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Development of a Geomorphological Map of Assateague Island National Seashore

Principal Characteristics and Components

Natural Resource Report NPS/NRSS/GRD/NRR—2018/1592

ON THE COVER
Big Levels and Fox Hill Level
Assateague Island National Seashore
Image credit: Google™ Earth
March 8, 2013 (accessed December 17, 2014)

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Norbert P Psuty, Irina Beal, William Schmelz, Andrea Spahn

Sandy Hook Cooperative Research Programs
74 Magruder Road
N.J. Agricultural Experiment Station
Rutgers University
Highlands, New Jersey 07732

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Contents

Figures

Page

Tables

Page

Executive Summary

This report incorporates the post-Sandy geomorphological map, its philosophical underpinnings, legend descriptions, and the GIS data layers for the Maryland portion of Assateague Island National Seashore. The theme of the map follows the current scientific organization of geomorphological mapping that includes morphometrics, causative processes, and evolutionary stages. Surface form was interpreted from data sets including recent orthophotos and recent Light Detection and Ranging (LiDAR) data sets, augmented with spatial information on geomorphology, soils, and vegetation, as well as field visits.

The geomorphological features of the site include: 1) coastal topography that was created during an early phase of coastal barrier island development; 2) coastal topography that developed seaward of the early stage of barrier island evolution; 3) coastal topography that resulted from episodic breaches, inlet formation, and inlet closure; and 4) anthropogenic modifications to the natural topography, consisting of fill or excavation. The geomorphological map and its legend portray the spatial and temporal association of the surface features created during these stages of landscape development, as well as the broad anthropogenic alterations of the landscape. This portrayal of surface form is based on data sets from the post-Hurricane Sandy period (post-October 2012).

The geomorphological map is viewable as a full compilation of all of the data layers as well as user specified combinations of the data. Each of the map layers contained in this report meets the standards of Federal Geographic Data Committee (FGDC) compliant metadata. The full set of organized data layers is available from the National Park Service Geologic Resources Division: http://go.nps.gov/gripubs.

Acknowledgments

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Introduction

Assateague Island National Seashore (ASIS) is one of 270 National Park System units designated to have a digital geological/geomorphological map and an accompanying Geological Resources Inventory report. These products are intended to provide a valuable synthesis of the physical makeup of the site and assist in applying appropriate strategies in the management of its natural and cultural resources. Under the sponsorship of the NPS Geological Resources Division, an early version of an ASIS geomorphological map was produced by Morton et al. (2008), a hydrogemorphological map was generated by Krantz (2010), and a report by Schupp (2013) described the geological resources and the evolution of the surface configuration.

The concept of a geomorphological map has its origins in a publication by Passarge (1914) and the representation of the surface characteristics of the Stadtremba, Germany quadrangle that gave emphasis to the presence of river terraces as specific physical features in the landscape. Following this early representation, subsequent portrayals of the geomorphological character of the earth surface incorporated elements of the morphology as well as the causative origins of the features (processes) and their chronological development (sequence of formation) (St. Onge 1968). The modern geomorphological map incorporates the elements of form, functional processes, and sequential development to depict the evolution of surficial and spatial characteristics (Dramas et al. 2011). The geomorphological map presented in this report identifies the products of the earth-forming processes on the deposition, mobilization, and subsequent accumulation of sediments to create the resulting sequential assemblage of geomorphological characteristics at ASIS.

Coastal areas are especially dynamic because of the interaction of variable sediment supply, sea-level rise, and aperiodic storm events. The resulting topography is further affected by the human manipulation of the drivers of change as well as the products of change. The geomorphological features of ASIS were affected by Hurricane Irene (August 2011) and Hurricane Sandy (October 2012) that added another step in the geotemporal evolution of the barrier island. As a result, the focus of this report is the creation of a geomorphological map representing the landform characteristics following Hurricane Sandy, an event that caused considerable overwash, sediment mobilization, and modification to the pre-existing topography.

Site and Situation

The Assateague Island barrier island extends north-south 58 km from Ocean City Inlet at its northern margin to Chincoteague Inlet at its southern point (Figure 1). The geomorphological maps of Assateague Island National Seashore (ASIS) encompass the northern 36 km of the island, extending to the border with Chincoteague National Wildlife Refuge, the boundary between the two national holdings is near the Maryland and Virginia border. Assateague State Park lies within ASIS, with an alongshore extent of 3.26 km. North of Assateague State Park, the island is very narrow, 330 m from the ocean to the bay. South of the state park, island width increases to as much as 890 m. Although in a protected status at present, human manipulation of the surface has altered many aspects of the natural topography, resulting in a combination of original and anthropogenically-modified landforms.

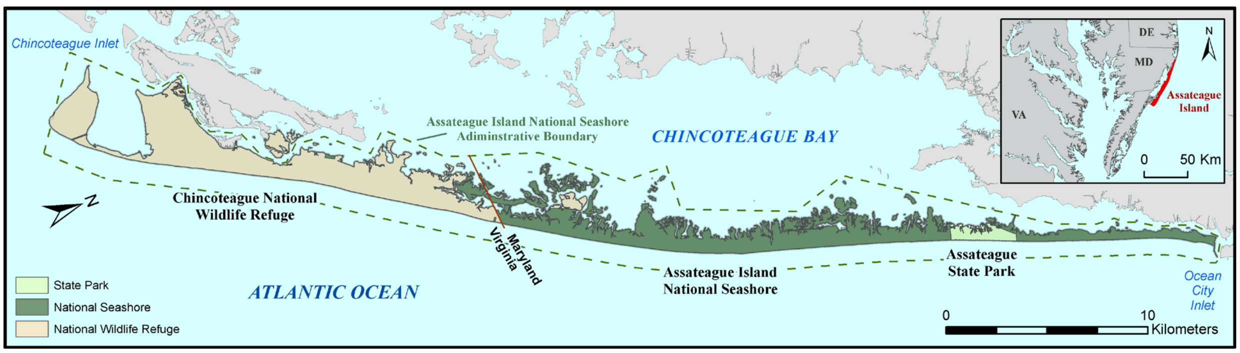

Figure 1. Location of Assateague Island and the administrative units present on the barrier island.

Geomorphological Evolution

The conceptual approach to describing, depicting, and mapping the geomorphological characteristics of Assateague Island is based on the components of morphometrics, causative processes, and temporal sequence of development of the surface of the island. This tripartite organization is the essence of modern geomorphological maps (Dramis et al. 2011) that combines the processes and the surface expression of the sedimentary formations (either in their erosional or depositional form). Further, the map legend (discussed later) is developed to track the evolution of the surface features and their associated causative processes, and to add the cultural imprint on the landscape.

Assateague Island is of Late Holocene age (~3,000 years) and is a continuation of the barrier island system that extends southward from the Pleistocene headlands in Delaware (Walker and Coleman 1987; Hobbs et al. 2008). It is part of the barrier island system that has undergone stages in development following the model proposed by Fisher (1982) that is driven by a downdrift reduction in sediment supply. In this model, the very dynamic downdrift terminus of a group of barrier islands is characterized by multiple inlet openings and closures that result in alternating segmentation and continuity of the island system and its associated surface features. Assateague Island is such a downdrift component of a barrier island system and it has evolved from a geomorphological site with a variable number of islands separated by inlets at times in the past to a continuous island seen today. Krantz et al. (2009) portray this dynamic condition as recorded in several of the historical maps and charts of the area (Figure 2). The most recent inlet development occurred in 1933 when a breach created Ocean City Inlet and produced the present Assateague Island. Jetties were constructed in 1934-35 to maintain this inlet. The jetties stabilized the inlet; as a result, they caused an interruption in alongshore sediment transport that led to downdrift sediment starvation and the displacement of the northern part of Assateague and its associated landforms inland by more than 350 m (Brock et al. 2004; Zimmerman 2004).

The dominant geomorphological processes creating the surface topography are the coastal waves and currents that transport and shape the ambient sediment supply to form an active beach and adjacent foredune. The foredune is further molded by wind. The foredune feature is the primary landform throughout Assateague Island, as it is on all barrier islands. The active foredune represents the sand in storage above the active beach, and abandoned foredunes represent periods and locations of positive sediment budget that have prograded the island seaward and/or extended the island downdrift (to the south).

Whereas the foredune ridge is the prominent topographical feature on the island, the myriad of open and closed inlets along Assateague in the past are fundamental in determining the distribution and spatial sequences of these ridges. The inland portion of the island retains the oldest forms, the ancestral features. These are locations of ancestral barrier islands composed of accretionary ridge and swale complexes formed at former shorelines associated with inlets and island migration. Many of the ancestral ridge and swale areas have subsequently been dissected by a combination of storm surge and eolian processes (i.e., overwash, breaching, deflation, blowouts) to form discontinuous lineations. Seaward of the segmented dunal ridges are dunal features that are more continuous alongshore but are no longer in active sediment exchange with the beach. They are associated with a progradational phase of the island, seaward displacement of the beach-dune system and greater alongshore continuity. Some of these ridge forms may be dissected to various degrees due to the continual reworking by wind and storm surge. Located between the ancestral island segments and the continuous active beach, these dune ridges are now abandoned (no longer in active exchange with the beach) or relict foredune features. At the seaward margin of the barrier island is the active beach-dune system composed of the free sand beach and the adjacent foredune ridge. The active foredune is in the state of exchanging sediment with the beach during a variety of temporal cycles, storing sand and enlarging the shore-parallel ridge form at some times but losing sand to the beach and decreasing in dimension at other times. Under conditions of severe erosion, the coastal foredune ridge may have gaps in its continuity, or may be reduced to a series of shore-parallel mounds or hummocks. It is the potential for active sediment exchange in an alongshore mode that describes the active zone of beach and foredune.

At Assateague, the landform pattern is greatly influenced by storm events that have moderately or severely disrupted the continuity of the coastal foredune. This disruption may be accompanied by overwash events that have led to the creation of sand flats that extend inland into and through the zone of active, abandoned, and ancestral features. These sand flats are generally planar, but may have an array of sand mounds and ridges in active displacement on the bare sand surface. In some instances, the inlets have become sealed and the sand mounds and ridges have become abandoned features.

The natural evolution of the surface topography at Assateague has created a mosaic of ancestral, abandoned, and active ridges and swales interrupted by washover features. The topography has also been modified by the actions of humans. Roads, artificial ridges, dikes, dredged channels, and other associated anthropogenic impacts have altered the natural topography and describe another suite of surface forms.

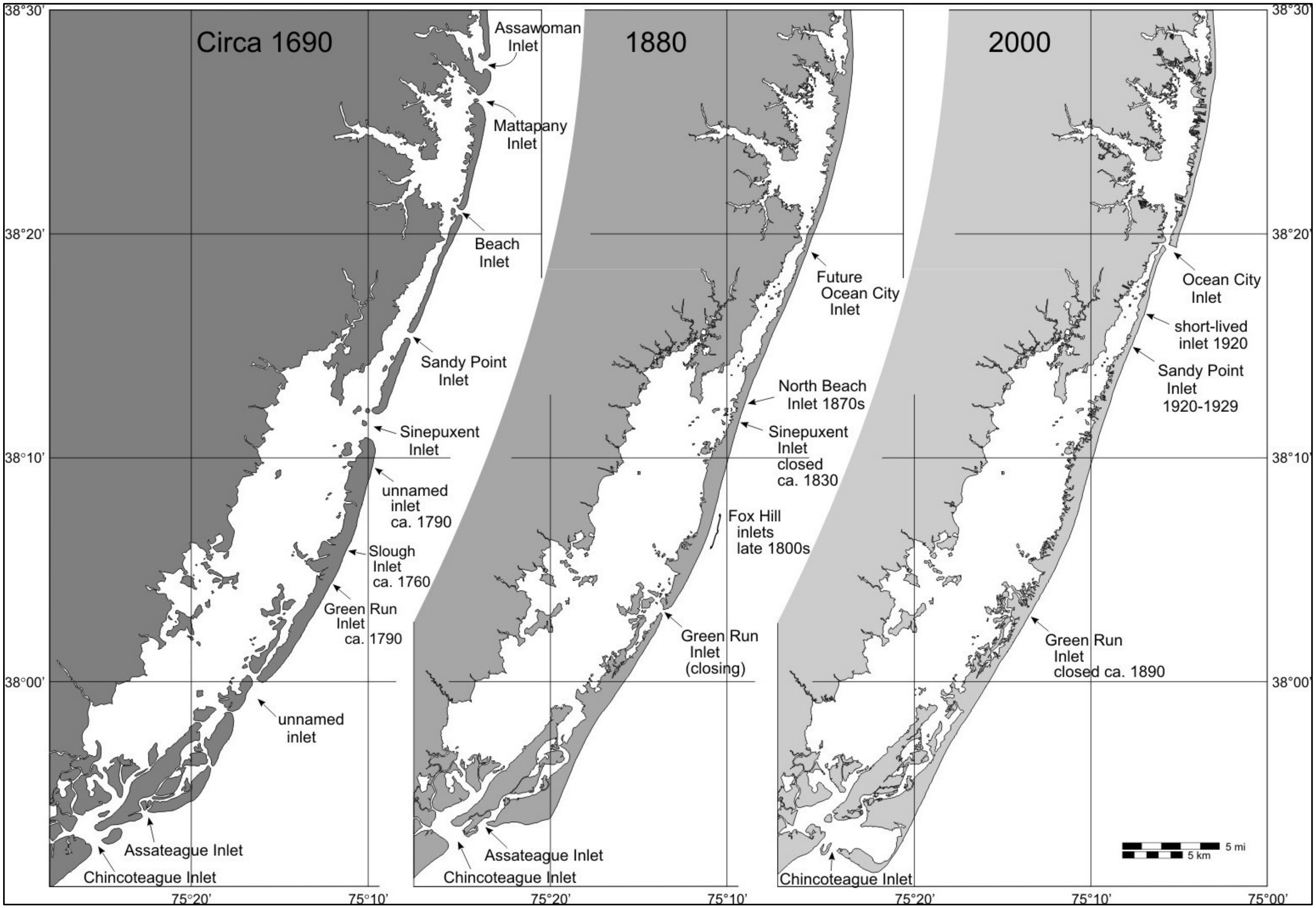

Figure 2. Portrayal of the dynamic nature of barrier island inlets through time within Assateague and Fenwick Islands (Krantz et al. 2009).

Resources to Aid in Spatial Recognition of Features

A geographical information system (GIS) was utilized for the construction of the geomorphological map of ASIS. A number of spatial datasets, including orthophotos, light detection and ranging (LiDAR), and additional sources of geographical information that are described below (Table 1), comprised a geodatabase used as a resource to generate the map.

Orthophotography

A primary tool in the identification of geomorphological features was post-Hurricane Sandy orthophotography, collected on October 31, 2012 by the National Oceanic and Atmospheric Administration (NOAA) and distributed by the Hazard Data Distribution System.
Imagery covering the Maryland portion of Assateague Barrier Island included 43 image tiles taken with 0.5 ft spatial resolution (NOAA 2012). Portions of the images were obscured by dense cloud cover or did not cover the mapped area in its entirety. Thus, as a supplement, a 2013 high-resolution imagery data set was also used. This data set comprised 74 image tiles at 0.5 ft spatial resolution collected by Axis Geospatial (MD iMap 2013). Images were acquired on February 25, March 4-5, and March 23, 2013.

LiDAR

LiDAR data sets were used to generate surface topography and measures of elevation and slope. The post-Hurricane Sandy 2012 LiDAR data set covering coastal Maryland and Virginia was collected on November 9-11, 2012, by the Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), and Office for Coastal Management (OCM) (NOAA et al. 2012). It was published on November 14, 2012, by NOAA's Ocean Service and Office for Coastal Management (OCM). The point cloud was classified into bare-earth (Class 2 – Ground) and non-ground points. The data sets incorporated topographic LiDAR data in Log ASCII Standard (LAS) format.

Surface Geomorphology

Among pre-Hurricane Sandy portrayals of the surface topography of ASIS was the geomorphological map produced by Morton et al. (2008) and the hydrogeomorphic map produced by Krantz (2010). Each map source presented aspects of the topographical conditions that were helpful in understanding the evolution of the surface forms and in considering the modifications created by the Hurricane Irene (August 2011) and Hurricane Sandy (October 2012).

Additional Sources

Additional sources of spatially-organized data include a land cover and land use map derived from NOAA Coastal Change Analysis Program sources downloaded from the NPS Integrated Resource Management Application (IRMA) website (https://irma.nps.gov/). An administrative history of Assateague Island National Seashore provided information about park development, use, and hunting practices (Mackintosh 1982). A recent study compiled the history of waterfowl hunting camps and related properties (Eshelman and Russell 2004). Thornberry-Ehrlich (2005) summarized the physiography, geologic history, and stratigraphy of the area. Locations of buildings, infrastructure, and boundaries were accessed from the NPS IRMA website. Roads and walkways were acquired through the NPS IRMA site as well as digitized from the orthophotos. Historical aerial imagery available through the National Park Service provided context in identification of potential anthropogenic features. Classification of wetlands in 2010 by the Maryland Department of Agriculture (MDA 2012) were accessed through the NOAA OCM Coastal Change Analysis Program (C-CAP) website (https://data.noaa.gov/dataset/coastal-change-analysis-program-c-cap-regional-land-cover-data-and-change-data).

Table 1. Source and quality of spatial data

Data	Year of Acquisition	Spatial Resolution	File Type	Source
Orthophotos	2012	0.5 ft	.TIF	NOAA
Orthophotos	2013	0.5 ft	.JP2	MD iMAP
Aerial imagery	1962	0.5 ft	.TIF	NPS archives
LiDAR (bare earth)	2012	0.8 m (1.1 m)*	.LAS	NOAA OCM
Land Cover	2006	-	Raster	NPS IRMA
Road/ Walkways	2010	-	.shp	NPS IRMA and digitized from orthophotos
Wetlands	2010	-	.shp	NOAA OCM C-CAP

* point spacing

Methodology of Topographical Development

The initial approach of landform identification used 2012 and 2013 orthophotographs of Assateague Island (see example in Fig. 3) to establish the geographical coordinates of the geomorphological units. The next phase utilized the 2012 bare earth LiDAR data set for Assateague Island provided by NOAA's Office for Coastal Management to create digital elevation models (DEMs). The LiDAR bare earth DEMs produced by this data set exhibited some noise in areas of dense vegetation. To minimize these surface perturbations, the raw LiDAR data points were filtered using the Reduce Point Density method via Airborne LiDAR Data Processing and Analysis Tools (ALDPAT) software to create a new bare earth DEM (Zhang and Cui 2007). The Reduced Point Density method searches for and chooses the point of minimum elevation within a specified area, or window, to represent that location. Three iterations of this filtering were applied to the bare earth LiDAR points, enlarging the window each time (1 m, 3 m, and 5 m). Each subsequent iteration was applied to the filtered data points of the previous iteration and a reduced point density LiDAR surface was produced from the third iteration of this filtering process (Fig. 4). This provided sufficient relief to determine the spatial boundaries of the geomorphological features while discarding most noise associated with non-ground points. The reduced density point cloud was then interpolated into a 2.5 m resolution DEM using the Kriging method with a 50 m search radius. The resulting product of the reduced point density approach was a DEM that was less detailed than the original DEM because the minor variations had been smoothed to emphasize the general trends in elevation.

An additional product of the DEM was the identification of changes in slope and dimensions of relief to help focus on the major topographical forms. Isolines of slopes were plotted to depict boundaries between ridges and swales, and to group similar topographical units (Fig. 5). A measure of relief was used to eliminate minor topographic changes. The result was a landform distribution categorized into ridges and swales of various dimensions and continuity based on changes in elevation, slope, and local relief (Fig. 6). After the juxtaposition of dune ridge features was determined, their sequential evolution was interpreted using the fundamentals of vectors of sediment supply, sediment transport direction, and sediment budget. This process led to a dichotomy of active shore-parallel dune-beach features versus abandoned dune ridge and swale features that were situated at some inland position (Fig. 7). The inland dune ridges and swales were further subdivided into those parallel to the current shoreline (modern and abandoned) and those aligned with a prior shoreline with a different orientation (ancestral). Together, the spatial mix of dune ridges and swales, interspersed with breaks in the continuity and alignment to the active shoreline, combined to form the foundation for the ASIS geomorphological map (Fig. 8). An additional enhancement of the elevation portrayal was performed by adding a shading effect generated by applying the hillshade tool in ArcGIS on the reduced point density DEM layers and incorporating that view in the geomorphological map (Fig. 9). The hillshade tool simulates illumination and shading of a 3-dimensional topographic surface, creating the appearance of relief on a 2-dimensional surface.

Creation of a geomorphological map that represents a point in time (post-Sandy) leads to the issue of comparison with previous geomorphological maps and the establishment of metrics of change derived by that comparison. As intriguing as that may be, such as comparison would necessarily be grounded in maps that have the same methodology in defining boundaries and landform categories, as has been accomplished for post-Sandy geomorphological maps of Fire Island (Psuty et al. 2016) and Gateway National Recreation Area (Psuty et al. 2017). The lack of comparably-derived maps for ASIS precludes this possibility, although there is interest in the creation of a pre-Sandy map following the same procedures and producing metrics of change.

Figure 3. 2012 orthophotograph of active beach and adjacent inland topography at the northern extent of the historical Sinepuxent Inlet.

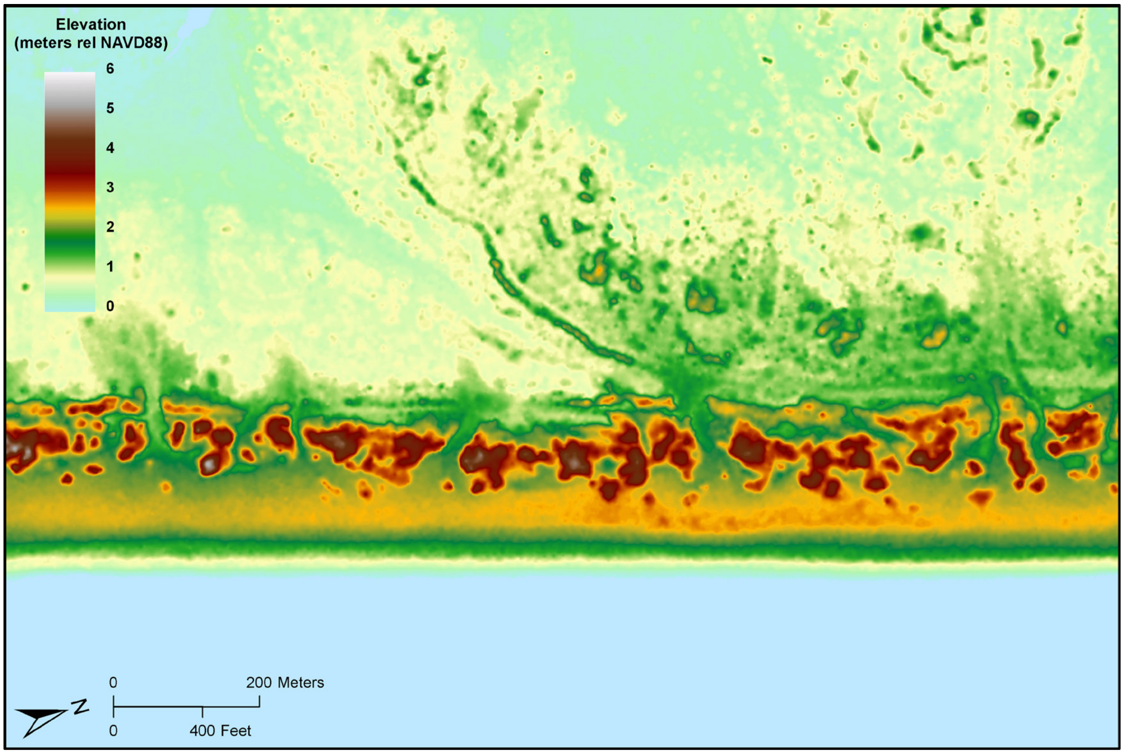

Figure 4. Digital elevation model (DEM) created from 2012 LiDAR data set with reduced point density.

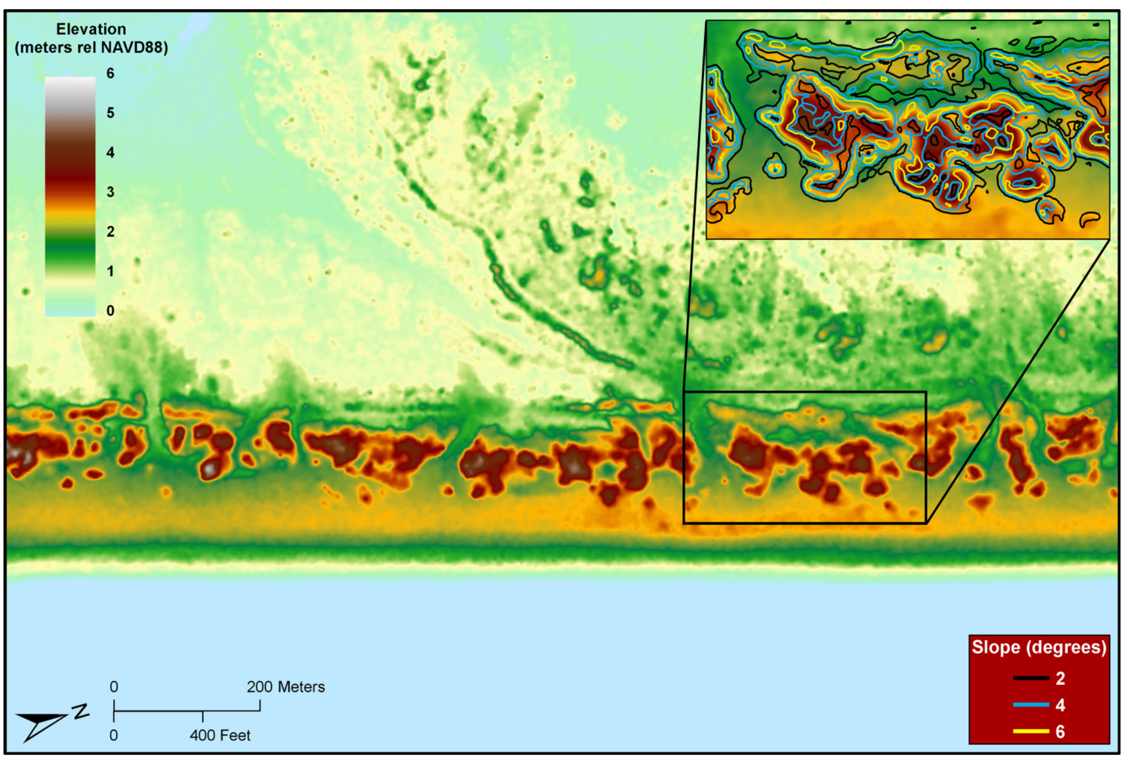

Figure 5. DEM with inset that incorporates the addition of slope isolines within the DEM to aid in the definition of landform boundaries.

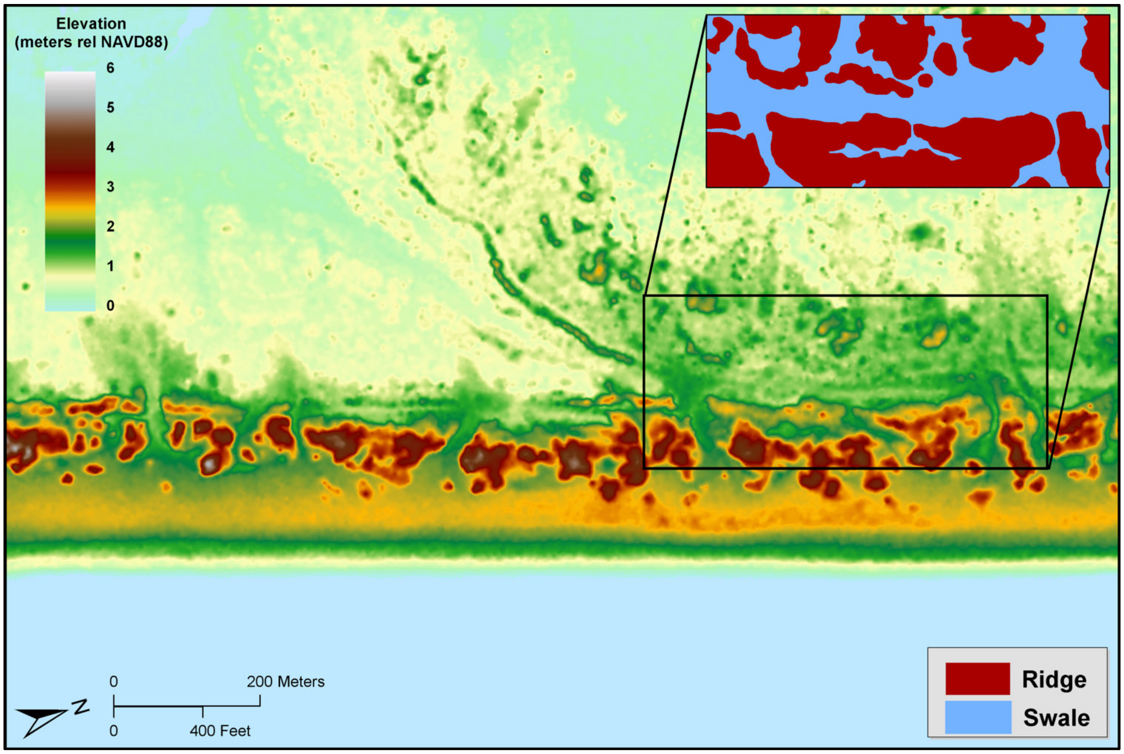

Figure 6. DEM with inset that portrays the distribution of coastal dune ridge features with intervening swales, incorporating elevation, slope, and relief.

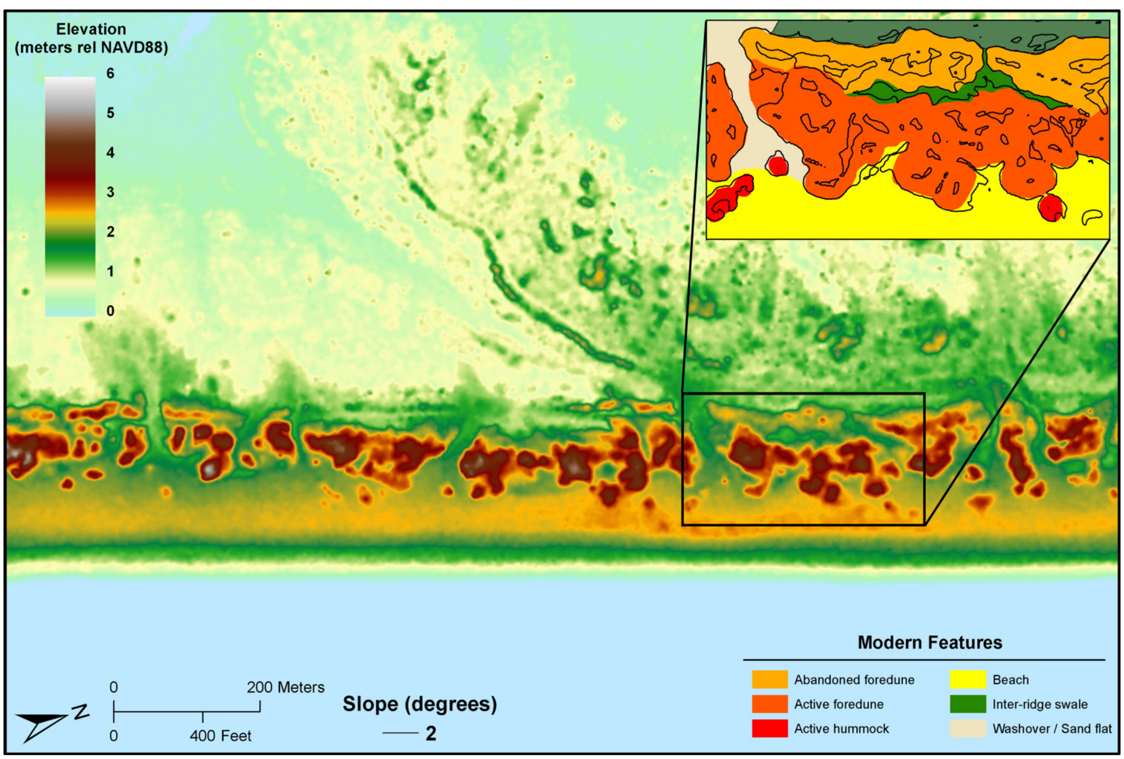

Figure 7. DEM with inset that portrays the distribution of Modern geomorphological features, incorporating active and abandoned categories with a slope isoline.

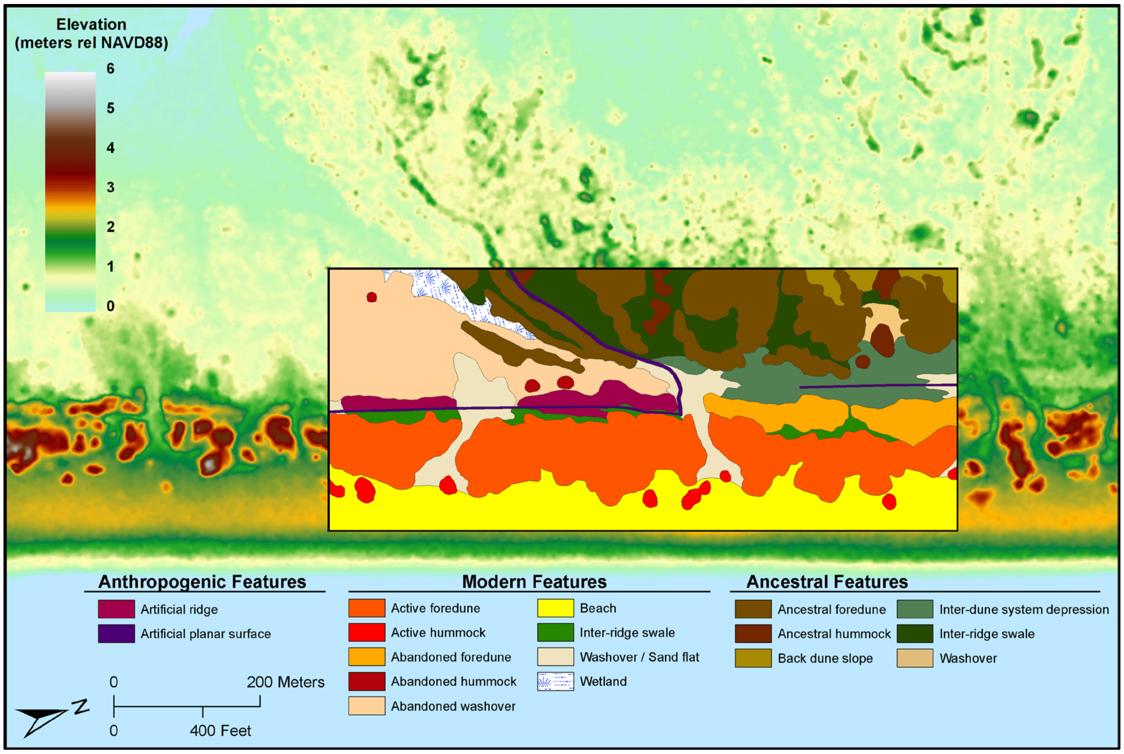

Figure 8. DEM with inset portraying the distribution of Modern and Ancestral geomorphological features.

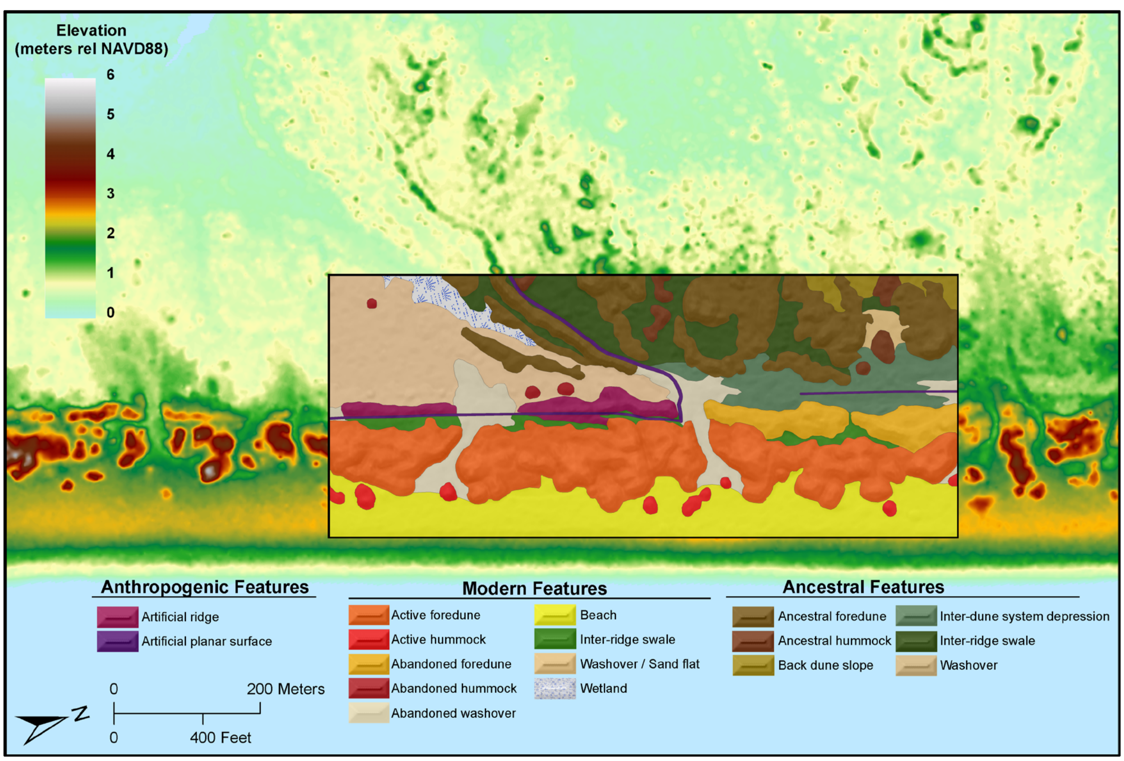

Figure 9. DEM with inset portraying Modern and Ancestral geomorphological features with hillshade.

Legend: Categories and Symbolization of Geomorphological Features

The legend is organized relative to the geomorphological evolution of the site, incorporating the spatial sequence of coastal landform development composed of ancestral and modern features (Fig. 10 and **Error! Not a valid bookmark self-reference.**). Ancestral features are elements of the landscape that were created at an earlier time when the shoreline and shore processes were active at that location. It is likely that the ancestral features composed a series of smaller separate barrier islands. They are now represented by groupings of dunal features arranged discontinuously in the present landscape, usually at or near the inland margin of the barrier island. These groupings have since coalesced into a single island through the accumulation of sediment that has both joined the several smaller islands and has displaced the shoreline and its accompanying geomorphologies seaward. The modern features are associated with the lengthier continuous barrier that tends to have a more linear array of dunal ridges parallel to the shoreline. In several areas, the foredune ridge has been dissected by overwash events that result in breaks in the ridge form and the creation of washover fans. Dune formation along the former dune ridge lines or on the surface of the washover fans has created a wide variety of dune hummocks. Because some portions of Assateague Island have been largely modified by anthropogenic activity in the past, as well as in the present time, a category of 'artificial ridge' and 'artificial planar surface' has been added to the legend to describe topographies that are elevated or leveled in the landscape. In a few locations, such as at the bayside and inlet shorelines, some anthropogenic features (bulkheads, jetty) are superposed on the geomorphology.

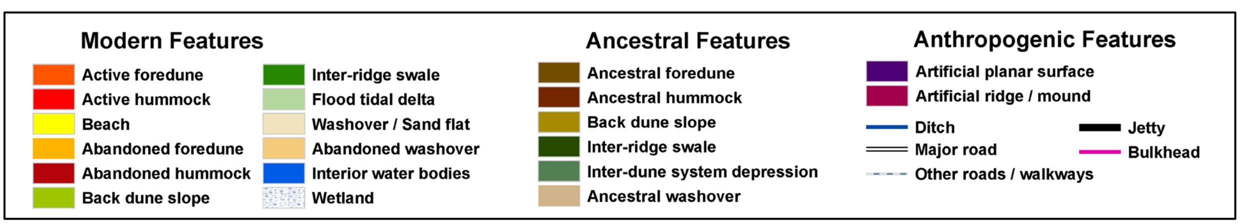

Figure 10. Map legend of geomorphological features including temporal and anthropogenic categories.

Table 2. Geomorphological features found on Assateague Island.

Geomorphological Classification	Conceptual Basis	Physical Description and Identification
Modern Active Features: Active foredune	Ridge formed by deposition of sand by wind and water at the inland margin of a beach, parallel to the coastline. It is vegetated by pioneer plant species that trap sediment. The foredune actively participates in sediment exchange with the beach.	A continuous, linear feature of elevated topography (positive relief) that is parallel to the shoreline and immediately inland of the oceanside or bayside beach. Foredunes may be irregular in areas of dissection by wind or water.
Modern Active Features: Active hummock	Isolated mounds of sediment caused by either the dissection of an active foredune or the accumulation of windblown sand on the leeward side of debris or vegetation.	Accumulations of sediment (positive relief) that may lie within the active foredune ridge zone but are independent of the ridge feature, or may exist within washover / sand flat area as either remnants of abandoned dune features or independent sand mounds.
Modern Active Features: Beach	Wave-deposited accumulation of sediment, specifically the seaward portion of the beach profile between the low tide line and the upper limit of storm wave action.	Alongshore area of low, nearly planar elevation on oceanside and bayside of barrier island. A very prominent feature that tends to be broad, continuous, and has sparse to no vegetation. Extends from the lowest tide level to the toe of the active foredune.
Modern Active Features: Washover / Sand flat	A relatively flat blanket of storm-deposited sediment that recently penetrated across and inland of the foredune ridge toward the bayside margin of the barrier across previously existing features, often including a washover fan-shaped deposit on the landward side of the barrier island.	A low, bare sand planar surface inland of the foredune location. It is visible as a break in continuous, shore-parallel linear features of positive relief such as the active foredune or abandoned foredune. Remnants of the previously existing dunes may be retained adjacent to or on the washover fan as hummocky features.
Modern Active Features: Interior water bodies	Topographic depressions that intersect with the water table or a freshwater lens. Only water bodies visible at the map scale and not subject to tidal inundation are delineated in this category.	Areas of open water within the boundaries of the barrier island, not connected by tidal channels to the bay or ocean. Often occurs as ponds within wetlands but may exist in other areas as well. Inland water bodies are distinctly visible on orthophotos.

Table 3 (continued). Geomorphological features found on Assateague Island.

Geomorphological Classification	Conceptual Basis	Physical Description and Identification
Modern Active Features: Wetland	A general term describing swamps and marshes, i.e., an area of very low elevation vegetated by saltwater, brackish water, and freshwater plants. Often found in areas sheltered from ocean waves such as the bayward side of the barrier island or isolated islands on the bayside.	A planar surface in the intertidal zone characterized by wetland vegetation identified through the use of vegetation maps and aerial imagery. Wetlands may also exist on the margins of interior water bodies.
Modern Abandoned Features: Abandoned foredune	A previously active foredune ridge that is no longer in sediment exchange with the beach because of shoreline progradation. The abandoned ridge is parallel or adjacent to an active foredune. It may form on the oceanside or bayside margins of the barrier island. It may have formed on the supratidal portion of a flood tidal delta.	A dune ridge that is inland of and parallel to the active foredune. It may be a continuous ridge form or segmented. It is inland of the beach and inland of the position of active foredune development.
Modern Abandoned Features: Abandoned hummock	Isolated mounds of sediment created by the dissection of an abandoned foredune or through localized accumulations on sand flats or washover fans. Sedimentation occurs through a combination of eolian and overwash processes.	Mounds of sediment that lie within the abandoned foredune ridge zone but are independent of the ridge feature. Sand mounds within a washover / sand flat area exist as either remnants of past dune features or are independent mounds.
Modern Abandoned Features: Inter-ridge swale	A topographical low area between shore-parallel dune ridges that forms during time of abundant sediment supply (shoreline progradation). The swale extends alongshore parallel to the active shoreline. Swales are the products of a positive sediment budget.	Swales are the continuous and low areas that occur between the sequential, parallel foredune ridges, usually parallel to the active shoreline.
Modern Abandoned Features: Back dune slope	Low area immediately inland of the leeward slope of the inland-most dune ridge. It is the feature at the inland margin of the dune-forming processes.	Located on the inland margin of a dune ridge or series of dune ridges. Elevation and slope are generally low and tend to decrease toward the bay side, i.e., slopes away from the dune ridge toward the water.

Table 4 (continued). Geomorphological features found on Assateague Island.

Geomorphological Classification	Conceptual Basis	Physical Description and Identification
Modern Abandoned Features: Abandoned washover	A relatively flat blanket of storm-deposited sediment that penetrated inland of an abandoned foredune ridge toward the bayside margin of the barrier. It does not cross or interrupt the active foredune.	Visible as a break in continuous, shore-parallel linear features of positive relief such as the abandoned foredune. A vegetated, fan-shaped raised area inland of the modern dunes or within the back dune slope.
Modern Abandoned Features: Flood tidal delta	Supratidal planar surface located on the bayside of a current or former inlet mouth that was deposited by flood-tide currents. These vegetated shoals continue to trap sediment through eolian transport and/or storm-surge deposition.	The supratidal portion of a broad, planar feature on the bayside of an inlet surrounded by intertidal wetland.
Ancestral Features: Ancestral ridge	A dune ridge that has been formed in association with a smaller barrier island early in the development of the present barrier. It is less continuous, and not parallel to the modern shoreline. It is often curving along the shoreline of a former inlet.	An inactive dunal ridge at the inland margin of the barrier. It is lower and more discontinuous than the modern features. It is not parallel to the modern shoreline and is often adjacent to an inactive inlet. It is spatially separated from the shore-parallel active foredune and forms the core of highly stable, broad sections of the barrier island.
Ancestral Features: Ancestral hummock	Isolated mounds of sediment caused by the dissection of an ancestral foredune by eolian or washover processes. A product of past topographic alteration due to storm events and human interaction.	Mounds of sediment that lie within the ancestral foredune ridge zone but are independent of the ridge feature.
Ancestral Features: Back dune slope	Area immediately inland of the leeward slope of the inner dune ridge.	Elevation is generally low and tends to decrease toward the bay side (i.e., slopes away from the dune ridge toward the water).
Ancestral Features: Inter-ridge swale	A topographical low between dune ridges that forms during a time of abundant sediment supply (shoreline progradation), and occupies the depression between the sequential, parallel foredune ridges.	A linear hollow or topographical low between parallel dune ridges that is usually parallel to the shoreline at that time. Swales will have lower elevation and negative relief in relationship to the adjacent dune ridges.

Table 5 (continued). Geomorphological features found on Assateague Island.

Geomorphological Classification	Conceptual Basis	Physical Description and Identification
Ancestral Features: Inter dune system depression	Accumulation of sand that forms during time of abundant sediment supply (shoreline progradation), it is a topographical low separating the development of modern foredune systems from the ancestral foredune system. It is a prominent linear depression at a lower elevation than adjacent ridge systems.	Substantial area of lower elevation (negative relief) between major dune systems. Often parallel to the coastline, separating the modern shore-parallel active dune ridges from the non-shore-parallel ancestral dune ridges. In some areas where the older dune system has been substantially reworked, the inter dune system depression merges with the back dune slope.
Ancestral Features: Ancestral washover	Remnant of a paleo-storm event that inundated the past shoreline. A relatively flat blanket of sediment deposited in place of previously existing features. The fan shaped deposit is present inland of the foredune.	Visible as an interruption in a continuous linear feature such as an ancestral foredune. It is an area with little to no relief that lies inland of a ridge feature and rises slightly above the surrounding terrain.

Final Product

The Assateague Island geomorphological map is the spatial portrayal of the evolution of the barrier island system that developed from a series of several discrete ancestral units through its consolidation into a continuous barrier. It has topographical features that show a series of accretionary ridges and swales that record inlet creation and closure. The Assateague Island geomorphological map consists of 16 panels, covering the island from Ocean City Inlet to the Maryland-Virginia border. One set of panels portrays the distribution of geomorphological features without hillshade and the other incorporates hillshade in its depiction.

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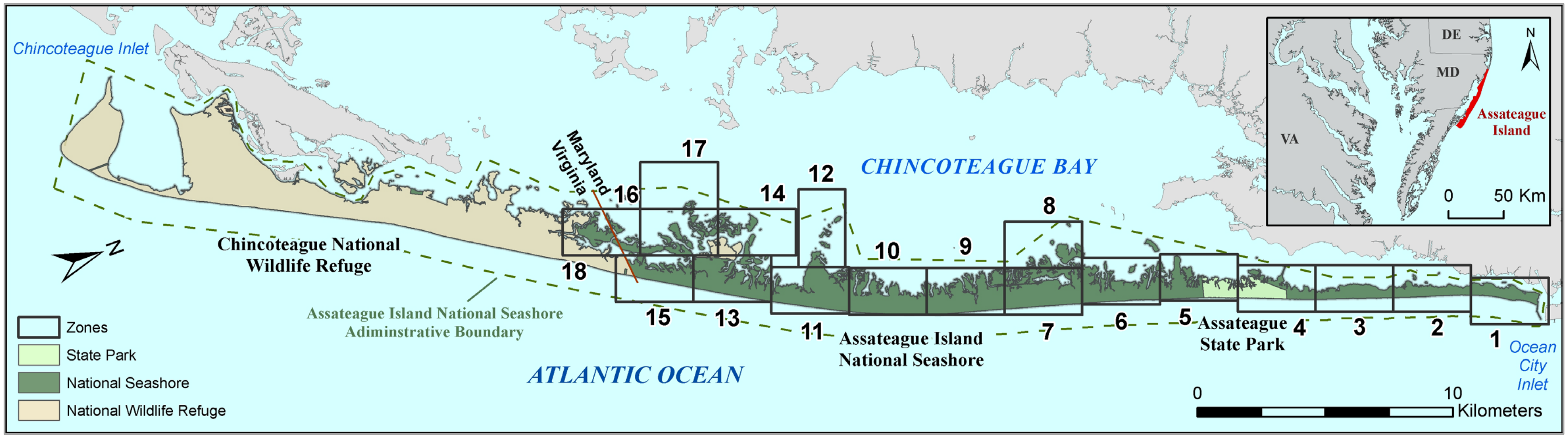
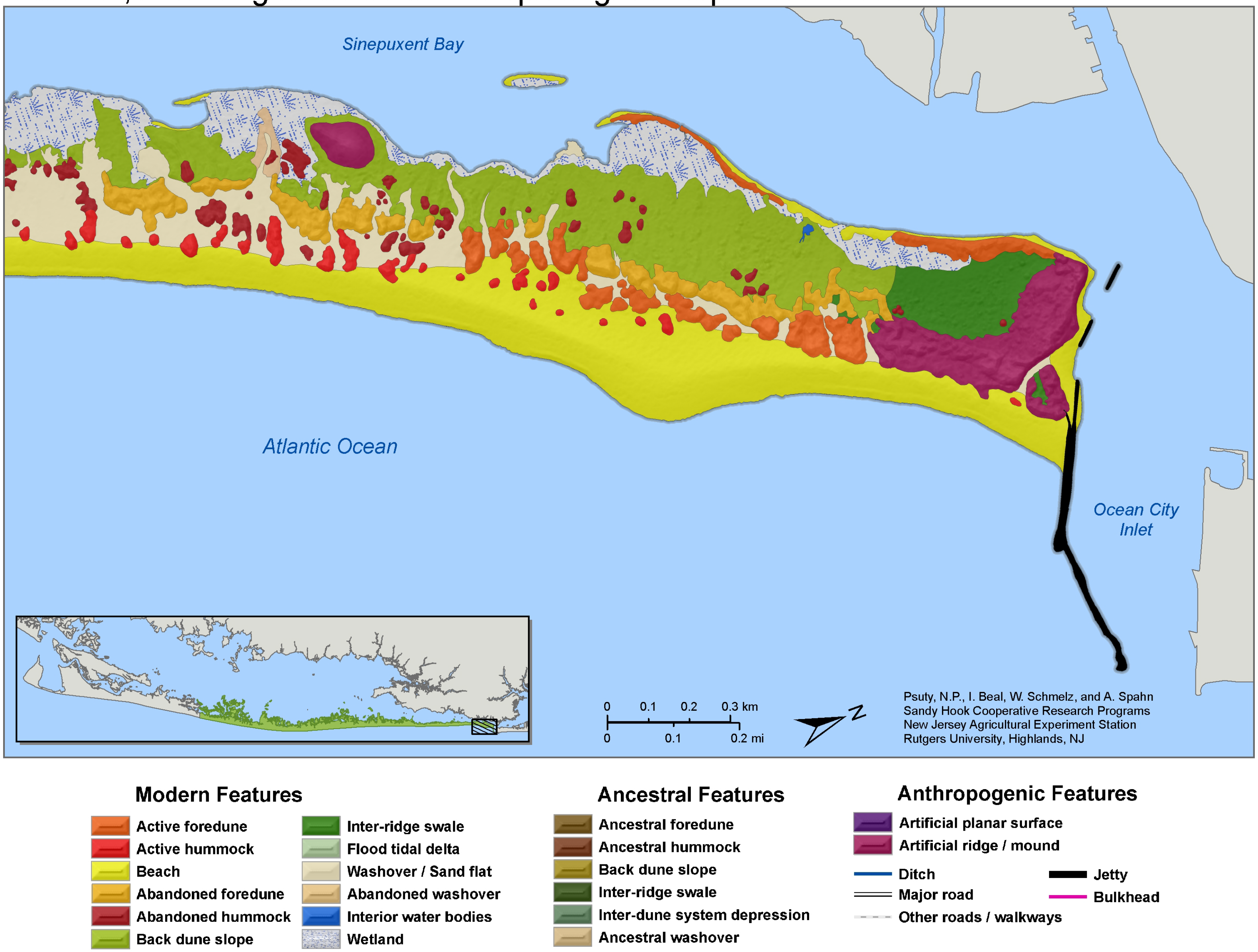
Appendix: Maps of Assateague Island Geomorphology, with and without Hillshade

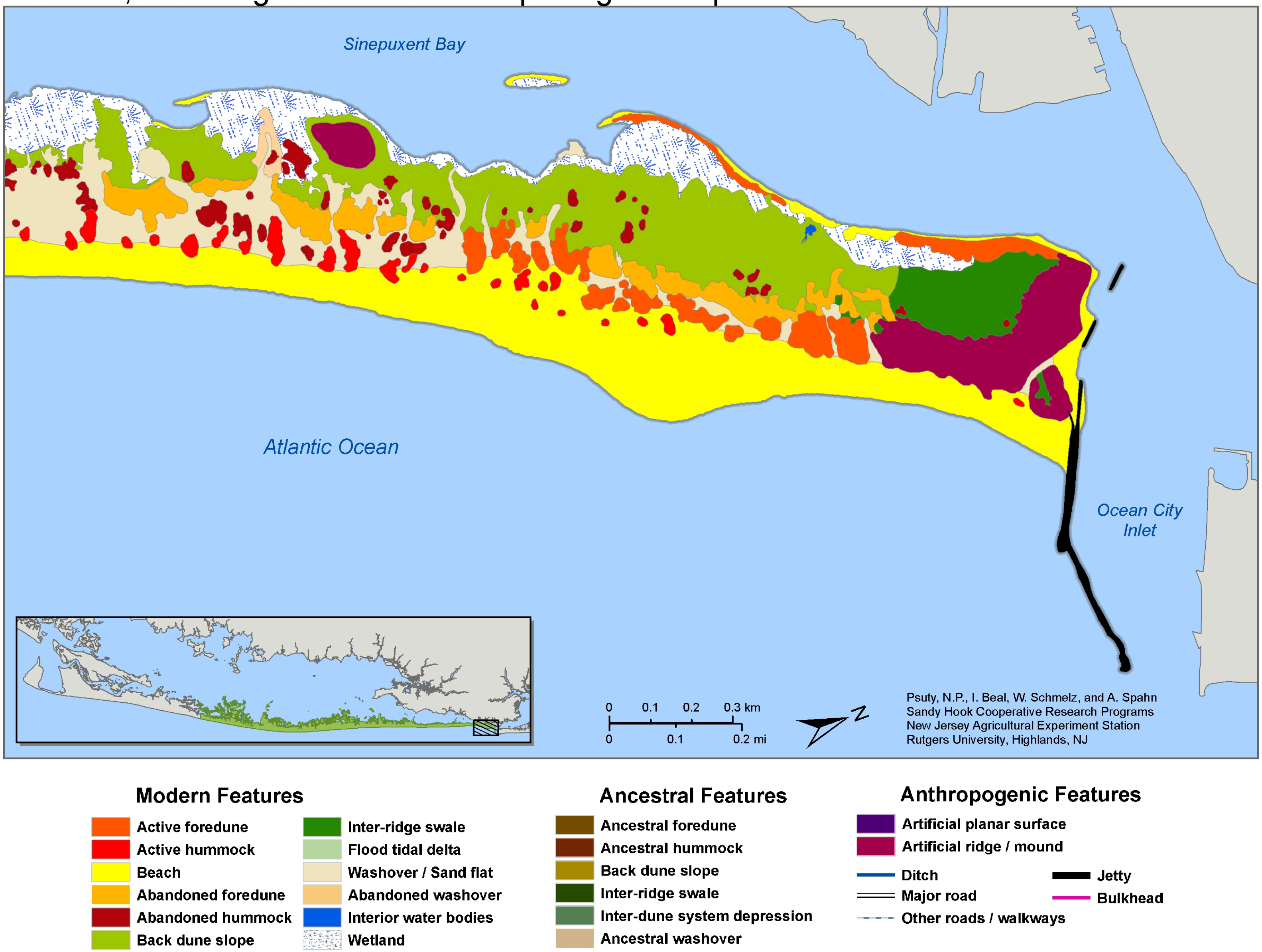


Locations of individual map "Zones" for each of the 1:12000 scale maps.

"Zone 1", Assateague Island Geomorphological Map with Hillshade



"Zone 1", Assateague Island Geomorphological Map



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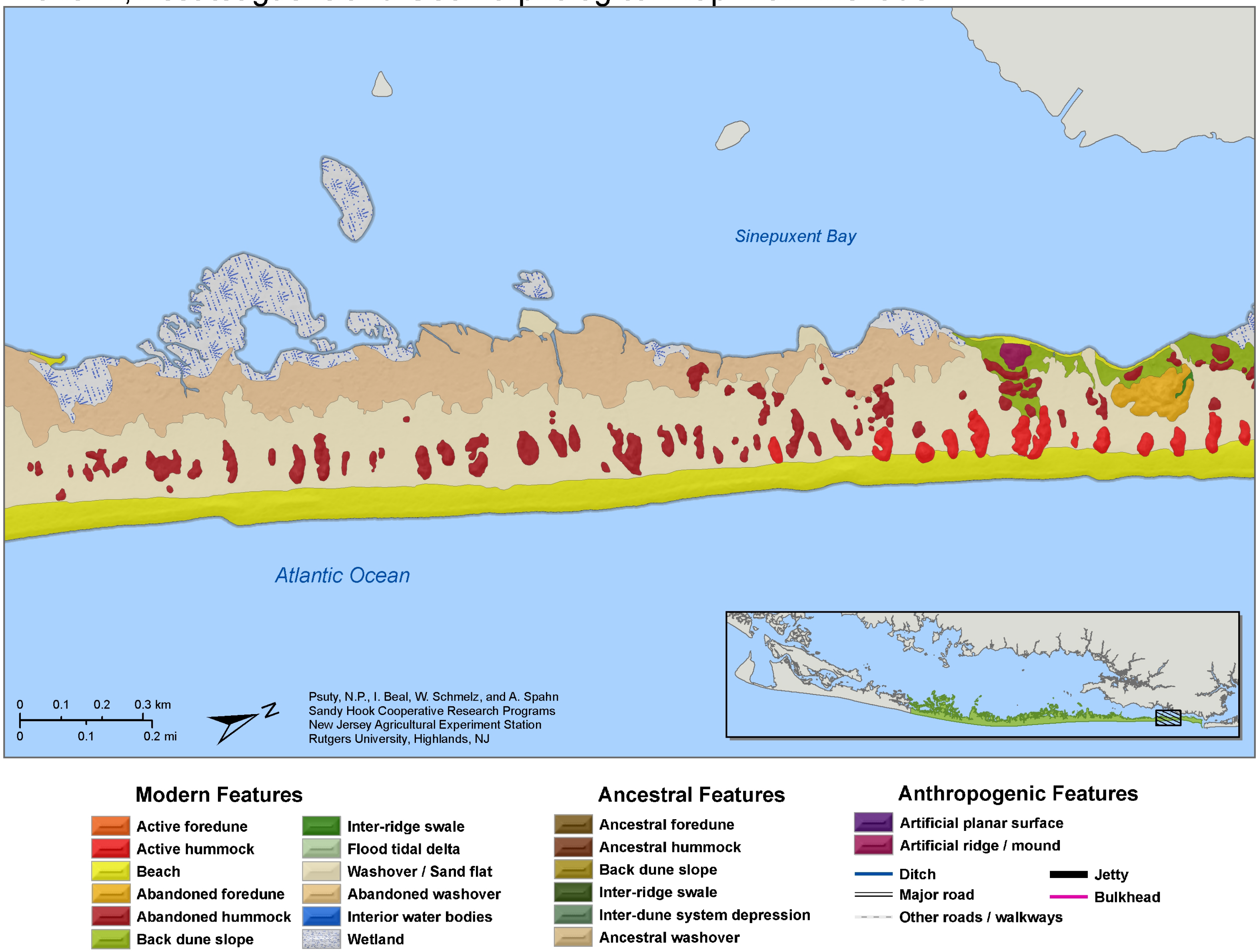
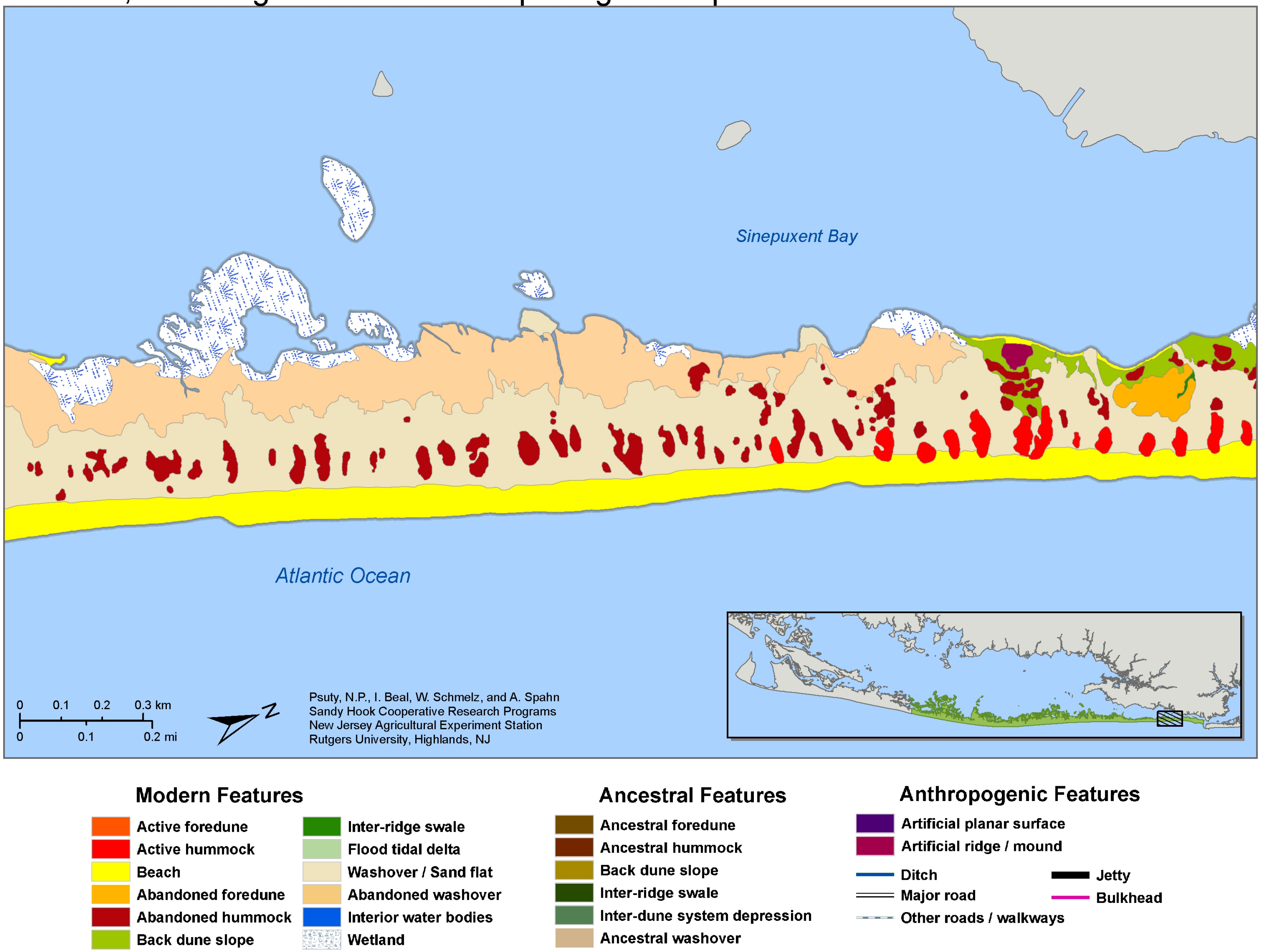


"Zone 2", Assateague Island Geomorphological Map



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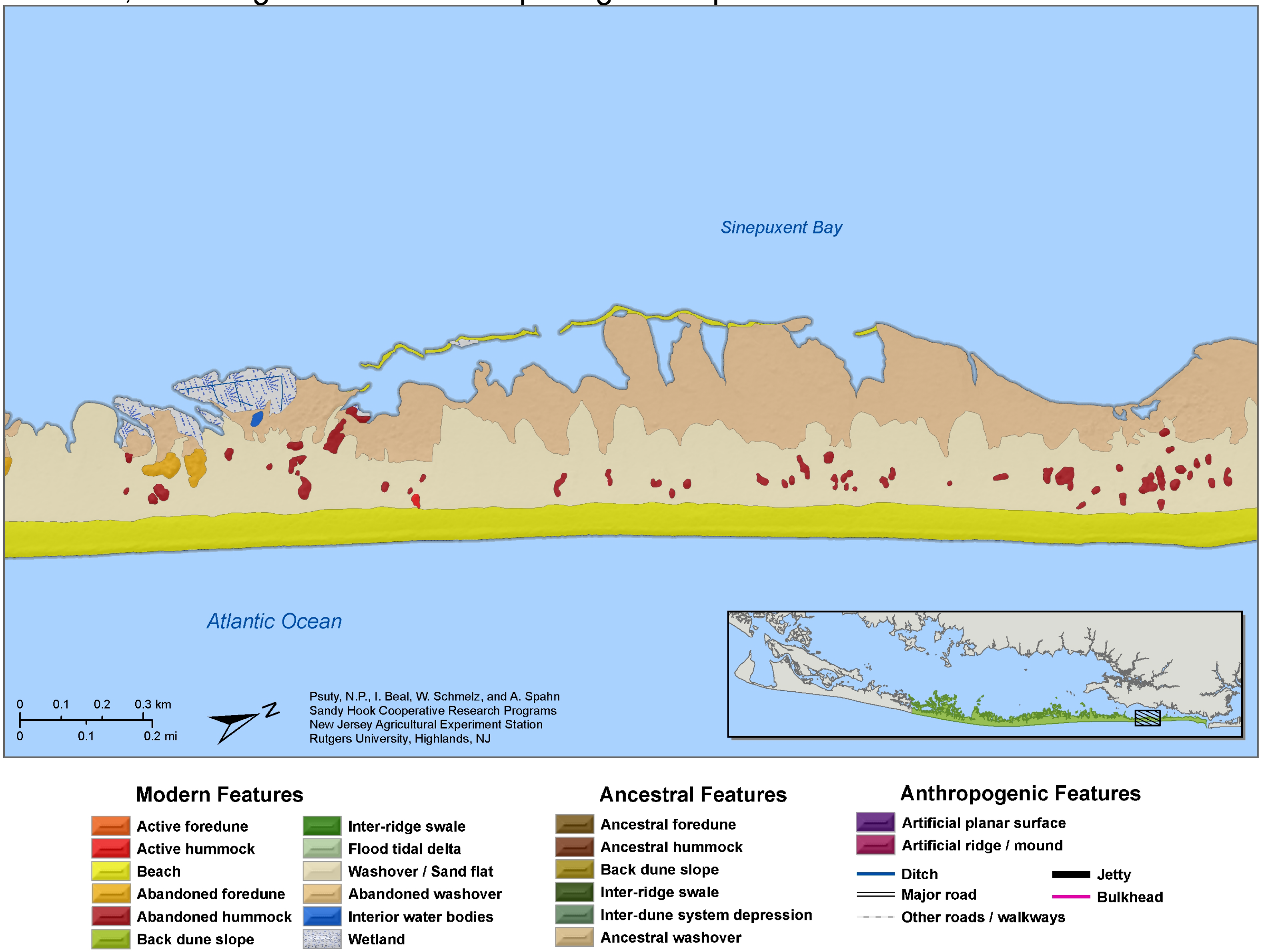
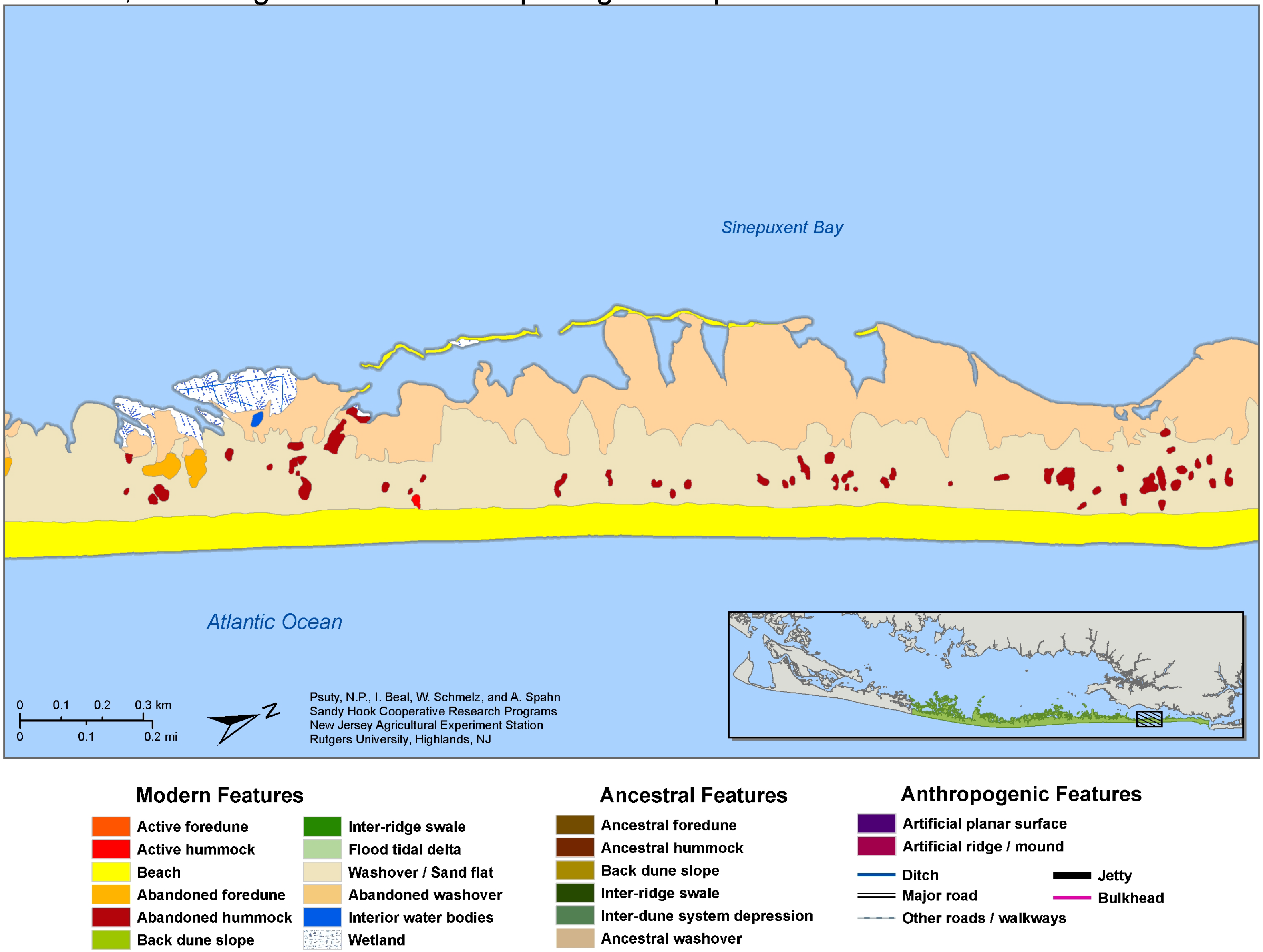


"Zone 3", Assateague Island Geomorphological Map



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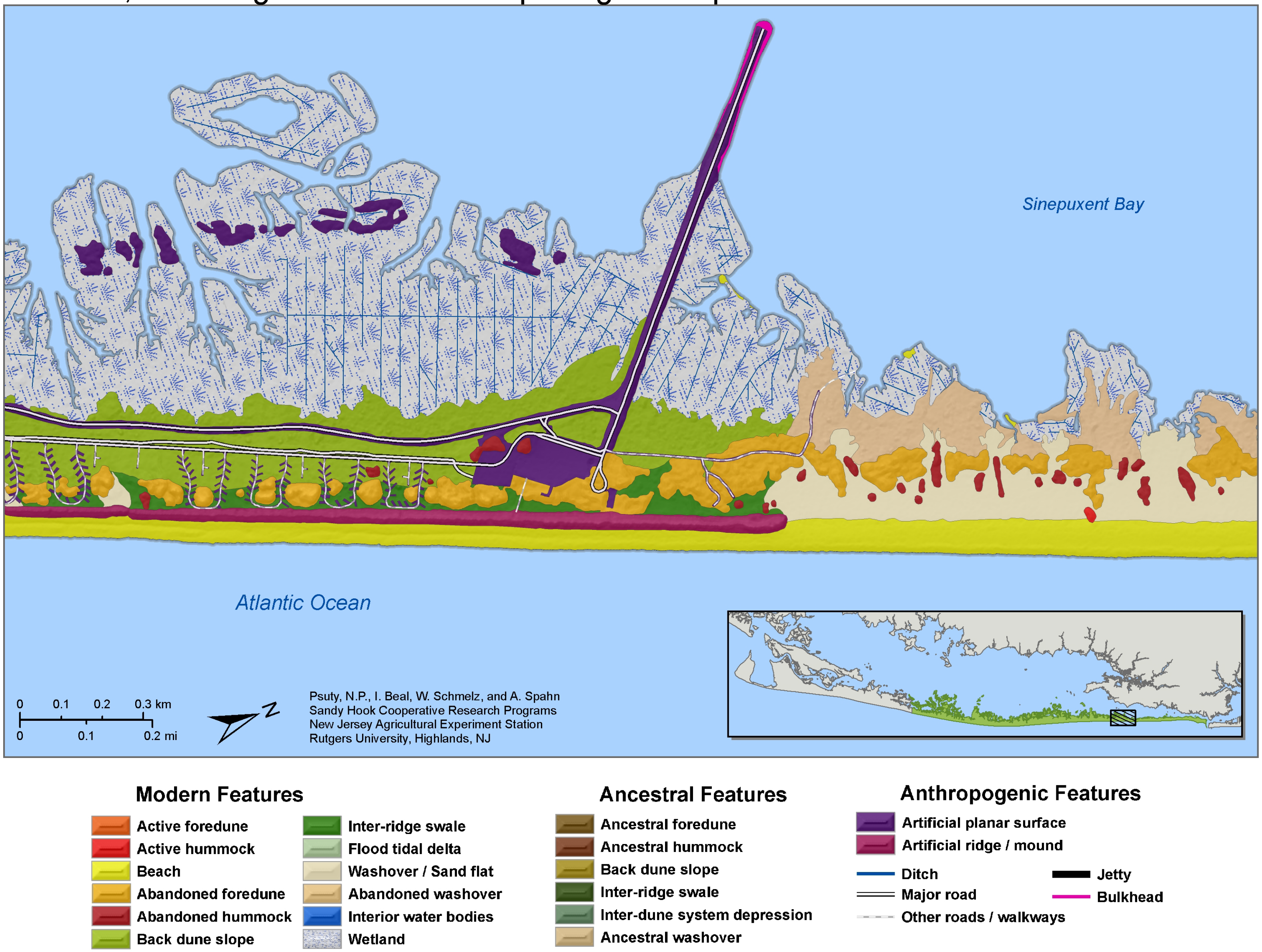
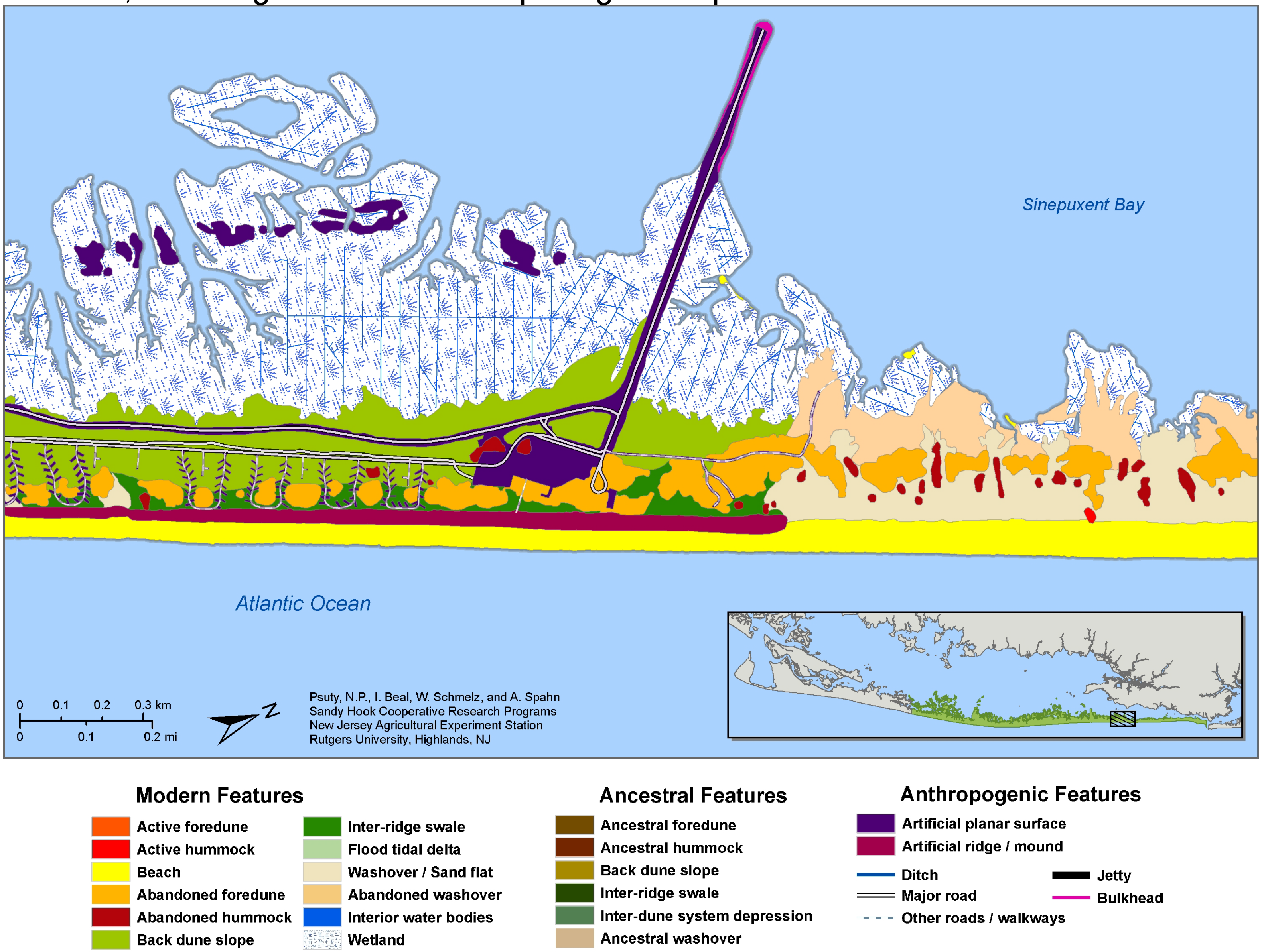
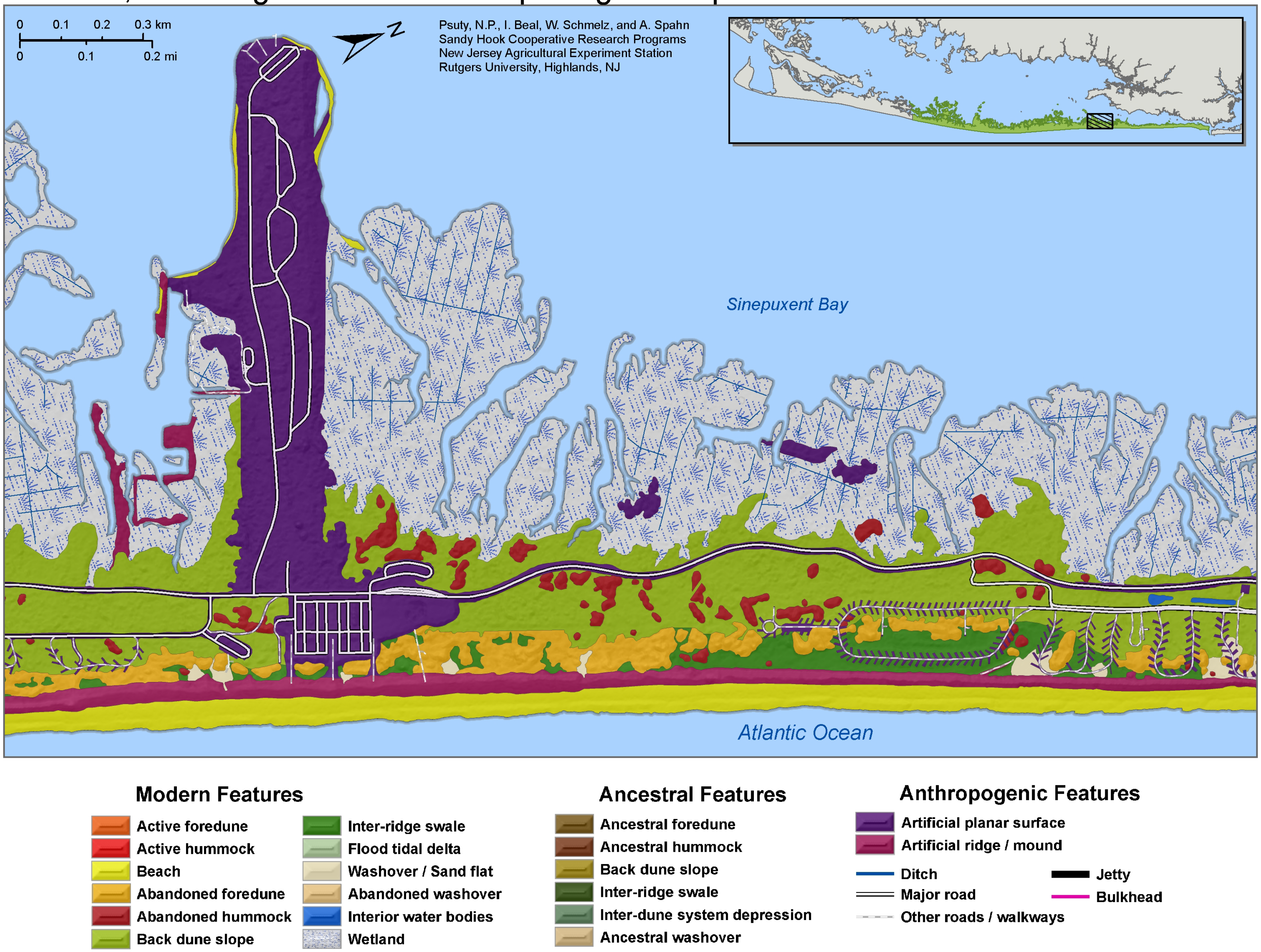


"Zone 4", Assateague Island Geomorphological Map



"Zone 5", Assateague Island Geomorphological Map with Hillshade



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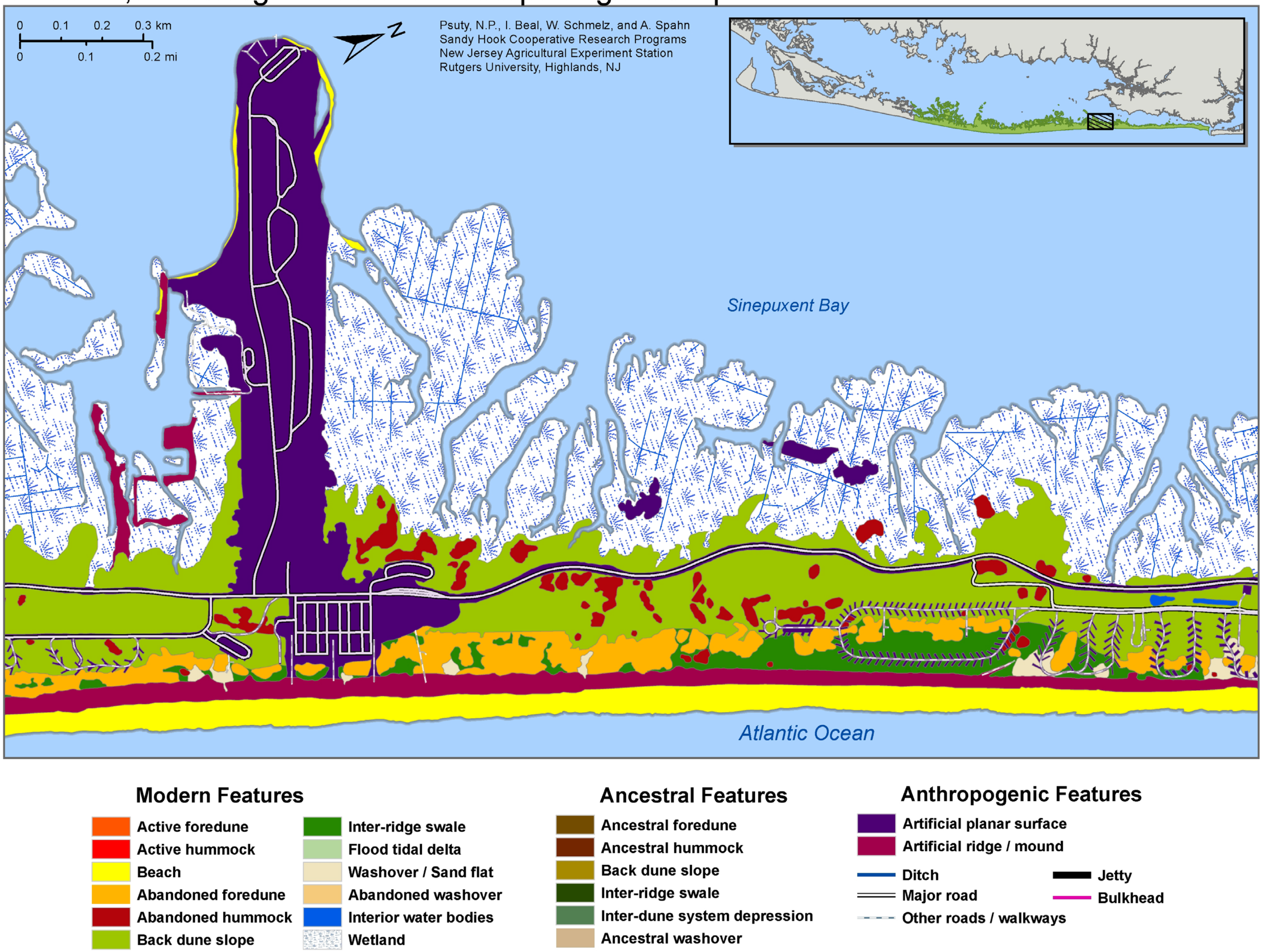

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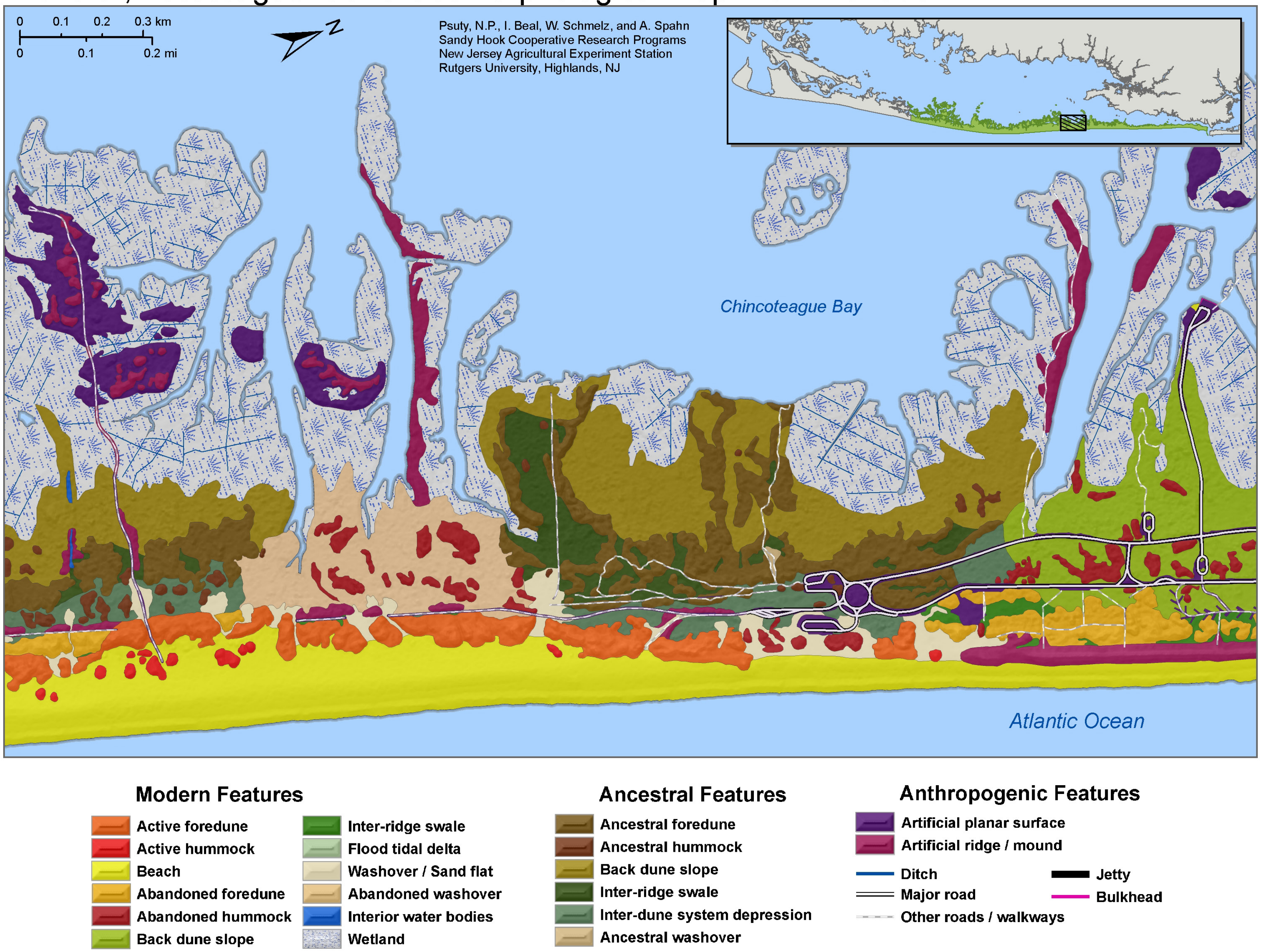

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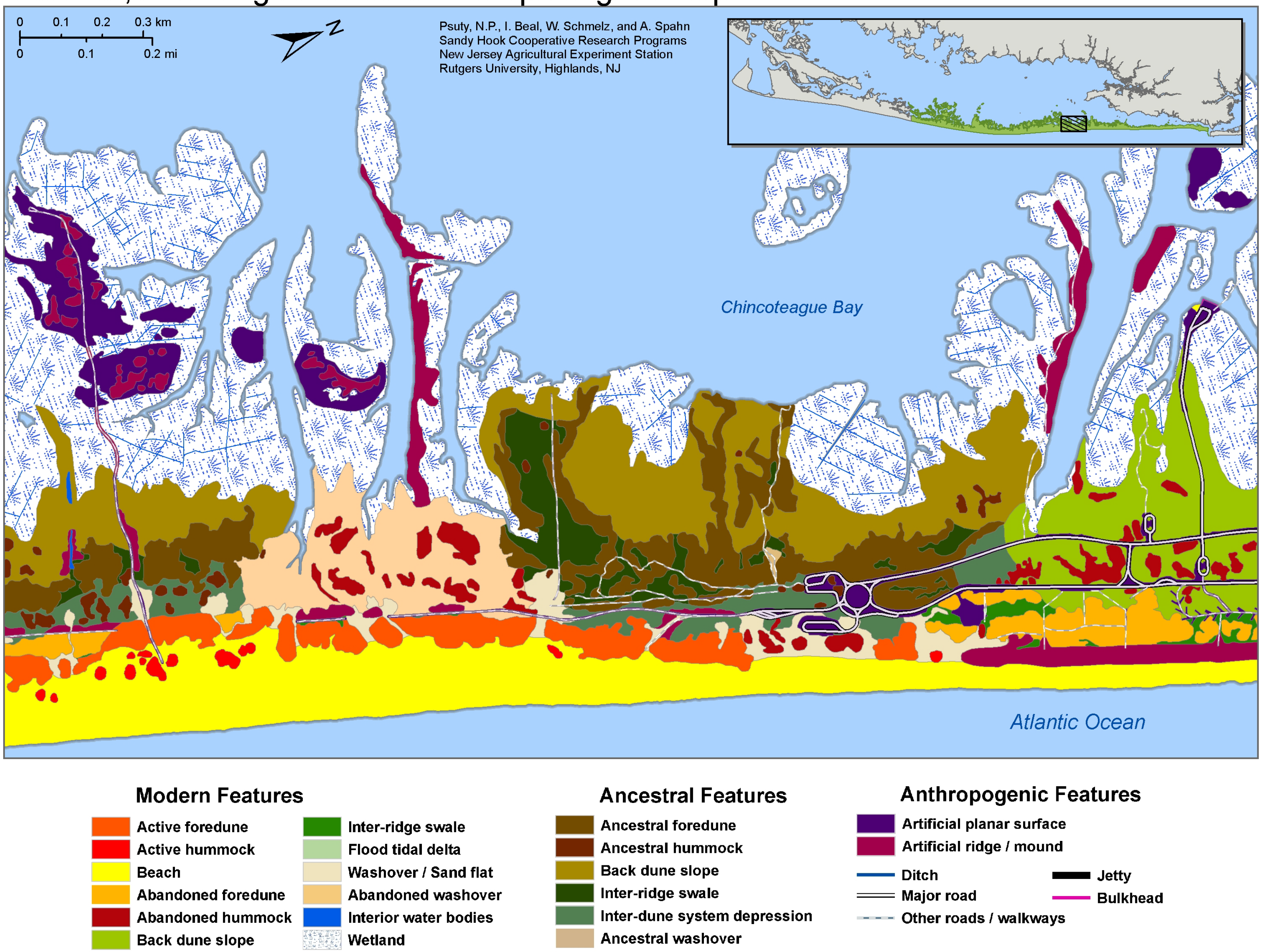
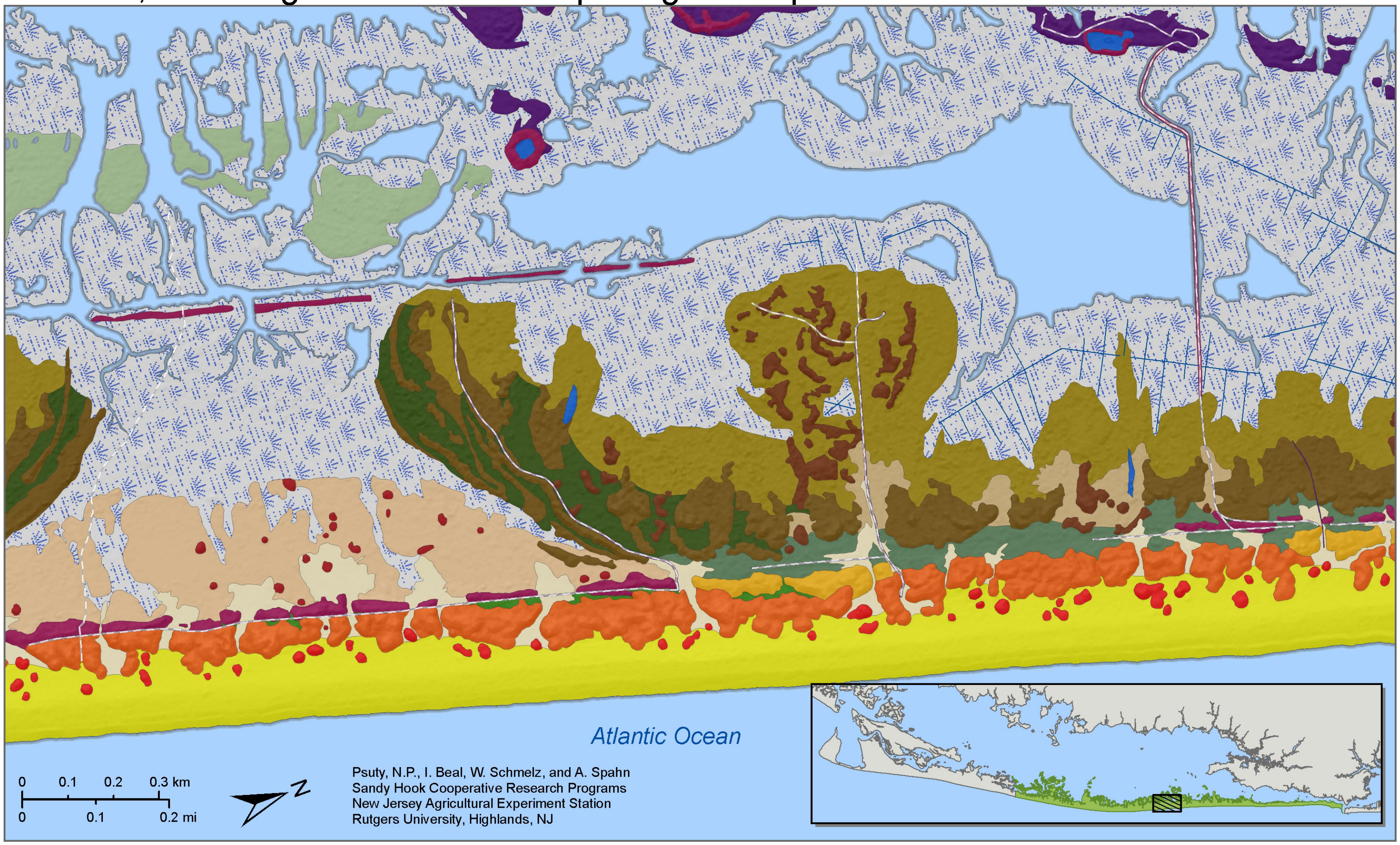


"Zone 7", Assateague Island Geomorphological Map with Hillshade



Modern Features

- Active foredune
- Active hummock
- Beach
- Abandoned foredune
- Abandoned hummock
- Back dune slope
- Inter-ridge swale
- Flood tidal delta
- Washover / Sand flat
- Abandoned washover
- Interior water bodies
- Wetland

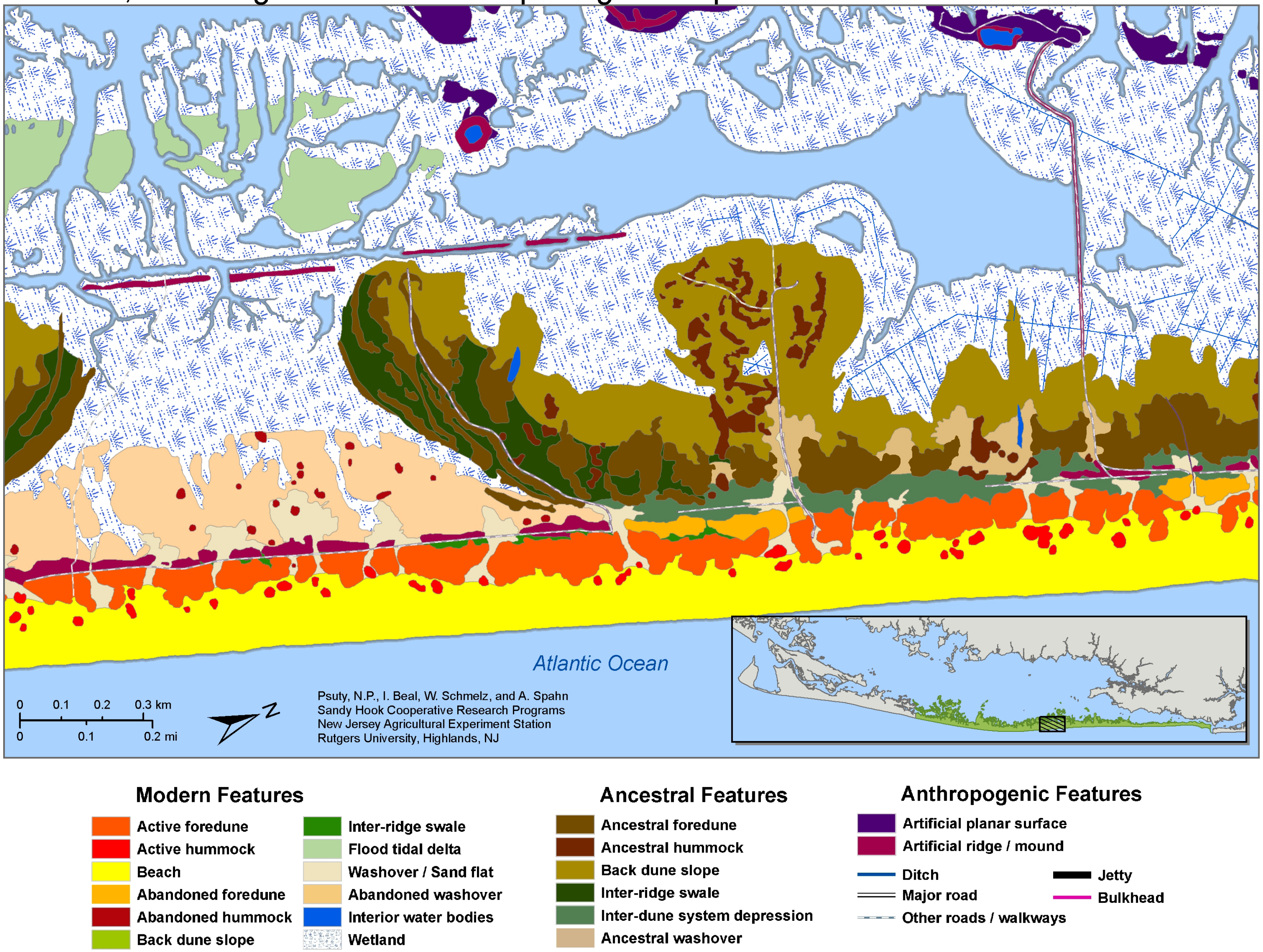
Ancestral Features

- Ancestral foredune
- Ancestral hummock
- Back dune slope
- Inter-ridge swale
- Inter-dune system depression
- Ancestral washover

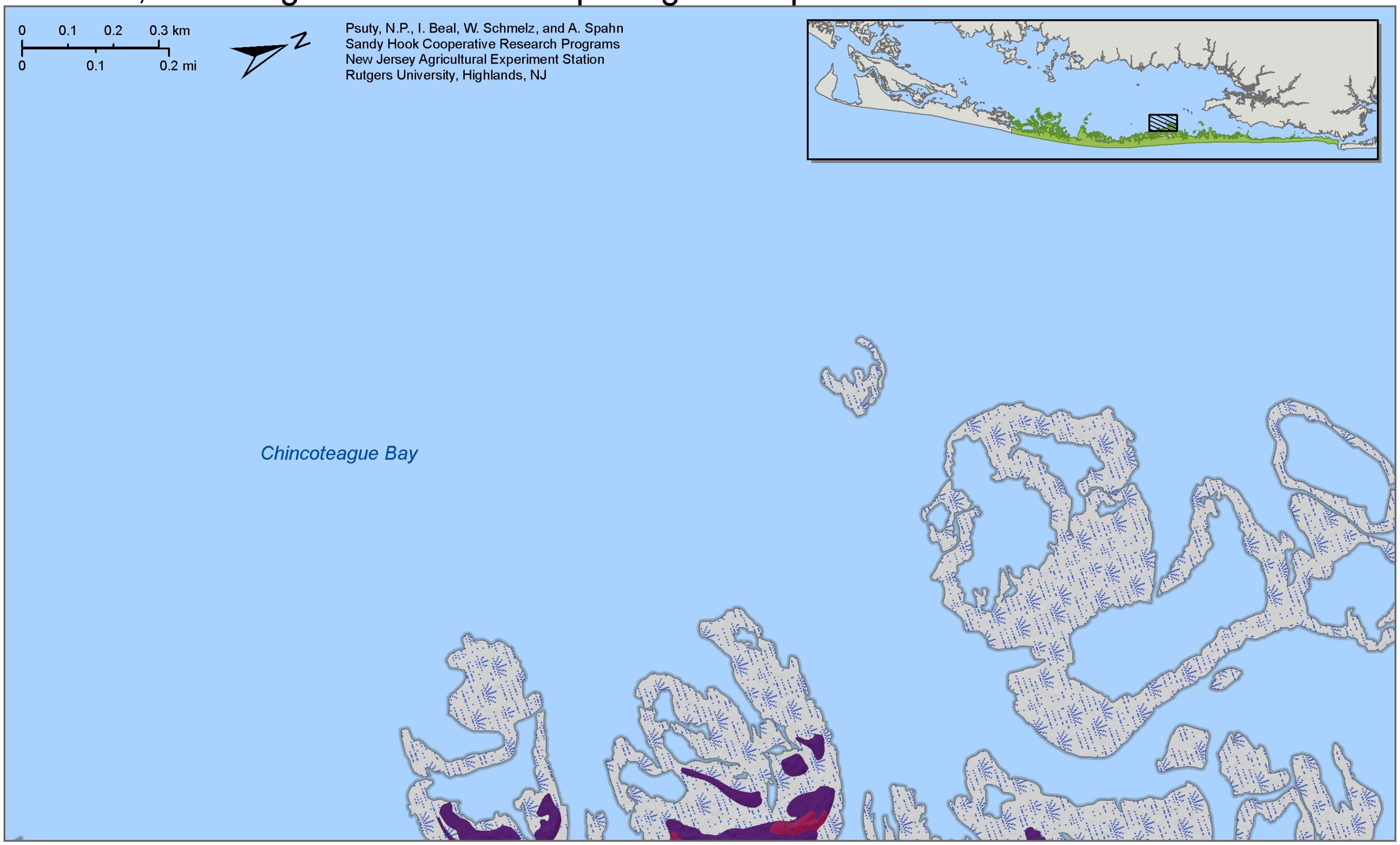
Anthropogenic Features

- Artificial planar surface
- Artificial ridge / mound
- Ditch
- Major road
- Other roads / walkways
- Jetty
- Bulkhead

"Zone 7", Assateague Island Geomorphological Map



"Zone 8", Assateague Island Geomorphological Map with Hillshade



Modern Features

- Active foredune
- Active hummock
- Beach
- Abandoned foredune
- Abandoned hummock
- Back dune slope
- Inter-ridge swale
- Flood tidal delta
- Washover / Sand flat
- Abandoned washover
- Interior water bodies
- Wetland

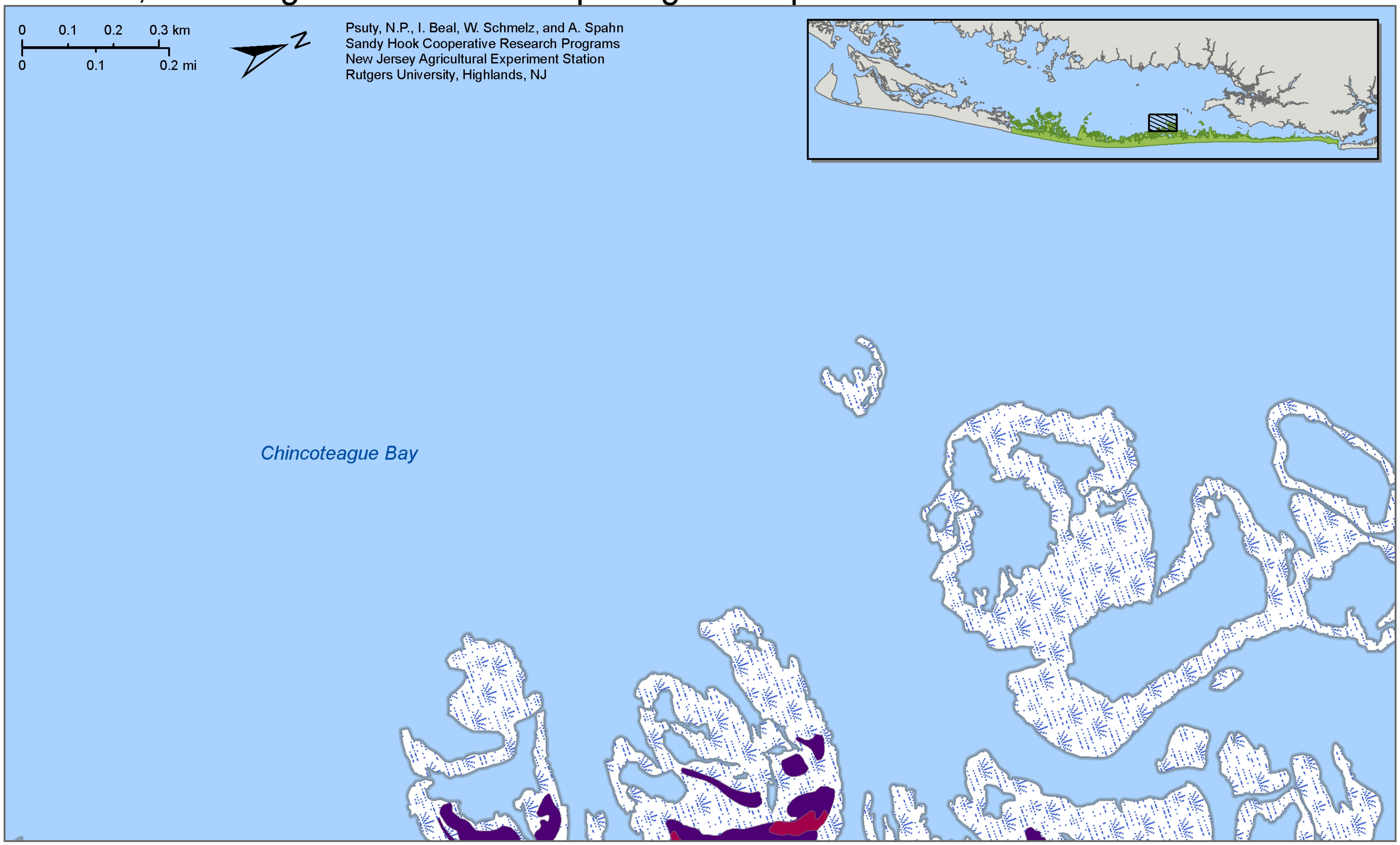
Ancestral Features

- Ancestral foredune
- Ancestral hummock
- Back dune slope
- Inter-ridge swale
- Inter-dune system depression
- Ancestral washover

Anthropogenic Features

- Artificial planar surface
- Artificial ridge / mound
- Ditch
- Major road
- Other roads / walkways
- Jetty
- Bulkhead

"Zone 8", Assateague Island Geomorphological Map



Modern Features

- Active foredune
- Active hummock
- Beach
- Abandoned foredune
- Abandoned hummock
- Back dune slope
- Inter-ridge swale
- Flood tidal delta
- Washover / Sand flat
- Abandoned washover
- Interior water bodies
- Wetland

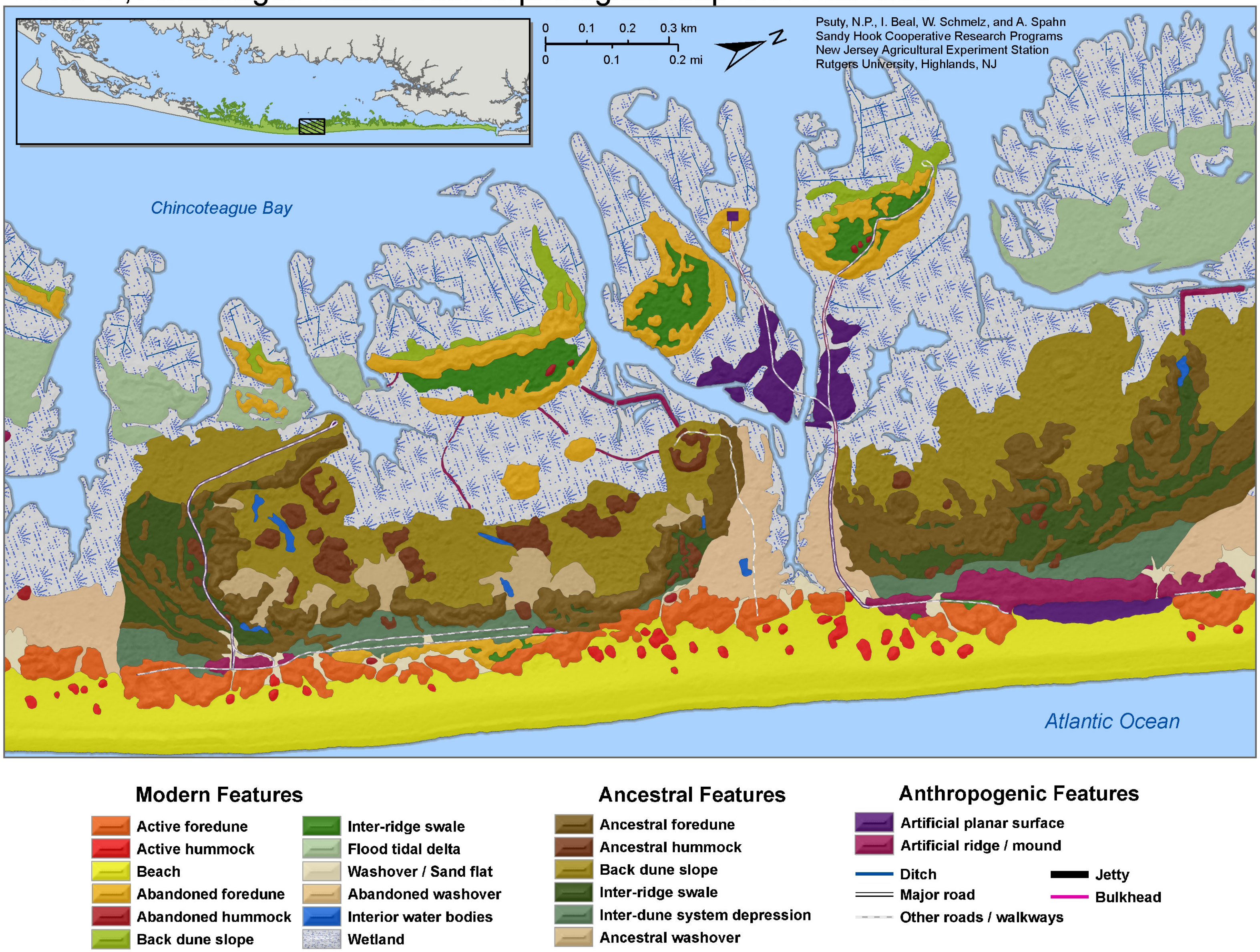
Ancestral Features

- Ancestral foredune
- Ancestral hummock
- Back dune slope
- Inter-ridge swale
- Inter-dune system depression
- Ancestral washover

Anthropogenic Features

- Artificial planar surface
- Artificial ridge / mound
- Ditch
- Major road
- Other roads / walkways
- Jetty
- Bulkhead

"Zone 9", Assateague Island Geomorphological Map with Hillshade



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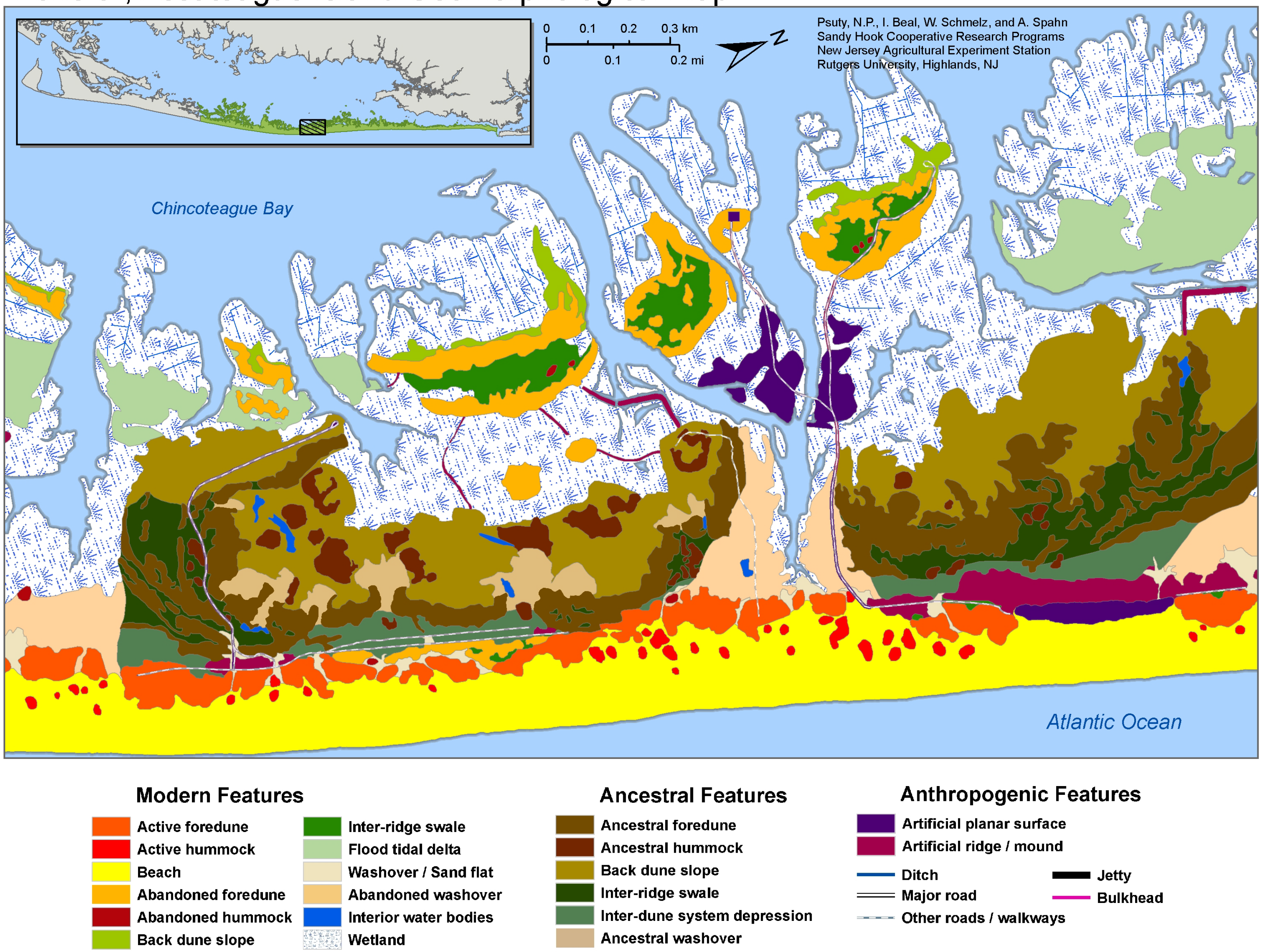
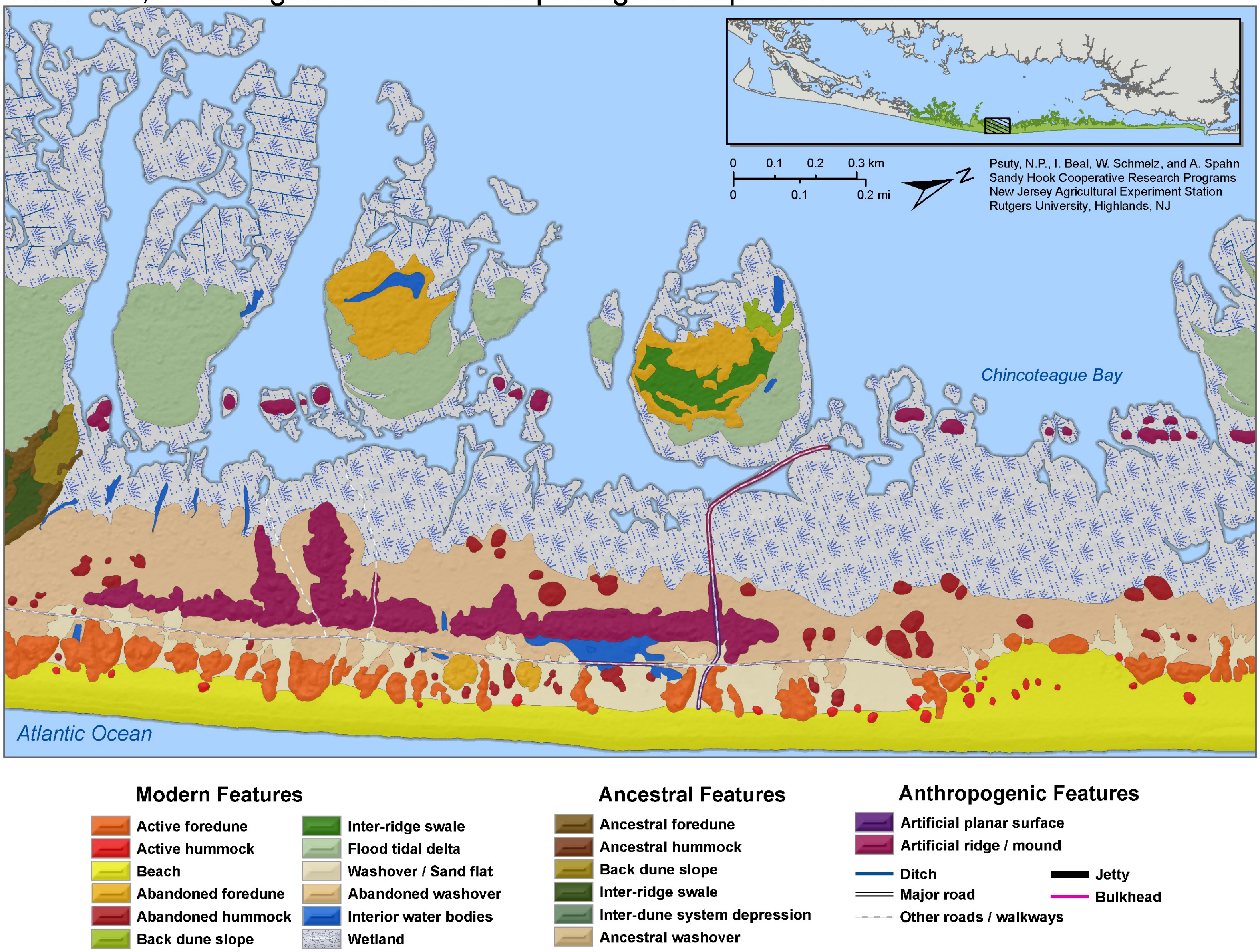


"Zone 10", Assateague Island Geomorphological Map with Hillshade



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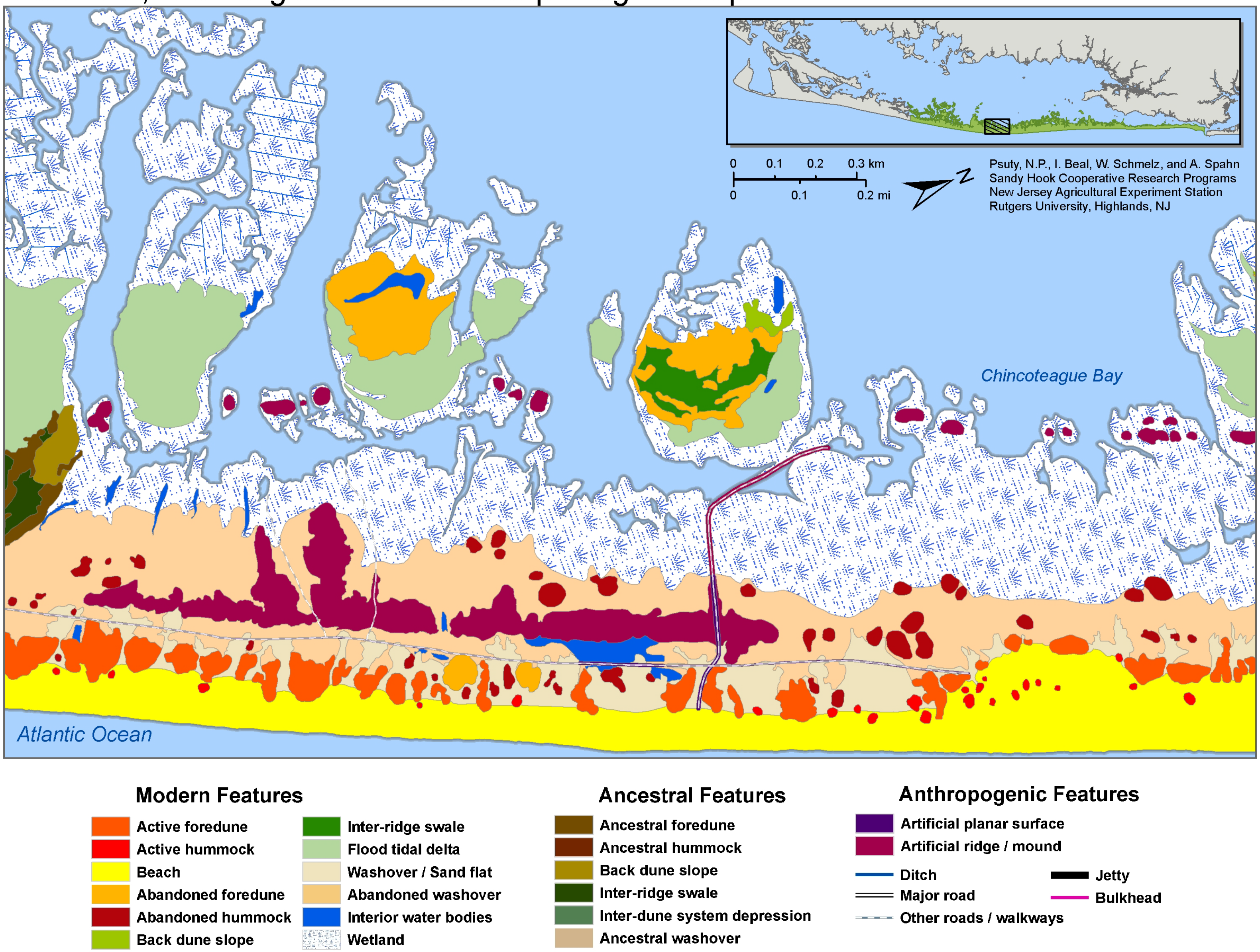
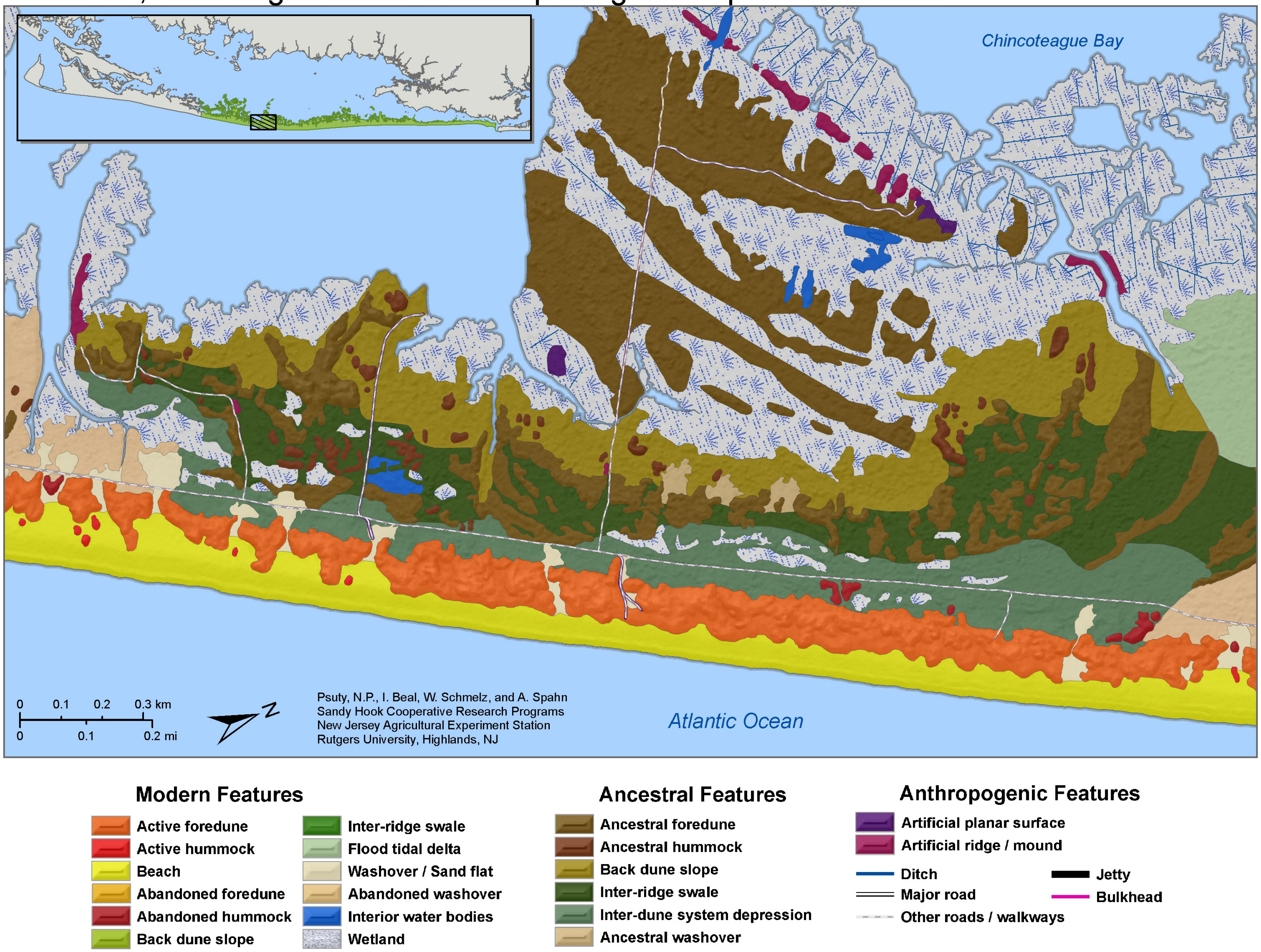
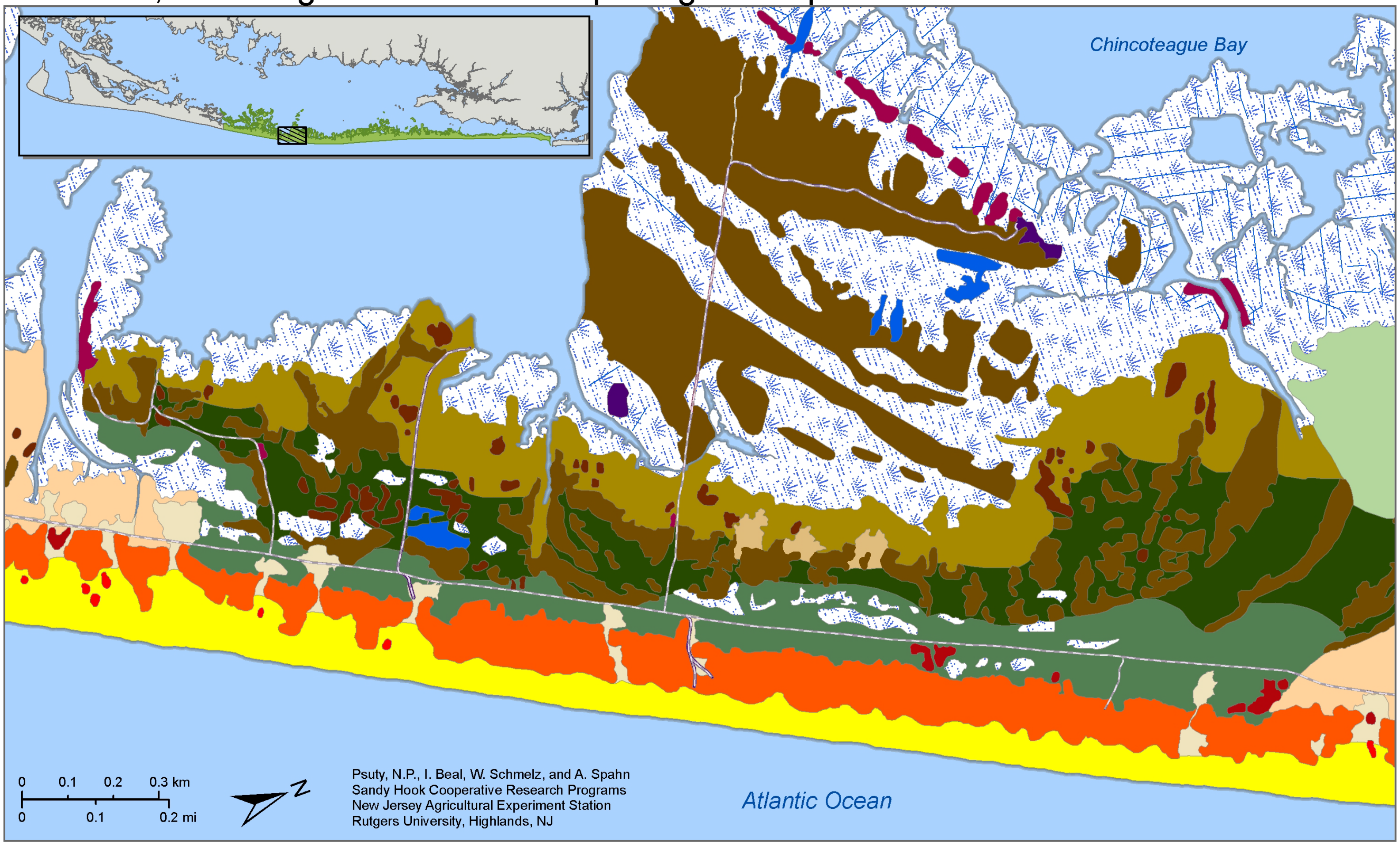


"Zone 11", Assateague Island Geomorphological Map with Hillshade



"Zone 11", Assateague Island Geomorphological Map



Modern Features

- Active foredune
- Active hummock
- Beach
- Abandoned foredune
- Abandoned hummock
- Back dune slope
- Inter-ridge swale
- Flood tidal delta
- Washover / Sand flat
- Abandoned washover
- Interior water bodies
- Wetland

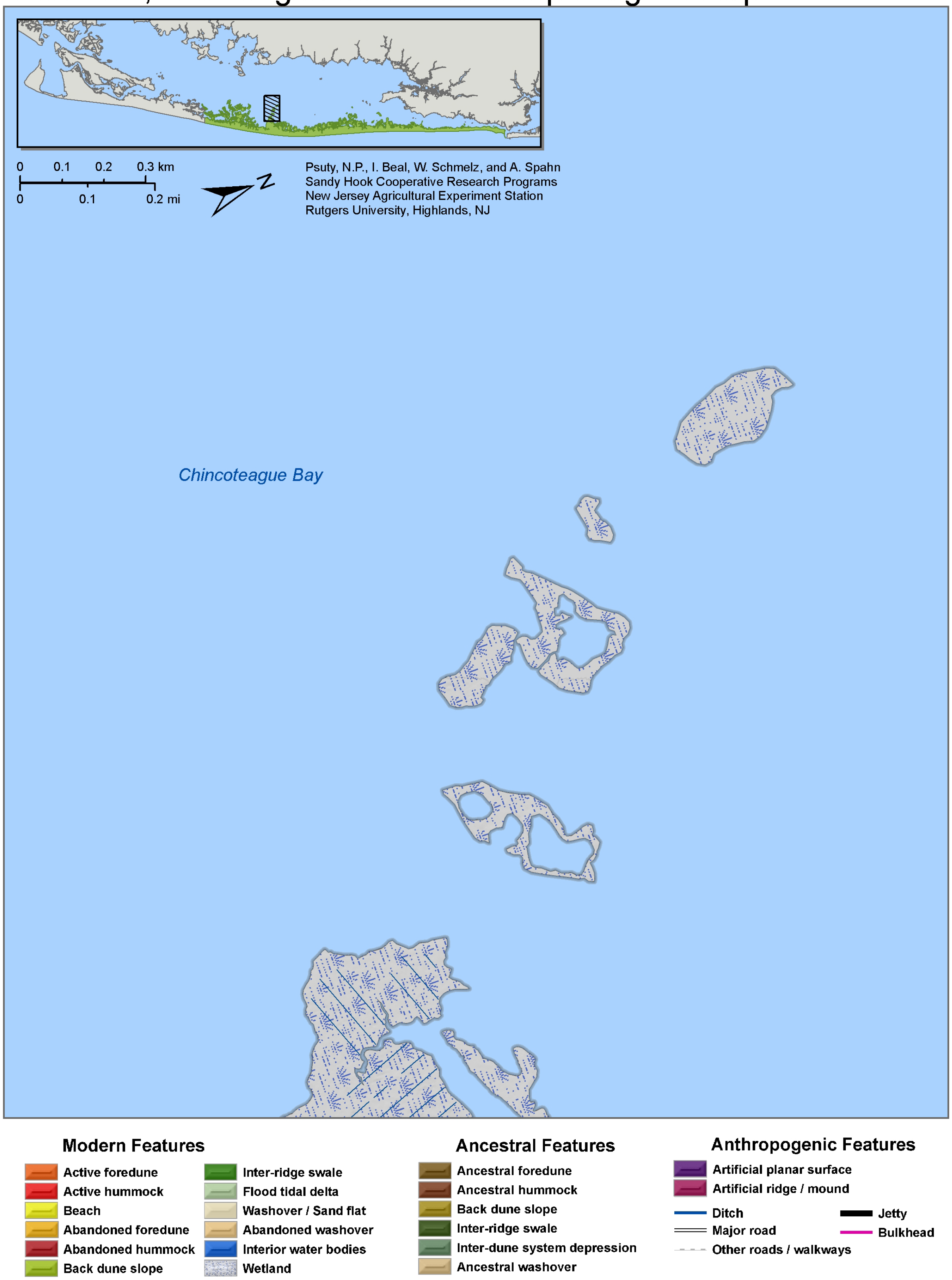
Ancestral Features

- Ancestral foredune
- Ancestral hummock
- Back dune slope
- Inter-ridge swale
- Inter-dune system depression
- Ancestral washover

Anthropogenic Features

- Artificial planar surface
- Artificial ridge / mound
- Ditch
- Major road
- Other roads / walkways
- Jetty
- Bulkhead

"Zone 12", Assateague Island Geomorphological Map



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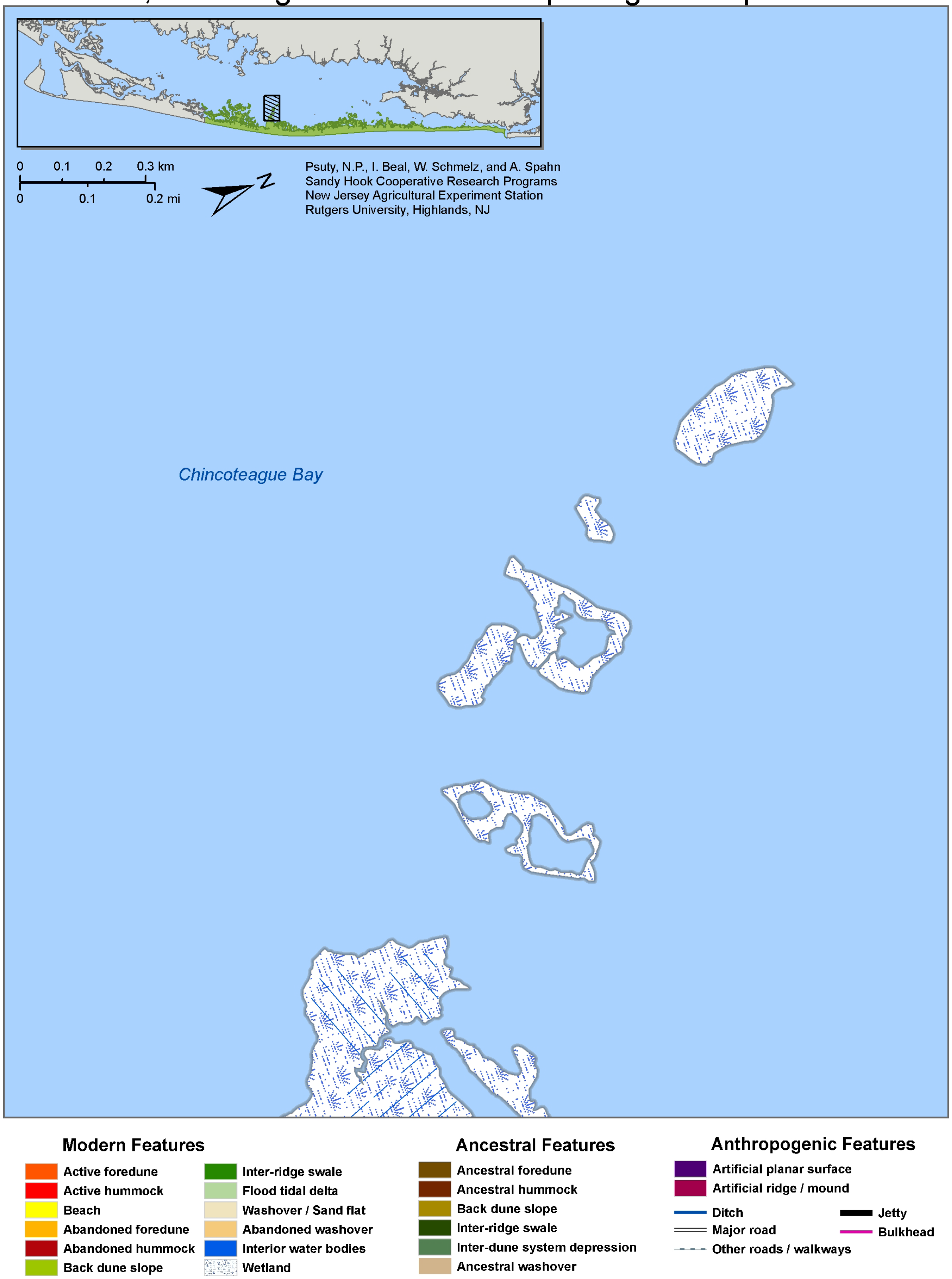
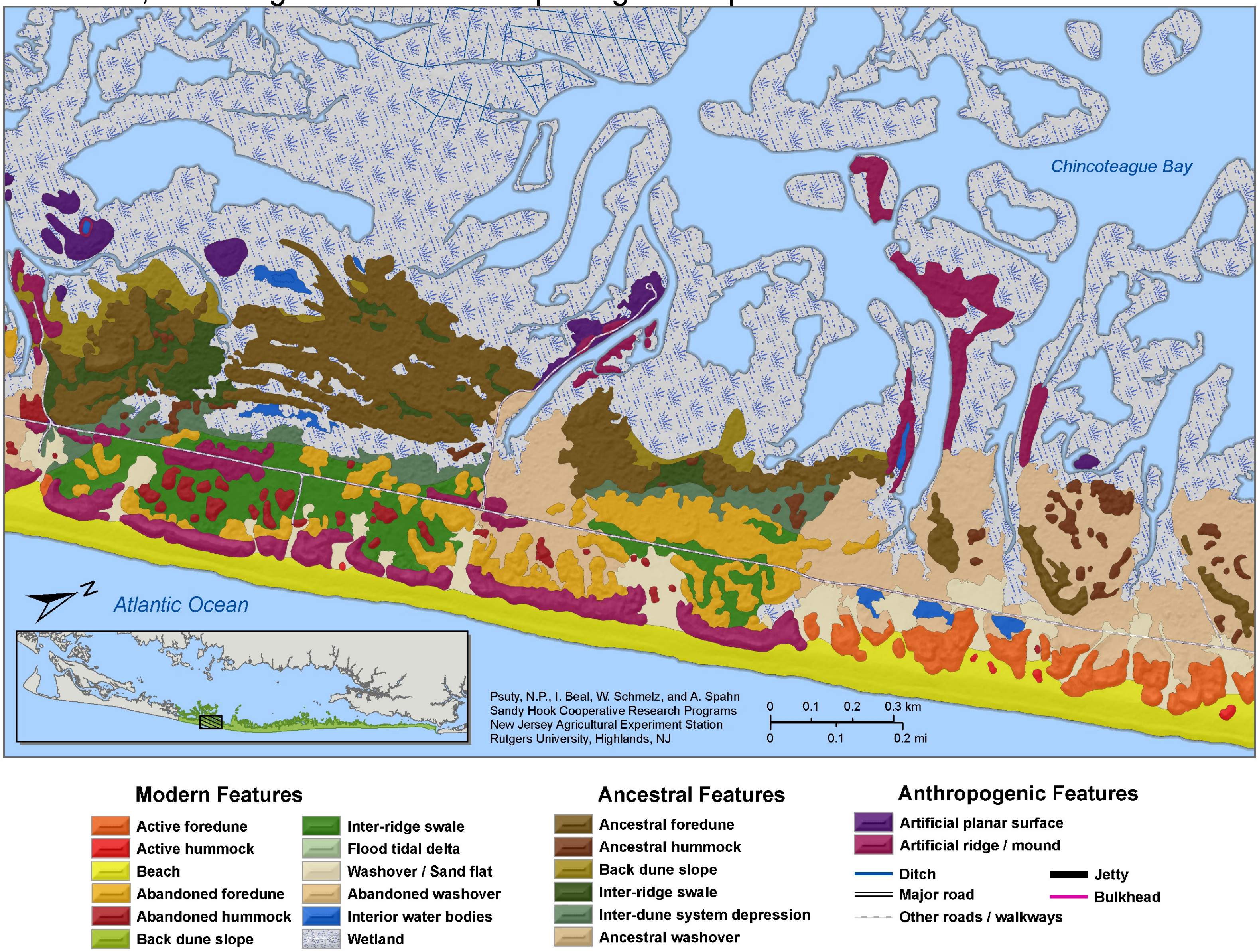


"Zone 13", Assateague Island Geomorphological Map with Hillshade



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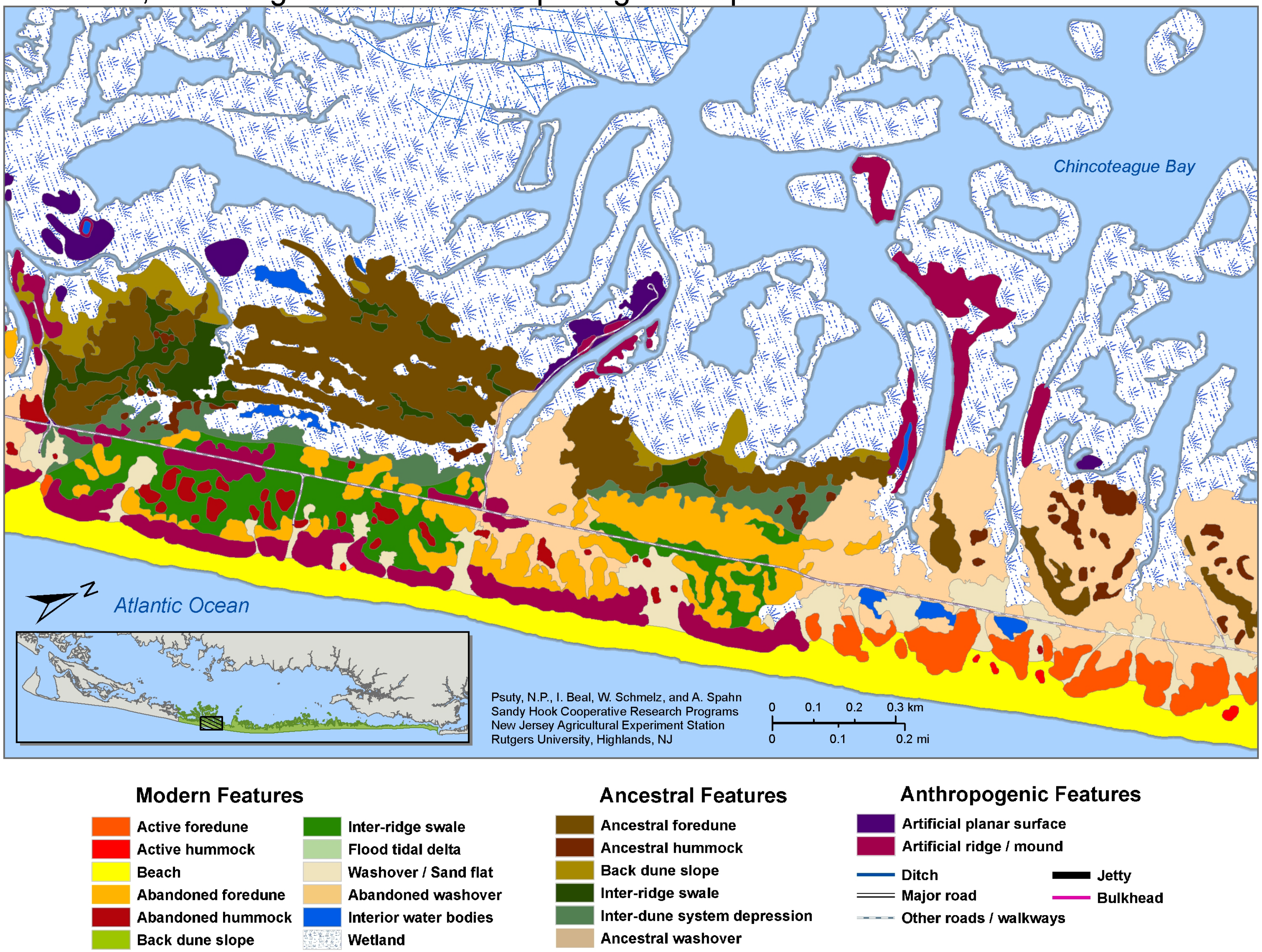
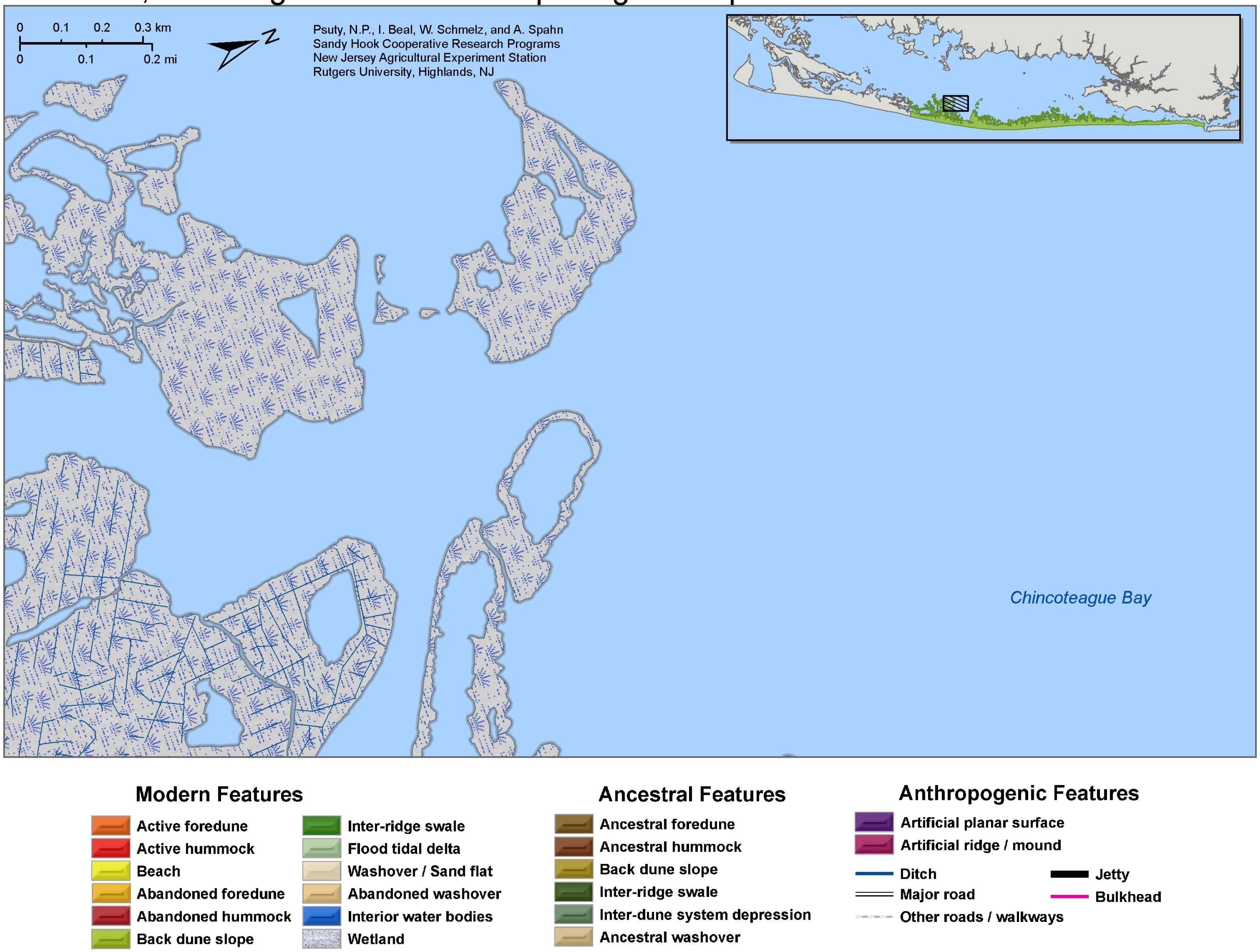
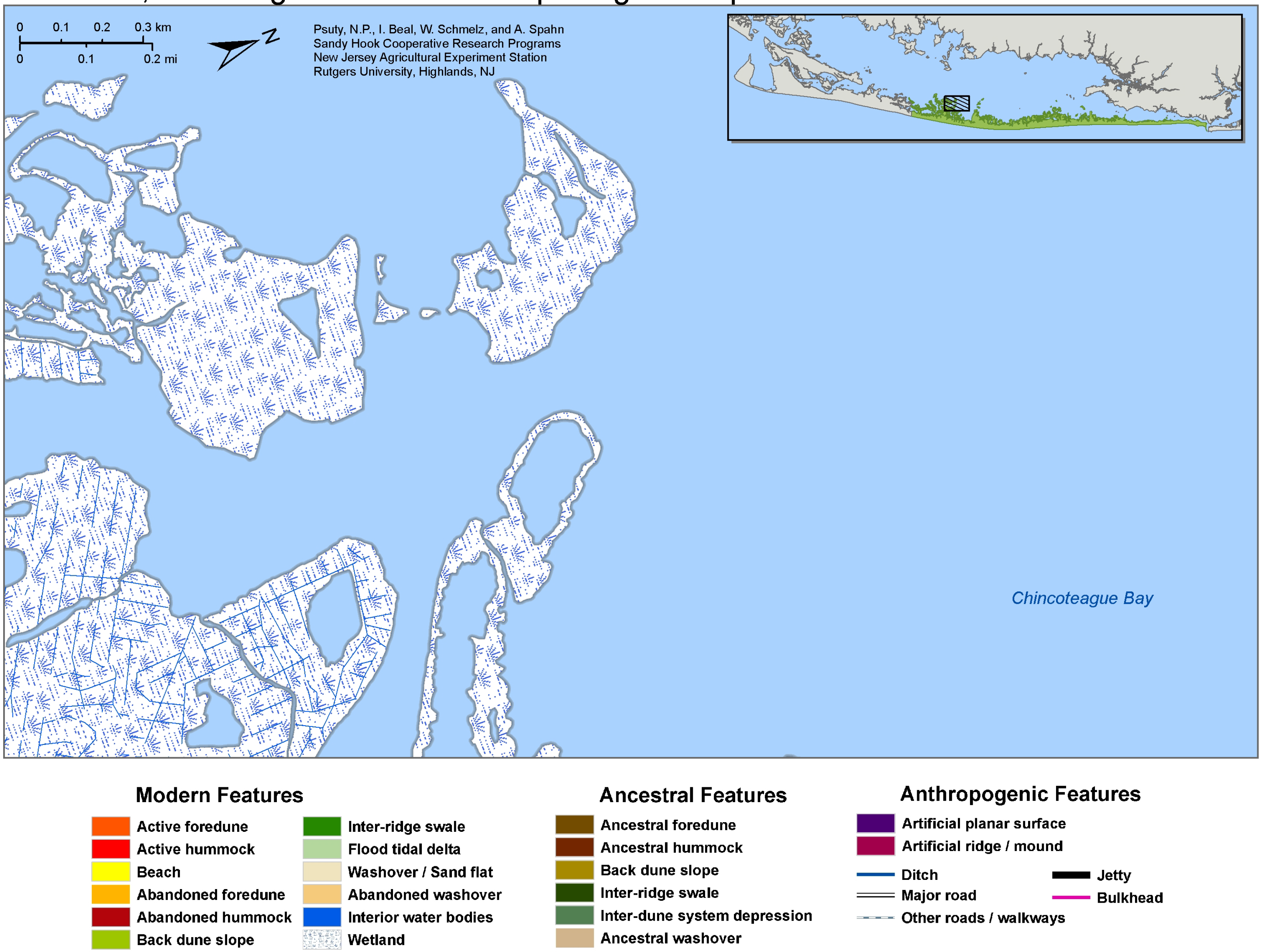


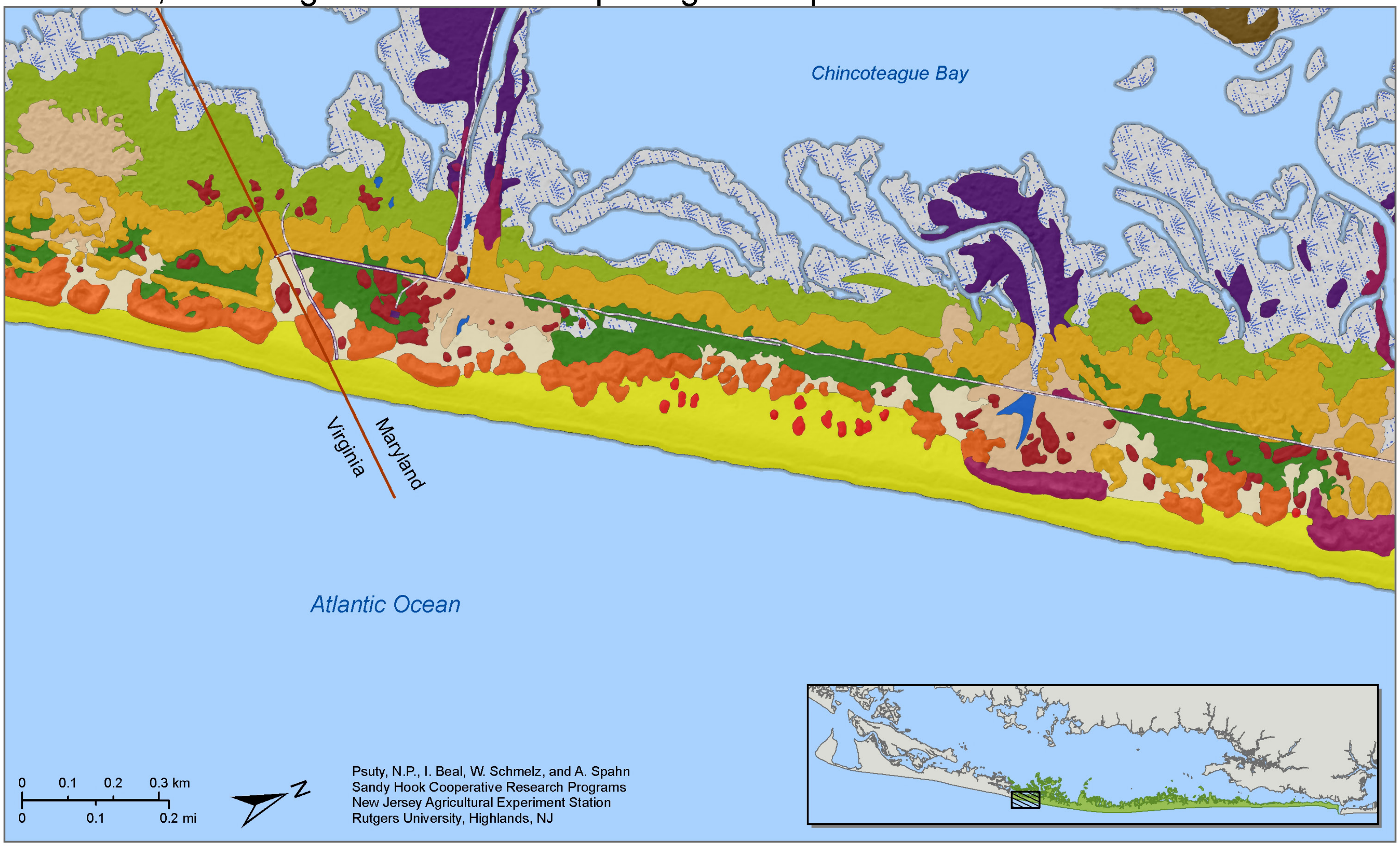
"Zone 14", Assateague Island Geomorphological Map with Hillshade



"Zone 14", Assateague Island Geomorphological Map



"Zone 15", Assateague Island Geomorphological Map with Hillshade

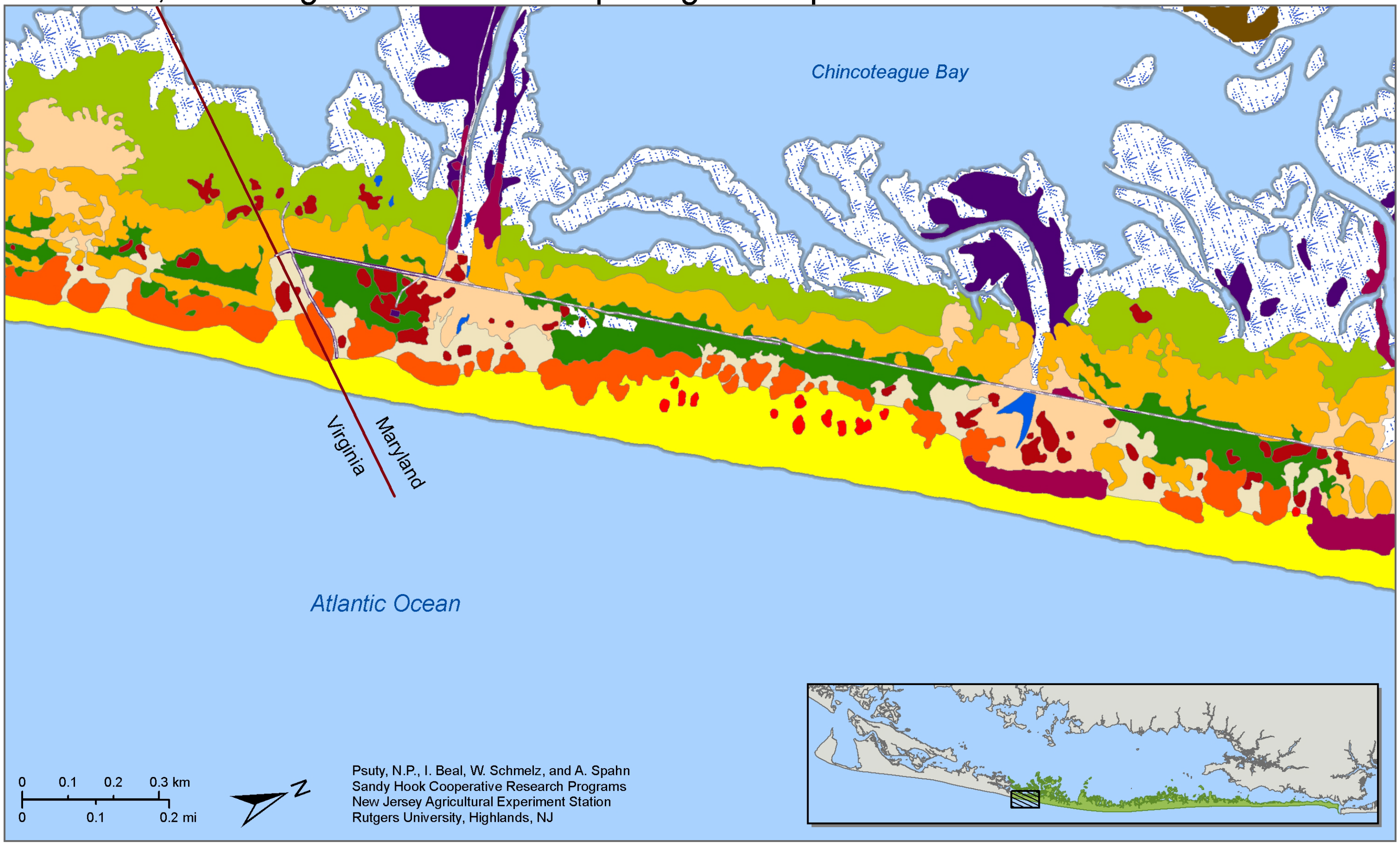


Modern Features
- Active foredune
- Active hummock
- Beach
- Abandoned foredune
- Abandoned hummock
- Back dune slope
- Inter-ridge swale
- Flood tidal delta
- Washover / Sand flat
- Abandoned washover
- Interior water bodies
- Wetland

Ancestral Features
- Ancestral foredune
- Ancestral hummock
- Back dune slope
- Inter-ridge swale
- Inter-dune system depression
- Ancestral washover

Anthropogenic Features
- Artificial planar surface
- Artificial ridge / mound
- Ditch
- Major road
- Other roads / walkways
- Jetty
- Bulkhead

"Zone 15", Assateague Island Geomorphological Map



Modern Features

- Active foredune
- Active hummock
- Beach
- Abandoned foredune
- Abandoned hummock
- Back dune slope
- Inter-ridge swale
- Flood tidal delta
- Washover / Sand flat
- Abandoned washover
- Interior water bodies
- Wetland

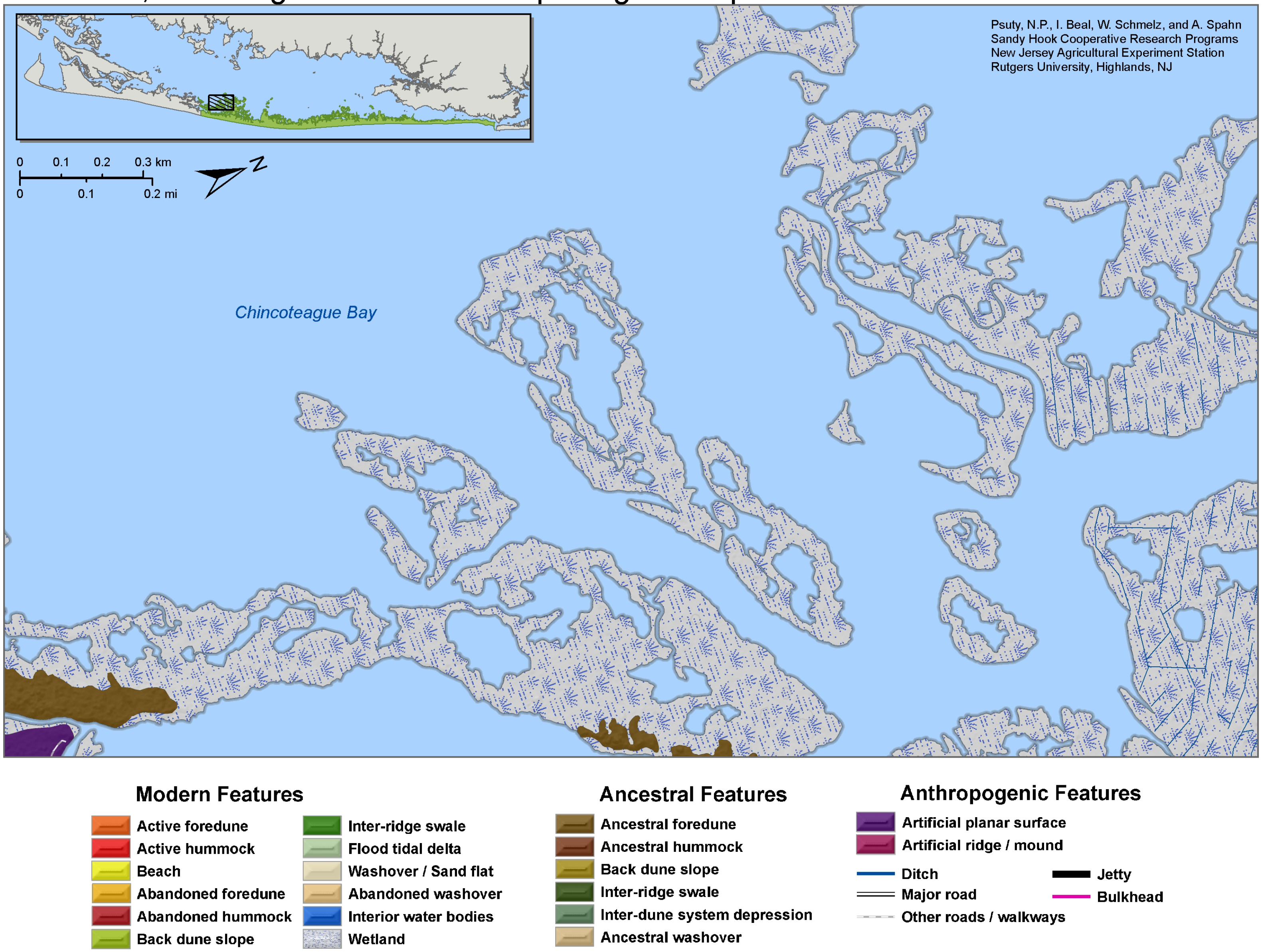
Ancestral Features

- Ancestral foredune
- Ancestral hummock
- Back dune slope
- Inter-ridge swale
- Inter-dune system depression
- Ancestral washover

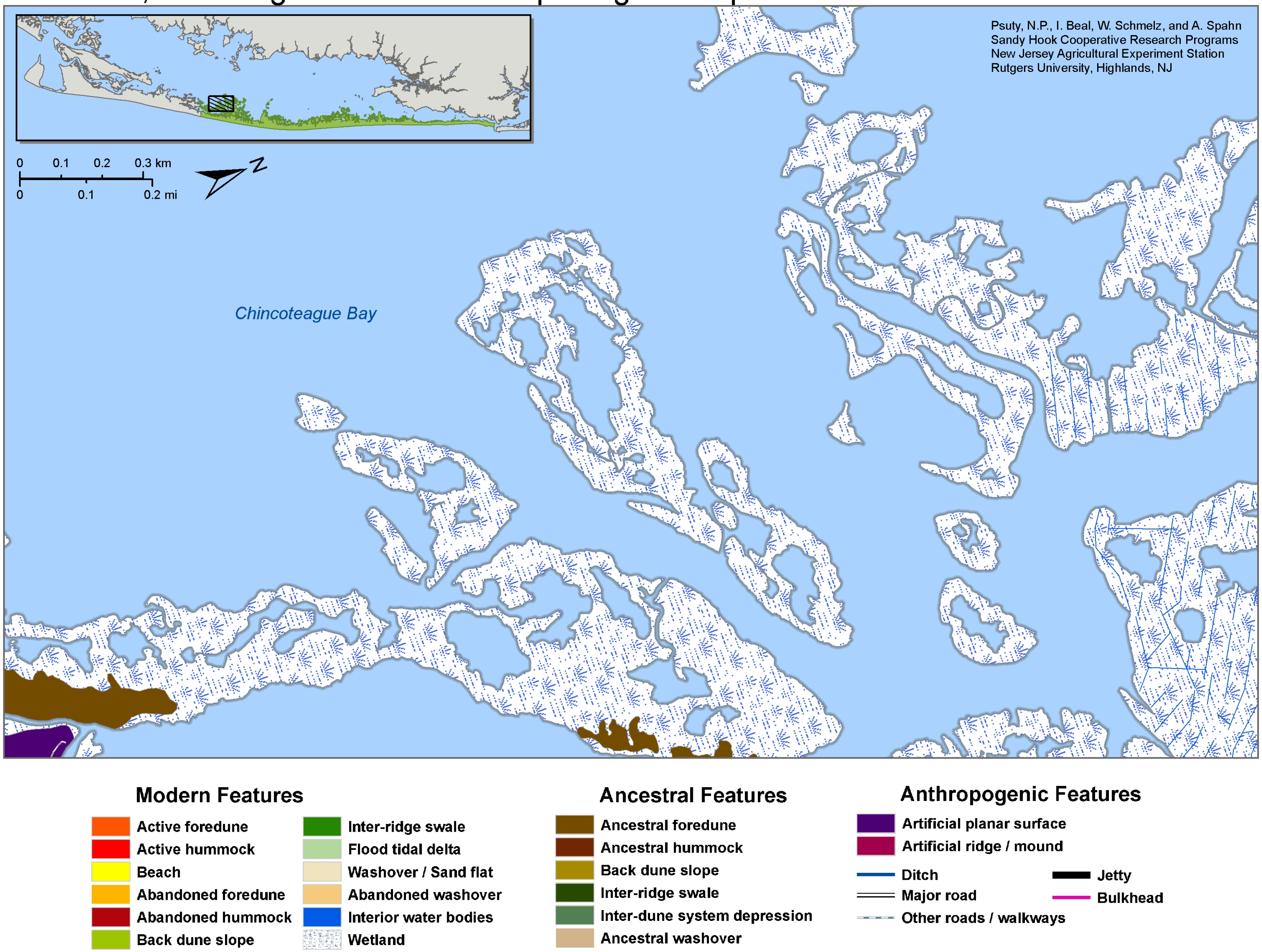
Anthropogenic Features

- Artificial planar surface
- Artificial ridge / mound
- Ditch
- Major road
- Other roads / walkways
- Jetty
- Bulkhead

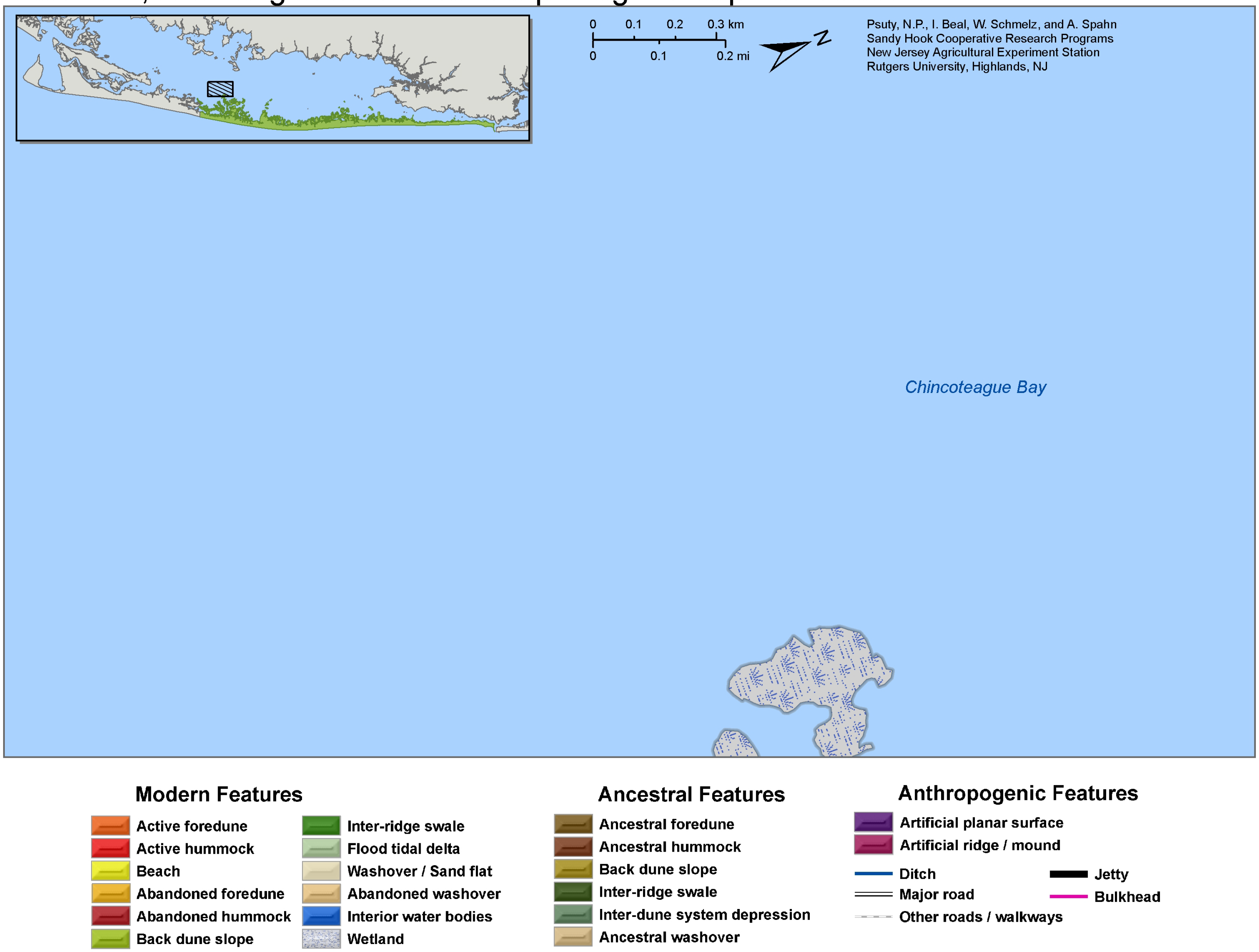
"Zone 16", Assateague Island Geomorphological Map with Hillshade



"Zone 16", Assateague Island Geomorphological Map



"Zone 17", Assateague Island Geomorphological Map with Hillshade



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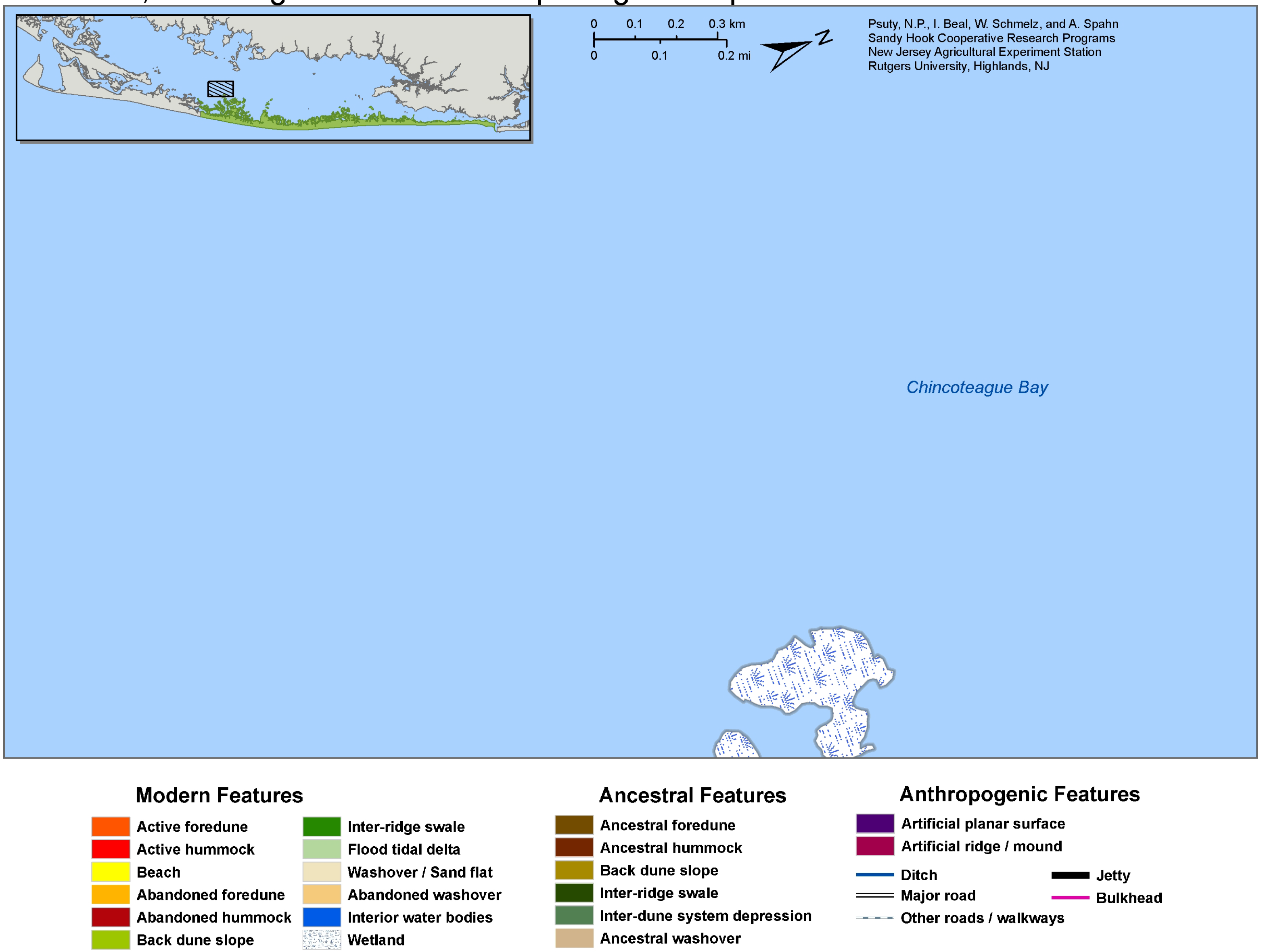
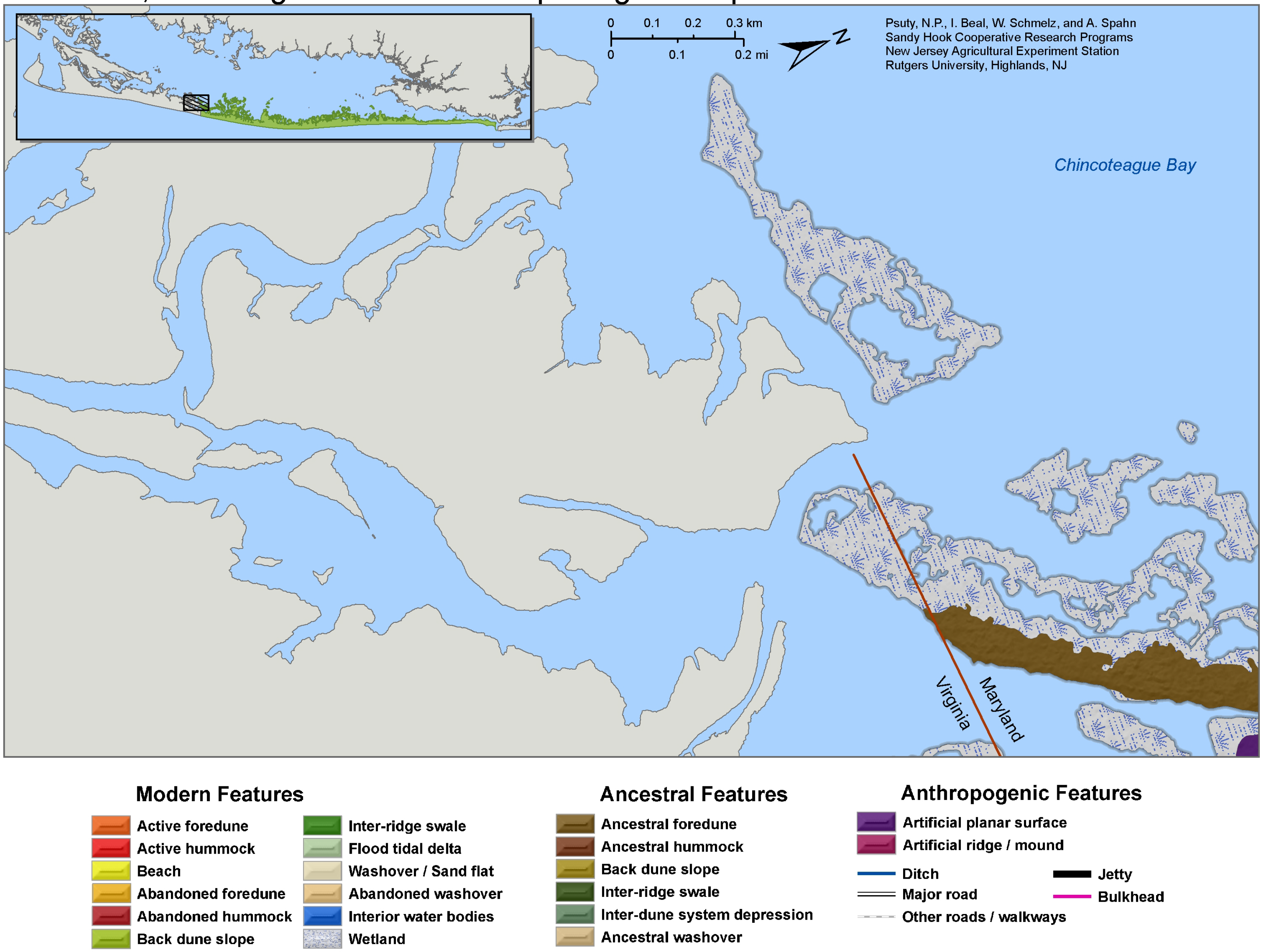
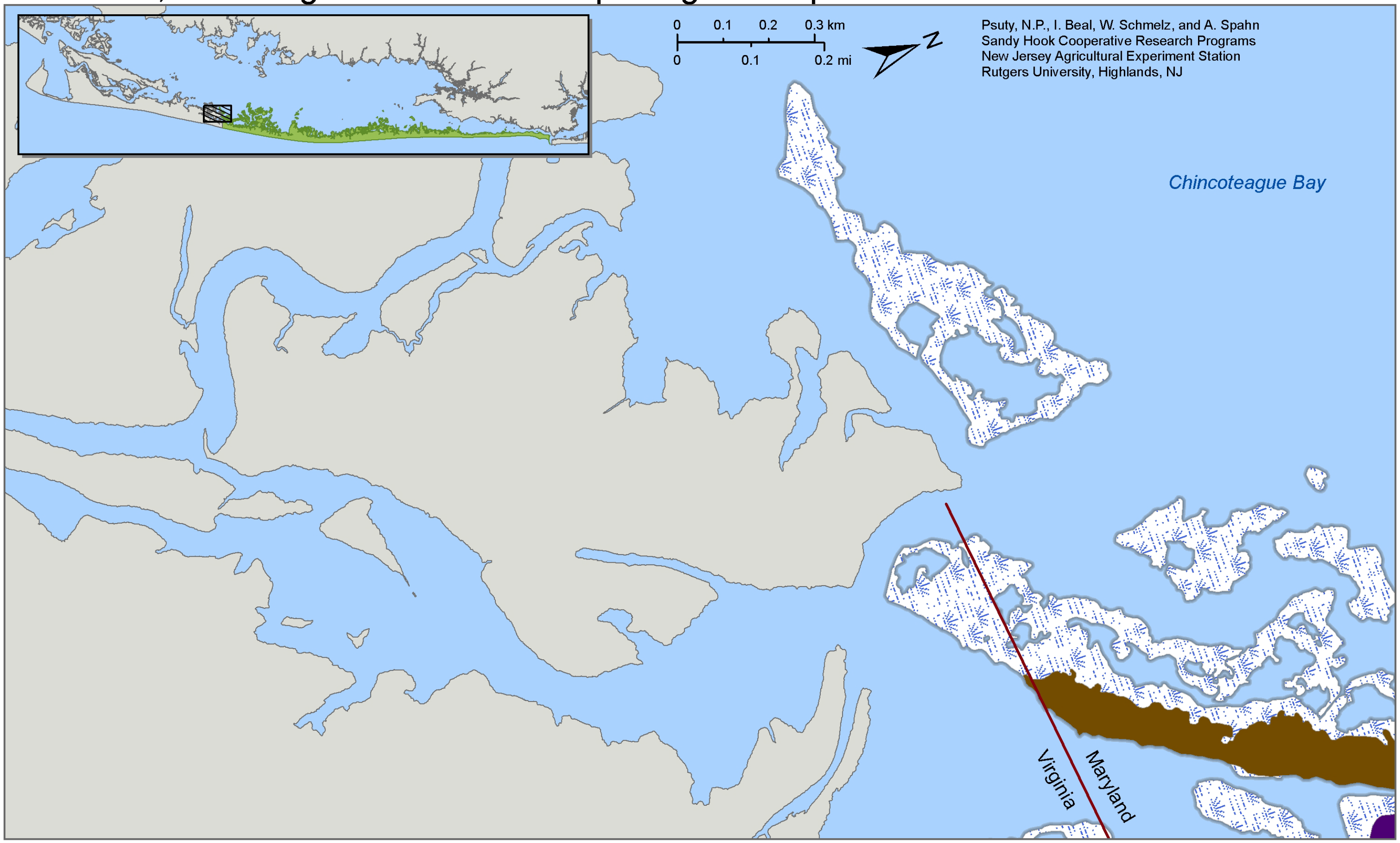
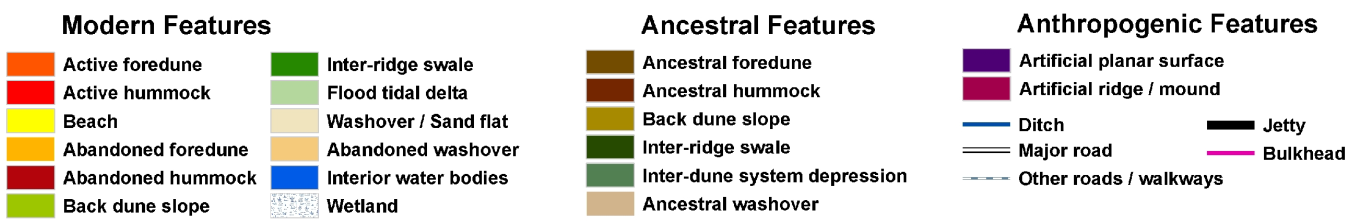


"Zone 18", Assateague Island Geomorphological Map with Hillshade



"Zone 18", Assateague Island Geomorphological Map





The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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