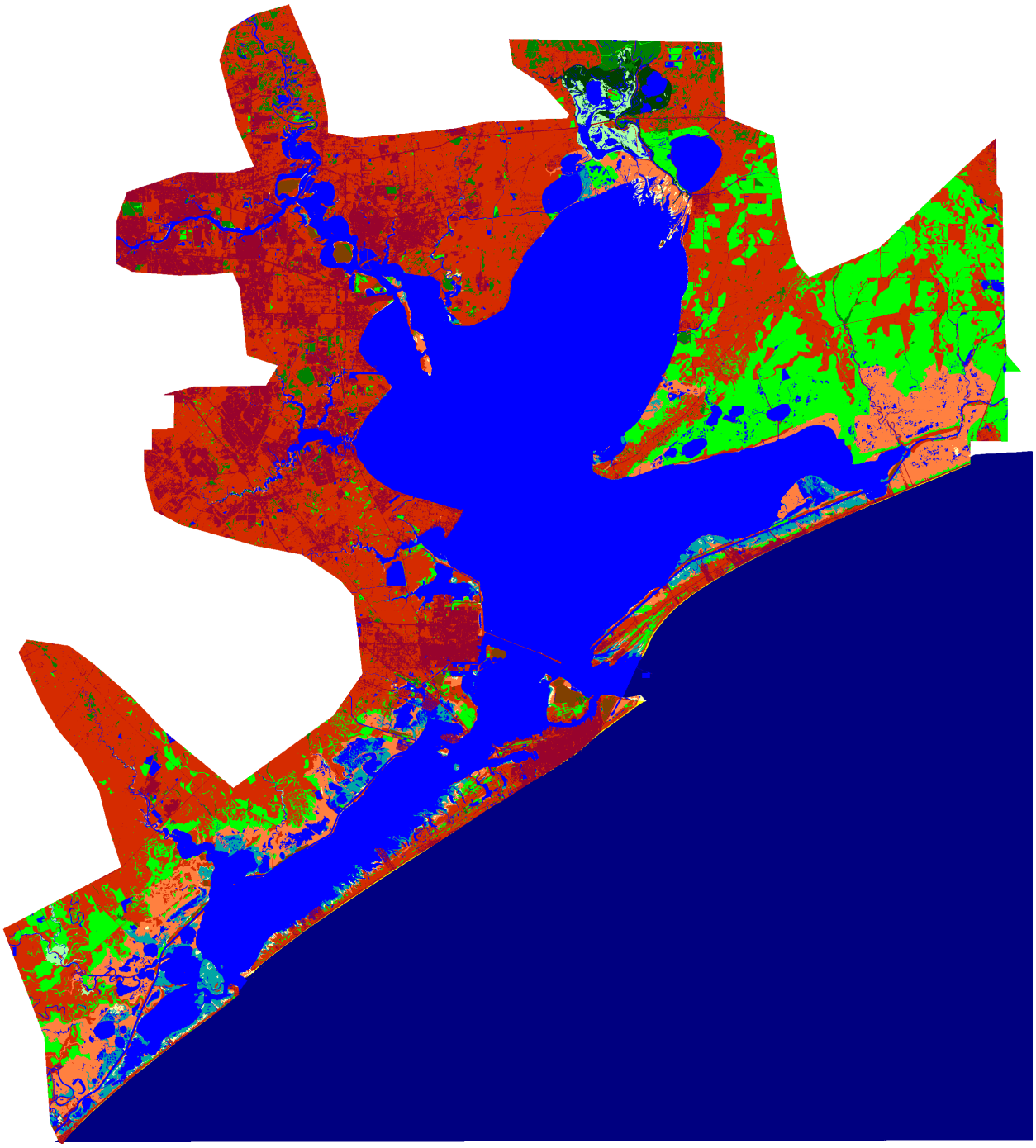
Appendix A: Contextual Results

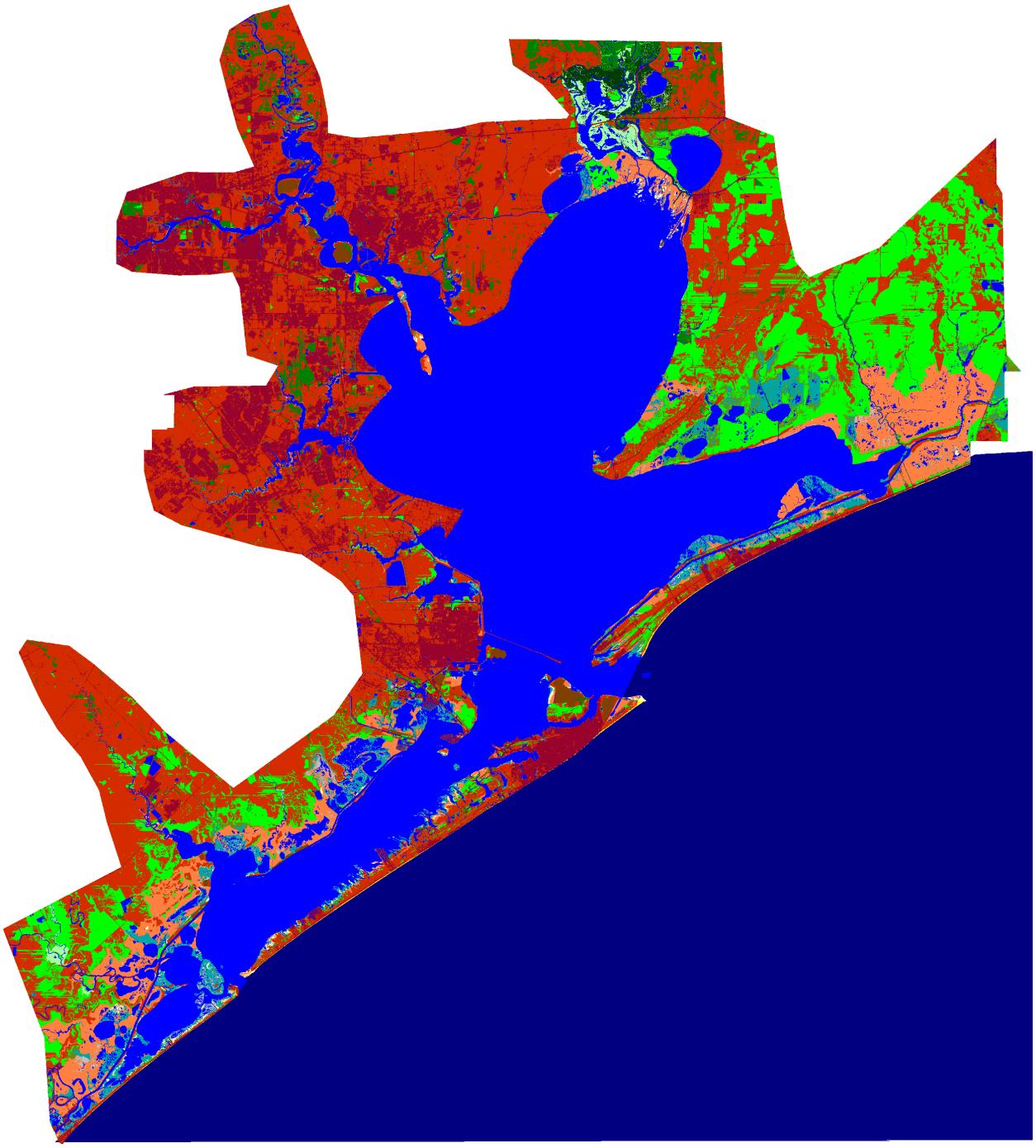
The SLAMM model does take into account the context of the surrounding lands or open water when calculating effects. For example, erosion rates are calculated based on the maximum fetch (wave action) which is estimated by assessing contiguous open water to a given marsh cell. Another example is that inundated 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. A full analysis of this study are was funded by the Sea-Level Rise and Conservation Project of The Nature Conservancy who also provided GIS processing in support of these analyses. Funding for this project of The Nature Conservancy was provided through a grant from the Gulf of Mexico Foundation, Inc., to support the Gulf of Mexico Alliance.



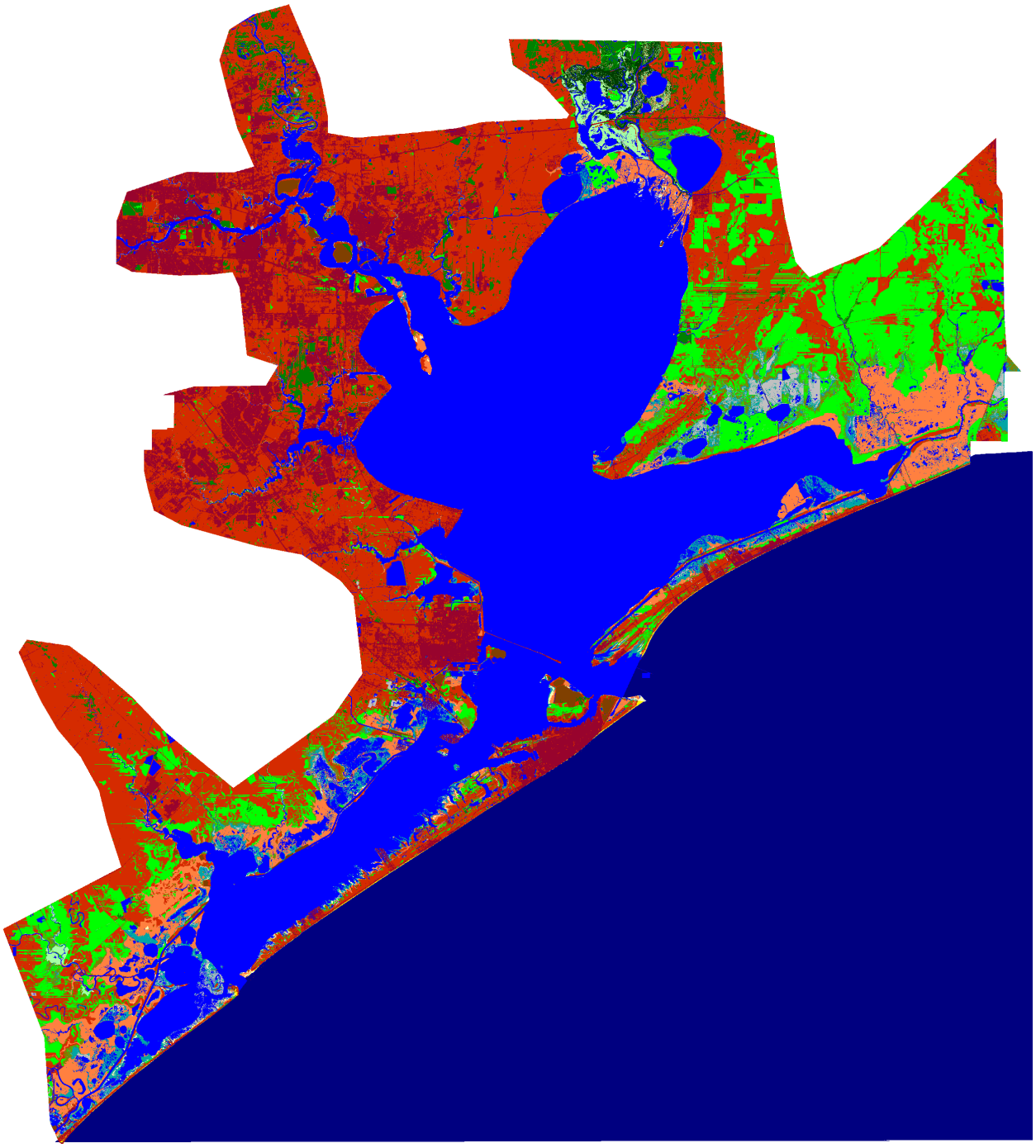
Moody National Wildlife Refuge within simulation context (outlined in black).



Moody Context, Initial Condition



Moody Context, 2025, Scenario A1B Mean



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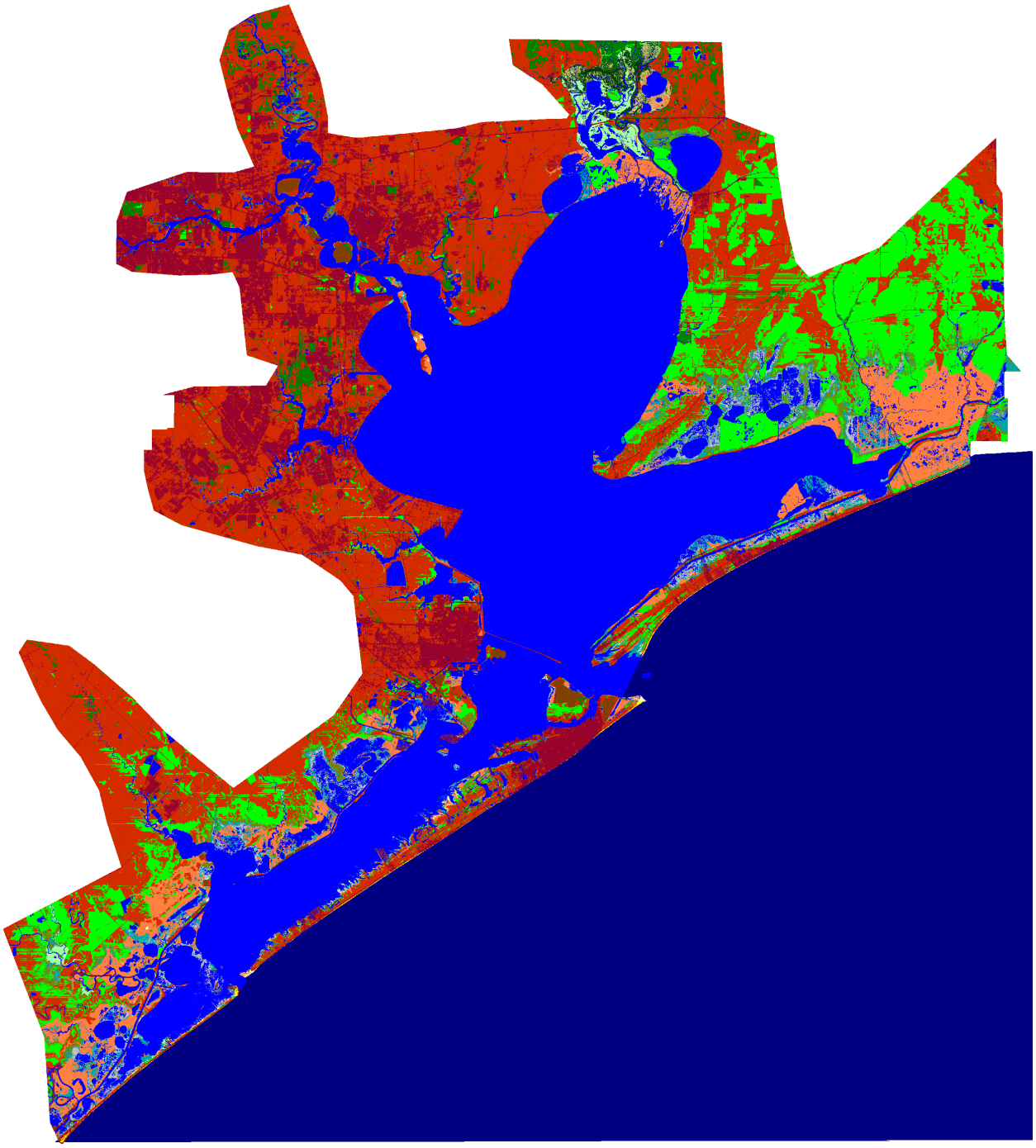
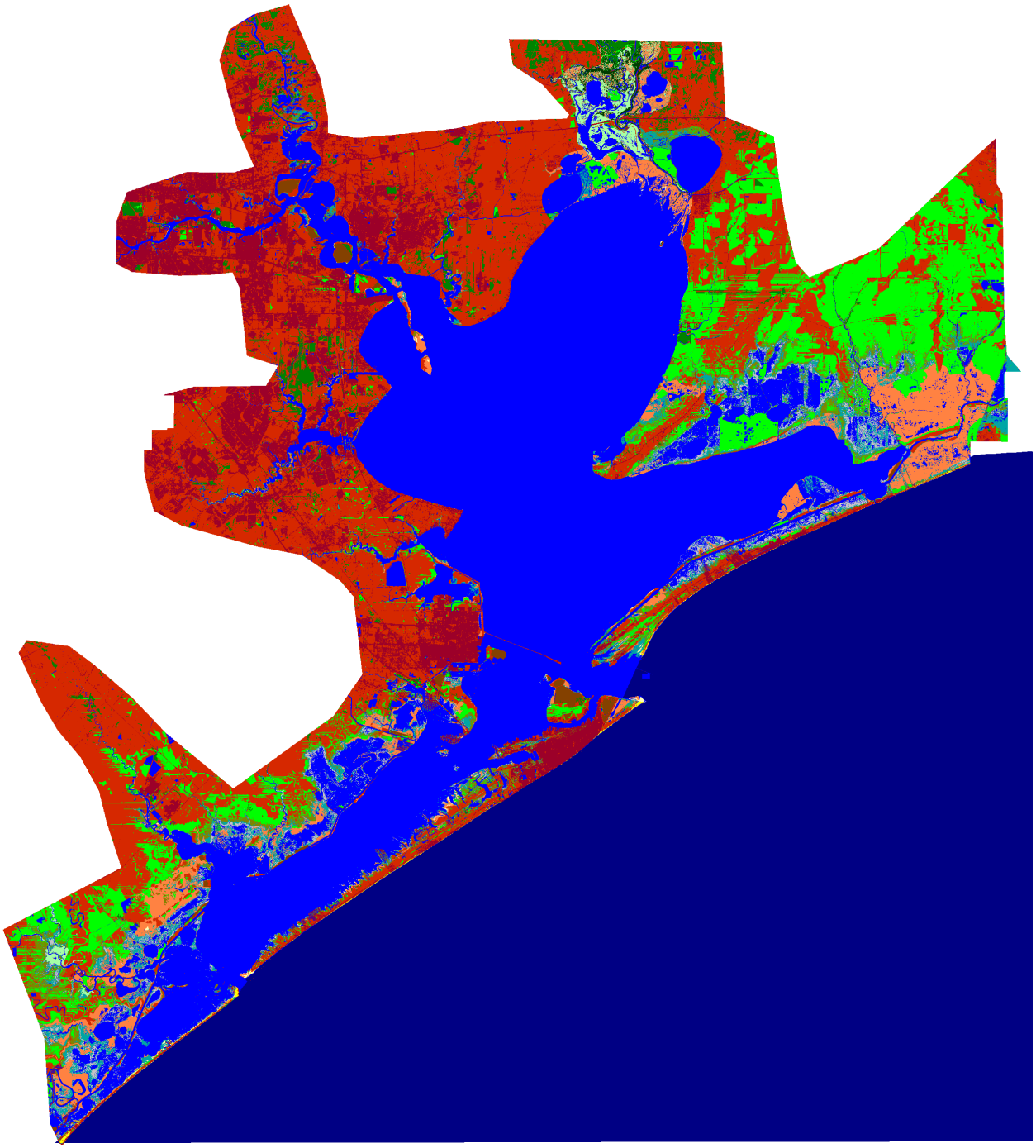
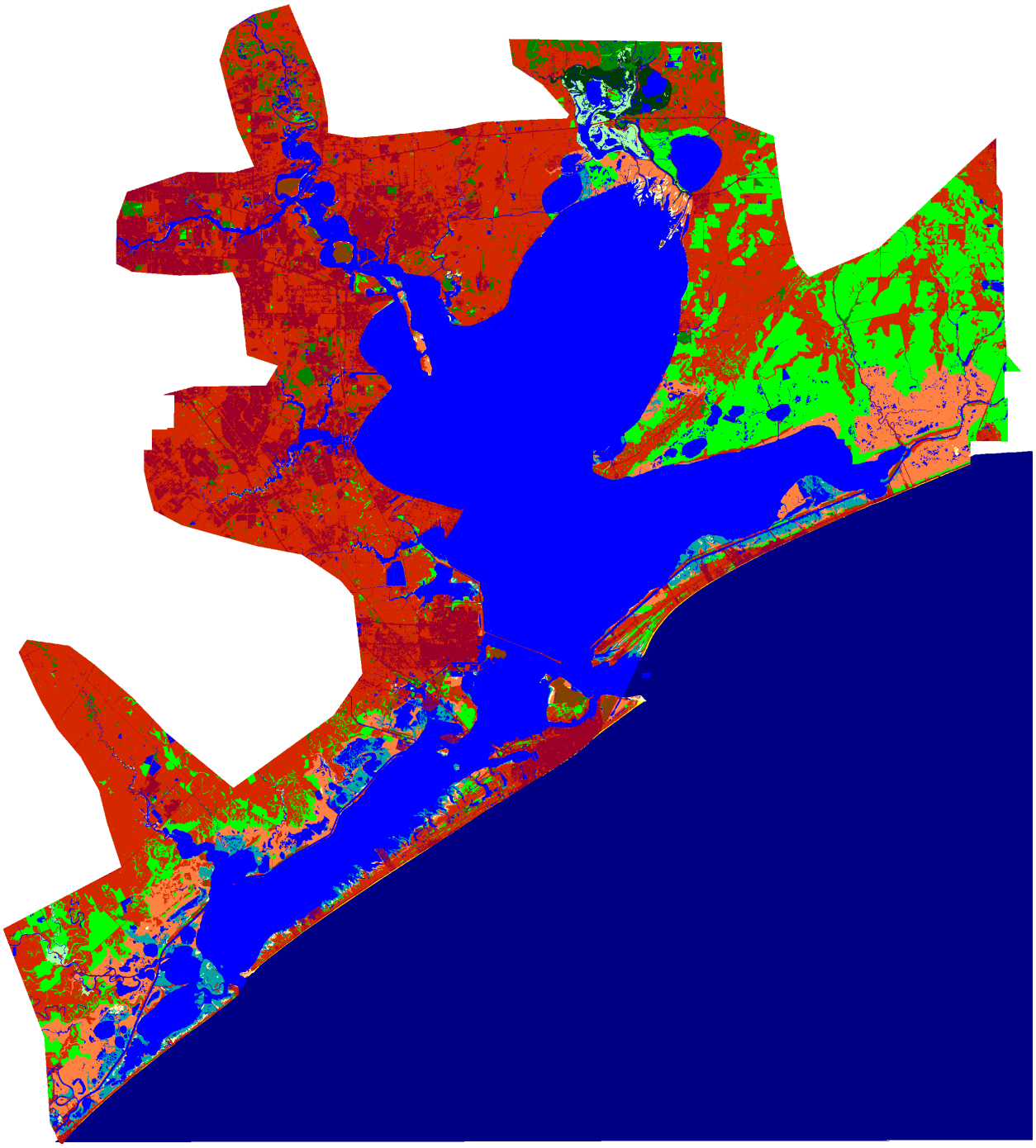


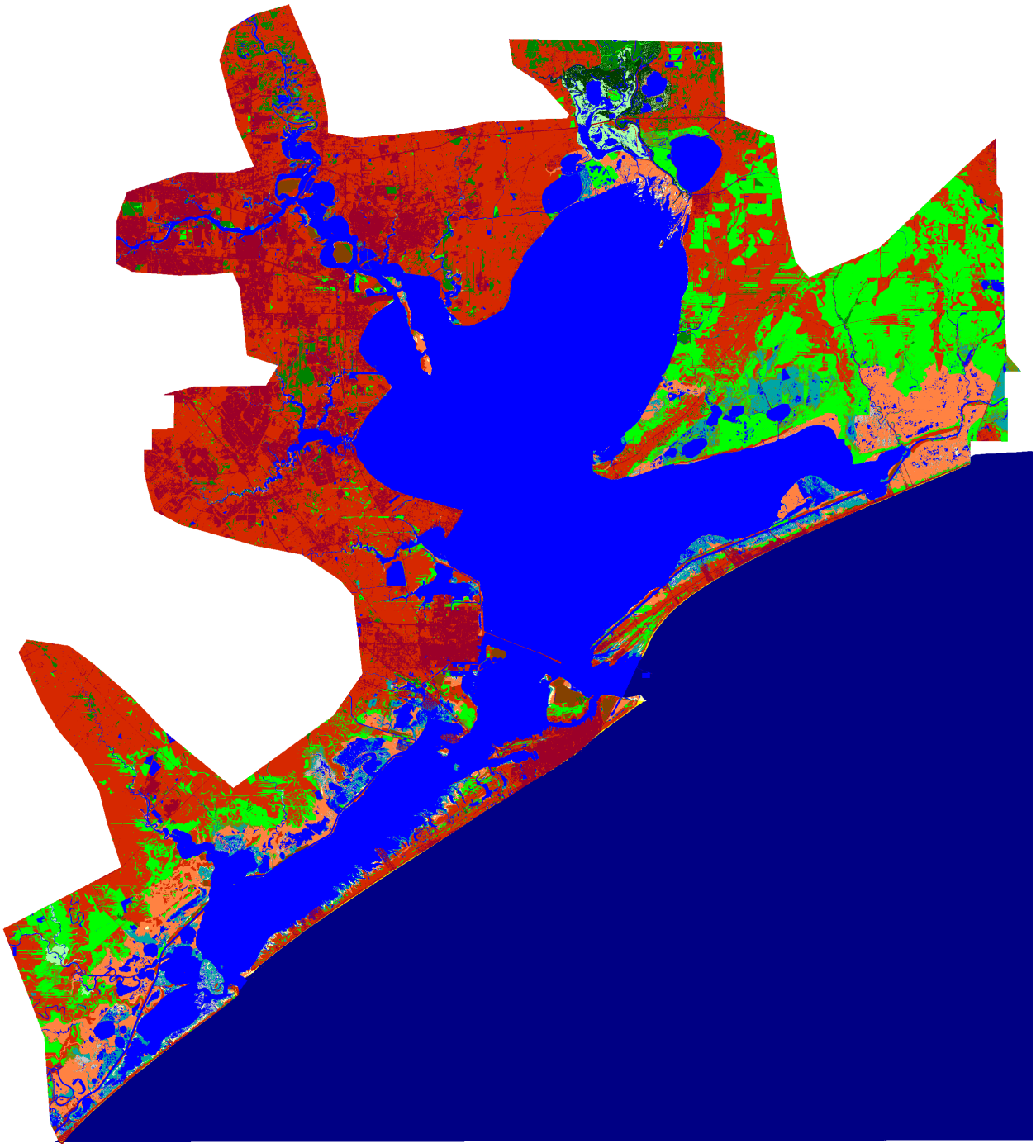
Moody Context, 2075, Scenario A1B Mean



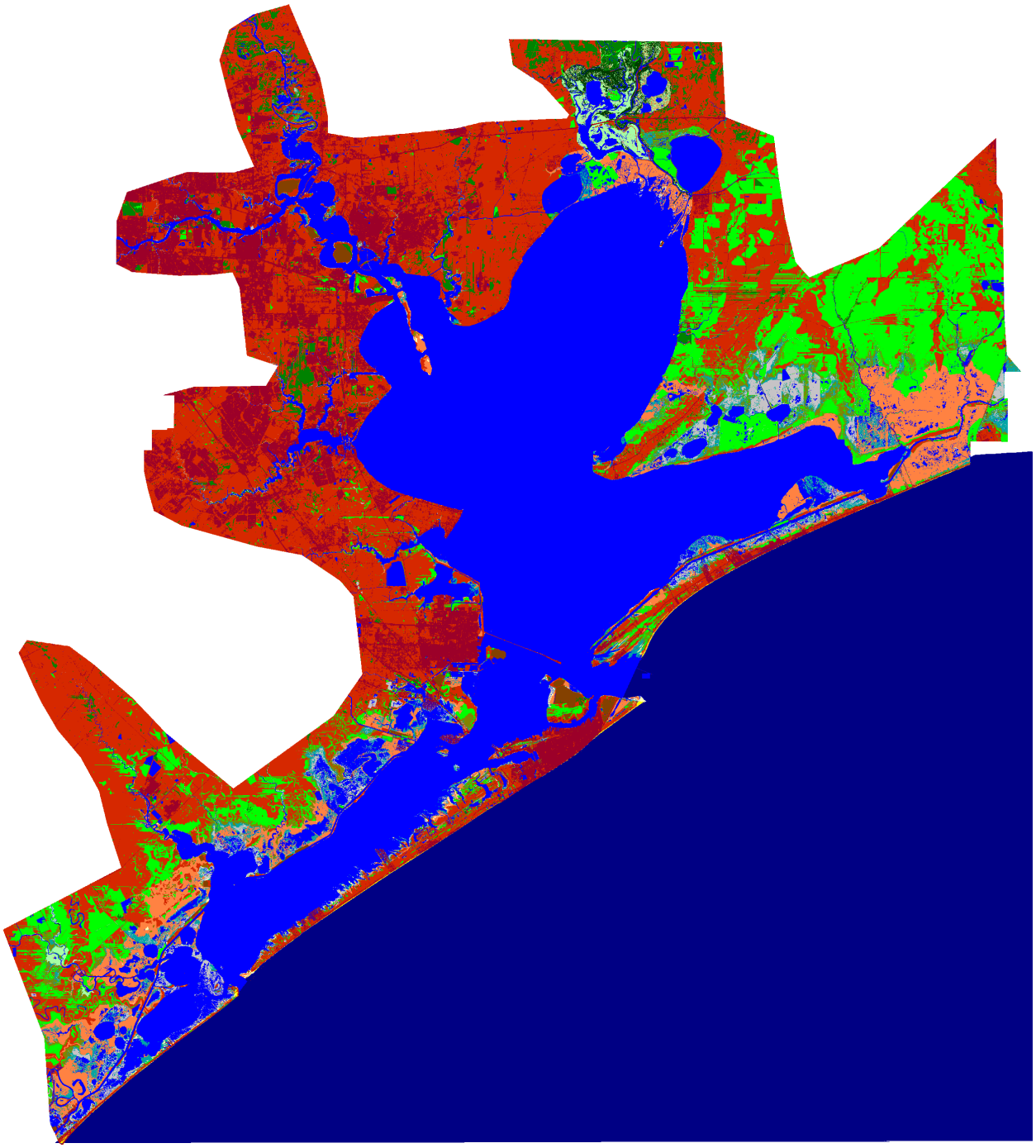
Moody Context, 2100, Scenario A1B Mean



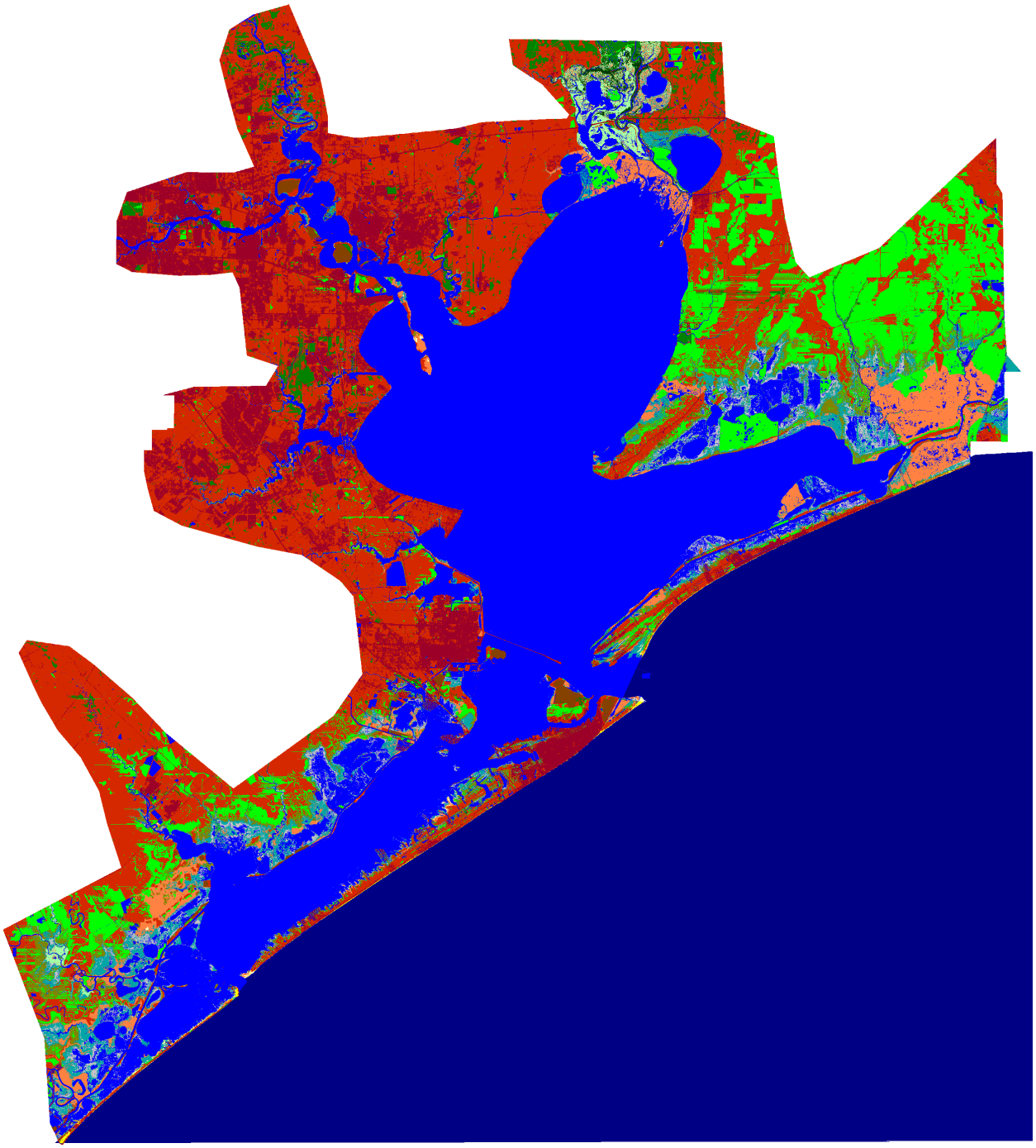
Moody Context, Initial Condition



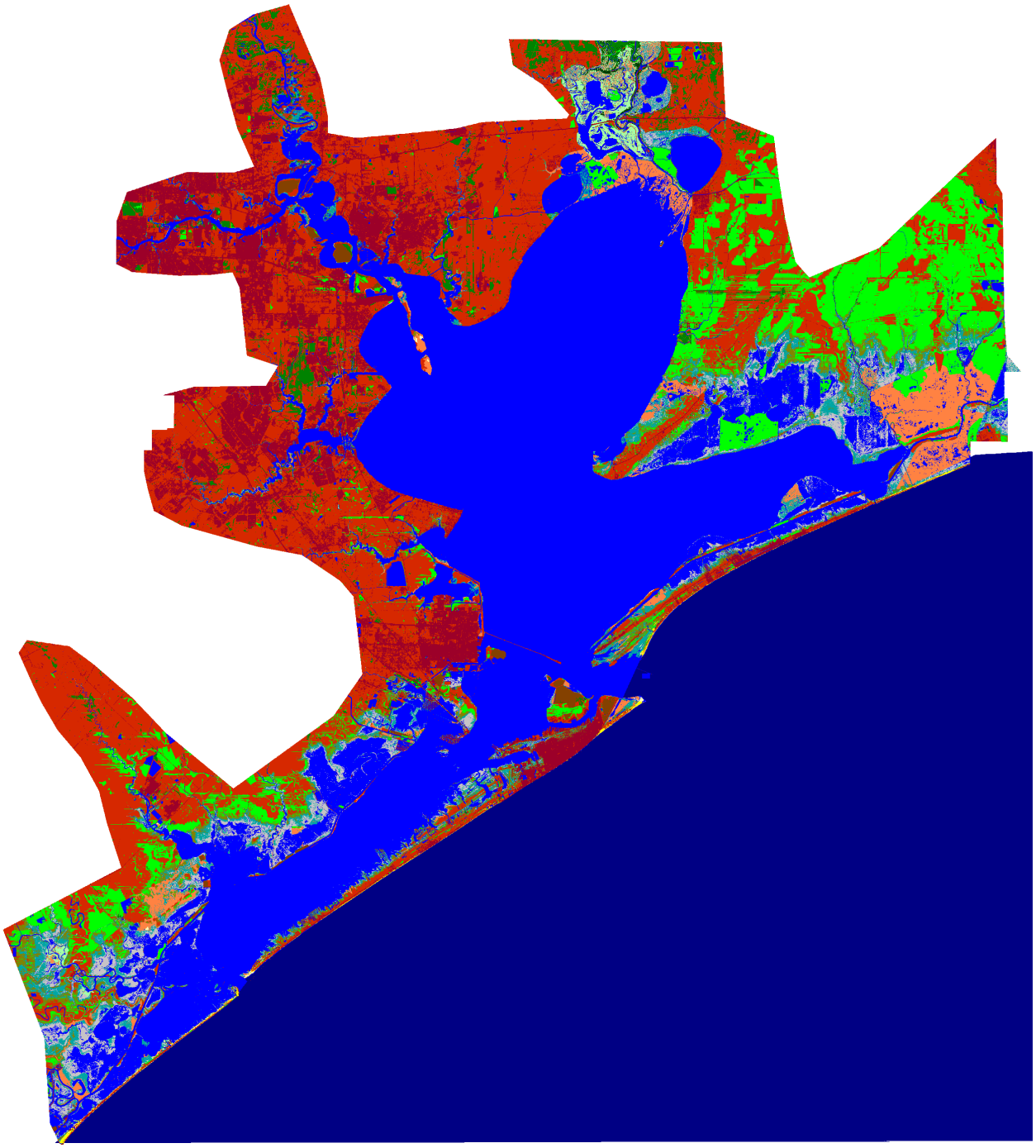
Moody Context, 2025, Scenario A1B Maximum



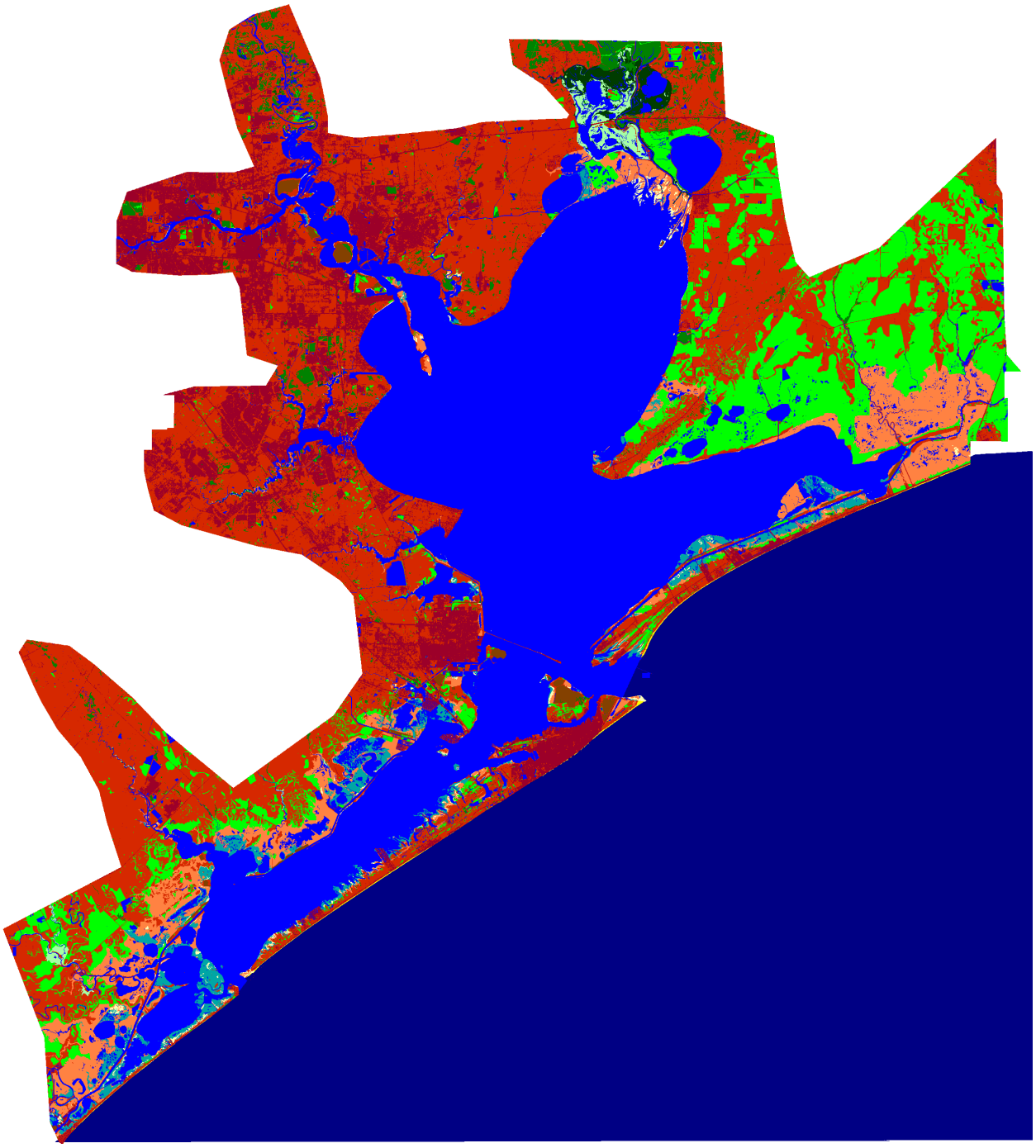
Moody Context, 2050, Scenario A1B Maximum



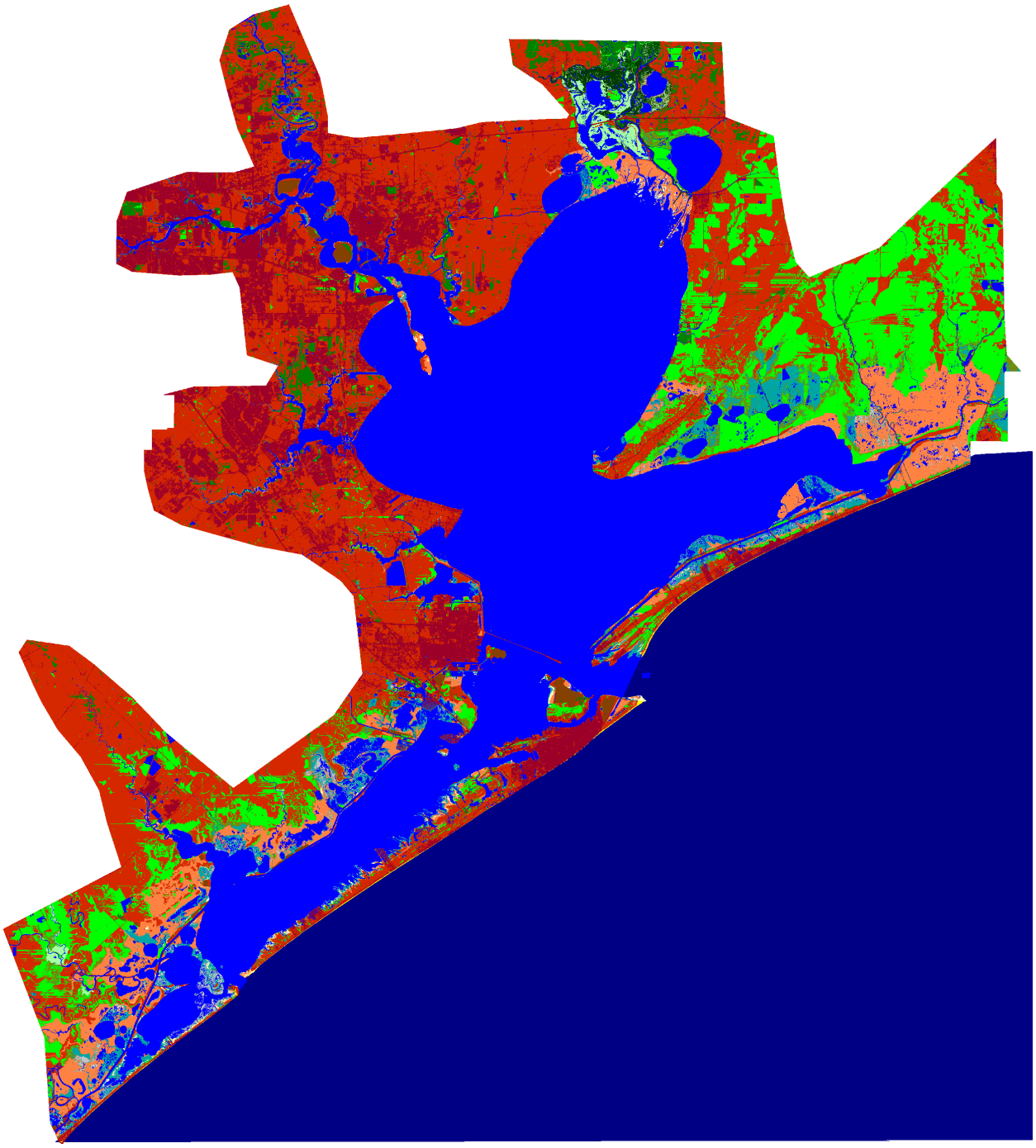
Moody Context, 2075, Scenario A1B Maximum



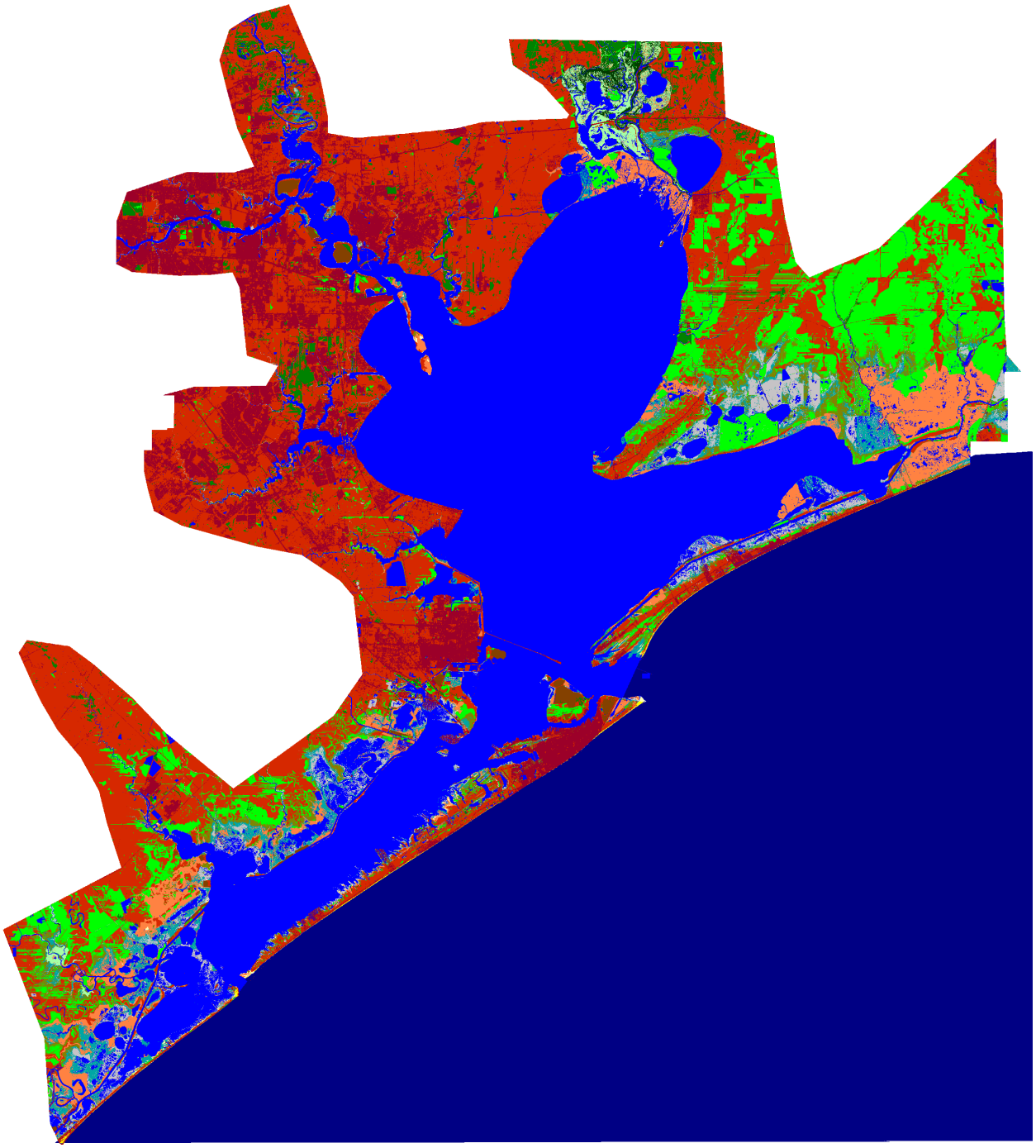
Moody Context, 2100, Scenario A1B Maximum



Moody Context, Initial Condition



Moody Context, 2025, 1 m



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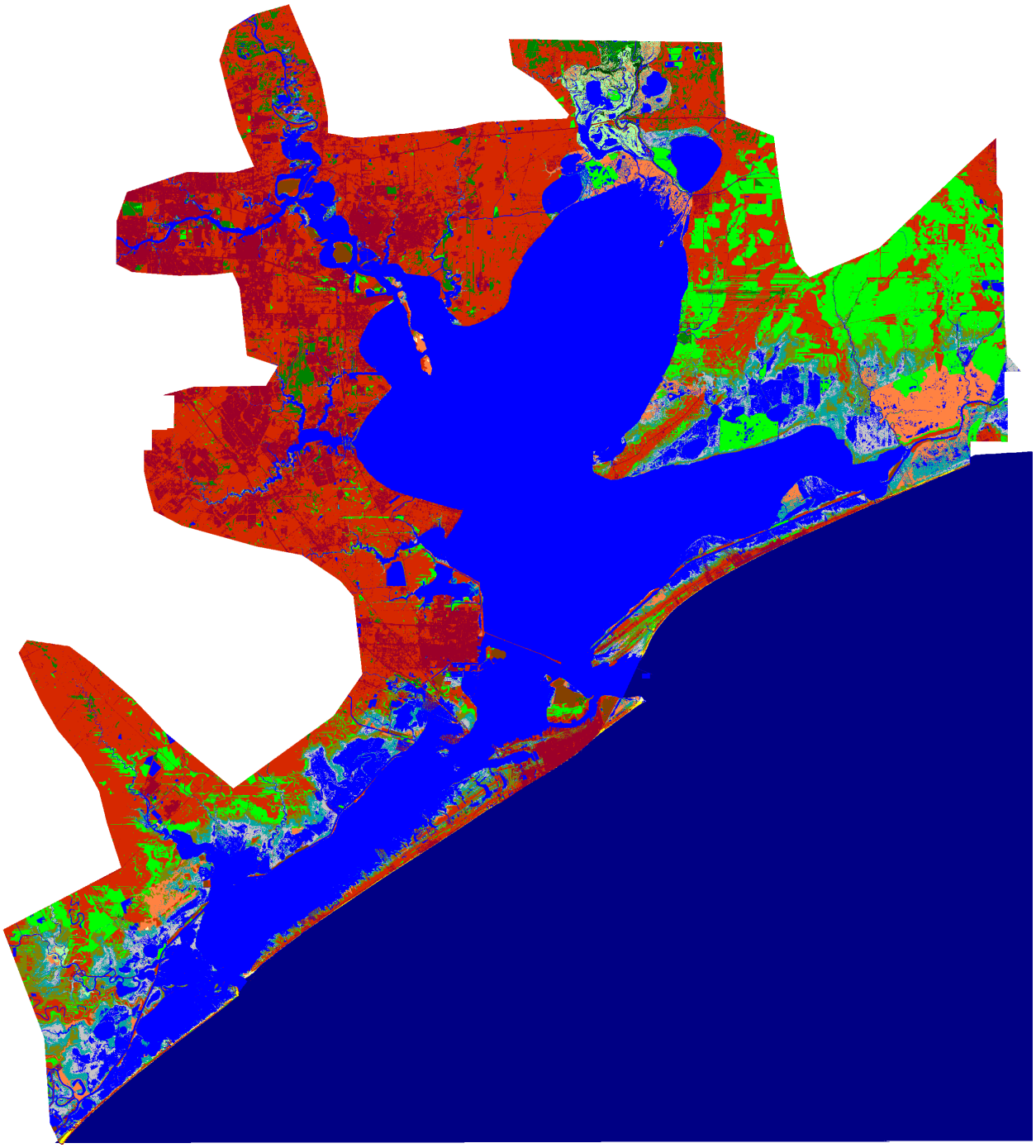

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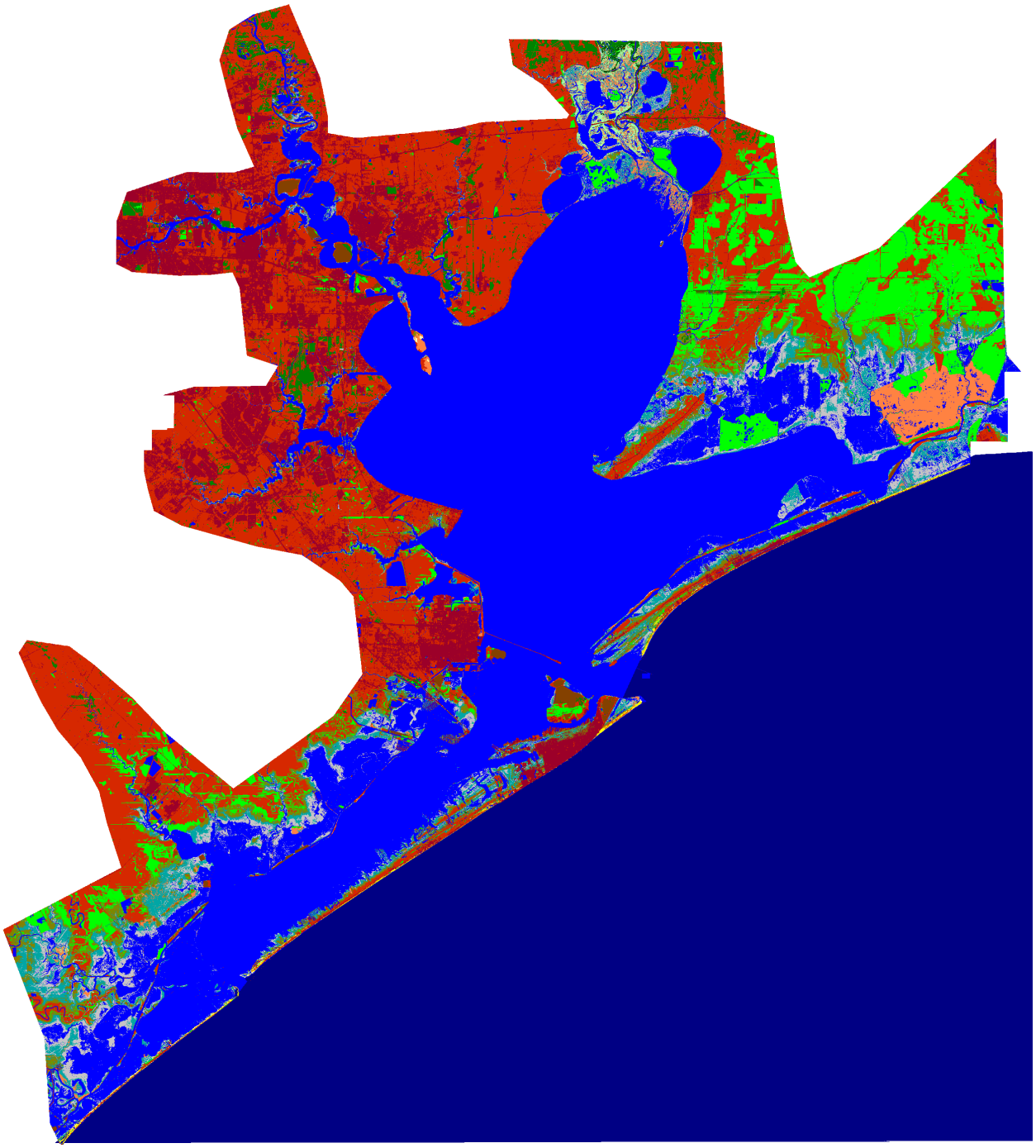
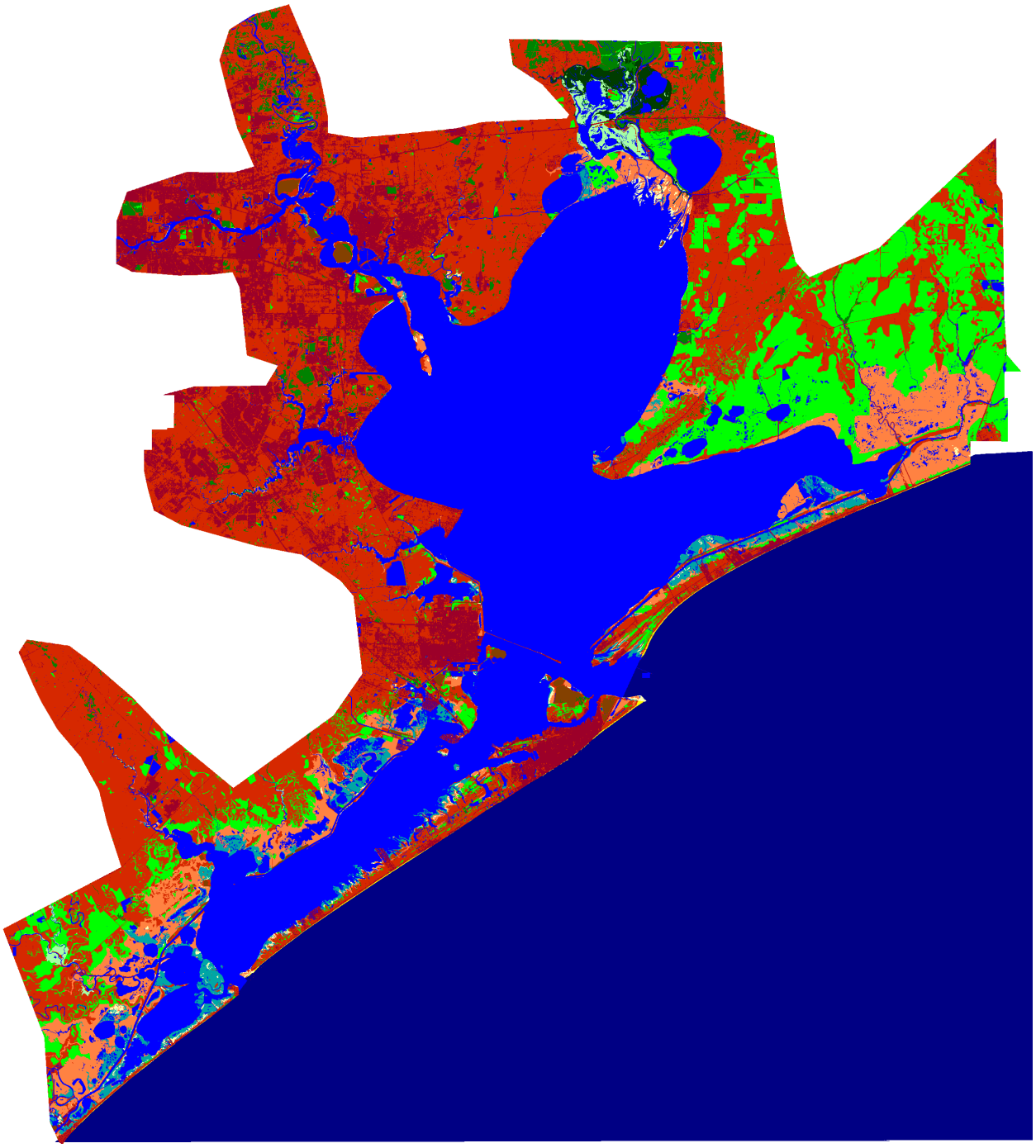
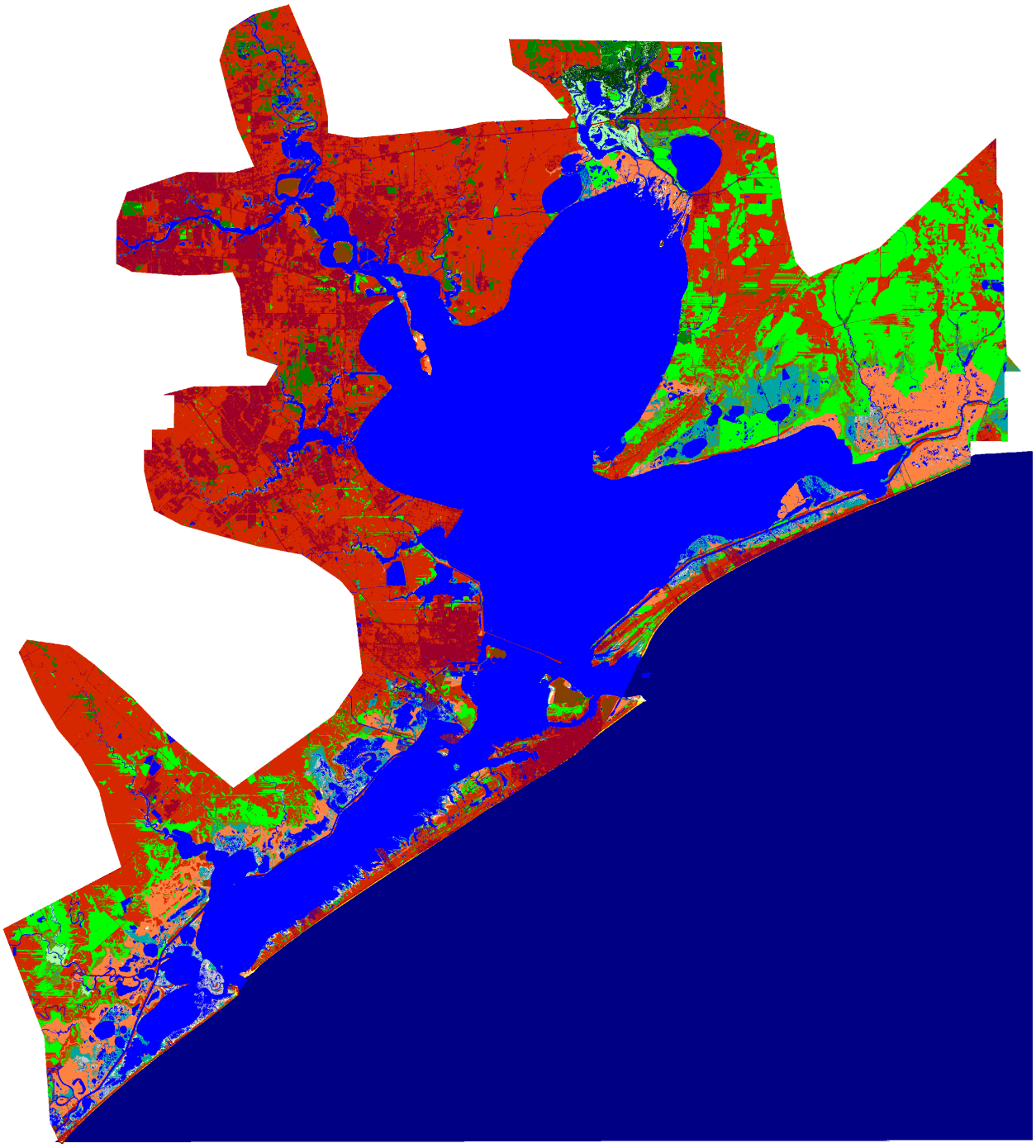


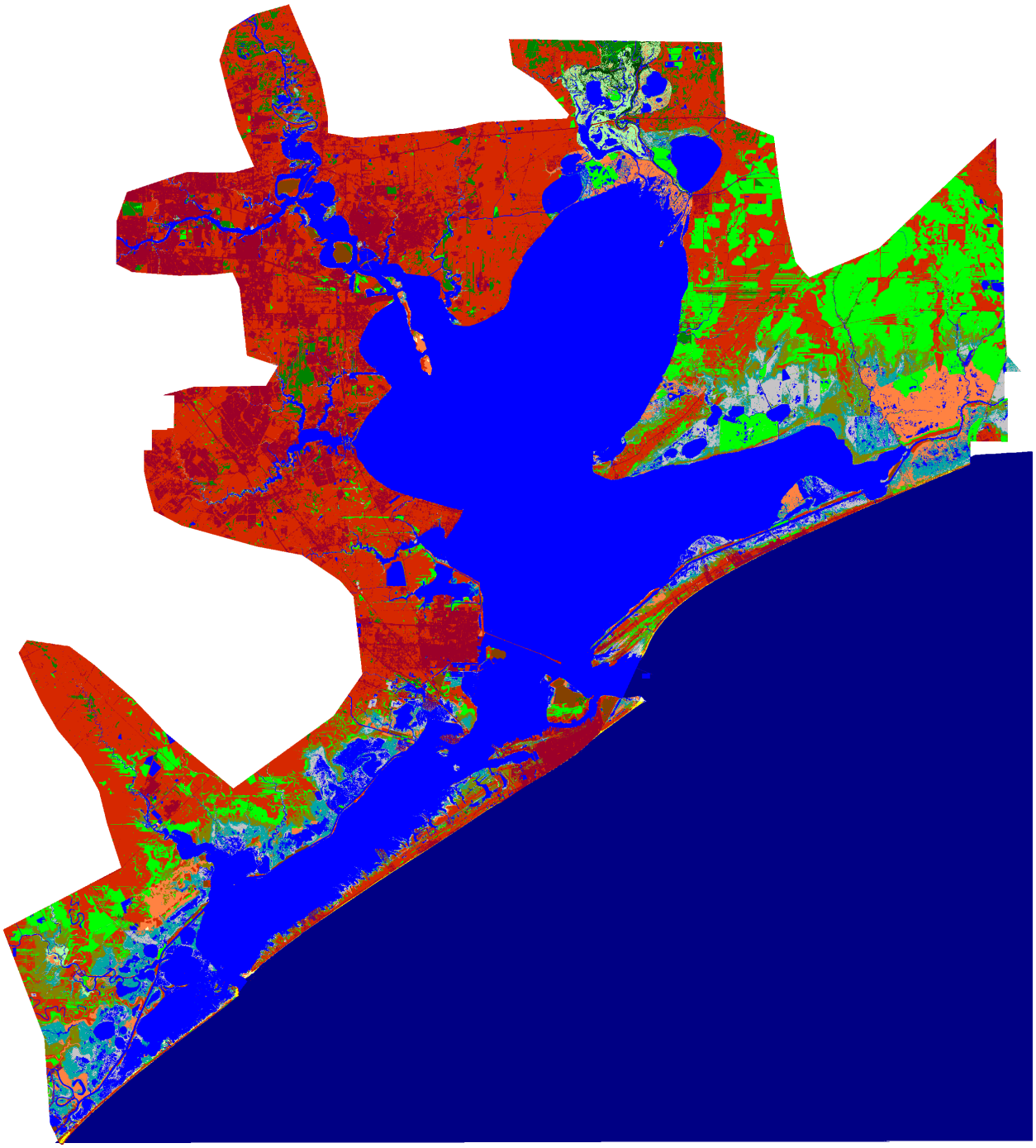
Moody Context, 2100, 1 m



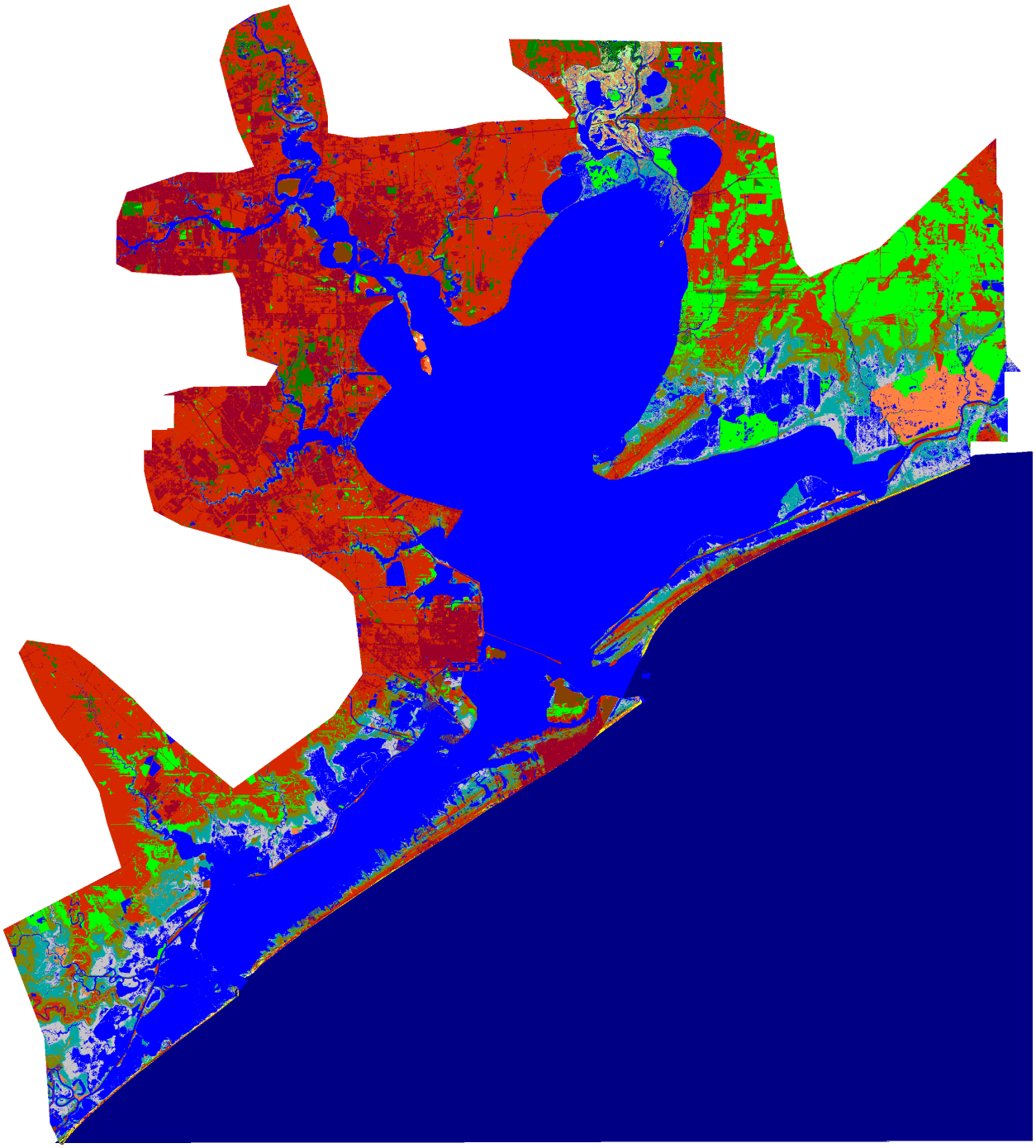
Moody Context, Initial Condition



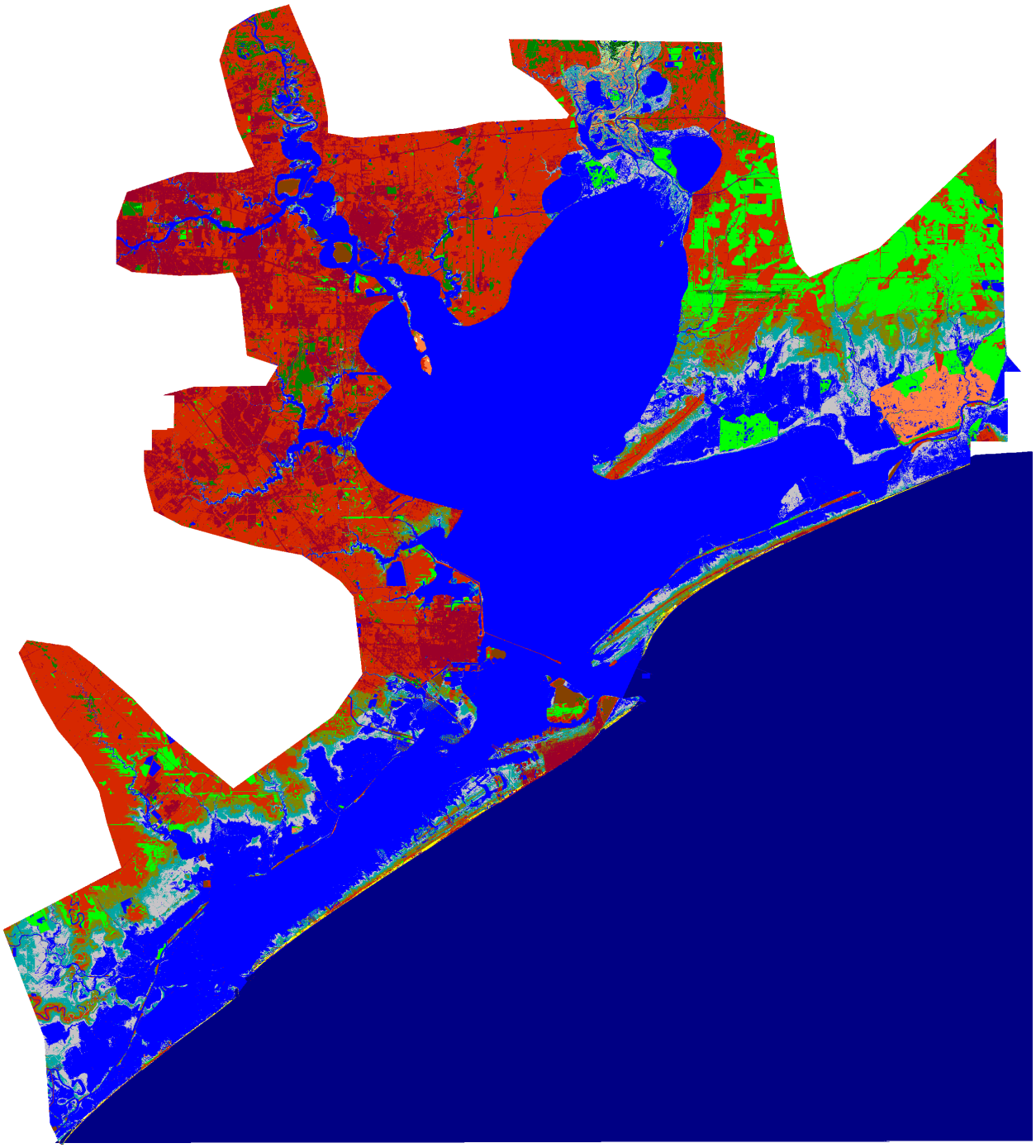
Moody Context, 2025, 1.5 m



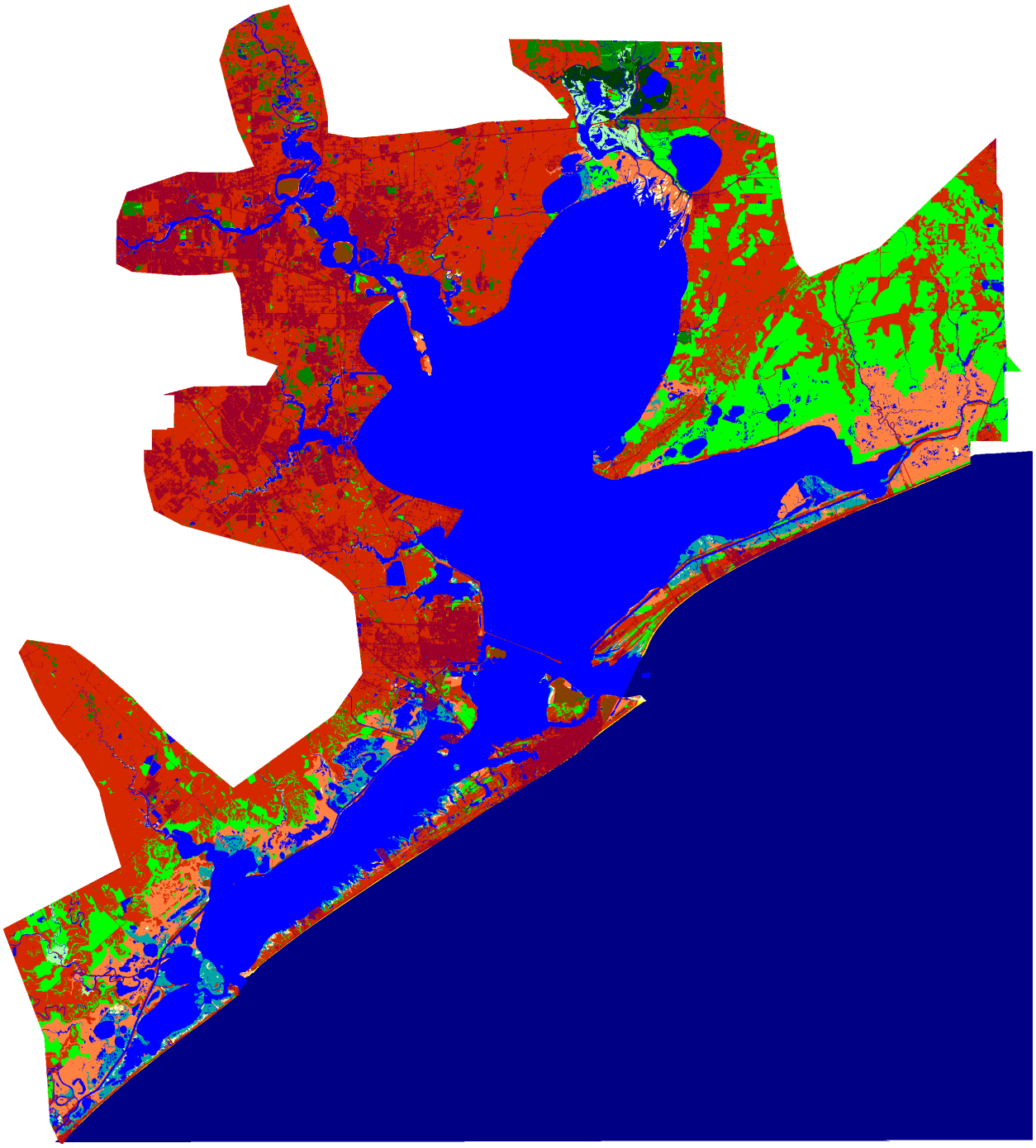
Moody Context, 2050, 1.5 m



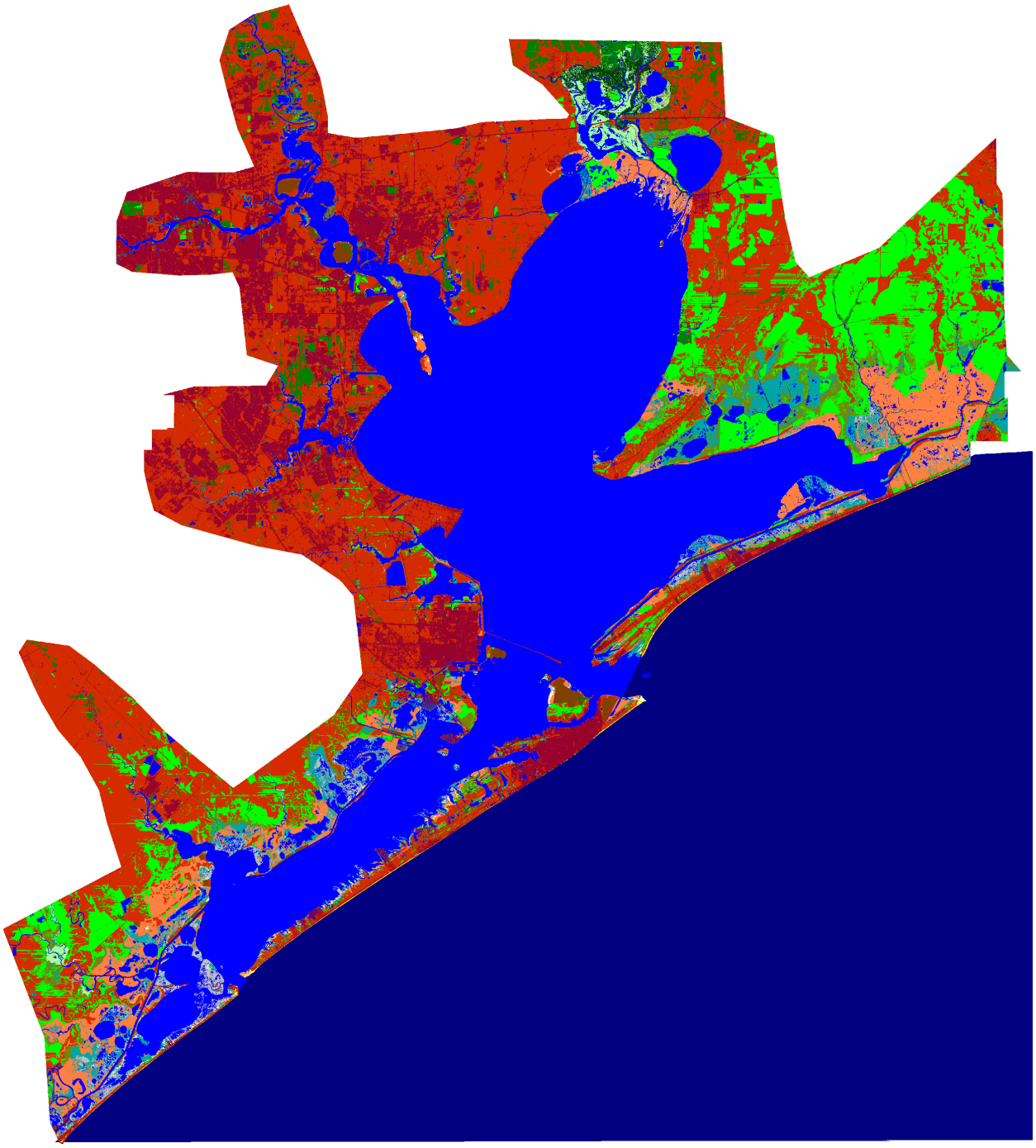
Moody Context, 2075, 1.5 m



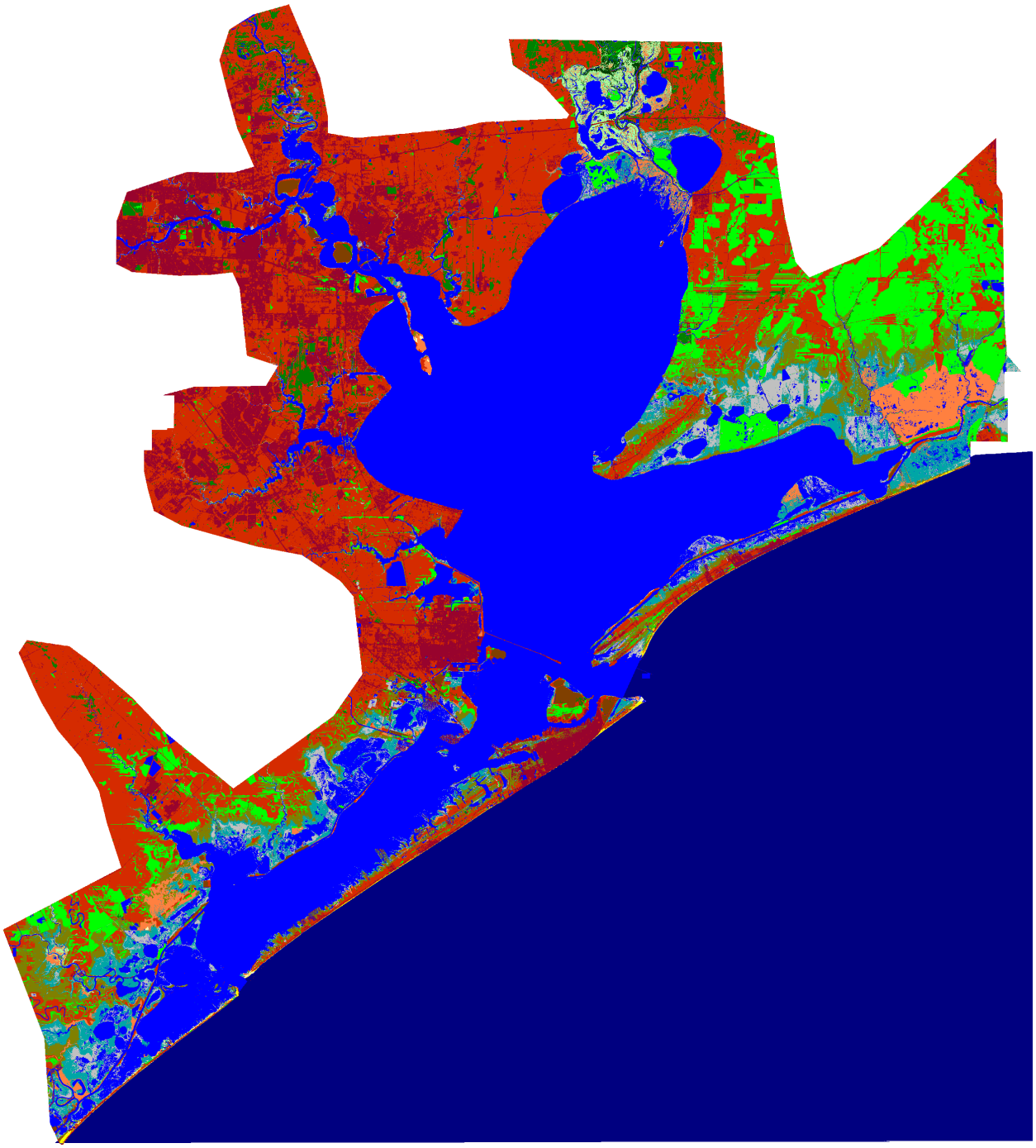
Moody Context, 2100, 1.5 m



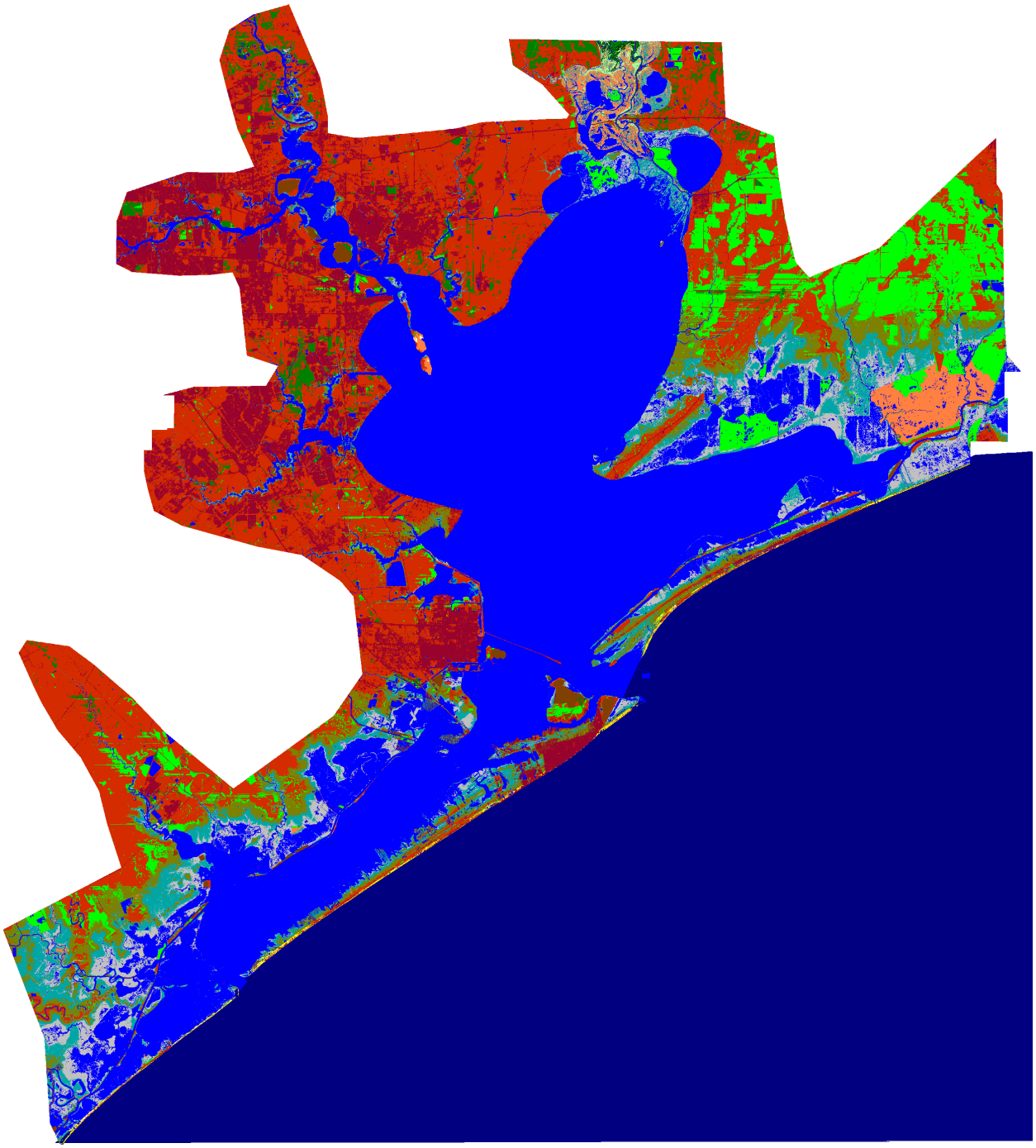
Moody Context, Initial Condition



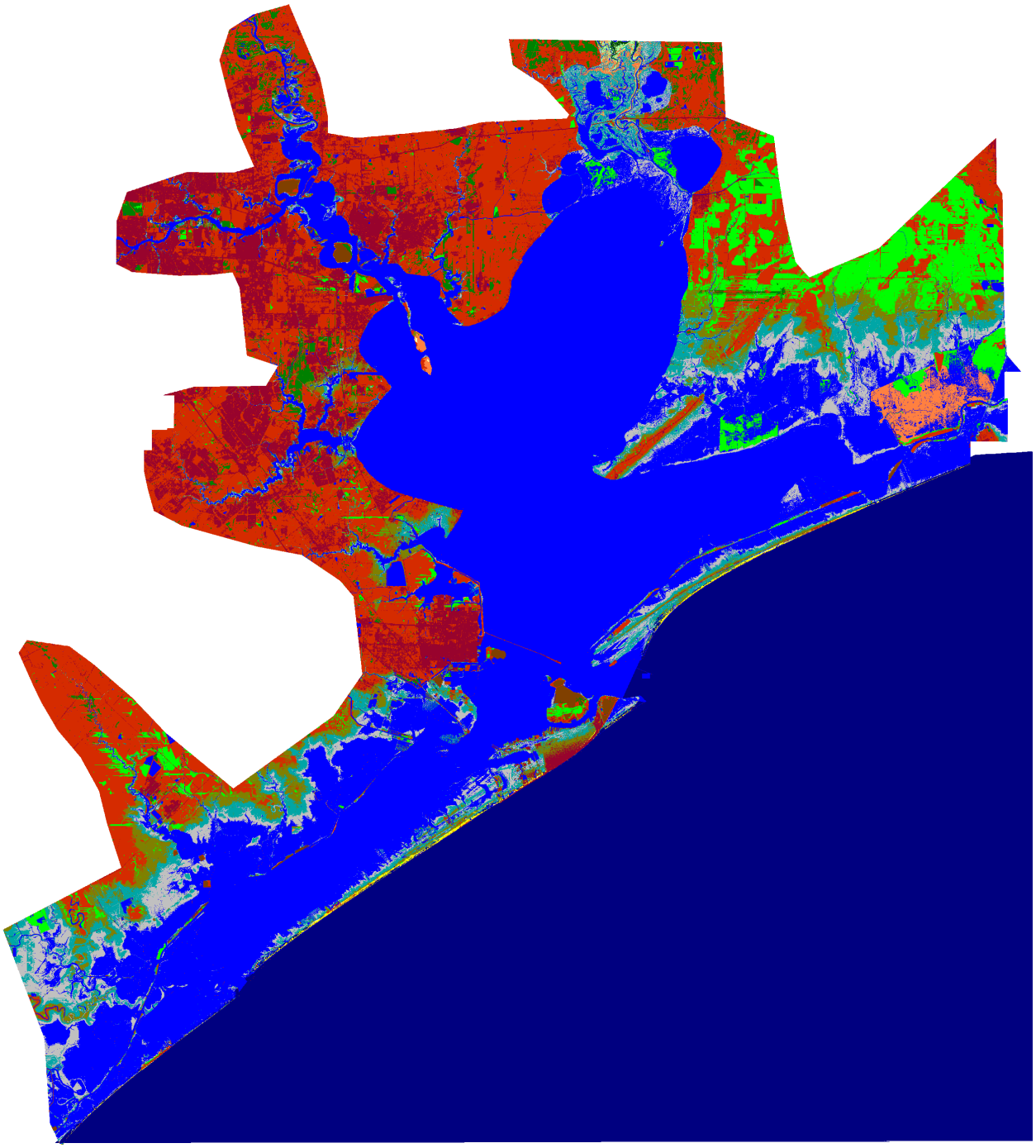
Moody Context, 2025, 2 m



Moody Context, 2050, 2 m



Moody Context, 2075, 2 m



Moody Context, 2100, 2 m