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

Prepared For

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Division of Natural Resources and Conservation Planning
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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 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 1 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 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 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 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, 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.

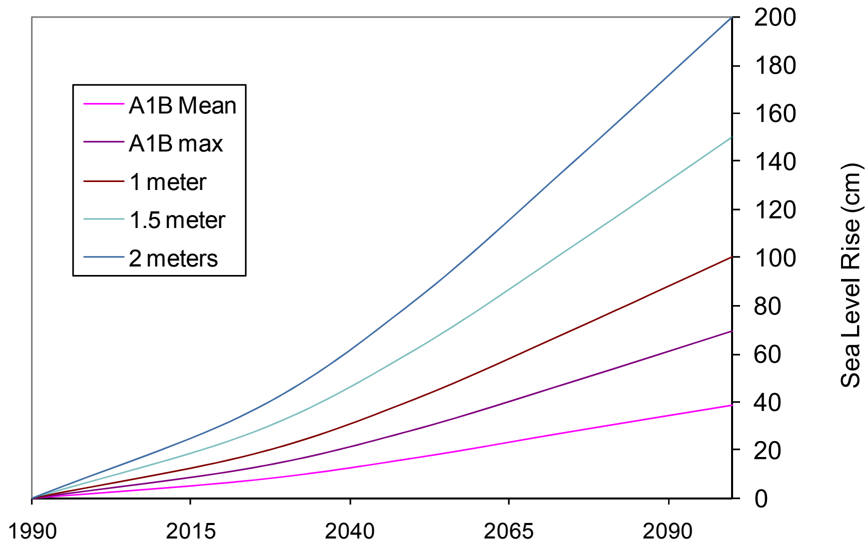
Sea Level Rise Scenarios

SLAMM 6 was run using scenario A1B from the Special Report on Emissions Scenarios (SRES) – mean and maximum estimates. The A1 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 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 0.39 meters of global sea level rise by 2100. A1B-maximum predicts 0.69 meters 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 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…" 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 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 used in this simulation was derived from 1/9 arc second LiDAR data within the National Elevation Dataset (NED). The original source of these data were LiDAR data collected with a domain of "Lower Columbia River Basin, Oregon and Washington" in 2005 (Figure 1).

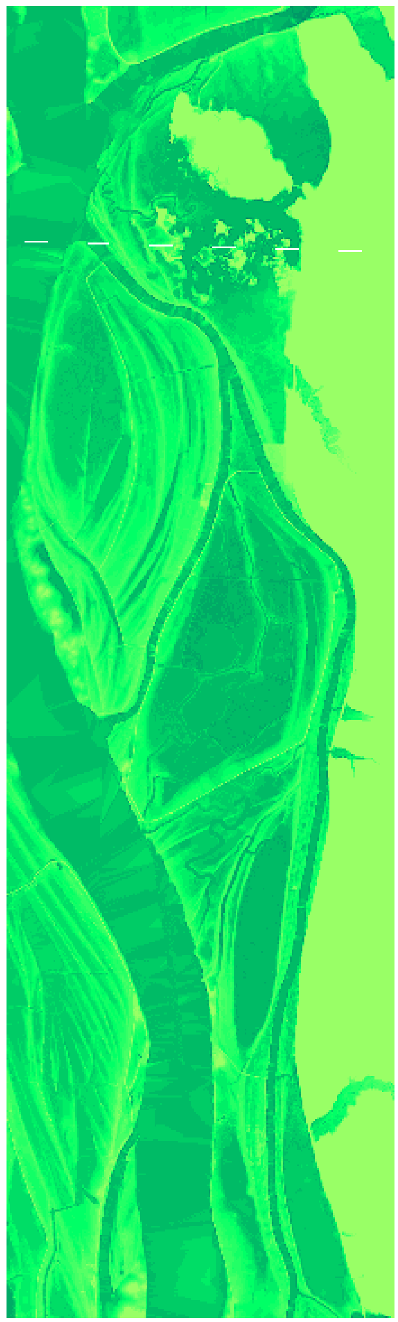


Figure 1: SLAMM-produced elevation map for refuge. Darker colors reflect lower elevations.

The wetlands layer for the study area was produced by the National Wetlands Inventory and is based on a 1981 photo date. Converting the NWI survey into 10 meter cells indicates that the approximately six thousand seven hundred acre refuge (approved acquisition boundary including water) is composed of the following categories:

Undeveloped Dry Land	49.2%
Inland Fresh Marsh	20.1%
Swamp	13.2%
Tidal Swamp	4.0%

The National Wetland Inventory does not designate any portion of Ridgefield NWR as diked. However, according to communication with Eric Anderson of the Ridgefield National Wildlife Refuge Complex, the "River S Unit" of the refuge is diked. Inspection of the digital elevation data surrounding this region also indicates that dikes protect this region. Rather than add a "diked" designation to the lands in question, the SLAMM "connectivity algorithm" was utilized. When the connectivity model is utilized, if freshwater wetlands and dry lands are not connected to a salt water source, they are not assumed to be subject to saline inundation. An eight-sided connectivity algorithm is utilized to examine whether a cell is connected to an adjoining cell. Utilizing this analysis with the Ridgefield site's elevation data suggests that lands in this region will not be subject to inundation until 2.0 meters of eustatic SLR.

There are few data regarding the historical SLR trend in the Ridgefield NWR area. Probably the closest measured NOAA trend is from Astoria OR, which suggests that sea levels have been falling since 1925. However, this value is based on a small node of uplift near the mouth of the Columbia River (Douglas Canning, Personal Communication). Additionally, several studies suggest little to no uplift is occurring in the Ridgefield NWR areas (Verdonck, 2006. Mitchell, et al., 1994). For this reason, a regional average of 2.0 mm/year was used as the historic SLR for this site; this means that local SLR will be estimated to be quite similar to global SLR over the next 100 years.

The tide range was estimated at 1.0 meters (great diurnal range or GT) using the value from the tide gage at St. Helens, OR (9439201).

For accretion values, regularly flooded marsh was set to 3.2 mm/year, irregularly flooded marsh to 3.75 mm/year and tidal fresh marsh to 4 mm/year. These data were based on regional measurements taken by Thom (1992). The SLAMM marsh erosion rate parameters are not important at this site, because of insufficient open water for wave setup. Tidal-flat erosion rates were estimated at 0.2 horizontal meters per year.

An MTL to NAVD correction of 2.33 was used for this model as taken from the nearest NOAA gage with such a correction (9439201, St. Helens, OR).

Modeled U.S. Fish and Wildlife Service refuge boundaries for Washington 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 meter by 10 meter cells.

SUMMARY OF SLAMM INPUT PARAMETERS FOR RIDGEFIELD NWR

Parameter	Global
Description	Ridgefield
NWI Photo Date (YYYY)	1981
DEM Date (YYYY)	2005
Direction Offshore [n,s,e,w]	West
Historic Trend (mm/yr)	2.0
MTL-NAVD88 (m)	2.33
GT Great Diurnal Tide Range (m)	1
Salt Elev. (m above MTL)	0.7
Marsh Erosion (horz. m /yr)	2
Swamp Erosion (horz. m /yr)	1
T.Flat Erosion (horz. m /yr)	0.2
Reg. Flood Marsh Accr (mm/yr)	3.2
Irreg. Flood Marsh Accr (mm/yr)	3.75
Tidal Fresh Marsh Accr (mm/yr)	4
Beach Sed. Rate (mm/yr)	0.5
Freq. Overwash (years)	0
Use Elev Pre-processor [True,False]	FALSE

Results

The SLAMM model predicts Ridgefield NWR to be somewhat resilient to sea level rise (SLR) inundation. Between 1% and 6% of refuge undeveloped dry land – comprising roughly half the refuge – is predicted to be lost across SLR scenarios of up to 1.5 meters. At two meters, several dikes are predicted to be overtopped and 30% of dry land is predicted lost. Inland fresh marsh – 20% of the refuge – is predicted to be resilient in scenarios of up to 1.5 meters of SLR. Up to two-thirds of refuge swamp and tidal swamp is predicted to be lost in the 2 meter SLR scenario.

SLR by 2100 (m)	0.39	0.69	1	1.5	2
Undeveloped Dry Land	1%	2%	3%	6%	30%
Inland Fresh Marsh	0%	2%	4%	23%	72%
Swamp	4%	14%	22%	43%	64%
Tidal Swamp	21%	36%	46%	58%	69%

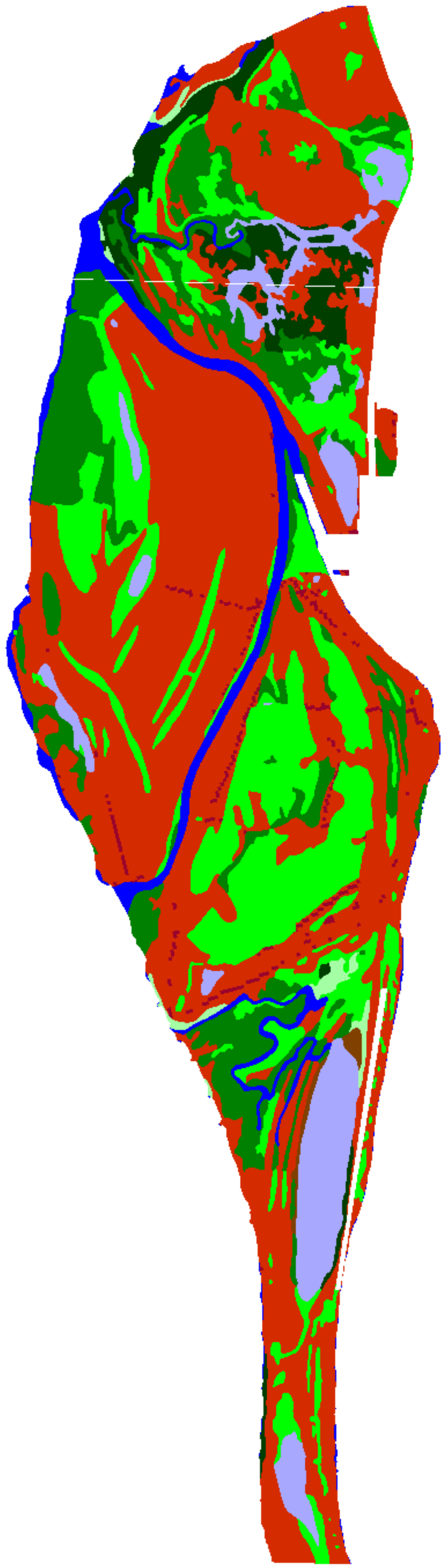
Predicted Loss Rates of Land Categories by 2100 Given Simulated Scenarios of Eustatic Sea Level Rise

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

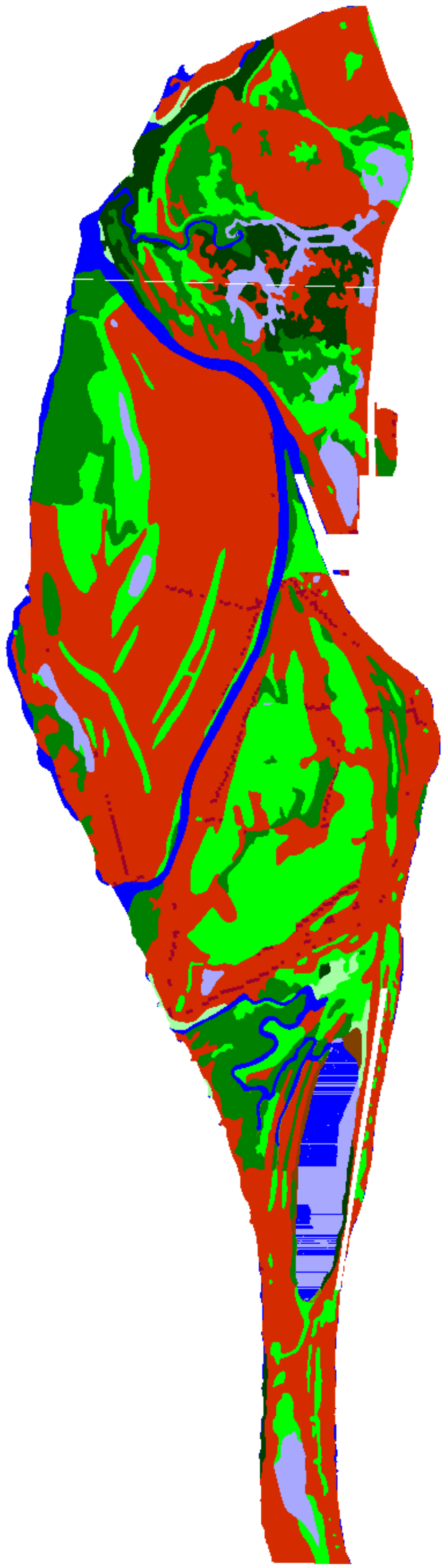
Ridgefield Raster
IPCC Scenario A1B-Mean, 0.39 M SLR Eustatic by 2100

Results in Acres

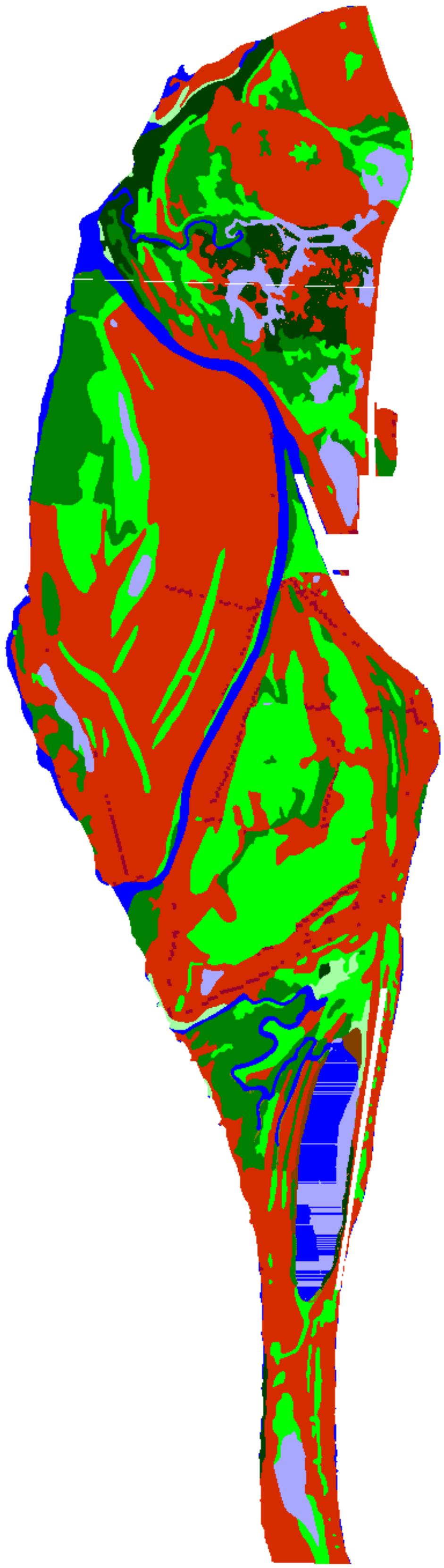
	Initial	2025	2050	2075	2100
Undeveloped Dry Land	3318.2	3311.2	3308.0	3282.6	3271.2
Inland Fresh Marsh	1358.4	1357.1	1357.0	1356.5	1356.0
Swamp	892.6	888.9	886.7	869.2	860.4
Inland Open Water	467.2	376.6	348.8	282.7	243.5
Riverine Tidal	312.8	307.6	303.1	288.3	267.1
Tidal Swamp	267.3	263.4	258.9	235.4	210.8
Developed Dry Land	58.9	58.9	58.8	58.8	58.7
Tidal Fresh Marsh	48.1	48.0	48.0	48.0	48.0
Inland Shore	21.5	21.5	21.5	21.5	21.5
Estuarine Open Water	0.0	95.9	128.2	209.1	269.5
Trans. Salt Marsh	0.0	9.9	15.1	57.8	55.3
Brackish Marsh	0.0	3.2	7.7	31.1	55.7
Saltmarsh	0.0	2.9	2.9	3.6	27.1
Tidal Flat	0.0	0.0	0.3	0.3	0.3
Total (incl. water)	**6745.1**	**6745.1**	**6745.1**	**6745.1**	**6745.1**



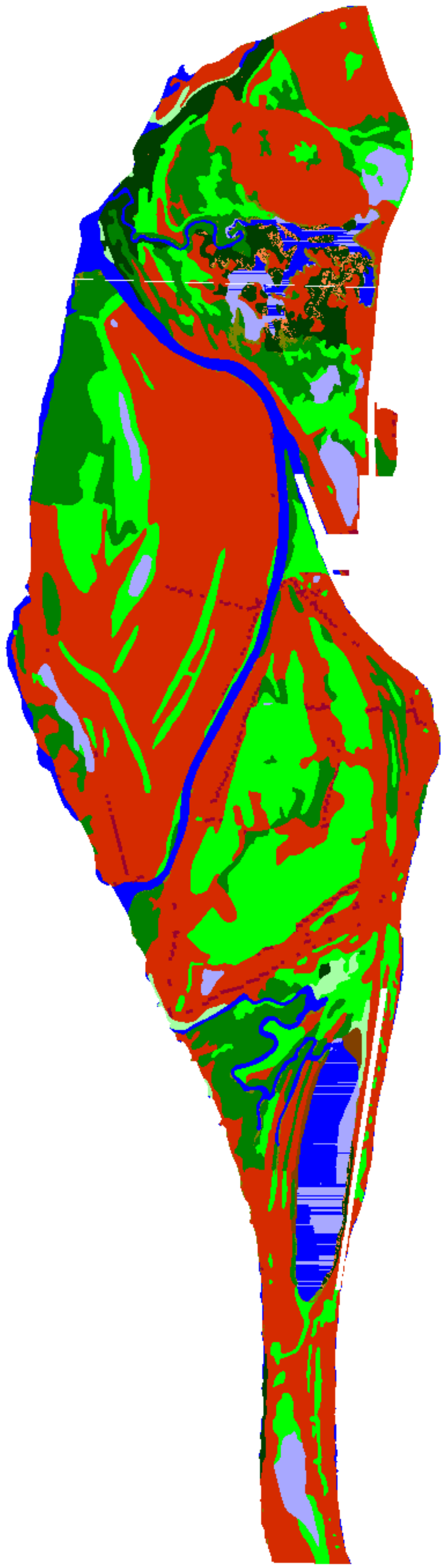
Ridgefield NWR, Initial Condition



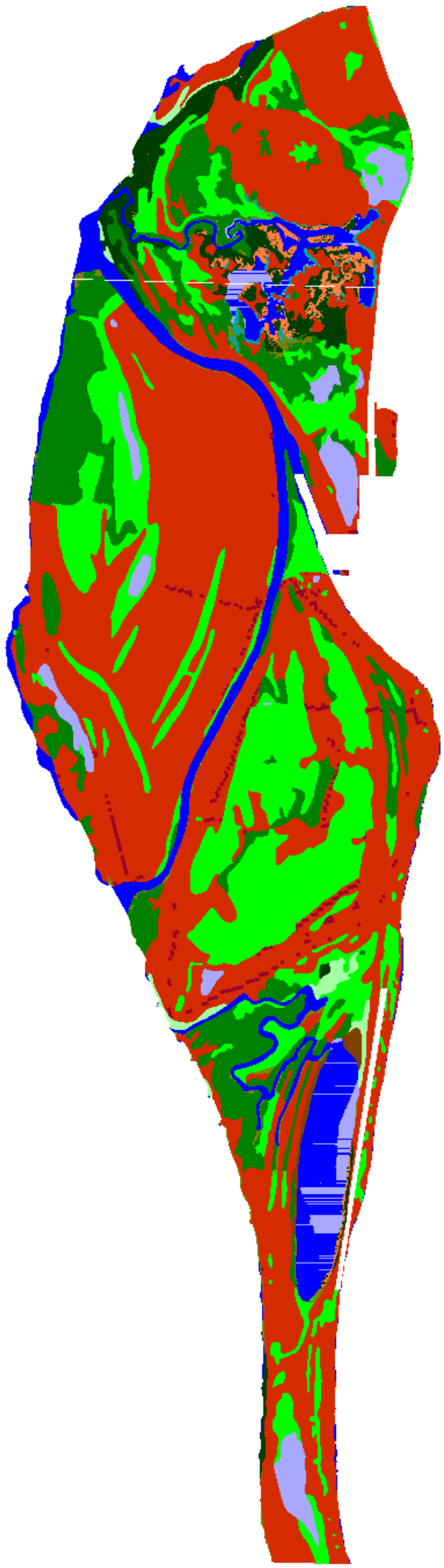
Ridgefield NWR, 2025, Scenario A1B Mean



Ridgefield NWR, 2050, Scenario A1B Mean



Ridgefield NWR, 2075, Scenario A1B Mean

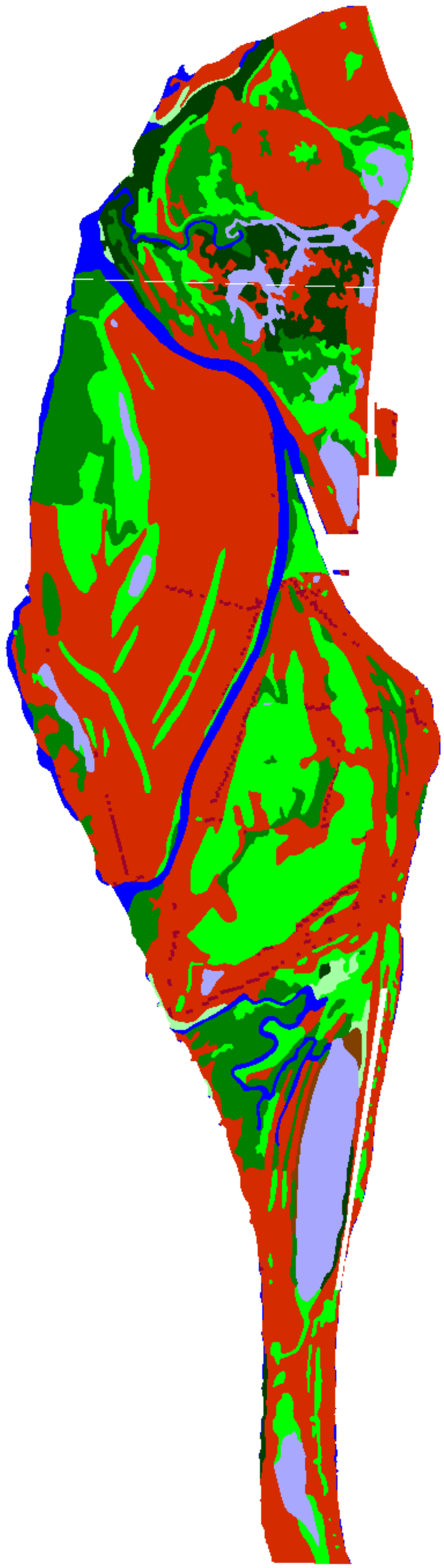


Ridgefield NWR, 2100, Scenario A1B Mean

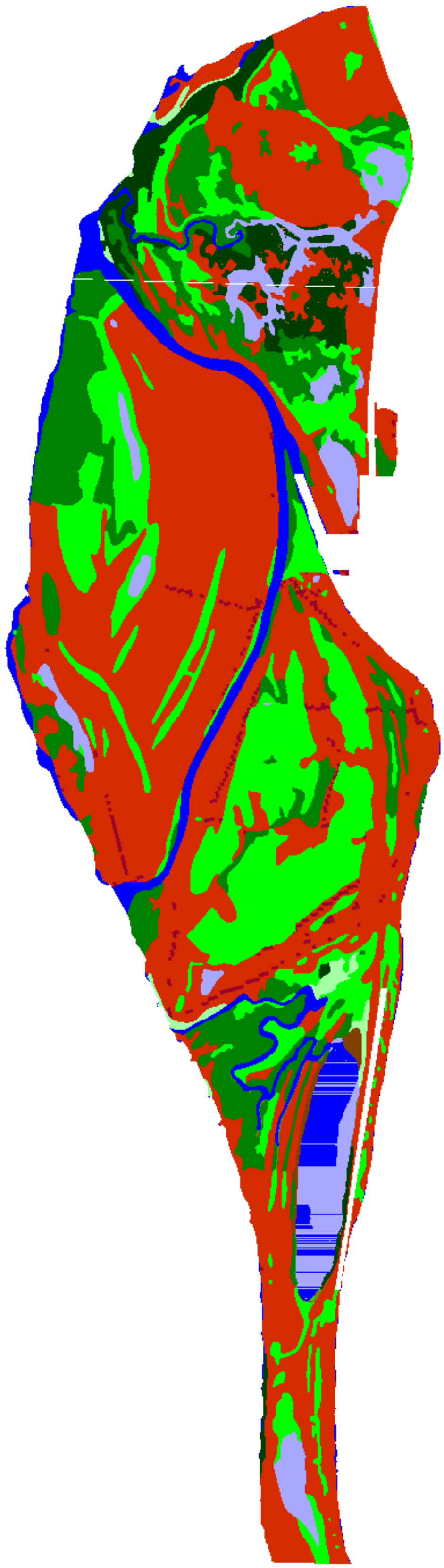
Ridgefield Raster
IPCC Scenario A1B-Max, 0.69 M SLR Eustatic by 2100

Results in Acres

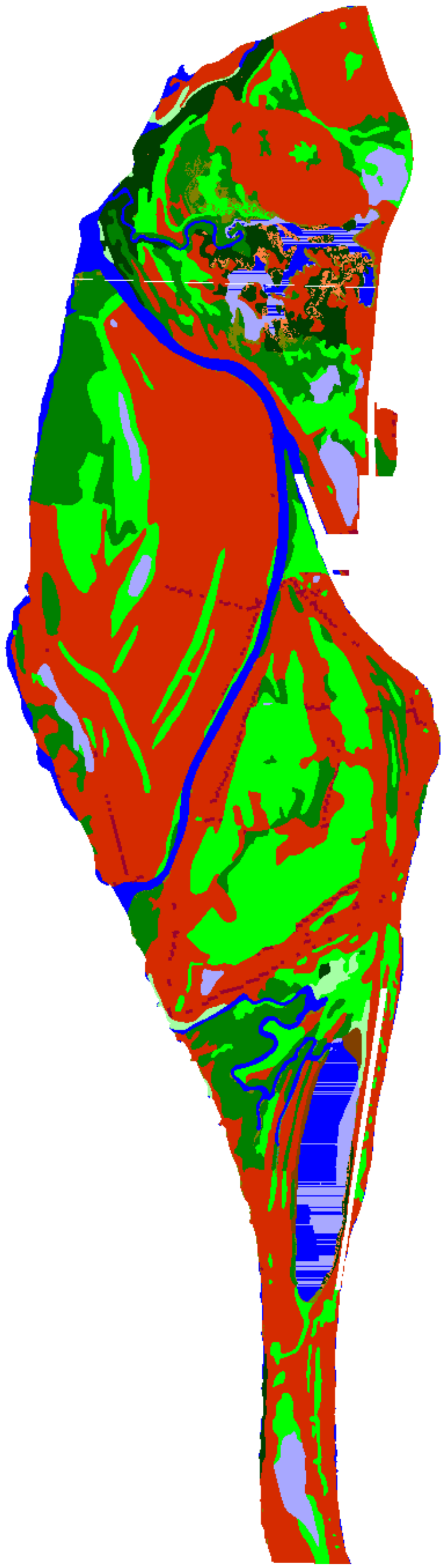
	Initial	2025	2050	2075	2100
Undeveloped Dry Land	3318.2	3309.7	3282.8	3262.3	3248.3
Inland Fresh Marsh	1358.4	1357.0	1352.7	1345.2	1327.8
Swamp	892.6	887.9	854.6	808.9	764.5
Inland Open Water	467.2	375.5	300.6	242.3	224.2
Riverine Tidal	312.8	306.5	292.0	260.4	233.9
Tidal Swamp	267.3	260.9	227.2	192.5	171.9
Developed Dry Land	58.9	58.9	58.8	58.7	58.5
Tidal Fresh Marsh	48.1	48.0	48.0	47.8	47.1
Inland Shore	21.5	21.5	21.5	21.5	21.5
Estuarine Open Water	0.0	98.1	187.5	277.5	322.6
Trans. Salt Marsh	0.0	12.0	74.6	104.8	111.2
Brackish Marsh	0.0	5.5	38.9	71.0	45.3
Saltmarsh	0.0	3.7	5.3	51.3	162.1
Tidal Flat	0.0	0.0	0.6	0.7	6.2
Total (incl. water)	**6745.1**	**6745.1**	**6745.1**	**6745.1**	**6745.1**



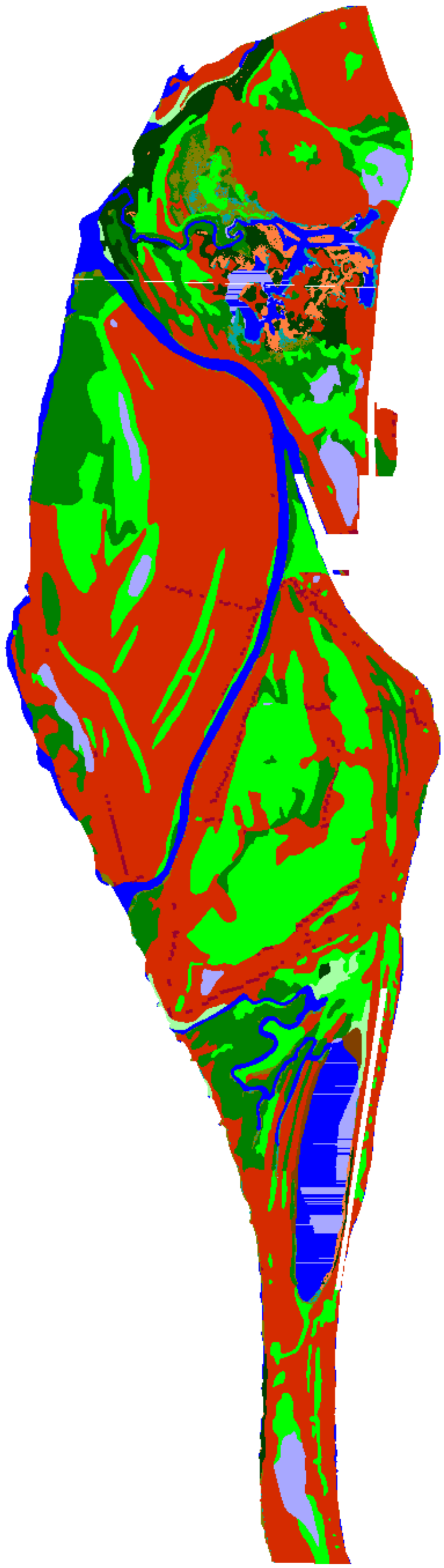
Ridgefield NWR, Initial Condition



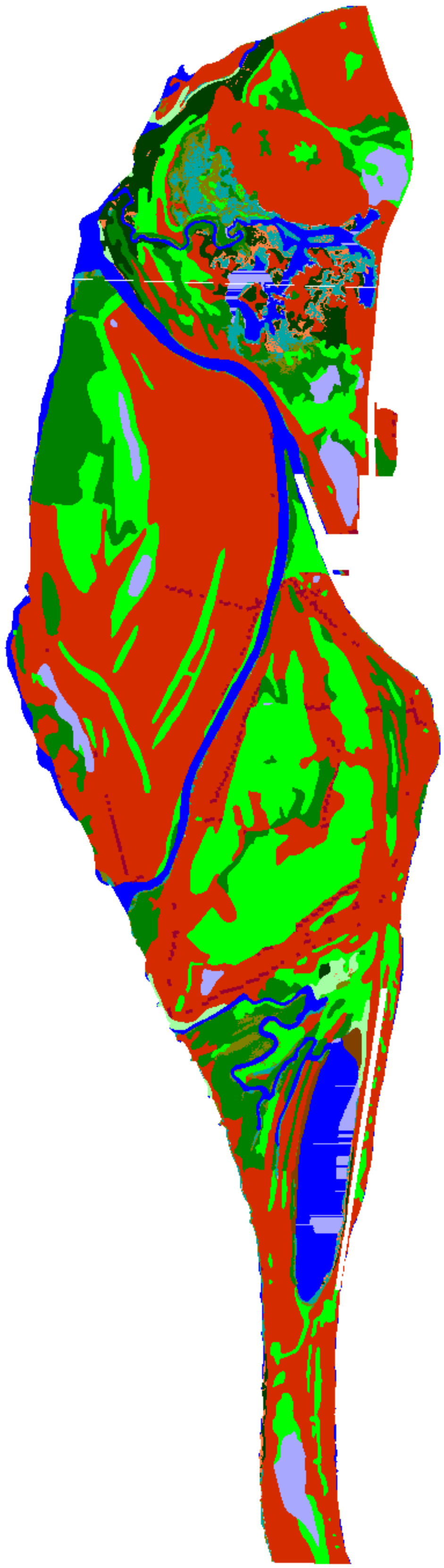
Ridgefield NWR, 2025, Scenario A1B Maximum



Ridgefield NWR, 2050, Scenario A1B Maximum



Ridgefield NWR, 2075, Scenario A1B Maximum

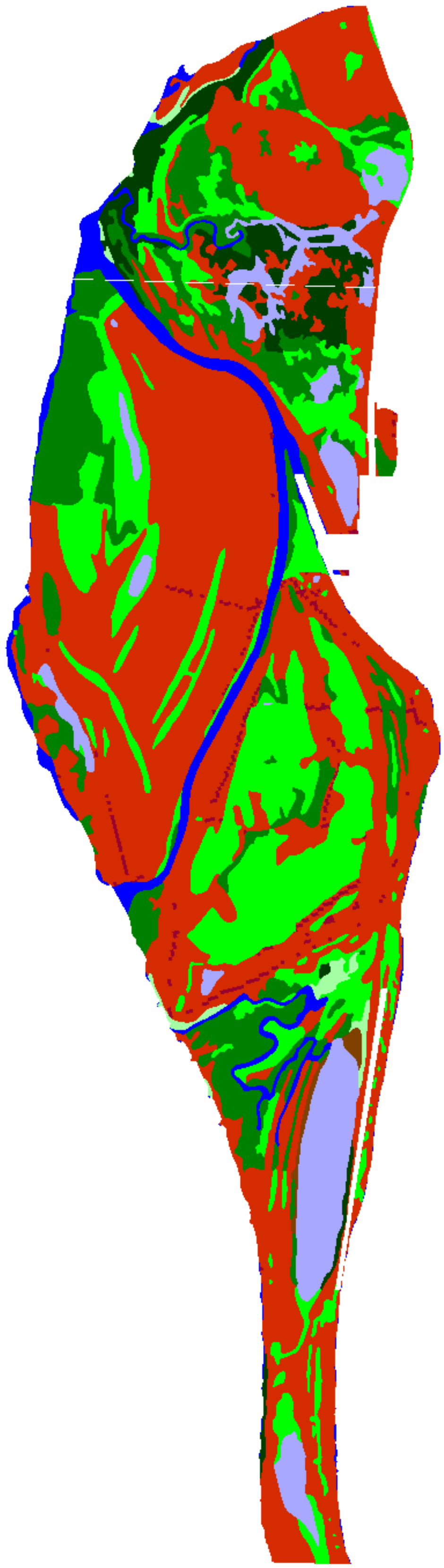


Ridgefield NWR, 2100, Scenario A1B Maximum

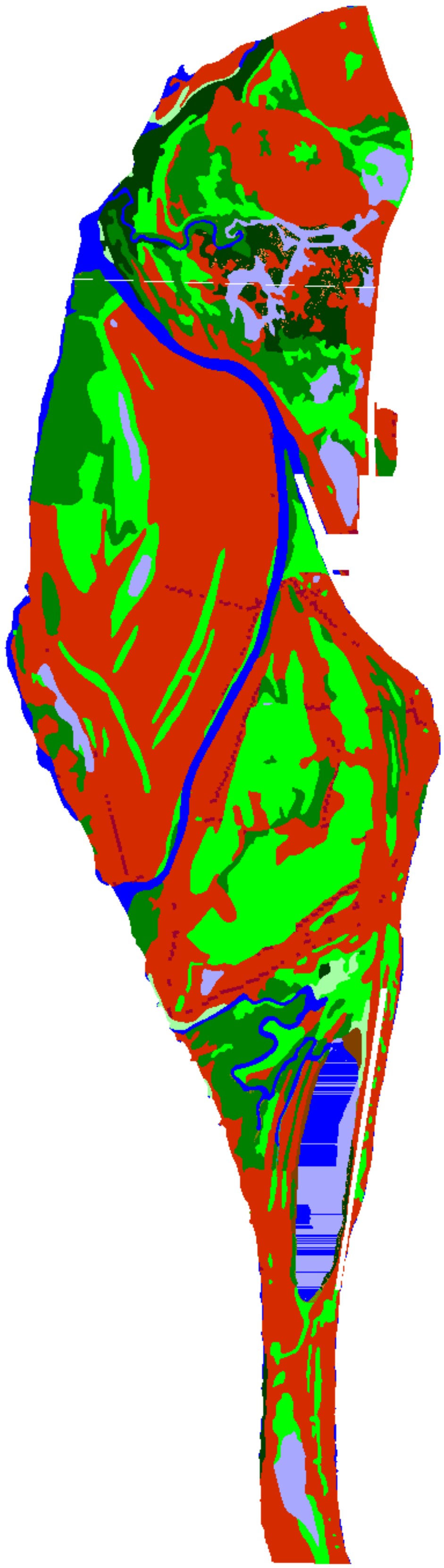
Ridgefield Raster
1 Meter Eustatic SLR by 2100

Results in Acres

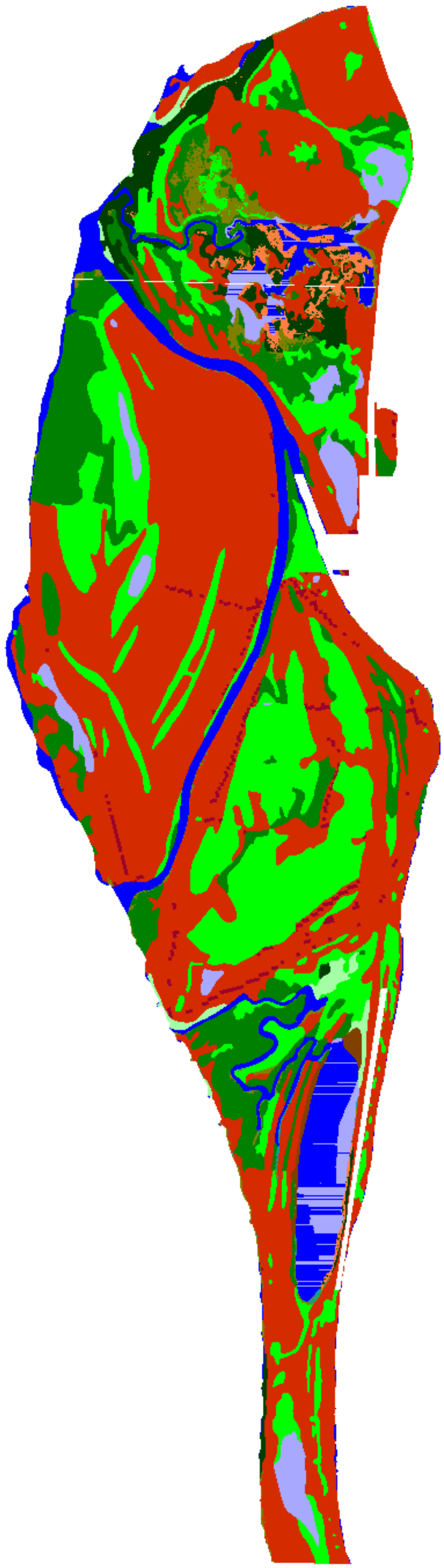
	Initial	2025	2050	2075	2100
Undeveloped Dry Land	3318.2	3307.6	3268.9	3248.5	3228.3
Inland Fresh Marsh	1358.4	1356.6	1343.5	1319.3	1301.9
Swamp	892.6	886.2	823.0	763.5	692.5
Inland Open Water	467.2	375.4	277.6	228.3	218.3
Riverine Tidal	312.8	304.5	276.0	240.6	206.7
Tidal Swamp	267.3	251.9	200.3	169.3	143.3
Developed Dry Land	58.9	58.8	58.7	58.5	58.4
Tidal Fresh Marsh	48.1	48.0	47.8	43.4	36.0
Inland Shore	21.5	21.5	21.5	21.5	20.8
Estuarine Open Water	0.0	100.2	226.6	311.9	363.0
Trans. Salt Marsh	0.0	15.2	122.3	109.3	112.5
Brackish Marsh	0.0	14.3	64.4	44.3	38.2
Saltmarsh	0.0	4.9	13.4	184.2	240.7
Tidal Flat	0.0	0.0	1.2	2.4	84.5
Total (incl. water)	**6745.1**	**6745.1**	**6745.1**	**6745.1**	**6745.1**



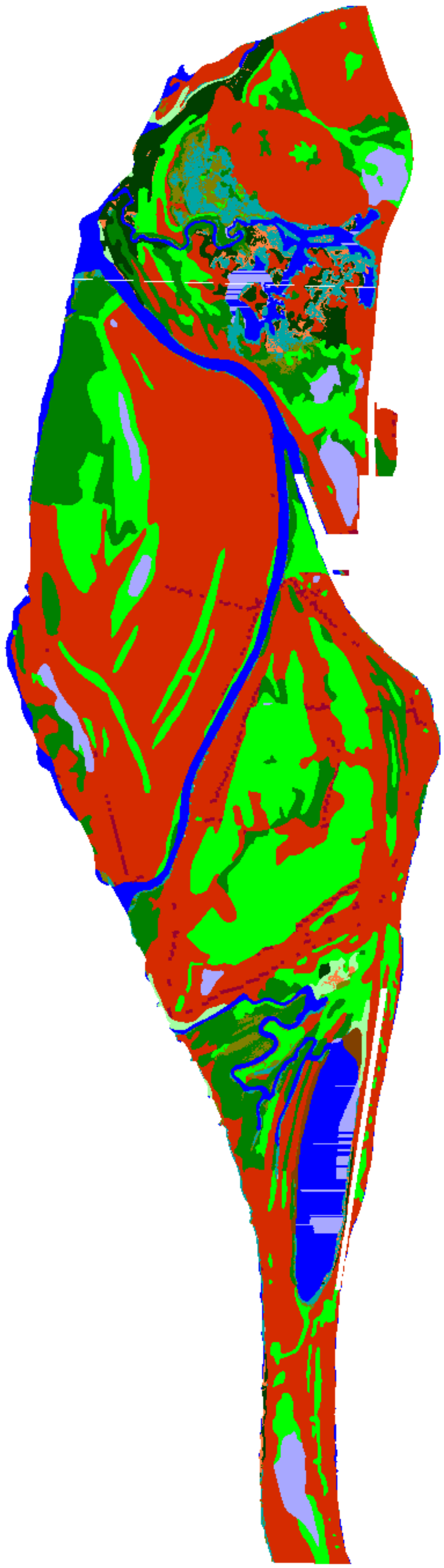
Ridgefield NWR, Initial Condition



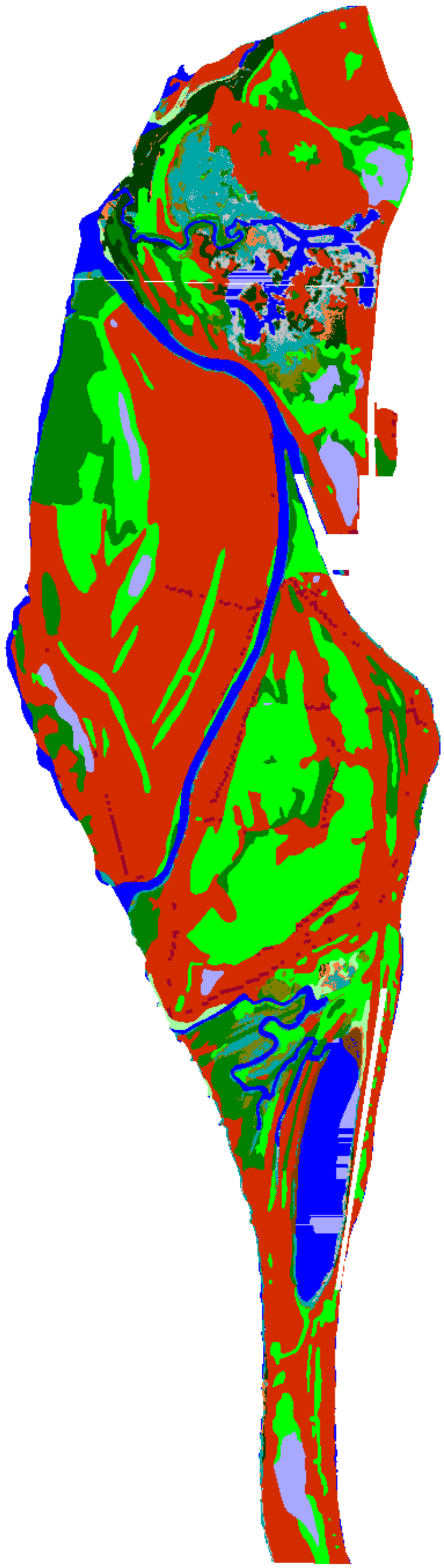
Ridgefield NWR, 2025, 1 meter



Ridgefield NWR, 2050, 1 meter



Ridgefield NWR, 2075, 1 meter

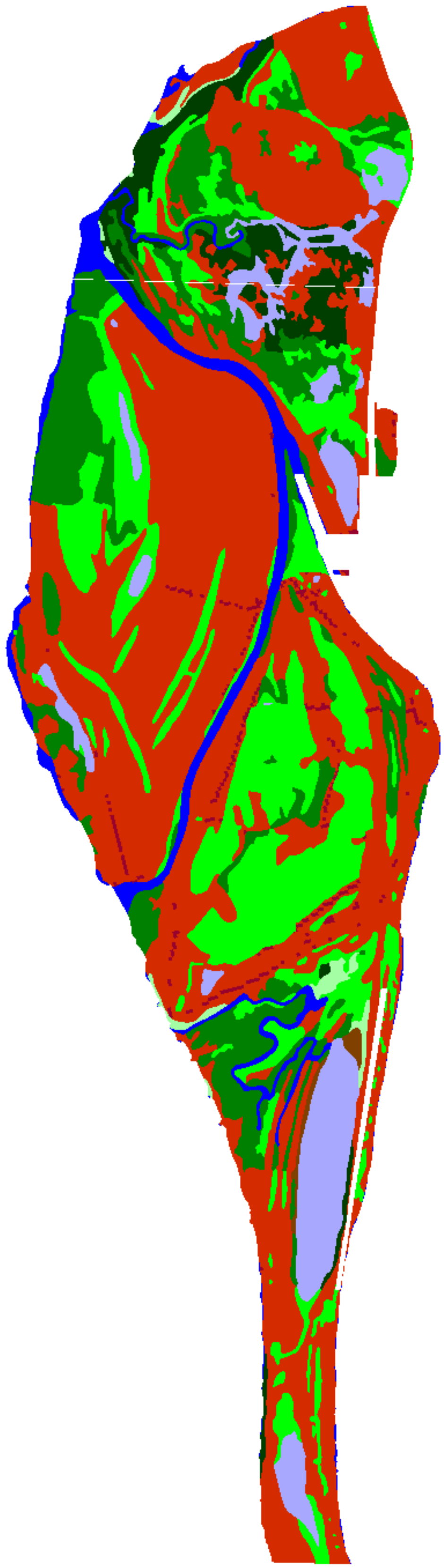


Ridgefield NWR, 2100, 1 meter

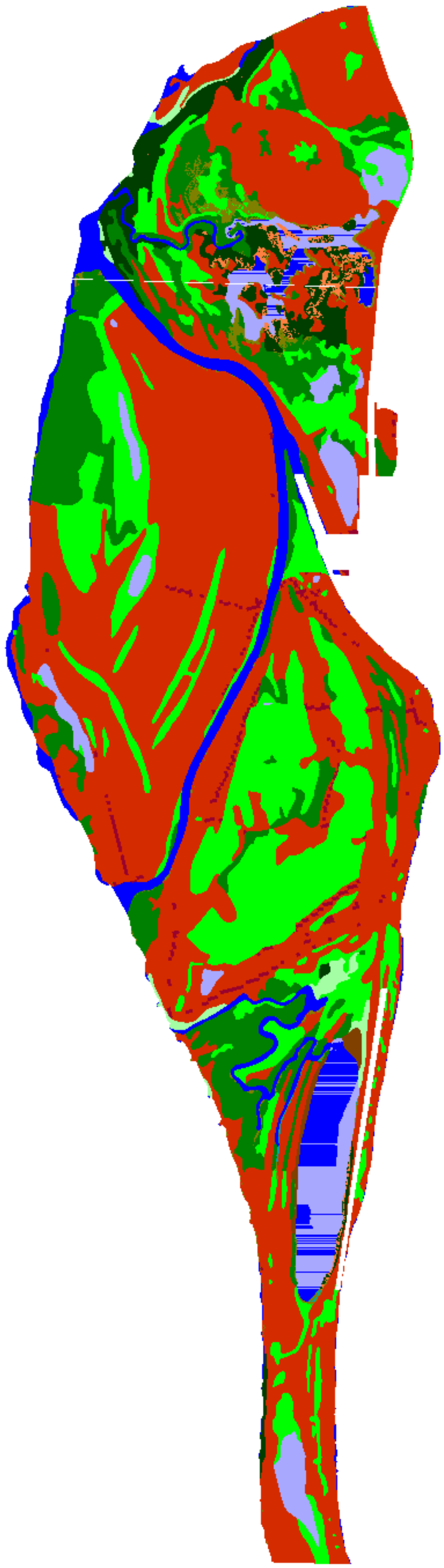
Ridgefield Raster
1.5 Meters Eustatic SLR by 2100

Results in Acres

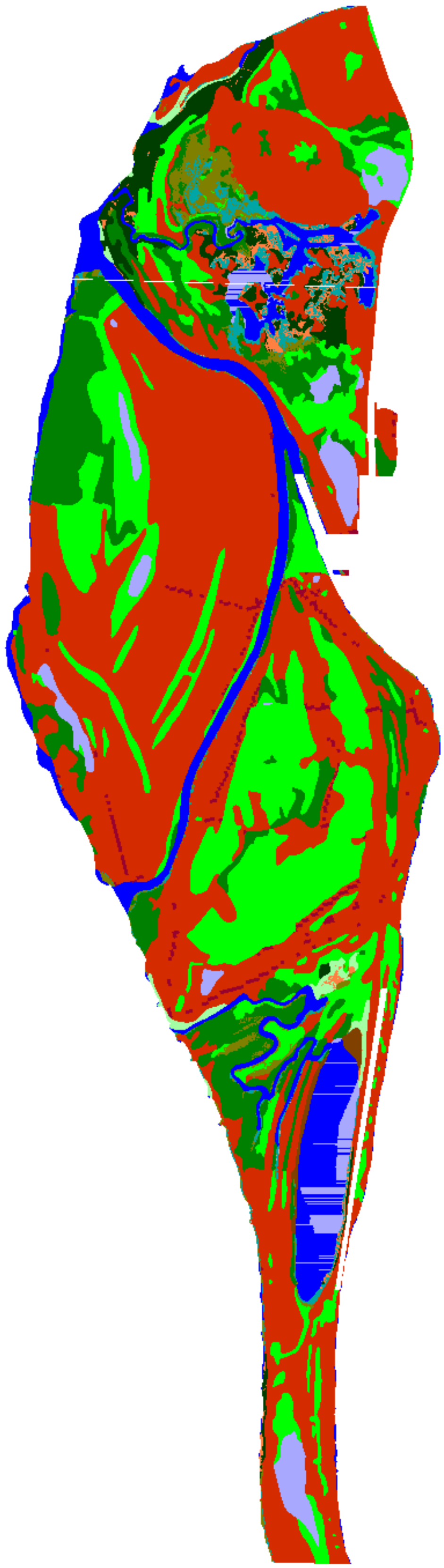
	Initial	2025	2050	2075	2100
Undeveloped Dry Land	3318.2	3283.5	3253.8	3219.8	3135.1
Inland Fresh Marsh	1358.4	1347.3	1318.9	1286.1	1041.8
Swamp	892.6	854.9	781.5	684.5	506.2
Inland Open Water	467.2	349.1	242.5	219.7	200.8
Riverine Tidal	312.8	298.1	253.6	209.1	182.3
Tidal Swamp	267.3	223.6	175.7	137.6	112.0
Developed Dry Land	58.9	58.8	58.6	58.4	58.2
Tidal Fresh Marsh	48.1	47.9	43.0	31.4	21.1
Inland Shore	21.5	21.5	21.5	18.4	6.1
Estuarine Open Water	0.0	132.9	284.6	364.8	509.7
Trans. Salt Marsh	0.0	77.4	131.2	165.0	508.7
Brackish Marsh	0.0	42.0	52.9	50.3	36.4
Saltmarsh	0.0	8.0	124.3	211.1	217.2
Tidal Flat	0.0	0.0	2.8	88.7	209.4
Total (incl. water)	**6745.1**	**6745.1**	**6745.1**	**6745.1**	**6745.1**



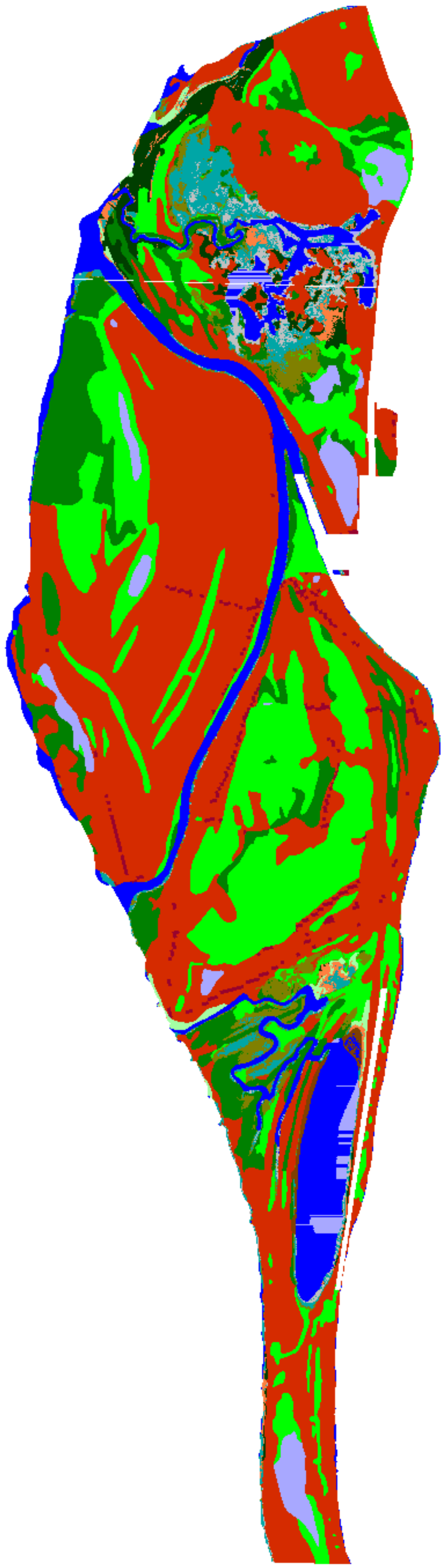
Ridgefield NWR, Initial Condition



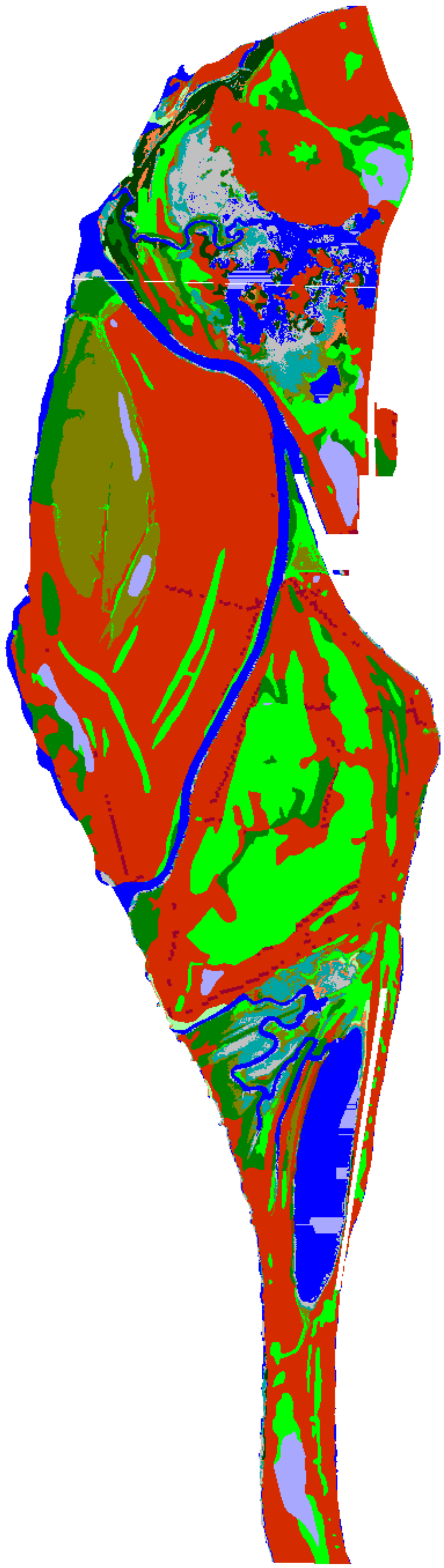
Ridgefield NWR, 2025, 1.5 meter



Ridgefield NWR, 2050, 1.5 meter



Ridgefield NWR, 2075, 1.5 meter

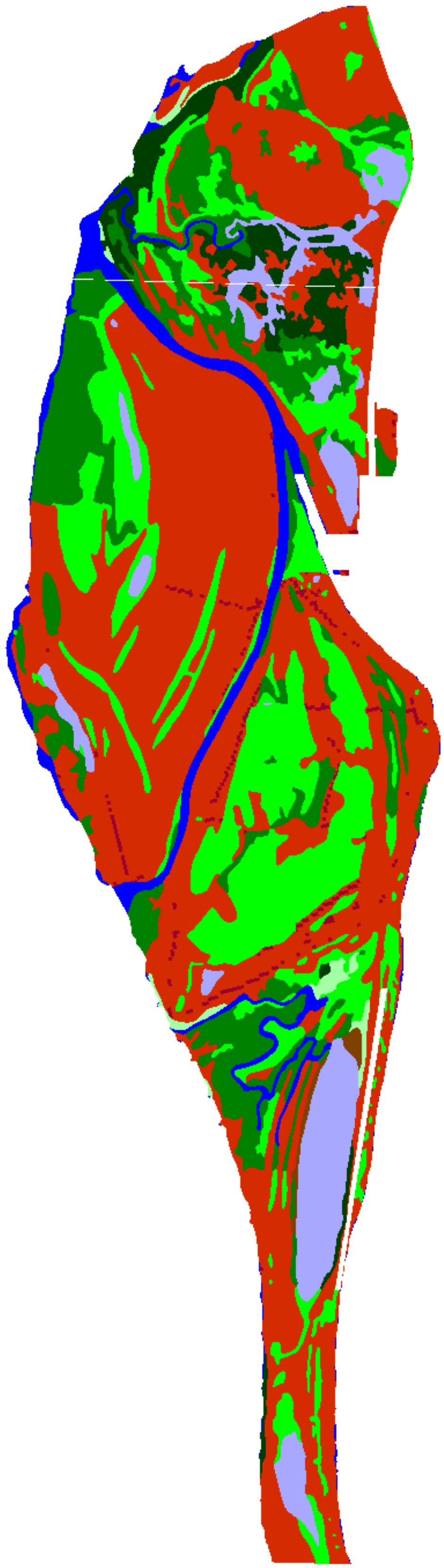


Ridgefield NWR, 2100, 1.5 meter

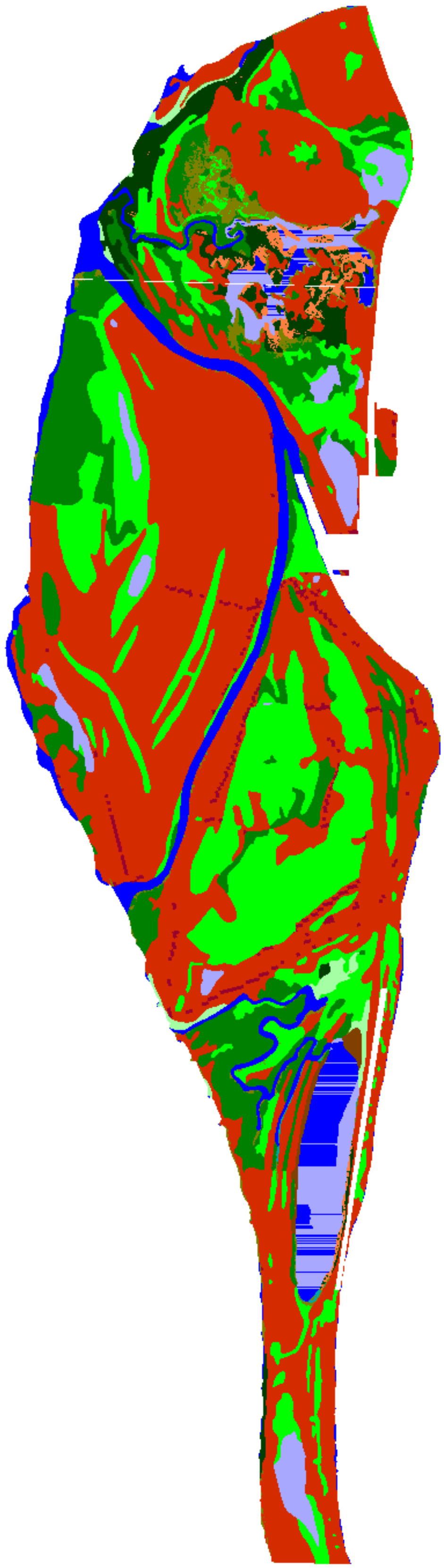
Ridgefield Raster
2 Meters Eustatic SLR by 2100

Results in Acres

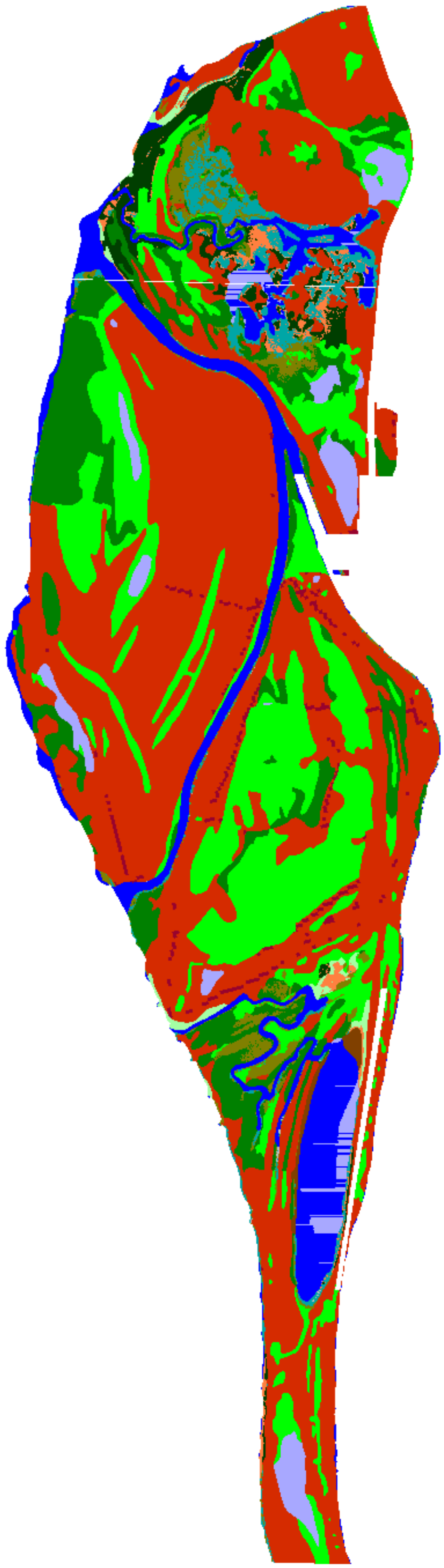
	Initial	2025	2050	2075	2100
Undeveloped Dry Land	3318.2	3274.1	3240.9	3186.2	2313.2
Inland Fresh Marsh	1358.4	1336.8	1303.2	1244.4	374.7
Swamp	892.6	832.2	731.4	631.7	322.5
Inland Open Water	467.2	348.9	231.1	209.2	147.8
Riverine Tidal	312.8	292.2	236.4	192.0	166.2
Tidal Swamp	267.3	203.7	155.3	116.4	83.7
Developed Dry Land	58.9	58.7	58.5	58.2	26.6
Tidal Fresh Marsh	48.1	47.6	35.9	21.4	14.3
Inland Shore	21.5	21.5	21.5	7.3	3.2
Estuarine Open Water	0.0	139.0	314.5	412.7	683.1
Trans. Salt Marsh	0.0	118.1	168.8	214.7	2084.5
Brackish Marsh	0.0	61.3	60.8	53.7	40.0
Saltmarsh	0.0	11.0	180.5	229.2	268.5
Tidal Flat	0.0	0.0	6.4	168.1	216.9
Total (incl. water)	**6745.1**	**6745.1**	**6745.1**	**6745.1**	**6745.1**



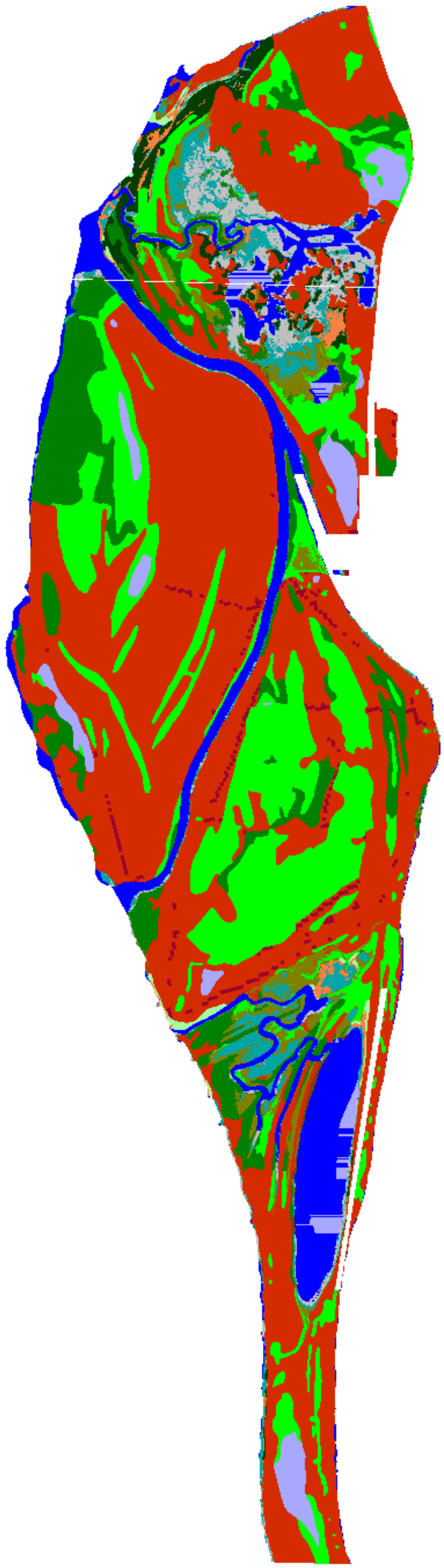
Ridgefield NWR, Initial Condition



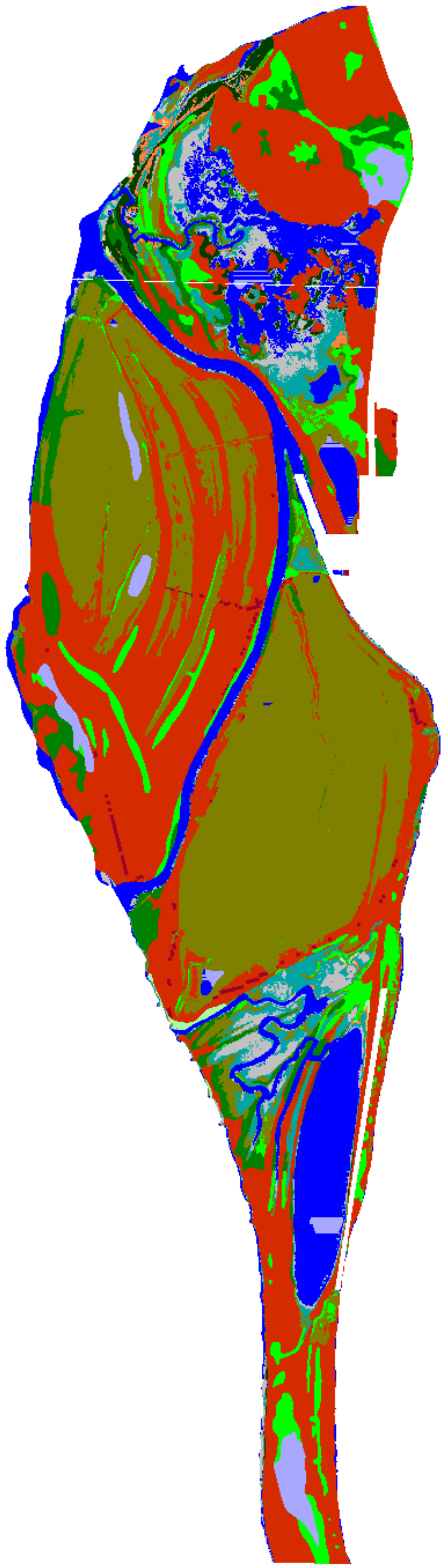
Ridgefield NWR, 2025, 2 meters



Ridgefield NWR, 2050, 2 meters



Ridgefield NWR, 2075, 2 meters



Ridgefield NWR, 2100, 2 meters

Discussion

Ridgefield National Wildlife Refuge is comprised of five units: Carty, Bachelor Island, River "S", Roth and Ridgeport Dairy Units (Figure 2). Refuge vulnerability to sea level rise (SLR) can be broken down by unit.

The unit predicted to be first affected by SLR is the Carty Unit, where tidal swamp is predicted to convert to irregularly flooded (brackish) marsh by 2100 in the 0.39 meter scenario. Swamp, tidal swamp, and inland fresh marsh are all located at relatively low elevations relative to the tide and are predicted to be vulnerable to SLR.

The Roth Unit is the second most vulnerable, with tidal fresh marsh converting to irregularly flooded marsh and swamp converting to transitional marsh by 2100 in the 0.69 meter scenario. In the 1 meter scenario, the Roth Unit is predicted to lose inland fresh marsh to transitional marsh. Land elevations are higher in this unit, but not by much.

In the 1.5 meter SLR scenario are the Bachelor Island and River "S" Units are predicted to have effects from saline inundation. Bachelor Island swamp and inland fresh marsh are both predicted to convert to transitional marsh and River "S" inland fresh marsh (notably lying north of the diked area) is predicted to convert to transitional marsh.

In the 2-meter scenario, the dikes of the River "S" Unit are predicted to be breached (Figure 3) and some inland fresh marsh of the Ridgeport Dairy Unit is predicted to be lost. There is considerable uncertainty as to the exact timing of a potential dike breach both due to elevation data uncertainty and future dike maintenance plans. However, these dikes are predicted to become vulnerable as SLR approaches two meters.

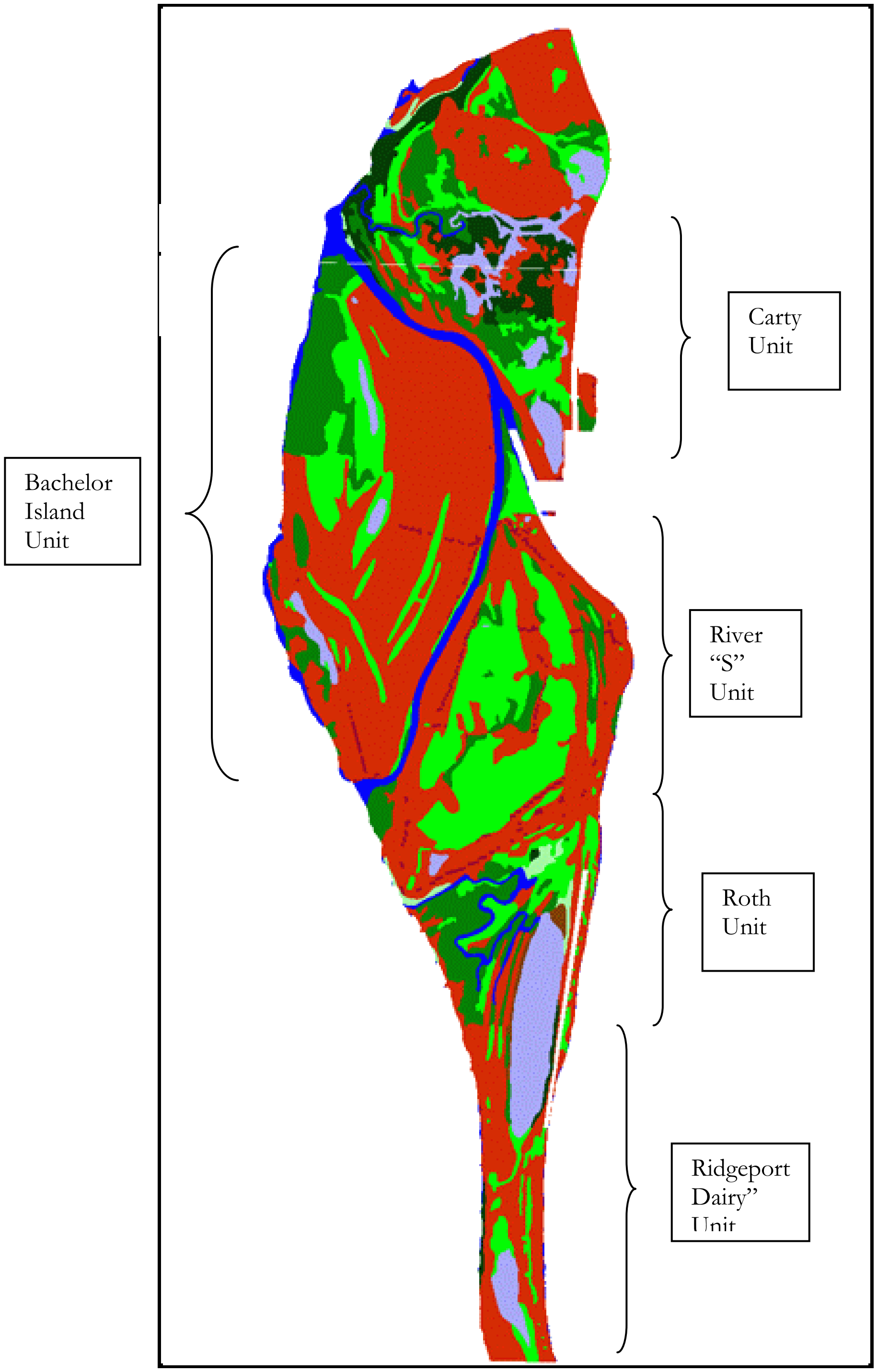


Figure 2: Ridgefield NWR units.

Figure 3: Potential location of initial levee breach.

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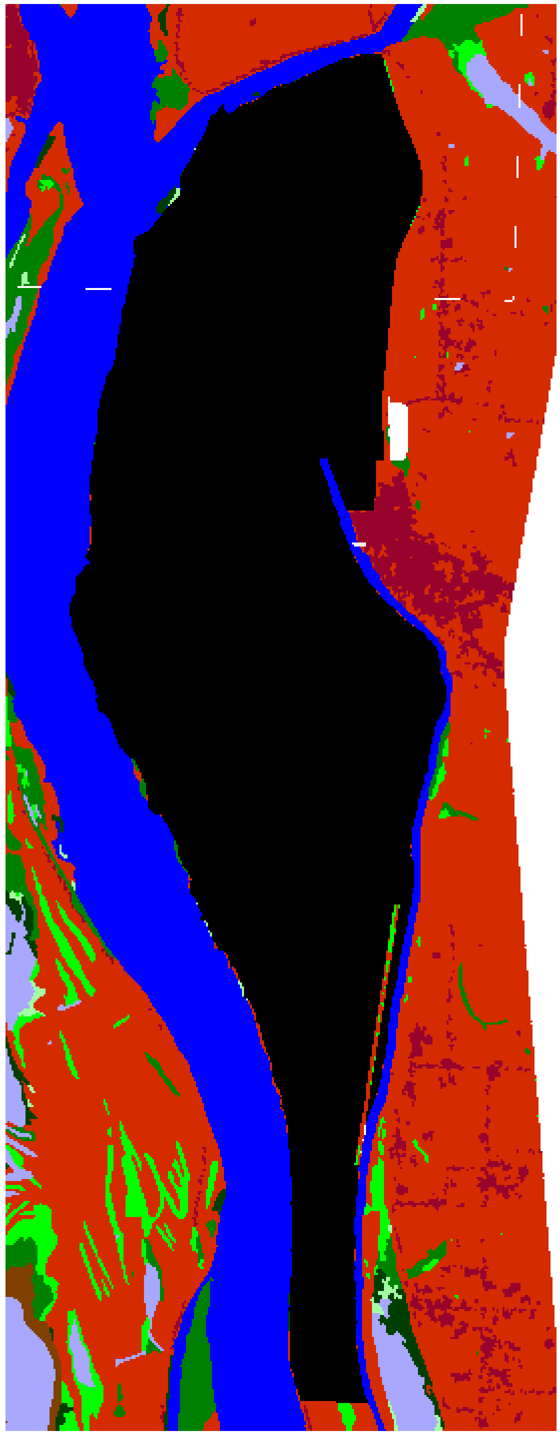
Appendix A: Contextual Results

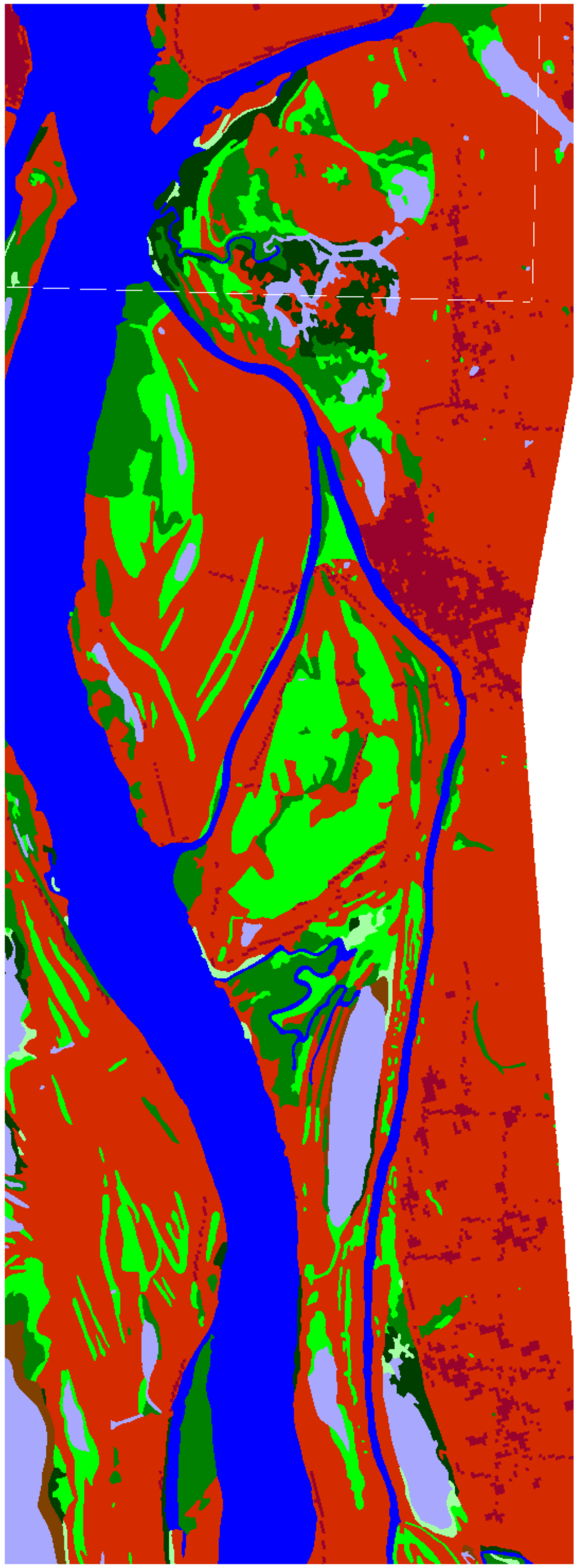
The SLAMM model does take into account the context of the surrounding lands or open water when calculating effects. For example, erosion rates are calculated based on the maximum fetch (wave action) which is estimated by assessing contiguous open water to a given marsh cell. Another example is that inundated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

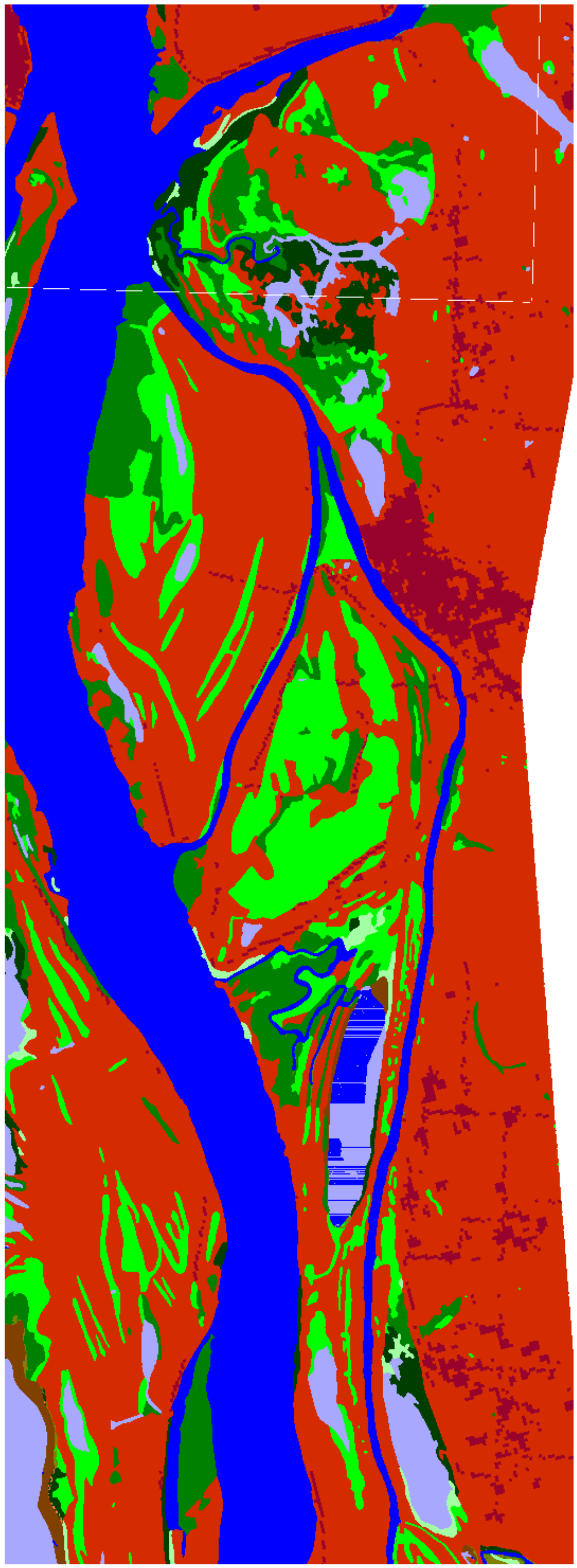
- Results were closely examined (quality assurance) within USFWS refuges but not closely examined for the larger region.
- Site-specific parameters for the model were derived for USFWS refuges whenever possible and may not be regionally applicable.
- Especially in areas where dikes are present, an effort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



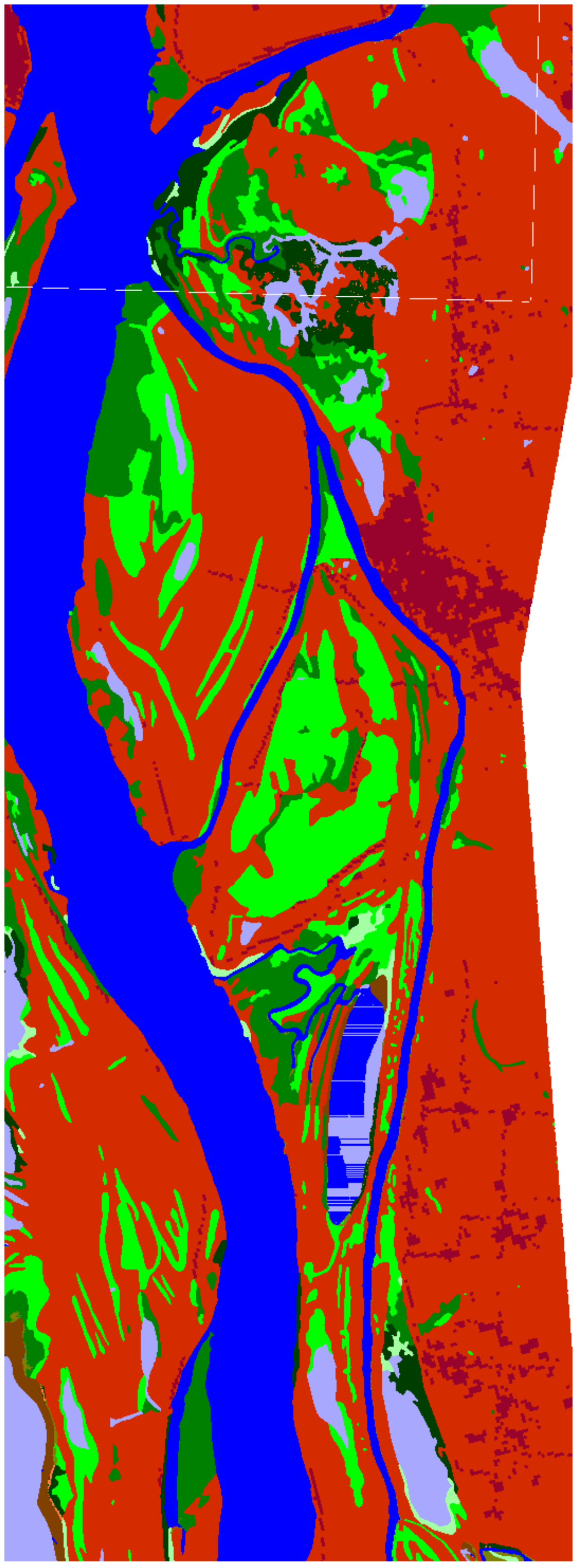
Ridgefield National Wildlife Refuge within simulation context (black).



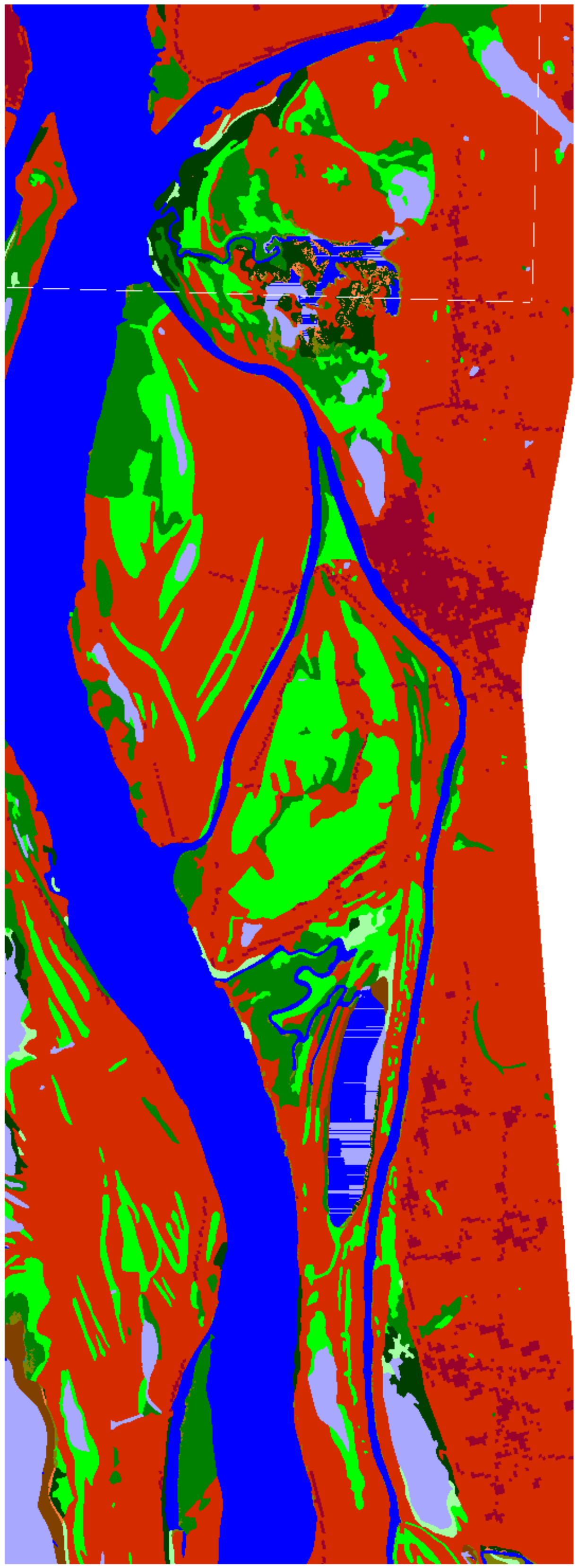
Ridgefield Context, Initial Condition



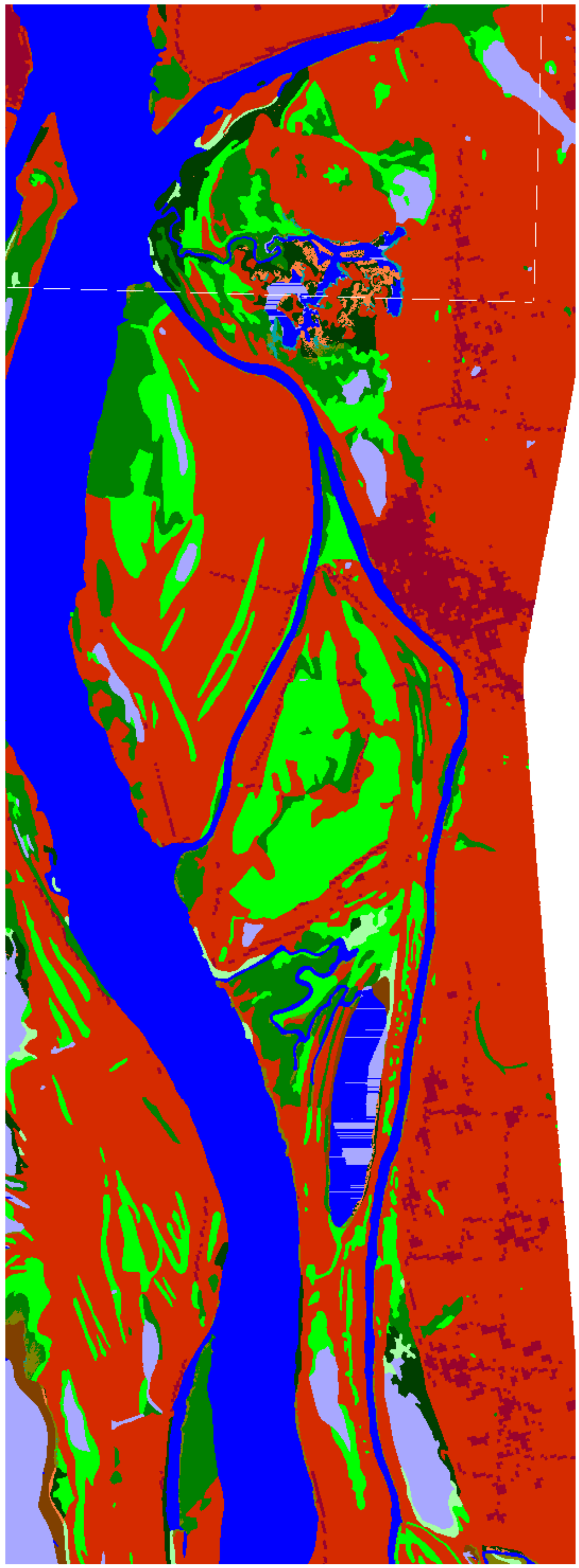
Ridgefield Context, 2025, Scenario A1B Mean



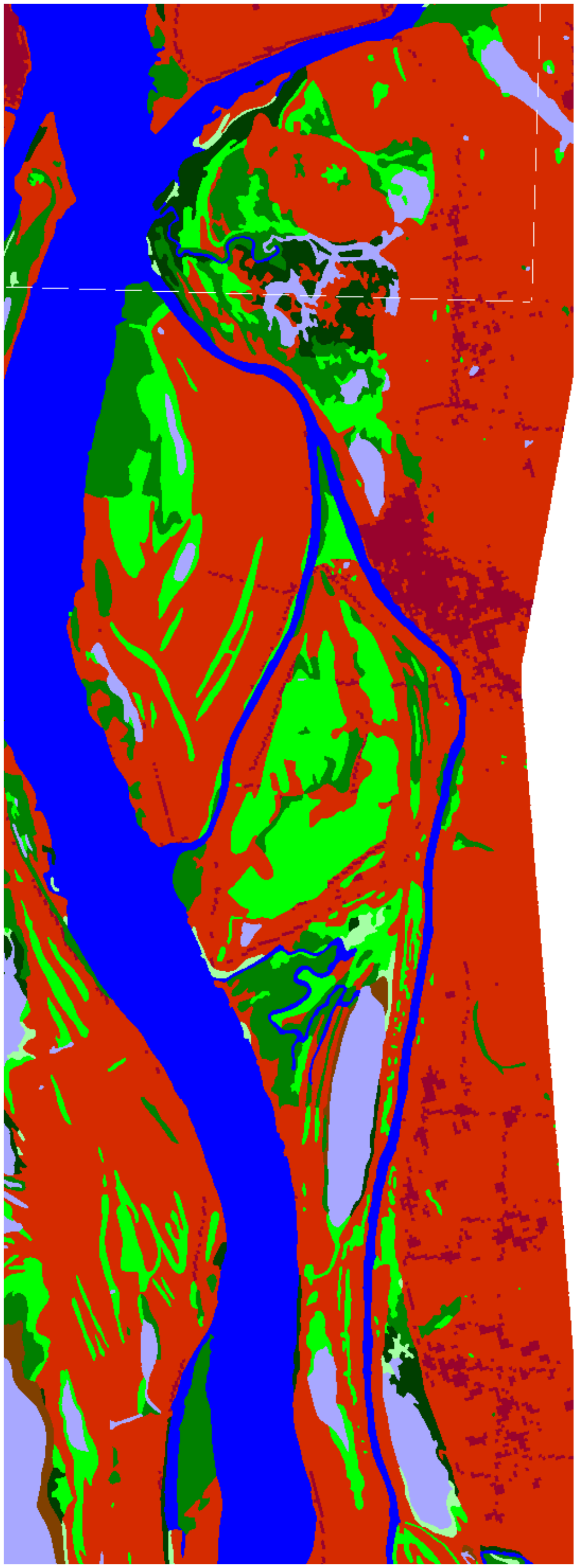
Ridgefield Context, 2050, Scenario A1B Mean



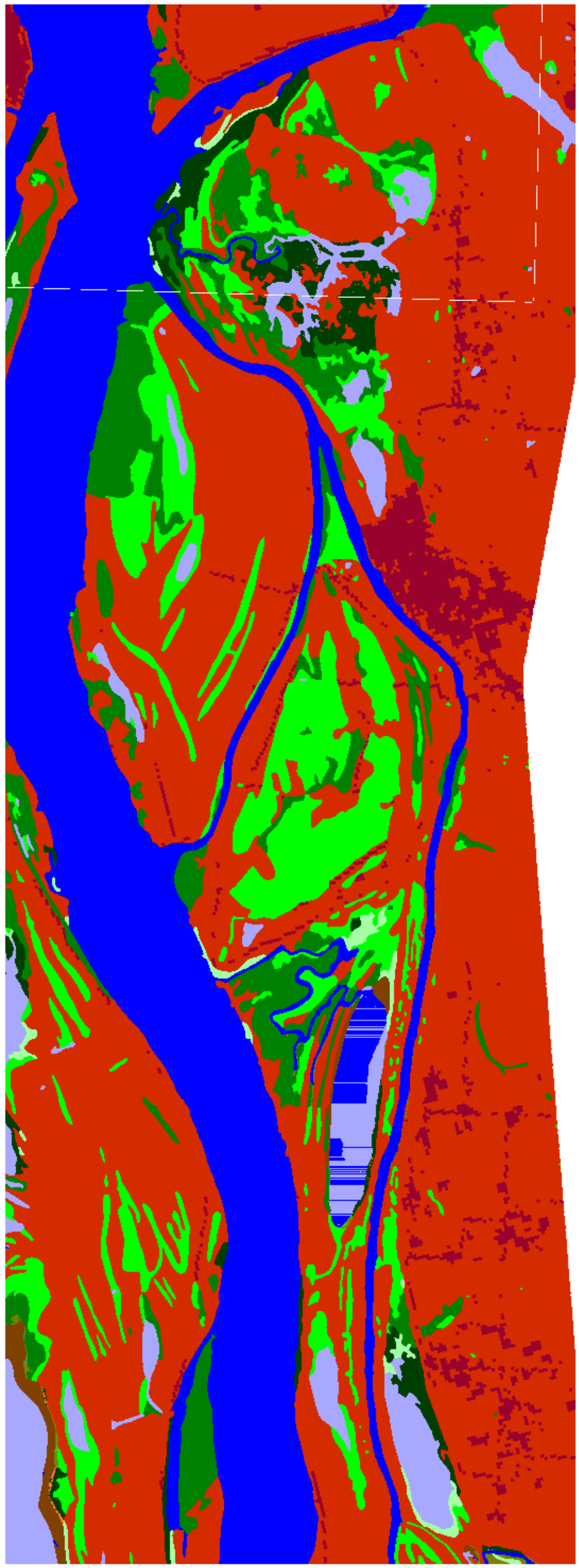
Ridgefield Context, 2075, Scenario A1B Mean



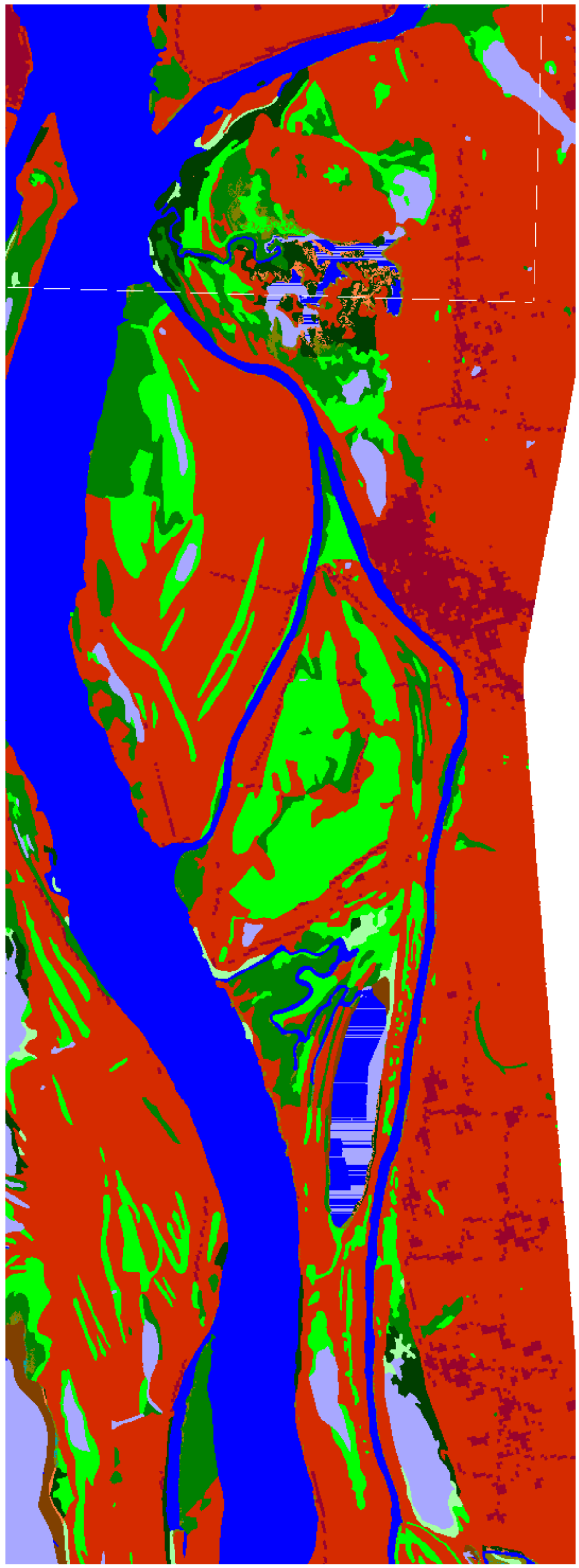
Ridgefield Context, 2100, Scenario A1B Mean

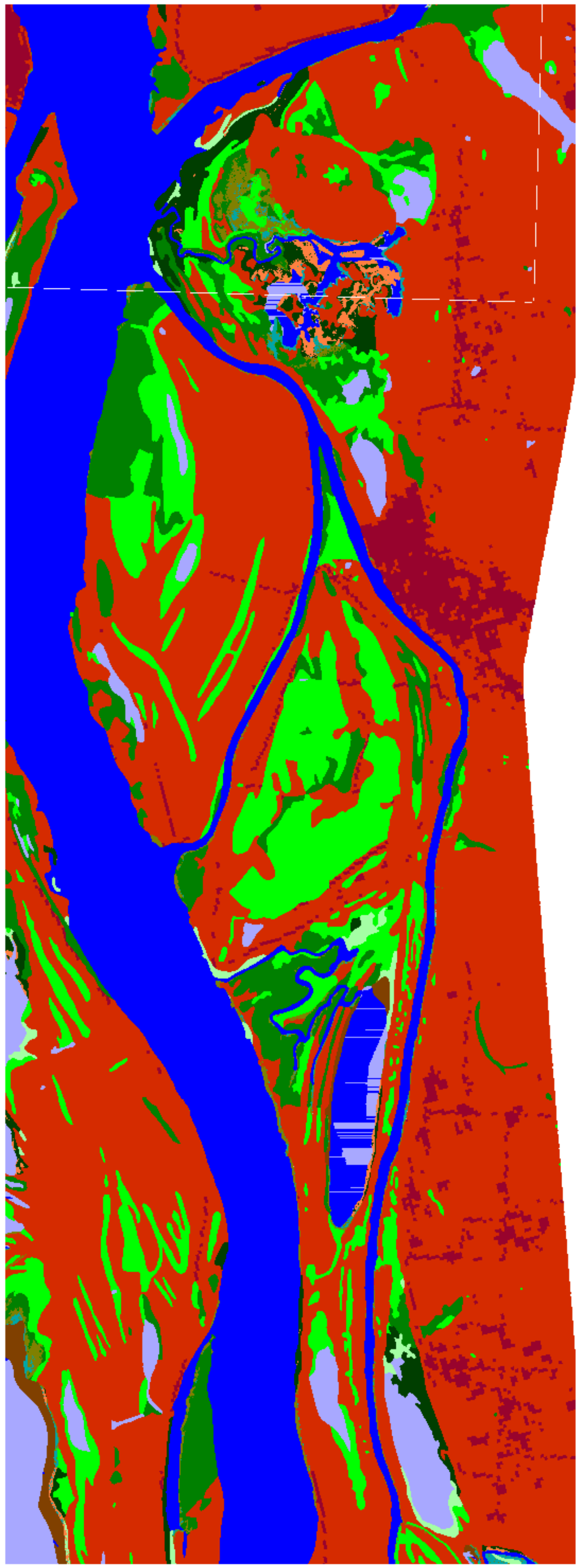


Ridgefield Context, Initial Condition

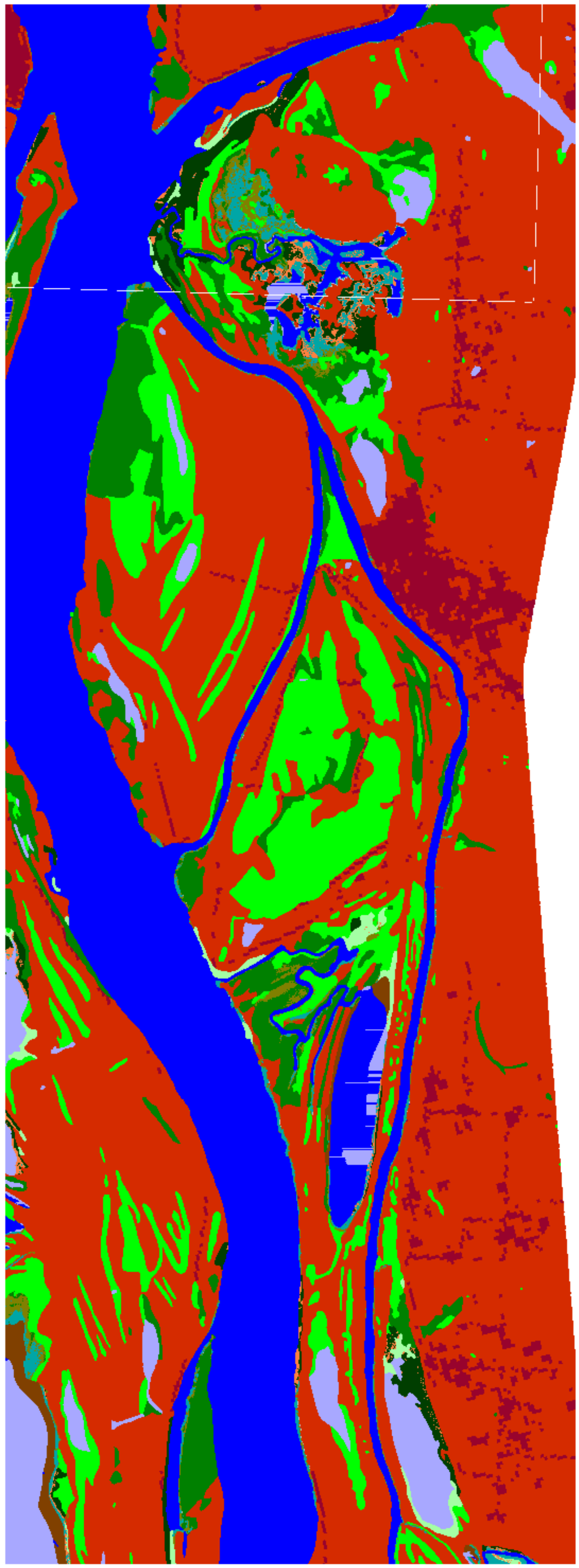


Ridgefield Context, 2025, Scenario A1B Maximum

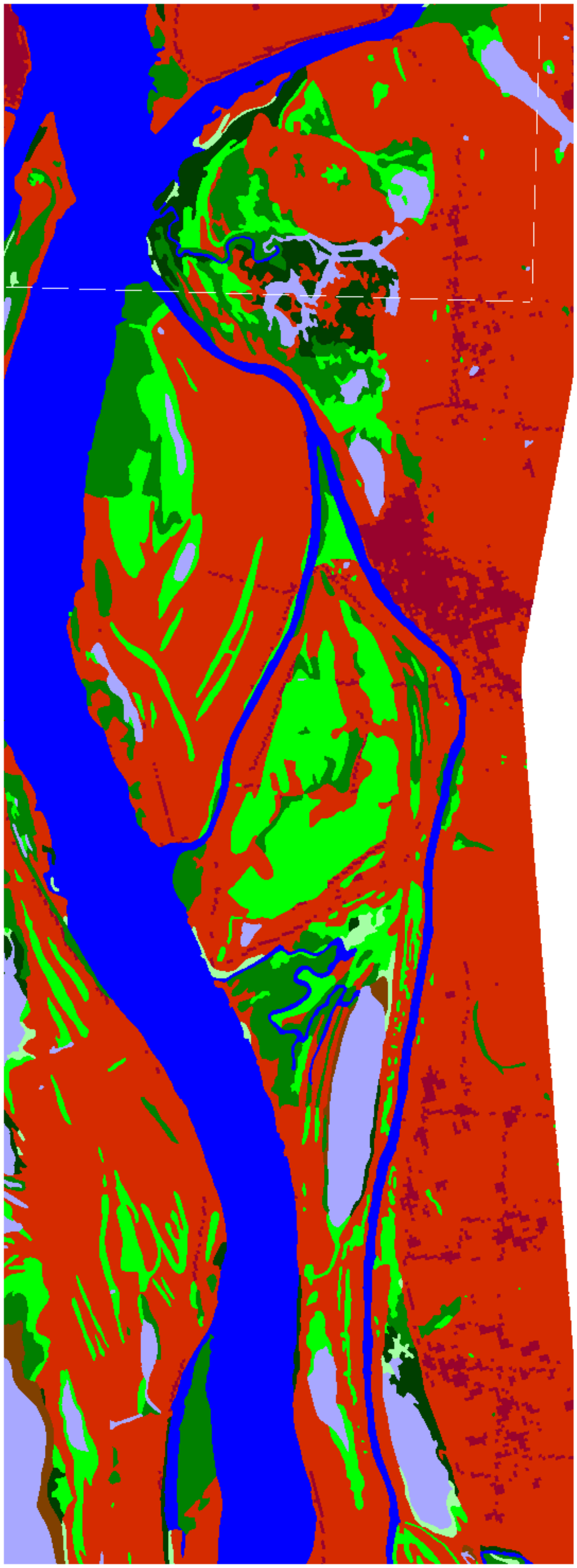

Ridgefield Context, 2050, Scenario A1B Maximum



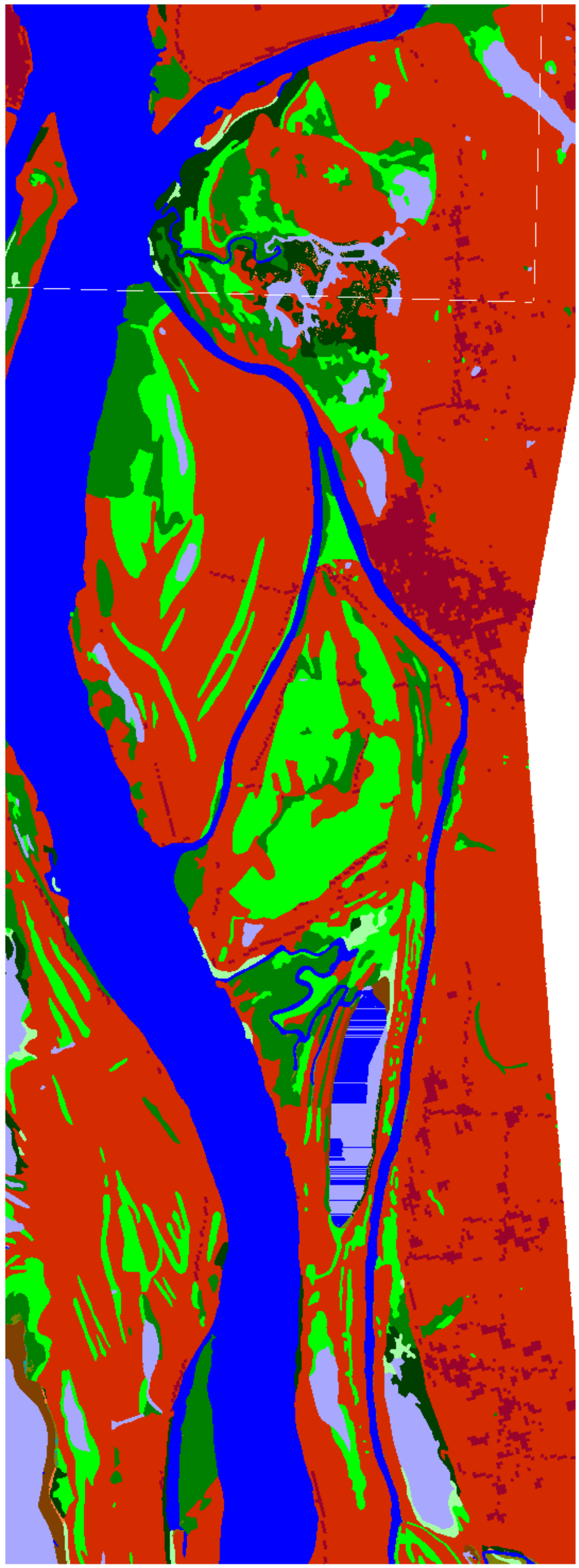
Ridgefield Context, 2075, Scenario A1B Maximum



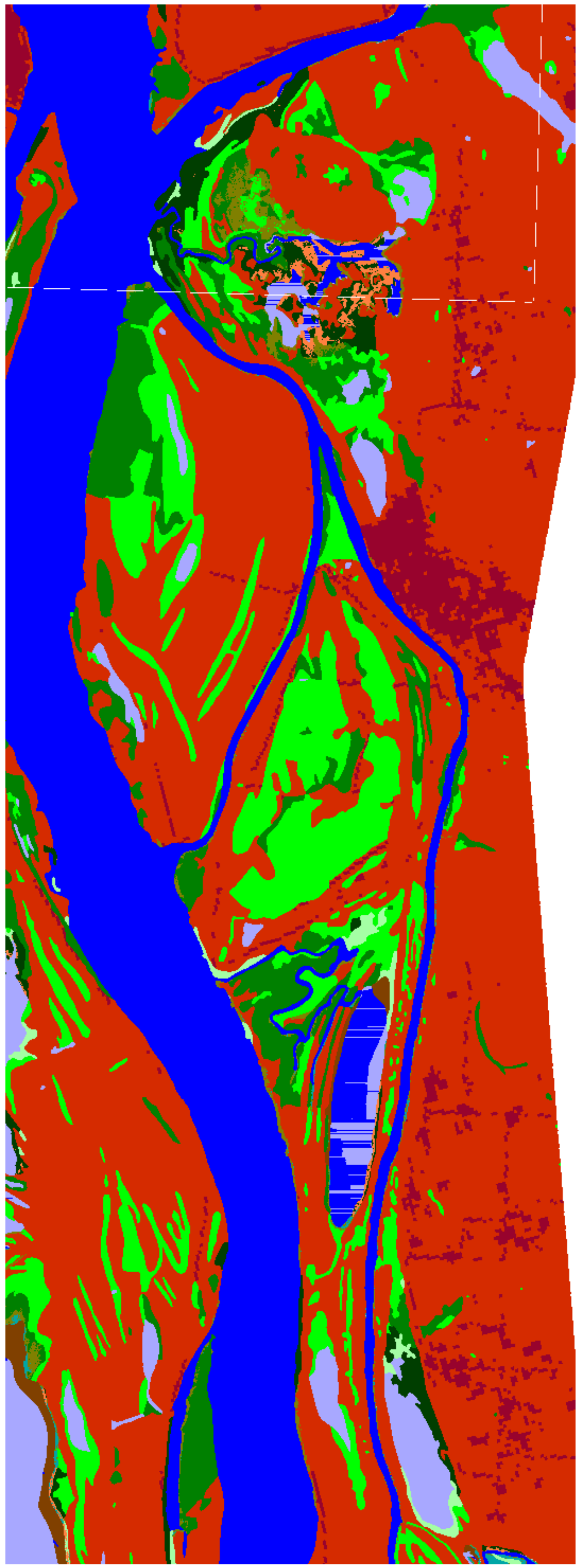
Ridgefield Context, 2100, Scenario A1B Maximum



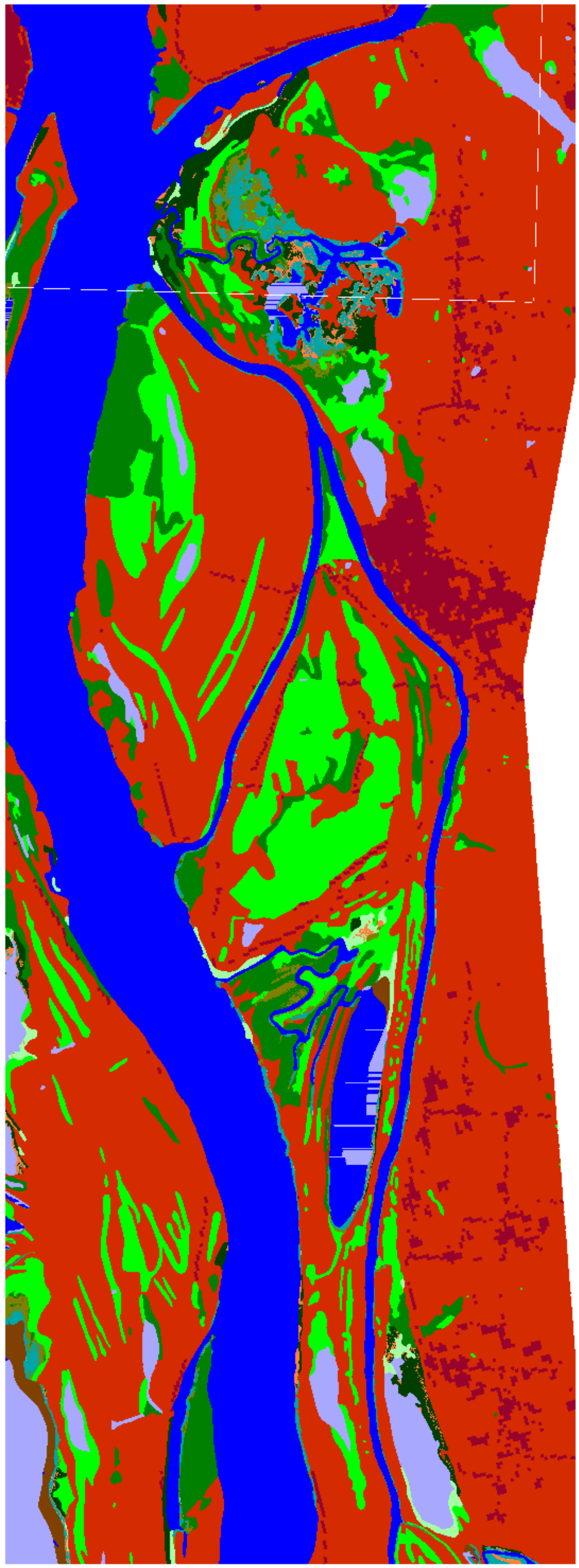
Ridgefield Context, Initial Condition



Ridgefield Context, 2025, 1 meter



Ridgefield Context, 2050, 1 meter



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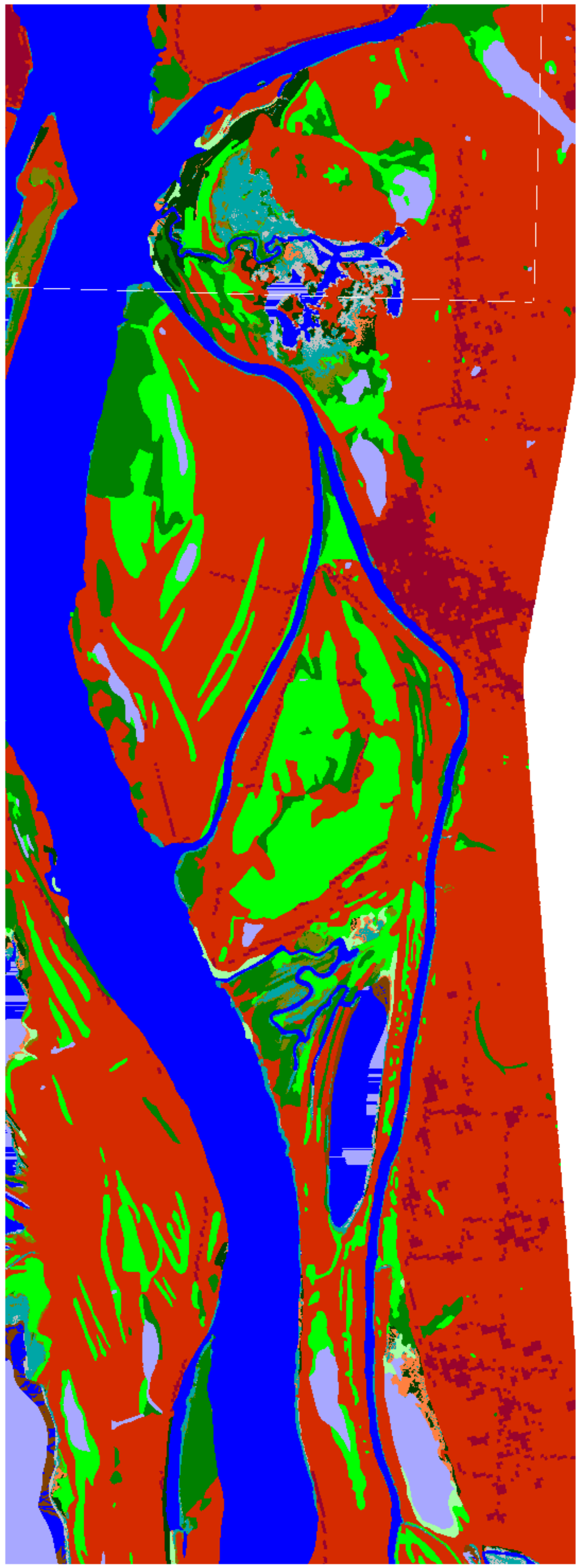

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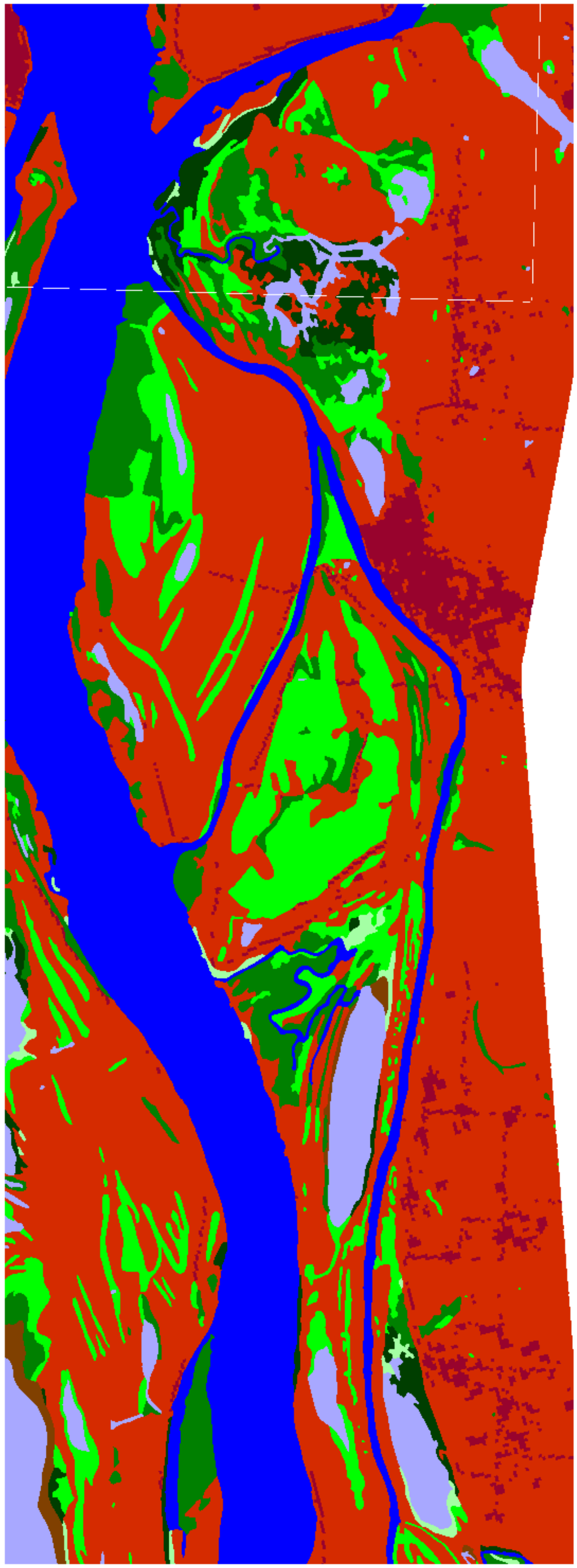
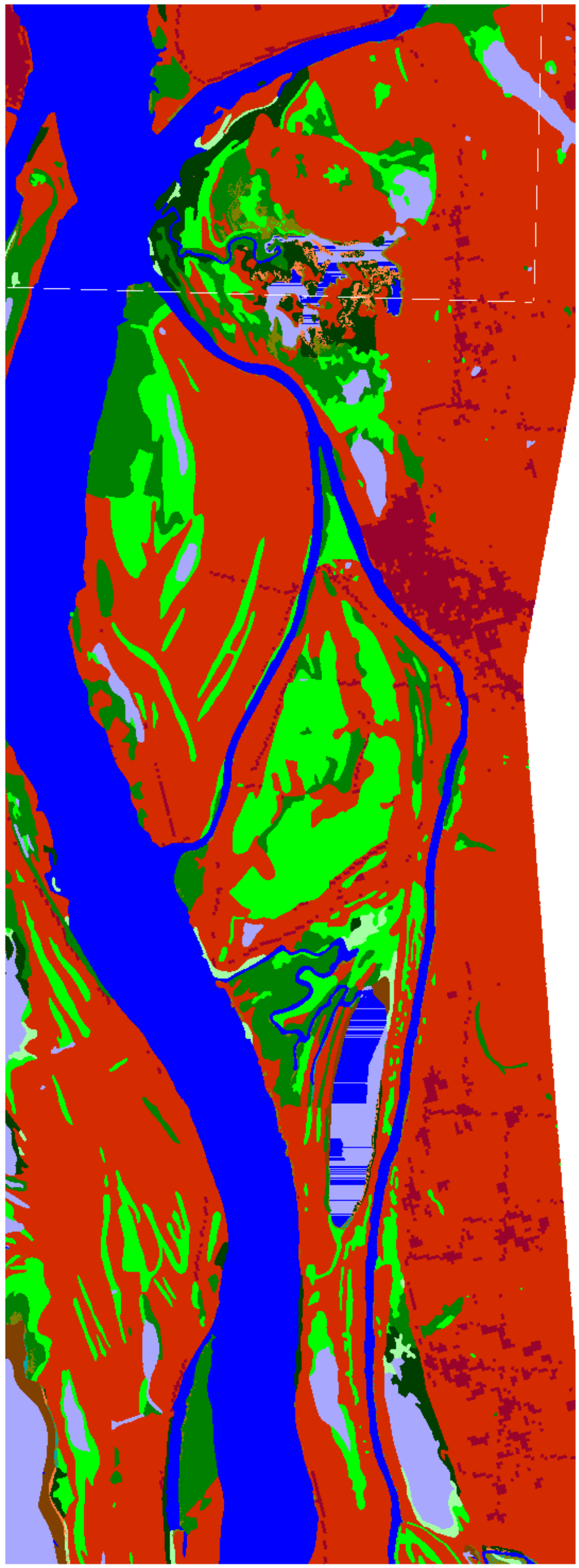
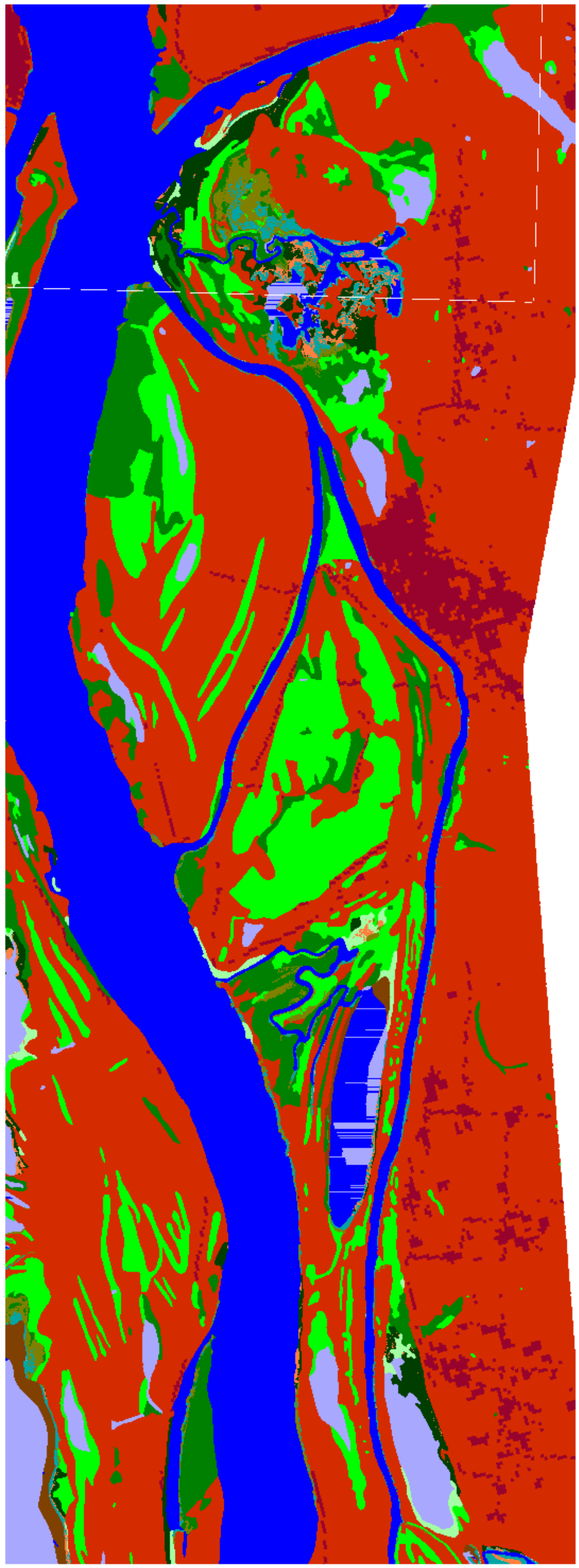


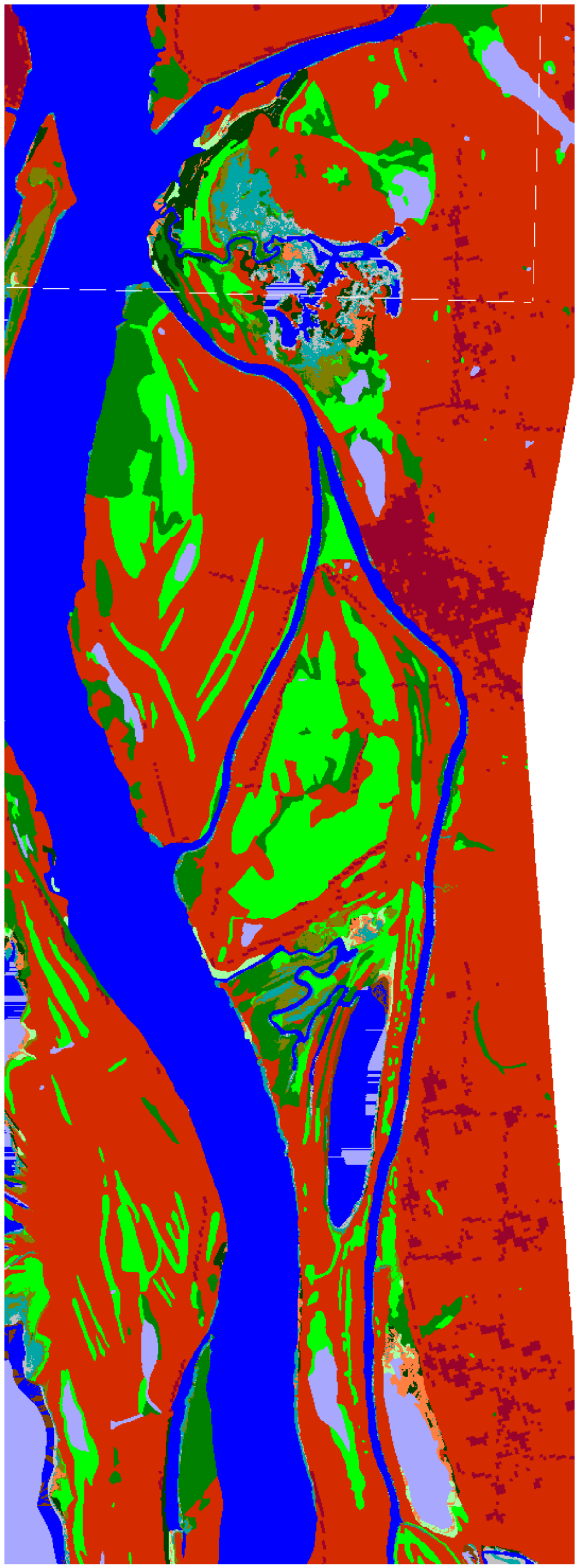
Ridgefield Context, Initial Condition



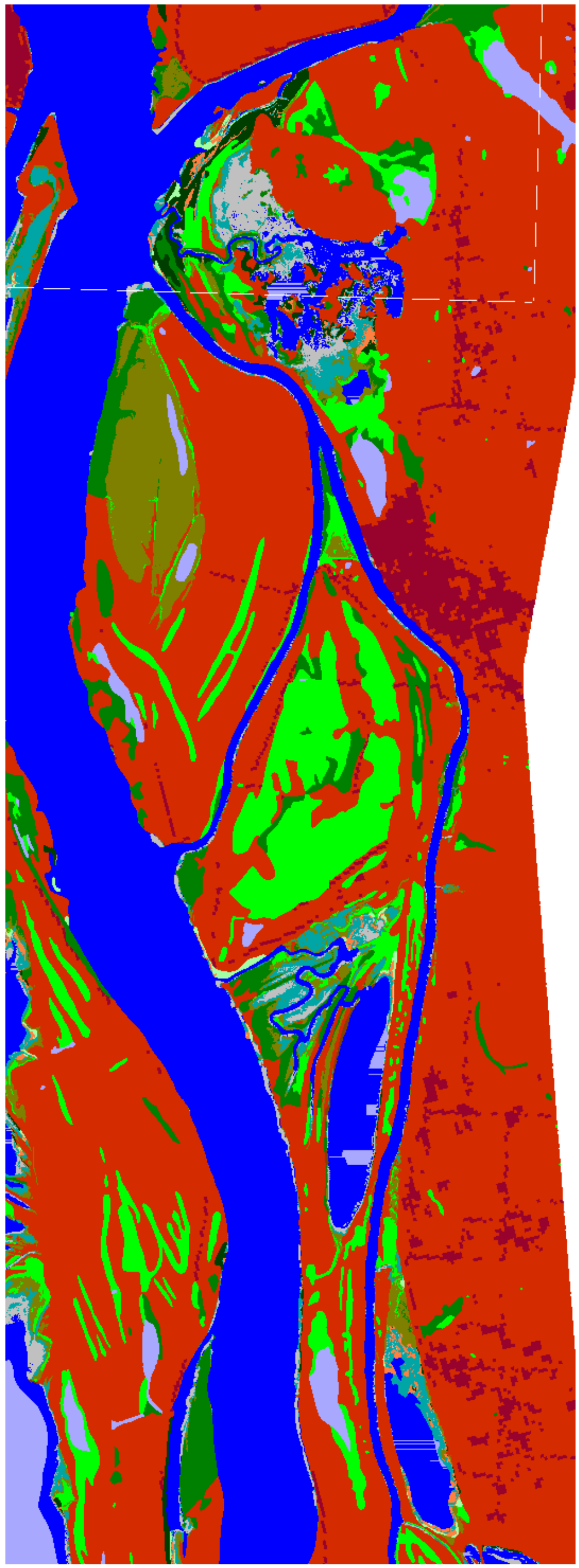
Ridgefield Context, 2025, 1.5 meter



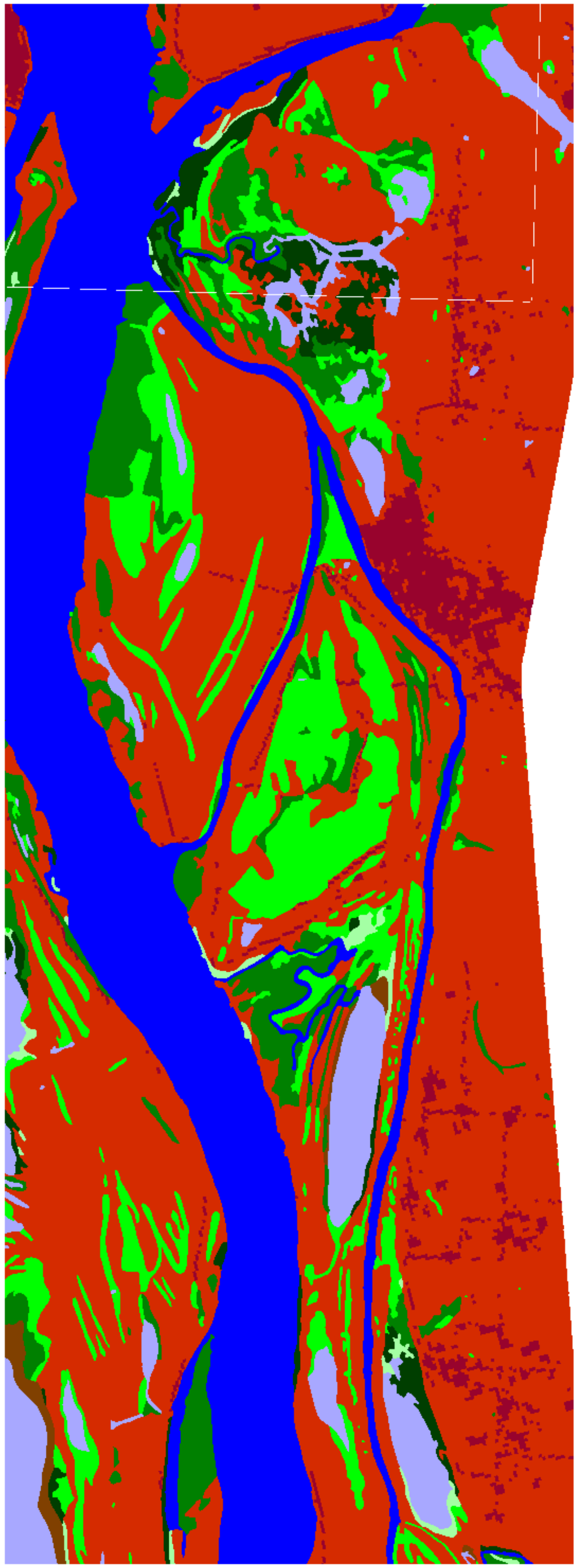
Ridgefield Context, 2050, 1.5 meter



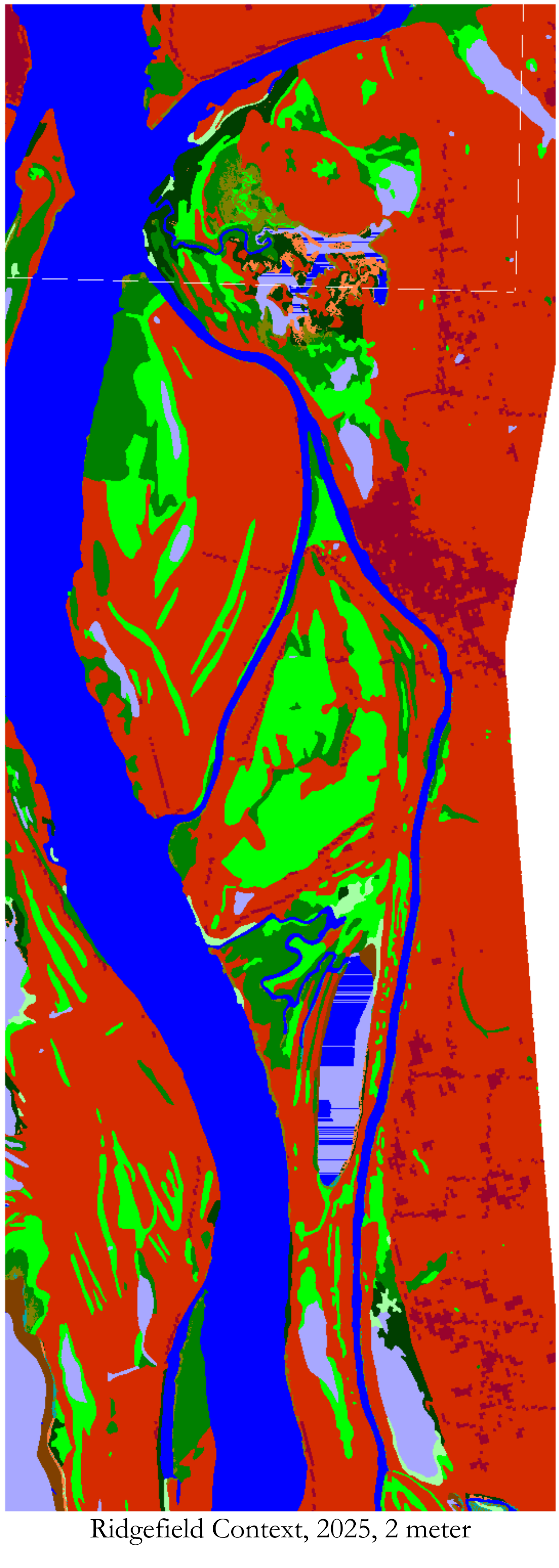
Ridgefield Context, 2075, 1.5 meter



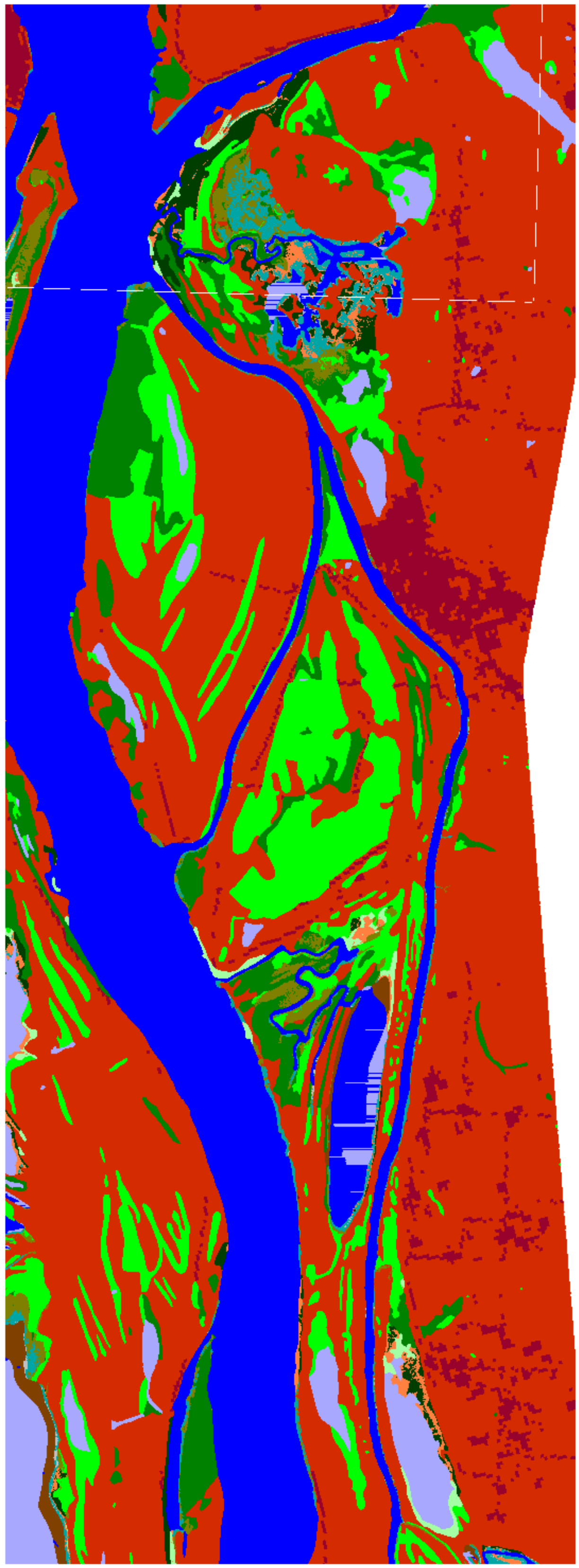
Ridgefield Context, 2100, 1.5 meter



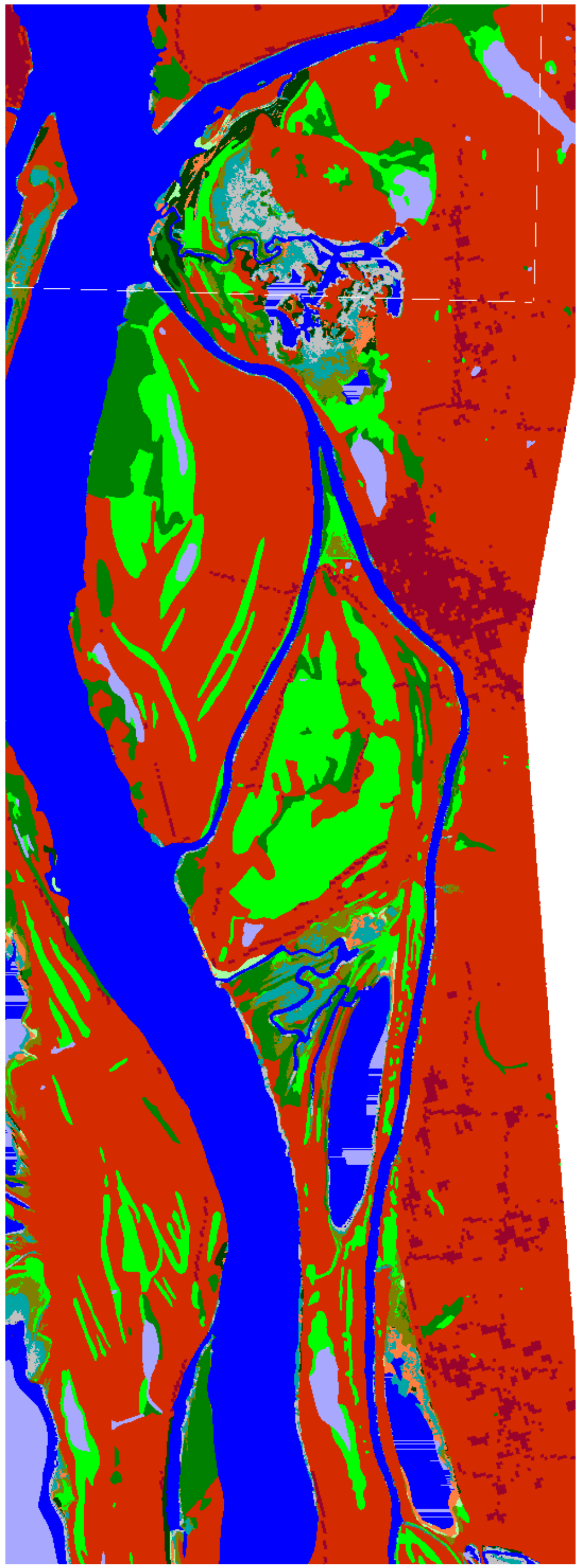
Ridgefield Context, Initial Condition



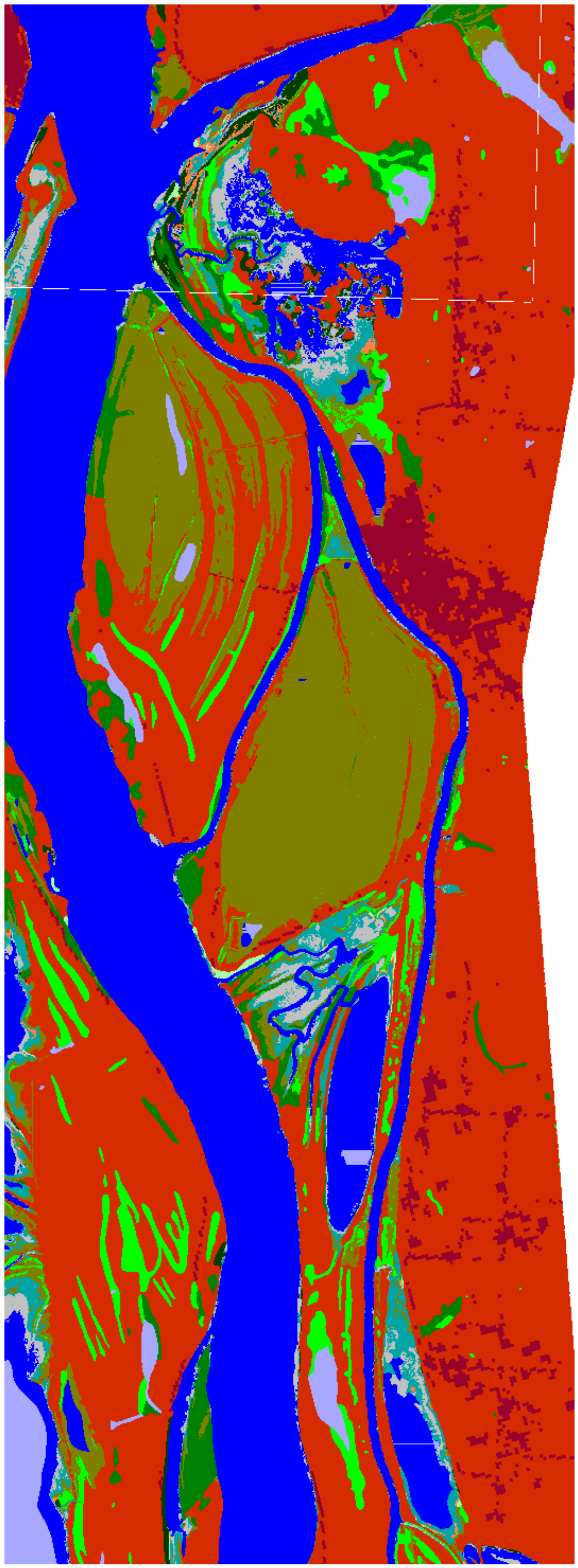
Ridgefield Context, 2025, 2 meter



Ridgefield Context, 2050, 2 meter



Ridgefield Context, 2075, 2 meter



Ridgefield Context, 2100, 2 meter