Using Salt Marsh Rapid Assessment to Help Guide Restoration and Conservation Prioritization

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Salt Marsh Restoration, Assessment, and Monitoring Program (RAMP)

Vision

Coastal wetlands perpetually retain the critical functions and ecosystem services they have provided historically.

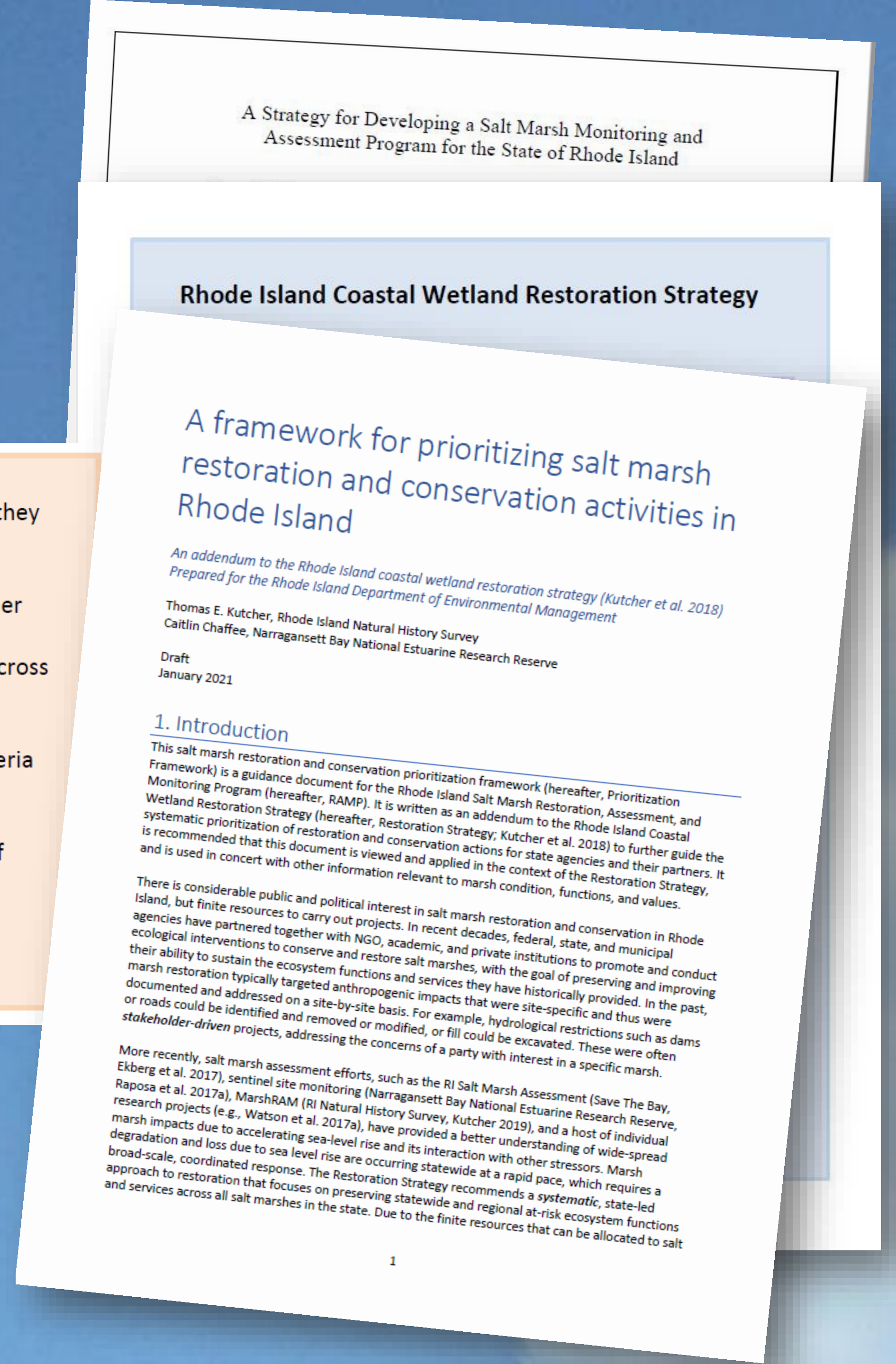
Goals

1. Wetland area loss is minimized through restoration, conservation, and other interventions;
2. Management minimizes loss of critical functions and ecosystem services across broad systems.

Objectives

1. Develop restoration and intervention prioritization tools based on the criteria outlined in this Strategy;
2. Prioritize coastal wetlands for restoration and migration potential;
3. Systematically maintain or restore the ecosystem functions and services of coastal wetlands based on priorities outlined in this Strategy;
4. Systematically evaluate restoration outcomes;
5. Identify, evaluate, adapt, and implement the most effective and efficient management practices.

- Systematic statewide prioritization
- Stakeholder-driven prioritization



A Strategy for Developing a Salt Marsh Monitoring and Assessment Program for the State of Rhode Island

Rhode Island Coastal Wetland Restoration Strategy

A framework for prioritizing salt marsh restoration and conservation activities in Rhode Island

An addendum to the Rhode Island coastal wetland restoration strategy (Kutcher et al. 2018)
Prepared for the Rhode Island Department of Environmental Management

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Draft
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1. Introduction

This salt marsh restoration and conservation prioritization framework (hereafter, Prioritization Framework) is a guidance document for the Rhode Island Salt Marsh Restoration, Assessment, and Monitoring Program (hereafter, RAMP). It is written as an addendum to the Rhode Island Coastal Wetland Restoration Strategy (hereafter, Restoration Strategy; Kutcher et al. 2018) to further guide the systematic prioritization of restoration and conservation actions for state agencies and their partners. It is recommended that this document is viewed and applied in the context of the Restoration Strategy, and is used in concert with other information relevant to marsh condition, functions, and values.

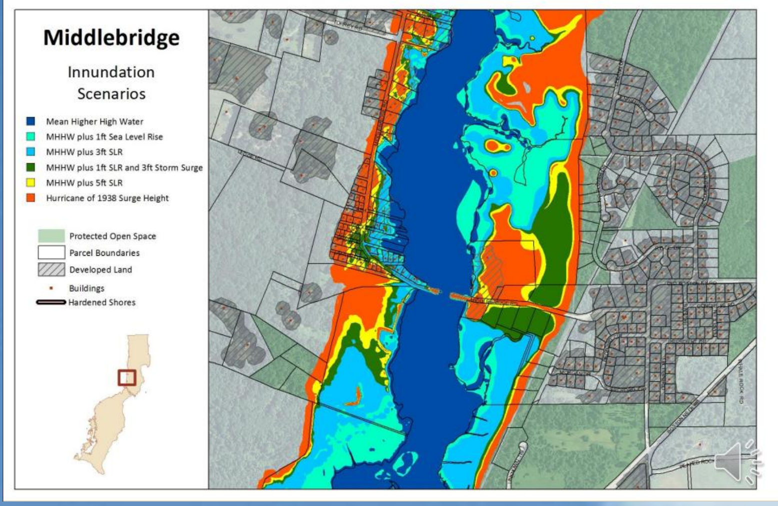
There is considerable public and political interest in salt marsh restoration and conservation in Rhode Island, but finite resources to carry out projects. In recent decades, federal, state, and municipal agencies have partnered together with NGO, academic, and private institutions to promote and conduct ecological interventions to conserve and restore salt marshes, with the goal of preserving and improving their ability to sustain the ecosystem functions and services they have historically provided. In the past, marsh restoration typically targeted anthropogenic impacts that were site-specific and thus were documented and addressed on a site-by-site basis. For example, hydrological restrictions such as dams or roads could be identified and removed or modified, or fill could be excavated. These were often ***stakeholder-driven*** projects, addressing the concerns of a party with interest in a specific marsh.

More recently, salt marsh assessment efforts, such as the RI Salt Marsh Assessment (Save The Bay, Ekberg et al. 2017), sentinel site monitoring (Narragansett Bay National Estuarine Research Reserve, Raposa et al. 2017a), MarshRAM (RI Natural History Survey, Kutcher 2019), and a host of individual research projects (e.g., Watson et al. 2017a), have provided a better understanding of wide-spread marsh impacts due to accelerating sea-level rise and its interaction with other stressors. Marsh degradation and loss due to sea level rise are occurring statewide at a rapid pace, which requires a broad-scale, coordinated response. The Restoration Strategy recommends a ***systematic***, state-led approach to restoration that focuses on preserving statewide and regional at-risk ecosystem functions and services across all salt marshes in the state. Due to the finite resources that can be allocated to salt

1

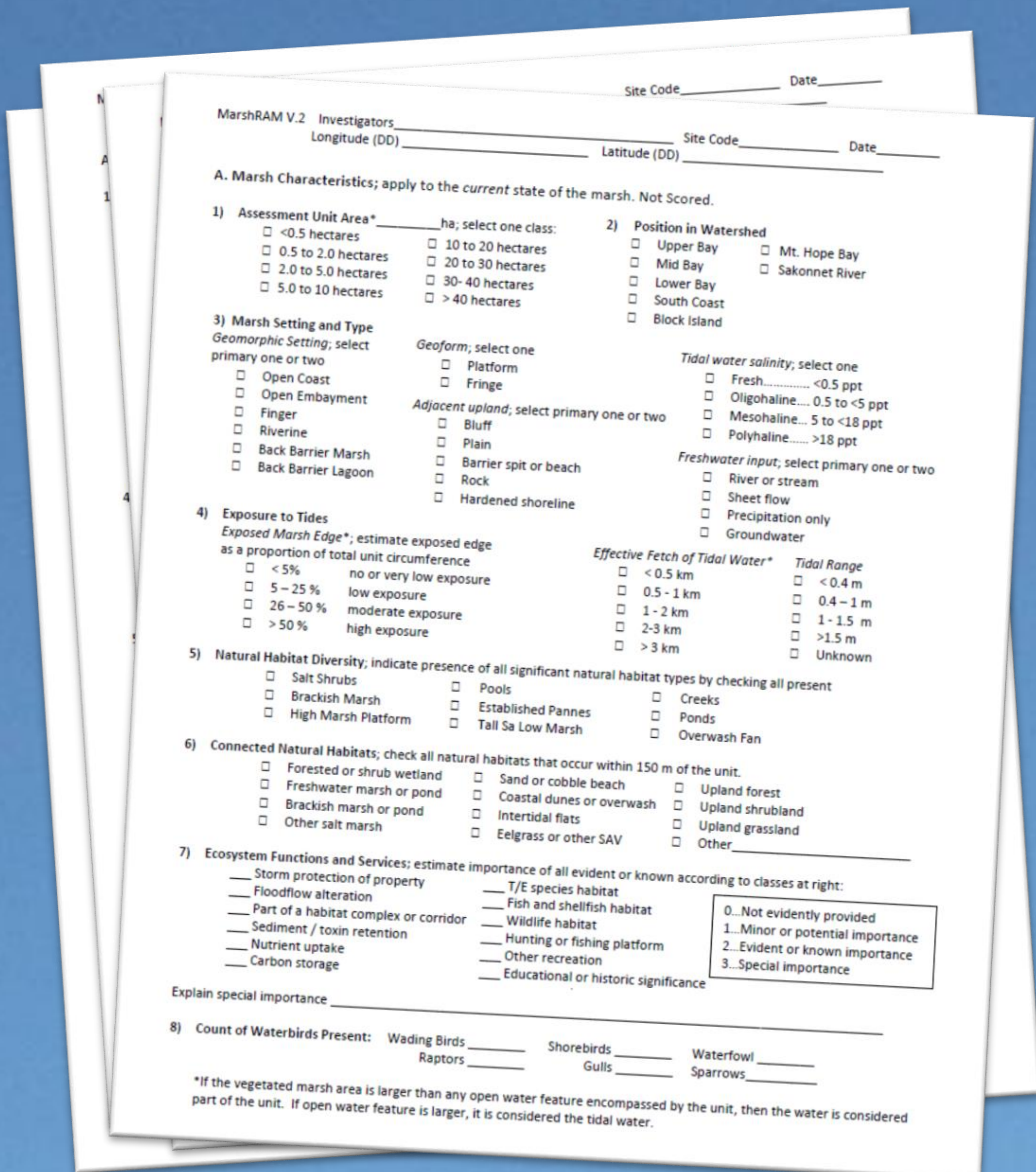
Three levels of wetland assessment

- Tier 1: Landscape-level assessment
  - Mapping, modeling, change per time
  - Limited, not always reliable at site level
- Tier 2: Rapid assessment
  - Data from observation, estimation, and rapid measurements, multiple parameters
  - Reliable at the site level across multiple marshes
- Tier 3: Intensive assessment
  - Intensive measurements of biological and physical parameters at few sites
  - Reliable at the site level, inferred across other marshes



Kevin Ruddock

1. Salt Marsh Rapid Assessment Method 'MarshRAM' (Kutcher et al. 2022)



MarshRAM V.2 Investigators________________ Site Code__________ Date________

Longitude (DD)______________ Latitude (DD)______________

A. Marsh Characteristics; apply to the *current* state of the marsh. Not Scored.

1) **Assessment Unit Area***______ha; select one class:
- ☐ <0.5 hectares
- ☐ 0.5 to 2.0 hectares
- ☐ 2.0 to 5.0 hectares
- ☐ 5.0 to 10 hectares
- ☐ 10 to 20 hectares
- ☐ 20 to 30 hectares
- ☐ 30- 40 hectares
- ☐ > 40 hectares

2) **Position in Watershed**
- ☐ Upper Bay
- ☐ Mid Bay
- ☐ Lower Bay
- ☐ South Coast
- ☐ Block Island
- ☐ Mt. Hope Bay
- ☐ Sakonnet River

3) **Marsh Setting and Type**

Geomorphic Setting; select primary one or two
- ☐ Open Coast
- ☐ Open Embayment
- ☐ Finger
- ☐ Riverine
- ☐ Back Barrier Marsh
- ☐ Back Barrier Lagoon

Geoform; select one
- ☐ Platform
- ☐ Fringe

Adjacent upland; select primary one or two
- ☐ Bluff
- ☐ Plain
- ☐ Barrier spit or beach
- ☐ Rock
- ☐ Hardened shoreline

Tidal water salinity; select one
- ☐ Fresh............ <0.5 ppt
- ☐ Oligohaline.... 0.5 to <5 ppt
- ☐ Mesohaline... 5 to <18 ppt
- ☐ Polyhaline...... >18 ppt

Freshwater input; select primary one or two
- ☐ River or stream
- ☐ Sheet flow
- ☐ Precipitation only
- ☐ Groundwater

4) **Exposure to Tides**

*Exposed Marsh Edge**; estimate exposed edge as a proportion of total unit circumference
- ☐ < 5% no or very low exposure
- ☐ 5 – 25 % low exposure
- ☐ 26 – 50 % moderate exposure
- ☐ > 50 % high exposure

*Effective Fetch of Tidal Water**
- ☐ < 0.5 km
- ☐ 0.5 - 1 km
- ☐ 1 - 2 km
- ☐ 2-3 km
- ☐ > 3 km

Tidal Range
- ☐ < 0.4 m
- ☐ 0.4 – 1 m
- ☐ 1 - 1.5 m
- ☐ >1.5 m
- ☐ Unknown

5) **Natural Habitat Diversity**; indicate presence of all significant natural habitat types by checking all present
- ☐ Salt Shrubs
- ☐ Brackish Marsh
- ☐ High Marsh Platform
- ☐ Pools
- ☐ Established Pannes
- ☐ Tall Sa Low Marsh
- ☐ Creeks
- ☐ Ponds
- ☐ Overwash Fan

6) **Connected Natural Habitats**; check all natural habitats that occur within 150 m of the unit.
- ☐ Forested or shrub wetland
- ☐ Freshwater marsh or pond
- ☐ Brackish marsh or pond
- ☐ Other salt marsh
- ☐ Sand or cobble beach
- ☐ Coastal dunes or overwash
- ☐ Intertidal flats
- ☐ Eelgrass or other SAV
- ☐ Upland forest
- ☐ Upland shrubland
- ☐ Upland grassland
- ☐ Other______________

7) **Ecosystem Functions and Services**; estimate importance of all evident or known according to classes at right:
- ___ Storm protection of property
- ___ Floodflow alteration
- ___ Part of a habitat complex or corridor
- ___ Sediment / toxin retention
- ___ Nutrient uptake
- ___ Carbon storage
- ___ T/E species habitat
- ___ Fish and shellfish habitat
- ___ Wildlife habitat
- ___ Hunting or fishing platform
- ___ Other recreation
- ___ Educational or historic significance

0...Not evidently provided
1...Minor or potential importance
2...Evident or known importance
3...Special importance

Explain special importance ______________________________

8) **Count of Waterbirds Present:** Wading Birds______ Shorebirds______ Waterfowl______ Raptors______ Gulls______ Sparrows______

*If the vegetated marsh area is larger than any open water feature encompassed by the unit, then the water is considered part of the unit. If open water feature is larger, it is considered the tidal water.

Builds on NERAM, RISMA

- •Characteristics and classification
- •Ecosystem functions and services
- •Water bird tallies
- •Surrounding landscape condition
- •In-wetland disturbances
- •Rapid marsh migration metrics
- •Indicator of marsh integrity (IMI)

B. Ecosystem Functions and Services; estimate importance of all evident or known according to ranks provided:

___ Storm protection of property
___ Floodflow alteration
___ Part of a habitat complex or corridor
___ Sediment / toxin retention
___ Nutrient uptake
___ Carbon storage

___ T/E species habitat
___ Fish and shellfish habitat
___ Wildlife habitat
___ Hunting or fishing platform
___ Other recreation
___ Educational or historic significance

0...Not evidently provided
1...Minor or potential importance
2...Evident or known importance
3...Special importance

Sum of ranks = ☐ Explain special importance ____

Appendix 4. Definitions and decision processes for ranking *Ecosystem Functions and Services* in MarshRAM

Rank definitions

The MarshRAM *Ecosystem Functions and Services* section uses a four-rank system. The ranking system focuses on the three lower ranks (0, 1, and 2), with *special importance* (3) being reserved for truly unique or critically-important examples of the function or service. An experienced salt marsh scientist (the investigator) uses all available information and best professional judgement to assign one rank to each function and service for each marsh. These **general scoring ranks** for all categories are defined as follows:

Not evidently provided (0): There is no evidence or knowledge of the salt marsh providing the function or service.

Minor or potential importance (1): There is evidence or knowledge of the marsh having a minor or potential contribution to providing the function or service.

Evident or known importance (2): There is clear evidence or knowledge of the marsh providing or largely contributing to the function or service.

Special importance (3): Used sparingly; the evident or known function or service provided by the marsh is uniquely, unusually, or critically important to people or wildlife.

Decision processes and breakpoints

Each of the following **ecosystem functions and services** were ranked according to the above definitions using a combination of geospatial analysis, field investigation, and investigator knowledge for each salt marsh. The sum of the ranks was used as a metric of aggregate "value" for categorizing salt marshes statewide as above average (AA; upper quartile), average (A; interquartile), or below average (B; lower quartile). The category was applied to the prioritization matrix in the Prioritization Framework (Table 2). Unique decision processes and breakpoints used to determine the rank of each function and service are provided below. Examples are provided when extra context seems useful.

1. <u>Storm protection of developed property</u>

Premise: The salt marsh platform and vegetation elevation and roughness provide resistance to the laminar flow of water, interrupting the momentum of tidal surges and causing wave energy to dissipate before reaching adjacent developed properties.

Evidence: The salt marsh lies between tidal waters and low-lying developed property (less than 3m above the marsh surface) vulnerable to damage by tidal flooding or wave action from tides, storm events or boat wakes. The marsh provides the service if it would prevent or mitigate such damage.

Not evidently provided (0): Common; there is no vulnerable developed property landward of the marsh.

Minor or potential importance (1): There is some evidence or knowledge that the marsh geomorphology or vegetation could lessen the impacts of flooding or wave action on some vulnerable developed property, but it is not clear that the marsh would be effective.

- Examples: The marsh lies between tidal water and low-lying developed property, but:
  - The marsh is narrow (<5m) and unlikely to offer much protection
  - The developed property is somewhat elevated and it's unclear that the property is in danger

Evident or known importance (2): There is clear evidence or knowledge that the marsh is providing protection to vulnerable developed properties.

Special importance (3): Unlikely; protection of developed property from tides or waves clearly provided by the marsh is critically important to many people.

- Example: The marsh clearly protects a municipal water source from exposure or damage from tides or waves.

2. <u>Floodflow alteration</u>:

Premise: Salt marshes can provide or contribute to water-storage capacity that mitigates downstream flooding from upstream floodwaters. Because gross flood storage along any stretch of river is typically cumulative, each marsh's contribution may be important.

Evidence: The marsh lies upstream from low-lying developed land that is vulnerable to flooding from upstream waters.

Not evidently provided (0): Common; the marsh does not sit upstream of developed property vulnerable to upstream flooding.

Minor or potential importance (1): Unusual; it is unclear that the marsh provides storage of upstream flooding on vulnerable downstream developed property, or the storage it provides is negligible compared to the volume of flood water.

Example: It is unclear whether the downstream developed property is vulnerable to flooding.

Evident or known importance (2): The marsh is situated to provide flood storage upstream of vulnerable developed property.

➢ Decision Point: Most marshes situated anywhere upstream of vulnerable developed property should be assigned this rank (2), as all marsh area contributes to cumulative flood storage.

Special importance (3): Unlikely; protection of developed property from upstream flooding clearly provided by the marsh is critically important to many people.

- Example: The marsh clearly and largely contributes to the protection of important public infrastructure from upstream flooding.

3. <u>Part of a habitat complex or corridor</u>

Premise: Salt marshes may contribute to larger tracts of wildland, including wildlife corridors, which are important to support biodiversity.

Evidence: Investigation of aerial imagery or site visit reveals that the salt marsh is contiguous with other substantial wildlands that together provide a larger continuous wildlife area.

Not evidently provided (0): The marsh is not contiguous with any other wildlands (uplands/wetlands).

Minor or potential importance (1): The marsh is adjacent to a parcel of wildland that is not substantial or important in the landscape context.

MarshRAM V.2 Investigators__________ __________ Site Code_____________ Date_________

4) **Anthropogenic nutrient inputs.**

Select the evidence of sources an

- ☐ No evidence (10)
- ☐ Sources observed only (7)
- ☐ Sources observed and some i
- ☐ Sources and multiple or stro

Evidence: check all that apply

- ☐ Known high-nutrient tidal or fresh waters
- ☐ Runoff sources evident
- ☐ Point sources evident
- ☐ Sewage smell
- ☐ Pervasive sulfide smell
- ☐ Excessive algae in surface waters
- ☐ Unusually tall Sa (≥ 1.5 m)
- ☐ Dense and tall Phragmites (≥ 3m) abuttin
- ☐ Obvious plumes or suspended solids

5) **Filling and dumping within wetlan**

Fill includes typical constructio

- ☐ No fill observed (10)
- ☐ Scattered trash in the mar
- ☐ Fill covers <10% of the uni
- ☐ Fill covers 10-60% of the u
- ☐ Fill covers >60% of the uni
- ☐ Fill has hardened edge (su

Evidence: check all that apply

- ☐ Unnaturally abrupt change in
- ☐ Abrupt change in soil texture
- ☐ Unnaturally straight or abrup
- ☐ Unnatural items on or within

6) **Edge erosion.** Select the appropri

Intensity of edge erosion

- ☐ Minimal erosion observ
- ☐ Low (7): <10% of the se
- ☐ Moderate (4): 10-60% o
- ☐ High (1): >60% of the s

7) **Crab burrow intensity.** Select t

- ☐ None (10): Burrows are
- ☐ Low (7): <10% of the m
- ☐ Moderate (4): 10-60%
- ☐ High (1): >60% of the m

Evidence: check all obse

- ☐ Dense crab burrows
- ☐ Eroding or oversized
- ☐ Abundant fiddler crabs
- ☐ Purple marsh crabs
- ☐ Clipped vegetation
- ☐ Denuded areas of peat

D. Wetland Disturbances. Average metrics D.1 to D.10

1) Buffer Encroachment.

Estimate % cultural cover on adjacent land within 30-m buffer.

- ☐ <5% (10)
- ☐ 6 to 25% (8)
- ☐ 26-50% (6)
- ☐ 51-75% (3)
- ☐ >75% (1)

Primary Associated Stressor; check one or two:

- ☐ Road
- ☐ Railway
- ☐ Fill
- ☐ Raised Trail
- ☐ Power Lines
- ☐ Cleared/mowed Land
- ☐ Buildings
- ☐ Paved Lot
- ☐ Dirt Lot
- ☐ Dam/dike
- ☐ Other_______________

Primary Source of Stress; indicate as current (C) or historic (H):

- __ Private / Residential
- __ Commercial
- __ Agricultural
- __ Public transportation
- __ Public utilities
- __ Public recreation
- __ Undetermined

2) Impoundment and Tidal Restriction.

Change in depth or hydroperiod. Select one. If less than half of the marsh is impounded or restricted, average score with 10.

- ☐ None observed (10)
- ☐ Restriction observed but no change in vegetation or elevation evident (7)
- ☐ Restriction observed with change in vegetation evident (4)
- ☐ Restriction observed with subsidence, ponding, or die-off evident (1)

☐ Less than half the marsh is affected, average with 10 = _____

Evidence: check all that apply

- ☐ Physical barrier across seaward edge of wetland
- ☐ Dam or restricting culvert downstream of wetland
- ☐ Ponding or subsidence evident
- ☐ Widening of wetland upstream of barrier
- ☐ Change in vegetation across barrier
- ☐ Dead or dying vegetation

Primary Associated Stressor; check one:

- ☐ Road
- ☐ Railway
- ☐ Weir / Dam
- ☐ Raised Trail
- ☐ Development Fill
- ☐ Other __________

Primary Source of Stress; indicate as current (C) or historic (H):

- __ Private / Residential
- __ Commercial
- __ Agricultural
- __ Public transportation
- __ Public utilities
- __ Public recreation
- __ Undetermined

3) Ditching and draining density.

Estimate the density of ditching and draining. For difficult determinations, use key.

Select one

- ☐ None observed (10)
- ☐ Low (7)
- ☐ Moderate (4)
- ☐ High (1)

Key: density classes of ditches

Low:	< 100 m/Ha
Moderate:	100-300 m/Ha
High:	> 300 m/Ha

Investigator______________________________ Site ________________________ Date______________

F. Migration Potential

Estimate the proportion, to the nearest tenth, of surrounding land within 60m falling into each class, and multiply. Total sum of proportions must = 1.0 and sum of weighted values must = 0.0 to 10.0.

Landward* Surface Waters

No Potential:

____Ocean
____Estuary
____ Lake/pond
____Other

Sum = ____ **x 0 =** __0__

*separated from marsh by upland

Elevated Land >1.5m above MHW

No Potential:

____Bedrock
____Hardened shoreline
____Developed land
____Landfill
____Other________________

Sum = ____ **x 0 =** __0__

Low Potential:

____Elevated erodible Land

Sum = ____ **x 2 =** ____

Low-lying Land <1.5m above MHW

No Potential:

_____Ocean Beach / Dune
_____Estuarine Beach

Sum = ____ **x 0 =** __0__

Low Potential:

____Paved street or lot
____ Residential development (structures present)
____ Industrial / commercial development (structures present)
____Other________________

Sum Low = ____ **x 2 =** ____

Moderate Potential:

____ Active farmland
____Golf course
____Sand and gravel operation
____Undeveloped land behind a raised shoreline feature
____Freshwater deep wetland
____Other________________

Sum Moderate = ____ **x 5 =** ____

Moderately High Potential:

____Forested or shrub wetland
____Phragmites marsh
____Forested or shrub upland
____Mowed land, no structures
____Pasture
____Other________________

Sum Mod High = ____ **x 8 =** ____

High Potential:

____Emergent FW wetland
____Upland field / meadow
____Abandoned farmland
____Other________________

Sum High = ____ **x 10 =** ____

Sum weighted values for **Migration Potential score:** [ ]

a. Area of Marsh = ________
b. Area of surrounding land to 60m = _______
c. Proportion of Moderately High +High class = _______

d. Migration Area = (b x c) = [ ]

e. Replacement Ratio = (d ÷ a) = [ ]

MIGRATION POTENTIAL

Marsh-specific

Elevation/physical resistance

Biological opportunity and resistance

Cultural resistance

Metrics of migration potential

MarshRAM: Index of Marsh Integrity (IMI)

MarshRAM V.2 Investigators________________ Site Code__________ Date________

D. Marsh Community Composition and Index of Marsh Integrity. Walking straight and evenly along each of 8 transects, tally every step traversing the listed community types.

Zone	T1		T2	
Salt Shrub				
Brackish Marsh Native				
Phragmites				
Meadow High Marsh				
Mixed High Marsh				

	CCI	Total Tally	CCI X TT	% Cover*
Salt Shrub	9			
Brackish Marsh Native	10			
Phragmites	3			
Meadow High Marsh	10			
Mixed High Marsh	7			
Sa High Marsh	5			
Dieoff Bare Depression	1			
Low Marsh	8			
Dieback Denuded Peat	0			
Natural Panne	8			
Natural Pool	6			
Natural Creek	8			
Ditch	2			
Bare Sediments	4			
	Sums:			

D. Index of Marsh Integrity

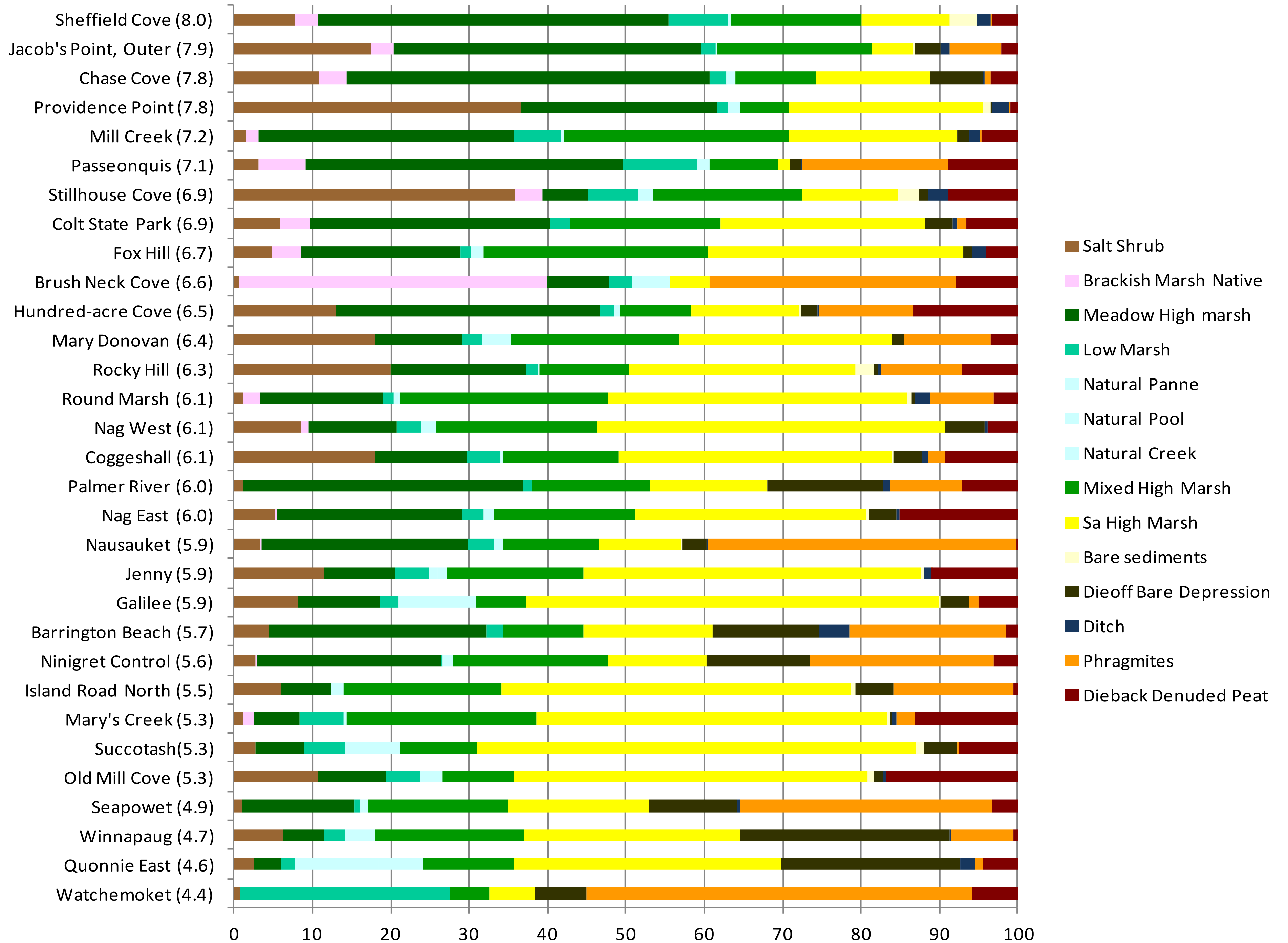
$$= \frac{\text{Sum (CCI X TT)}}{\text{Sum (Total Tally)}}$$

= ☐

Marsh Community Composition:

*For each cover type, % Cover = $\frac{\text{Total Tally}}{\text{Sum (Total Tally)}}$



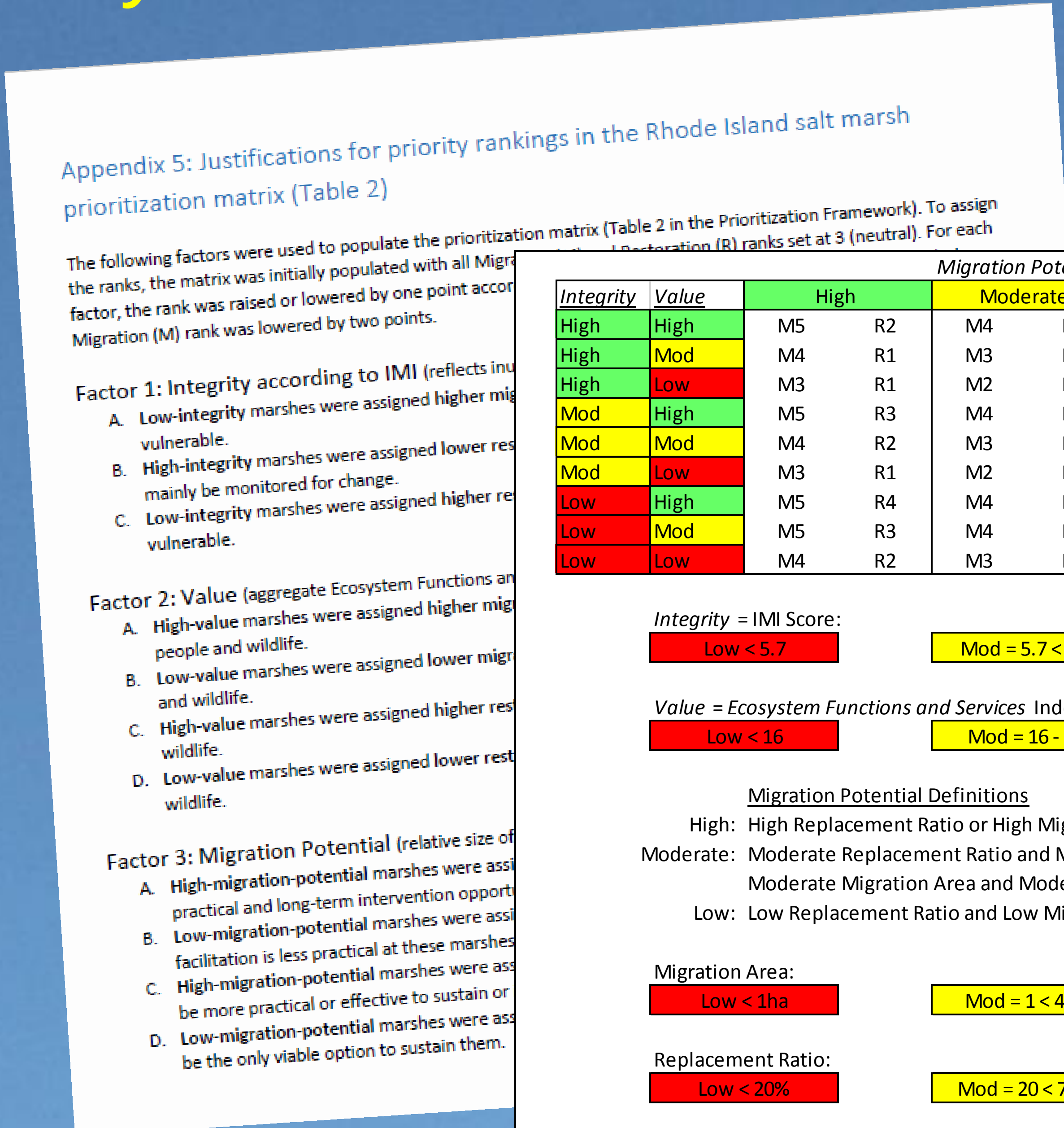



Sheffield Cove (8.0)
Jacob's Point, Outer (7.9)
Chase Cove (7.8)
Providence Point (7.8)
Mill Creek (7.2)
Passeonquis (7.1)
Stillhouse Cove (6.9)
Colt State Park (6.9)
Fox Hill (6.7)
Brush Neck Cove (6.6)
Hundred-acre Cove (6.5)
Mary Donovan (6.4)
Rocky Hill (6.3)
Round Marsh (6.1)
Nag West (6.1)
Coggeshall (6.1)
Palmer River (6.0)
Nag East (6.0)
Nausauket (5.9)
Jenny (5.9)
Galilee (5.9)
Barrington Beach (5.7)
Ninigret Control (5.6)
Island Road North (5.5)
Mary's Creek (5.3)
Succotash(5.3)
Old Mill Cove (5.3)
Seapowet (4.9)
Winnapaug (4.7)
Quonnie East (4.6)
Watchemoket (4.4)
0
10
20
30
40
50
60
70
80
90
100
Salt Shrub
Brackish Marsh Native
Meadow High marsh
Low Marsh
Natural Panne
Natural Pool
Natural Creek
Mixed High Marsh
Sa High Marsh
Bare sediments
Dieoff Bare Depression
Ditch
Phragmites
Dieback Denuded Peat

MarshRAM Supports Prioritization for Restoration, Conservation, Management

SITE CODE	IMI Bin	Disturbance	Elevation	Functions and Services	Migration Potential	Migration Area (ha)	Replacement Ratio	Buffer	Impoundment	Ditching	Nutrients	Fill	Erosion	Crabs	Die-off	Mowing	Phragmites
Sheffield Cove	LD	Low	ND	A	High	1.5	92%	X		XX		XX	XXX				X
Jacob's Point, Outer	LD	High	High	A	Low	0.5	6%	XX		XX	XX	XX	XX	XX	X		XX
Chase Cove	LD	Mod	High	A	High	4.1	80%		X	XX	X	X	XXX	XX	X		X
Providence Point	LD	Low	Med	B	High	2.5	53%			XX			X	X	X		X
Mill Creek	LD	Low	Med	B	Mod	1.4	29%			XX	X		XXX	XX			X
Passeonquis	LD	Mod	High	A	Low	2.3	75%	X		X	XXX		XXX	XX		X	XX
Stillhouse Cove	LD	High	Med	B	Low	0.0	0%	XXX		XX	XX	XX	XXX	X	XX	X	X
Colt State Park	LD	High	High	A	Mod	8.2	39%	X		XXX	XX	X	XXX	XXX	X	X	X
Fox Hill	ID	Low	Low	A	Mod	3.9	25%	X		X		X	XX	X	X		X
Brush Neck Cove	ID	Low	Low	A	Mod	3.2	114%				XXX		XX		X		XX
Hundred-acre Cove	ID	Mod	Med	AA	Mod	1.3	20%			X	XXX		XXX	XXX	X	X	X
Mary Donovan	ID	Mod	Low	A	Mod	5.4	15%	X		X	XXX	X	XX	XXX	X	X	X
Rocky Hill	ID	Mod	Med	AA	High	5.0	29%	XX	XX	X	XX	X	X	X	X	X	X
Round Marsh	ID	Mod	Med	A	High	11.7	37%	X	X	XX	XX	X	XX	X	X		X
Nag West	ID	Mod	Med	AA	Mod	2.9	22%			XX		X	XXX	XXX	X	X	X
Coggeshall	ID	Mod	Med	A	Mod	7.7	38%			XX	X		XXX	XXX	X		X
Palmer River	ID	Mod	Med	AA	High	5.2	27%			XX	XX		XXX	XXX	XX		X
Nag East	ID	Mod	Med	AA	Mod	3.9	18%	X		XX	X	X	XXX	XXX	X	X	X
Nausauket	ID	Low	ND	B	Low	1.0	13%	X		XX	XX			X	X		XX
Jenny	ID	Mod	Med	A	Mod	3.8	30%	X		XXX		X	XXX	XXX		X	X
Galilee	ID	Mod	Med	B	Low	1.4	13%	XX		X		XXX	XXX		X	X	X
Barrington Beach	ID	Mod	High	AA	Mod	1.1	18%	X	X	XX	XXX	XX		X	XX		XX
Ninigret Control	ID	Low	Low	A	Mod	0.0	0%				XX		XXX		XX		XX
Island Road North	MD	Mod	Med	B	Low	0.4	29%	XXX			XXX	XX	XX		X		XX
Mary's Creek	MD	High	Med	B	Low	0.0	0%	XXX		XX	XX	XXX	XXX	XXX	XX	X	X
Succotash	MD	High	Low	A	Mod	6.5	16%	XX	X	X	XX	XX	XX	XXX	X		X
Old Mill Cove	MD	High	Low	B	Mod	2.0	73%	X		X	XXX	XX	XXX	XXX	XX		X
Seapowet	MD	High	Med	AA	Mod	12.6	14%	XX	X	XX	XX		XXX	XXX	XX	X	XX
Winnapaug	MD	Low	Low	A	Mod	0.0	0%	X		X	XX	X	XX		XX		X
Quonnie East	MD	High	Low	AA	High	5.3	19%			XXX	XX	XX	XXX	XX	XX		X
Watchemoket	MD	High	Low	B	Low	0.8	136%	XX	X		XXX	XX	XX	XX			XXX

Systematic Prioritization


Appendix 5: Justifications for priority rankings in the Rhode Island salt marsh prioritization matrix (Table 2)

The following factors were used to populate the prioritization matrix (Table 2 in the Prioritization Framework). To assign the ranks, the matrix was initially populated with all Migra... ...Restoration (R) ranks set at 3 (neutral). For each factor, the rank was raised or lowered by one point accor... Migration (M) rank was lowered by two points.

Factor 1: Integrity according to IMI (reflects inu...

A. Low-integrity marshes were assigned higher mig... vulnerable.

B. High-integrity marshes were assigned lower res... mainly be monitored for change.

C. Low-integrity marshes were assigned higher re... vulnerable.

Factor 2: Value (aggregate Ecosystem Functions an...

A. High-value marshes were assigned higher mig... people and wildlife.

B. Low-value marshes were assigned lower migr... and wildlife.

C. High-value marshes were assigned higher rest... wildlife.

D. Low-value marshes were assigned lower rest... wildlife.

Factor 3: Migration Potential (relative size of...

A. High-migration-potential marshes were assi... practical and long-term intervention opport...

B. Low-migration-potential marshes were assi... facilitation is less practical at these marshes...

C. High-migration-potential marshes were ass... be more practical or effective to sustain or...

D. Low-migration-potential marshes were ass... be the only viable option to sustain them.

Migration Potential

Integrity	*Value*	High		Moderate		Low	
High	High	M5	R2	M4	R3	M2	R4
High	Mod	M4	R1	M3	R2	M1	R3
High	Low	M3	R1	M2	R1	M1	R2
Mod	High	M5	R3	M4	R4	M2	R5
Mod	Mod	M4	R2	M3	R3	M1	R4
Mod	Low	M3	R1	M2	R2	M1	R3
Low	High	M5	R4	M4	R5	M2	R5
Low	Mod	M5	R3	M4	R4	M2	R5
Low	Low	M4	R2	M3	R3	M1	R4

M=Migration Priority
R=Restoration Priority
5=Highest Priority
4=Higher Priority
3=Mod Priority
2=Lower Priority
1=Lowest Priority

Integrity = IMI Score:

Low	Mod	High
Low < 5.7	Mod = 5.7 < 7.0	High ≥ 7.0

Value = Ecosystem Functions and Services Index:

Low	Mod	High
Low < 16	Mod = 16 - 19	High ≥ 20

Migration Potential Definitions

High: High Replacement Ratio or High Migration Area

Moderate: Moderate Replacement Ratio and Moderate or Low Migration Area, or Moderate Migration Area and Moderate or Low Replacement Ratio

Low: Low Replacement Ratio and Low Migration Area

Migration Area:

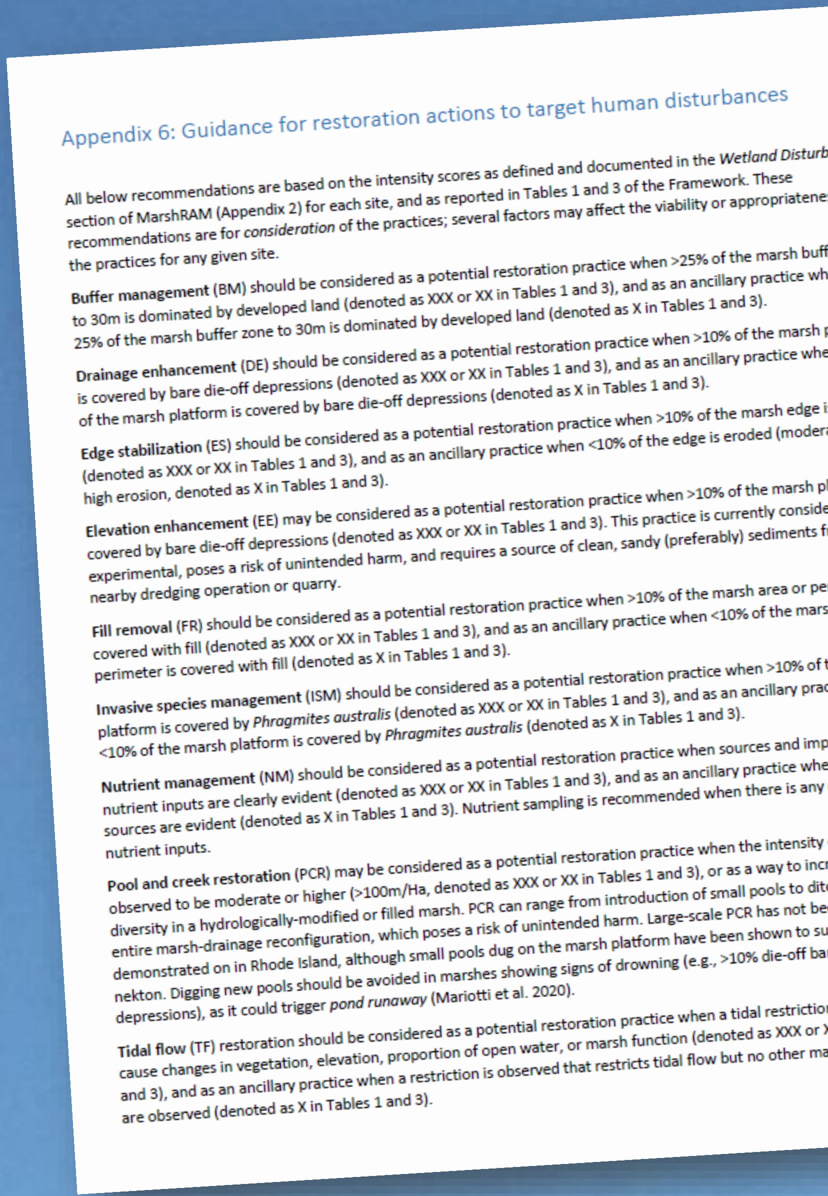
Low	Mod	High
Low < 1ha	Mod = 1 < 4ha	High ≥ 4ha

Replacement Ratio:

Low	Mod	High
Low < 20%	Mod = 20 < 70%	High ≥ 70%

Prioritization List

Imperfect but useful



Appendix 6: Guidance for restoration actions to target human disturbances

All below recommendations are based on the intensity scores as defined and documented in the *Wetland Disturb*
section of MarshRAM (Appendix 2) for each site, and as reported in Tables 1 and 3 of the Framework. These
recommendations are for *consideration* of the practices; several factors may affect the viability or appropriatenes
the practices for any given site.

Buffer management (BM) should be considered as a potential restoration practice when >25% of the marsh buff
to 30m is dominated by developed land (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice wh
25% of the marsh buffer zone to 30m is dominated by developed land (denoted as X in Tables 1 and 3).

Drainage enhancement (DE) should be considered as a potential restoration practice when >10% of the marsh p
is covered by bare die-off depressions (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice whe
of the marsh platform is covered by bare die-off depressions (denoted as X in Tables 1 and 3).

Edge stabilization (ES) should be considered as a potential restoration practice when >10% of the marsh edge is
(denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when <10% of the edge is eroded (modera
high erosion, denoted as X in Tables 1 and 3).

Elevation enhancement (EE) may be considered as a potential restoration practice when >10% of the marsh pl
covered by bare die-off depressions (denoted as XXX or XX in Tables 1 and 3). This practice is currently conside
experimental, poses a risk of unintended harm, and requires a source of clean, sandy (preferably) sediments fr
nearby dredging operation or quarry.

Fill removal (FR) should be considered as a potential restoration practice when >10% of the marsh area or per
covered with fill (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when <10% of the marsl
perimeter is covered with fill (denoted as X in Tables 1 and 3).

Invasive species management (ISM) should be considered as a potential restoration practice when >10% of t
platform is covered by *Phragmites australis* (denoted as XXX or XX in Tables 1 and 3), and as an ancillary prac
<10% of the marsh platform is covered by *Phragmites australis* (denoted as X in Tables 1 and 3).

Nutrient management (NM) should be considered as a potential restoration practice when sources and impa
nutrient inputs are clearly evident (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice whe
sources are evident (denoted as X in Tables 1 and 3). Nutrient sampling is recommended when there is any
nutrient inputs.

Pool and creek restoration (PCR) may be considered as a potential restoration practice when the intensity
observed to be moderate or higher (>100m/Ha, denoted as XXX or XX in Tables 1 and 3), or as a way to incr
diversity in a hydrologically-modified or filled marsh. PCR can range from introduction of small pools to ditc
entire marsh-drainage reconfiguration, which poses a risk of unintended harm. Large-scale PCR has not bee
demonstrated on in Rhode Island, although small pools dug on the marsh platform have been shown to su
nekton. Digging new pools should be avoided in marshes showing signs of drowning (e.g., >10% die-off bar
depressions), as it could trigger *pond runaway* (Mariotti et al. 2020).

Tidal flow (TF) restoration should be considered as a potential restoration practice when a tidal restriction
cause changes in vegetation, elevation, proportion of open water, or marsh function (denoted as XXX or X
and 3), and as an ancillary practice when a restriction is observed that restricts tidal flow but no other ma
are observed (denoted as X in Tables 1 and 3).

Site	Migration	Other Restoration	IMI Bin	Functions and Services	Migration Area (ha)	Replacement Ratio	Buffer	Impoundment	Ditching	Nutrients	Fill	Erosion	Crabs	Die-off	Mowing	Phragmites
Starr Drive	5	4	MD	AA	5.4	60%		XX	XX	XX	X	XX	X	XX	X	XX
Quonnie East	5	4	MD	AA	5.3	19%			XXX	XX	XX	XXX	XX	XX		X
Seapowet	5	4	MD	AA	12.6	14%	XX	X	XX	XX		XXX	XXX	XX	X	XX
Middlebridge North	5	3	ID	AA	3.8	74%		X	XX	X		X	X	XX		X
Andys Way	5	3	ID	AA	4.4	35%			X	X			X	X		X
Palmer River	5	3	ID	AA	5.2	27%			XX	XX		XXX	XXX	XX		X
Succotash East	5	3	MD	A	6.5	16%	XX	X	X	XX	XX	XX	XXX	X		X
ASRI Narrows NW	5	2	LD	AA	1.7	73%	X		X	XX	X	XXX		X	X	X
Succotash West	4	5	MD	AA	3.0	33%	XX		X	X	X			XX		X
Wilson Park	4	4	ID	AA	2.6	55%	X	X	XX	XX	X	XXX	XX	X		X
Belchers North	4	4	MD	A	4.0	35%			XX	XX		XX	XXX	XX		XX
Rocky Hill	4	4	ID	AA	5.0	29%	XX	XX	X	XX	X	X	X	X	X	X
Nag West	4	4	ID	AA	2.9	22%			XX		X	XXX	XXX	X	X	X
Hundred-acre Cove NE	4	4	ID	AA	1.3	20%			X	XXX		XXX	XXX	X	X	X
Stedman	4	4	ID	AA	3.3	20%			XX	X	X			XX		X
Barrington Beach	4	4	ID	AA	1.1	18%	X	X	XX	XXX	XX		X	XX		XX
Nag East	4	4	ID	AA	3.9	18%	X		XX	X	X	XXX	XXX	X	X	X
Watchemoket	4	2	MD	B	0.8	136%	XX	X		XXX	XX	XX	XX			XXX
Bissel Upper	4	2	MD	B	2.4	128%	X	XX	XX	XXX	X	X	X	X		XX
Brush Neck Cove	4	2	ID	A	3.2	114%				XXX		XX		X		XX
Old Mill Cove	4	2	MD	B	2.0	73%	X		X	XXX	XX	XXX	XXX	XX		X
Ninigret East	4	2	ID	A	4.4	63%			X	XX		XX		X		XX
Coggeshall	4	2	ID	A	7.7	38%			XX	X		XXX	XXX	X		X
Round Marsh	4	2	ID	A	11.7	37%	X	X	XX	XX	X	XX	X	X		X
Mary Donovan	4	2	ID	A	5.4	15%	X		X	XXX	X	XX	XXX	X	X	X
Colt State Park	4	2	ID	A	8.2	39%	X		XXX	XX	X	XXX	XXX	X	X	X
Dyer Island	4	1	LD	A	2.5	111%								XX		
Hog Island	4	1	LD	A	3.1	93%			XX	XX				X	X	X
Sheffield Cove	4	1	LD	A	1.5	92%	X		XX		XX	XXX				X
Chase Cove	4	1	LD	A	4.1	80%		X	XX	X	X	XXX	XX	X		X
Quicksand Pond	4	1	LD	A	3.6	78%				XX						XX
Passeonquis	4	1	LD	A	2.3	75%	X		X	XXX		XXX	XX		X	XX
Pork Barrel	2	5	MD	A	0.8	18%	X		XX	XX	X	XXX	X	XX	X	X
Winnapaug	2	5	MD	A	0.0	0%	X		X	XX	X	XX		XX		X
HAC Islands	2	5	MD	A	0.0	0%				X		XXX	XXX	XX		X
Ninigret Control	2	5	MD	A	0.0	0%				XX		XXX		XX		XX
Mary's Creek	1	4	MD	B	0.0	0%	XXX		XX	XX	XXX	XXX	XXX	XX	X	X
Avondale	3	3	ID	A	3.1	67%	XX	X	XX	XXX	XX	X		X		XX
Jenny	3	3	ID	A	3.8	30%	X		XXX		X	XXX	XXX		X	X
Island Road North	3	3	MD	B	0.4	29%	XXX			XXX	XX	XX		X		XX
Foddering Farm	3	3	ID	A	0.5	28%		X		X		XX	XXX	XX		XX
Fox Hill	3	3	ID	A	3.9	25%	X		X		X	XX	X	X		X
Greens River	3	3	ID	A	0.4	18%			XX	XX	X	XXX	XXX	X	X	XX
Rumstick Point	3	3	ID	A	1.4	11%	X		XXX	XX	X	XXX	XXX	X	X	X
Kickemuit School	3	2	LD	A	2.6	63%			XX	XX	X	XXX	XXX	X		XX
Common Fence Point S.	3	2	LD	A	2.2	37%	XX		XX	XX	X	XX	XX	X	X	X
Gulf Road	3	2	LD	A	0.5	37%			X	XXX	X	XX				X
Charlestown Beach	3	1	ID	B	1.9	136%	X			XX				X		XX
Providence Point	3	1	LD	B	2.5	53%			XX			X	X	X		X
Galilee Outer	2	2	ID	B	1.4	13%	XX		X		XXX	XXX		X	X	X
Sakonnet Point	2	1	LD	B	1.7	60%	XX	X	XX	XX	XX			X	X	XX
Fogland Beach	2	1	LD	B	1.3	32%	XX			XX	X		X	X		X
Mill Creek	2	1	LD	B	1.4	29%			XX	X		XXX	XX			X
Nausauket	1	3	ID	B	1.0	13%	X		XX	XX			X	X		XX
Jacob's Point Outer	1	3	LD	A	0.5	6%	XX		XX	XX	XX	XX	XX	X		XX

5 = Highest Priority 4 = Higher Priority 3 = Moderate Priority 2 = Lower Priority 1 = Lowest Priority

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For an overview and analysis of MarshRAM:

Kutcher, T.E., Raposa, K.B. and Roman, C.T., 2022. A rapid method to assess salt marsh condition and guide management decisions. *Ecological Indicators*, *138*, p.108841.

Pearson correlation coefficients (*r*) and probability values comparing MarshRAM IMI values with loss and elevation estimates from prior studies, and with latitude—Bonferroni adjusted α=0.013; [1]loss per year of vegetated marsh area from 1981 to 2008 estimated using aerial photo-interpretation, derived from Berry et al. (2015); [2]median marsh surface elevation in relation to NADV88, from Watson et al. (2017b); [3]Wetland Disturbance + Median Elevation represents the additive effect of the two prior metrics analyzed against IMI using stepwise regression (*r* reported rather than r^2 for comparison); values from Stillhouse Cove were removed prior to the analyses for this table because a major marsh-platform restoration was recently conducted at the site, which was expected to have affected IMI values in relation to the other metrics.

Reference Indicators		IMI	
	n	*r*	*P*
Historic Loss[1]	10	-0.78	0.008
Latitude	30	0.37	0.044
Median Elevation[2]	28	0.53	0.004
MarshRAM Wetland Disturbance	30	0.44	0.016
Wetland Disturbance + Median Elevation[3]	28	0.75	0.004

Using MarshRAM to Assess Restoration Outcomes

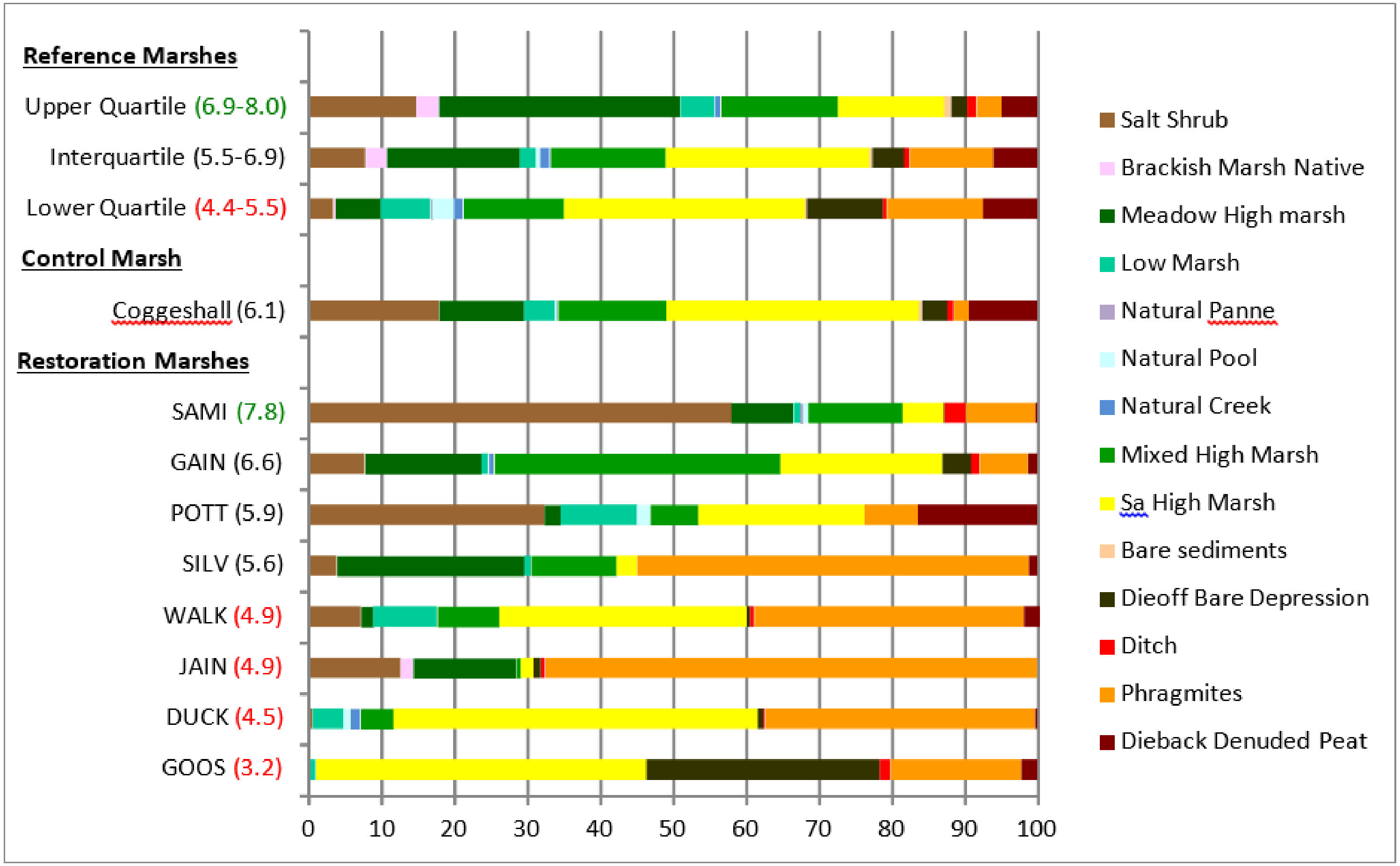

Figure 3. IMI scores (parenthetic) and relative proportions of IMI salt marsh cover types from 30 representative unrestricted salt marshes (Reference marshes), the marsh used as a Control marsh for vegetation and nekton analyses, and 8 Restoration salt marshes in Rhode Island. The IMI scores for Reference marshes are aggregated into quartiles, where the upper quartile (green scores) represents least-degraded salt marshes and the lower quartile (red scores) represents most-degraded salt marshes. The Restoration marshes are listed in descending order of IMI score.