

Efficacy of Runnels to Restore Tidal Exchange and Recovery Vegetation in New England Salt Marshes



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SMARTeams
Saltmarsh Sparrow Initiative



**University of
New Hampshire**

Coastal Habitat
Restoration Team

Photos provided by Bonnie Turek



Salt Marsh Adaptation and Resilience (SMART) Team

Geoff Wilson, Northeast Wetland Restoration

Sue Adamowicz, US Fish & Wildlife Service

David Burdick, Univ. of New Hampshire

Nicole Maher, The Nature Conservancy

Wenley Ferguson, Save the Bay

Roger Wolfe, CT Mosquito Control

Lorie Staver, University of Maryland

Joe Smith, US Fish and Wildlife Service

Grant McKown, Univ. of New Hampshire



This work could not have been possible without!

David Burdick, Univ. of New Hampshire

Gregg Moore, Univ. of New Hampshire

Jenny Gibson, Univ. of New Hampshire

Sue Adamowicz, US Fish & Wildlife Service

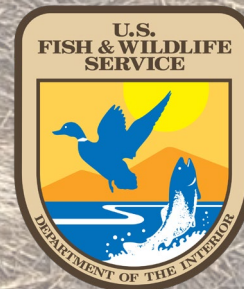
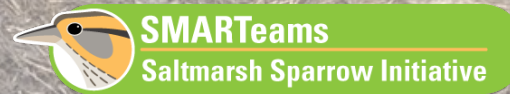
Wenley Ferguson, Save the Bay

Nancy Pau, US Fish and Wildlife Service

John Herbert, Mass Audubon

Russ Hopping, The Trustees

Burdick Lab



Photos provided by Bonnie Turek

Five Goals

1) Where do runnels fit into the broader frame of marsh hydrology and restoration?

2) Impact to tidal exchange and groundwater table

3) Vegetation recovery expectations

4) Difference in revegetation rates between pools and pannes

5) Adaptive management and post-restoration monitoring

Five Goals

1) Where do runnels fit into the broader frame of marsh hydrology and restoration?

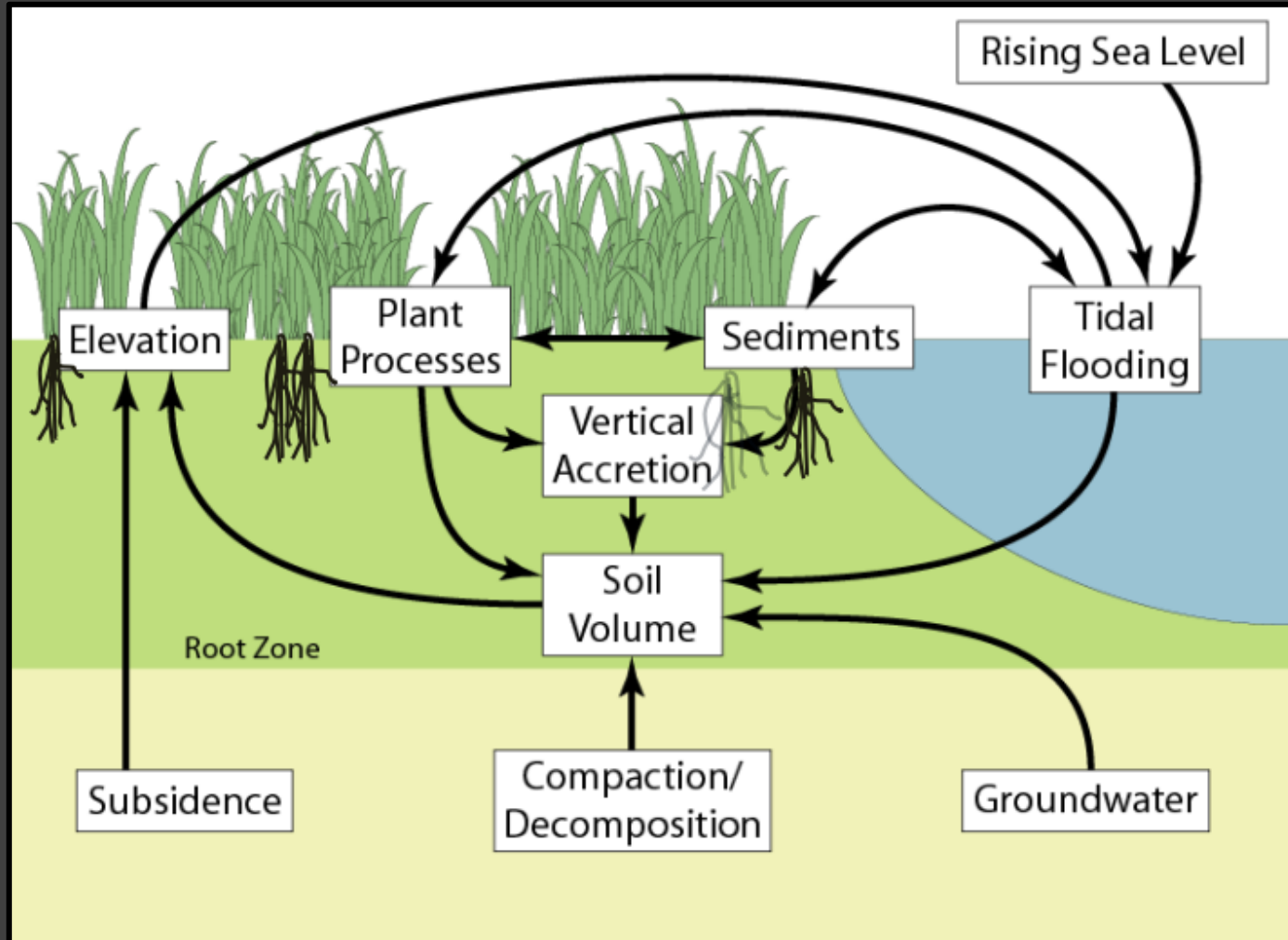
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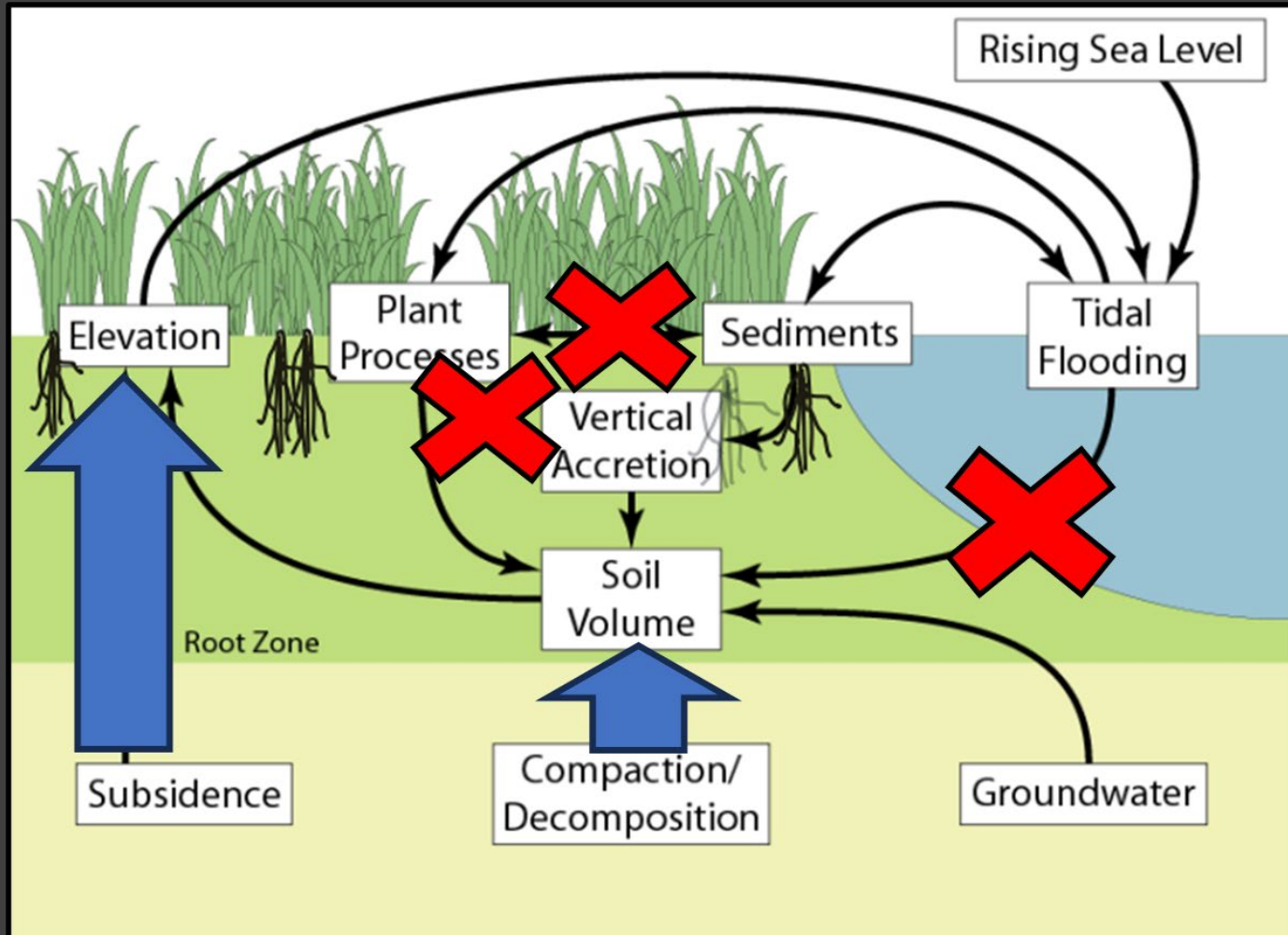
Taking A Step Back For One Second



Long-term marsh resilience is combination of numerous factors driven by:

- (1) Hydrology
- (2) Vegetation
- (3) Sediment supply
- (4) Marsh platform elevation

Taking A Step Back For One Second



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Restoration is focused on long-term recovery processes that sustain elevation capital:

- (1) Storage of belowground biomass
- (2) Sediment accretion

Waterlogging Subsidence Trajectory

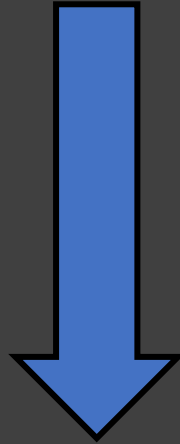


- Increased waterlogging stress
- Conversion of high marsh graminoids to short-form *Spartina alterniflora*

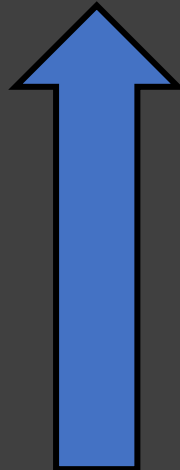
- Loss of live vegetation cover
- Patches of temporary open water
- Decomposition of belowground biomass stimulated

- Subsidence of marsh platform
- Permanent open water pools and floating green algae
- Pool expansion continues unabated

Re-establishment of Tidal Flow is the Goal!

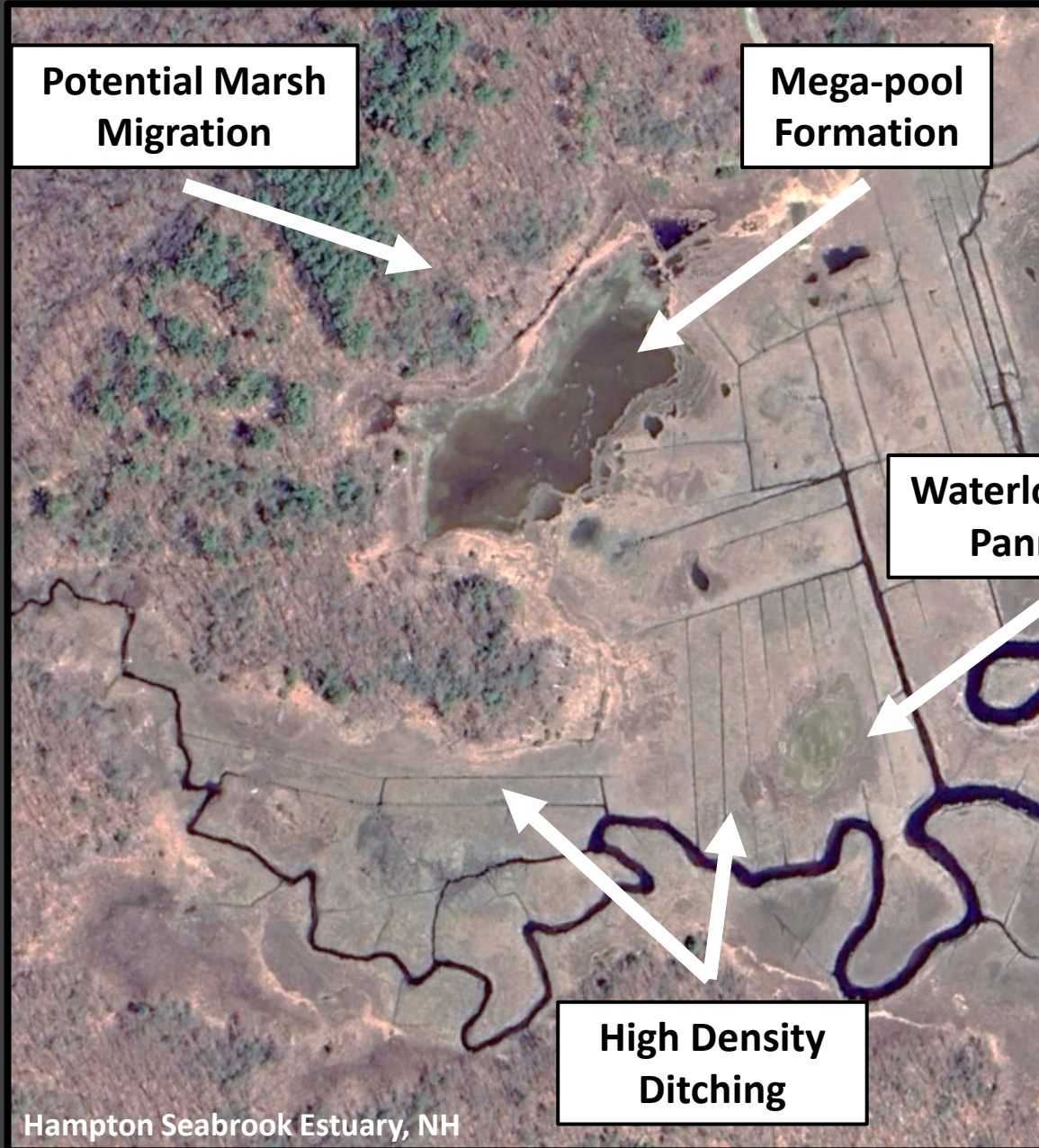


Standing Water
Root Zone Waterlogging
Anoxic Soil Conditions
High Sulfide and Salinity
Concentrations



Revegetation
Belowground Biomass
Soil Aeration
Regular Tidal Flushing
Removal of Freshwater Runoff

Restoration Requires a Broad, Holistic Approach



Numerous, complex hydrologic issues on marsh platforms

Runnels are just one tool in a larger toolbox

- Ditch Remediation
- Thin Layer Placement
- Marsh Migration Facilitation

Approach restoration with a “Whole Marsh” perspective

Overarching goals of hydrology restoration should be to re-create *Single-Channel Hydrology*

Broader Framework Takeaways

- 1) Hydrology influences long-term functions that enhance marsh resiliency and allow for sustained elevation gains
- 2) Runnels should be viewed as a tool to *restore tidal exchange* not just *drain pools*
- 3) Runnels are appropriate for any stage of waterlogging stress – short-form *S. alterniflora*, unvegetated pannes, and mega-pools
- 4) Runnels are just one tool in a toolbox to address deficient marsh platform hydrology

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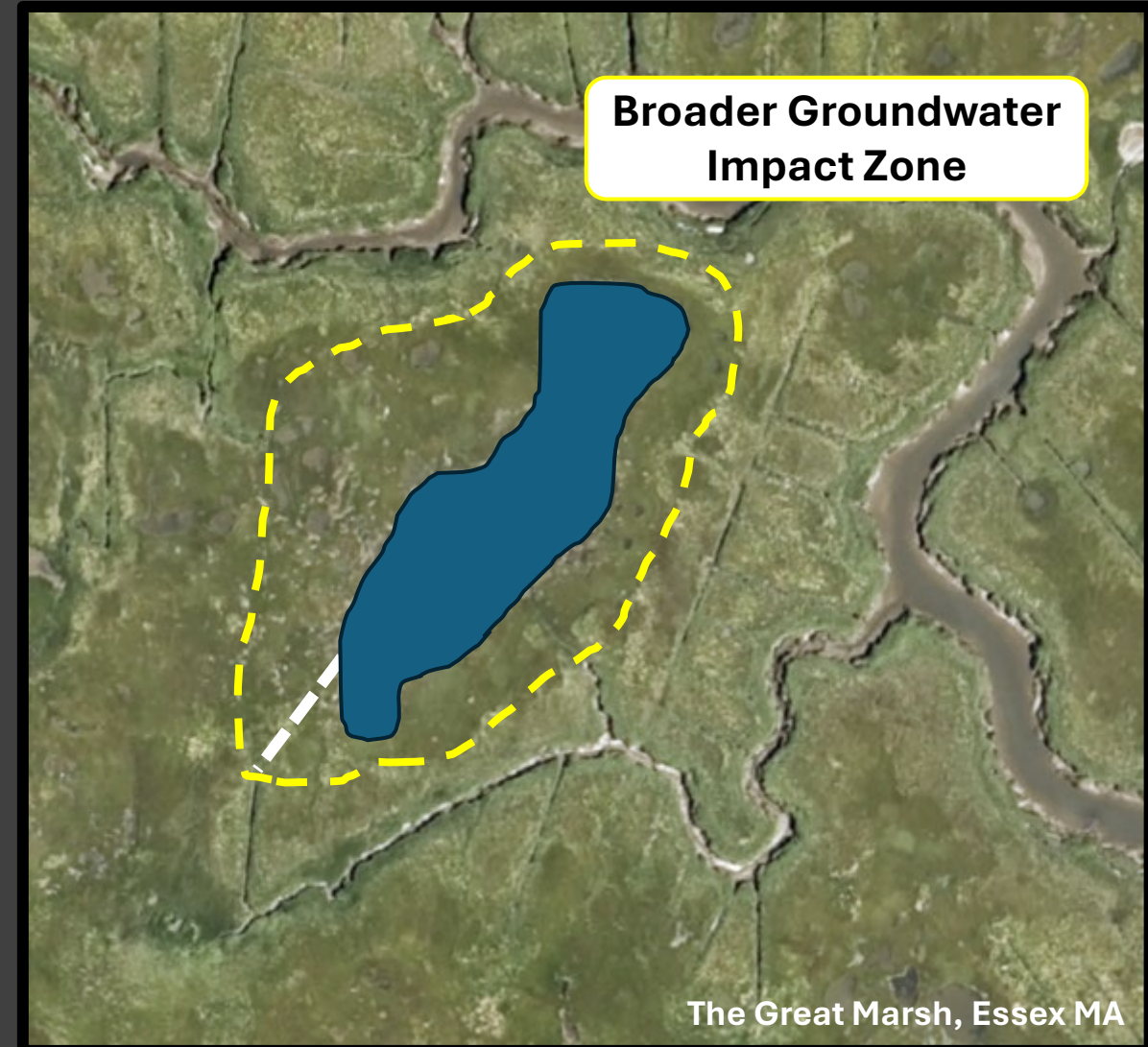
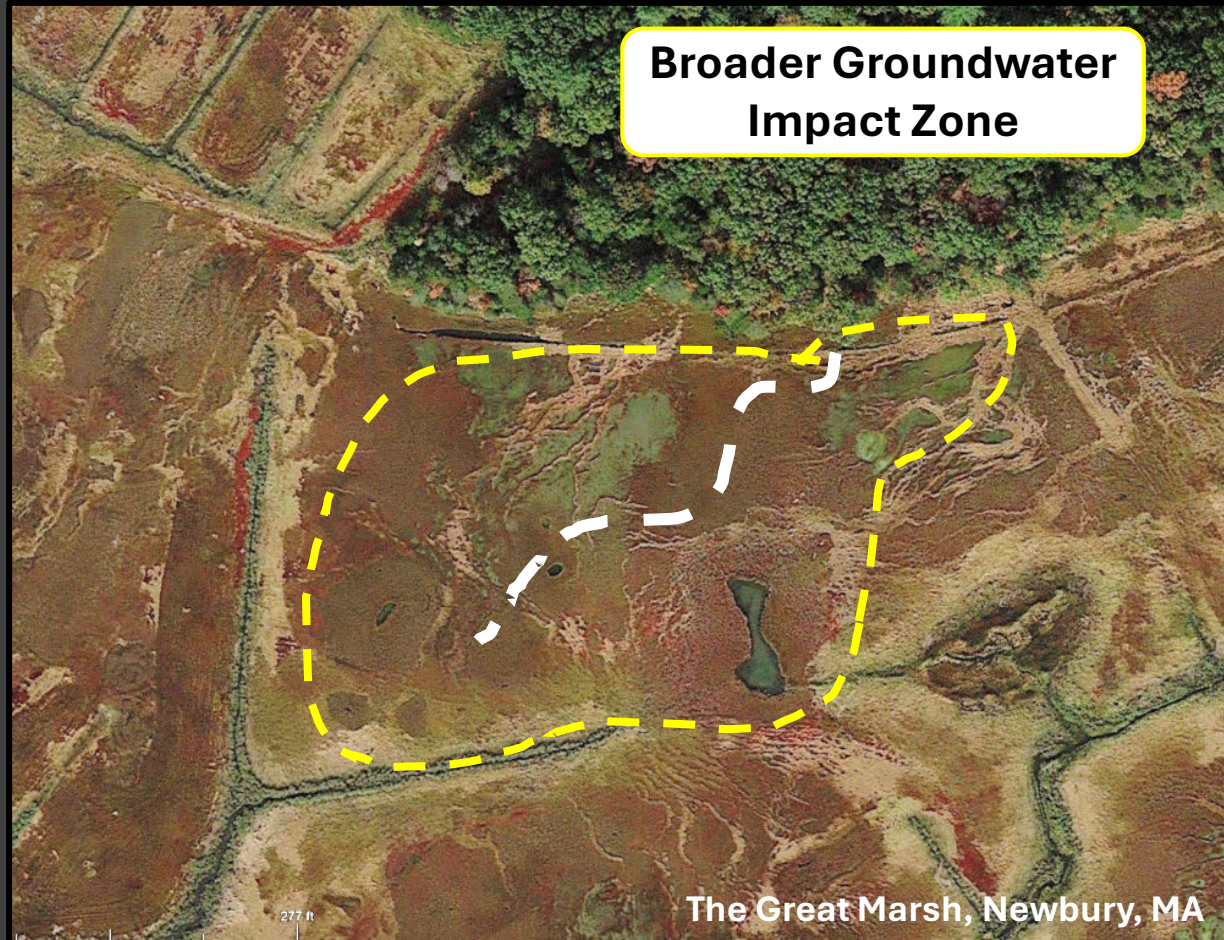
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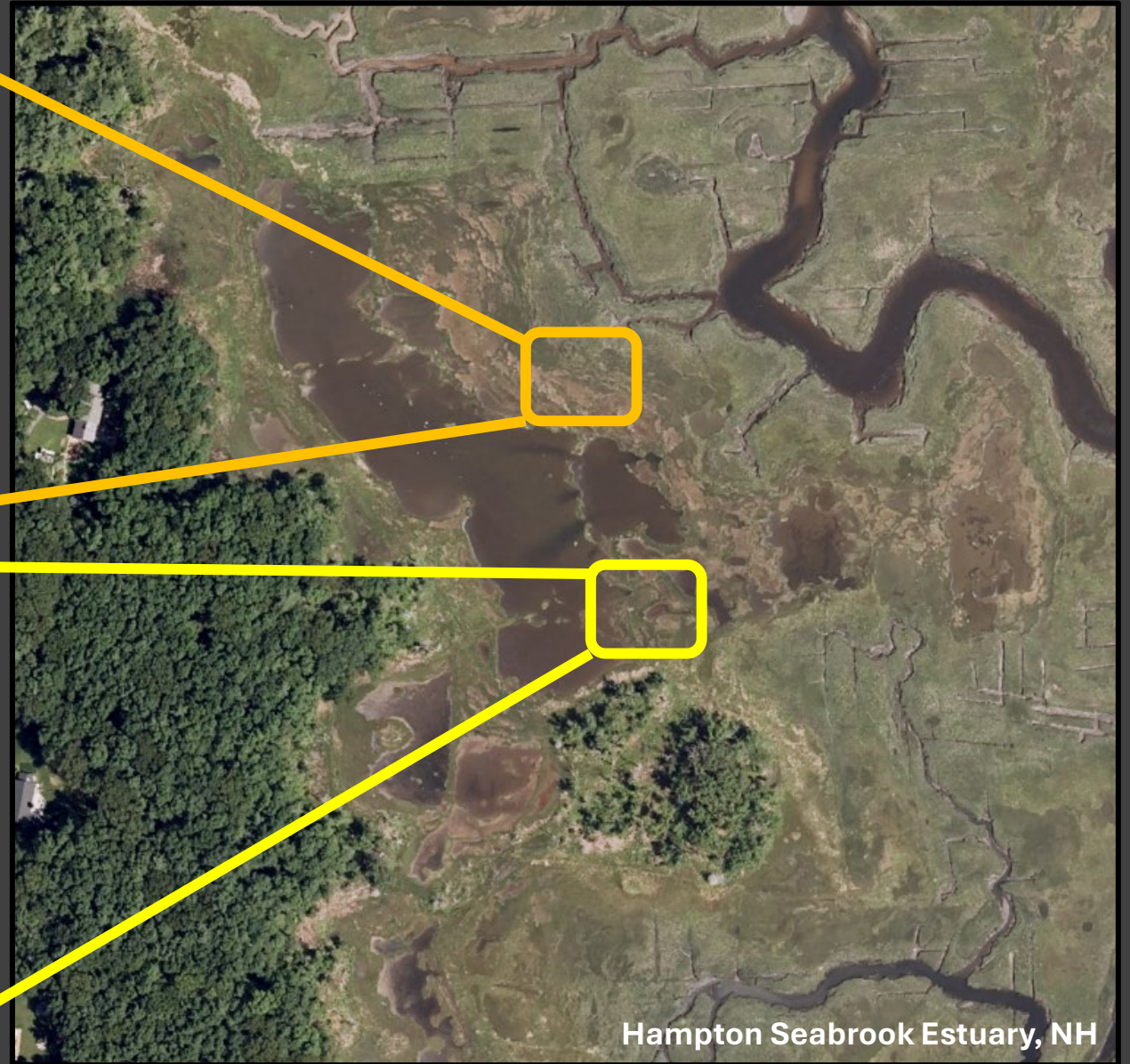
4) Difference in revegetation rates between pools and pannes

5) Adaptive management and post-restoration monitoring

Impacts to Groundwater Hydrology



Immediate Changes to Groundwater Table Depth



Hampton Seabrook Estuary, NH

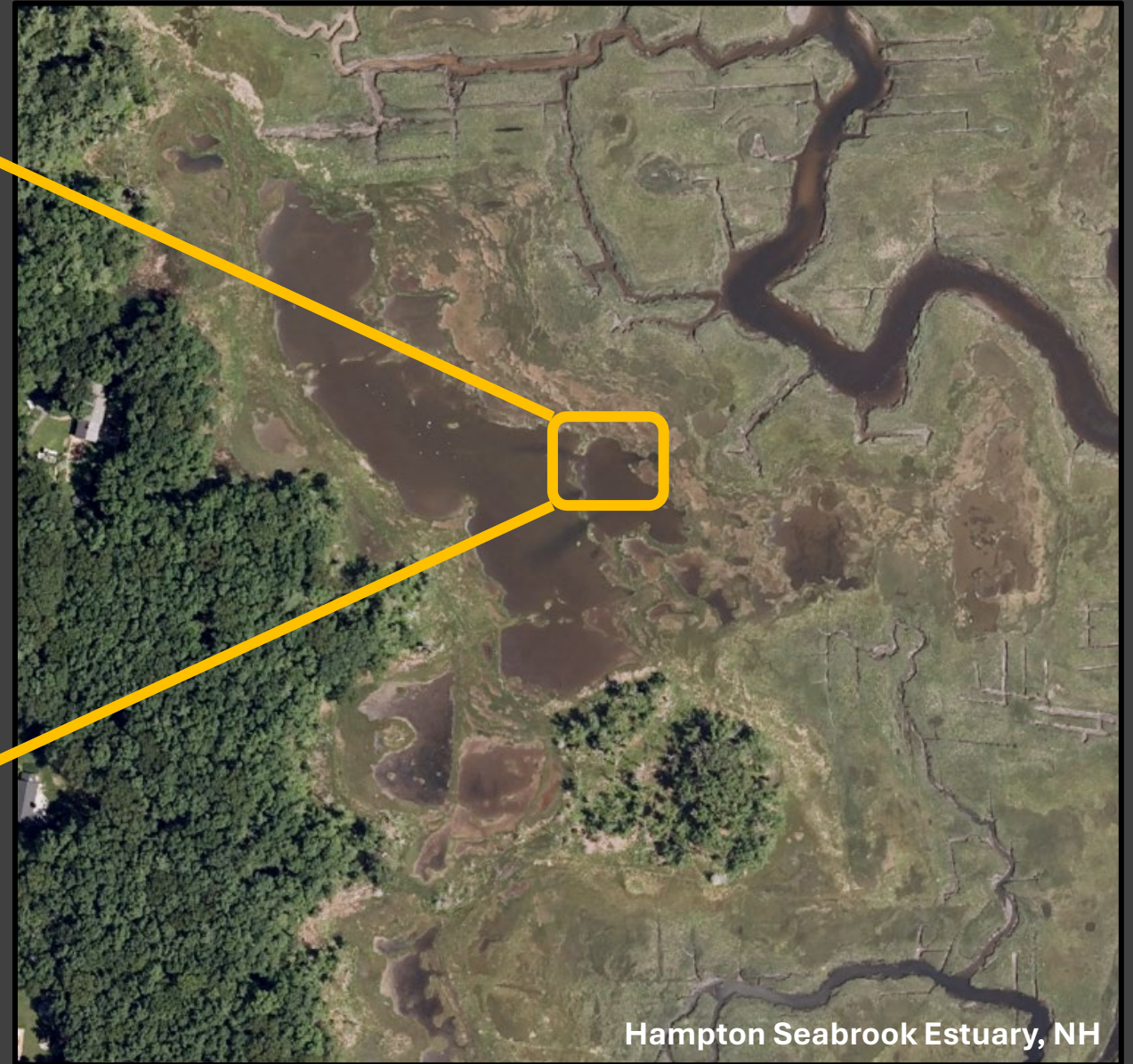


Immediate Changes to Groundwater Table Depth

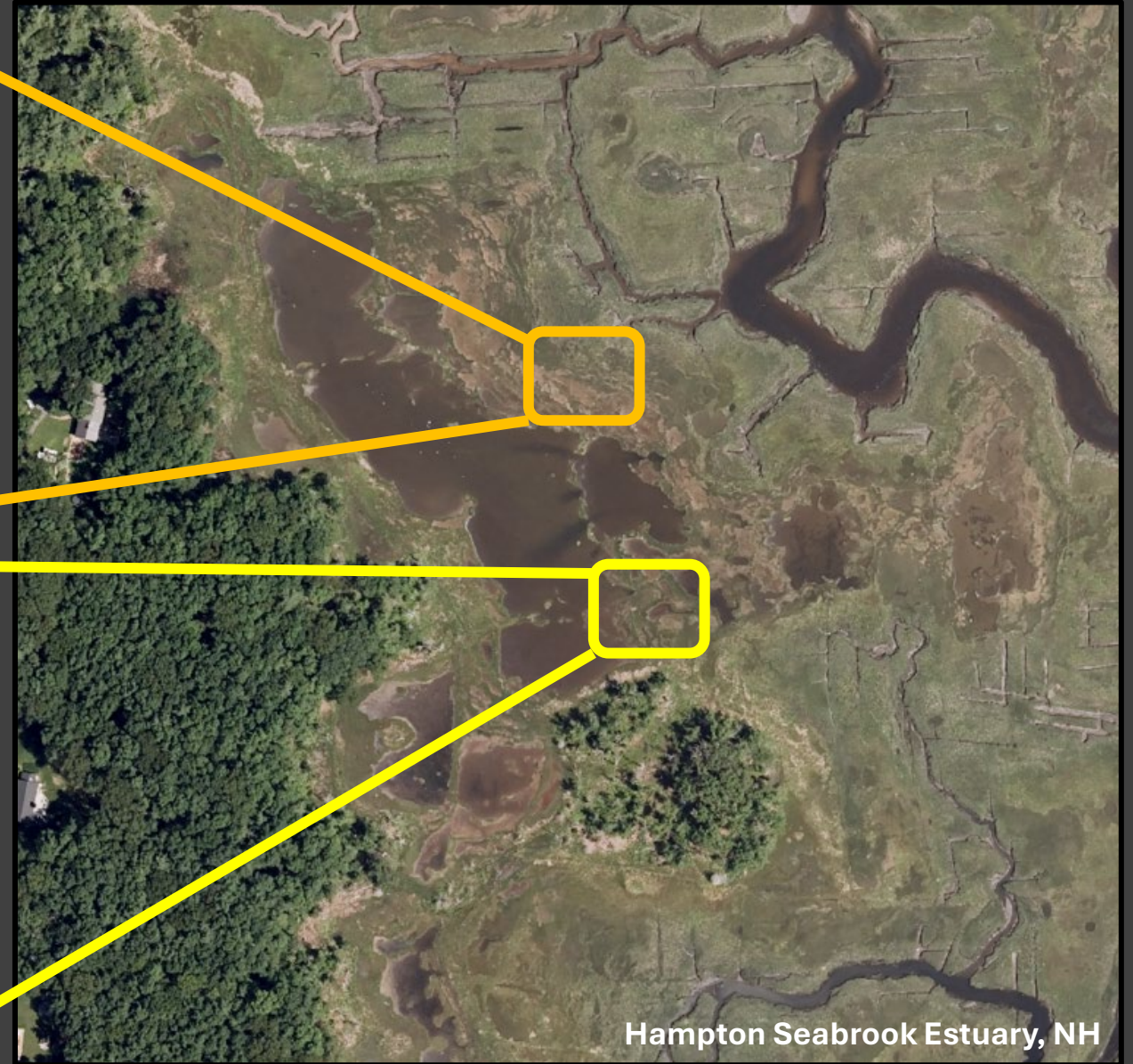


Hampton Seabrook Estuary, NH

Immediate Changes to Groundwater Table Depth



Immediate Changes to Groundwater Table Depth



Hampton Seabrook Estuary, NH

Study Area

3 States

23 Sites

2 seasons
per site

2021 - 2024

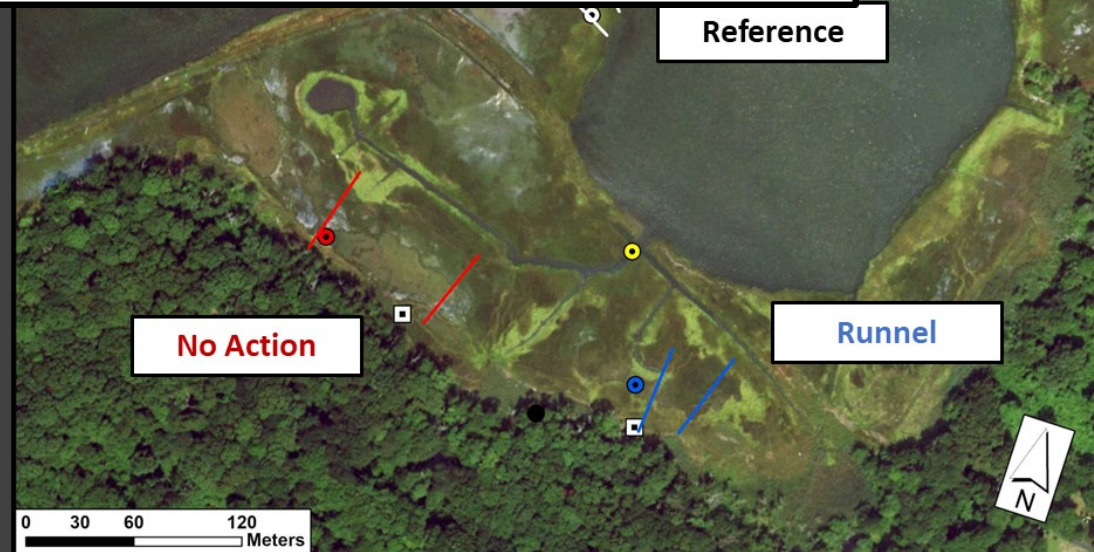
Mesotidal

Microtidal

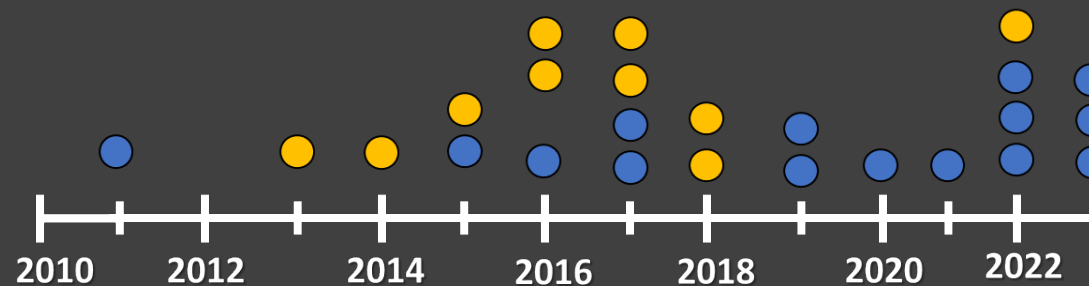
1 Runnelling Reduces Waterlogging Conditions in the Root Zone and Promotes Revegetation of 2 Salt Marshes Across New England

IN PREP!

3
4 Burdick DM¹, McKown JG², Moore GE³, Gibson JL³, Ferguson W⁴, Adamowicz S⁵, Wilson G⁶, Pau N⁷,
5 and Herbert J⁸

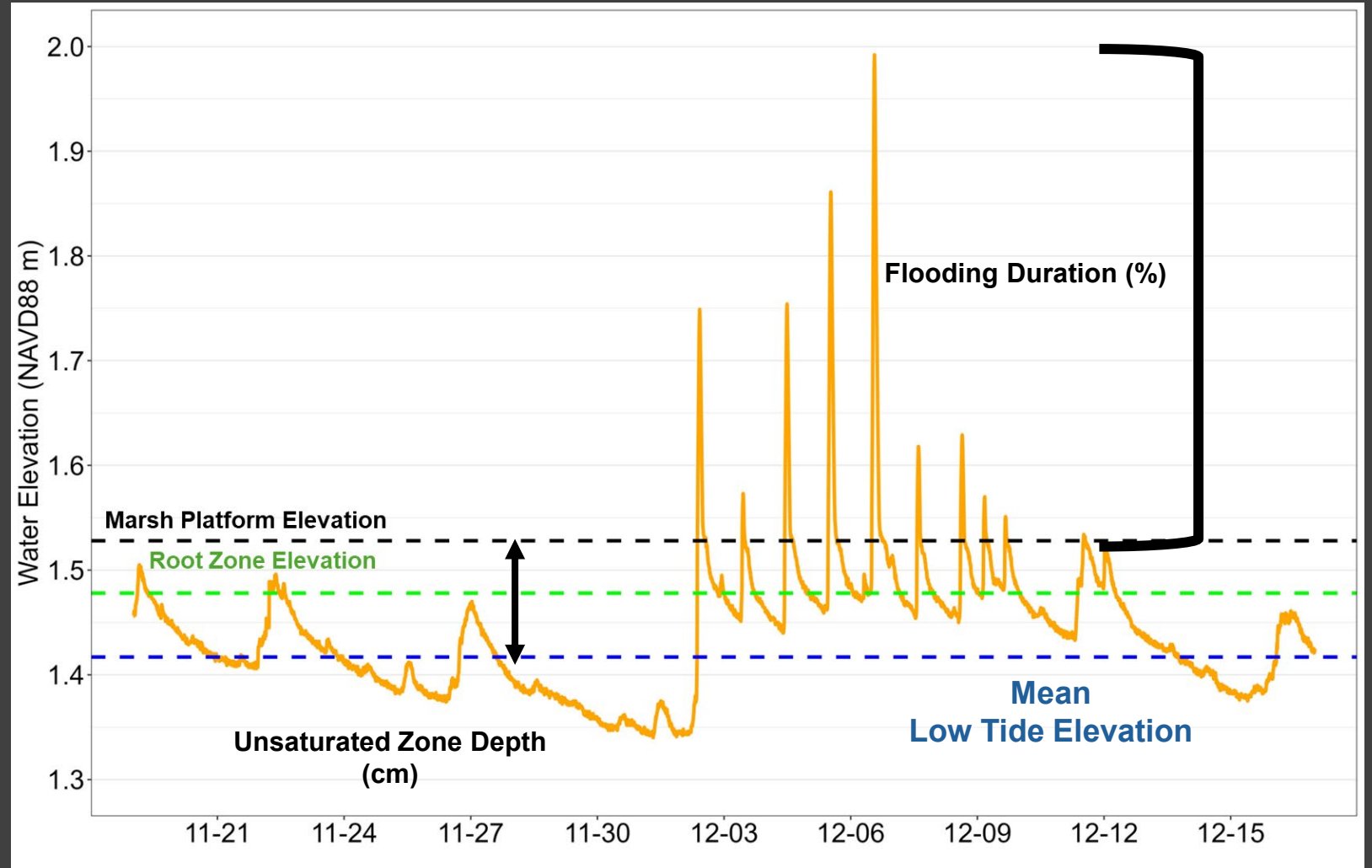


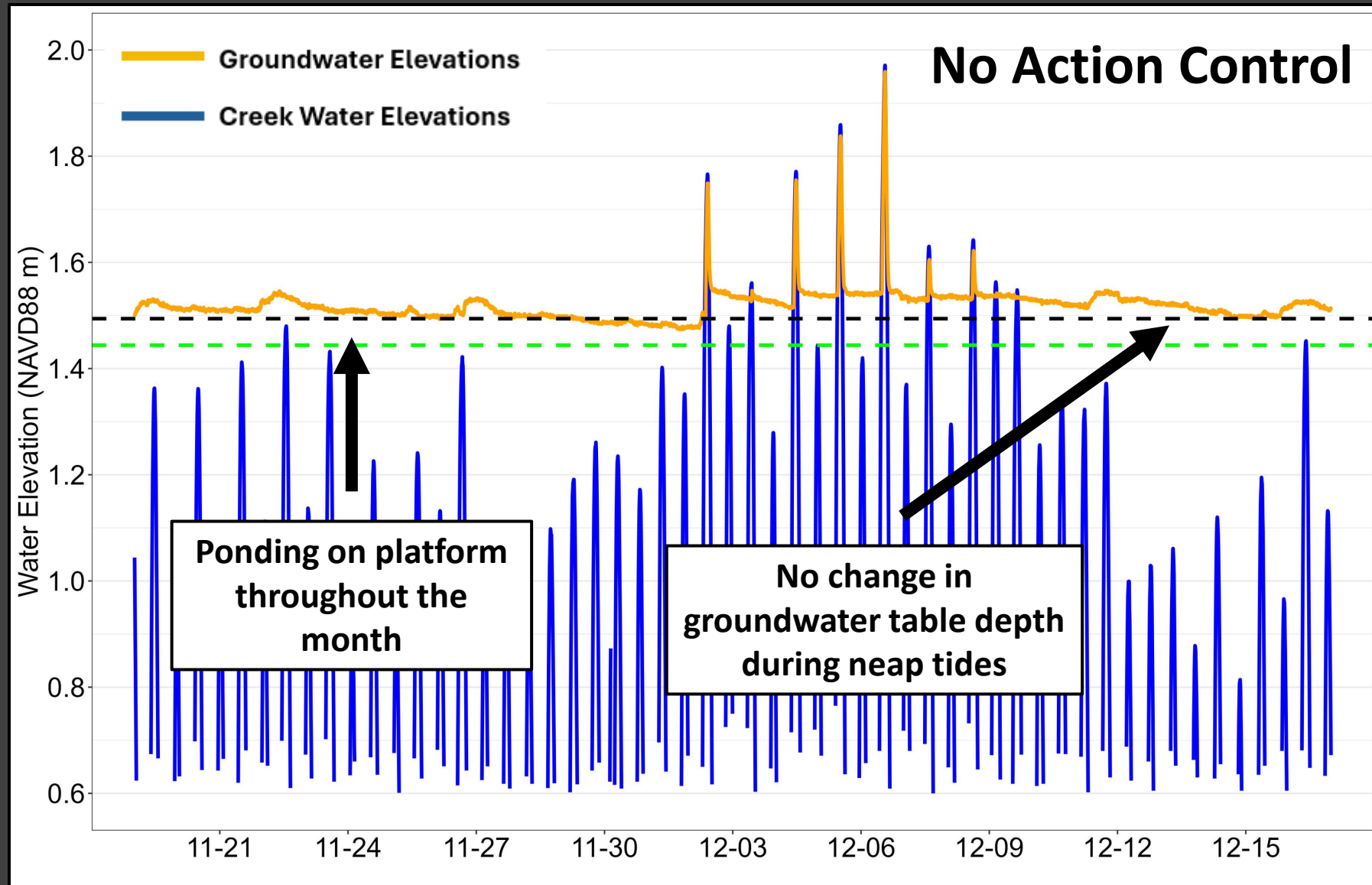
Date of Restoration per Site



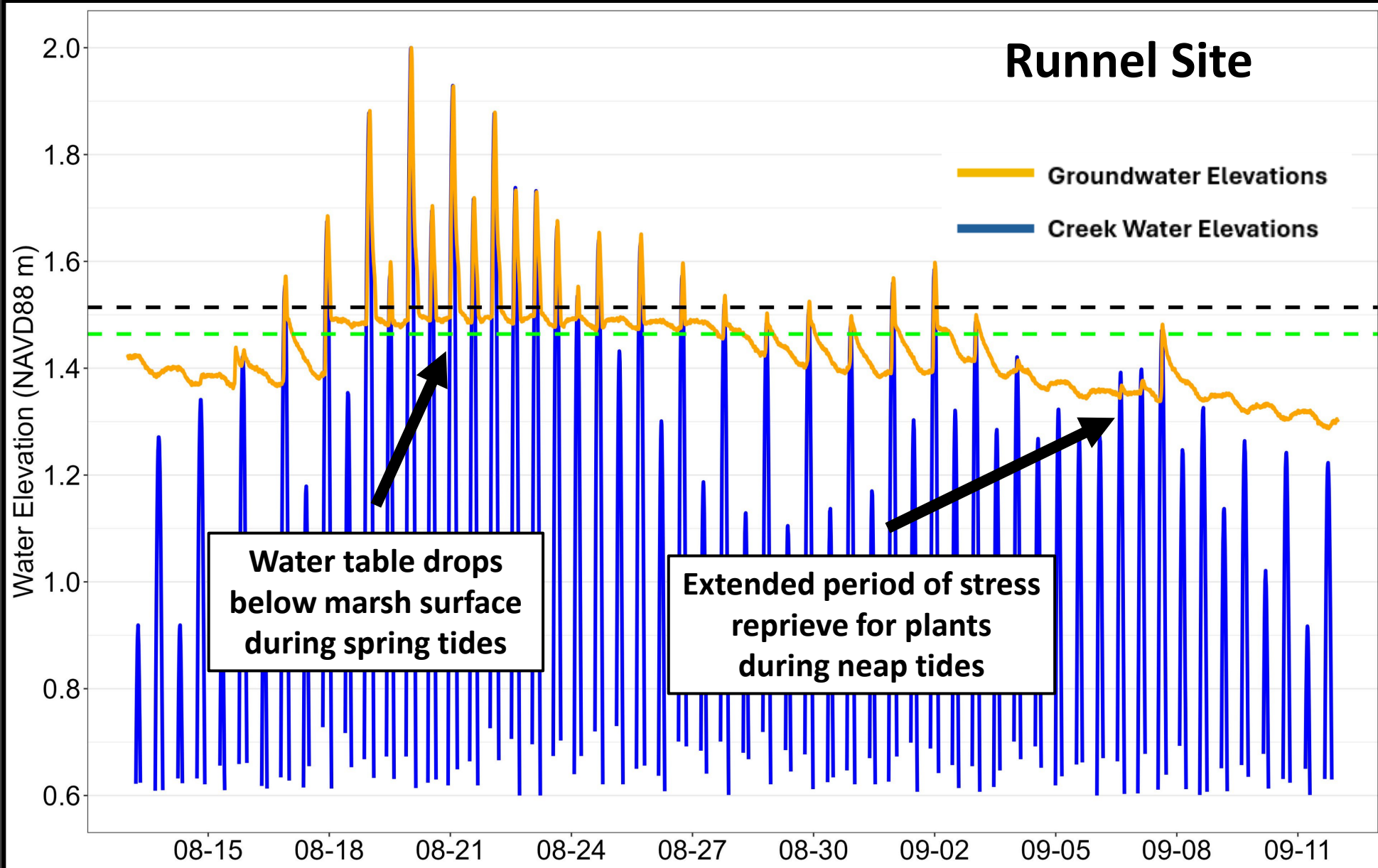


- Onset Hobo pressure transducer
- 28-day deployment (lunar cycle)
- Barometric pressure compensated
- Water elevations = NAVD88 m with RTK-GPS
- First season for analysis





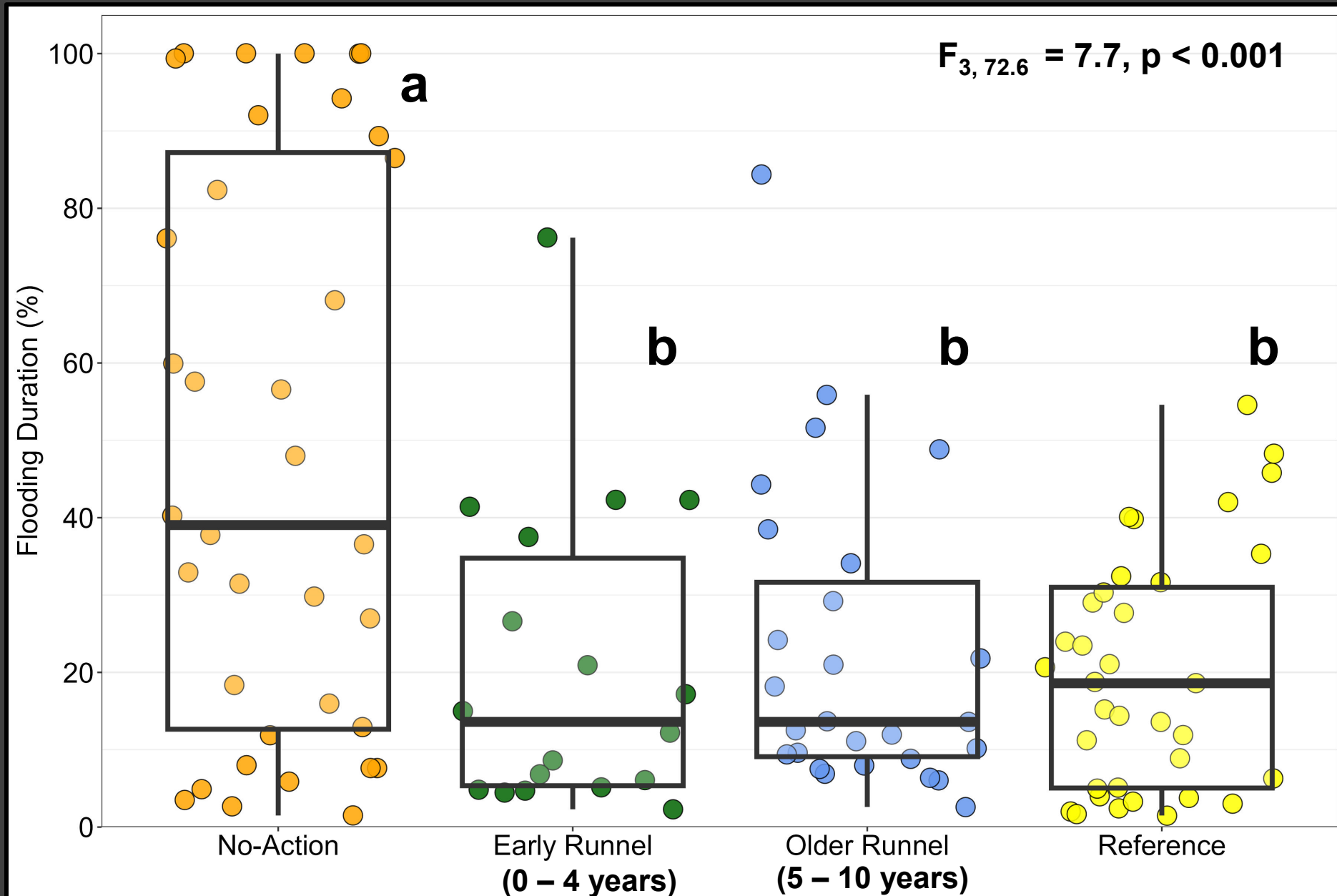
Runnel Site



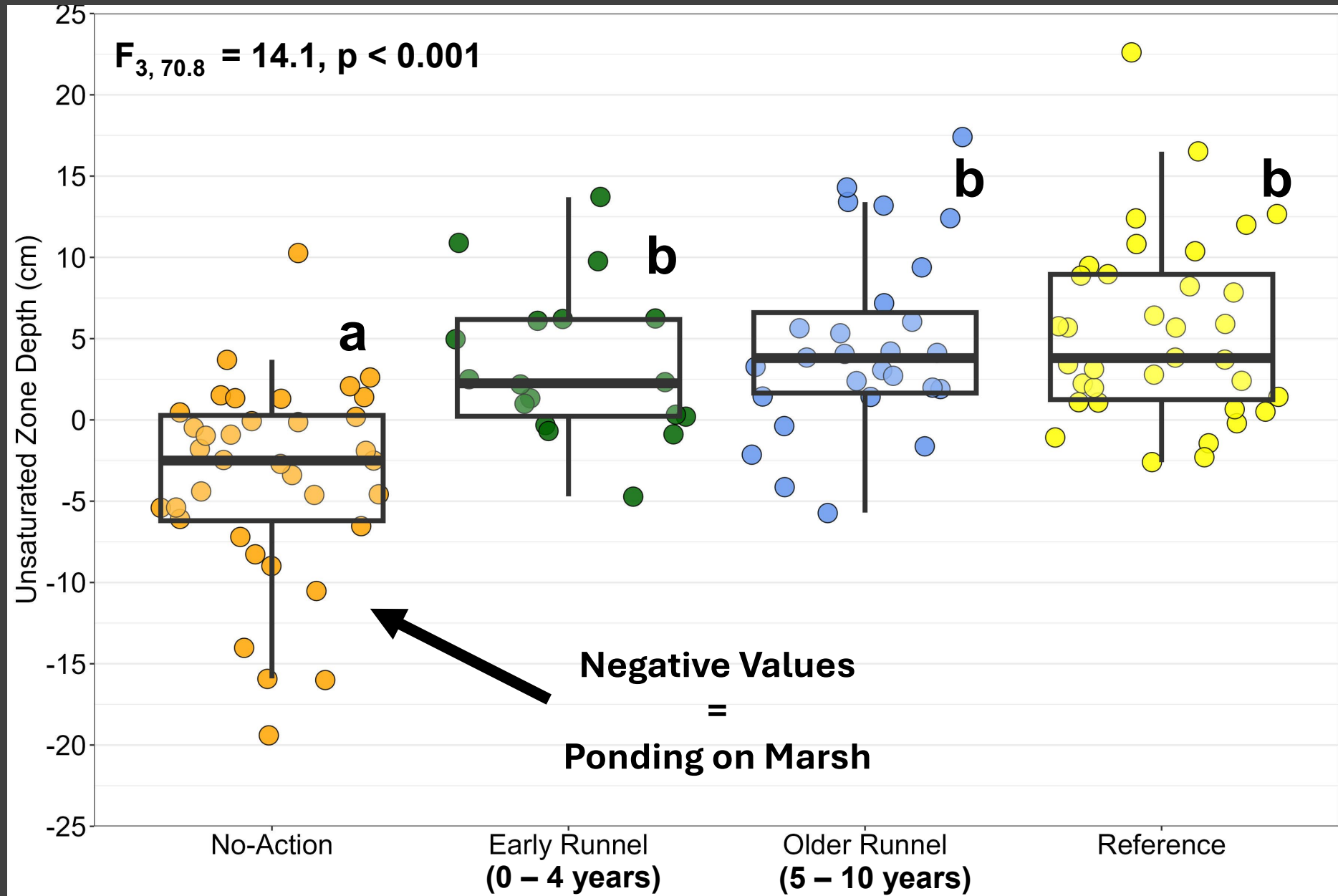
Water table drops below marsh surface during spring tides

Extended period of stress relieve for plants during neap tides

Flooding Duration of Marsh Platform (%)



Unsaturated Zone Depth (cm)



Groundwater Hydrology Takeaways

- 1) Runnels return tidal exchange into pools, lowers groundwater table surrounding pools
- 2) Groundwater table lowers 5 – 7 cm
- 3) Flooding duration of marsh platform decreased by 25%
- 4) Plants get anoxic stress reprieve for an extended period during neap tide cycles

The Effect of Runnels on Salt Marsh Sediment Dynamics, Vegetation, and Nitrogen Cycling

Hillary L. Sullivan^{1,2} · Julia Holtzer³ · Linda A. Deegan¹ · Jennifer L. Bowen²

Runnels mitigate marsh drowning in microtidal salt marshes

Elizabeth B. Watson^{1*}, Wenley Ferguson², Lena K. Champlin¹, Jennifer D. White^{3†}, Nick Ernst³, Habibata A. Sylla¹, Brittany P. Wilburn¹ and Cathleen Wigand⁴

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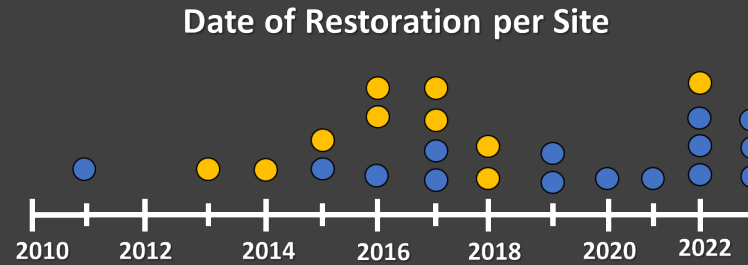
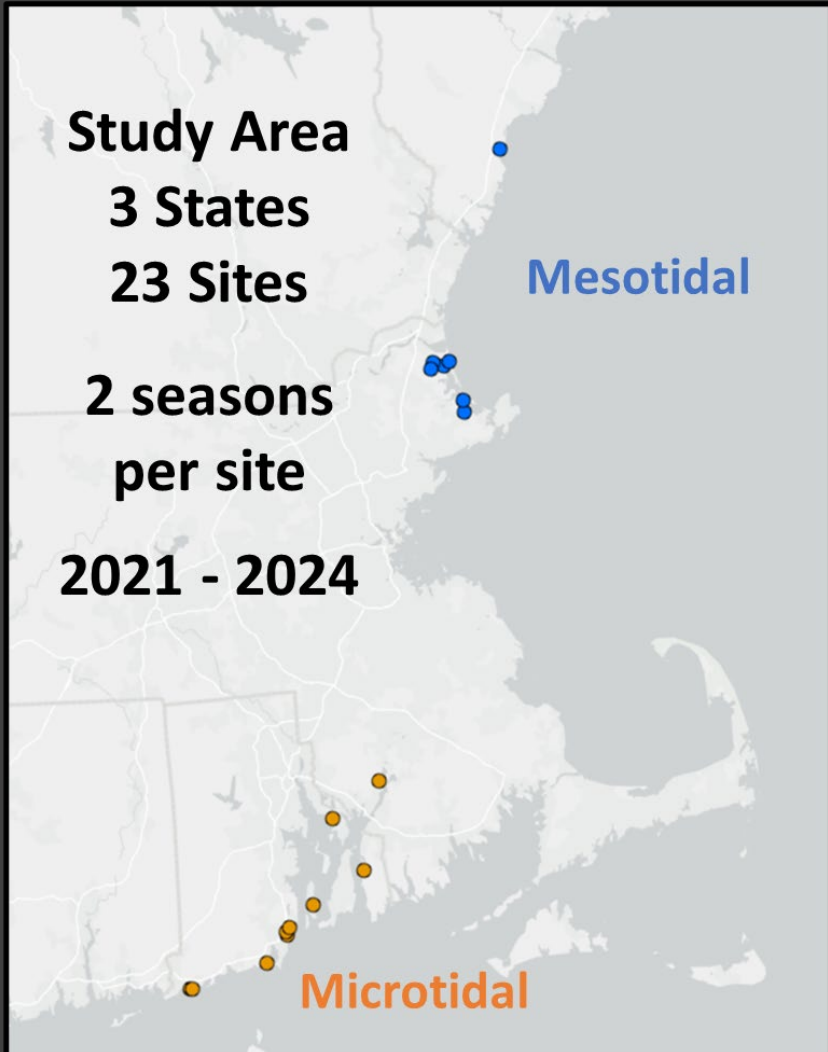
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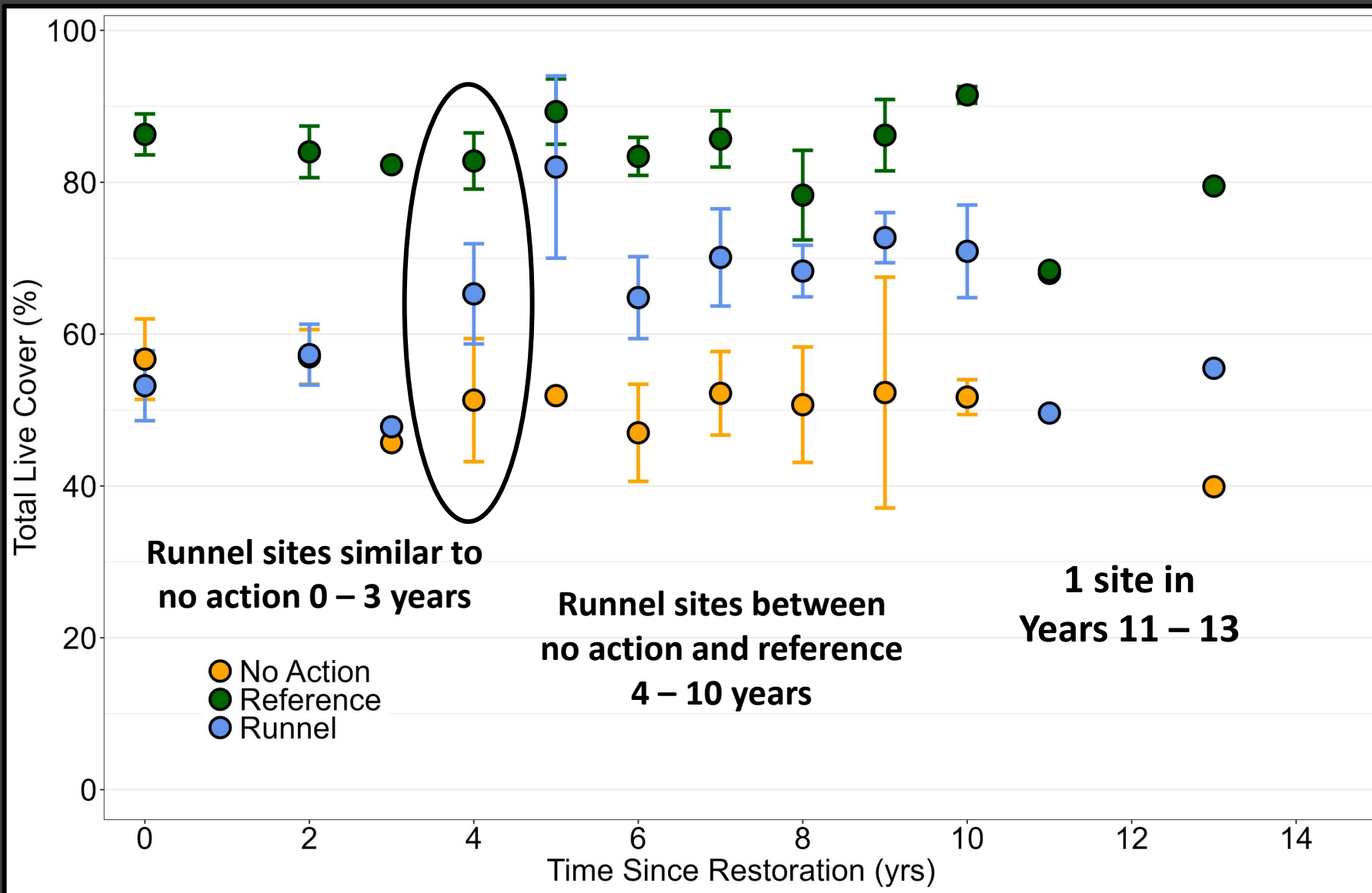
5) Adaptive management and post-restoration monitoring

Revegetation on the Marsh Platform

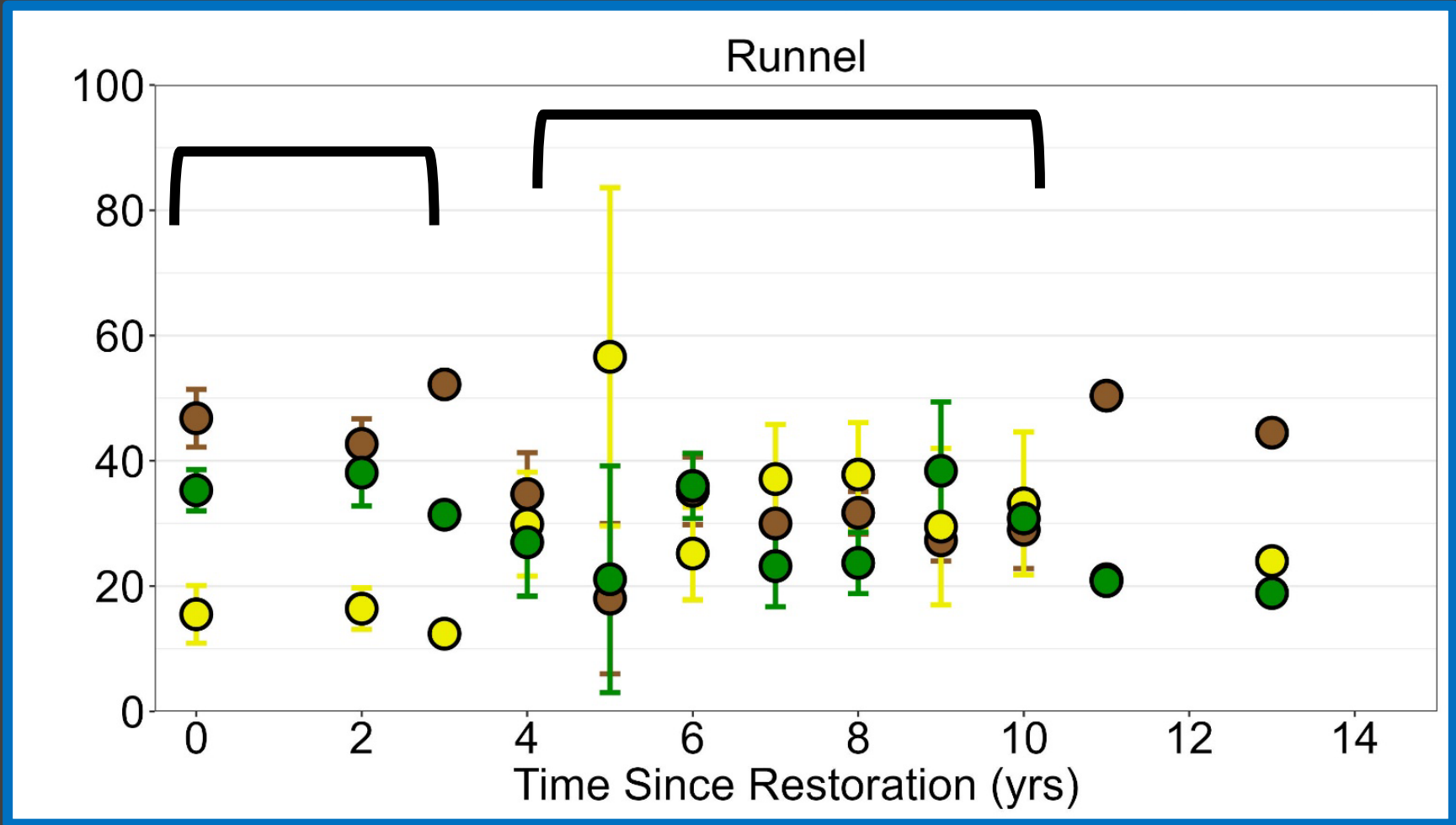


- Species identified and visual cover assigned
- Plots every 5 – 10 m
- Mixed linear regressions over restoration timeline

Total Live Vegetation Cover (%)



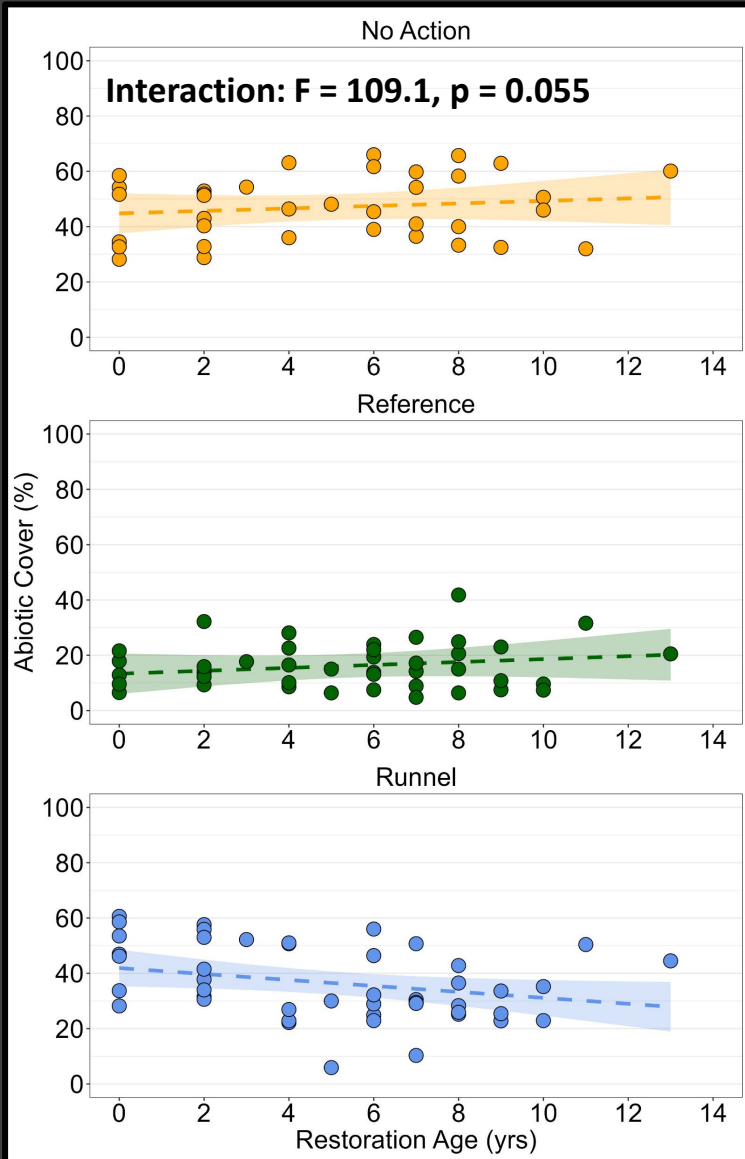
Vegetation Cover Broken Down By Cover Group (%)



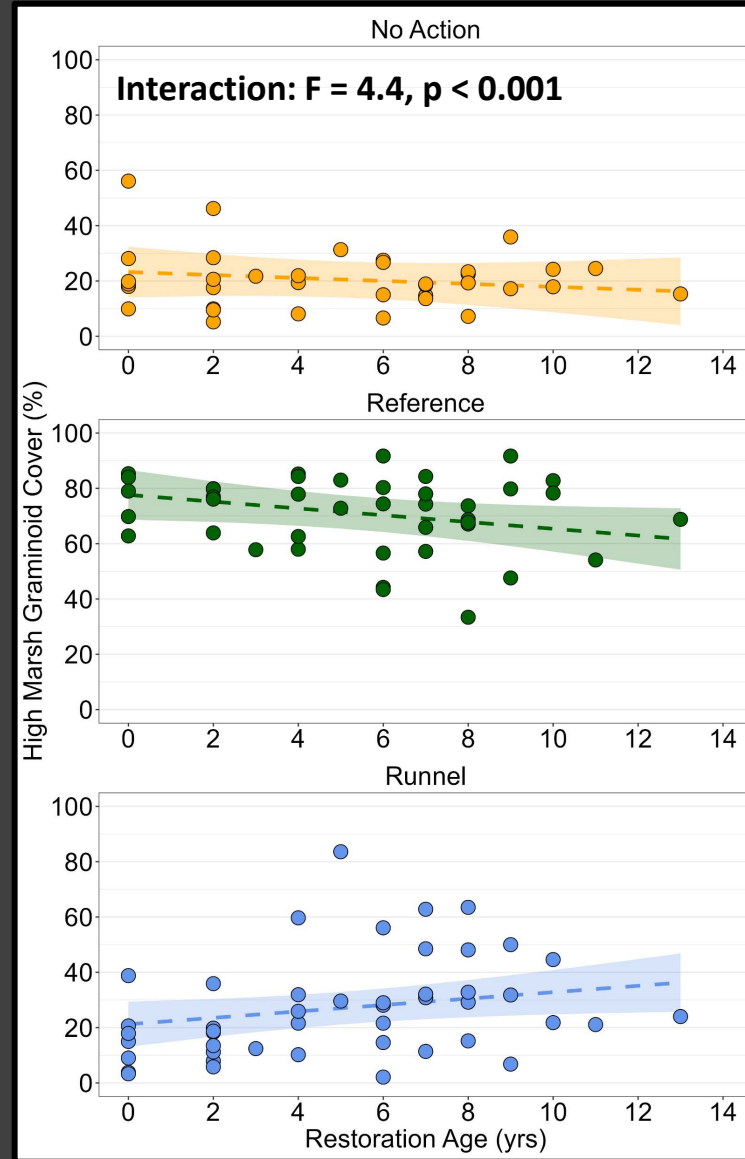
Abiotic



Abiotic Cover



High Marsh Graminoids



HMGs



Evaluation of Drainage Enhancement for Vegetation Recovery in New England Salt Marshes Using Public Domain, High-Resolution Aerial Imagery

J. Grant McKown^{†*}, David M. Burdick^{†‡}, Gregg E. Moore^{†§}, Jennifer L. Gibson^{†§}, and Wenley Ferguson^{††}



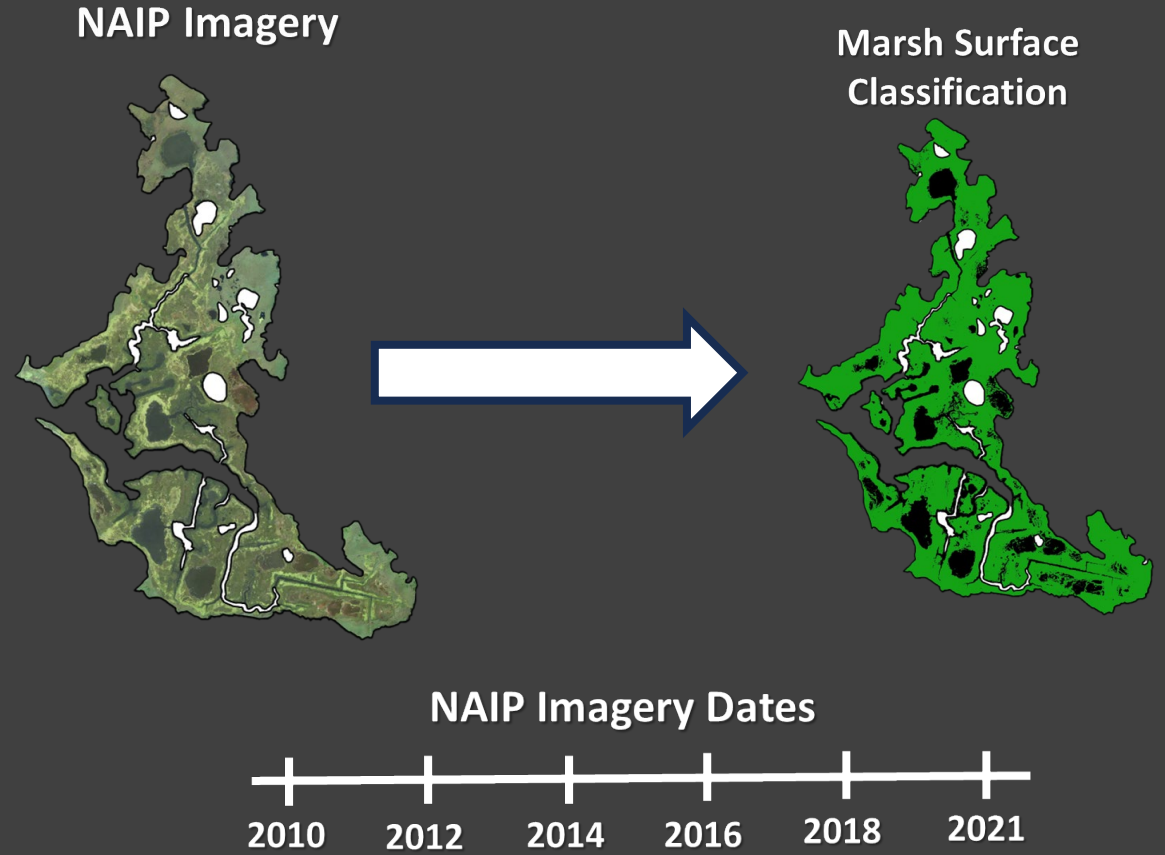
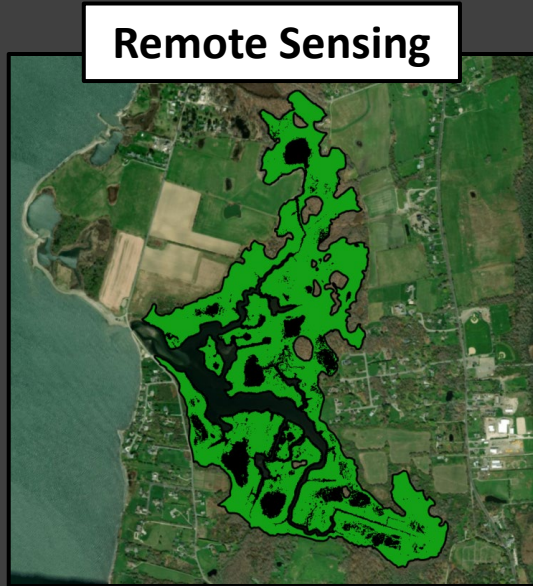
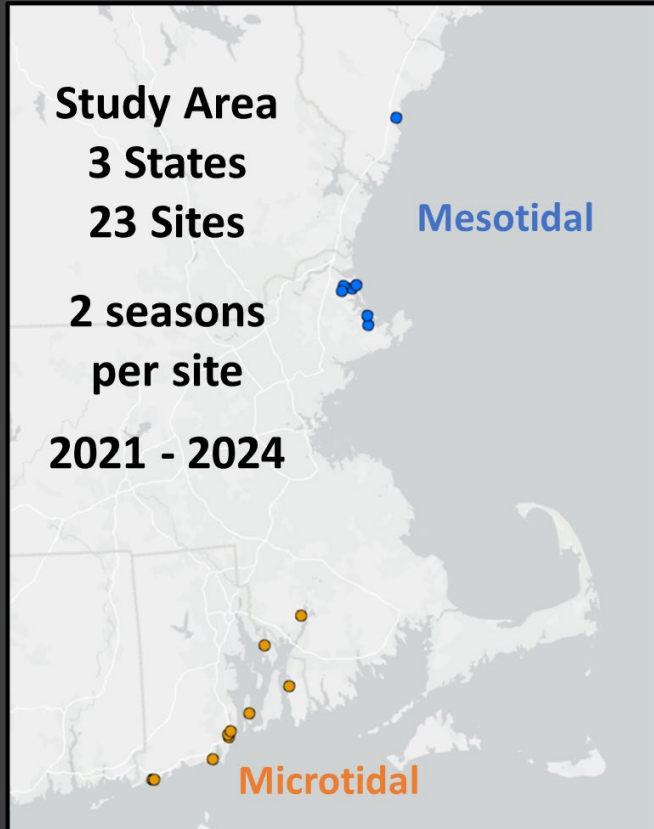
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[†]Jackson Estuarine Laboratory
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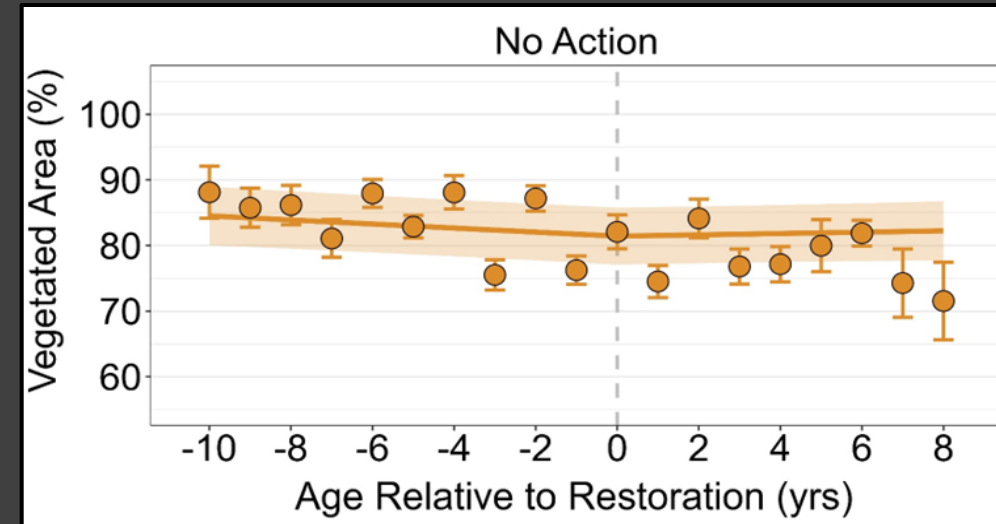
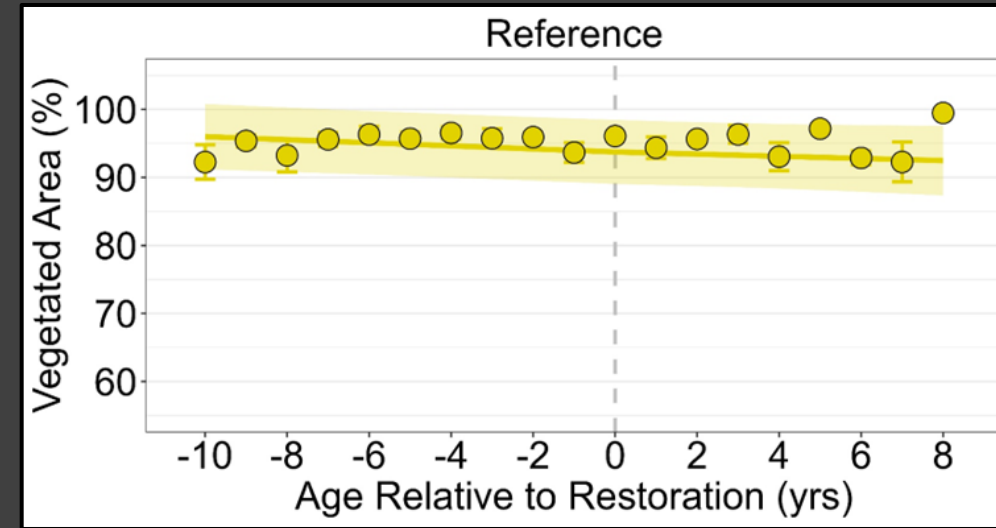
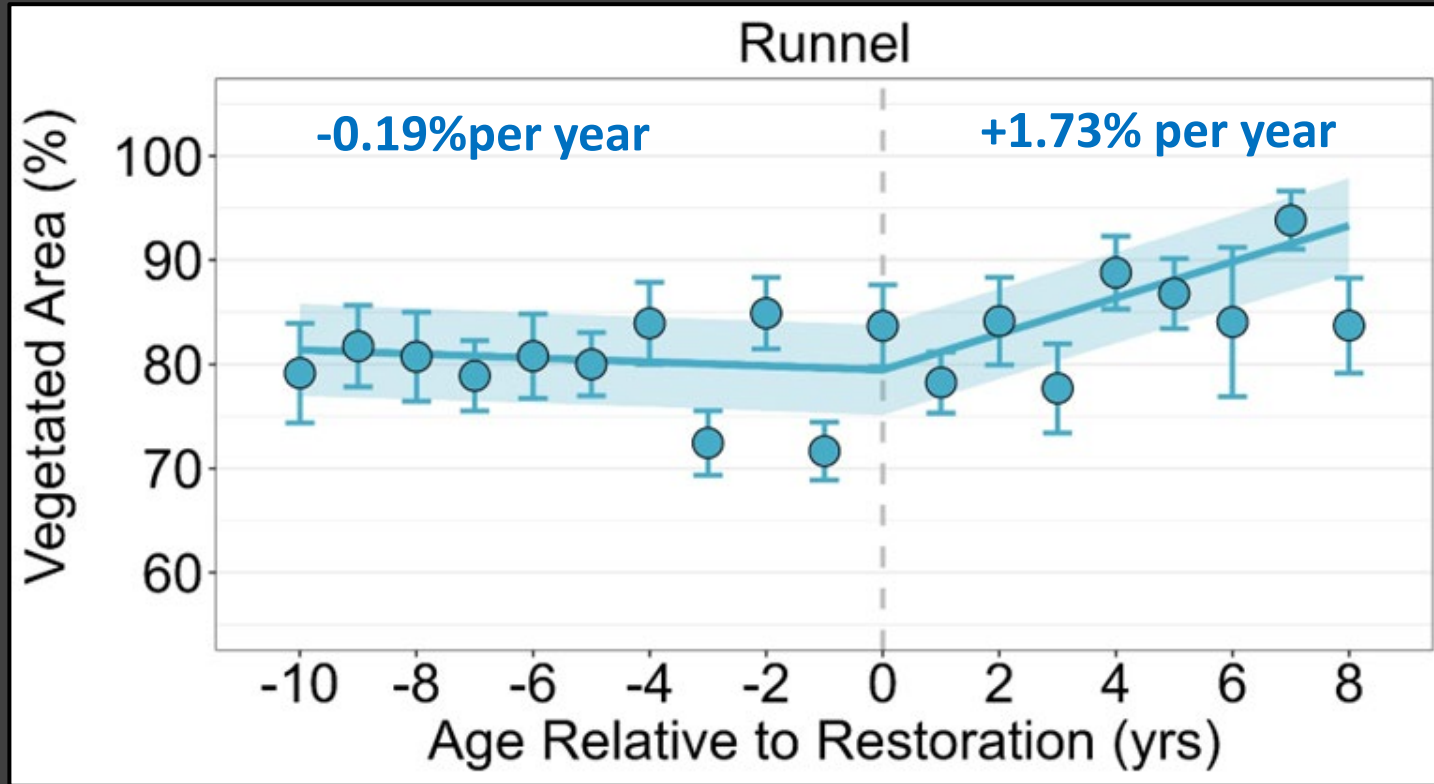
[‡]Department of Natural Resources
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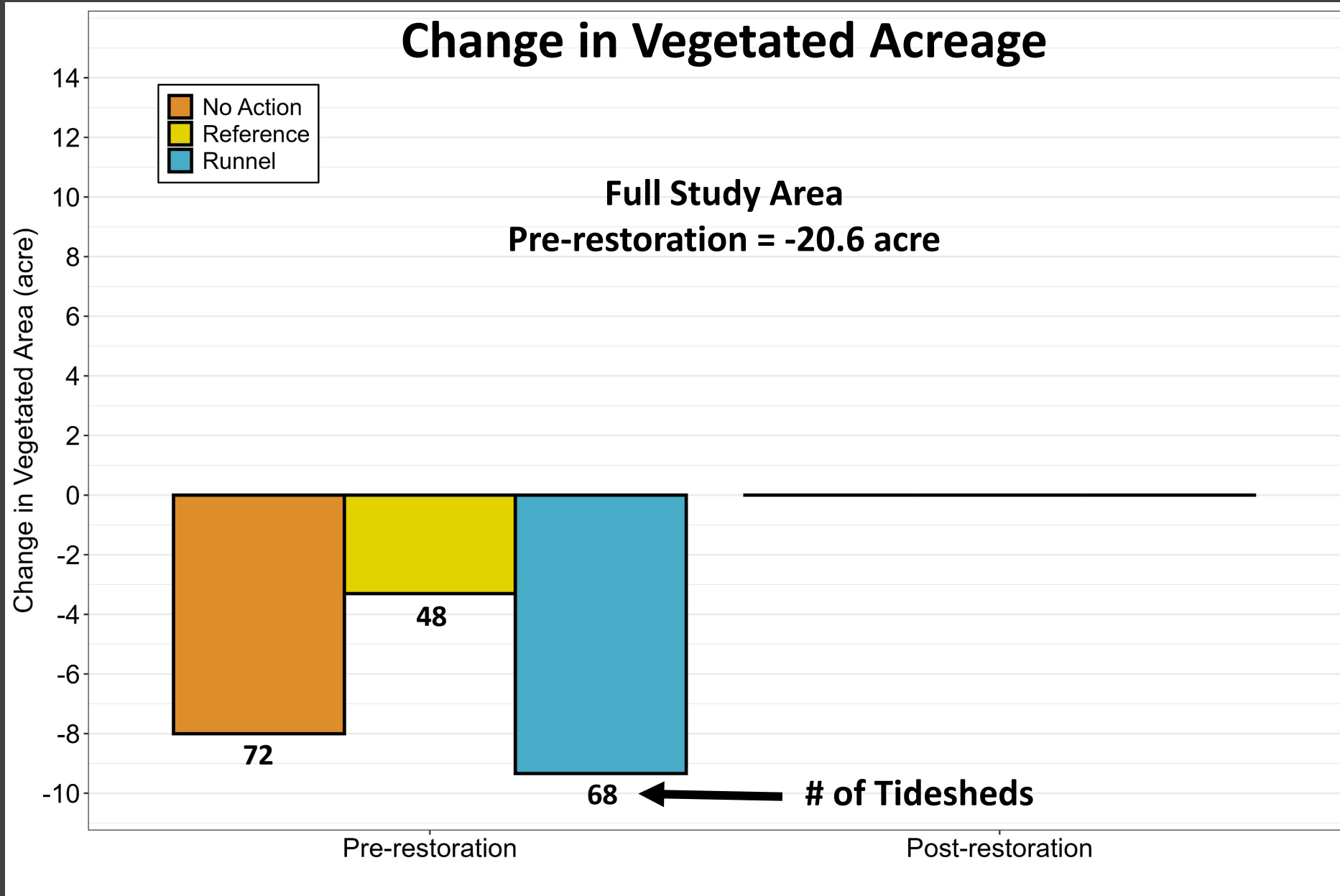
Substantial revegetation over time after restoration!



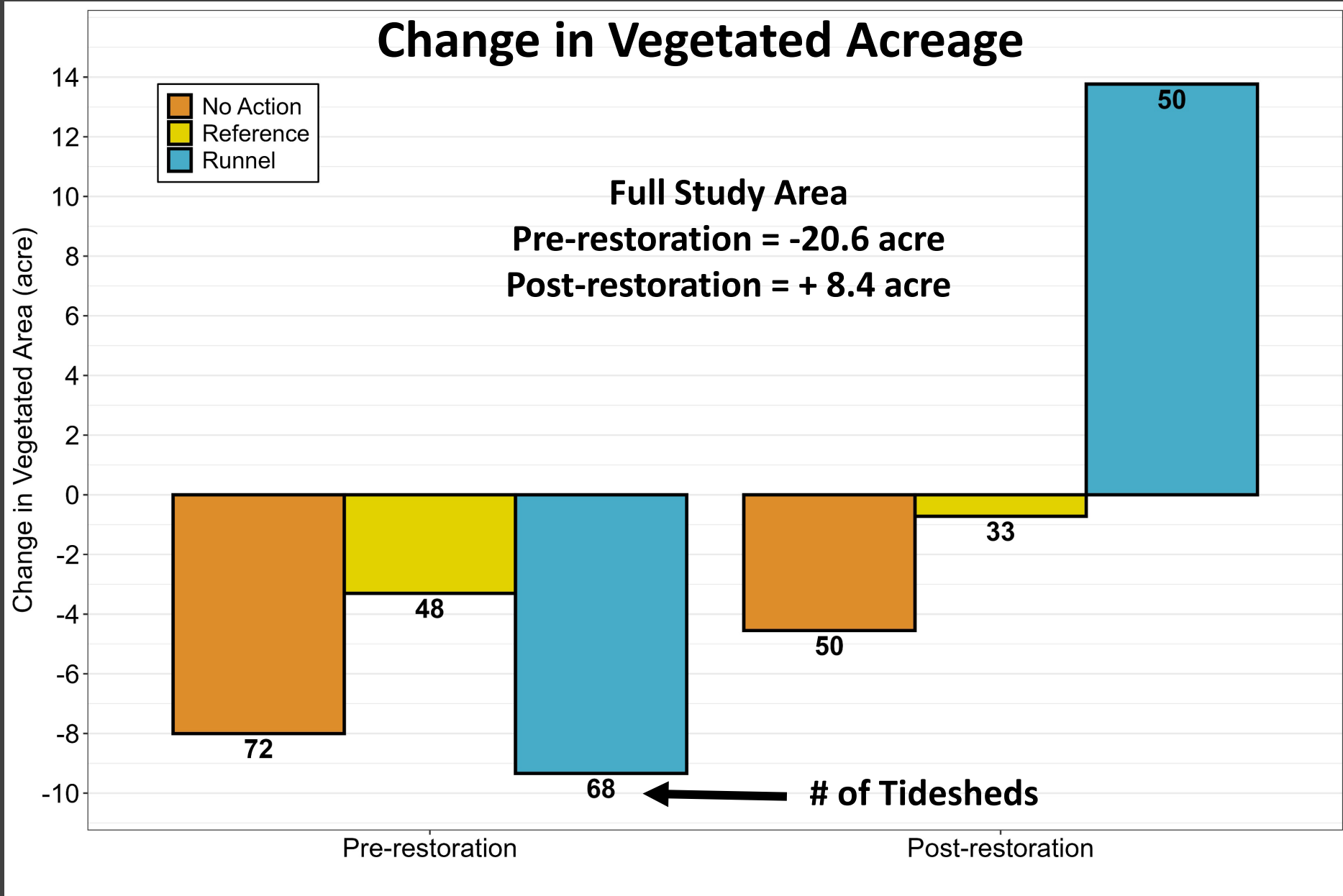
n = 1043

Treatment * Time: $F_{4, 838.1} = 839.2, p < 0.001$

Does runneling promote re-vegetation?



Does runneling promote re-vegetation?



Vegetation Recovery Takeaways

- 1) Possible lag of 1 – 4 years before meaningful vegetation recovery post-restoration**
- 2) Vegetation recovery despite ongoing losses in reference and no-action controls**
- 3) Other site factors may influence vegetation recovery – elevation, tidal regime, etc.**

The Effect of Runnels on Salt Marsh Sediment Dynamics, Vegetation, and Nitrogen Cycling

Hillary L. Sullivan^{1,2} · Julia Holtzer³ · Linda A. Deegan¹ · Jennifer L. Bowen²

Buying Time with Runnels: a Climate Adaptation Tool for Salt Marshes

Alice F. Besterman^{1,2} · Rachel W. Jakuba² · Wenley Ferguson³ · Diana Brennan⁴ · Joseph E. Costa⁵ · Linda A. Deegan²

Runnels mitigate marsh drowning in microtidal salt marshes

Elizabeth B. Watson^{1*}, Wenley Ferguson², Lena K. Champlin¹, Jennifer D. White^{3†}, Nick Ernst³, Habibata A. Sylla¹, Brittany P. Wilburn¹ and Cathleen Wigand⁴

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Differing vegetation recovery trajectories

Wetlands (2023) 43:35
<https://doi.org/10.1007/s13157-023-01683-6>



WETLAND RESTORATION



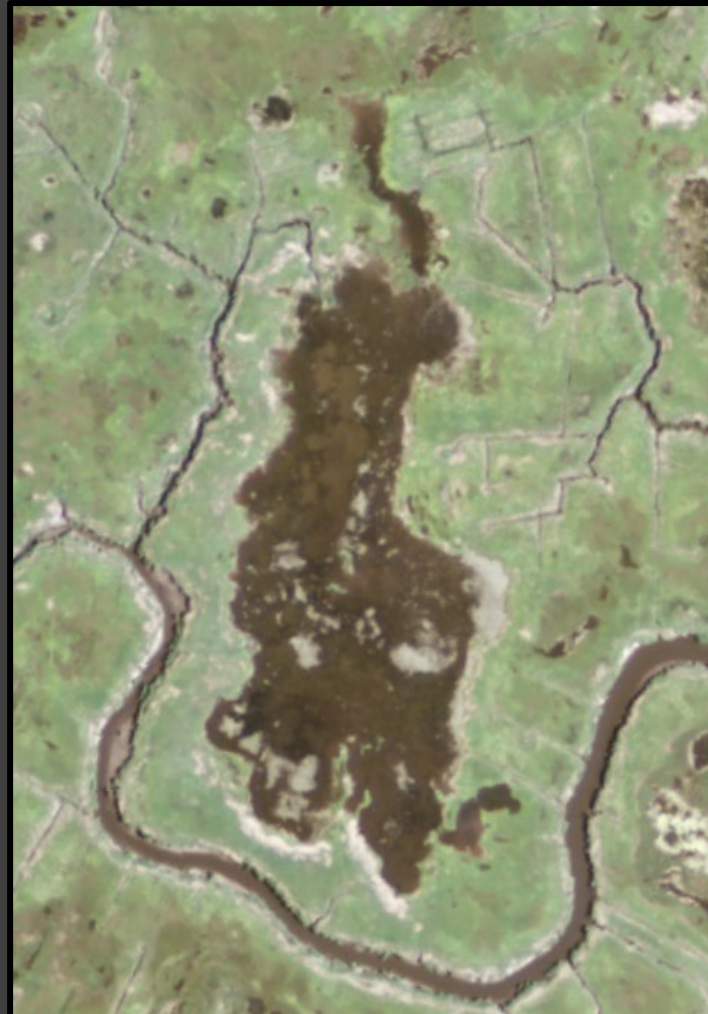
Runnels Reverse Mega-pool Expansion and Improve Marsh Resiliency in the Great Marsh, Massachusetts (USA)

J. Grant McKown¹ · David M. Burdick² · Gregg E. Moore³ · Christopher R. Peter⁴ · Andrew R. Payne⁵ · Jennifer L. Gibson³



Parker River National Wildlife Refuge

2014 (Pre-restoration)

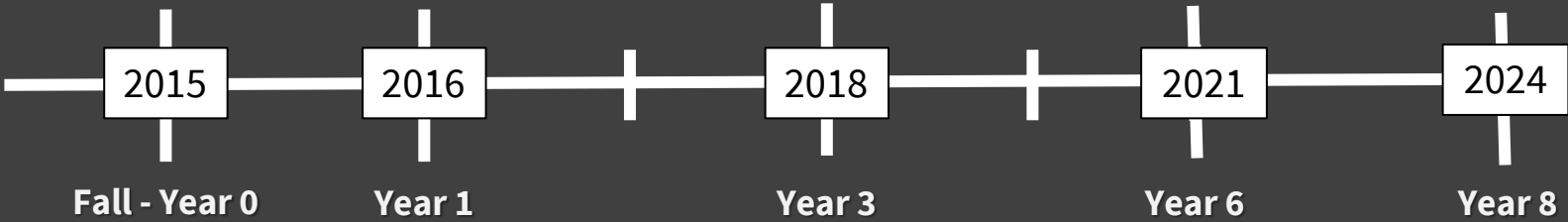


2023 (Year 8)



Pine Island Background

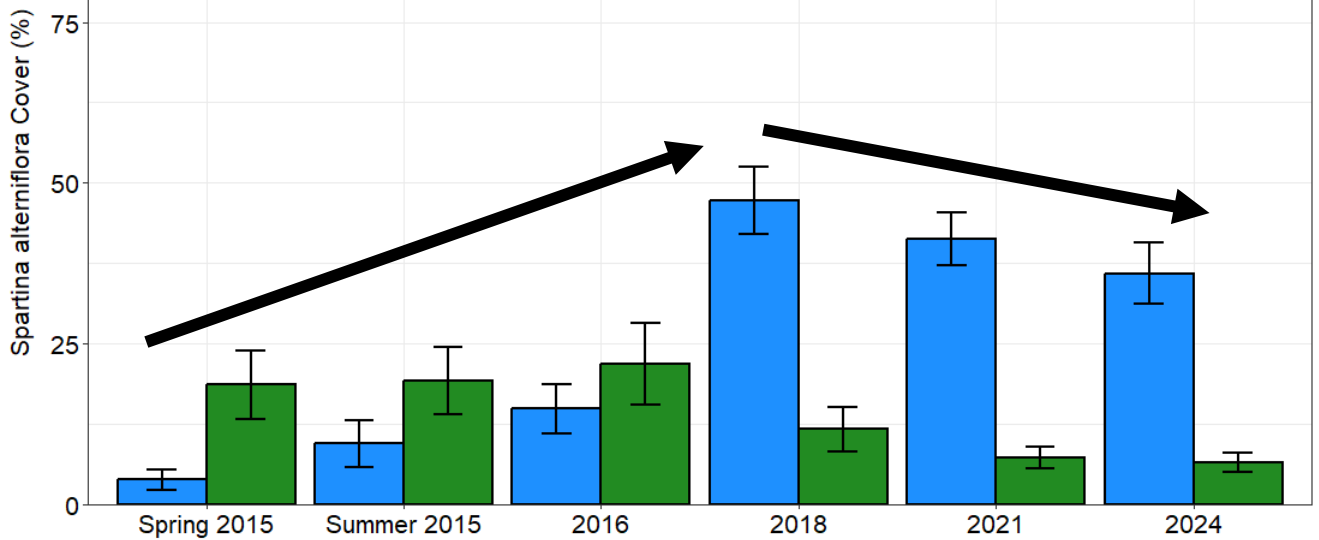
Spring – Runnels Created
Pre-Restoration Monitoring



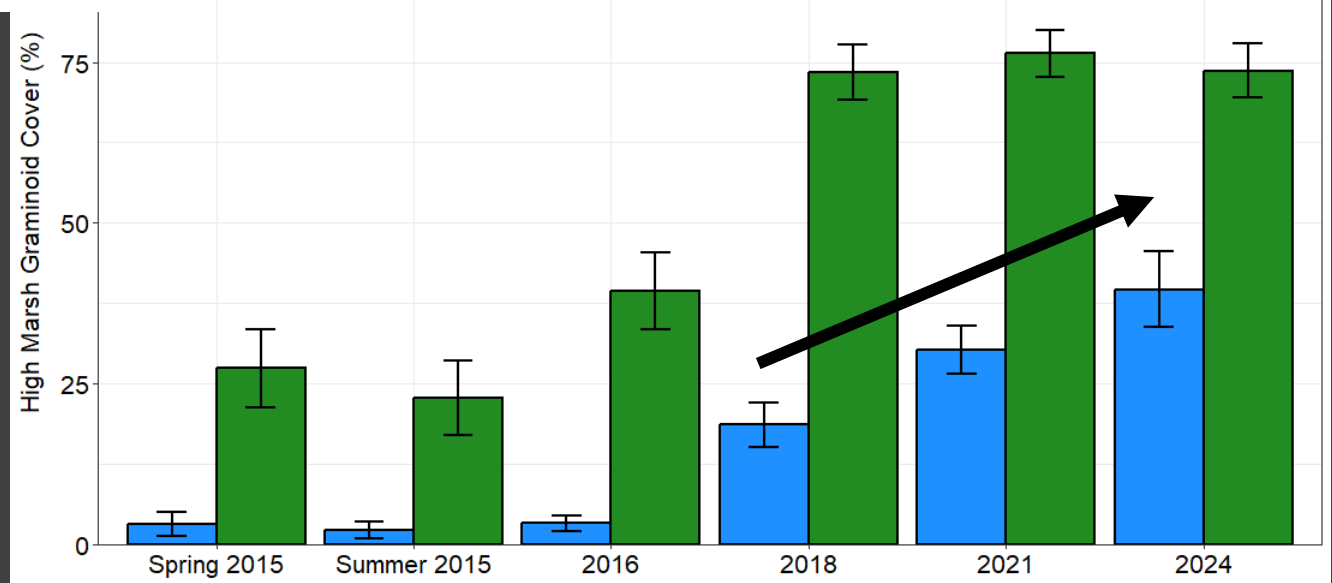
Runnel Construction at Parker River NWR

- Plots along four sides of each pool
- Paired plots in pool and on adjacent platform
- Vegetation cover estimated with ocular method

Spartina alterniflora Cover (%)



High Marsh Graminoid Cover (%)



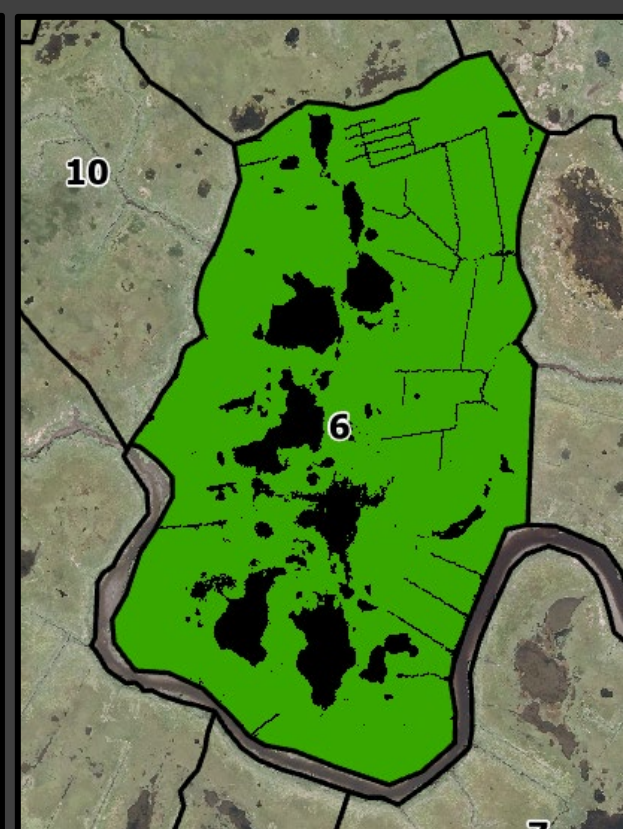
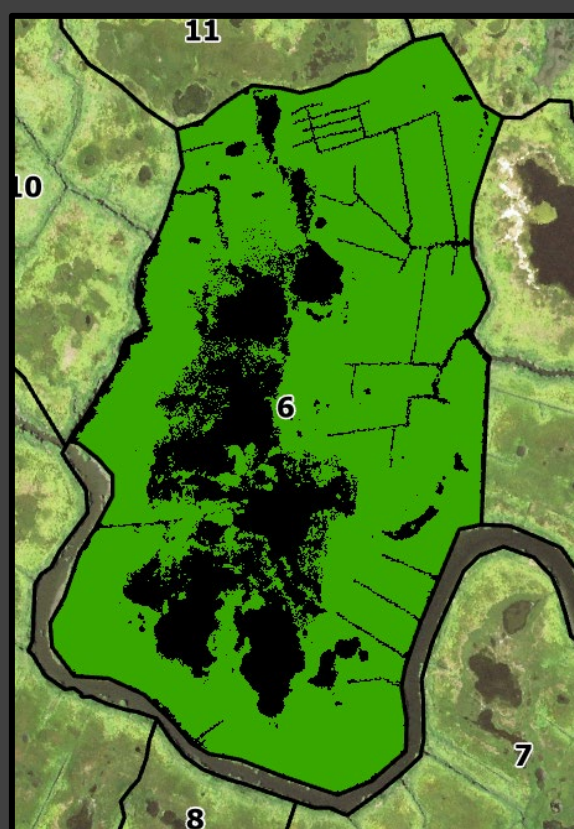
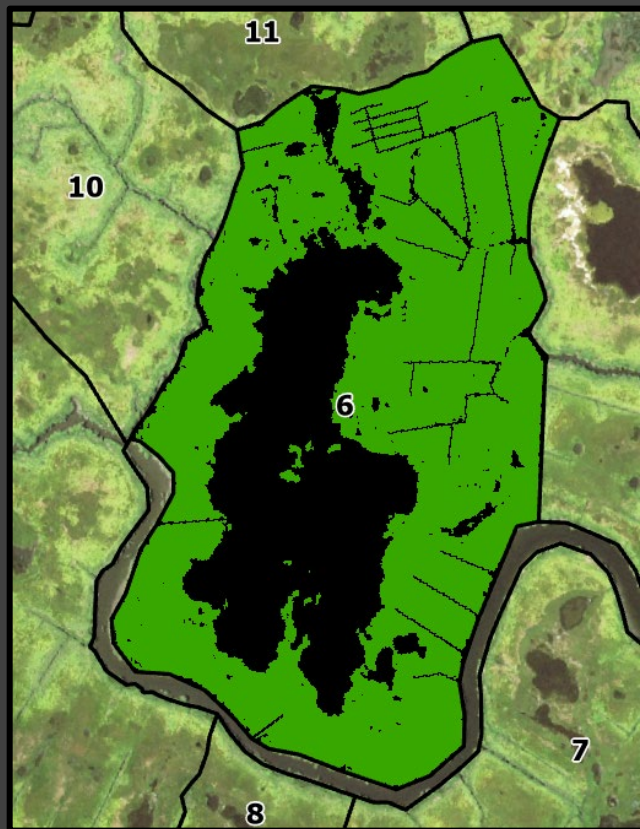
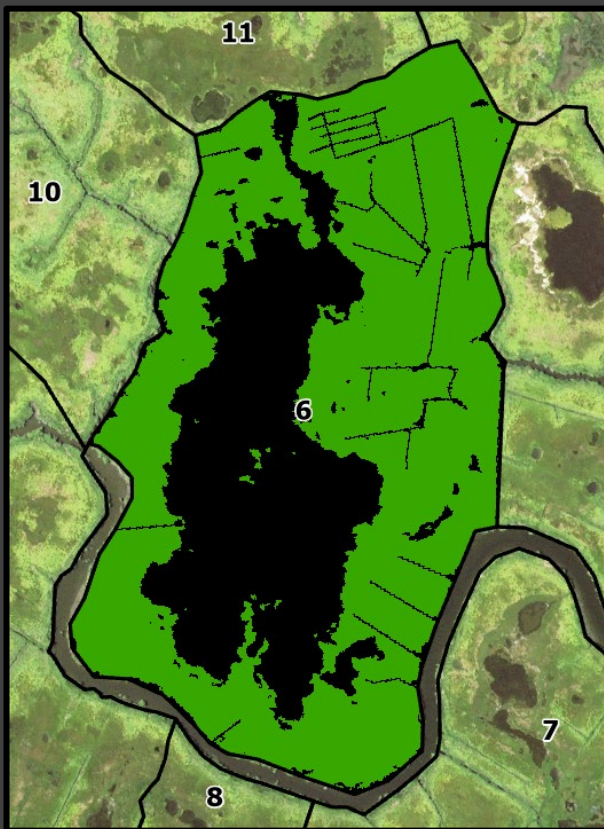
- Marsh Platform
- Former Pool



Year 0
6.66 ha

Year 3
7.15 ha

Year 6
7.81 ha

(Preliminary)
Year 8
8.51 ha



-  **Vegetated Marsh Surface**
-  **Open Water, Bare Surface**

Vegetation Response to Drainage Enhancement

2015



2021



2023



2024



Vegetation Trajectory Differences

- 1) High marsh graminoid recovery quicker (and may be immediate) on the marsh platform or in pannes**
- 2) Vegetation recovery on edges of pools was noticeable within 2 – 4 years**
- 3) Revegetation in interior of large mega-pools is on decadal scales**
- 4) No research yet on plantings or seeding pools to speed up recovery**

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- 3) Vegetation recovery expectations**
- 4) Difference in revegetation rates between pools and pannes**
- 5) Adaptive management and post-restoration monitoring**

Adaptive Management & Monitoring

Sizing & Installation



As-Built Surveys



Monitoring





Adaptive Management & Monitoring

- **Understand platform hydrology and topography** – *where does the flow naturally go after high tides?*
- **Maintain tidal flow on ebb and flow tidal stages to prevent clogging** – *slopes, runnel geometry*
- **Start with smaller geometries, they can always be expanded to handle the tidal prism**
- **For larger pools, be careful about “pulling the cork” to not cause erosion in runnel or receiving ditch/creek**

As-Built Surveys



Adaptive Management & Monitoring

- **As-built surveys of runnel geometry are crucial in the first 5 years to understand changes in geomorphology**
- **Annual inspections of vegetation or sediment clogs**
- **Clogged runnels can cause progress to stall or lose vegetation and hydrology gains**
- **Implementation of adaptive management activities**

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WETLAND RESTORATION



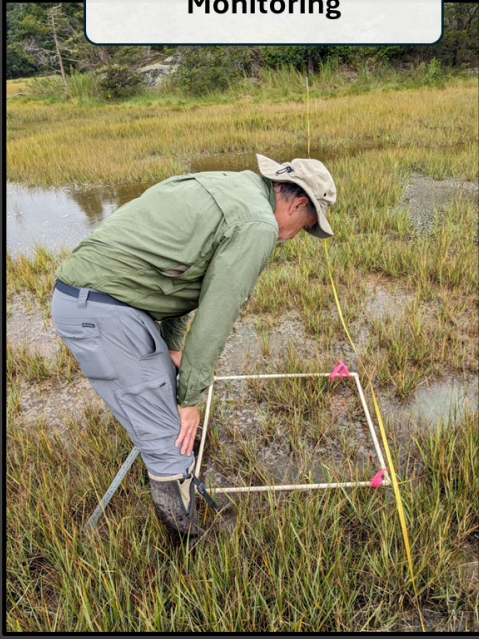
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Monitoring



Adaptive Management & Monitoring

- Pool surface and groundwater hydrology
- Flooding duration and unsaturated zone depth
- *Is the runnel having the intended effect?*

- Permanent plots and transects
- Total live cover, canopy height, and community composition
- *Is the vegetation community responding to restoration?*

- Transects surface elevation surveys
- Surface elevation relative to tidal elevation
- *What is loss in marsh capital or elevation?*

Overall Takeaways

- 1) **Runnels are successful to recover tidal exchange and promote re-vegetation**
- 2) **Recovery of the vegetation is dependent on numerous factors and could be require several decades**
- 3) **Gains in lost elevation in pools are pre-requisite for high marsh graminoid recovery**
- 4) **Runnels are not a *one and done* process but will require post-restoration monitoring, adaptive management, and placement in a broader restoration framework**

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Questions?

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WETLAND RESTORATION



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