Coastal Habitat Response to Changing Water Levels

NERR Sentinel Site Application Module 1

2016

OFFICE FOR COASTAL MANAGEMENT
NATIONAL ESTUARINE RESEARCH RESERVE

NOAA's Office for Coastal Management

"Coastal management" is the term used by communities and organizations working to keep the nation's coasts safe from storms, rich in natural resources, and economically strong. The national lead for these efforts is NOAA's Office for Coastal Management, an organization devoted to partnerships, science, and good policy. This agency, housed within NOAA's National Ocean Service, oversees major initiatives that include the Coral Reef Conservation Program, Digital Coast, National Coastal Zone Management Program, and National Estuarine Research Reserve System.

To learn more, please visit *coast.noaa.gov*.

National Estuarine Research Reserve System

The National Estuarine Research Reserve System protects more than 1.3 million acres in 28 reserves located in 22 states and Puerto Rico for purposes of long-term research, environmental monitoring, education, and stewardship. Each reserve represents a partnership between NOAA and the coastal state. NOAA provides funding, national guidance, and technical assistance, and each reserve is managed on a daily basis by a lead state agency or university with input from local partners. Reserve staff members work with local communities and regional groups to address natural resource management issues such as nonpoint source pollution, evaluation of habitat restoration strategies, invasive species, and sea level rise.

To learn more, please visit *nerrs.noaa.gov*.

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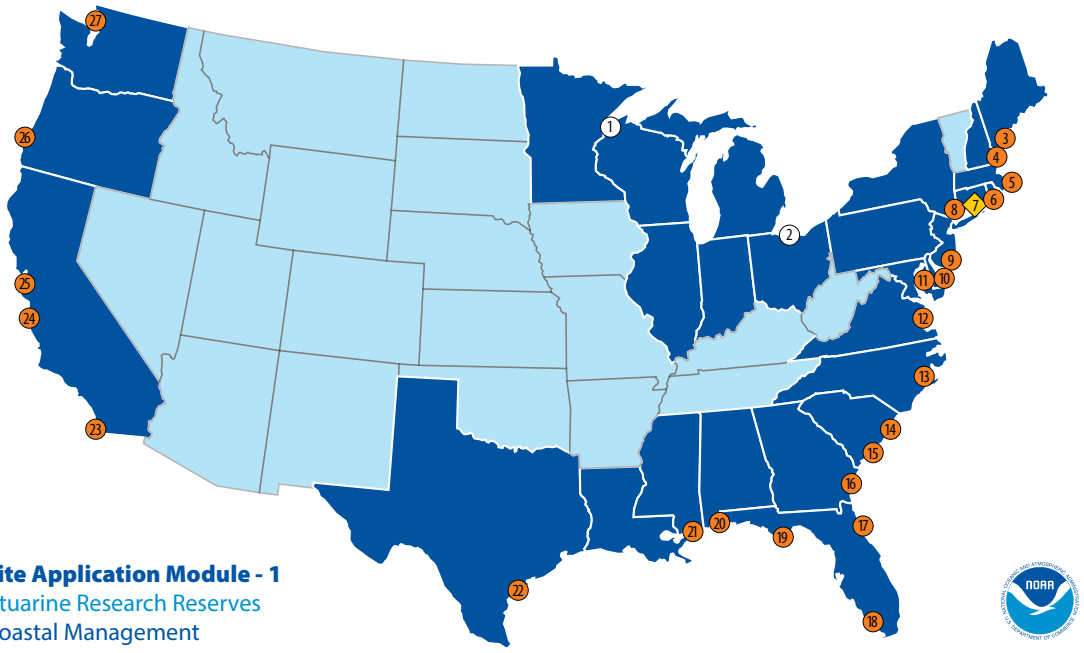
Overview

The concept of research reserves as sentinel sites refers to the capacity of each site to provide early detection of environmental change and enable timely management responses. Over the past decade, the research reserve system has implemented an innovative approach to understanding how climate change, manifested by changing water levels, is impacting coastal habitat.

Most reserves are participating in this place-based, national program dedicated to developing a standardized approach to answering management questions across a broad geographic scale. The protocol being used, the sentinel site application module (SSAM-1), allows each site to examine the interplay of water levels, elevation, and plant communities at scales relevant to local, regional, and national decision makers. Future modules will focus on other stressors, such as eutrophication or invasion by non-native species.

The first part of this document explains how research reserves function as sentinel sites and how this concept is related to the reserve system's Climate Change Initiative, System-Wide Monitoring Program, and the NOAA Sentinel Site Program. The second part describes the protocol, which is the first sentinel site application module for the research reserve system.



LIST OF RESERVES

Great Lakes
1. Lake Superior, Wisconsin
2. Old Woman Creek, Ohio

Northeast
3. Wells, Maine
4. Great Bay, New Hampshire
5. Waquoit Bay, Massachusetts
6. Narragansett Bay, Rhode Island
7. Connecticut (*Proposed*)

Mid-Atlantic
8. Hudson River, New York
9. Jacques Cousteau, New Jersey
10. Delaware
11. Chesapeake Bay, Maryland
12. Chesapeake Bay, Virginia

Southeast
13. North Carolina
14. North Inlet-Winyah Bay, South Carolina
15. ACE Basin, South Carolina
16. Sapelo Island, Georgia
17. Guana Tolomato Matanzas, Florida

Gulf of Mexico
18. Rookery Bay, Florida
19. Apalachicola, Florida
20. Weeks Bay, Alabama
21. Grand Bay, Mississippi
22. Mission-Aransas, Texas

West
23. Tijuana River, California
24. Elkhorn Slough, California
25. San Francisco Bay, California
26. South Slough, Oregon
27. Padilla Bay, Washington
28. Kachemak Bay, Alaska

Pacific
29. Hawaii (*Pending*)

Caribbean
30. Jobos Bay, Puerto Rico

Research Reserves as Sentinel Sites

Application of System-Wide Monitoring Data

All national estuarine research reserves monitor key indicators of estuarine function using the consistent, vetted protocols of the System-Wide Monitoring Program, also known as SWMP. The monitoring program is designed to detect short-term variation and long-term trends and includes abiotic, biotic, and habitat elements. These data can be applied to a variety of scientific questions or management applications. SWMP is designed to provide long-term environmental monitoring data that can be used to address management issues, rather than for testing specific predetermined hypotheses.

In contrast, the sentinel site application modules are designed to answer specific scientific or management questions using a subset of the SWMP data and other relevant protocols. End users inform module development. The goal of developing application modules is to identify reserve vulnerabilities to environmental change and to translate this understanding to coastal communities and coastal managers.

The concept of research reserves as sentinel sites refers to the capacity for early detection of environmental change in response to natural or anthropogenic stressors to enable timely management responses. Sentinel site application modules, for example, could focus on specific stressors such as eutrophication or invasion by non-native species. The first module, which is profiled in this document, focuses on climate change—specifically, how changes in local water levels impact coastal habitat.

Research Reserves and Climate Change

In July 2008, the National Estuarine Research Reserve System released a strategy document entitled "Climate Change: Science, Education and Stewardship for Tomorrow's Estuaries." This document described a framework for the reserve system to address the challenges of climate change and outlined several potential stressors and impacts specifically relevant to the reserves (e.g., changes in sea level, shifts in marsh community structure and spatial extent, increased shoreline erosion, and deteriorating water quality). The document also stressed the need to accurately measure climate impacts to better inform coastal community decision-making. In January 2011, the reserve system launched a climate change initiative, with the goal to better understand, mitigate, and adapt to climate change-driven impacts on estuaries and coastal communities.

The first sentinel site application module was developed in response to this initiative. The focus is on changes in marsh, mangrove, and submerged aquatic vegetation related to climate-driven changes in sea levels and inundation.

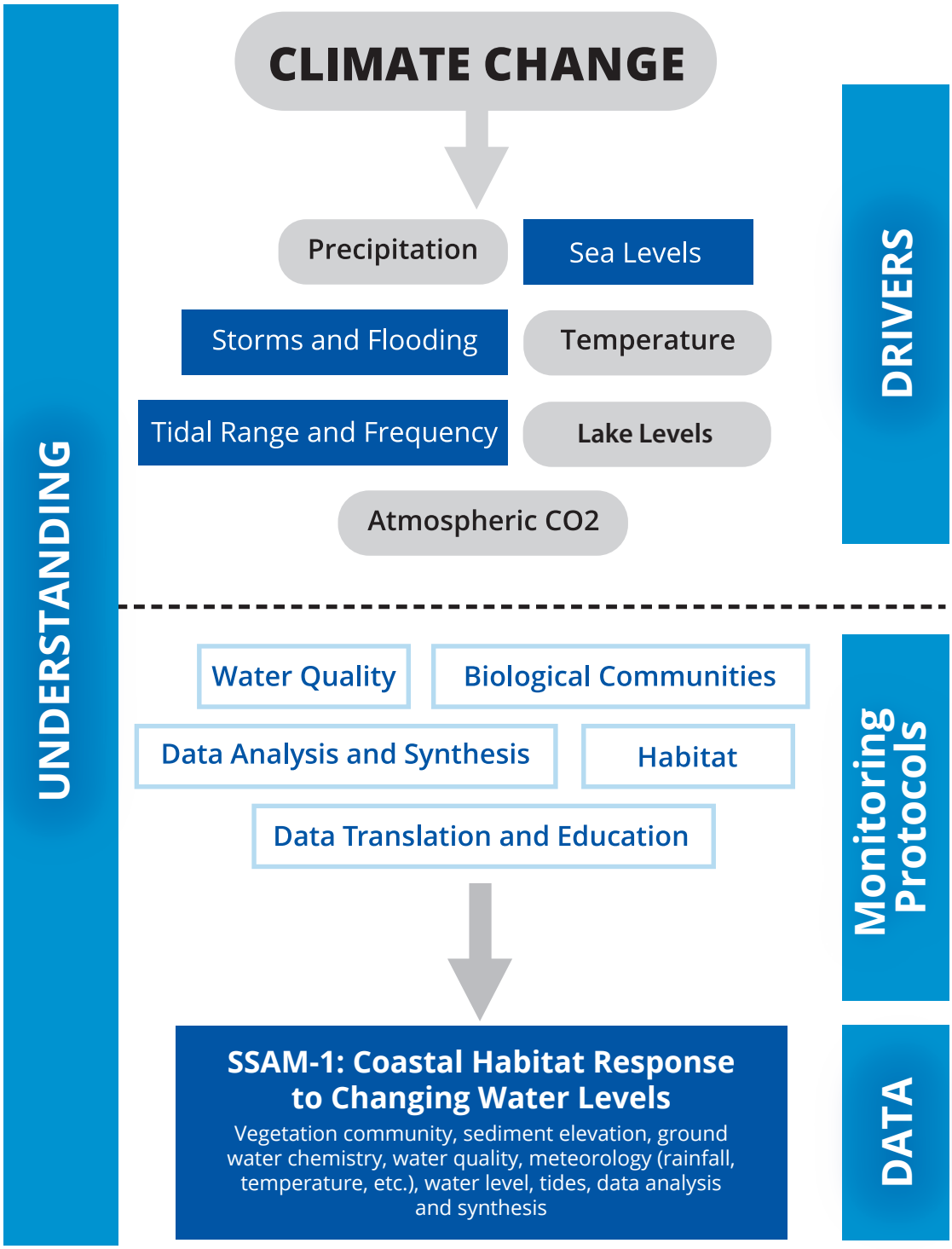


Figure 1: Conceptual model showing the reserve system's capacity to address a variety of climate change issues by using the Sentinel Site Application Module 1 (SSAM-1). A subset of climate drivers directly related to sea-level change and inundation (in blue squares) are investigated by a subset of monitoring elements and associated protocols to generate the necessary data (Sentinel Site Application Module) about these particular climate change impacts. Other climate change issues (e.g., drought or ocean acidification) or other challenges (eutrophication, invasive species) could be addressed by different application modules that target another subset of drivers and relevant monitoring elements

Relationship with NOAA's Sentinel Site Program

The NOAA Sentinel Site Program (*oceanservice.noaa.gov/sentinelsites*) provides a larger context for the information generated by the reserve system's sentinel site application modules. Because the reserves are place-based and have substantial investment in infrastructure and data products, the reserve data represent a foundational component of the larger NOAA effort. An added value is the syntheses of coastal responses to environmental change provided across a network of reserve sites consistently collecting data using the same protocols.

The initial focus of the NOAA Sentinel Site Program, like that of the reserve system's first sentinel site application module, is changing climate, particularly the effects of sea-level change and coastal inundation. Five "cooperatives" (Hawaii, San Francisco Bay Area, Chesapeake Bay, North Carolina, and Northern Gulf of Mexico) were chosen for study based on each location's scientific relevance to the issue, as well as capacity for leveraging existing resources, partnerships, and assets and the potential to inform the larger issues and respond with management action. Each cooperative includes at least one federally managed or funded coastal or marine protected area (e.g., a research reserve or a national marine sanctuary) for gathering data and a coastal commerce center. The reserve system has sites in San Francisco, Gulf of Mexico, Chesapeake Bay, and North Carolina, and all participate in the cooperative. A proposed research reserve site is in Hawaii.

Sentinel Site Application Module 1 – Coastal Habitat Response to Changing Water Levels

Focus

The first sentinel site application module (SSAM-1) developed for the National Estuarine Research Reserve System's SWMP data is focused on understanding changes in sea levels, inundation, and the associated responses of marsh, mangrove, and submerged aquatic vegetation. This focus could be expanded to include ecologically important transition zones that are characterized by scrub-shrub and coastal maritime forest.

Audiences and Applications

Audiences for products of this module include reserve staff members and their partners who need to understand the vulnerability of reserve resources to climate change to evaluate potential adaptation strategies. The data can also inform other resource managers and coastal communities in the vicinity of the reserve with similar interests and coastal management needs, such as setting restoration and land acquisition priorities; enhancing and conserving ecosystem services related to fish habitat, carbon sequestration, and nutrient and sedimentation traps; and studying wave attenuation. At a national scale, the SSAM-1 syntheses can highlight overall resilience of coastal vegetation in the face of water level changes and identify areas at greatest risk. These data can also be used to provide context for national products such as the Environmental Protection Agency's national wetlands assessment.

The information can be adapted by reserve education coordinators for teachers and students to satisfy the Next Generation Science Standards and other state-based educational standards, and can also form the basis for educating community members on these concepts.

Standardized Protocols

SSAM-1 protocols provide an integrated characterization of water levels and vegetation elevation measured on the same vertical scale, and are designed to detect correlated changes in water levels, wetland elevations, and vegetation. SWMP vegetation sampling protocols3 are designed to quantify horizontal rates of marsh migration and upland transgression, changes in species composition, and changes in the areal extent of submerged aquatic vegetation (SAV) communities. Protocols associated with measuring accretion and subsidence, and for establishing a geodetic frame of reference while simultaneously measuring water levels, provide the vertical component of the spatial reference system.

SSAM-1 protocols have been standardized and vetted by the SWMP guidance committee in partnership with the SSAM-1 workgroup. Carefully planned sampling designs and the use of standardized protocols are critically important for detecting changes and attributing them to related climate stressors, as well as characterizing the high natural variability in these coastal habitats. Standardized approaches are also critical for comparing data among sentinel sites or creating national syntheses.

Framing Questions

The following scientific questions are foundational to the implementation of SSAM-1, and all SSAM-1 reserves have the capability to respond to each framing question with the required protocols:

- What are the current distributions of vegetation communities with respect to elevation and tidal range, and how sensitive are spatial distributions and community composition of marshes, mangroves, and SAV beds to interannual variability, including that driven by discrete episodic inundation events in local sea levels, tidal range, and inundation patterns?
- What is the response, in terms of spatial distribution and community composition of marshes, mangroves, and SAV beds, to long-term changes in local water levels and inundation patterns (e.g., changes in mean water level, tidal amplitude, and storm frequency and intensity)?
- What is the response of sediment elevation of marsh, mangrove, and SAV habitats (with respect to changes in sediment deposition, accretion, or subsidence) to discrete episodic inundation events, as well as long-term changes in local water levels and inundation patterns?

Required Components

The following components are required for full participation in the National Estuarine Research Reserve System's Sentinel Site Application Module-1:

Development of a SSAM-1 Plan: Working with NOAA staff members and external partners, reserves must develop an implementation plan. A plan template has been developed by the SSAM-1 workgroup with input from reserves, and all reserve plans will be reviewed by the workgroup. The plans must identify appropriate audiences and management issues. Reserve staff members, in collaboration with local and national stakeholders, must develop an explicit written plan and rationale for the use of the information generated by SSAM-1 monitoring, and should clearly articulate the relevance to management issues both within the reserve and in adjacent coastal communities. The plan should also include how the reserve will communicate the data or related activities to resource managers and other stakeholders, how the data will be used in education activities and other outreach programs, and how experiences and "lesson learned" will be communicated within the National Estuarine Research Reserve System.

The plans must also identify on-site programmatic capacity to implement SSAM-1. Reserve staff members must be trained to collect and analyze SSAM-1 data and ancillary information. These requirements are in addition to existing training requirements for collecting core system-wide monitoring data (water quality, nutrients, and meteorological data). The SSAM-1 plan for each reserve must identify resources for long-term continuous support (including staffing and funding) for SSAM-1 activities at the reserve. The plan should be incorporated into the reserve management plan, and the appropriate tasks should be included in reserve operations awards.

Tidal Marsh, Mangrove, or SAV Monitoring: Monitoring the quantity and quality (through sampling vegetation transects) of vegetation must be conducted in accordance with the SWMP biological monitoring protocols for emergent or submersed vegetation3 (Fig. 2), and the use of National Estuarine Research Reserve System habitat maps and mapping protocols.

Wetland Surface Elevation Change Measurements: Measurement of initial elevation and elevation change (both deposition/accretion and subsidence/erosion) of wetland sediments will be accomplished by using surface elevation tables (SETs) within the vicinity of permanent vegetation transects, so elevation changes can be correlated to changes in vegetation communities7 (Fig. 3). In some reserves (e.g., those impacted by ice, or with other sediment conditions not conducive to SET installation) this protocol is not required. Rather, other protocols for characterizing marsh elevation change, such as use of digital elevation models may be substituted.

Vertical Reference System for Water Level Measurements: NOAA protocols and procedures for establishing high accuracy local geodetic control networks to connect SETs, SWMP water quality stations, vegetation transects, ground water wells, and digital elevation models on the same vertical datum must be followed. Working with NOAA's National Geodetic Survey and Center for Operational Oceanographic Products and Services, reserves will establish a local network of benchmarks tied to both local tidal datums and the National Spatial Reference System. All relevant SWMP monitoring locations, including vegetation monitoring transects, SETs, and data loggers must be surveyed in to this local network consistently through time to establish and accurately track the spatial relationships between the observed environmental parameters.

Ability to Detect Elevation Changes: Elevation surveys should be conducted every two to three years at permanent vegetation transects, or a digital elevation model with appropriate resolution in the area of interest should be produced and updated every three to five years.

Water Quality Data: Continuous monitoring of core SWMP parameters including pH, turbidity, dissolved oxygen, temperature, and salinity2 at stations located adjacent to or within ecologically relevant proximity of SSAM-1 vegetation transects must be conducted.

Meteorological Data: Continuous monitoring of core SWMP parameters including temperature, relative humidity, barometric pressure, wind speed and direction, rainfall, and photosynthetic active radiation2 must be conducted at stations located adjacent to or within ecologically relevant proximity of SSAM-1 vegetation transects.

Elective Protocols: Elective protocols may be implemented by a single or a subset of reserves as part of their SSAM-1 plan, but are not required for a participating reserve to be included in a national synthesis of SSAM-1 data, and currently will not be funded at the system-wide level. These protocols may address issues that are associated with specific management issues, or provide data or other ancillary information that complements the suite of required protocols. For example, measurements of ground water levels and pore-water salinity along vegetation transects are useful in predicting vegetation zonation changes, and water column suspended sediment concentrations are critical to understanding net accretion rates. By adding the same elective protocols, groups of reserves facing similar issues can coordinate their activities. The rationale for these activities should be identified in the reserve's SSAM-1 Plan.

Products and Applications

SSAM-1 data will be used to inform local and regional management, characterizing the current status of vegetation and elevation relative to water levels, and elucidating the key processes of importance. An effort is currently underway to identify key audiences for SSAM-1 data and products.

The use of consistent protocols also allows for comparisons across reserves. A national product—an analysis of marsh resilience in the face of sea-level rise across 20 reserves—is being developed. Reserve scientists developed novel, multi-metric indices to assess the overall resilience of the nation's marshes in the face of sea-level rise and identify areas at greatest risk.

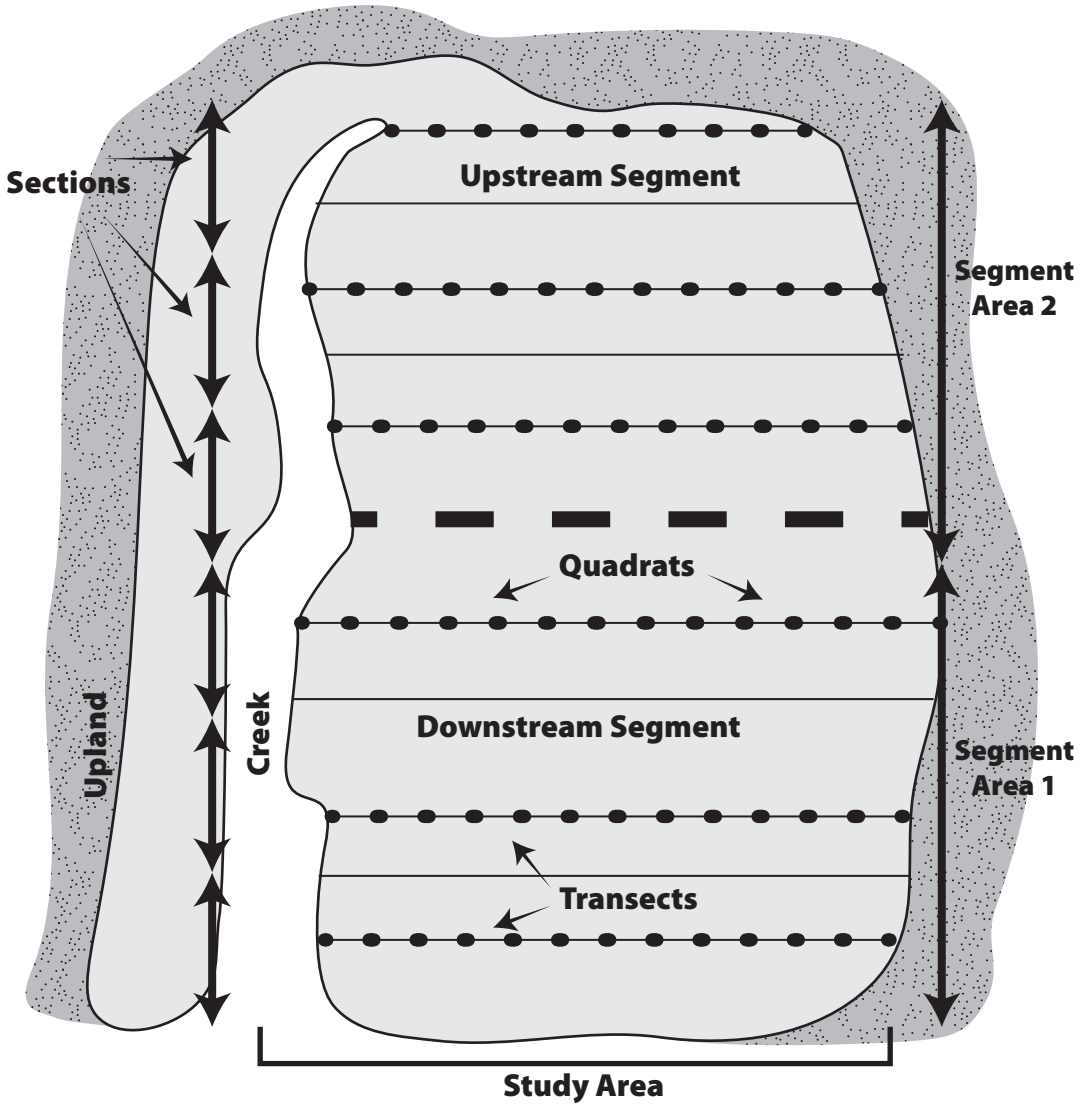


Figure 2: Emergent Marsh Sampling Design (Roman and others, 2001)

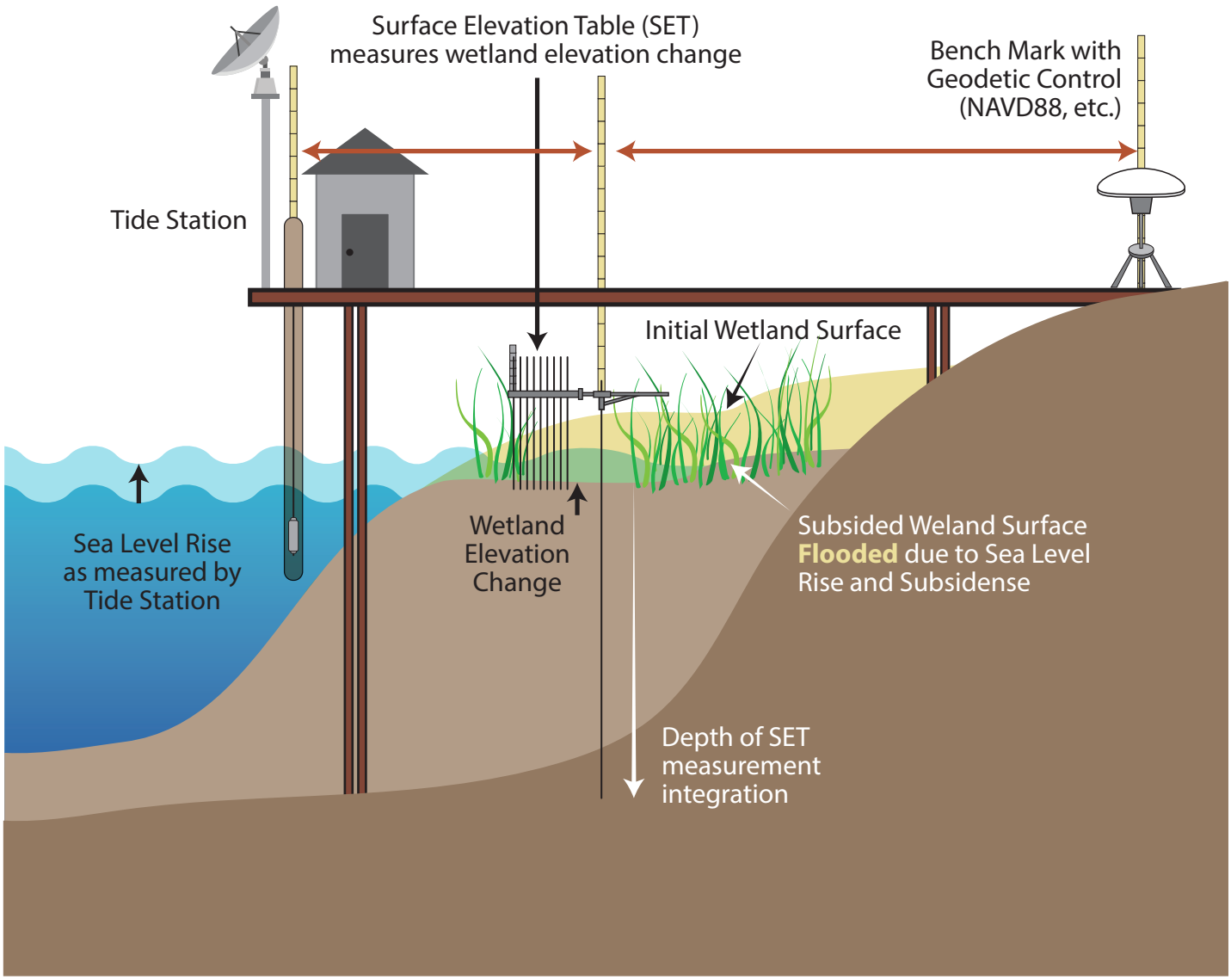


Figure 3: An example of a geospatial infrastructure conceptual model designed to study impacts of increasing water levels. This infrastructure will be tied to vegetation transects.

Supporting Documents

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