



Data Notes for the New Hampshire Salt Marsh Plan

This document provides an explanation of the data and methods used when developing the *New Hampshire Salt Marsh Plan: A Guide for Sustaining Tidal Marshes* and serves as metadata for the GIS layers associated with the plan: “**SaltMarshMetrics2022**”

To learn more about the NH Salt Marsh Plan, visit: www.greatbay.org/salt-marsh-plan

To access the GIS data layers, visit: NH GRANIT <https://www.nhgeodata.unh.edu/>

To access data on the interactive viewer, go to:

<https://experience.arcgis.com/experience/edc275ade5434e7aa5ff3f353fd8e22d>

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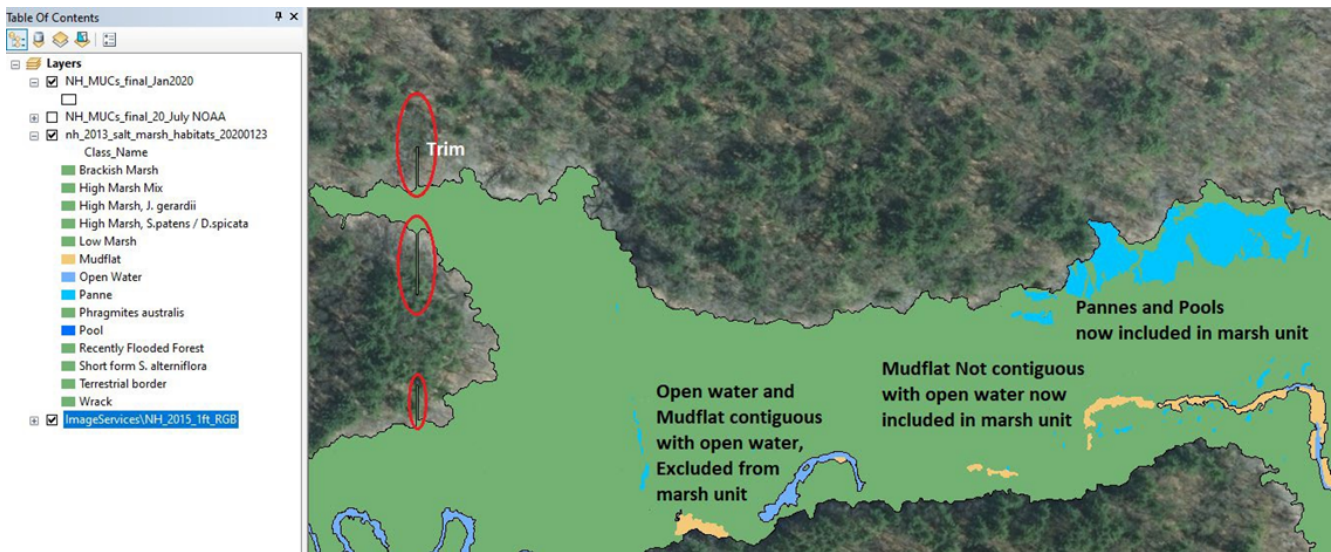
Overview of Methods

Efficient stewardship of tidal wetlands requires robust comparative assessments of different marshes to understand their resilience to stressors, particularly in the face of relative sea level rise. To address this need, NH Fish and Game and the Great Bay National Estuarine Research Reserve developed a framework based on three elements of marsh resilience: **current condition**, **vulnerability to sea level rise**, and **adaptation potential**. In collaboration with other agencies and academics, we identified a set of metrics that influence resilience and then calculated a score for each element of resilience as well as an overall resilience score. The underlying data uses diverse units and scales and can have either positive or negative influence on resilience, as a result the raw data have been transformed to quantile metric scores before calculating the resilience scores. To inform natural resource planning, we link resilience scores to a series of management options by assigning an ordinal category of either “low” or “high” based on their quantile score for current condition, vulnerability, and adaptation potential.

Marsh Unit Delineation Process

To establish a spatial unit of analysis, we created 224 marsh units by delineating “similar” areas of marsh based on the nearest neighbor clustering of NOAA’s high resolution tidal wetland habitat data: “nh_2013_salt_marsh_habitats_20200123” using the following process.

- We removed Open Water, and Mudflat polygons contiguous with open water.
- We dissolved all remaining habitat polygons to create a high-res habitat external boundary
- We trimmed off noise, tiny isolated polygons, and linear artifacts in the high res habitat - for example:



- Tidal marsh area was divided into marsh unit polygons based on a nearest neighbor clustering analysis conducted by NOAA in July of 2019.
- The initial systematic analysis produced over 900 marsh units; the technical advisory team reviewed these to create units that are locally relevant and of a suitable size for project planning. When possible, roads and waterways were used as boundaries.
- The size of marsh units ranges 0.03 to 212.81 acres, with a mean of 25.85 acres.

General Descriptive Data

The following data fields are included in the GIS files that are available through GRANIT.

Data layer: SaltMarshMetrics2022

NH_Clump_ID = unique identifier for each marsh unit

Marsh_Name = name commonly used for the marsh unit

Town = town location

Region = region within seacoast NH with broadly similar tidal regimen

Acres = size of marsh unit, range 0.03 to 212.81 acres, mean 25.85 acres

SQMeters = size of marsh unit in square meters

HighMarshAc = acres of high marsh habitats *

LowMarshAc = acres low marsh habitat *

VegAcres = total vegetated area in marsh unit *

PctHigh = percentage of vegetated marsh area that is high marsh habitat *

PctLow = percentage of vegetated marsh area that is low marsh habitat *

** Habitat characterizations are based on NOAA's high resolution tidal habitat data collected in 2013.*

See: <https://coast.noaa.gov/digitalcoast/data/ccapsalthabitat.html>

Salt Marsh Metrics

The following 19 variables were used to calculate four resilience scores for each salt marsh. Following each metric name in parentheses is an indication of the agency that led the calculation of that metric. The raw values (before transformation) for each metric are included in the publicly accessible GIS layer and are listed in the Marsh Profile PDFs that can be downloaded from the Data Viewer.

Current Condition Metrics

The current condition of a marsh represents its relative starting point for ecosystem function before taking into account the effects of future sea level rise. The following eleven metrics are used to calculate a current condition score.

Core/Edge = (NOAA) ratio, range 1.57 to 41.12, mean 11.45. Computed as marsh unit area / edge length for each marsh unit. A low value represents more edge which means exposure and increased risk of loss, and is a negative.

UVVR = (NOAA) ratio, range 0 to 8.081, mean 0.106. Computed as the Unvegetated area / Vegetated area within each marsh unit. Computed using the marsh extent layer OCM generated as part of the marsh habitat mapping project because it includes the non-vegetated classes. Polygons were derived from the raw marsh clump dataset with a 10 meter buffer to enclose/capture small pannes, pools, and creeks that were not included in the marsh polygons. A low value represents more vegetation and is a positive, while a high value indicates higher amount of unvegetated surface and is a negative.

% Impervious = (NHFG) range 0 to 82%, mean 11.3%. Percent impervious cover within 150 meter buffer of each marsh unit. Computed using "Impervious Surfaces in the Coastal Watershed of NH and Maine, High Resolution – 2021" (NH GRANIT). A high value represents more impervious cover and potentially polluted runoff that can negatively impact marsh habitat.

% Natural = (NOAA) range 7 to 100%, mean 87.7%. Percent natural cover within 150 meter buffer of each marsh unit. Computed using NOAA 2016 C-CAP BETA 10m land cover data and derived from all the natural cover classes. A high value represents more natural cover that can absorb runoff and filter pollutants and is a positive.

% Agriculture = (NOAA) range 0 to 56.8%, mean 4.3%. Percent agricultural cover within 150 meter buffer of each marsh unit. Computed using NH 2015 Land Use data and derived from the "Agricultural Land" and "Other Agricultural Land" classes. A high value can result in more potentially polluted runoff and is a negative.

TEspecies = (NHFG) range 0 to 28, mean 5. Count number of different species of rare animals and plants within the marsh unit (occurrences provided by NH Natural Heritage Bureau, Dec. 2022).

Nitrogen = (NHFG) range 132 to 963222, mean 85963 kg/y estimated from water quality samples. Computed by intersecting marsh units with USGS SPARROW catchments, calculated the area-weighted average of the "tn" value.

DitchDensity = (NHFG) range 0 to 3.52, mean 0.32. Computed as a line density raster dataset (feet per acre); and the metric represents the maximum value for any portion of the marsh unit (ditch presence verified using recent orthophotos). Value increases with ditch density, and is a negative.

% Phrag = (UNH) range 0 to 100, mean 7. Computed as percent area of each marsh unit, using the data layer "nh_salt_marsh_habitats_20191010_Phrag_only". Value increases with higher potential impact from invasive plants, and is a negative.

HabitatDiversity = (NHFG) range 0 to 1.875, mean 1.05 Computed Shannon diversity index based on habitat types mapped in the data layer "nh_2013_salt_marsh_habitats_20200123" within each marsh unit. The value, Shannon index, increases as both the richness and the evenness of the community increase, and is a positive.

Berms = (NHFG) range 0 to 0.401, mean 0.126 Computed as the proportion of migration space immediately adjacent to marsh unit boundary that has berms present. Berms are based on TPI, derived from the LiDAR DEM using a raster calculator equation: ("tpi" > 0.1) & ("slopedeg" < 8), where tpi = elevation – focal mean of elevation in a 8x8 neighborhood. Marsh units buffered by 16m and clipped to migration space, measured amount of berm area in that resulting area. Value increases with berm presence and is a negative.

Vulnerability to Sea Level Rise Metrics

Four metrics are used to calculate a marsh's vulnerability to sea level rise. These metrics evaluate how current marsh area will respond to increased stress from rapid sea level rise. Higher vulnerability is associated with lower overall resilience.

Erodibility = (NOAA) range 0 to 0.587, mean 0.23. Erodibility of soils within each marsh unit. Computed by averaging the "AVG_KFACT" attribute from the Area- and Depth-Weighted Averages of Selected SSURGO Variables for the Conterminous United States and District of Columbia data set across soil units contained in the MUPOLYGON feature class from the gSSURGO database. It is a unitless erodibility factor ranging from 0 to 0.64, which quantifies the susceptibility of soil particles to detachment by water. Soils resistant to detachment have low values < 0.15 and erodible soils that easily detach have values > 0.4. This metric is a Negative, higher erodibility indicates higher vulnerability and lower resilience.

(Source: <https://catalog.data.gov/dataset/area-and-depth-weighted-averages-of-selected-ssurgo-variables-for-the-conterminous-united-state#sec-dates>)

Mean Tidal Range (m) = (NOAA) range 1.41 to 2.92, mean 2.21. Mean tidal range computed for each marsh unit. Units are meters. Tidal range values represent the height from Mean Lower Low Water to Mean Higher High Water as derived from NOAA's Vdatum model. Higher value indicates larger tidal range and better resilience, it is a Positive.

% Below MHHW = (NOAA) range 0 to 100%, mean 53.89%. Percent of marsh unit below Mean Higher High Water (MHHW). Computed using tidal surface generated from NOAA's Vdatum model. It is a Negative - more area below MHHW indicates higher vulnerability and lower resilience.

% Below MTL = (NOAA) range 0 to 100%, mean 13.4%. Percent of marsh unit below Mean Tide Level (MTL). Computed using tidal surface generated from NOAA's Vdatum model. It is a Negative.

Adaptation Potential Metrics

Adaptation potential metrics take into account how likely a marsh is to expand vertically or laterally in response to sea level rise. These four metrics are associated with shoreline features that indicate how easily the borders of a marsh can expand geographically.

% Hardened Shoreline NH = (NOAA) range 0 to 1.09%, mean 0.065%. Percent of shoreline within marsh unit that is hardened. Computed by dividing the length of New Hampshire's shoreline structure inventory.shp by the length NHShoreline.shp contained within a 10 meter buffered version of each marsh unit. Higher value indicates more impediment to migration, and is a negative.

Migration Space = (NHFG) range 3,738 to 4,380,204, mean 604,729 square meters. Migration space represents the area into which marsh units may migrate under future sea level rise scenarios. Unioned marsh units with the 2022 SLAMM results ("salt marsh persistent" and "salt marsh potential" status for the 1.5 meter SLR by 2100 scenario which represents the high end of the range for this region). Calculated area (sq. meters) contiguous with each marsh unit. Higher value indicates marsh persistence, and is a positive.

Connectedness (local) = (NOAA) range 0 to 6,382, mean 270.3. This represents the degree to which each marsh unit will be connected to adjacent marsh units under future sea level rise scenarios. This was computed by using the combined 2025, 2050, and 2075 marsh migration areas (persistent and potential) under the 2-meter SLR scenario and counting the number of connections with adjacent marsh units. The count was scaled by the total lengths of the connections for each marsh unit. Higher value indicates better connectedness and is a positive.

Sinuosity = (NOAA) range -0.99 to 0, mean -0.5. The sinuosity of shoreline within each marsh unit. (from Anderson and Barnett, 2017: "An intricate shoreline with lots of inlets and variable physical characteristics provides diverse habitat options and harbors greater ecological diversity than a simple shoreline, and creates resilience by dividing and distributing inundation levels." Computed using NOAA's Environmental Sensitivity Index shoreline and the Sinuosity python script provided by Esri, using ESI shoreline segments intersected with 10m buffered marsh units. Marsh units without intersecting shoreline segments were assigned values of '0'. High values represent linear shorelines and low values represent sinuous shorelines. Since the sinuosity script generates values from 0-1, where 1 is a straight feature, we multiplied the sinuosity index by -1 so that values closer to 0 were scored higher in the quantile index. A value closer to 0 is a more complex shoreline, and is a positive.

Quantile Metric Scores

For each metric, NH Fish and Game calculated decile breaks to create 10 equal bins within the raw data, and then assigned a rank score to each marsh unit based on the corresponding bin: 1-10.

We multiplied metrics with a negative impact by negative 1, so that scores within an element (Condition, Vulnerability or Adaptation) are on a consistent scale, e.g., from poor condition to good condition. For example, a high percentage of phragmites was transformed to a low decile score so that it would correspond with poor condition and low resilience.

Quantile scores are available within the attribute table accessible through Data Viewer to enable users to learn more about an individual marsh and see how it compares to other marshes in NH.

Quantile Name	Metric Name	Scale	How this Metric Influences Resilience	
			+ / -	Explanation
QUANTILE_coreedge	Core/Edge	1 - 10	+	Low quantile (1) is poor condition and low resilience and High quantile (10) is good condition and high resilience
QUANTILE_uvvr	UVVR	1 - 10	-	
QUANTILE_pctimp	% Impervious	1 - 10	-	
QUANTILE_pctnat	% Natural	1 - 10	+	
QUANTILE_pctag	% Agriculture	1 - 10	-	
QUANTILE_tespecies	TEspecies	1 - 10	+	
QUANTILE_nitrogen	Nitrogen	1 - 10	-	
QUANTILE_ditches	DitchDensity	1 - 10	-	
QUANTILE_pctphrag	% Phrag	1 - 10	-	
QUANTILE_habdiv	HabitatDiversity	1 - 10	+	
QUANTILE_berms	Berms	1 - 10	-	
QUANTILE_erod	Erodibility	1 - 10	-	Low quantile (1) is low vulnerability and high resilience and High quantile (10) is high vulnerability and low resilience
QUANTILE_tidalrange	Mean Tidal Range (m)	1 - 10	+	
QUANTILE_mhhw	% Below MHHW	1 - 10	-	
QUANTILE_mtl	% Below MTL	1 - 10	-	
QUANTILE_hardshore	% Hardened Shoreline NH	1 - 10	-	Low quantile (1) is low adaptation potential and low resilience and High quantile (10) is high adaptation potential and high resilience
QUANTILE_migspace	Migration Space	1 - 10	+	
QUANTILE_connected	Connectedness (local)	1 - 10	+	
QUANTILE_sinu	Sinuosity	1 - 10	+	

Key: *Current Condition (Green), Vulnerability to Sea Level (Orange) and Adaptation Potential (Blue)*

Calculating Resilience Scores

The raw data for each metric variable was weighted and transformed to a similar scale to facilitate calculation of the resilience scores. Weightings were determined with input from the project technical advisory team such that metrics with a higher weighting had a larger influence on the final resilience scores. Metrics with a negative impact were multiplied by negative 1, so that scores within an element (Condition, Vulnerability or Adaptation) are on a consistent scale, e.g., from poor condition to good condition.

Metric Name	Weighting in Resilience Calculation	How this Metric Influences Resilience	
		+ / -	Explanation
Core/Edge	60%	+	High raw value = Good current condition
UVVR	100%	-	Low raw value = Good current condition
% Impervious	80%	-	Low raw value = Good current condition
% Natural	70%	+	High raw value = Good current condition
% Agriculture	70%	-	Low raw value = Good current condition
TEspecies	55%	+	High raw value = Good current condition
Nitrogen	50%	-	Low raw value = Good current condition
DitchDensity	70%	-	Low raw value = Good current condition
% Phrag	50%	-	Low raw value = Good current condition
HabitatDiversity	60%	+	High raw value = Good current condition
Berms	70%	-	Low raw value = Good current condition
Erodibility	50%	-	High raw value = More vulnerable
Mean Tidal Range (m)	50%	+	Low raw value = More vulnerable
% Below MHHW	80%	-	High raw value = More vulnerable
% Below MTL	60%	-	High raw value = More vulnerable
% Hardened Shoreline NH	100%	-	Low raw value = More adaptation potential
Migration Space	100%	+	High raw value = More adaptation potential
Connectedness (local)	70%	+	High raw value = More adaptation potential
Sinuosity	60%	+	High raw value = More adaptation potential

Key: *Current Condition (Green), Vulnerability to Sea Level (Orange) and Adaptation Potential (Blue)*

The raw values for each metric were normalized and a score for each element of resilience was calculated using a weighted sum. Final resilience scores are reported on a scale of 1 - 100.

Current Condition Score

$$\text{Condition_Raw} = [\text{Core/Edge}_n * 0.6] + [\text{UVVR}_n * 1] + [\text{UVVR2100}_n * 1] + [\% \text{Impervious}_n * 0.8] + [\% \text{Natural}_n * 0.7] + [\% \text{Agriculture}_n * 0.7] + [\text{TESpecies}_n * 0.55] + [\text{Nitrogen}_n * 0.5] + [\text{Ditch density}_n * 0.7] + [\% \text{Phrag}_n * 0.5] + [\text{Habitat Diversity}_n * 0.6] + [\text{Berms}_n * 0.7]$$

Vulnerability Score

$$\text{Vulnerable_Raw} = [\text{Erodibility}_n * 0.5] + [\text{Tidal Range}_n * 0.5] + [\% \text{Below MHHW}_n * 0.8] + [\% \text{Below MTL}_n * 0.6]$$

Adaptation Potential Score

$$\text{Adaptation_Raw} = [\text{Hardened Shoreline}_n * 1] + [\text{Migration Space}_n * 1] + [\text{Connectedness}_n * 0.7] + [\text{Sinuosity}_n * 0.6]$$

Overall Resilience

Score_Overall = equally weighted sum of Condition + Vulnerability(inverted) + Adaptation

Score_Condition = 1 to 100

Score_Vulnerability = 1 to 100

Score_Adaptation = 1 to 100

Score_Overall = 1 to 100

Higher score = Good current condition, higher resilience

Higher score = More vulnerable, lower resilience

Higher score = More adaptation potential, higher resilience

High Score = High overall resilience, good condition, low vulnerability, more adaptation potential

Assigning a Management Category

To inform natural resource planning, we link resilience scores to a series of management options. We assigned results for each marsh unit an ordinal category, either “low” or “high” based on their score for current condition, vulnerability, adaptation potential and overall resilience. For each element of resilience (condition, vulnerability, adaptation), the lower scoring half of the marshes are categorized as “low” and the higher scoring half of the marshes are categorized as “high”.

Condition = the high/low designation indicates whether the marsh unit is in the top half or lower half of all marshes in NH based on the current condition score

Vulnerability = the high/low designation indicates whether the marsh unit is in the top half or lower half of all marshes in NH based on the vulnerability score

Adaptation = the high/low designation indicates whether the marsh unit is in the top half or lower half of all marshes in NH based on the adaptation potential score

A marsh’s combination of high and low designations for each element of resilience corresponds to a management category and recommended management strategies for that marsh as outlined here:

[Management Options Table](#).

Citations

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For More Information

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Learn more

www.greatbay.org/salt-marsh-plan

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