



Cape Cod Ecosystem Monitoring



As part of the National Park Service effort to *“improve park management through greater reliance on scientific knowledge,”* the Cape Cod Ecosystem Monitoring (CEM) program was established to develop and implement a long-term monitoring program to aid park managers in making sound natural resource stewardship and management decisions.

Introduction

The Cape Cod National Seashore (CCNS) is part of the Northeast Coastal and Barrier Network (NCBN), one of the 32 National Park Service Inventory and Monitoring (I&M) Networks. The I&M program utilizes long-term ecosystem monitoring to track specific physical, chemical, and biological components and processes called “Vital Signs,” which were selected to serve as indicators of the status and trend of park resources. At CCNS, 17 protocols are currently implemented for Vital Signs monitoring, using standardized methods for training, data collection, and analysis. Additional monitoring, focused on collecting short-term or project-specific data, has been developed to augment Vital Signs monitoring, providing a more comprehensive description of park resources.

The overall goals of the Vital Signs Monitoring Program are:

- determine the status and trends, in selected indicators, of the condition of park ecosystems
- provide early warning of abnormal conditions of selected resources
- provide data to better understand the dynamic nature and condition of park ecosystems
- provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment
- provide a means of measuring progress toward ecosystem performance goals

Spadefoot toad at Cape Cod National Seashore. The relatively robust populations documented at CCNS highlight the importance of the park as critical habitat for these and other pond-breeding amphibians.



CCEM Goals & Responsibilities

In addition to the overall goals of the NPS I&M Program, CCEM has several goals specific to the park:

- detect changes in particular attributes of the coastal ecosystem and determine if those changes are within the bounds of natural or historic variability
- predict how those changes relate to natural processes and human influences
- understand how such changes ultimately affect the condition of coastal ecosystems

CCEM Responsibilities:

- develop an ecosystem monitoring program that is scientifically sound and relevant to management of park resources
- test inventory and monitoring methods
- develop and implement long-term monitoring protocols
- conduct studies to help refine monitoring questions and to interpret monitoring results
- share experiences and technical expertise with other parks

CCEM Approach

The CCEM program utilizes a long-term approach to data collection and analysis to deepen the understanding of the ecosystems within the park and support long-term decision making. Toward this end, the CCEM program has adopted an ecosystem-based, issue-oriented approach for monitoring ecosystem integrity. The ecosystem-based approach uses natural, hierarchical subdivisions of the coastal landscape as a template for monitoring changes in ecological phenomena associated with both natural and human causes. The issues orientation focuses on the relevance of the monitoring

results to meet the goals of management directed at sustaining the quality or the integrity of coastal ecosystems. Monitoring protocols have been developed to track specific aspects, or indicators, of the status and trend of priority ecosystems and issues.

One of the goals of the program is to design and implement monitoring protocols not only for CCNS but for other NPS units sharing similar resources and ecological communities; therefore, protocols are designed to be park-specific but adaptable to other parks within the NCBN and those along the Atlantic and Gulf coasts.

CCEM Supporting NCBN and Other Regional I&M Needs

CCNS scientists are available to support NPS I&M needs beyond the boundaries of the seashore. To date, significant contributions have been made to the development of I&M programs for other NPS units and regional I&M networks. Examples of CCEM support to external units include:

- serving on the NCBN Estuarine Nutrient Enrichment Science Advisory Group
- completing chlorophyll analyses for NCBN parks for the Estuarine Nutrient Enrichment protocol
- providing technical reviews of the vegetation monitoring protocol for the NCBN
- assisting with shoreline change data collection at Fire Island and protocol development for the NCBN
- Real Time Kinematic (RTK) GPS training for the NCBN
- completing amphibian and reptile inventories for Northeast parks and reviewing technical documents on park amphibians and reptiles, such as “Resource Briefs” or “Watershed Condition Assessments” (Acadia, Assateague, Delaware Water Gap, Fire Island, Gateway, Minuteman, Morristown, Saint-Gaudens, Sagamore Hill, Saratoga, Saugus Ironworks, Weir Farm, William Floyd Estate)
- providing analyses of forest monitoring data and consultation for the Northeast Temperate Network (NETN) forest monitoring effort
- providing protocols, SOPs, and field guidance to the NETN to assist them in establishing a hydrologic protocol for their parks



Kettle pond water quality monitoring



Collecting RTK GIS data for shoreline position monitoring

CCEM Monitoring for Management Decision Making

CCEM data have been used in numerous instances to support resource management in the park and in the communities of the outer Cape. Examples include:

- Cape Cod Transportation Planning utilized CCEM pond breeding amphibian data to reduce road-related mortalities of threatened spadefoot toads
- data from kettle pond water quality monitoring were used to identify nitrogen as a limiting factor for certain

species of phytoplankton, allowing for management of N inputs to reduce nutrient loading

- coastal shoreline and eelgrass monitoring data were used to inform decision-making regarding the removal of cottages on a barrier beach
- groundwater monitoring data were used to document that variation in pond water levels was due to climate variations and not municipal groundwater pumping

Short-term or Project-specific Monitoring

The CCEM monitoring team is invaluable to the successful deployment of the long-term monitoring program at the seashore. This team and its expertise has also contributed to project-specific, short-term monitoring when needed to meet management goals. Examples of key project-specific monitoring efforts include:

- baseline monitoring prior to restoration of the Herring River watershed
- monitoring of horseshoe crab populations in East Harbor
- monitoring of shorebird activities including federally protected piping plovers and endangered roseate terns

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CCEM Vital Signs (as of July 2013) Each vital sign has been categorized according to the NPS ecological monitoring framework. This table is built off Table 3.1 in Stevens et al. (2005), but contains updated CCEM program information and example parameters under each vital sign.

Tier 1	Tier 2	Vital Sign	Example parameters	Protocol	Protocol Status	Start Date
Air and Climate	Air Quality	Air Contaminants	Concentration	Meteorologic & Atmospheric Monitoring	These air and climate parameters are monitored according to standard program protocols developed and implemented by various cooperating agencies. Information about these specific monitoring programs in the CCEM is presented in USGS, URI, and CCNS (2001) and Lee (2011).	1981
		Ozone				
		Fine Particles				
		Visibility	Haze index			
	Nitrogen/Sulfur Deposition	Concentration in wet and dry deposition				
Weather and Climate	Weather	Precipitation				
Biological Integrity	Focal Species or Communities	Anurans	Egg mass counts, calling surveys	Pond-Breeding Amphibians	CCEM-specific	2003
		Salamanders	Egg mass counts		CCEM-specific	2003
		Marsh Birds	Abundance	Marsh Birds	Joint CCEM/NCBN protocol in development, based on Saltmarsh Habitat & Avian Research Program	2013
		Kettle Pond Vegetation	Community Structure	Pond Vegetation	CCEM-specific	1995
		Provincelands Pond Vegetation			CCEM-specific	1995
		Vernal Wetland Vegetation		Vernal Wetland Vegetation	CCEM-specific	2006
		Coastal Forest Vegetation		Coastal Forests	CCEM-specific	1983
		Salt Marsh Nekton		Estuarine Nekton	Joint CCEM/NCBN protocol	2003
		Salt Marsh Vegetation		Salt Marsh Vegetation	Draft joint CCEM/NCBN protocol in review	2003
		Coastal Heathland Vegetation		Coastal Heathlands	CCEM-Specific	1987
		Dune Grassland Vegetation		Dune Grassland Vegetation	CCEM-specific	2005
		Dune Slack Wetlands		Dune Slack Wetland Vegetation	CCEM-specific	2003
		Seagrass Condition		Eelgrass biomass, abundance, fouling, light available	Estuarine Nutrient Enrichment	Joint CCEM/NCBN protocol
		Upland Birds	Species richness & abundance	Upland Birds	CCEM-specific, protocol in development	2001
		Small Mammals	Species richness & abundance	Small Mammals	CCEM-specific	2000
Geology and Soils	Geomorphology	Salt Marsh Sediment Elevation	Accretion/erosion	Salt Marsh Sediment Elevation	Joint CCEM/NCBN protocol in development	1998
		Shoreline Position	High tide line position in spring and fall	Shoreline Change - position	Joint CCEM/NCBN protocol	2005
		Coastal Topography	2D, 3D, changes, e.g. bluff edge, dune crest		Joint CCEM/NCBN protocol in draft	2011
Land-scapes	Landscape Dynamics	Landscape Change/Cover Type Mapping	Change in distribution of habitats, disturbed areas	Cover-type Mapping	CCEM-specific, protocol in development	2013
Water	Hydrology	Groundwater Dynamics	Monthly water level	Hydrology	CCEM-specific	2000
		Surface Water Dynamics	Stream gage, pond stage		CCEM-specific	2000
	Water Quality	Estuarine Water Chemistry	Dissolved oxygen, temperature, salinity	Estuarine Nutrient Enrichment	Joint CCEM/NCBN protocol	2007
		Estuarine Water Clarity	Photosynthetically available radiation, turbidity		Joint CCEM/NCBN protocol	2007
		Kettle Pond Water Quality	Secchi depth, pH, temperature, conductivity, dissolved oxygen, etc.	Kettle Pond Water Quality	CCEM-specific	1970s