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

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Introduction

Tidal marshes are among the most susceptible ecosystems to climate change, especially accelerated sea level rise (SLR). The International 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 could be 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 brackish 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 most Region 8 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.

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, J.K., R.A. Park, and P.W. Mausel. 1992; Park, R.A., J.K. Lee, and D. Canning 1993; Galbraith, H., R. Jones, R.A. Park, J.S. Clough, S. Herrod-Julius, B. Harrington, and G. Page. 2002; National Wildlife Federation et al., 2006; Glick, Clough, 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 width are assumed to undergo overwash during each 25-year time-step due to 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 inundation.

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 will be used in USFWS simulations, but only 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 confirm the SLAMM conceptual model at each site.
- 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, Park, Fuller, 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.

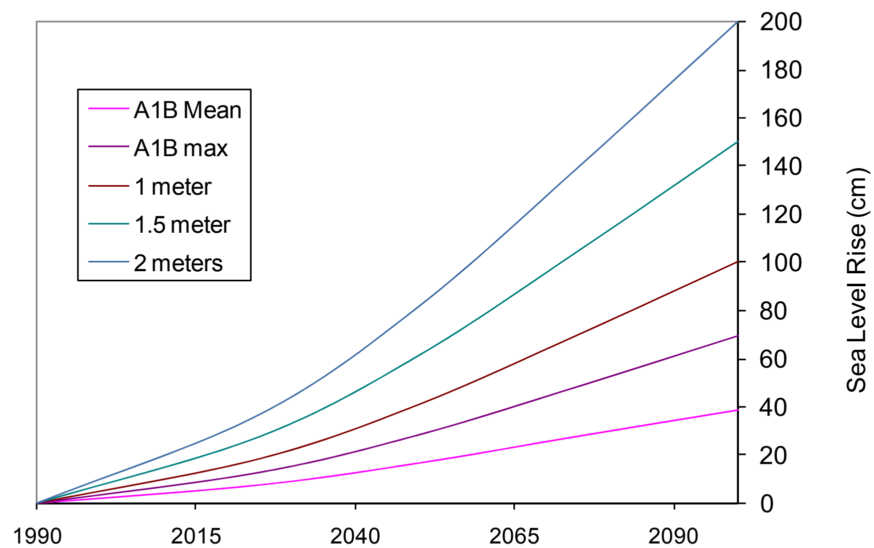
Sea Level Rise Scenarios

SLAMM 6 was run using scenario A1B from the Special Report on Emissions Scenarios (SRES) – mean and maximum estimates. The A1 scenario assumes that the future world includes very 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 (IPC, 2007) suggests a likely range of 0.21 to 0.48 meters 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 0.40 meters of global sea level rise 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 might be 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 meters 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." (US Climate Change Science Program, 2008) 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, with low probability of the rise being within Intergovernmental Panel on Climate Change (IPCC) confidence limits."

To allow for flexibility when interpreting the results, SLAMM was also run assuming 1 meter, 1½ meters, and 2 meters 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 (DEM) used in this model simulation was derived from a combination of LiDAR sources: 2004 USGS data and 2007 National Elevation Dataset LiDAR (Figure 1). The LiDAR DEM was provided to us almost exclusively within the NWR boundaries, with contextual results based on 10 foot contour USGS topographical DEMs.

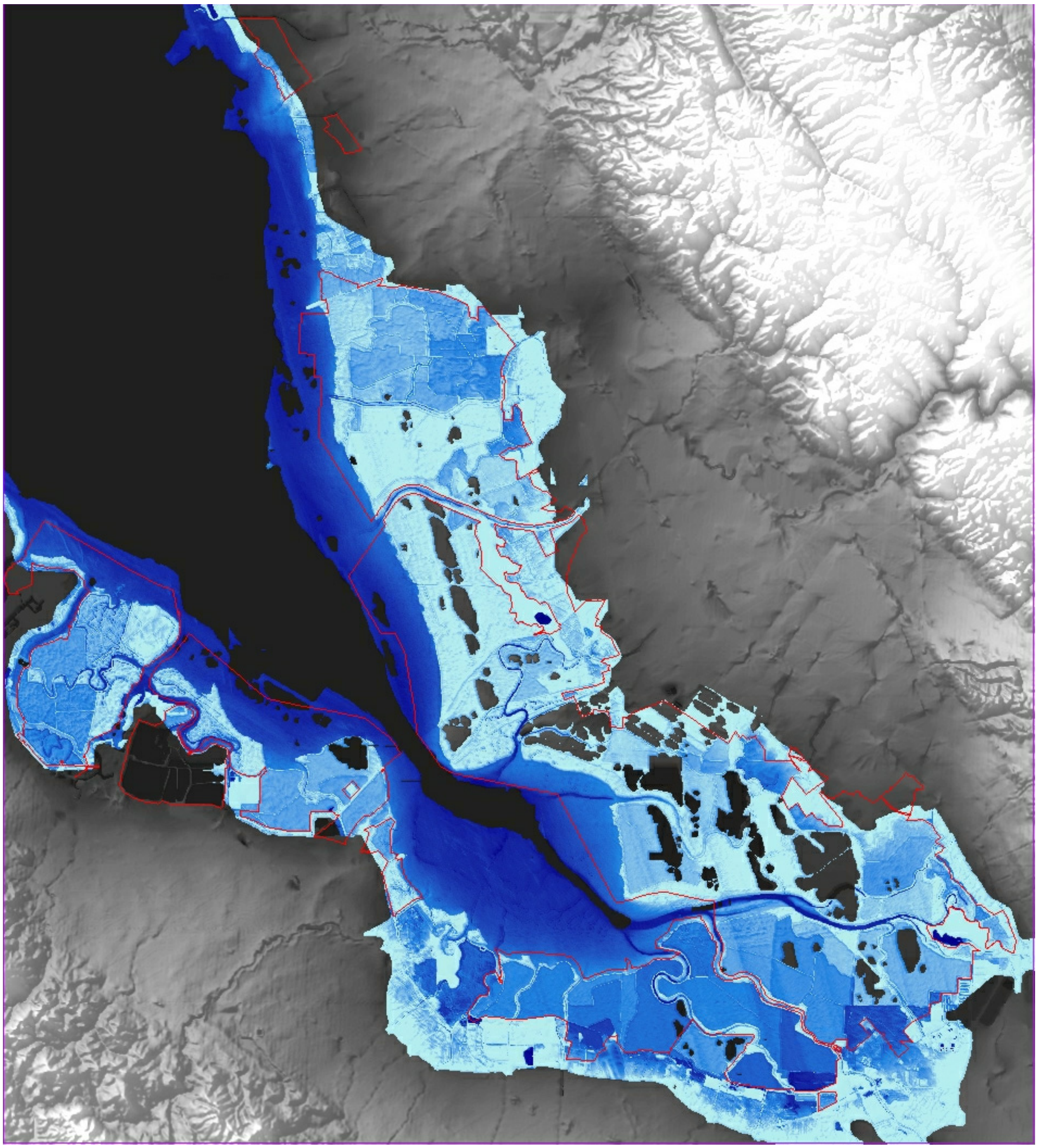


Figure 1: LiDAR coverage map of Don Edwards NWR (boundary in red).

The National Wetlands Inventory for Don Edwards is based on photo dates of 2006. This NWI survey was converted into 30 meter cells and assigned to SLAMM categories. Based on this analysis, the approximately fifty one thousand acre refuge (approved acquisition boundary including water) is composed of primarily the following categories:

Tidal Flat (incl. salt ponds)	63.4%
Irregularly Flooded Marsh	10.0%
Inland Fresh Marsh	8.4%
Dry Land	4.3%
Regularly Flooded Marsh	3.7%
Dev. Dry Land	3.2%
Estuarine Open Water	3.0%
Inland Shore	1.8%
Tidal Creek	1.3%

The refuge has numerous impounded zones covering much of the refuge, according to the National Wetlands Inventory (Figure 2).

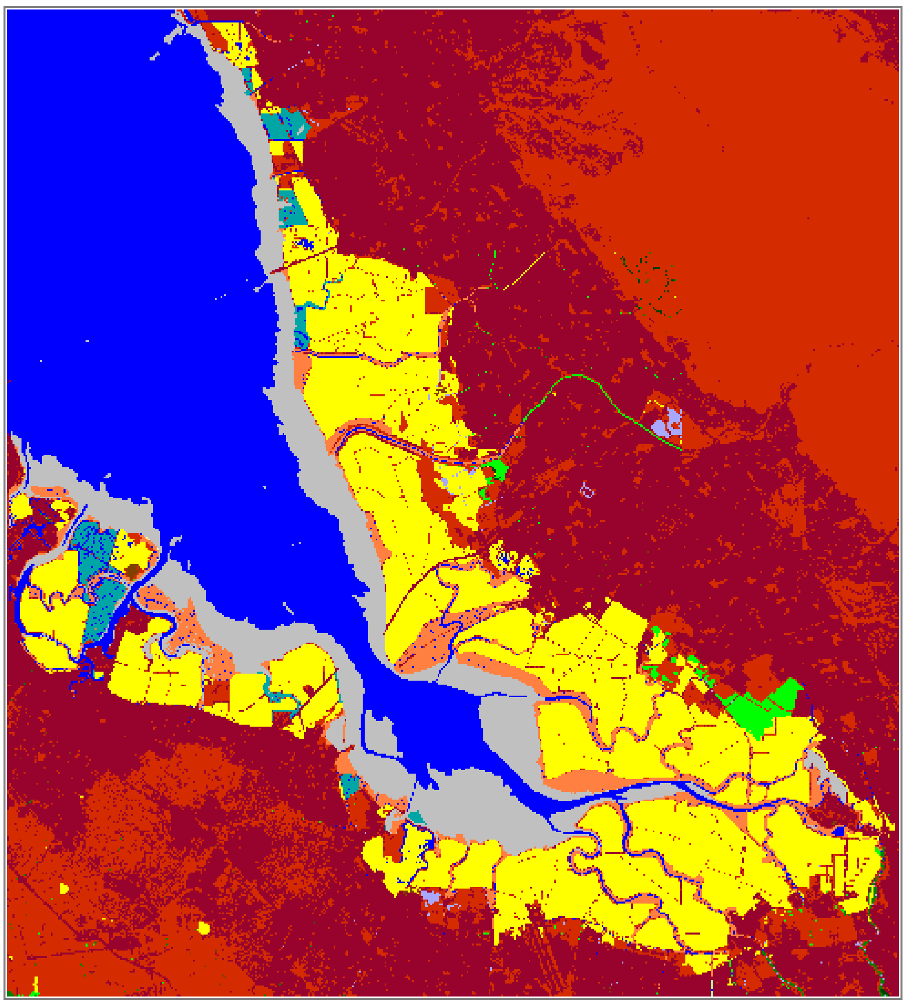


Figure 2: Diked areas in yellow.

The historic trend for sea level rise was estimated 2.06 mm/year using the nearest NOAA gage (9414523, Redwood City, CA). The rate of sea level rise for this refuge is slightly higher than the global average for the last 100 years (approximately 1.7 mm/year).

The study area was divided into four areas by tide range and accretion values (Figure 4). Sub-site tide ranges were determined using averages of nearby NOAA tide gages (9414551, Gold Street Bridge, Alviso Slough, CA; 9414575, Coyote Creek, CA; 9414519, Mowry Slough, San Francisco Bay, CA; 9414525, Palo Alto Yacht Harbor, S.F. Bay, CA; 9414509, Dumbarton Bridge, CA; 9414632, Alameda Creek, San Francisco Bay, CA; 9414523, Redwood City, CA) (Figure 3). Tide ranged from a low of 2.45 meters towards the mouth of the Bay to a high of 2.83 meters in the south.

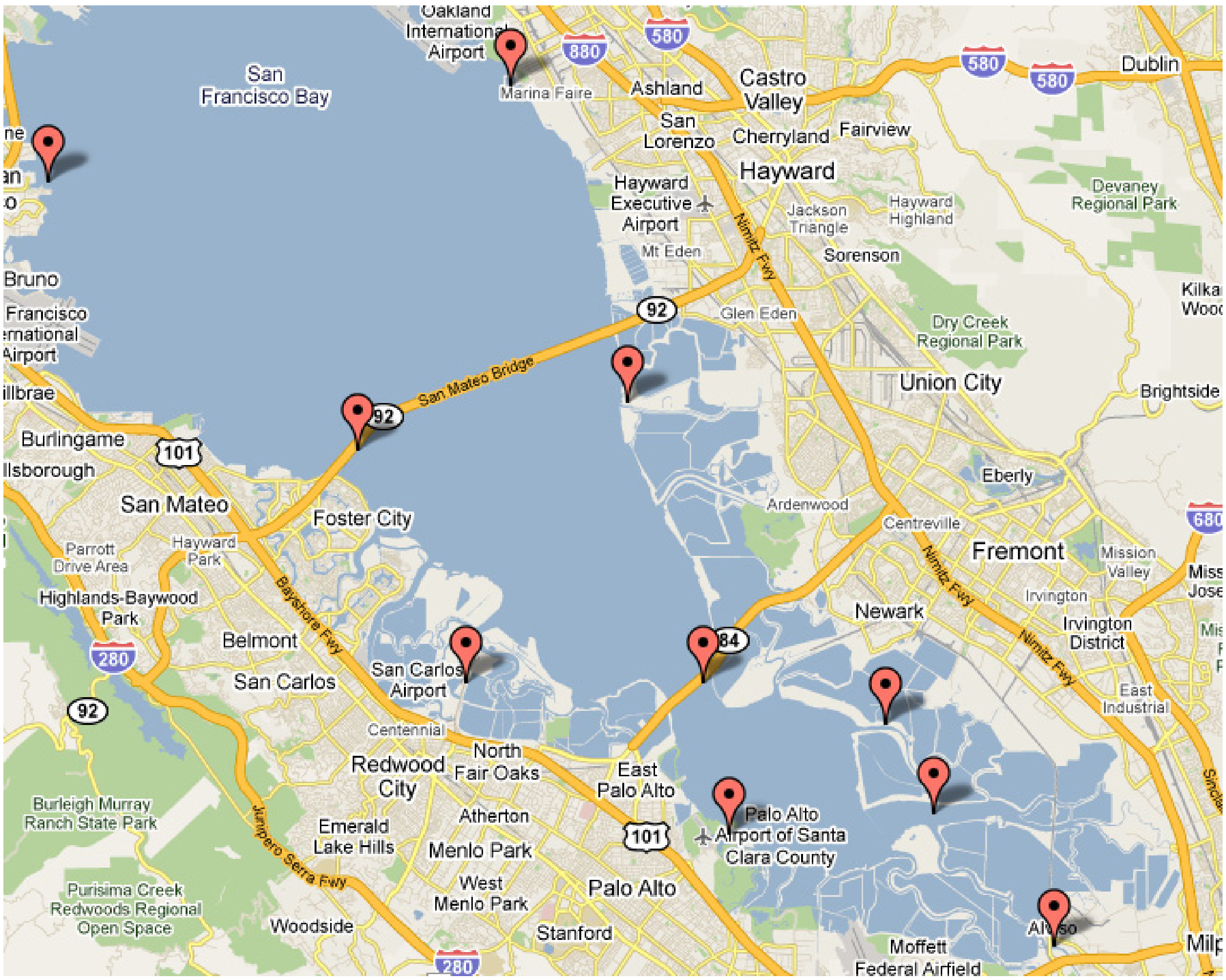


Figure 3: NOAA Gage Relevant to the Study Area.

Two papers have suggested that accretion rates in the southernmost regions of San Francisco bay have been much higher than surrounding areas due to land subsidence (Patrick, 1990, 39 mm/year; Burke Watson, 2004, 22 mm/year). The use of these rates as model parameters would result in two to four meters of vertical accretion over the next 100 years. Lacking spatial subsidence data to offset this accretion (or a defined elevation-to-accretion relationship), the model would produce unreasonable results using such high sediment inputs. Therefore, extremely high accretion values were not used in the south of the bay, primarily due to the lack of spatially variable subsidence data.

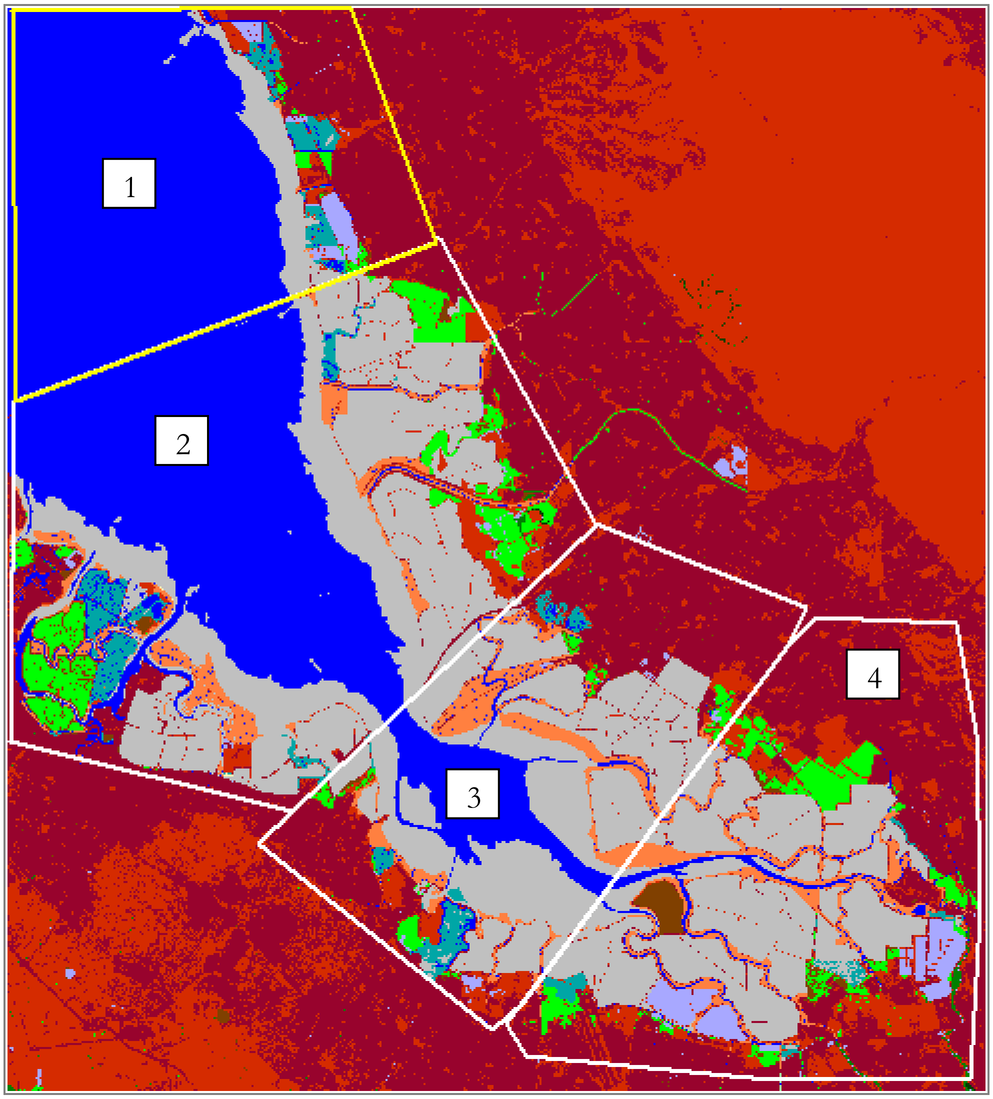


Figure 4: Input sub-sites

Instead, marsh accretion values for this site were divided spatially by sub-site (Figure 4) using an accretion study from three sites in South San Francisco Bay (Patrick, 1990). An average accretion rate of 6.5 mm/year was determined using the average from Bird Island (5 mm/yr) and Baumberg (8 mm/yr). For input sub-sites 1 through 3, all marsh accretion values were determined to be 6.5 mm/year. For input sub-site 4, marsh accretion was increased to 8.5 mm/year based on evidence of higher accretion.

Marsh erosion values were set to zero meters per year based on a south San Francisco Bay study that indicated that the bay has been depositional over the years 1983 to 2005 (Jaffe, 2006).

The MTL to NAVD88 correction was derived using the NOAA VDATUM product. This value was split into four input sites, with the lowest value of 1.14 meters near the mouth of the bay and the highest value of 2.78 at the southern end of the bay.

Modeled U.S. Fish and Wildlife Service refuge boundaries for California 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 30 meter by 30 meter cells. Additionally, the SLAMM model will track partial conversion of cells based on elevation and slope.

SUMMARY OF SLAMM INPUT PARAMETERS FOR DON EDWARDS NWR

Parameter	Global	Sub-site 1	Sub-site 2	Sub-site 3	Sub-site 4
Description	Don Edwards	Sub-site 1	Sub-site 2	Sub-site 3	Sub-site 4
NWI Photo Date (YYYY)	2006	2006	2006	2006	2006
DEM Date (YYYY)	2006	2006	2006	2006	2006
Direction Offshore [n,s,e,w]	East	East	East	East	East
Historic Trend (mm/yr)	2.06	2.06	2.06	2.06	2.06
MTL-NAVD88 (m)	1.18	1.14	1.17	1.21	1.28
GT Great Diurnal Tide Range (m)	2.6	2.45	2.55	2.63	2.78
Salt Elev. (m above MTL)	1.9	1.79	1.86	1.92	2.03
Marsh Erosion (horz. m /yr)	0	0	0	0	0
Swamp Erosion (horz. m /yr)	0	0	0	0	0
T.Flat Erosion (horz. m /yr)	0	0	0	0	0
Reg. Flood Marsh Accr (mm/yr)	6.5	6.5	6.5	6.5	8.5
Irreg. Flood Marsh Accr (mm/yr)	6.5	6.5	6.5	6.5	8.5
Tidal Fresh Marsh Accr (mm/yr)	6.5	6.5	6.5	6.5	8.5
Beach Sed. Rate (mm/yr)	0.5	0.5	0.5	0.5	0.5
Freq. Overwash (years)	0	0	0	0	0
Use Elev Pre-processor [True,False]	TRUE	FALSE	FALSE	FALSE	FALSE

Results

The SLAMM simulation of Don Edwards NWR indicates some effects to even the lowest predicted rates of sea level rise (SLR). Under lower SLR scenarios, non-impounded tidal flats are predicted to convert to open water. Additionally, between 19% and 94% of irregularly flooded marsh is predicted to be lost, with the steepest losses occurring at rates above 1 meter SLR (eustatic by 2100).

SLR by 2100 (m)	0.39	0.69	1	1.5	2
Tidal Flat	17%	23%	30%	40%	45%
Brackish Marsh	19%	21%	39%	84%	94%
Inland Fresh Marsh	9%	10%	13%	21%	39%
Undev. Dry Land	12%	12%	13%	13%	14%
Inland Shore	10%	18%	44%	69%	82%

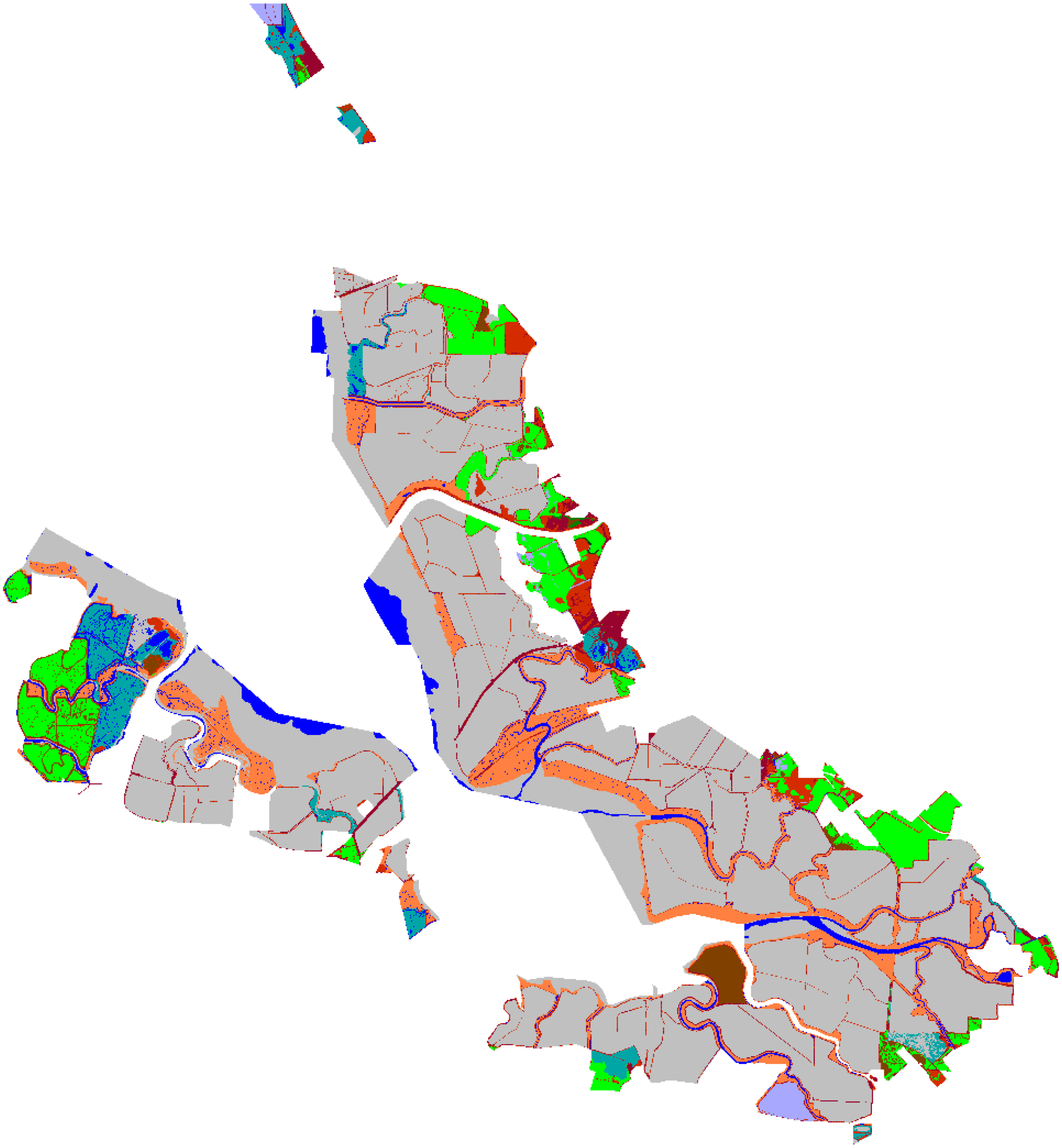
Predicted Loss Rates of Land Categories by 2100 Given Simulated Scenarios of Eustatic Sea Level Rise

Maps of SLAMM input and output to follow will use the following legend:

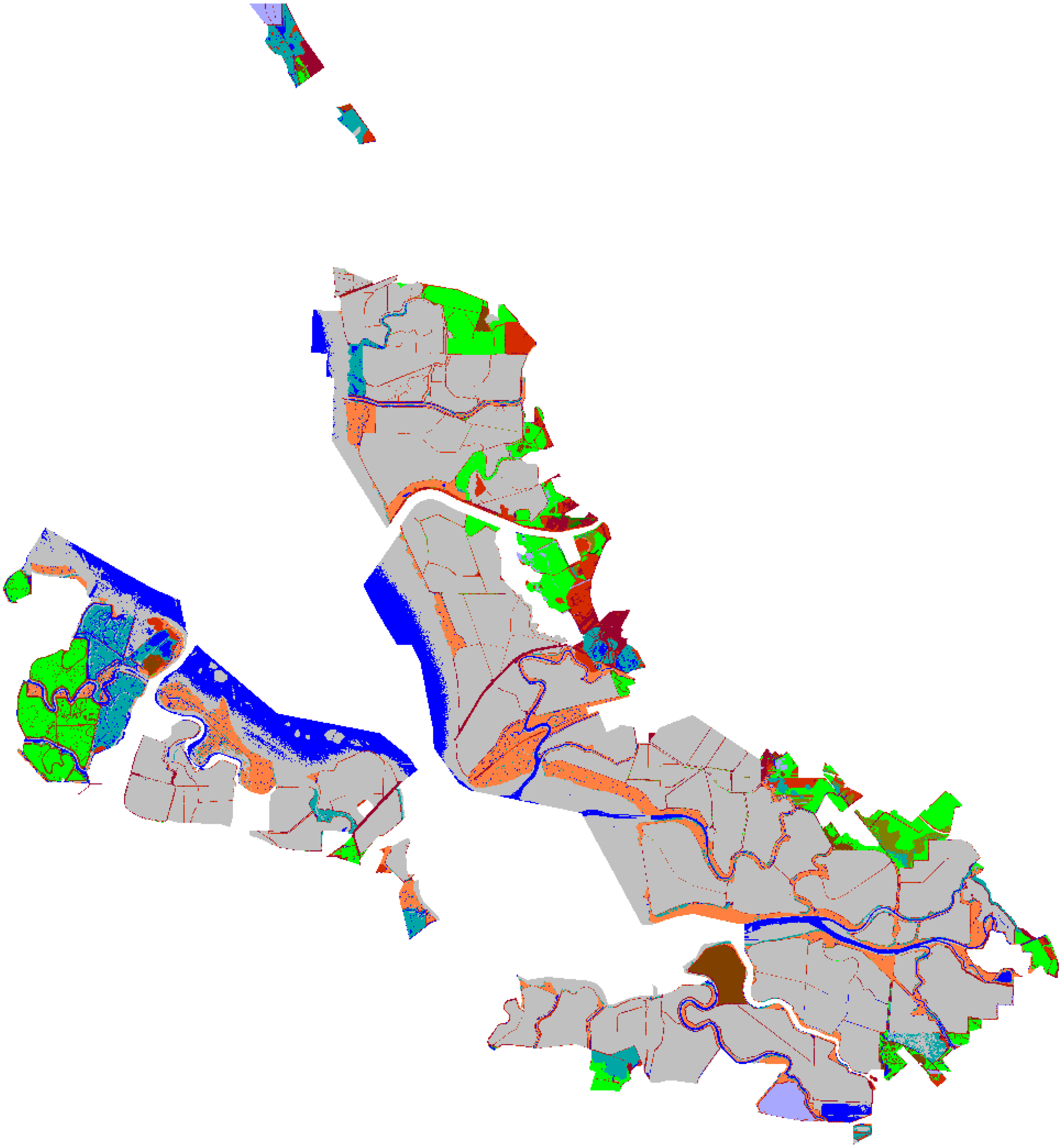
Don Edwards NWR
IPCC Scenario A1B-Mean, 0.39 M SLR Eustatic by 2100

Results in Acres

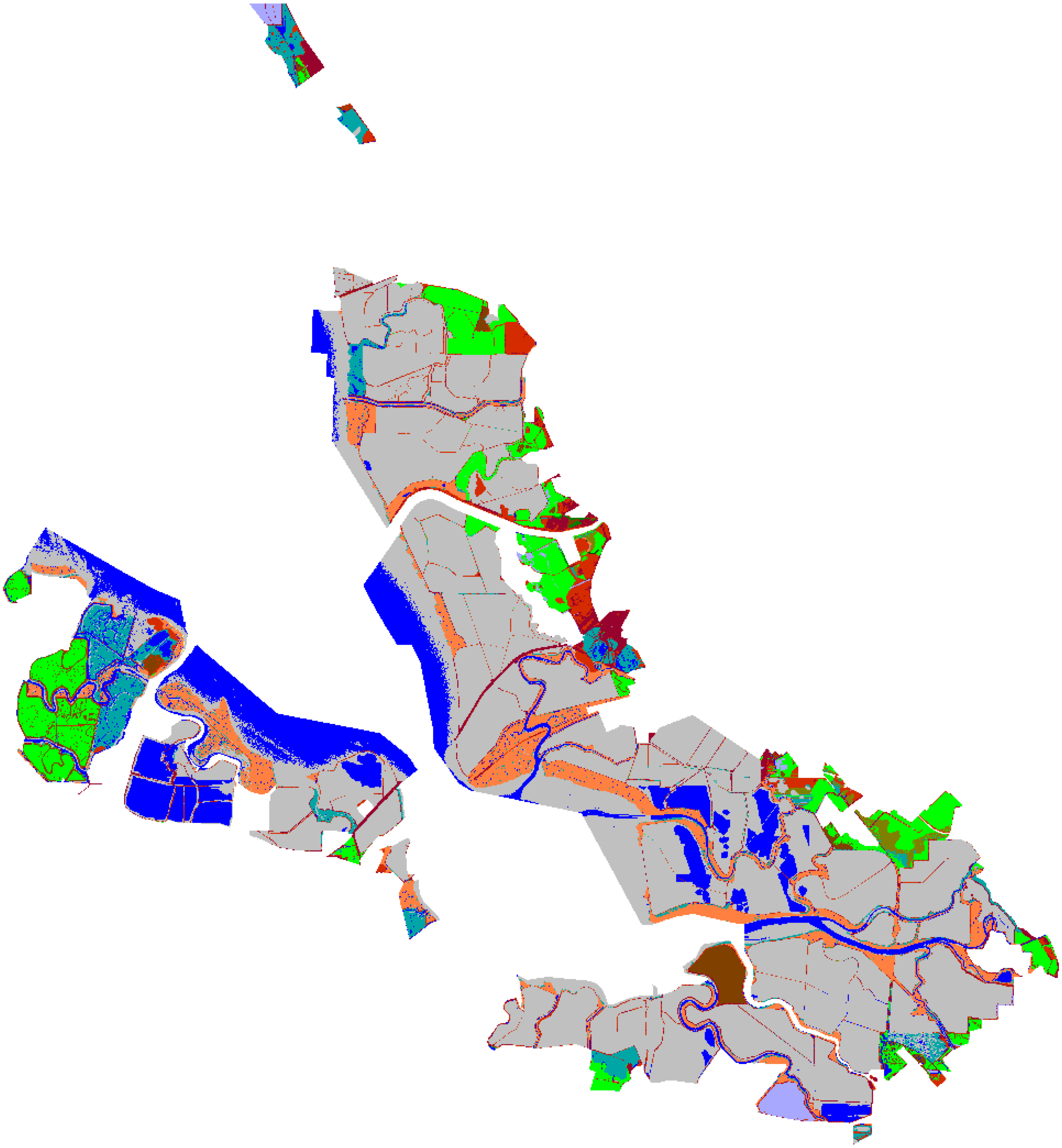
	Initial	2025	2050	2075	2100
Tidal Flat	32399.2	30678.8	28349.5	27605.9	26955.5
Brackish Marsh	5088.8	4101.1	4101.1	4101.2	4101.2
Inland Fresh Marsh	4266.0	3969.1	3918.7	3905.9	3903.2
Undev. Dry Land	2191.5	1950.9	1937.3	1933.2	1929.8
Regularly Flooded Marsh	1883.0	2386.6	2461.4	2466.4	2436.6
Dev. Dry Land	1642.2	1642.2	1642.2	1642.2	1642.2
Estuarine Open Water	1548.1	3916.8	6311.8	7137.3	7859.2
Inland Shore	903.6	882.2	865.0	837.8	810.7
Tidal Creek	647.2	647.2	647.2	647.2	647.2
Inland Open Water	465.0	479.4	475.7	474.6	475.6
Swamp	27.6	28.8	27.6	27.6	27.6
Tidal Swamp	9.3	3.4	3.3	3.3	3.2
Estuarine Beach	4.0	4.0	4.0	4.0	4.0
Trans. Salt Marsh	0.0	385.1	330.9	289.0	279.6
Total (incl. water)	**51075.4**	**51075.4**	**51075.4**	**51075.4**	**51075.4**



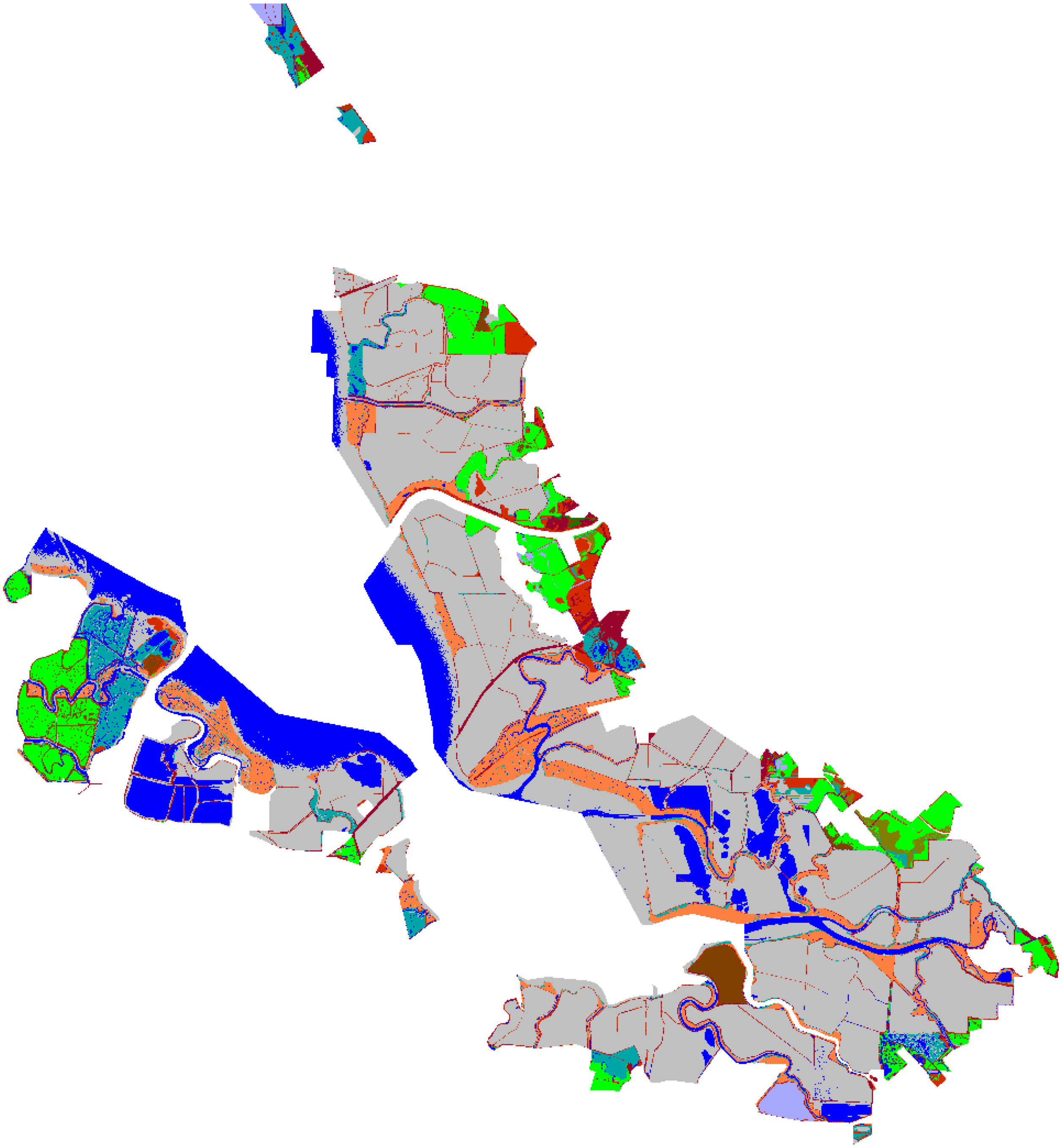
Don Edwards NWR, Initial Condition



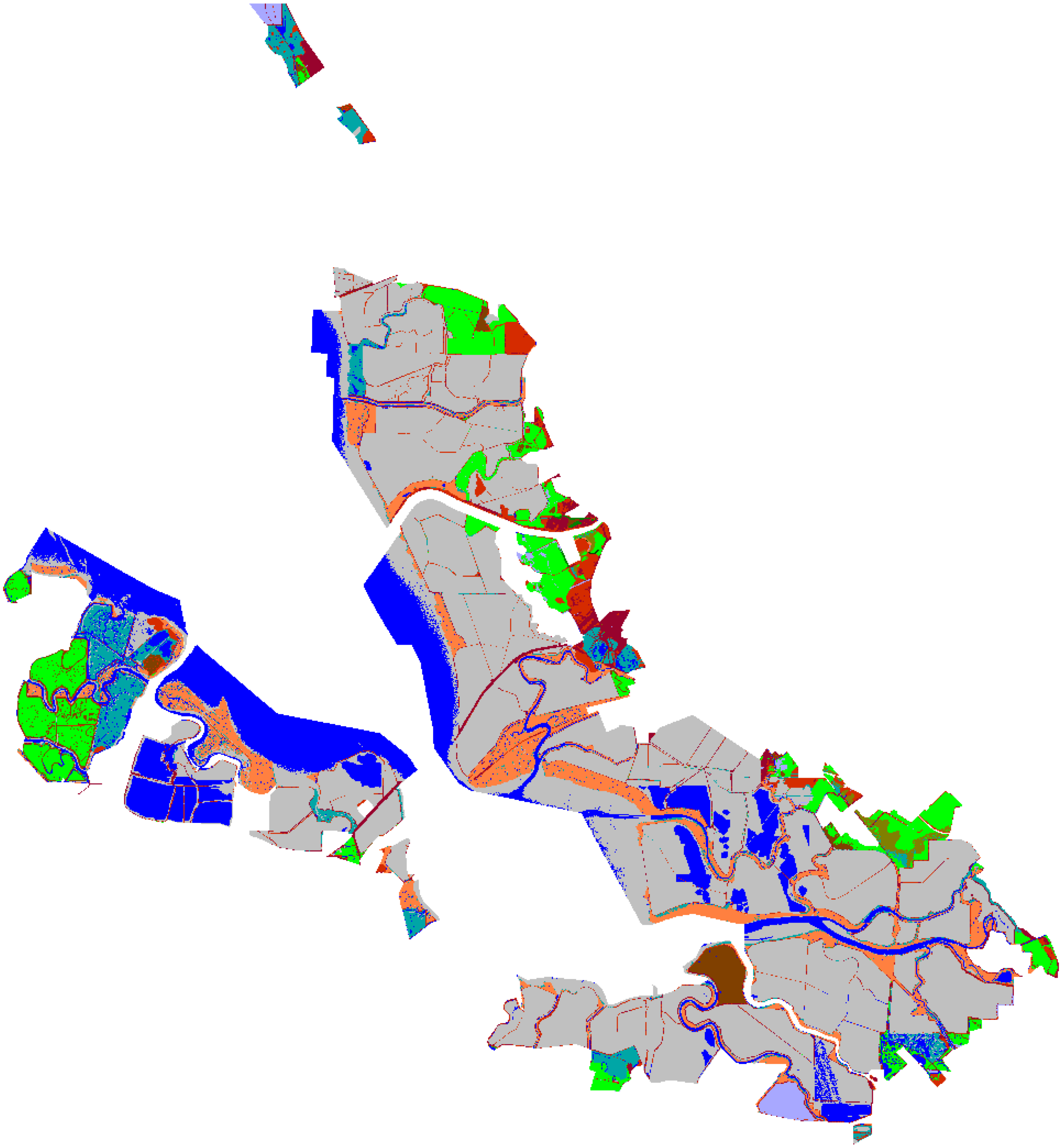
Don Edwards NWR, 2025, Scenario A1B Mean



Don Edwards NWR, 2050, Scenario A1B Mean



Don Edwards NWR, 2075, Scenario A1B Mean

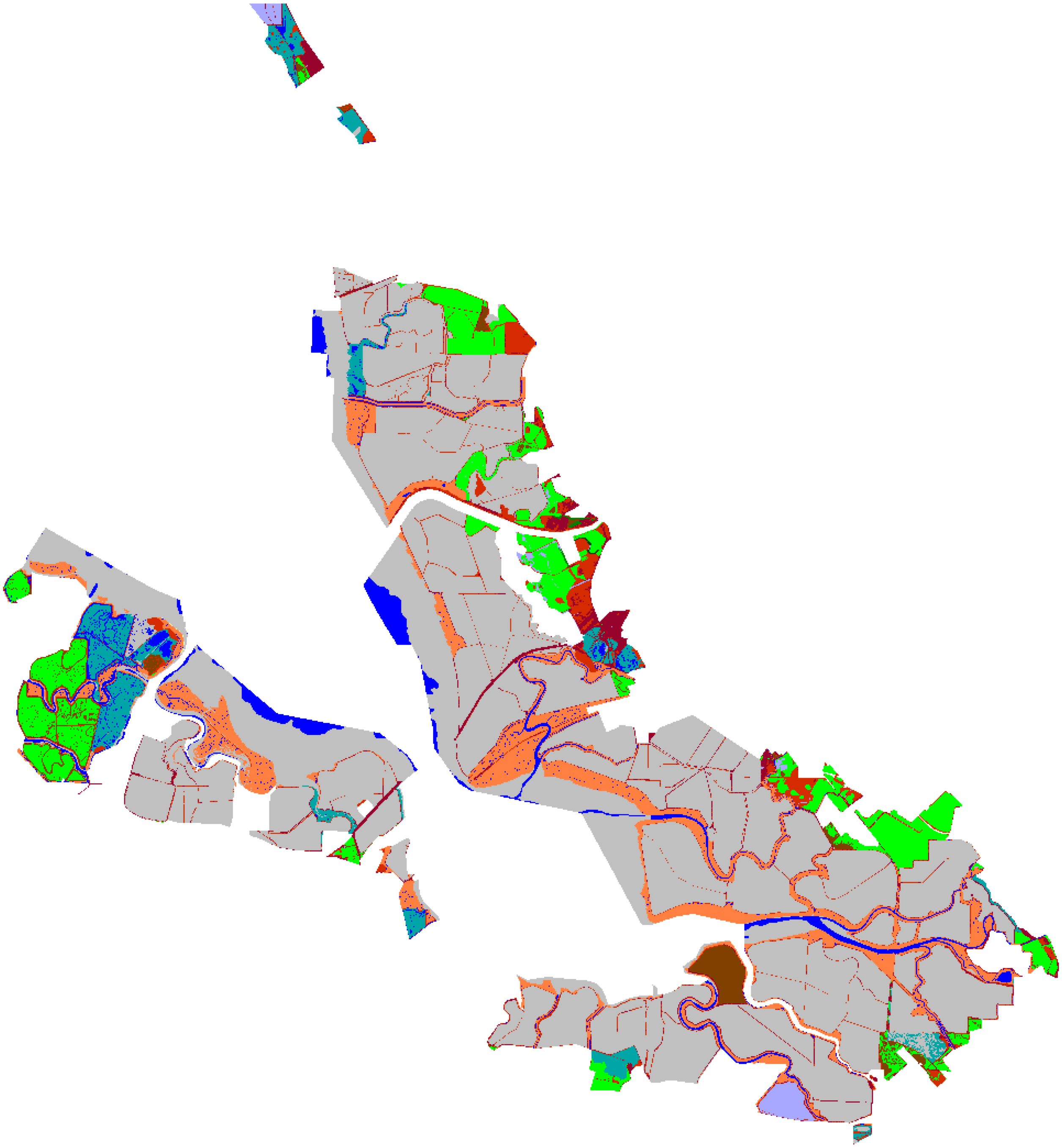


Don Edwards NWR, 2100, Scenario A1B Mean

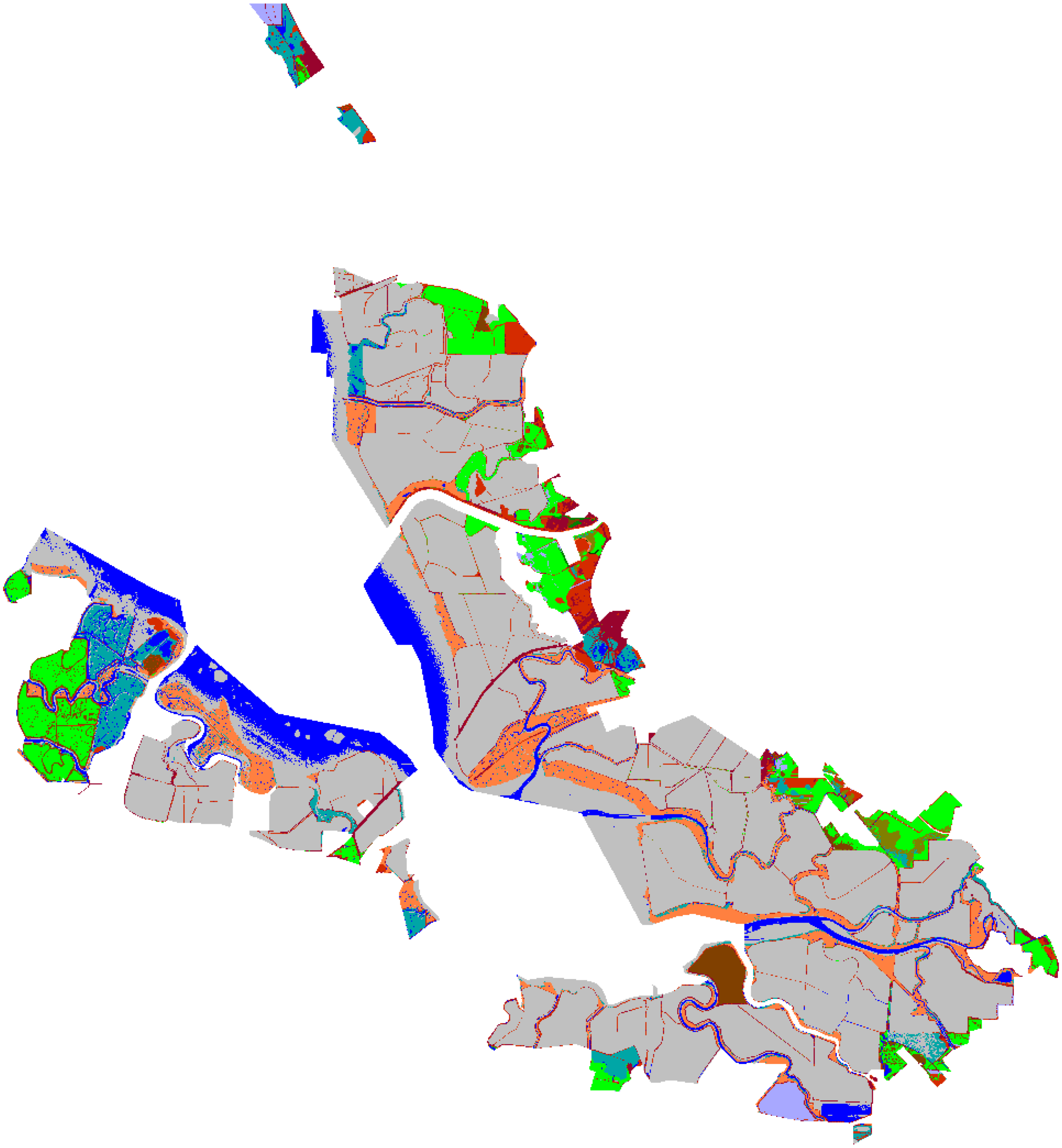
Don Edwards NWR
IPCC Scenario A1B-Max, 0.69 M SLR Eustatic by 2100

Results in Acres

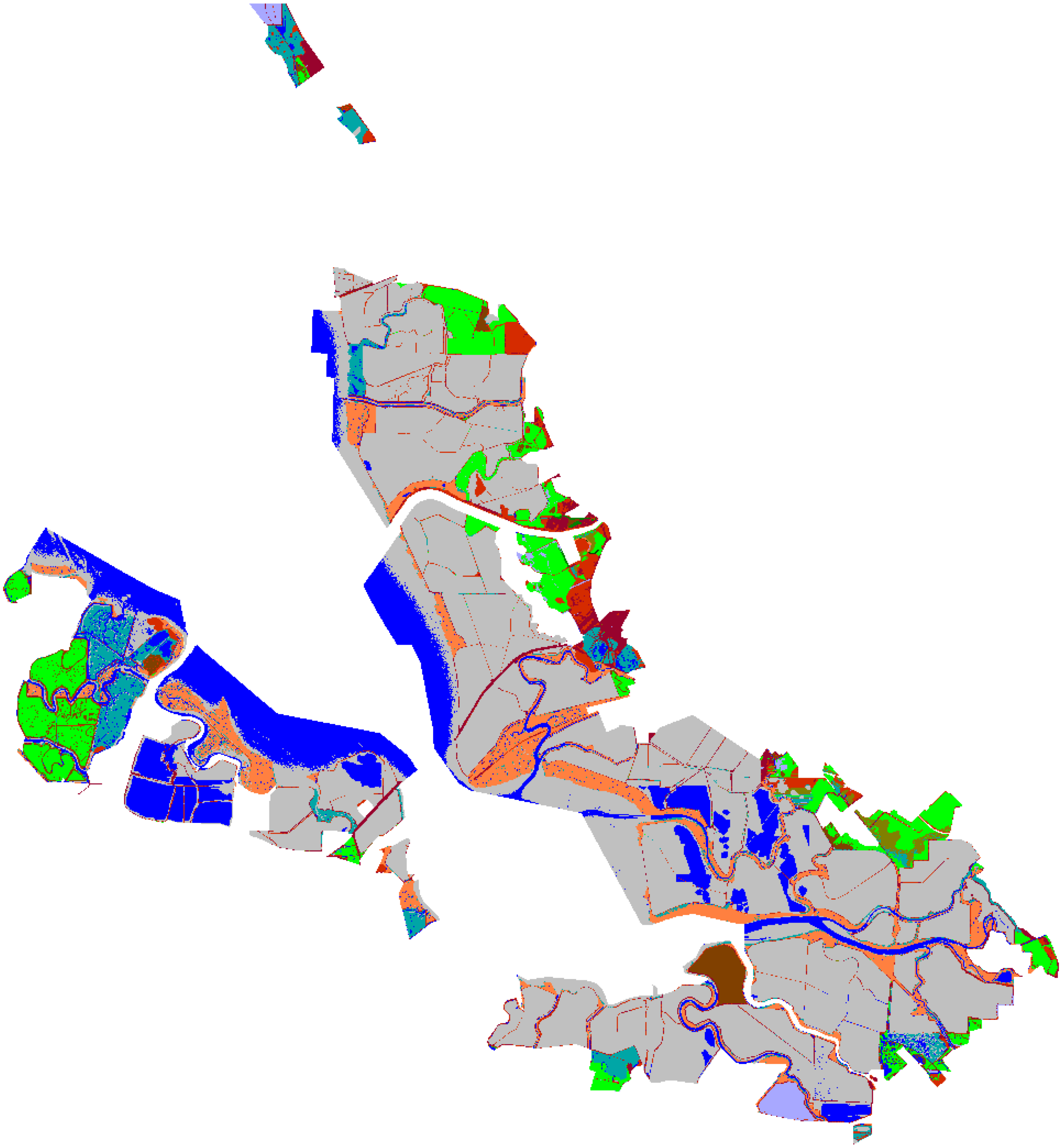
	Initial	2025	2050	2075	2100
Tidal Flat	32399.2	30483.8	27683.8	26471.1	24930.1
Brackish Marsh	5088.8	4101.2	4101.2	4099.4	4044.2
Inland Fresh Marsh	4266.0	3967.8	3914.4	3896.2	3859.9
Undev. Dry Land	2191.5	1949.8	1933.5	1926.0	1922.5
Regularly Flooded Marsh	1883.0	2379.6	2456.3	2438.8	2367.0
Dev. Dry Land	1642.2	1642.2	1642.2	1642.2	1642.2
Estuarine Open Water	1548.1	4129.5	7019.7	8367.1	10143.3
Inland Shore	903.6	878.1	843.6	796.5	740.3
Tidal Creek	647.2	647.2	647.2	647.2	647.2
Inland Open Water	465.0	479.5	476.2	476.5	475.3
Swamp	27.6	28.8	27.6	27.6	27.6
Tidal Swamp	9.3	3.3	3.3	3.1	2.6
Estuarine Beach	4.0	4.0	4.0	4.0	4.0
Trans. Salt Marsh	0.0	380.7	322.7	280.0	269.3
Total (incl. water)	**51075.4**	**51075.4**	**51075.4**	**51075.4**	**51075.4**



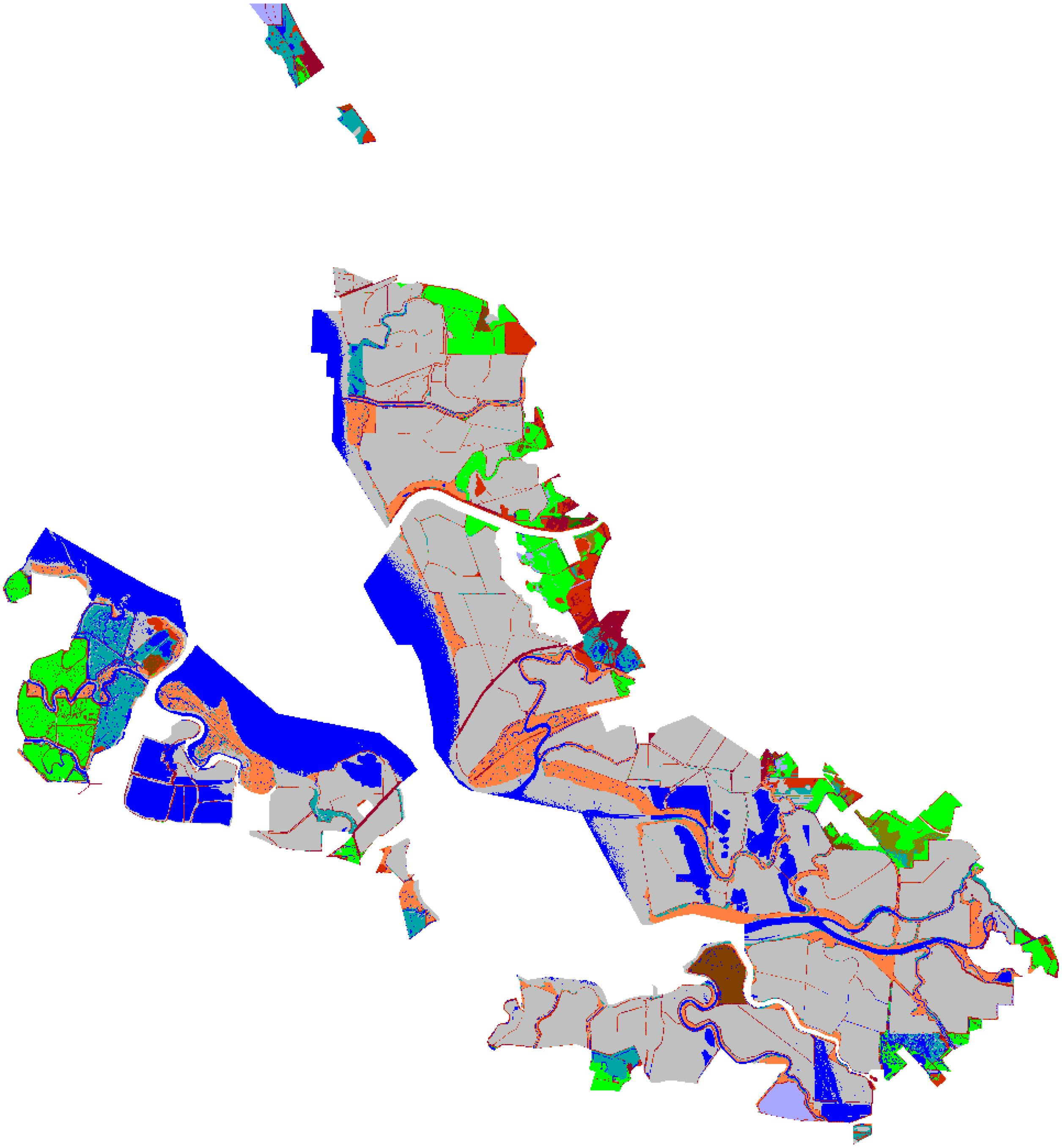
Don Edwards NWR, Initial Condition



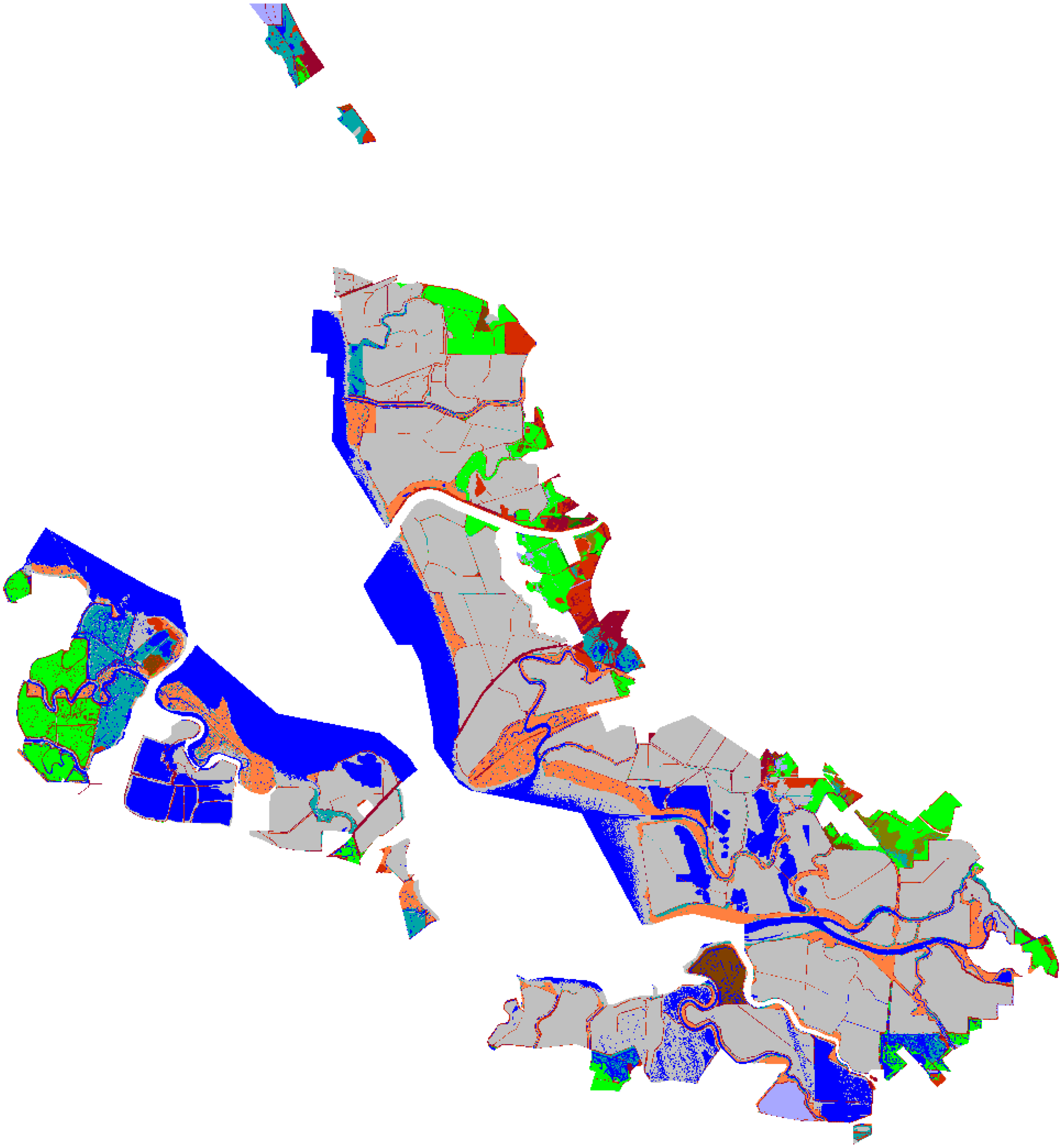
Don Edwards NWR, 2025, Scenario A1B Maximum



Don Edwards NWR, 2050, Scenario A1B Maximum



Don Edwards NWR, 2075, Scenario A1B Maximum

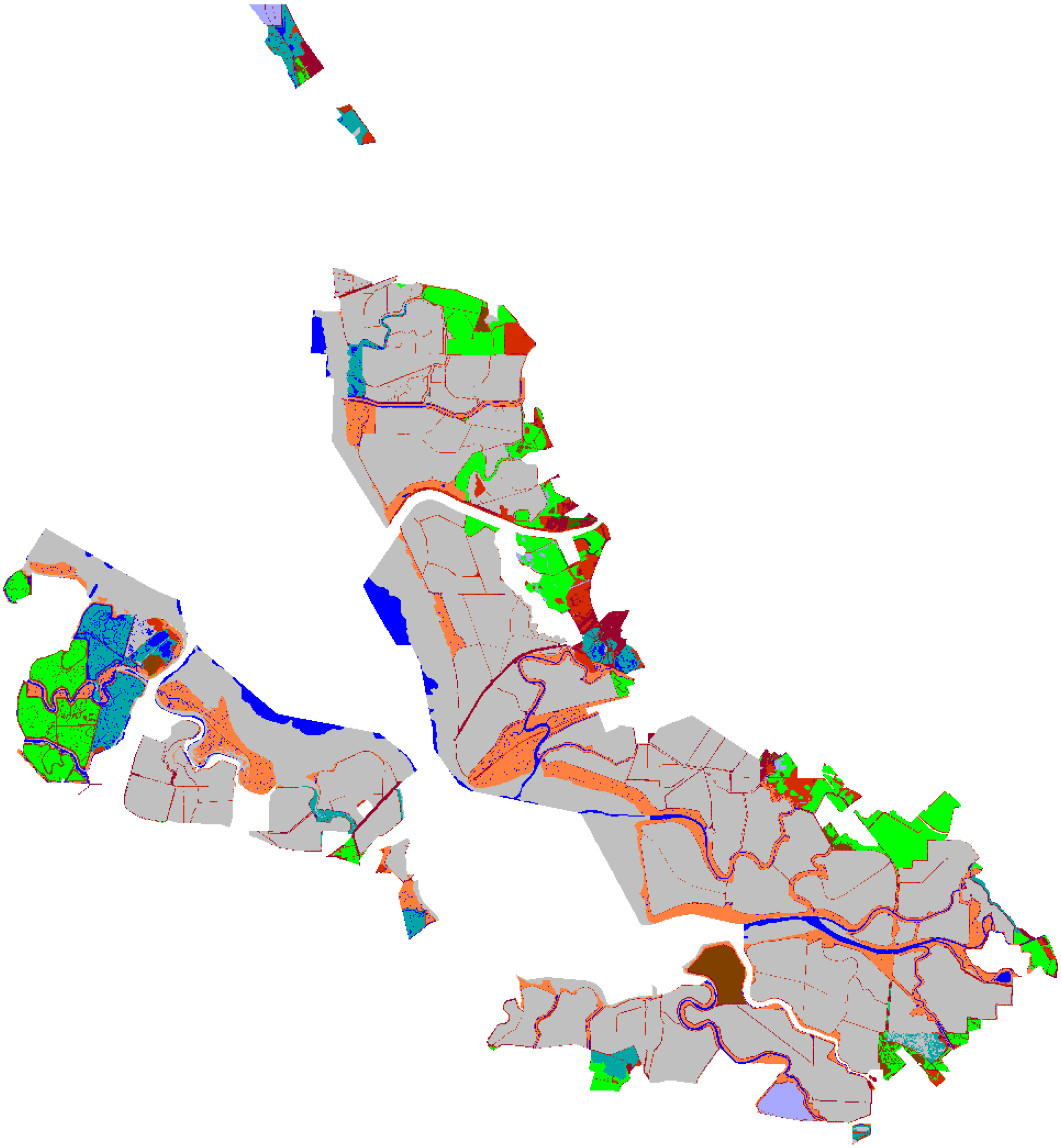


Don Edwards NWR, 2100, Scenario A1B Maximum

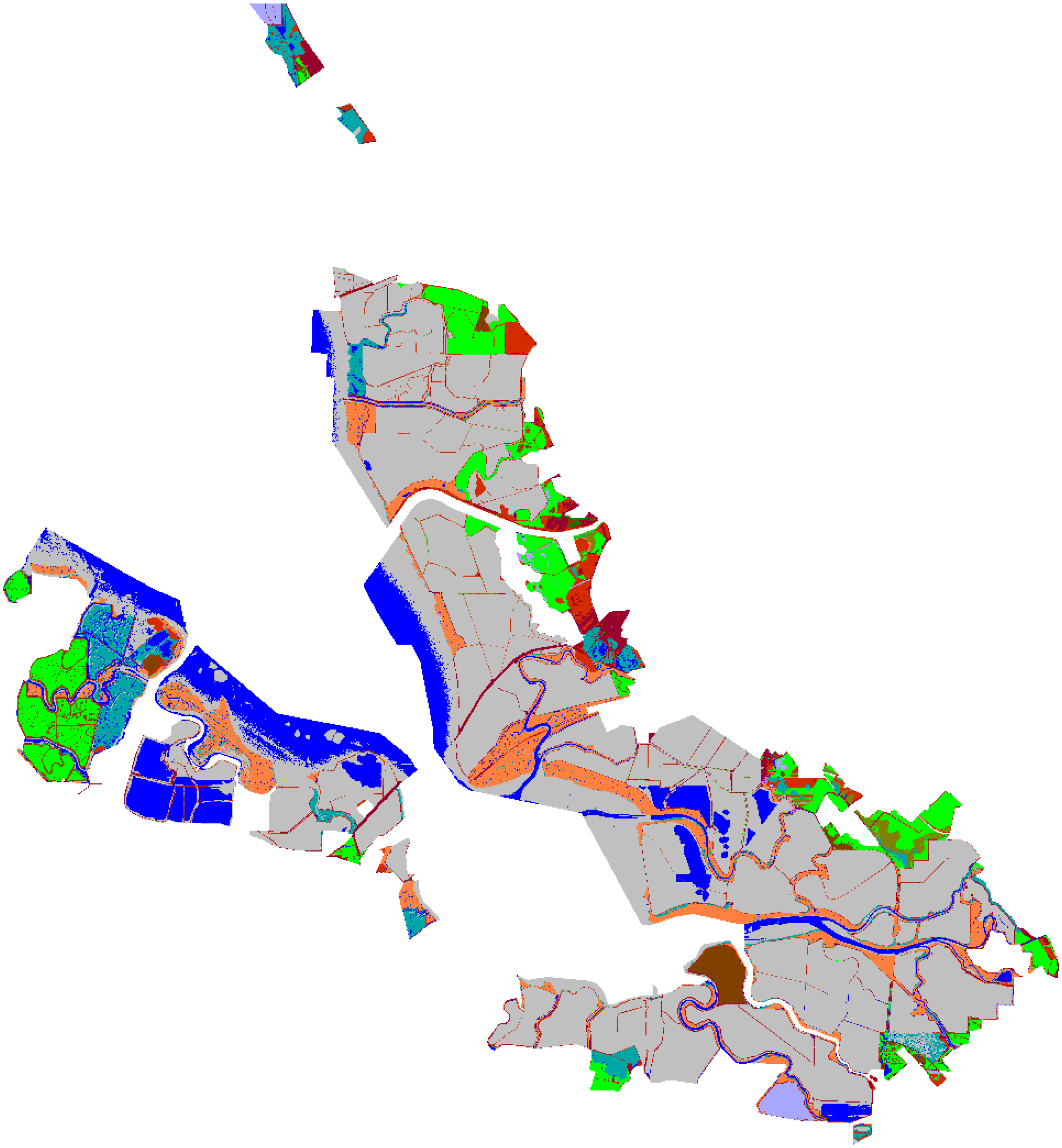
Don Edwards NWR
1 Meter Eustatic SLR by 2100

Results in Acres

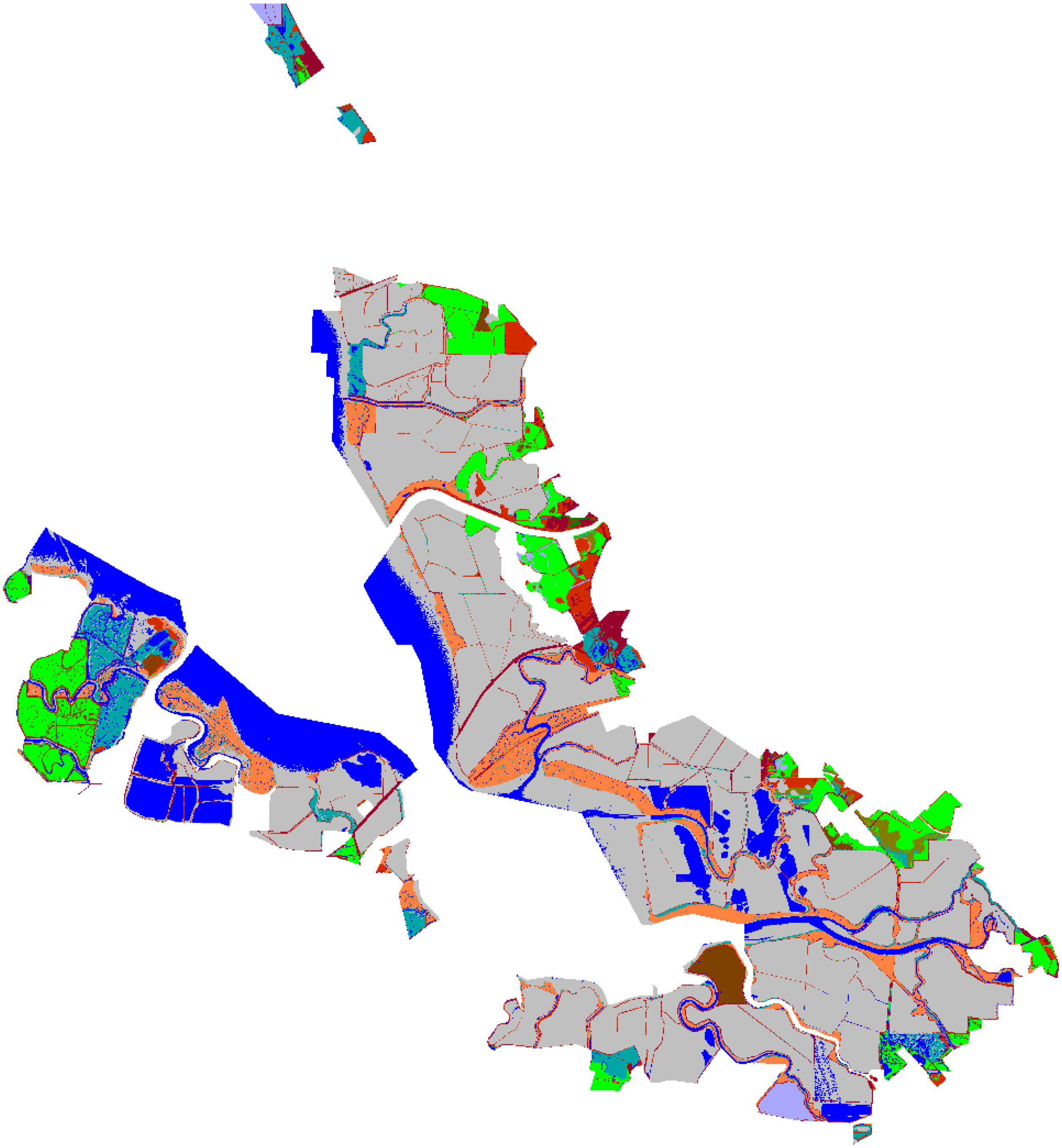
	Initial	2025	2050	2075	2100
Tidal Flat	32399.2	28980.2	27112.7	25214.9	22544.4
Brackish Marsh	5088.8	4101.2	4047.5	3824.8	3089.1
Inland Fresh Marsh	4266.0	3965.7	3907.5	3853.3	3709.8
Undev. Dry Land	2191.5	1948.6	1929.4	1919.7	1915.6
Regularly Flooded Marsh	1883.0	2370.9	2478.1	2596.5	3135.9
Dev. Dry Land	1642.2	1642.2	1642.2	1642.2	1642.2
Estuarine Open Water	1548.1	5653.9	7662.9	9853.6	13145.7
Inland Shore	903.6	873.0	820.6	752.7	505.4
Tidal Creek	647.2	647.2	647.2	647.2	647.2
Inland Open Water	465.0	479.7	477.1	476.2	476.8
Swamp	27.6	28.8	27.6	27.6	27.6
Tidal Swamp	9.3	3.3	3.2	2.6	0.6
Estuarine Beach	4.0	4.0	4.0	4.0	4.0
Trans. Salt Marsh	0.0	376.9	315.6	260.3	231.2
Total (incl. water)	**51075.4**	**51075.4**	**51075.4**	**51075.4**	**51075.4**



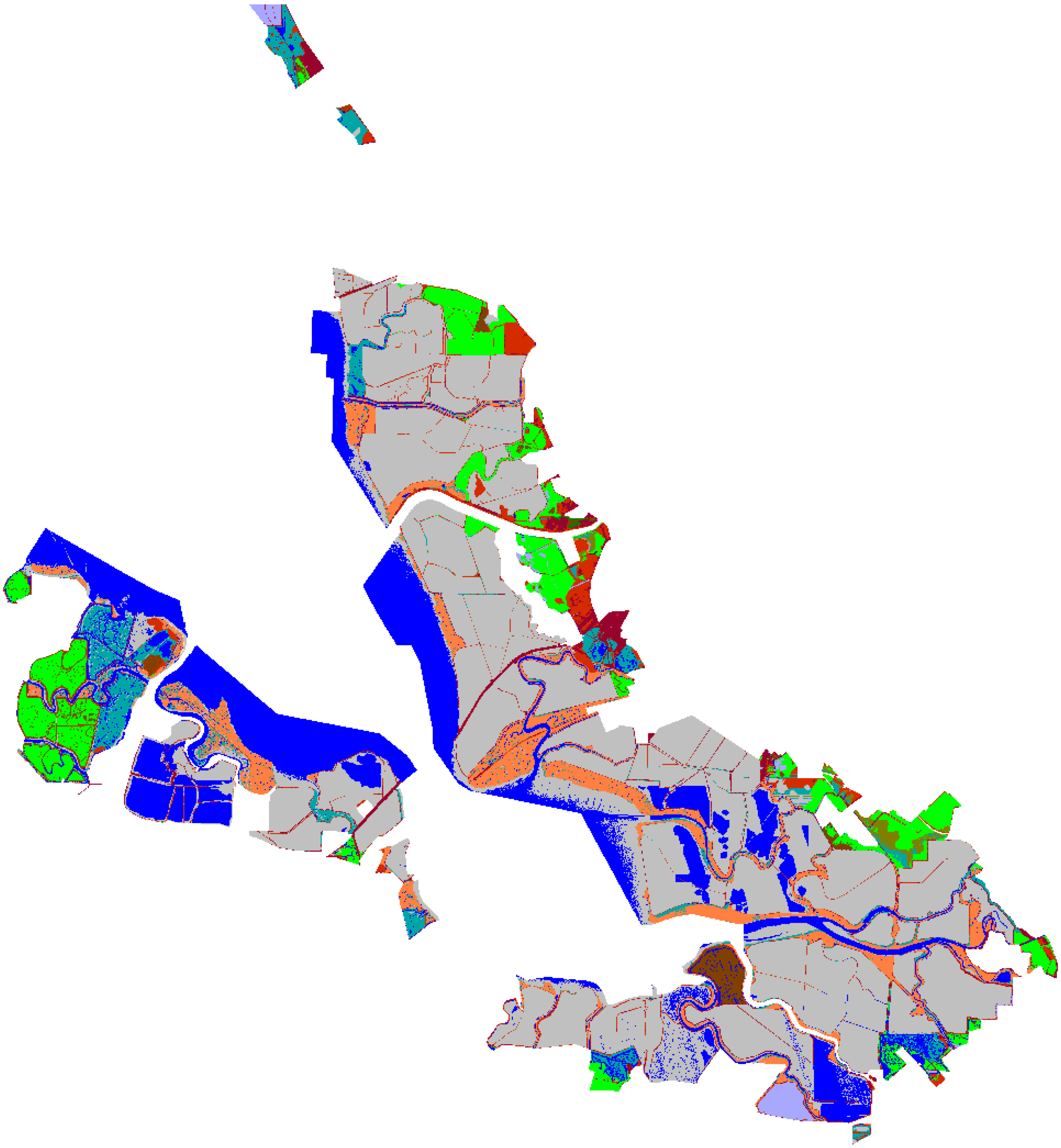
Don Edwards NWR, Initial Condition



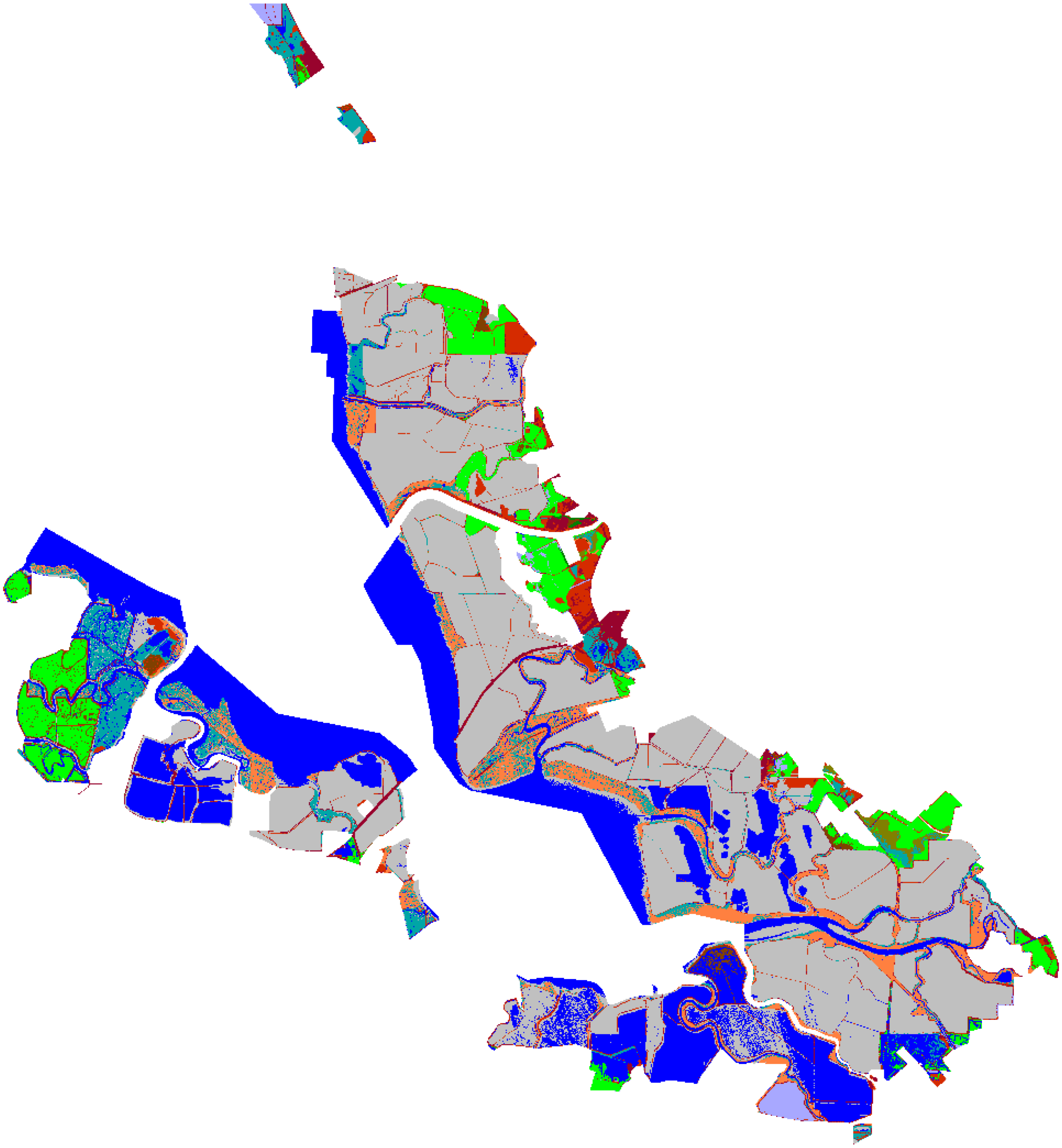
Don Edwards NWR, 2025, 1 meter



Don Edwards NWR, 2050, 1 meter



Don Edwards NWR, 2075, 1 meter

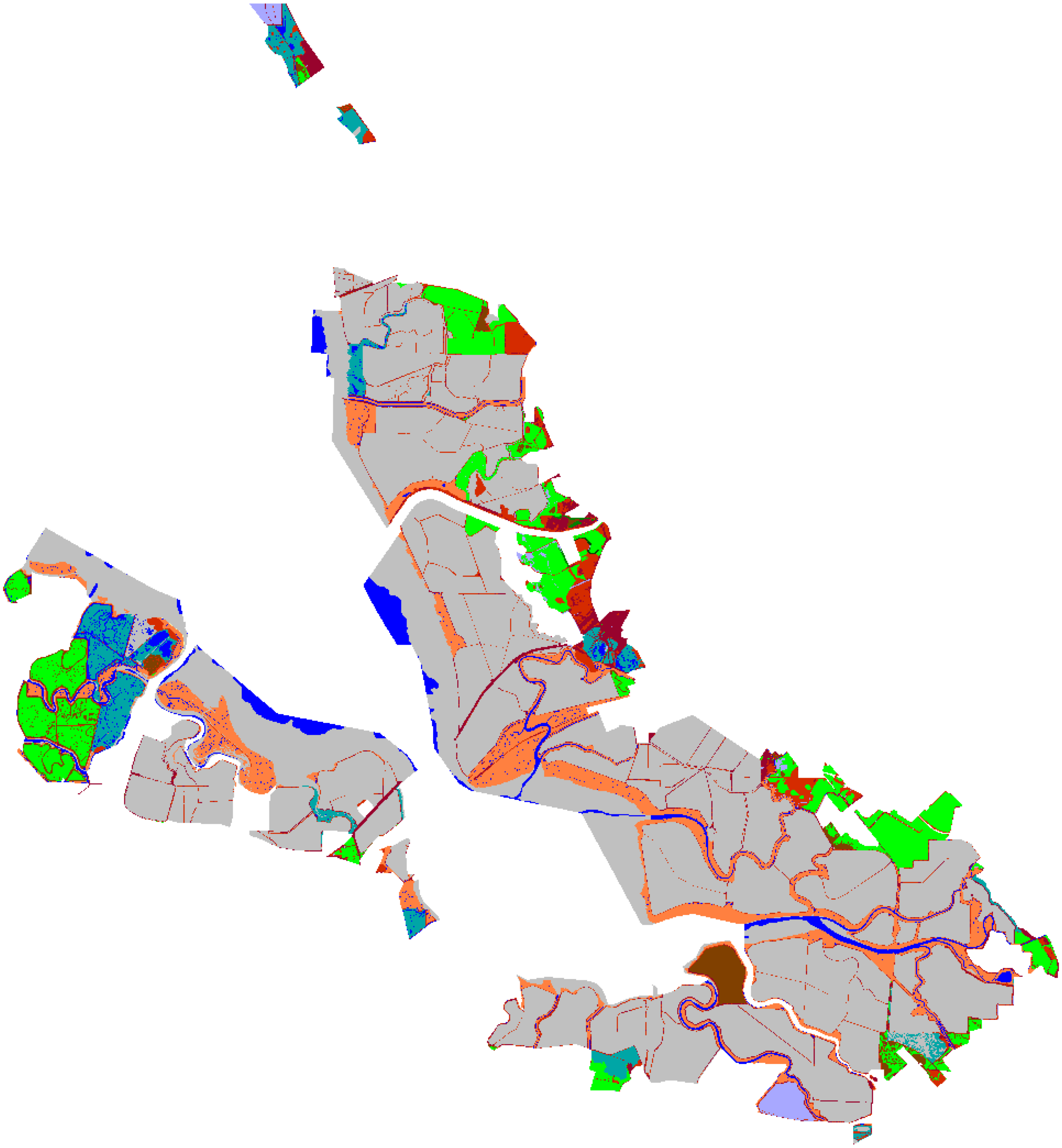


Don Edwards NWR, 2100, 1 meter

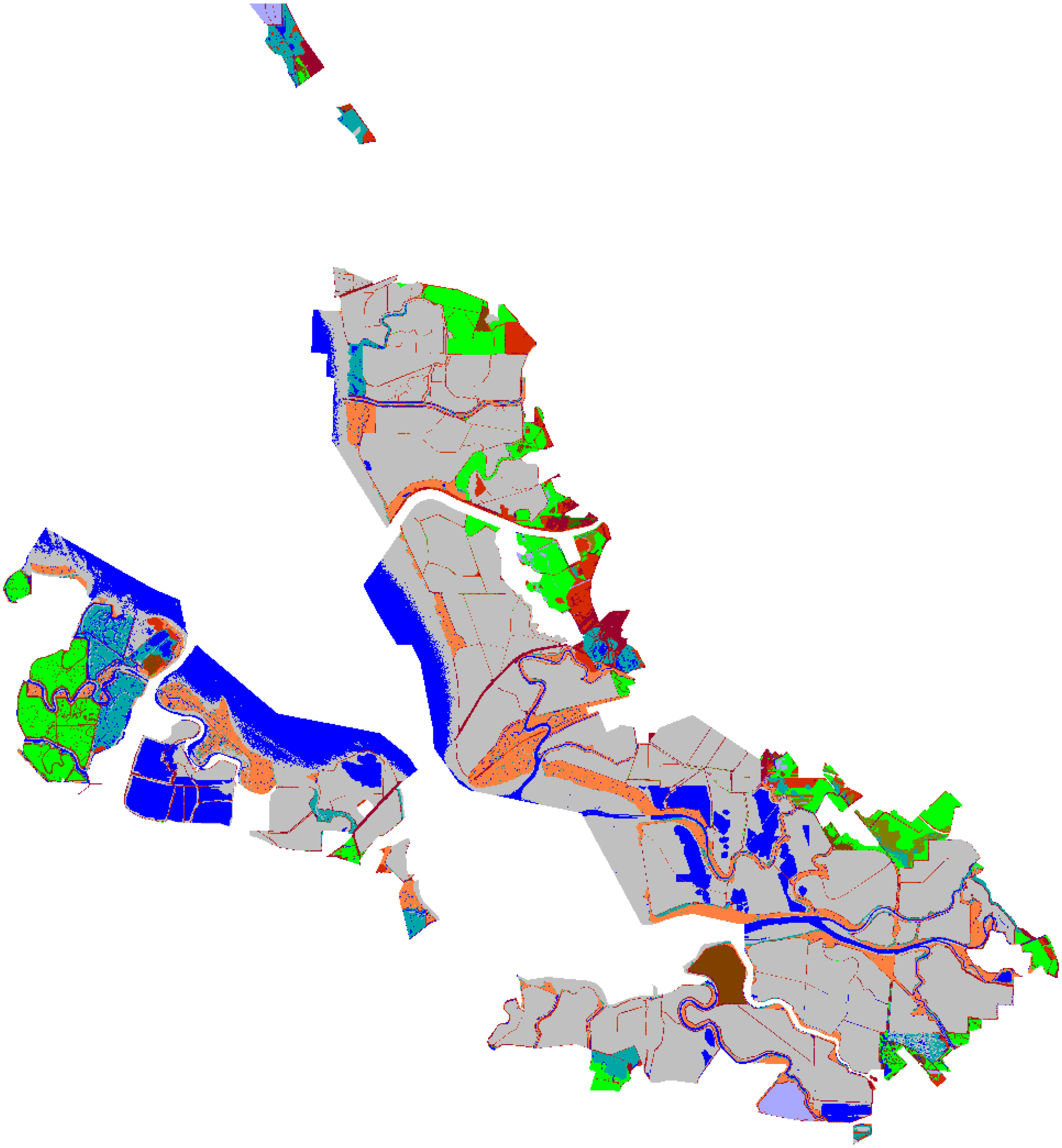
Don Edwards NWR
1.5 Meters Eustatic SLR by 2100

Results in Acres

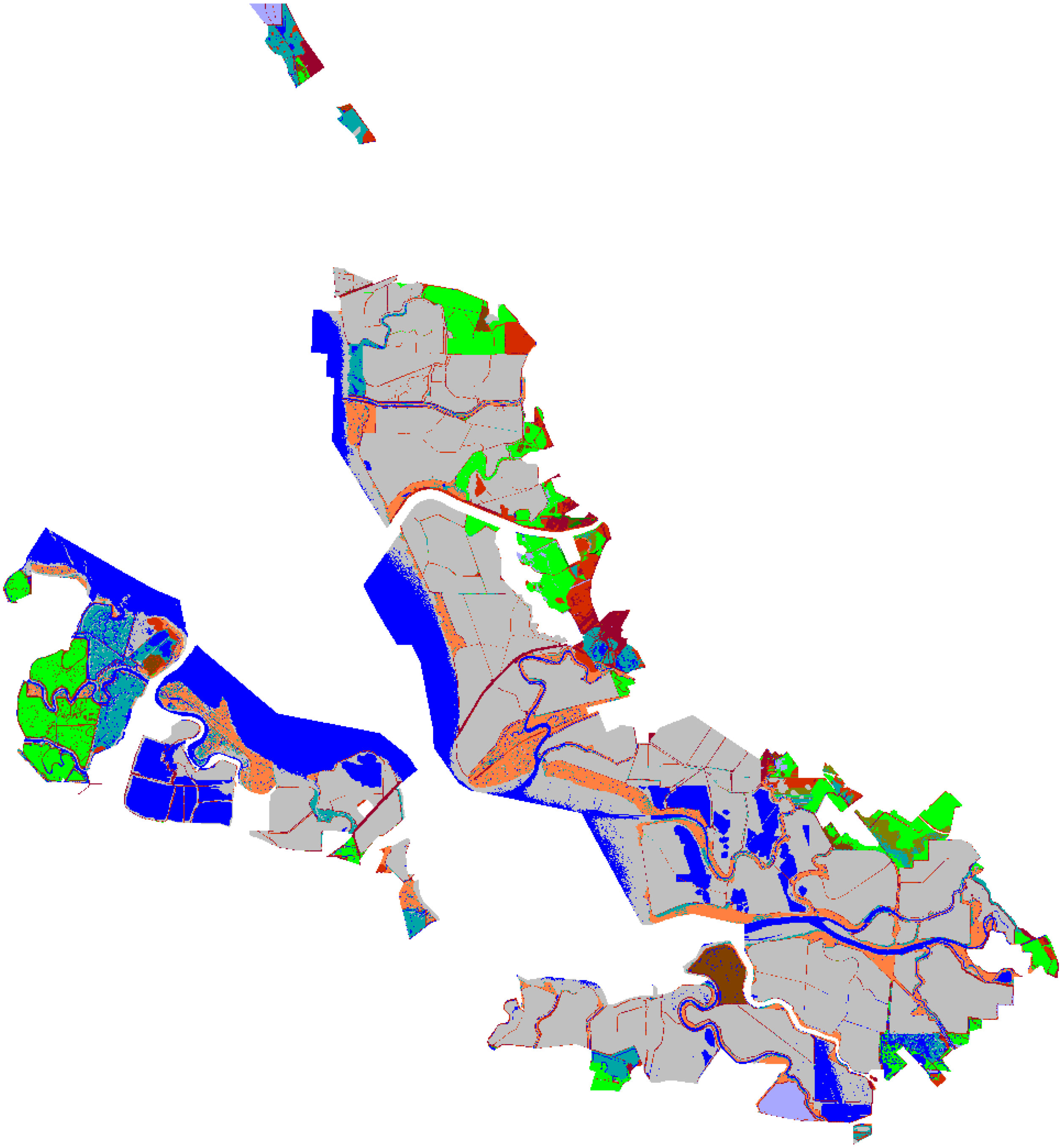
	Initial	2025	2050	2075	2100
Tidal Flat	32399.2	28290.1	26172.2	22690.0	19387.8
Brackish Marsh	5088.8	4069.2	3711.4	1627.8	810.0
Inland Fresh Marsh	4266.0	3961.1	3876.1	3656.9	3358.3
Undev. Dry Land	2191.5	1946.6	1921.5	1910.6	1901.1
Regularly Flooded Marsh	1883.0	2386.3	2752.2	4571.2	4765.7
Dev. Dry Land	1642.2	1642.2	1642.2	1642.2	1642.2
Estuarine Open Water	1548.1	6383.4	8764.3	13114.9	17522.1
Inland Shore	903.6	863.0	784.8	508.1	282.8
Tidal Creek	647.2	647.2	647.2	647.2	647.2
Inland Open Water	465.0	480.0	479.1	477.2	478.1
Swamp	27.6	28.8	27.6	27.6	27.6
Tidal Swamp	9.3	3.3	2.9	0.4	0.1
Estuarine Beach	4.0	4.0	4.0	4.0	4.0
Trans. Salt Marsh	0.0	370.4	290.0	197.4	248.8
Total (incl. water)	**51075.4**	**51075.4**	**51075.4**	**51075.4**	**51075.4**



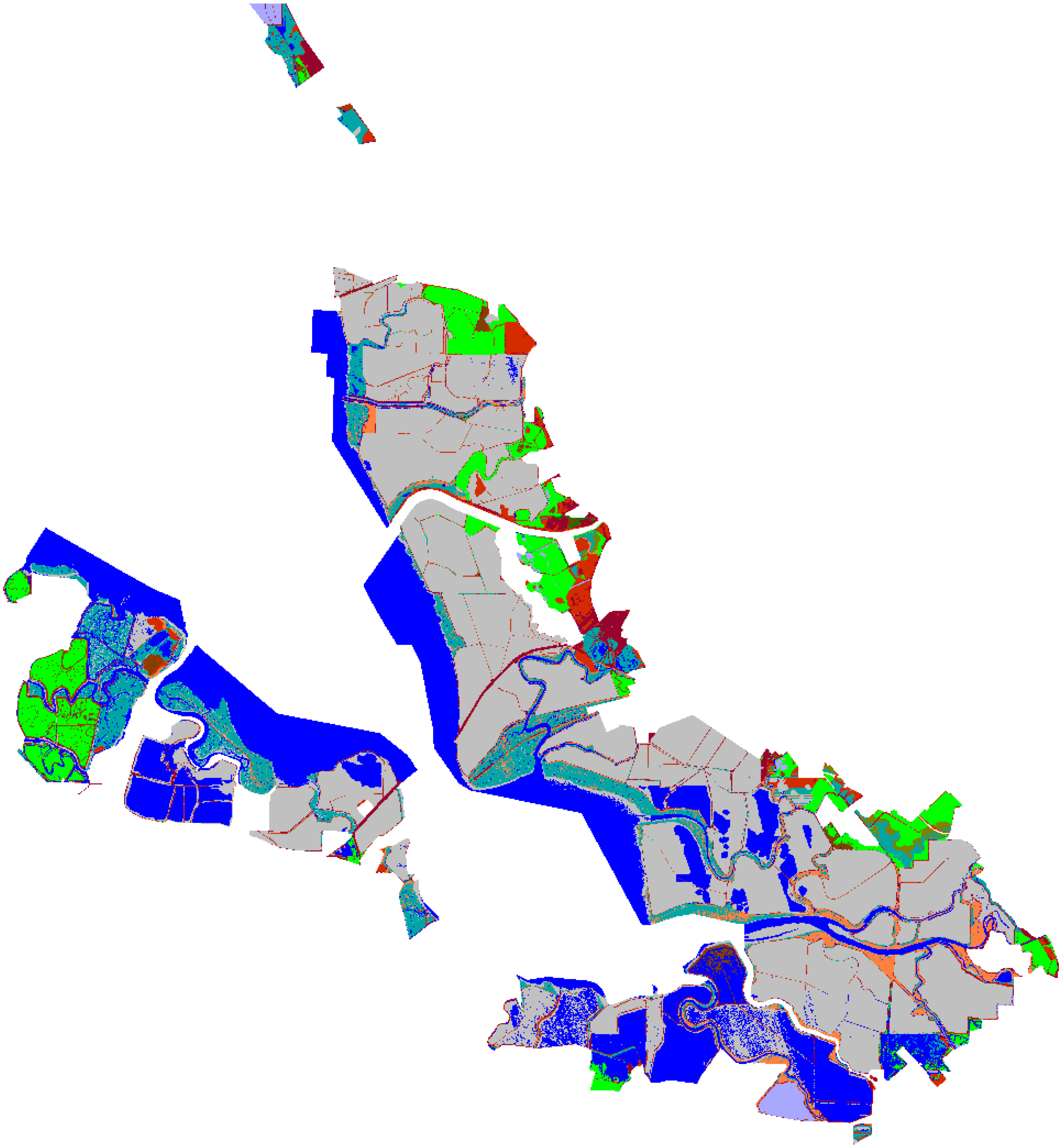
Don Edwards NWR, Initial Condition



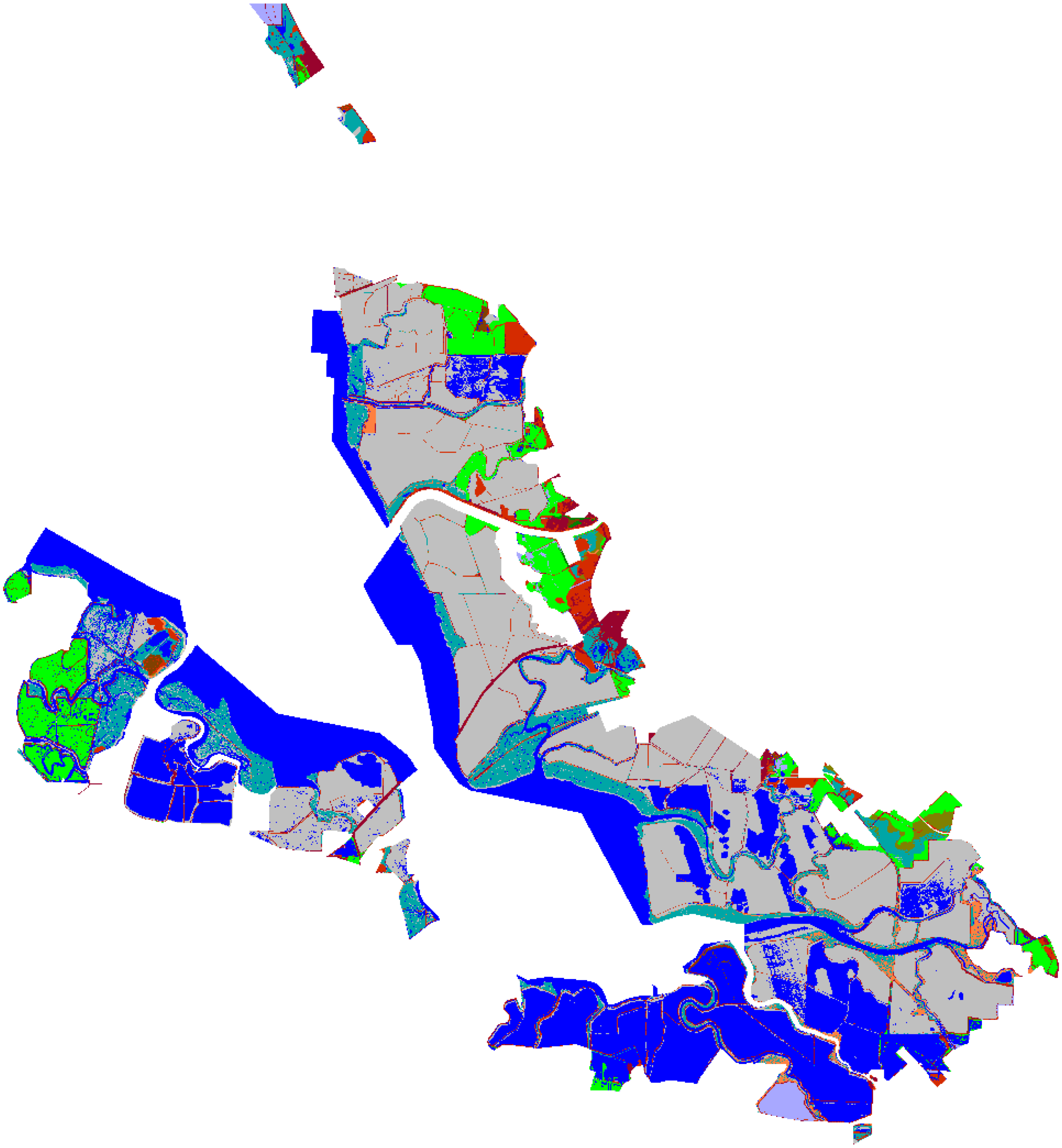
Don Edwards NWR, 2025, 1.5 meter



Don Edwards NWR, 2050, 1.5 meter



Don Edwards NWR, 2075, 1.5 meter

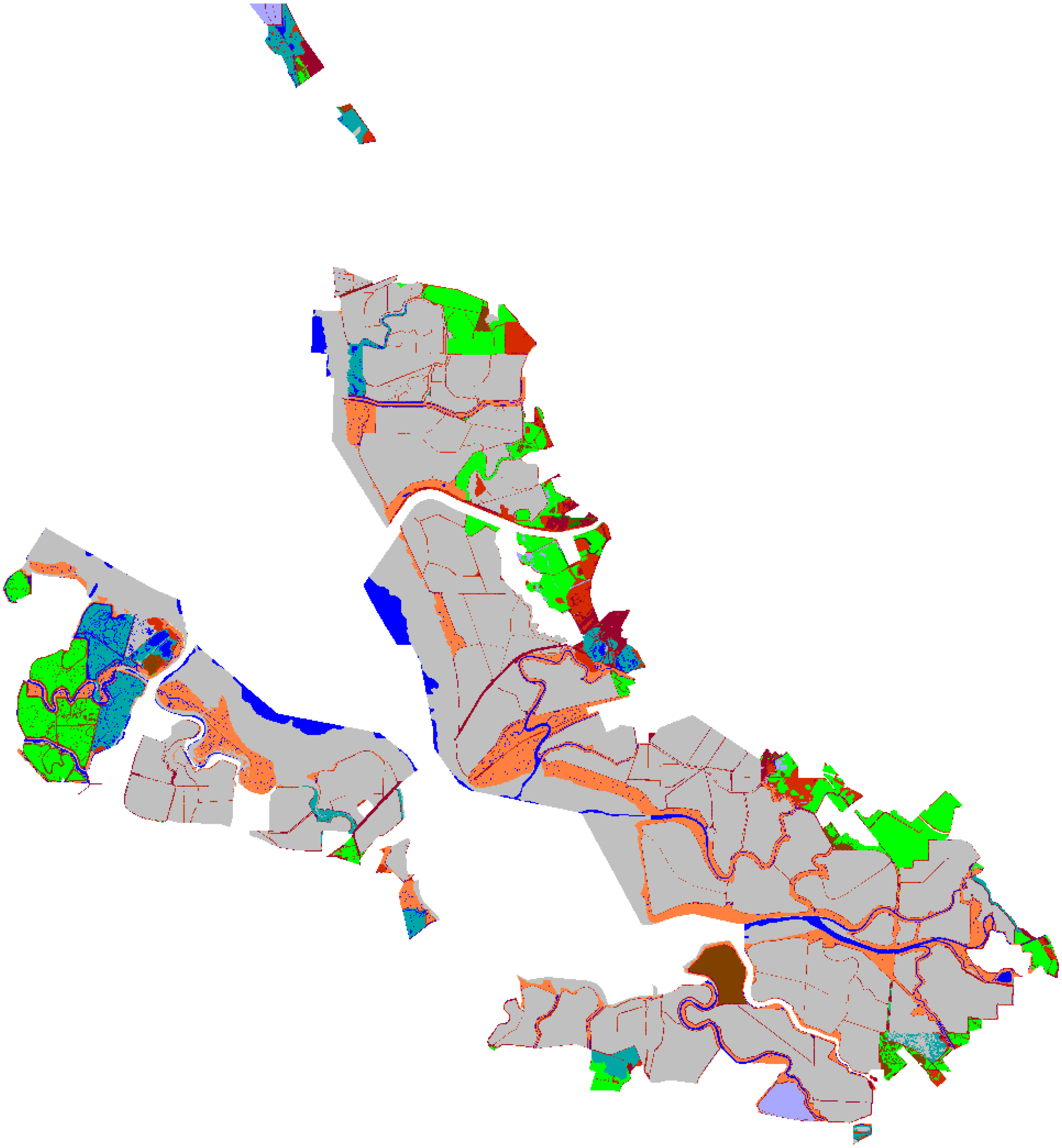


Don Edwards NWR, 2100, 1.5 meter

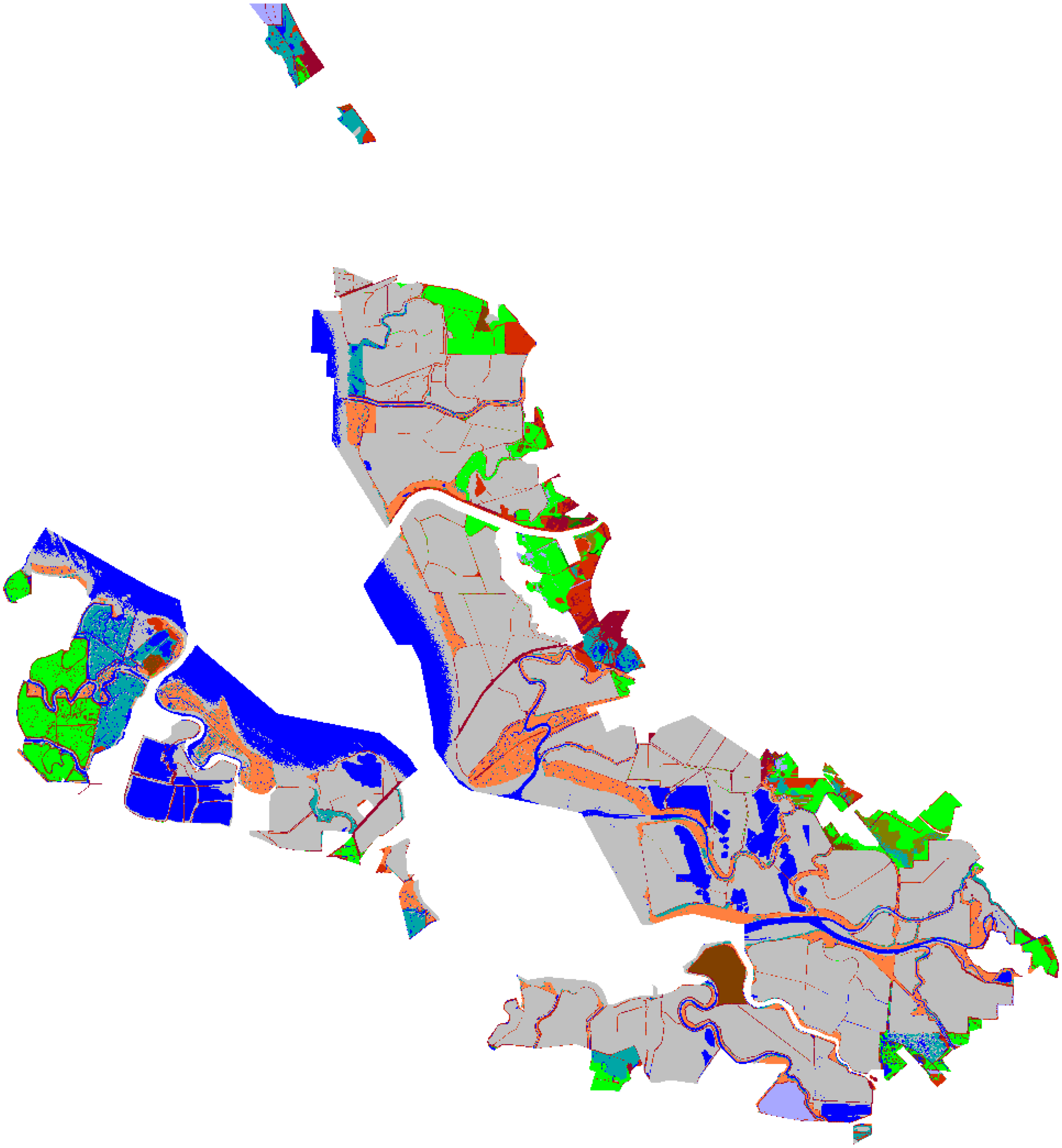
Don Edwards NWR
2 Meters Eustatic SLR by 2100

Results in Acres

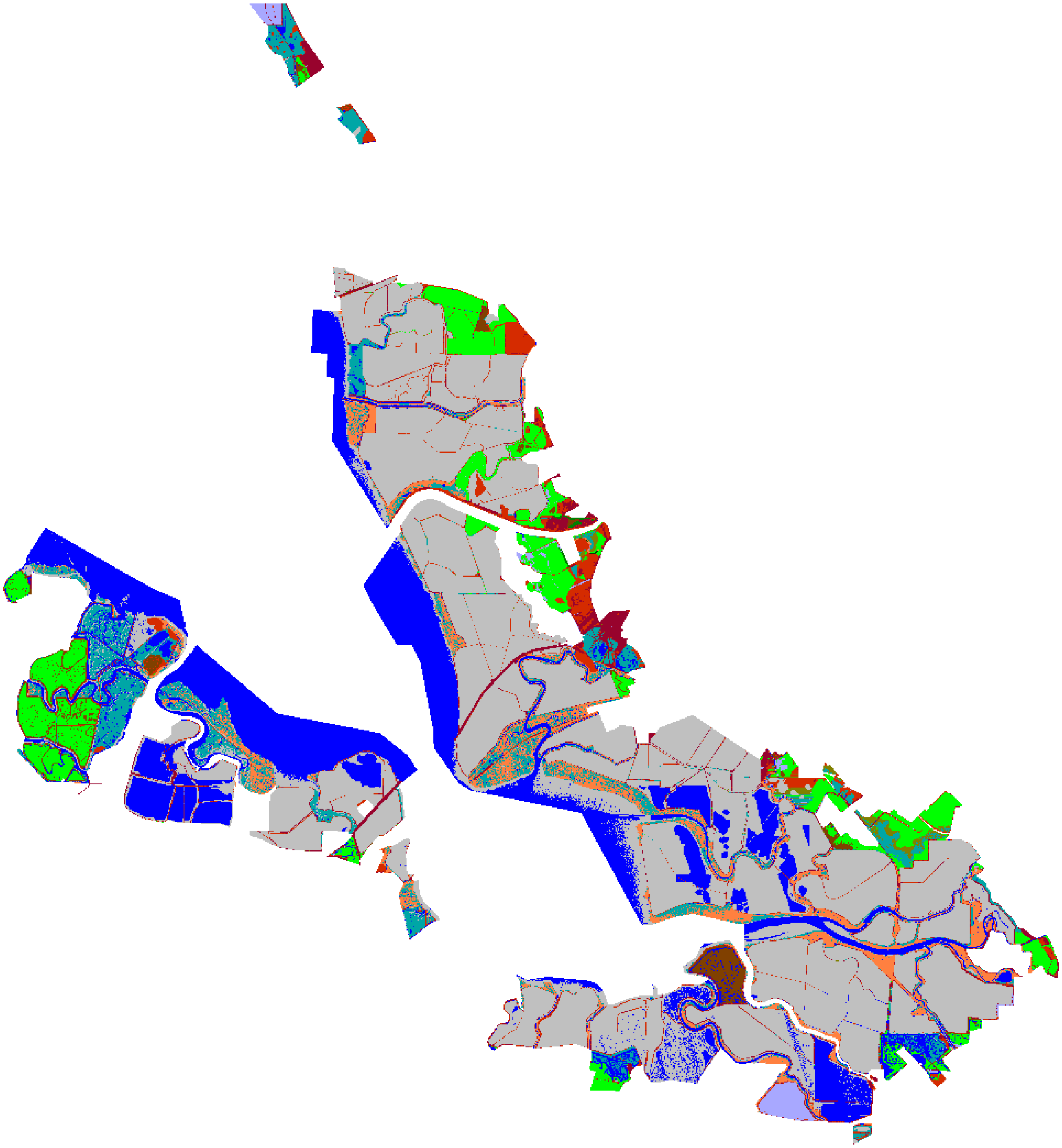
	Initial	2025	2050	2075	2100
Tidal Flat	32399.2	27965.3	24986.6	20444.0	17959.6
Brackish Marsh	5088.8	3997.8	2617.2	730.0	293.5
Inland Fresh Marsh	4266.0	3950.6	3817.7	3389.8	2604.3
Undev. Dry Land	2191.5	1944.2	1917.4	1904.6	1895.4
Regularly Flooded Marsh	1883.0	2441.3	3748.4	4862.8	1987.5
Dev. Dry Land	1642.2	1642.2	1642.2	1642.2	1642.2
Estuarine Open Water	1548.1	6752.9	10210.4	16320.9	23152.3
Inland Shore	903.6	851.7	741.8	348.9	163.6
Tidal Creek	647.2	647.2	647.2	647.2	647.2
Inland Open Water	465.0	480.9	479.0	477.9	479.2
Swamp	27.6	28.8	27.6	27.6	27.6
Tidal Swamp	9.3	3.3	2.5	0.1	0.0
Estuarine Beach	4.0	4.0	4.0	4.0	3.8
Trans. Salt Marsh	0.0	365.2	233.5	275.3	219.5
Total (incl. water)	**51075.4**	**51075.4**	**51075.4**	**51075.4**	**51075.4**



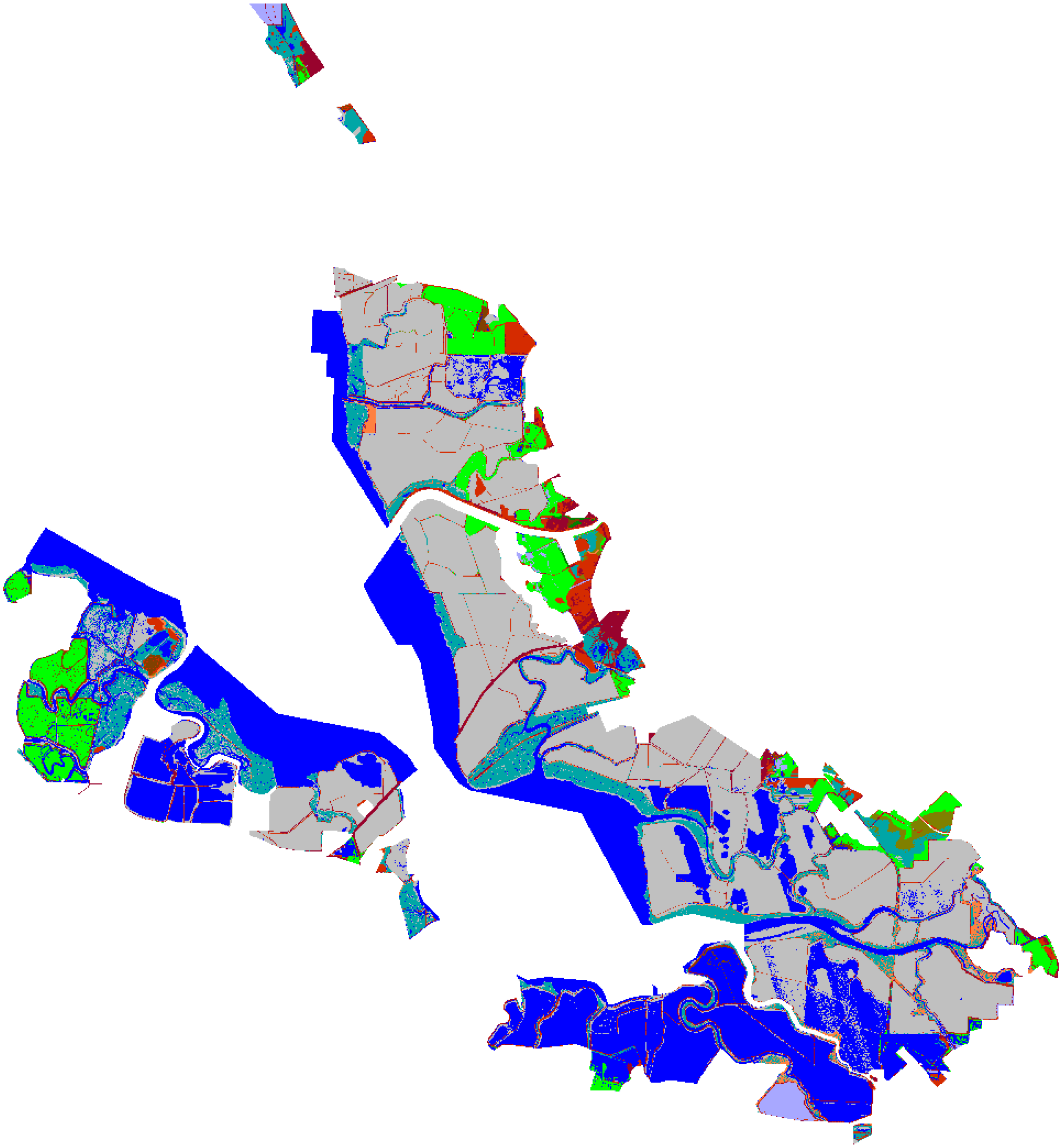
Don Edwards NWR, Initial Condition



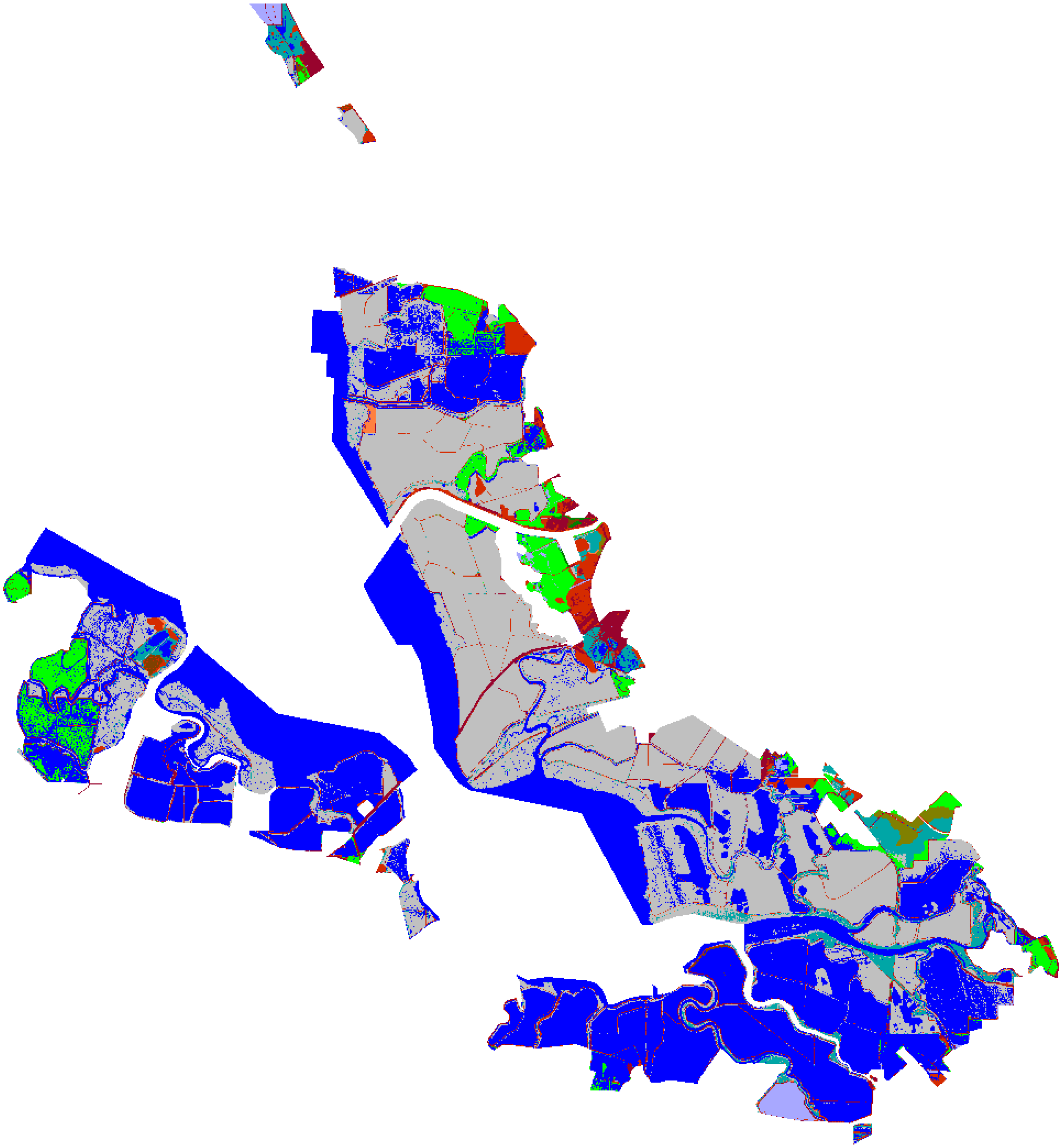
Don Edwards NWR, 2025, 2 meters



Don Edwards NWR, 2050, 2 meters



Don Edwards NWR, 2075, 2 meters



Don Edwards NWR, 2100, 2 meters

Discussion

Don Edwards NWR is comprised mostly of impounded salt ponds or salt evaporators. As SLAMM does not have a wetland classification specifically for salt ponds, these areas were designated as impounded tidal flats. This designation makes some sense within the conceptual model considering that salt ponds are generally non-vegetated and sub-tidal. These "impounded tidal flats" are assumed to be protected until their elevations falls two meters below mean tide level at which point they are assumed to convert to estuarine open water.

The refuge and surrounding zones have been heavily modified over the past century for the purpose of salt production. The addition of manmade channels and culverts makes the area hydrodynamically complex. SLAMM is not a hydrodynamic model, which increases the uncertainty of results in such a heavily modified area. This uncertainty is particularly pronounced for non-impounded lands behind the modified zones. Tide ranges are certainly affected in these zones, though to what degree is uncertain. Inland fresh marsh losses therefore may be especially uncertain due to non-modeled variations in tidal ranges.

Developed dry lands were assumed to be protected in these simulations. It was assumed that areas that are already developed will be protected by additional infrastructure in the event of SLR. As a result, model output for dry land will be somewhat conservative.

The most threatened ecological areas within the Don Edwards refuge may be the irregularly-flooded marshes. Above the 1 meter SLR scenario, the loss of irregularly flooded marsh is predicted to jump by 45%. Most of these marshes back up against dikes or seawalls, meaning that marsh transgression is not possible.

San Francisco Bay appears to have a complex relationship between suspended sediments, land subsidence, and accretion rates that can result in very high rates of accretion, particularly in the southernmost part of the bay. Lacking spatially-variable subsidence data, this relationship was not explicitly modeled. Future model applications could further explore the relationship between land subsidence, cell elevations, sediment concentrations, and predicted accretion rates.

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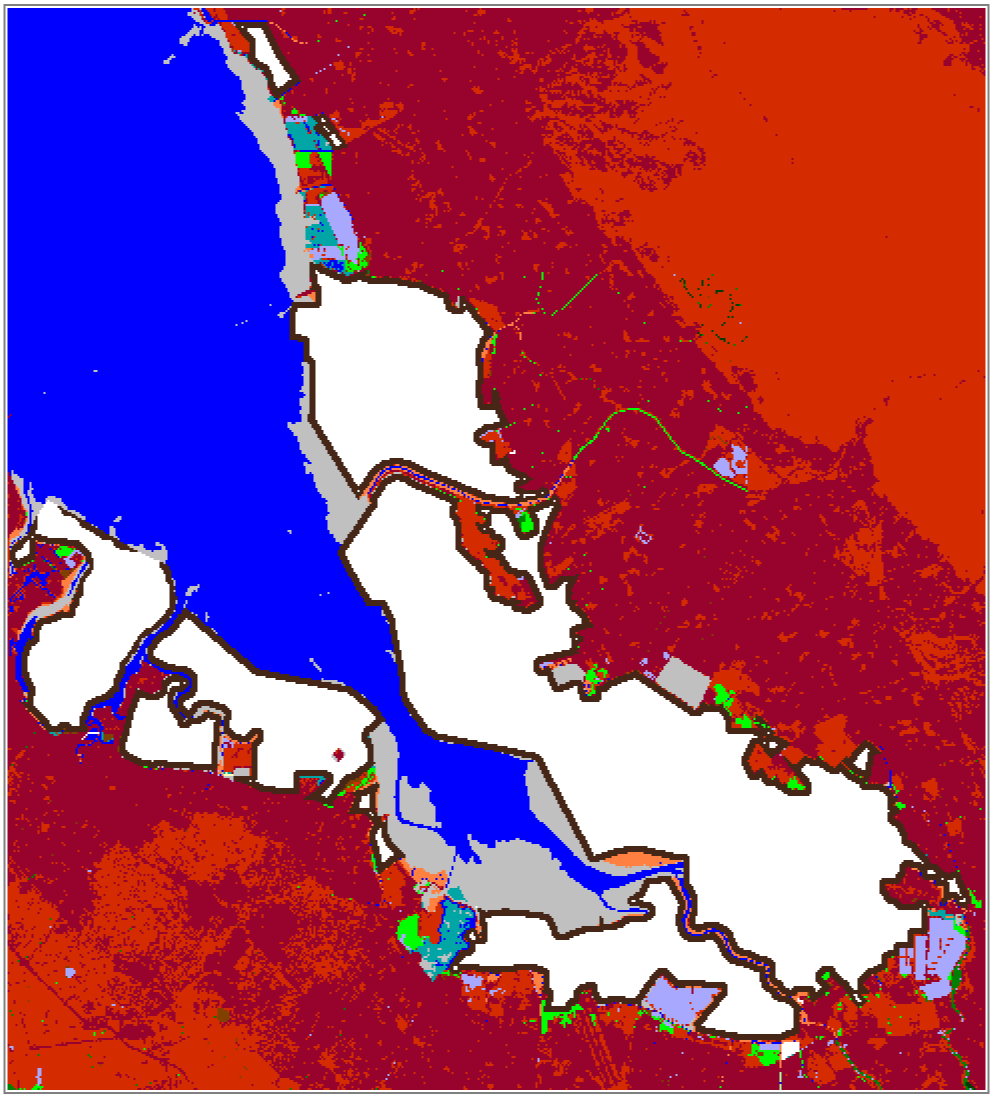
Appendix A: Contextual Results

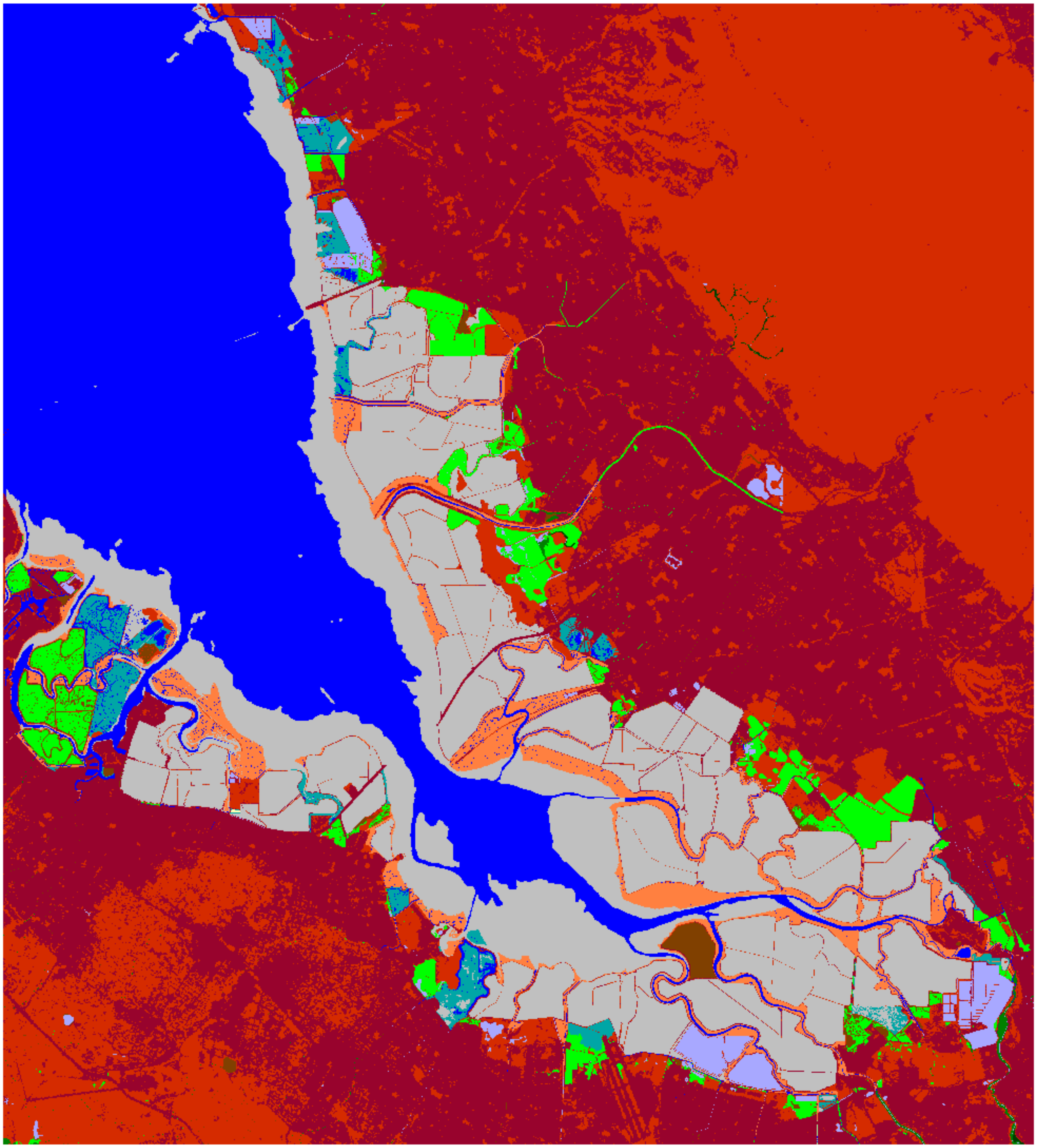
The SLAMM model does take into account the context of the surrounding lands or open water when calculating effects. For example, erosion rates are calculated based on the maximum fetch (wave action) which is estimated by assessing contiguous open water to a given marsh cell. Another example is that inundated 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. These results maps are presented here with the following caveats:

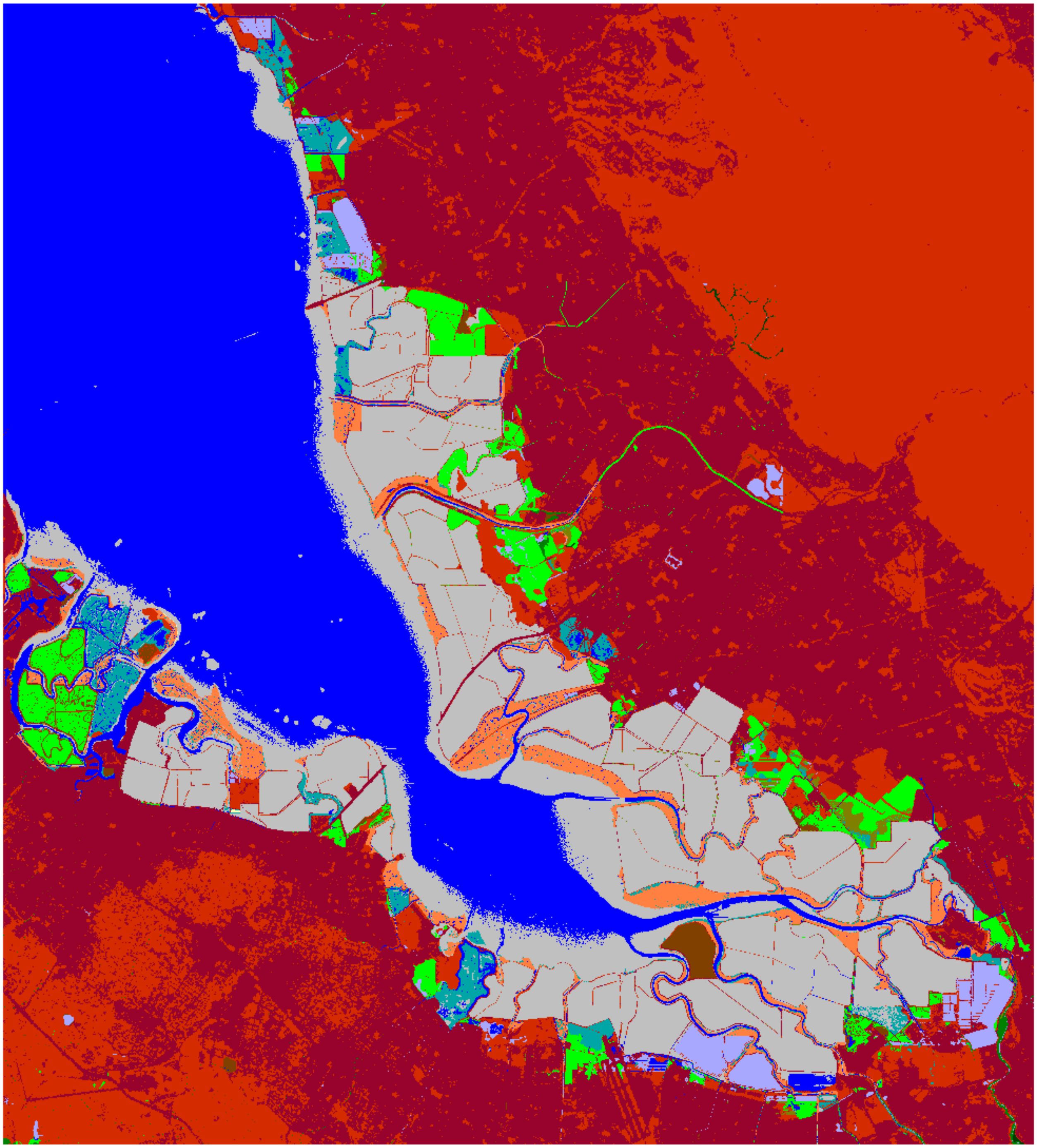
- Results were closely examined (quality assurance) within USFWS refuges but not closely examined for the larger region.
- Site-specific parameters for the model were derived for USFWS refuges whenever possible and may not be regionally applicable.
- Especially in areas where dikes are present, an effort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



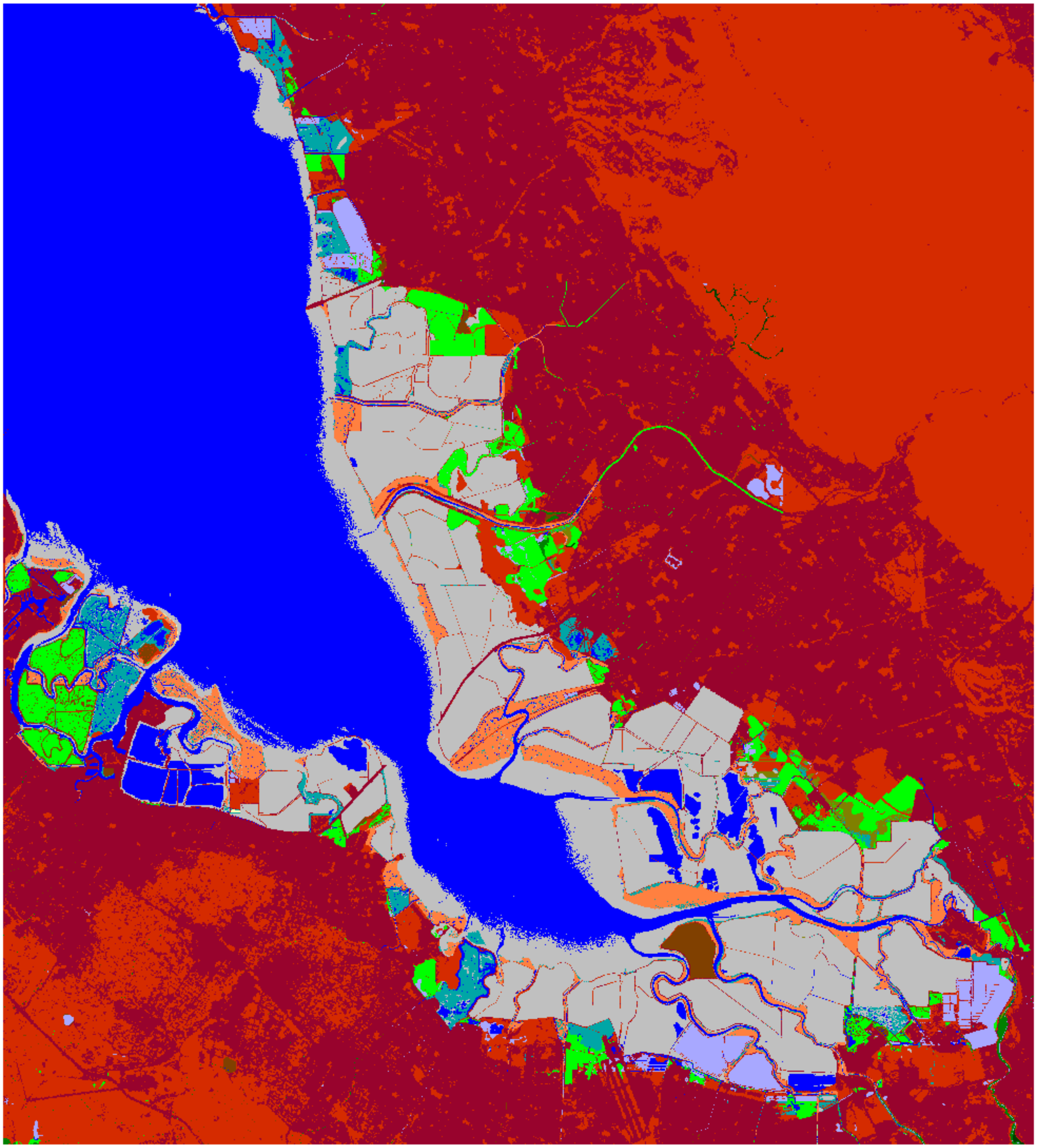
Location of Don Edwards National Wildlife Refuge within simulation context



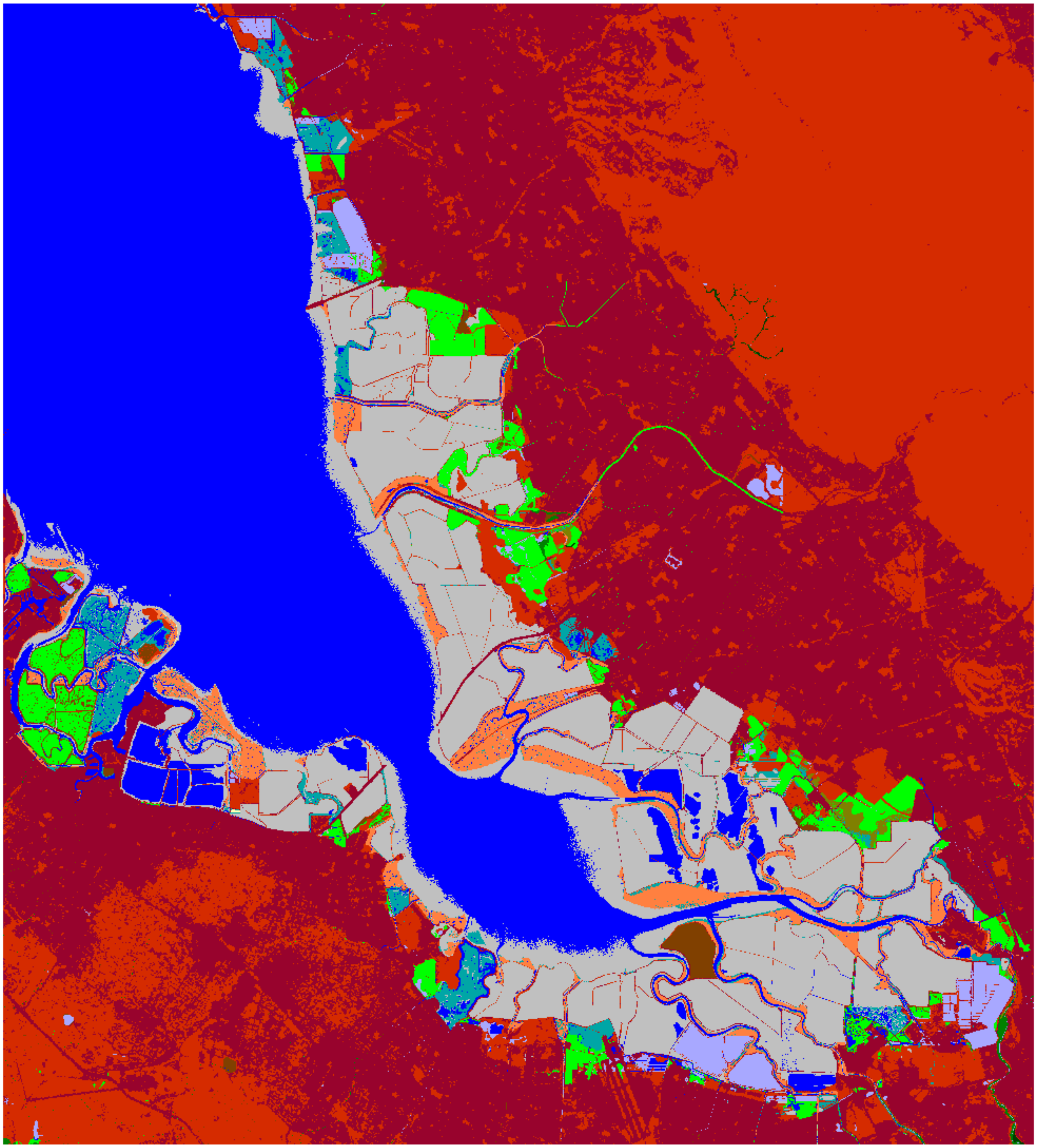
Don Edwards NWR, Initial Condition



Don Edwards NWR, 2025, Scenario A1B Mean



Don Edwards NWR, 2050, Scenario A1B Mean



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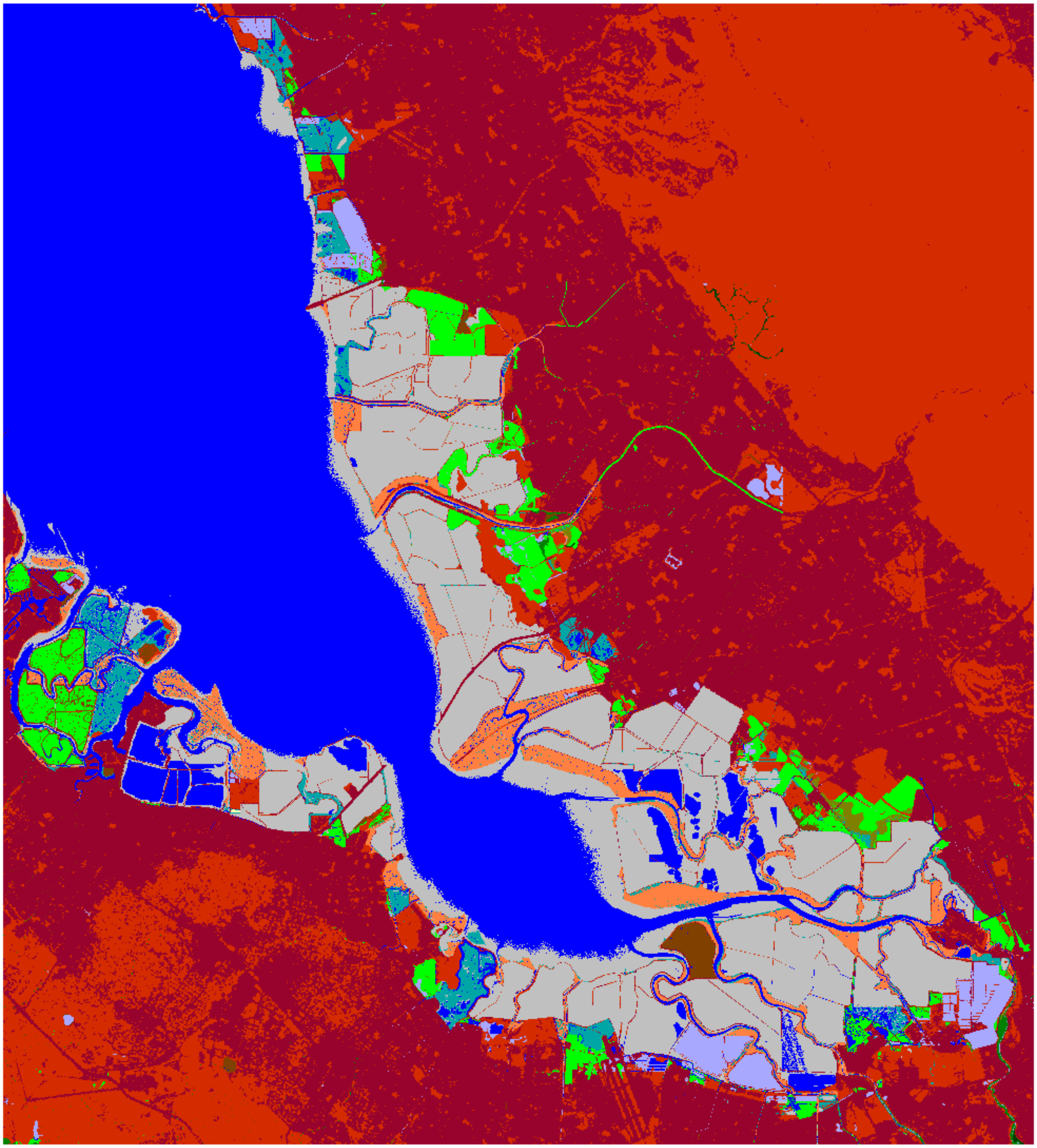
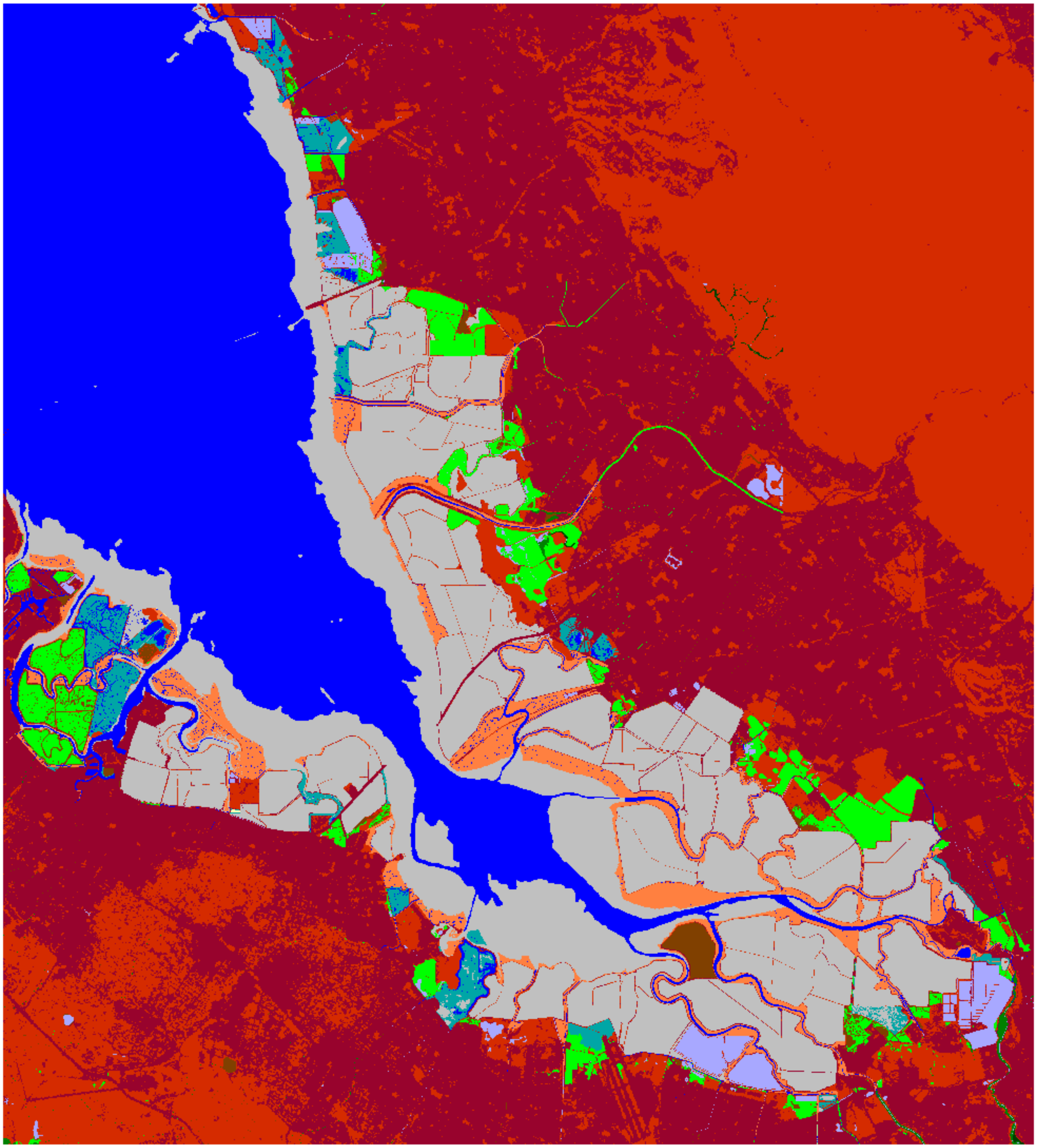


Don Edwards NWR, 2100, Scenario A1B Mean



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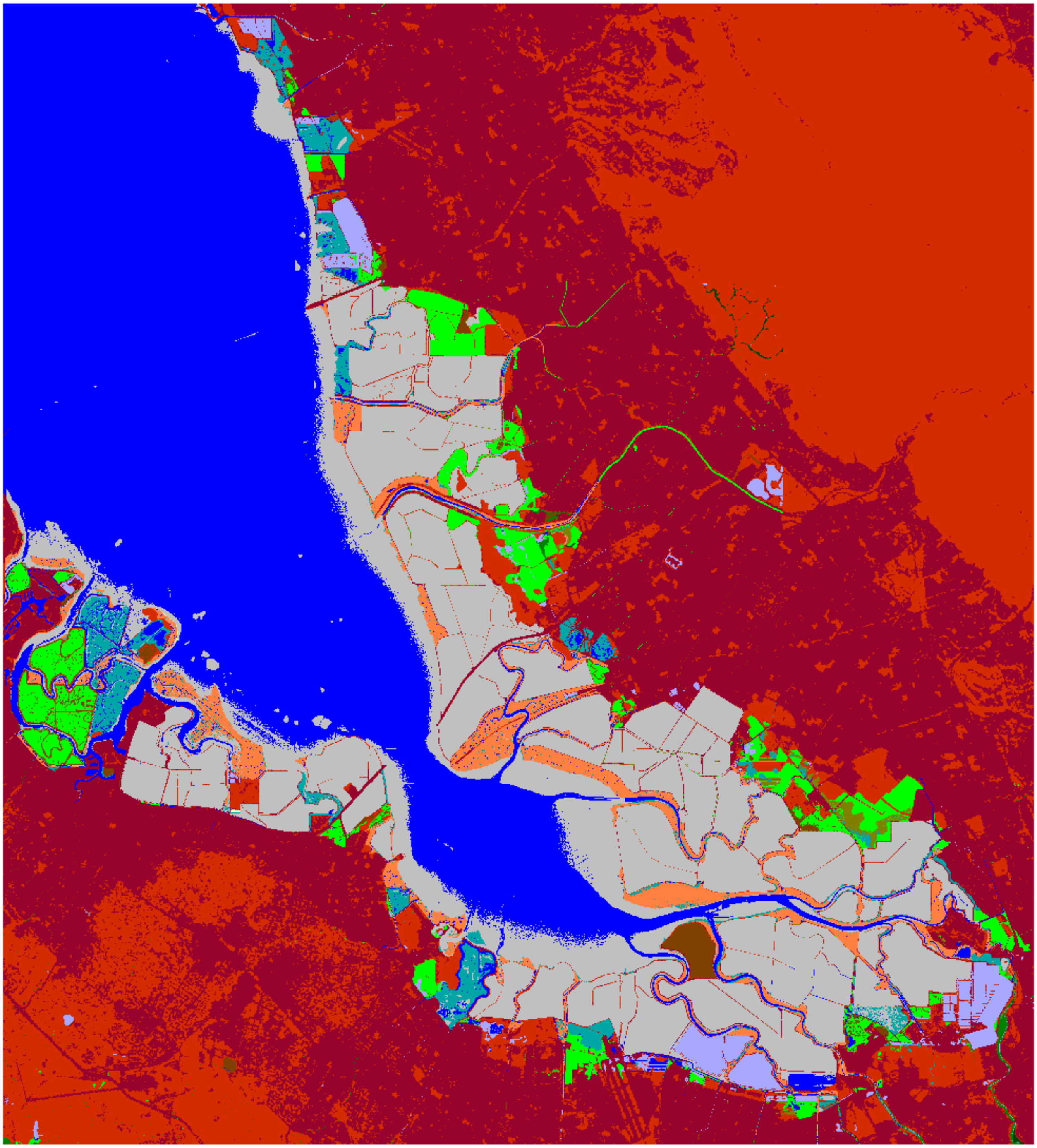
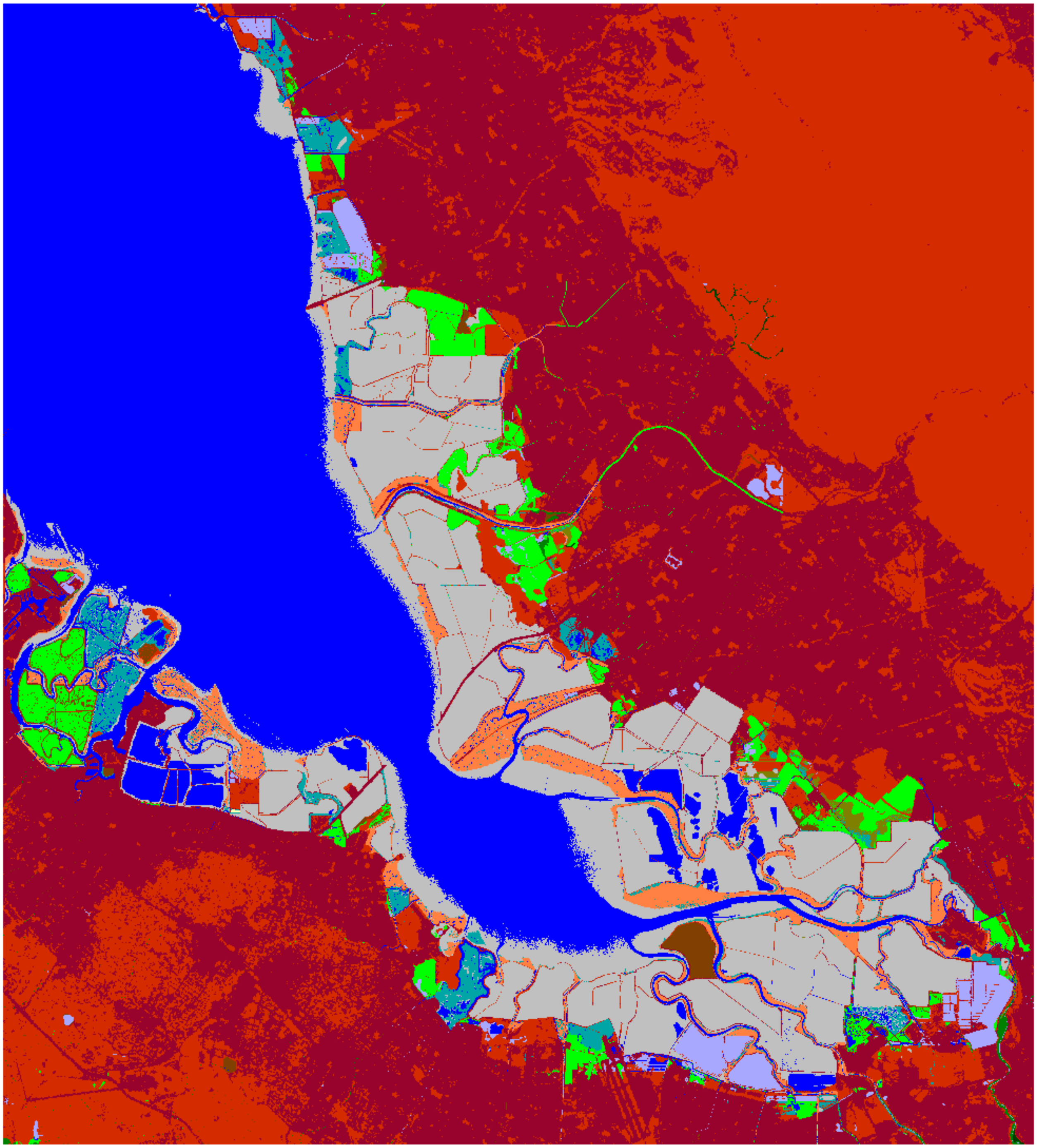


Don Edwards NWR, 2025, Scenario A1B Maximum



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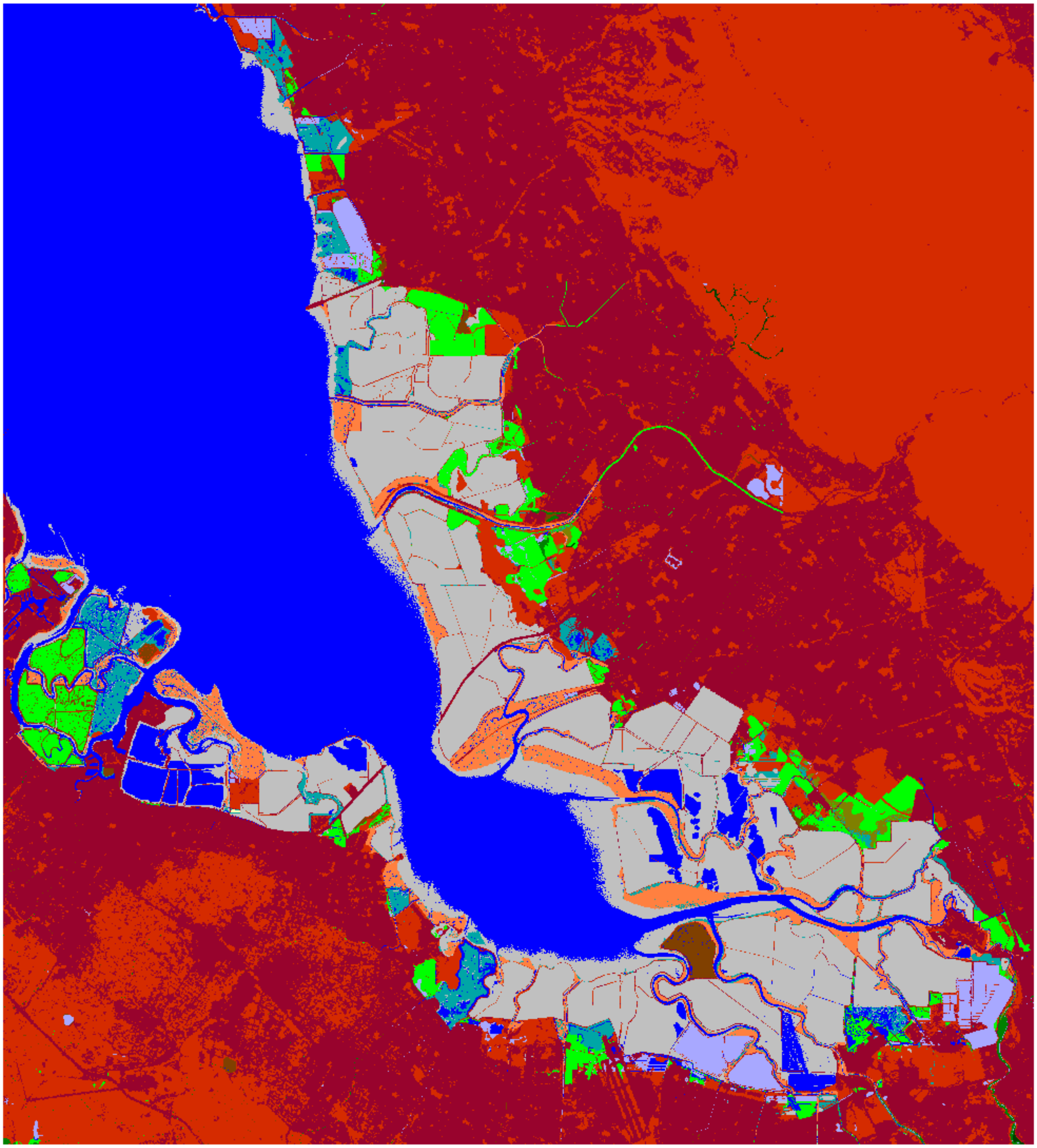

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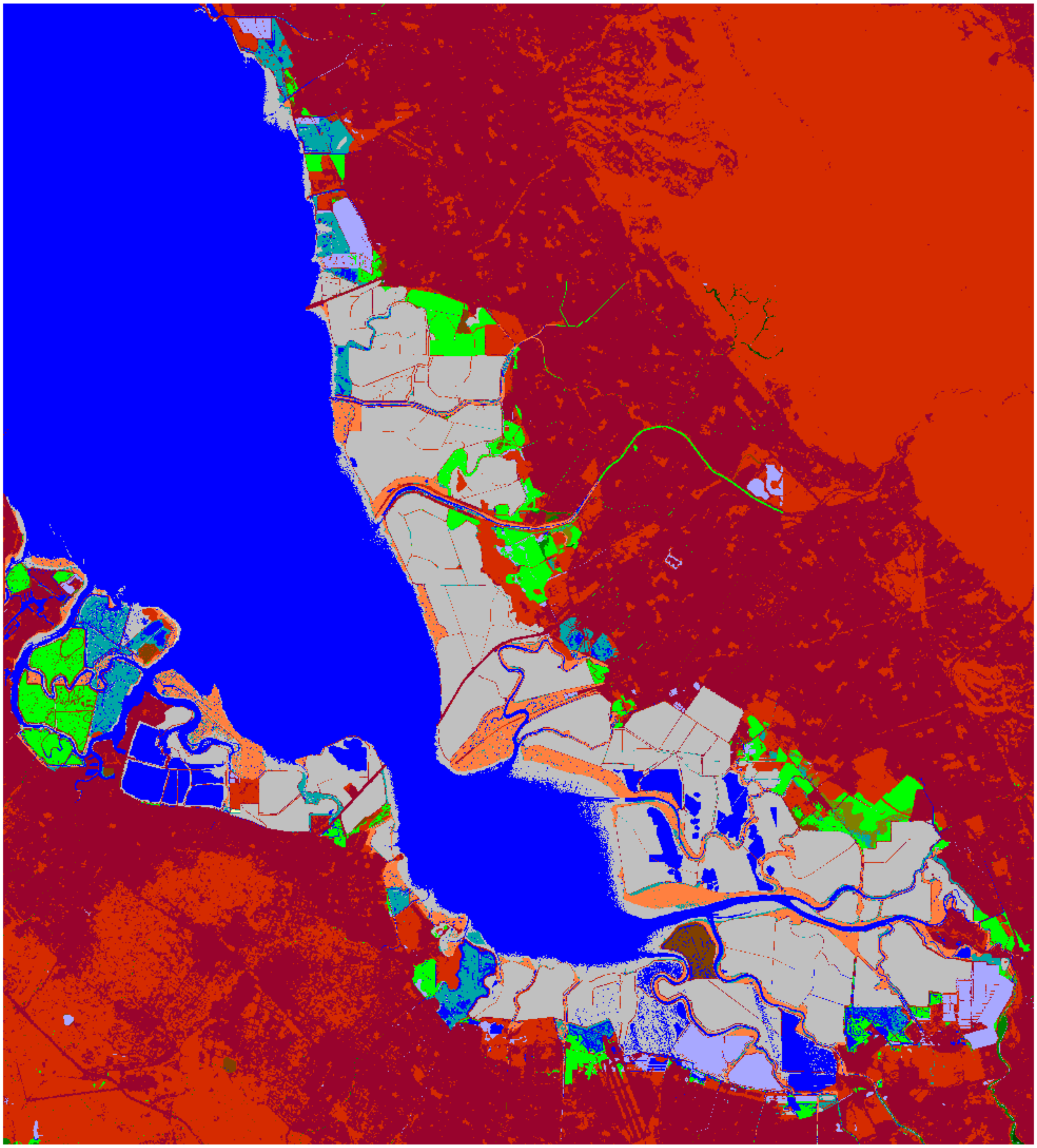

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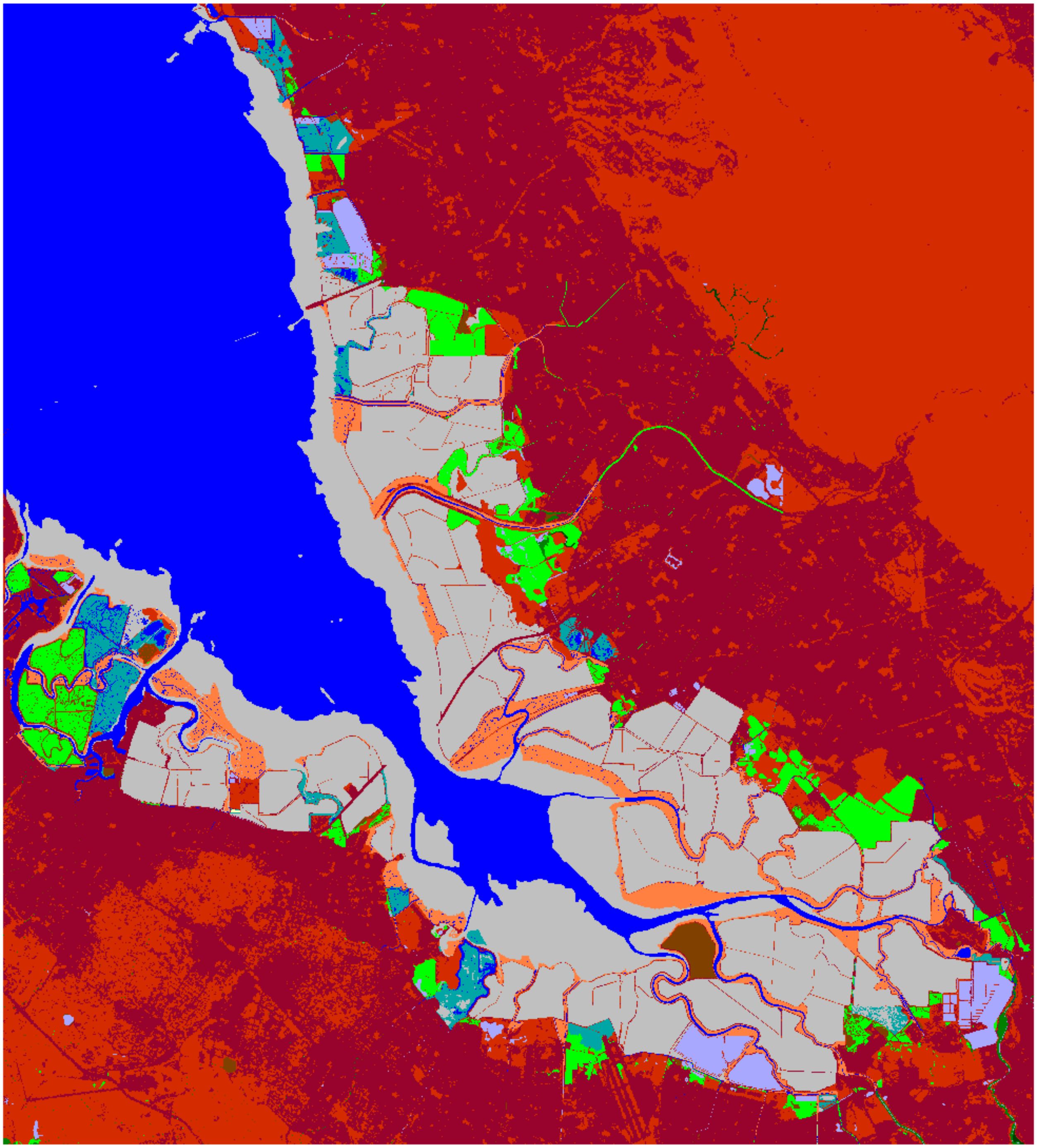
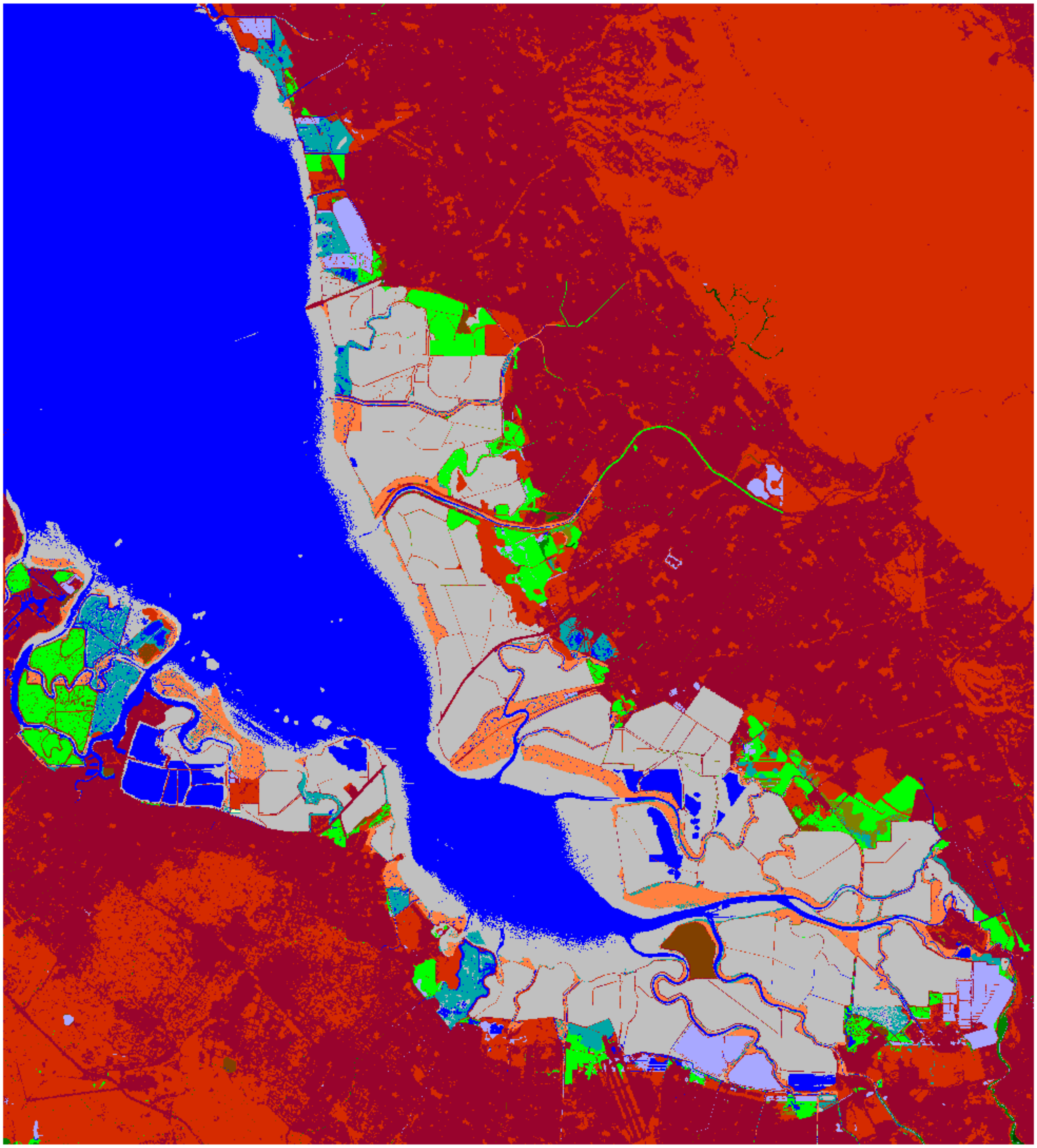
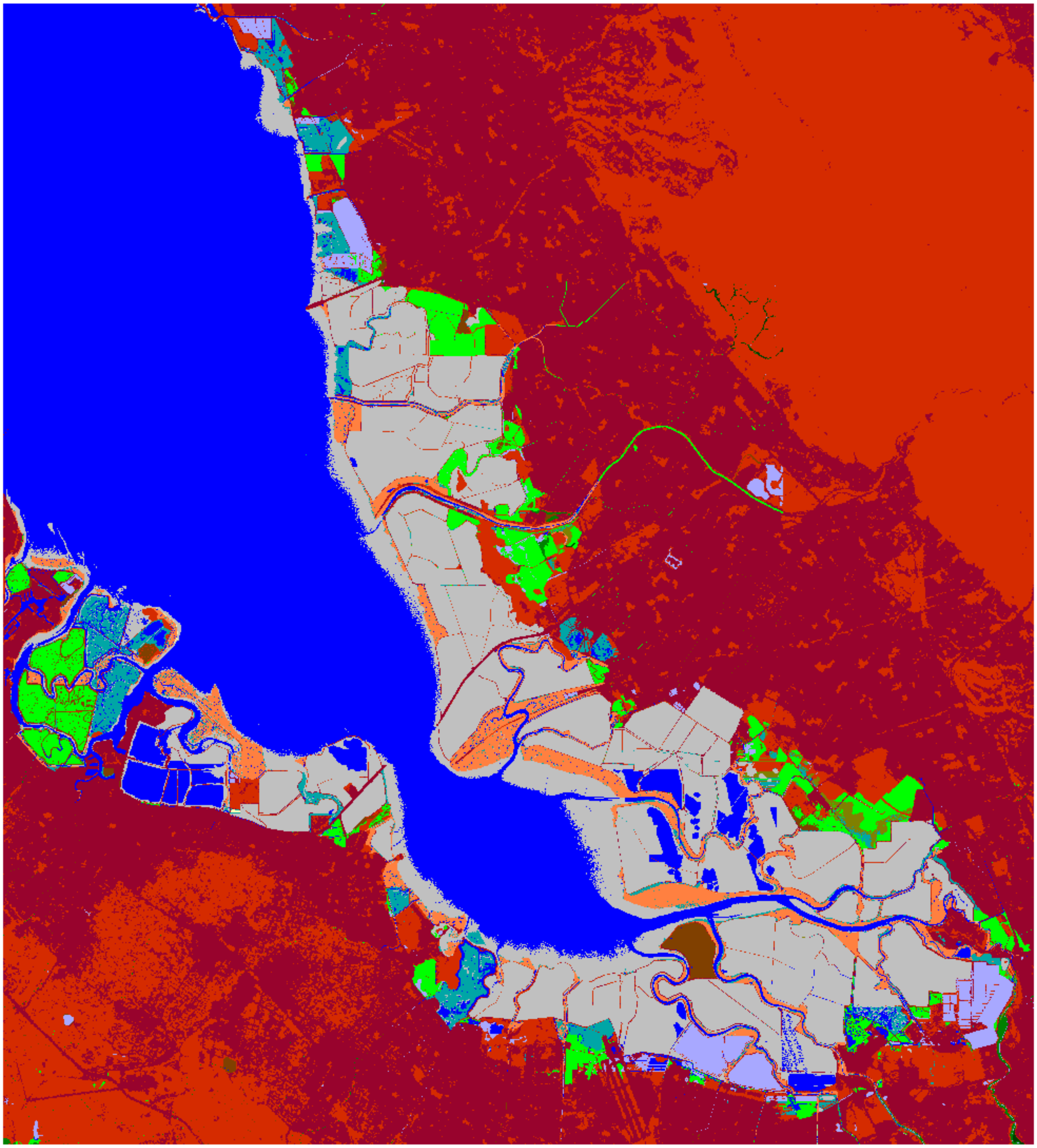


Don Edwards NWR, Initial Condition



Don Edwards NWR, 2025, 1 meter



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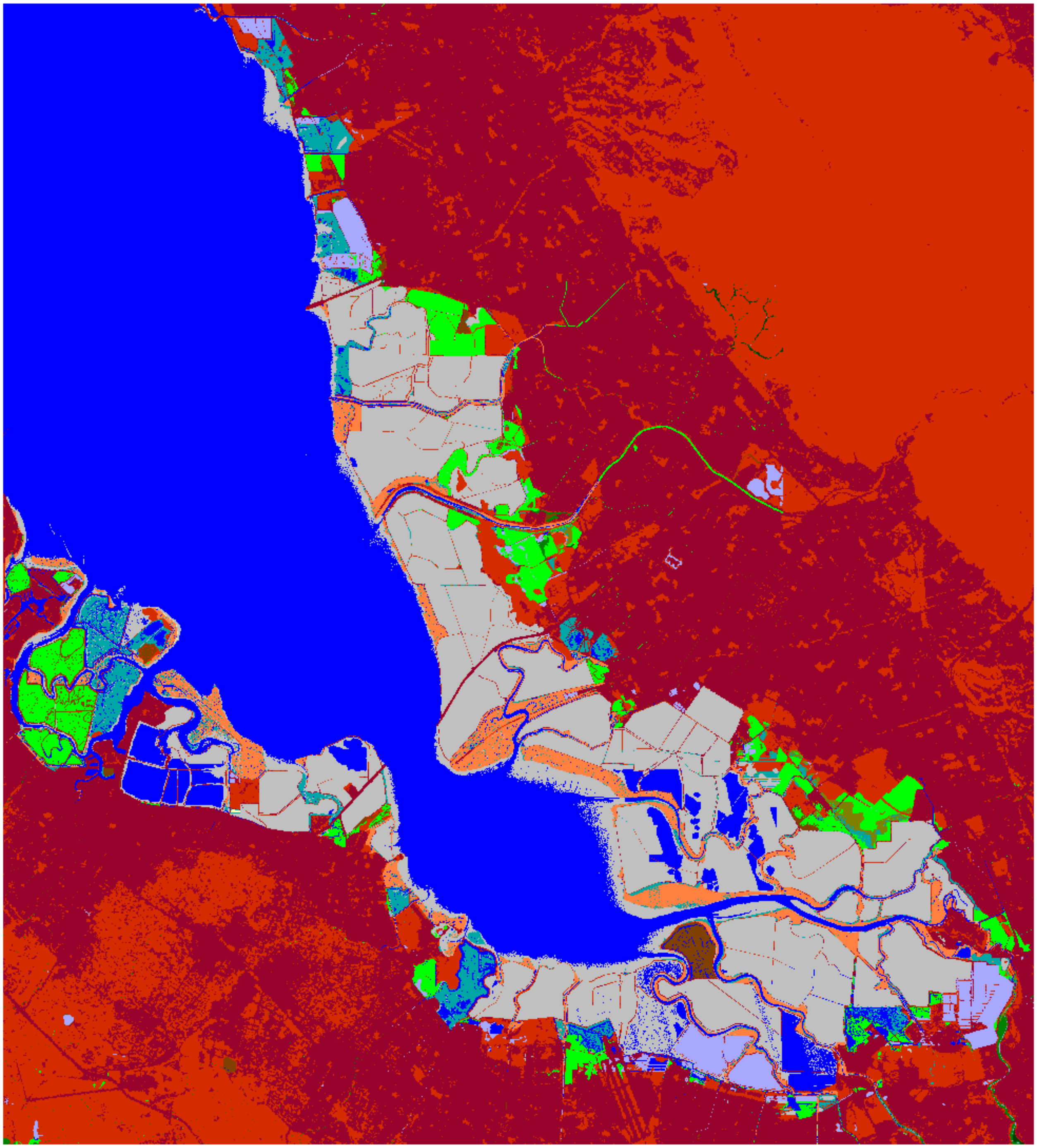

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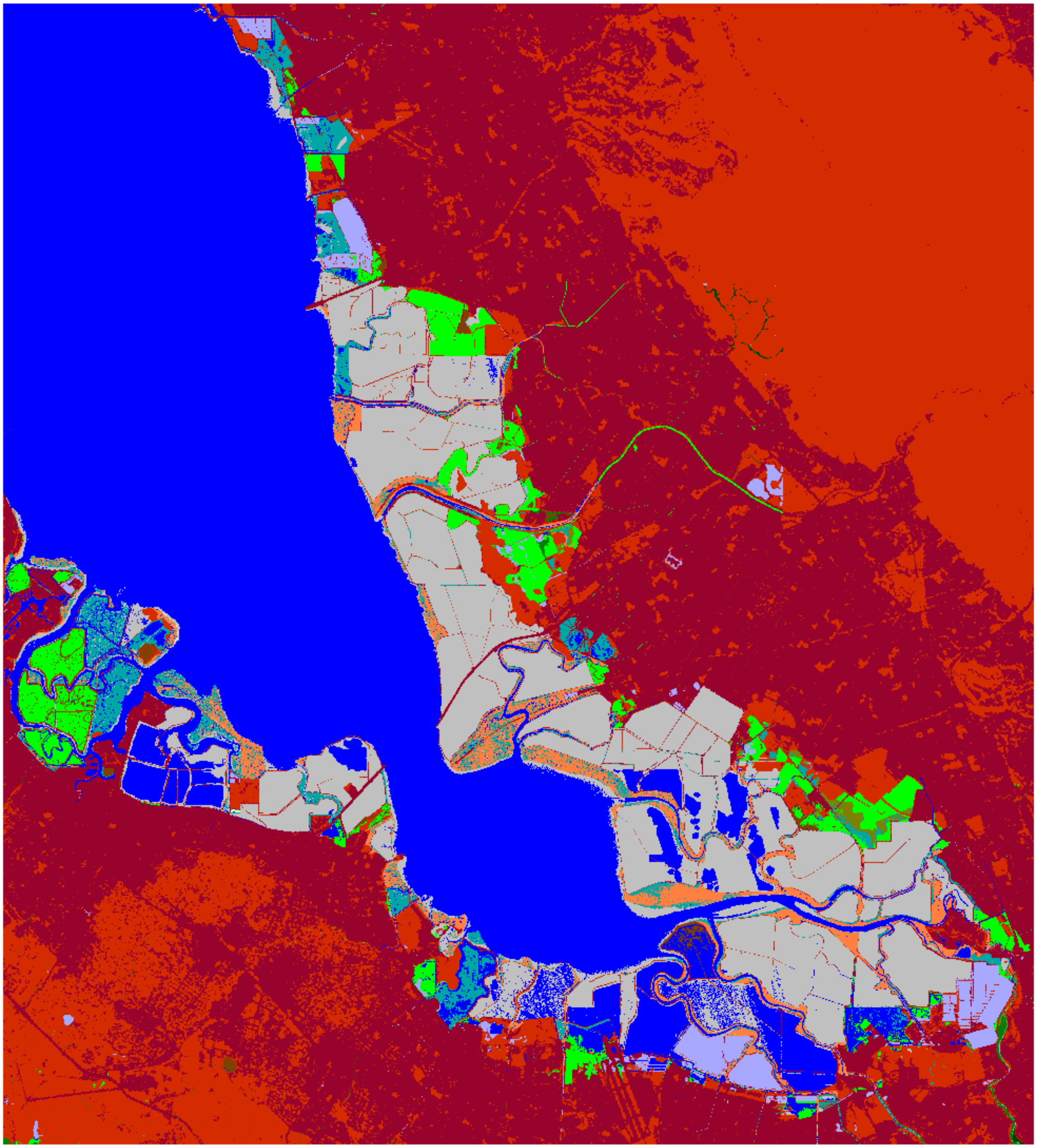

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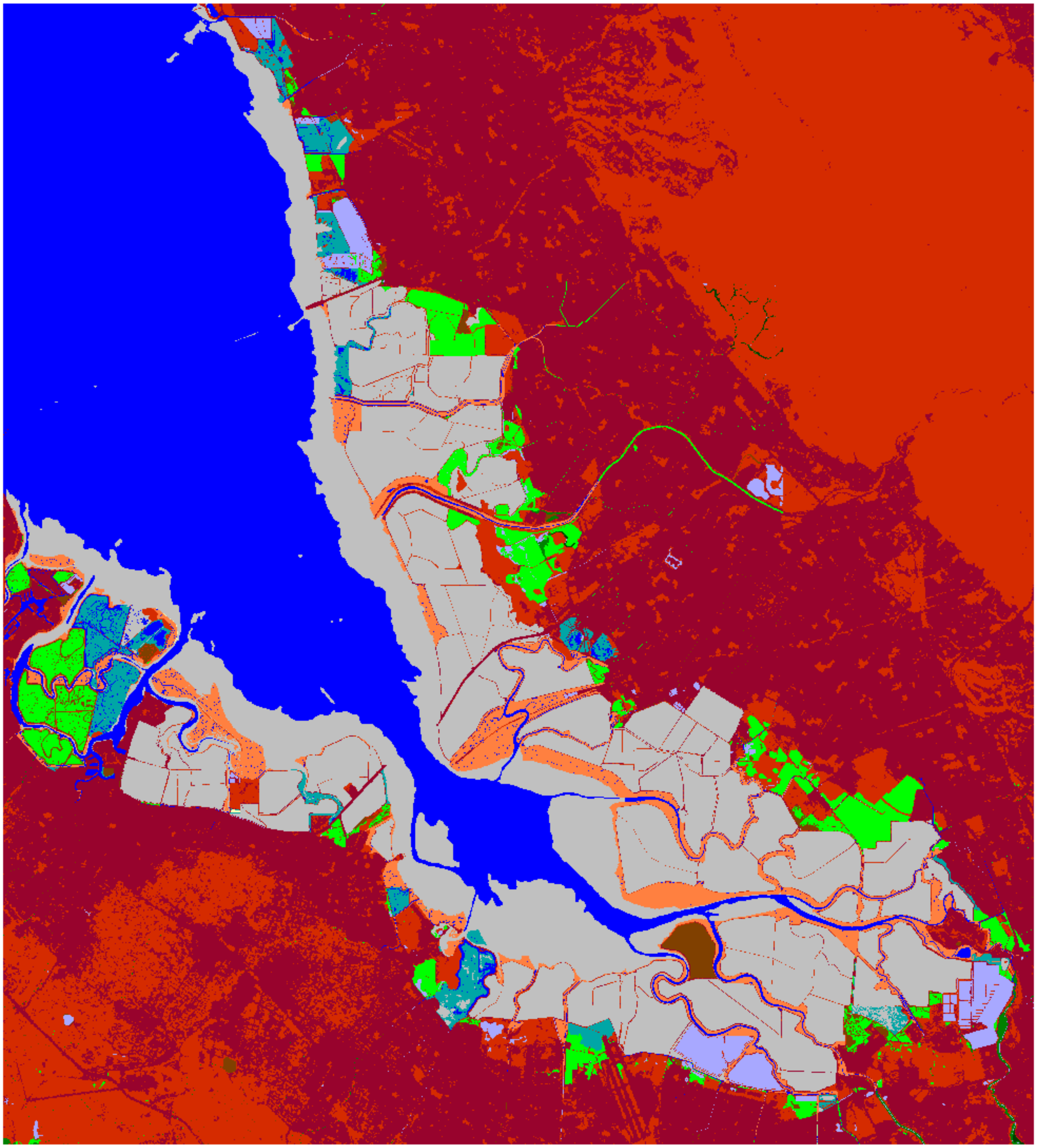
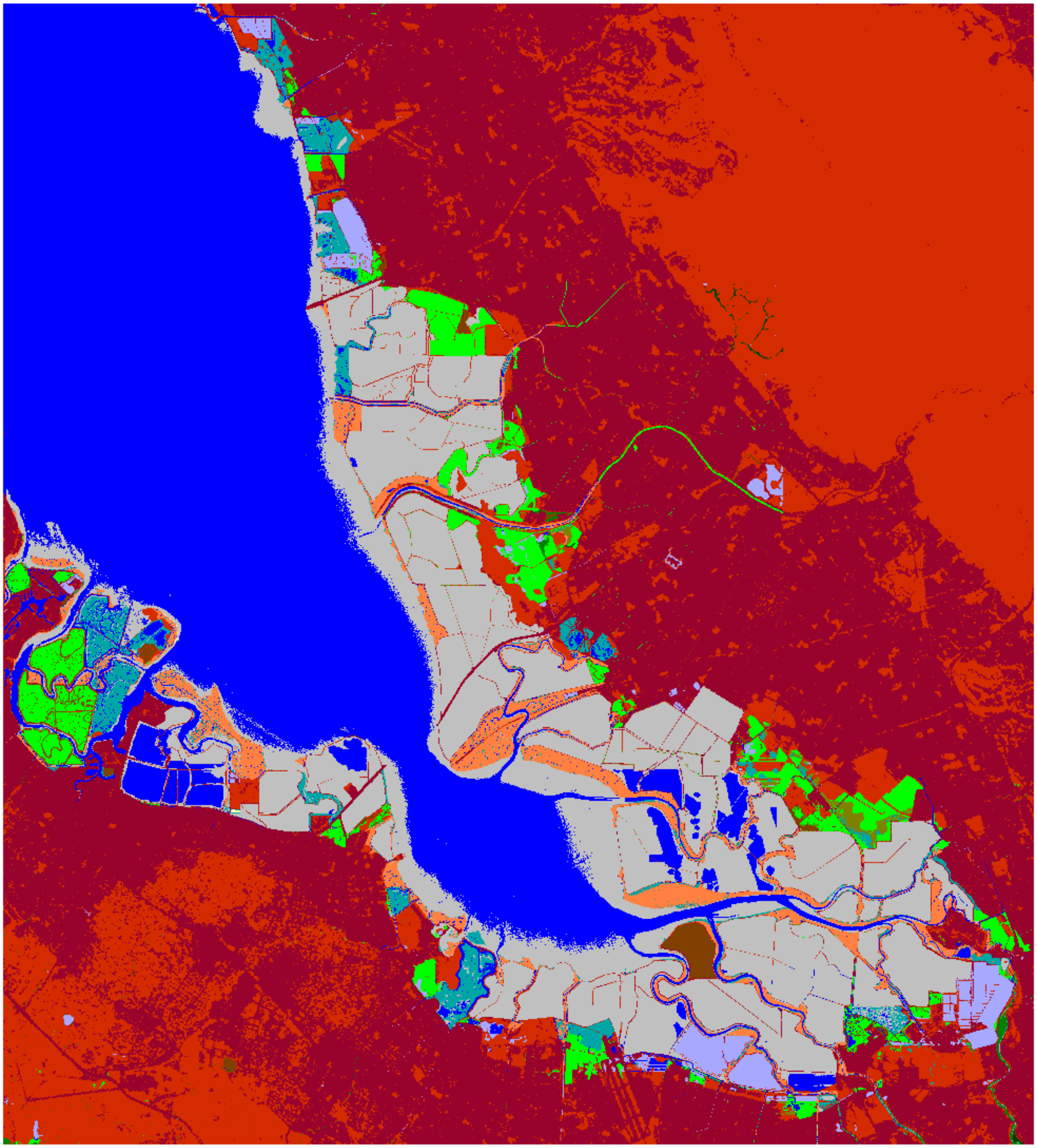
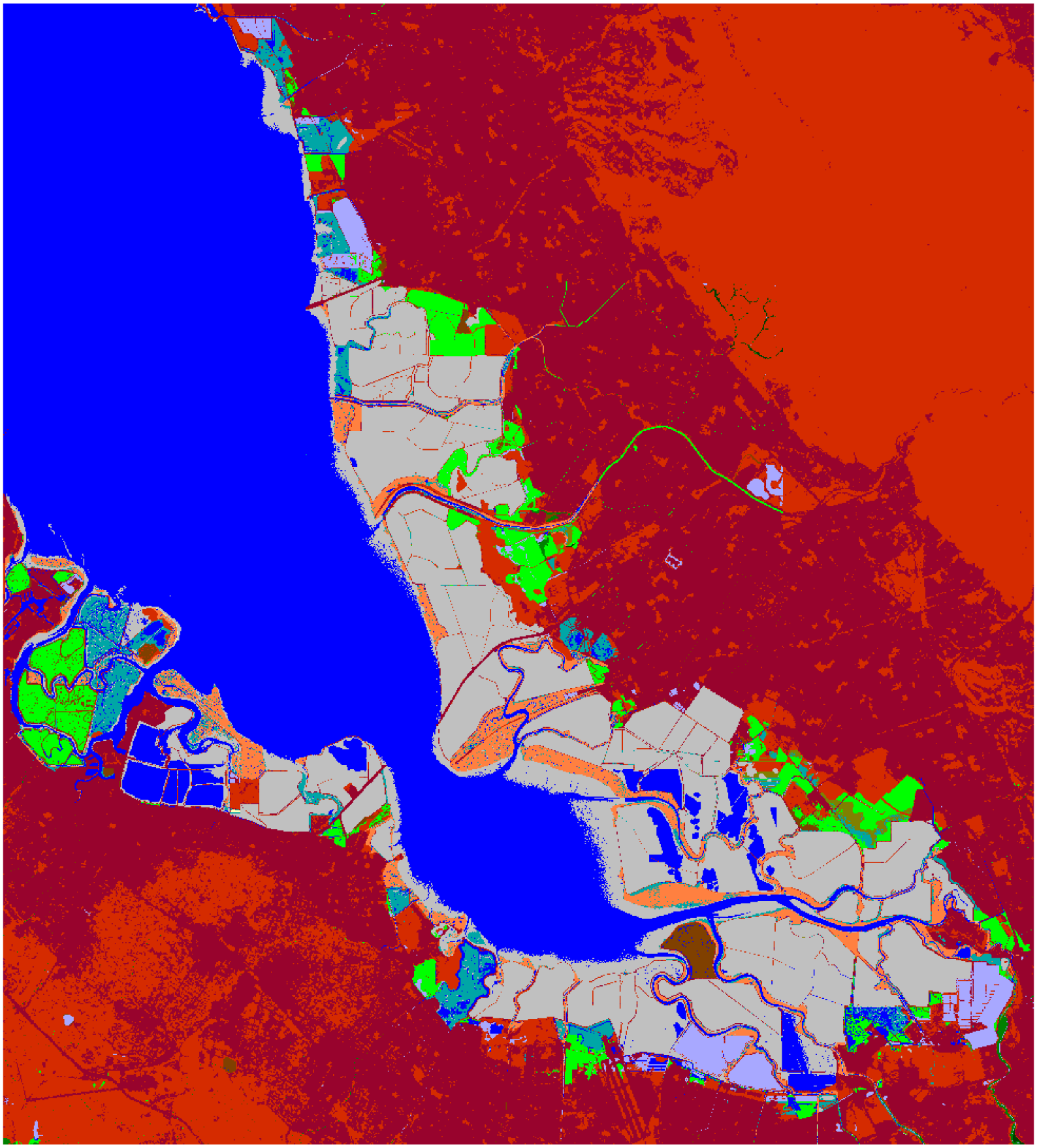


Don Edwards NWR, Initial Condition



Don Edwards NWR, 2025, 1.5 meter



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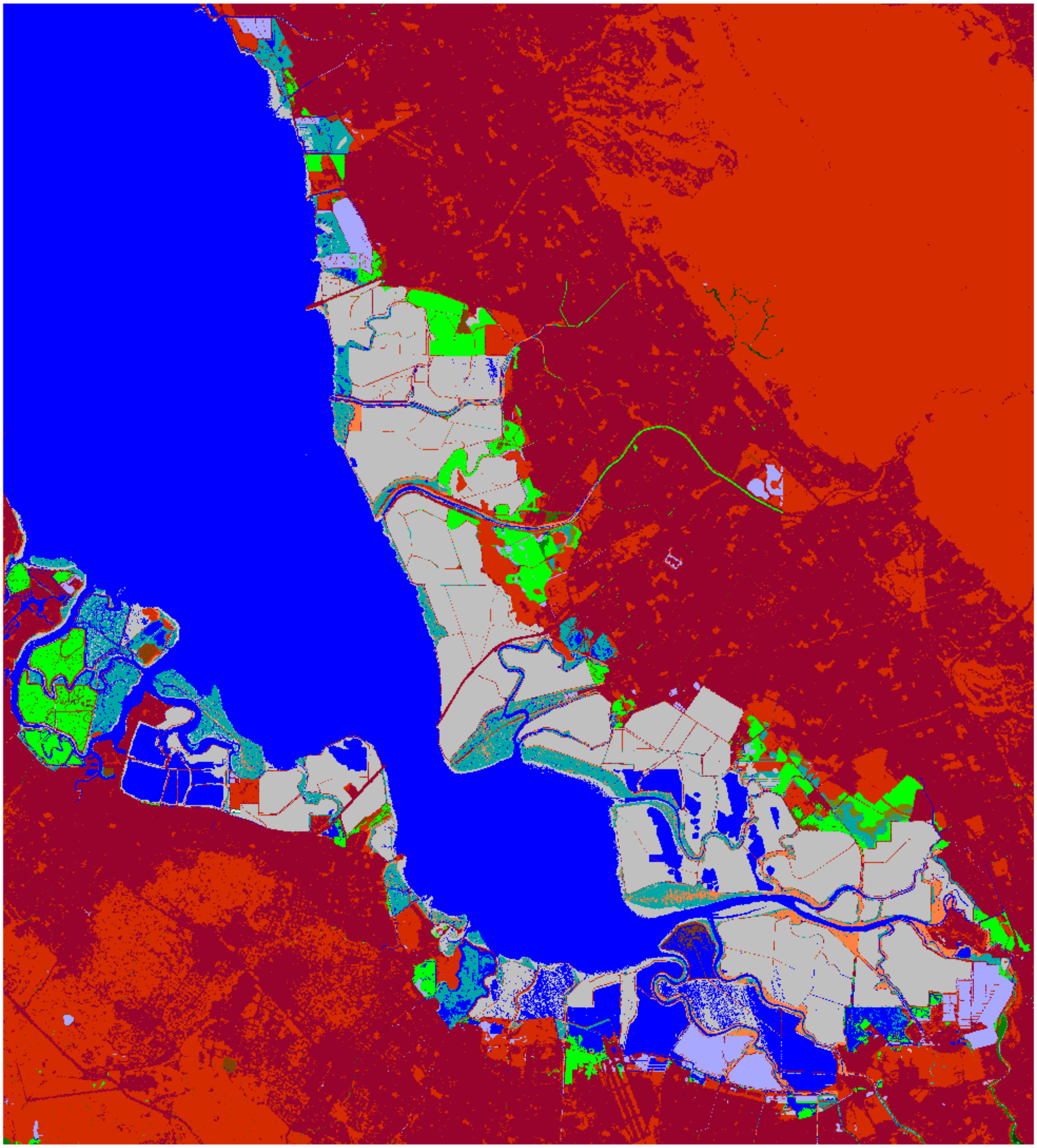

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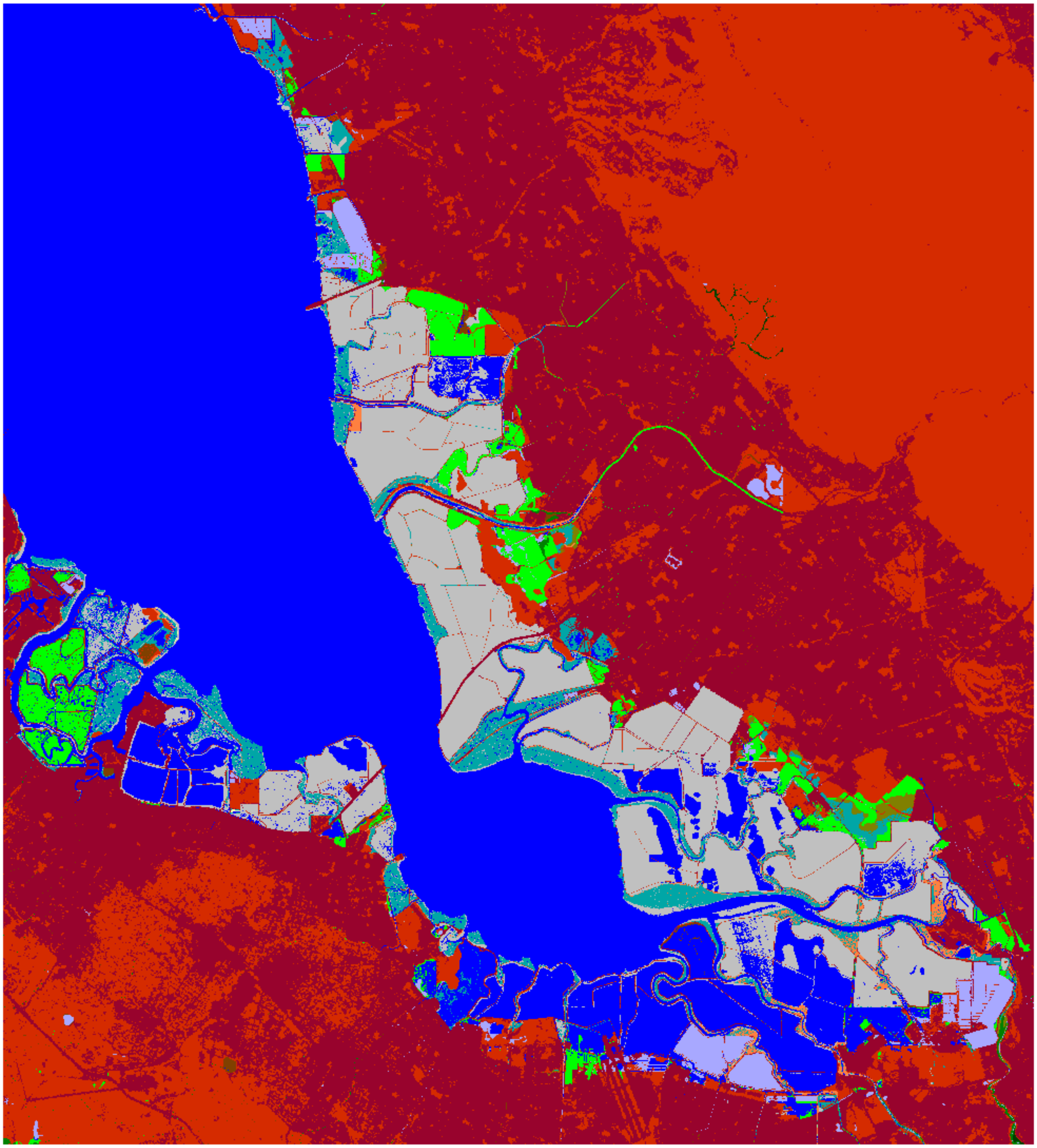
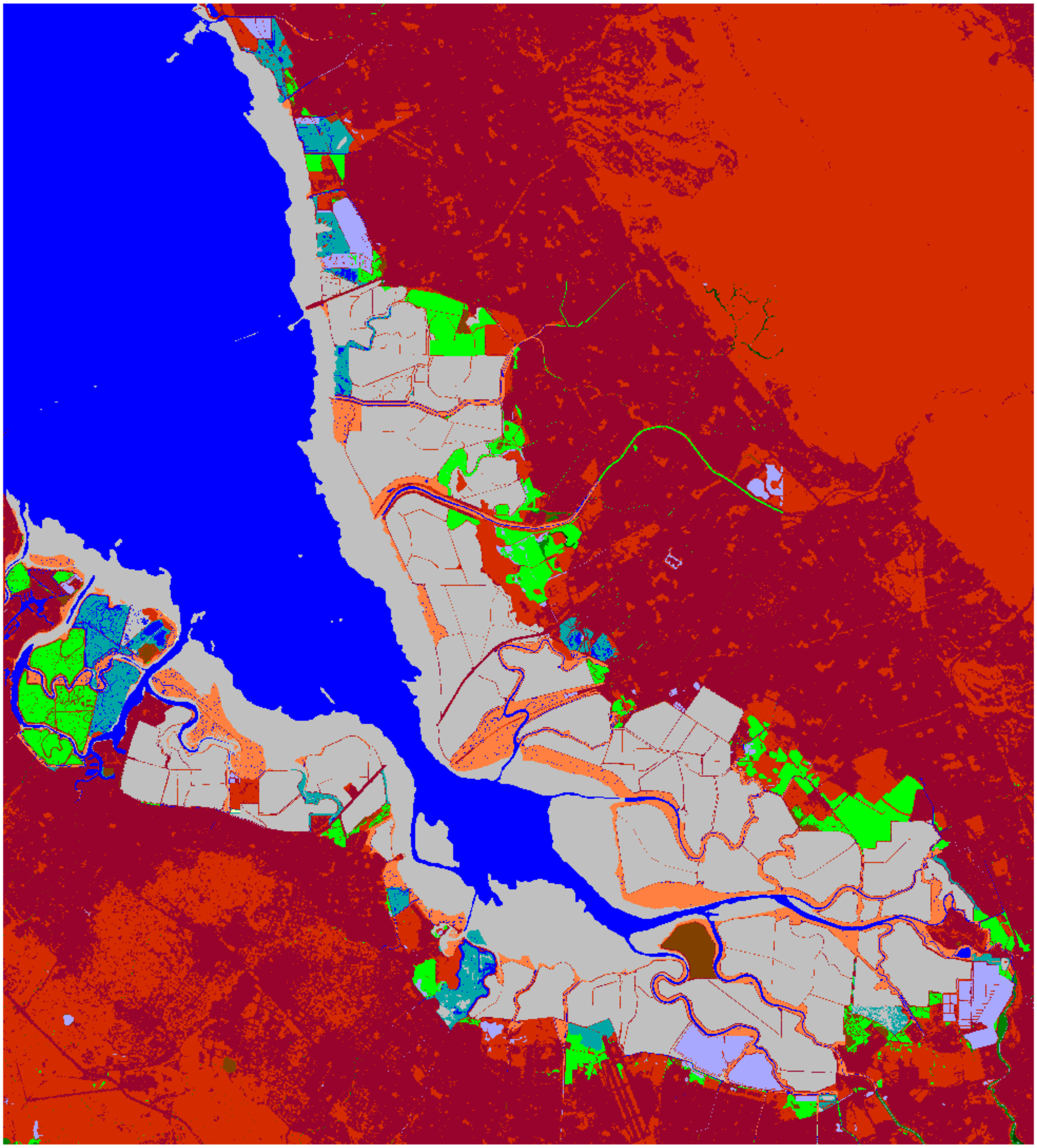


Don Edwards NWR, 2100, 1.5 meter



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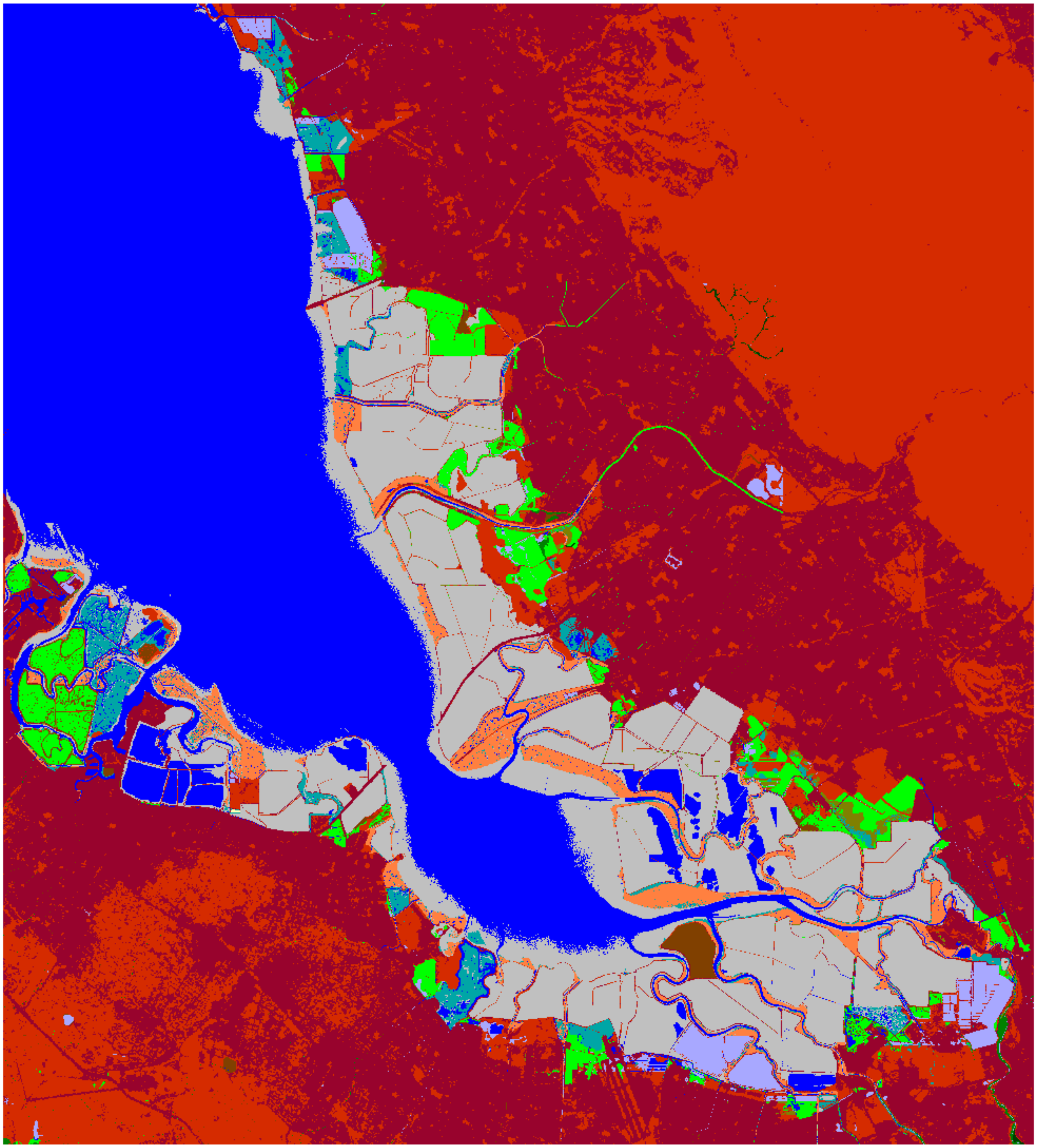
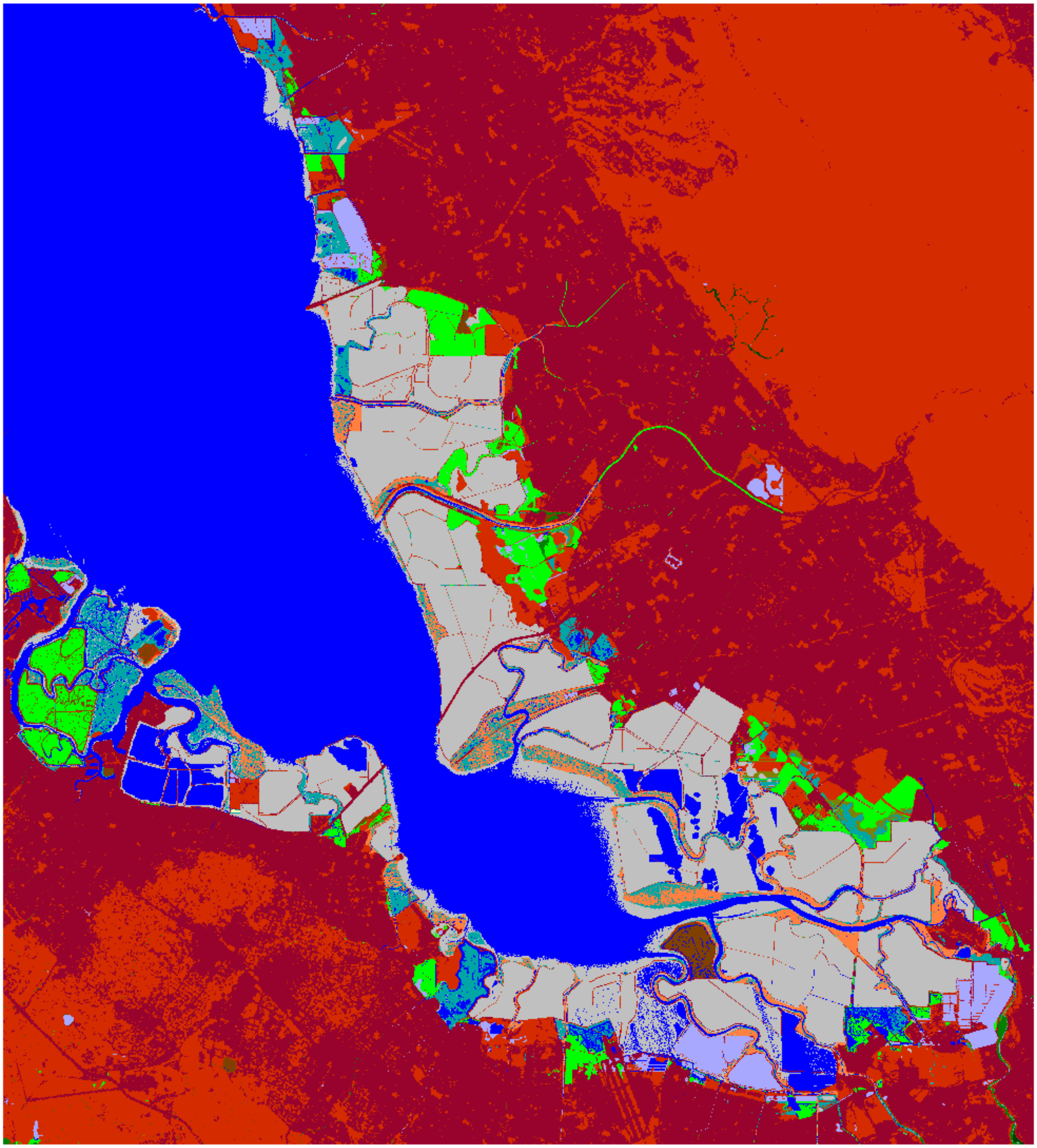


Don Edwards NWR, 2025, 2 meter



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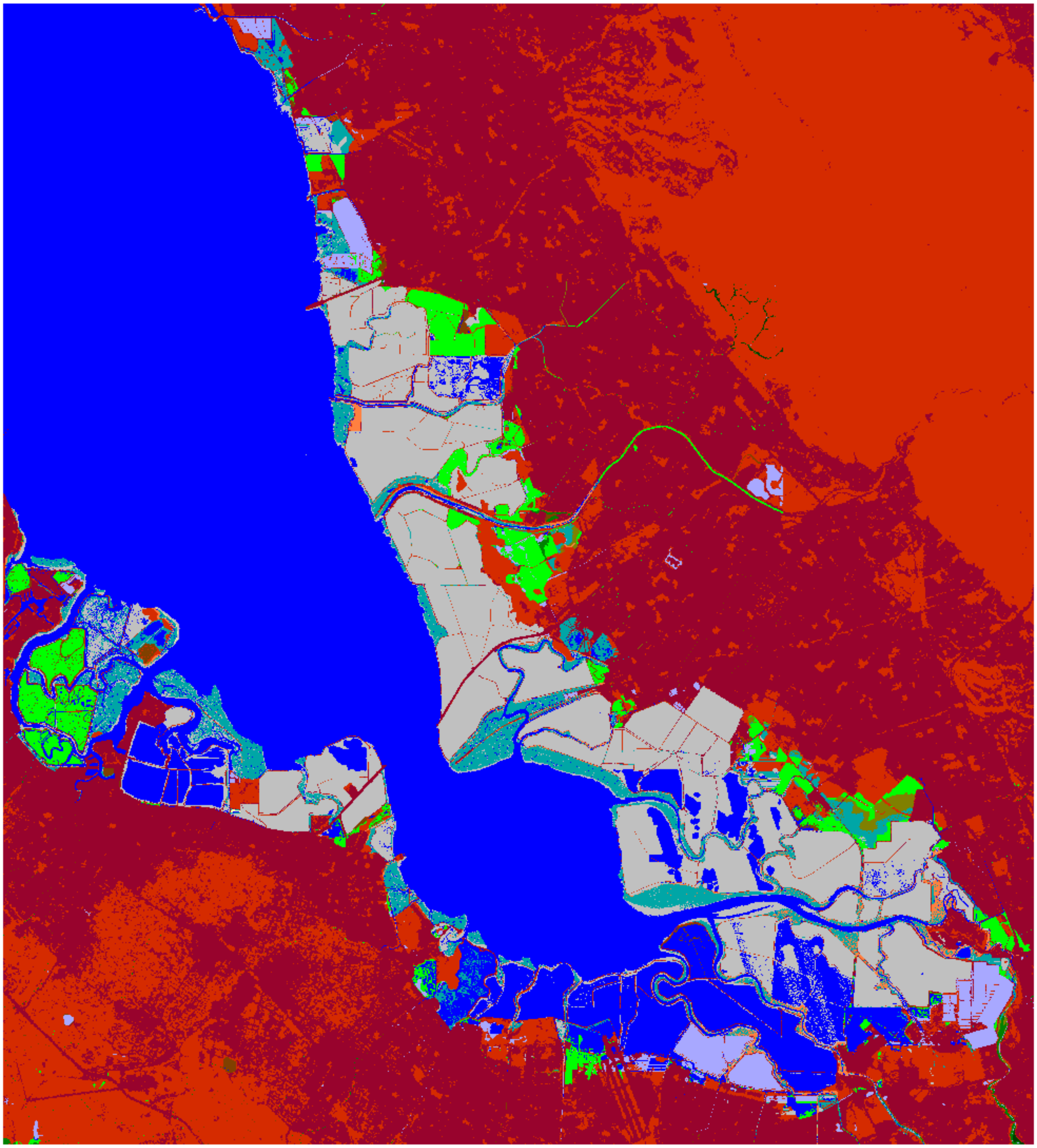

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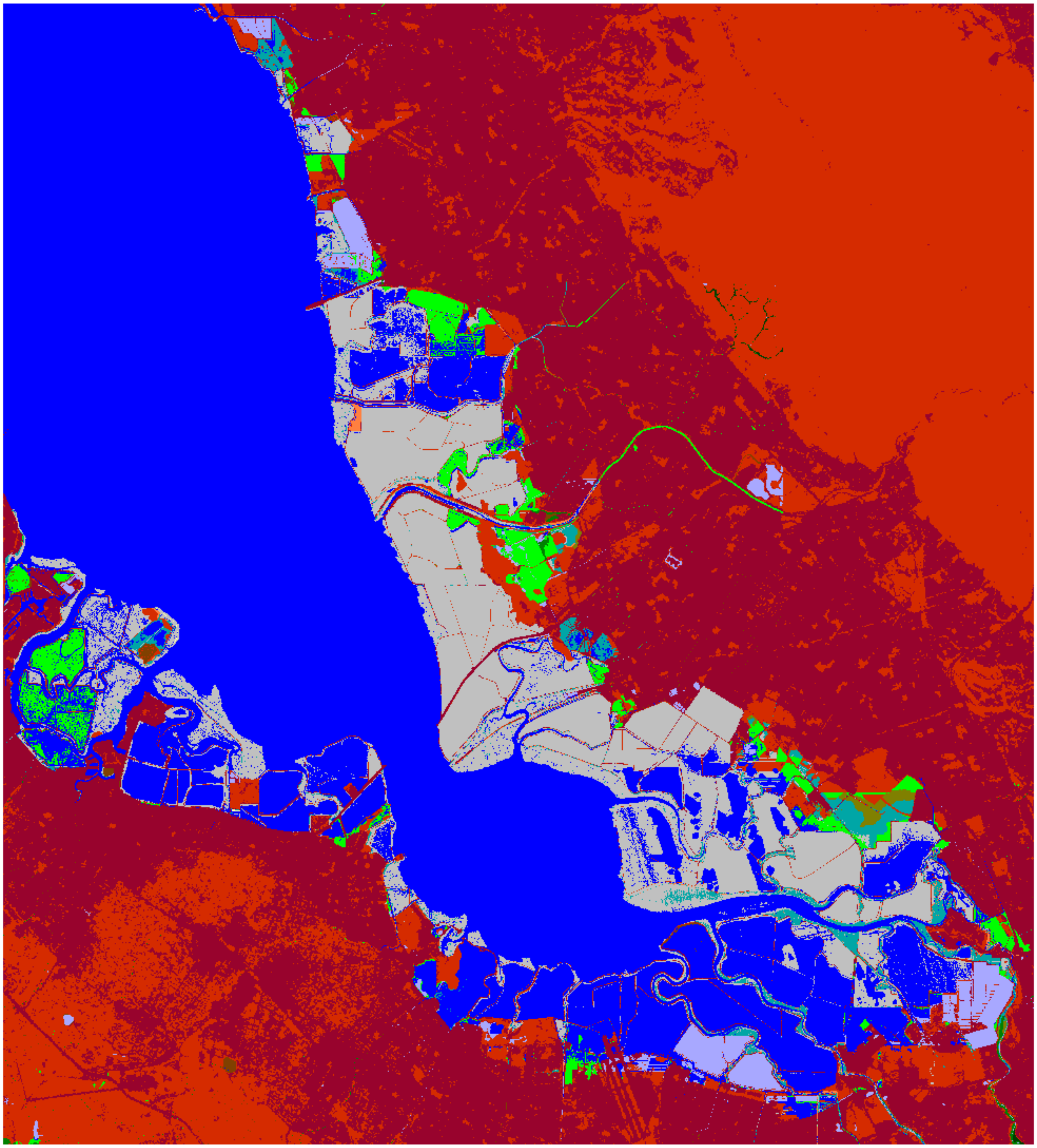

Don Edwards NWR, 2100, 2 meter