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[Manage Financials](#)  
[Program Income Reporting](#)  
[Grantee Cash Management Section Contacts](#)  
[Administration](#)  
[Lookup NSF ID](#)

## Preview of Award 0621014 - Final Project Report

[Cover](#) |  
[Accomplishments](#) |  
[Products](#) |  
[Participants/Organizations](#) |  
[Impacts](#) |  
[Changes/Problems](#)

### Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	0621014
Project Title:	Long-Term Drivers, State Change and Disturbance on the Virginia Coast Reserve: LTER V
PD/PI Name:	Karen McGlathery, Principal Investigator John H Porter, Co-Principal Investigator Patricia L Wiberg, Co-Principal Investigator
Recipient Organization:	University of Virginia Main Campus
Project/Grant Period:	12/15/2006 - 11/30/2014
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Submitting Official (if other than PD\PI):	John H Porter Co-Principal Investigator
Submission Date:	02/26/2015
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	John H Porter

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## Accomplishments

### \* What are the major goals of the project?

The central hypothesis of VCR V is that ecosystem dynamics and pattern on the landscape are controlled by the interaction between the vertical positions of the land, sea, and groundwater free surfaces, and the fluxes of organisms and materials across the landscape. Research during this grant was organized around 3 synthetic questions:

(A) How do long-term drivers of change (climate, rising sea level, and land-use change) and short-term disturbance events interact to alter ecosystem dynamics and state change, and how is their effect modified by internal processes and feedbacks at the local scale?

(B) How do fluxes of organisms and materials across the landscape influence ecosystem dynamics and state change?

(C) In the future, what will be the structure of the landscape and what processes will drive ecological state change?

**\* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities: We built on our long-term observations and experiments to develop quantitative models of these non-linear dynamics that show the emergence of alternative stable states, separated by thresholds, in the intertidal and subtidal parts the landscape. The attached table 2 provides a summary of the approaches and activities we used.

Of particular importance is a major experiment: In shallow coastal systems, seagrasses provide important ecosystem services including stabilizing sediment, sequestering carbon (C) and nutrients, and providing habitat and an energy source for a diverse fauna. The eelgrass (*Zostera marina*) that once carpeted the seafloor of the VCR coastal bays and supported a thriving economy became locally extinct in the early 1930s as a result of disease and storm disturbance, causing a catastrophic shift to an unvegetated state. We collaborated with colleagues at the Virginia Institute of Marine Sciences (VIMS) and The Nature Conservancy (TNC) in a large-scale ecosystem-level experiment to reverse the state change. This has resulted in >17 km<sup>2</sup> of restored habitat in a chronosequence of seagrass meadows 0 – 10 years since seeding. The first results of this long-term study are published in 10 papers in a special thematic issue of the journal Marine Ecology Progress Series. We document the recovery of key ecosystem functions related to primary productivity, C and nitrogen (N) sequestration, increased water column clarity, and sediment stabilization with a state change to seagrass dominance (Cole et al., 2012; McGlathery et al. 2012; Orth et al. 2012). Our longterm data indicate that at least a decade is required for these functions to be restored fully (McGlathery et al. 2012). The expansion of seagrass in the coastal bays has altered local hydrodynamics and switched the seafloor from an erosional environment to one that promotes deposition of suspended sediment by reducing near-bottom velocities (70-90%) and wave heights (45-70%) (Hansen & Reidenbach 2012).

Specific Objectives: Theme 1. State Change, Thresholds and Biotic Feedbacks

Significant Results:

Intertidal – Tidal marshes occur along the mainland coast, landward edges of barrier islands and in isolated patches within coastal bays. Their spatial extent and distribution is controlled by the balance between erosion at the bay-marsh interface and transgression at the upland-marsh interface as the marsh accretes vertically in response to sea-level rise. Based on our long-term experiments and observations, we found that VCR marshes are resistant to state change from high to low marsh in response to rising sea level over decadal time scales, and that disturbance is often necessary to overcome this resistance (Keusenkothen & Christian 2004). Disturbance also promotes fragmentation and pond formation, which in turn causes dynamic changes in food webs (Dame & Christian 2007, 2008). Our long-term record of marsh elevation indicates that some of the mainland marshes are accreting at a rate similar to that of sea-level rise (Fig. 2), but that bay marshes are

more vulnerable to submergence, which has adverse effects on waterbirds (Erwin et al. 2006, 2007). We also have evidence from short-term experiments that higher temperatures associated climate change could make marshes less resilient to sea-level rise by enhancing decomposition more than production (Kirwan & Blum 2011).

Barrier Islands – Long-term and landscape-scale vegetation patterns on the islands reflect non-linear dynamics and threshold responses to environmental drivers (Young et al. 2007, 2011; Zinnert et al. 2011). We showed that controls on plant community distribution can be explained by two key environmental parameters: distance from the shoreline (beach face) and elevation above sea level (Young et al. 2007, 2011). These two parameters integrate a number of important physical and biotic variables. For example, distance from the shoreline affects exposure to sea spray, burial by windblown sand, and vulnerability to storm-related disturbance (i.e., overwash) and, as a result, the extent to which ecological succession can take place. Elevation above sea level determines disturbance vulnerability, and influences groundwater and nutrient availability. The presence of plants feeds back to influence elevation by trapping and accumulating sand, or by maintaining low elevations (see below). These relationships can be used to assess changes in species distribution with variations in island geomorphology and with climate change scenarios of accelerating sea-level rise and altered storm frequencies. Over the last 30 years, we observed a dramatic increase in shrub thickets (*Myrica* sp.; now *Morella* sp.) by >400% as shrubs encroach onto grasslands (Fig. 4, Young et al. 2007). This has also been recorded in continental arid habitats and other coastal systems (Van Auken 2000; Knapp et al. 2008; Zinnert et al. 2011).

Shrub expansion was not related to island area or stability (Young et al. 2007), but instead to a decrease in precipitation and increases in winter temperatures and atmospheric CO<sub>2</sub> concentrations (Zinnert et al. 2011). Analysis of recent LiDAR (Light Detection And Ranging) data showed that *Morella* has only expanded into 50% of suitable habitat (based on elevation and distance to shoreline). These shrubs may be sentinels for climate change impacts on the barrier island landscape. Long-term observations also highlight effects of food webs in which predator (fox, raccoon) and small mammal populations are linked to the presence and patchiness of shrub thicket. In turn, the presence of predators on barrier islands is negatively correlated with the abundance of ground-nesting waterbirds (Erwin et al. 2011).

## Theme 2. Fluxes Between and Within Landscape Units Watershed Nutrient loading

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Nutrient fluxes from watersheds and airsheds potentially influence water quality (and clarity) and the dynamics of alternative stable states in the coastal bays. Since there are no large rivers that feed into VCR bays, nutrient inputs are primarily via groundwater and atmospheric deposition. Estimates of baseflow N loading from stream monitoring in a subset of the 54 subwatersheds that drain into the VCR coastal bays and a N loading model based on watershed land use/land cover show that loading is low relative to other coastal bays, making this an excellent reference system for more eutrophic systems regionally and globally (Fig. 5; McGlathery et al. 2007; Giordano et al. 2011; Cole 2011). These low nutrient-loading rates are corroborated by 17 years of water quality data (Fig. 6) and shorter-term monitoring

data (Moore et al., 2012) showing high water quality in the coastal bays (low inorganic N and chlorophyll concentrations). Although agricultural fertilizer is the dominant terrestrial N source to the region (Stanhope et al. 2009; Giordano et al. 2011; Cole et al. 2011), denitrification in the riparian zone and stream sediments is an important mechanism removing agricultural N from the shallow aquifer before it reaches the coastal bays (Gu et al. 2007; 2008a,b).

Faunal movements and trophic dynamics on barrier islands – Migrating songbirds are important vectors of seed transfer, influencing vegetation community structure and patch dynamics of shrub thickets and grasslands (Shifflet & Young 2010). Long-term observations showed that mammalian predators (foxes, raccoons) are highly mobile, moving from island to island based on accessibility and routes requiring the least expenditure of energy. Mammal movements and population dynamics related to vegetation structure (see above) together influence waterbird vulnerability to predation and indicate ‘hotspots’ where monitoring, experimental predator removal/reduction and behavioral modification (food aversion to reduce egg predation) would be most effective.

### Theme 3. Landscape Analysis

Our long-term analysis of decadal-scale land use/land cover data indicate that while there have been rapid rates of ecosystem state change at the local scale, there has been little apparent change in the aggregate distribution of landscape types. For example, decadal comparisons show that there was a 43% chance that any given location the barrier island upland would shift to another ecosystem state (e.g., marsh); however, at the landscape level, no ecosystem experienced major changes in total coverage (only 7% marsh and 6% barrier island coverage lost) (dataset: knb-lter-vcr.145). This reshuffling of habitats may be typical of coastal barrier landscapes that have been impacted relatively little by human activities, where there are no, or few, barriers to movement (e.g., island overwash, marsh transgression) and little human engineering that modifies natural hydrological and geomorphic processes.

Ecogeomorphic feedbacks – On the barrier islands, dune-building grasses (e.g., *Ammophila breviligulata*) aid accretion by trapping sand as they grow upward, thereby expanding the high-relief habitat in which they thrive (“dune-builder feedback”). Following overwash, this feedback can restore dunes given sufficient sand supply. However, if overwash recurs before dunes have reestablished, overwash-adapted species (e.g., *Spartina patens*) may preferentially survive, and by stabilizing the sediment so that it is unavailable for dune building, may lengthen the time needed for dune recovery and increase the vulnerability to persistent overwash (“maintainer feedback”). Over time, these feedbacks could lead to large-scale morphological changes, with 2 types of islands emerging: high-relief, less-frequently disturbed islands or low-relief, overwash-dominated islands (Fig. 8; Wolner et al. 2011).

Key outcomes or  
Other achievements:

VCR/LTER observations and experiments led to models that extend our ability to understand the processes and future states of VCR systems.

In the lagoons, the observed positive feedback of reduced sediment suspension and increased water clarity is the basis for a hydrodynamic model of vegetation-sediment-water flow interactions we developed, which shows the emergence of alternative stable states, one with clear water and a seagrass-covered bottom and

the other with more turbid water and no seagrass cover (Carr et al., 2010). The model shows that under current conditions, bistable dynamics occur at a depth range of 1.6 – 1.8 m (mean sea level – MSL), which agrees remarkably well with the 1.6 m maximum depth limit of current restored populations determined from our long-term monitoring (McGlathery et al. 2012). Bare sediment is the stable state deeper than 1.8 m, and the seagrass meadow is the stable state between 0.9 and 1.6 m depth (MSL). Seagrass meadows in the bistable depth range have limited resilience on decadal time scales, particularly to high temperature events associated with climate change, which causes state change by shifting the bistable range to shallower depths, and reduces aerial coverage of meadows (Carr et al. 2012 a,b).

In the intertidal, non-linear interactions between vegetation and the flow of water and suspended sediment drive state change dynamics of intertidal marshes (Brinson 2006; Day et al. 2008; Kirwan et al. 2010; Kirwan & Blum 2011). We developed a model that describes the strong coupling between the evolution of marshes and tidal flats, and the existence of these as alternative stable states as a function of vertical elevation (Fagherazzi et al. 2006; Mariotti & Fagherazzi 2010). Marsh edge erosion and sediment transport influence the dynamics of these alternative states. Our decadal scale (1957 – 2009) and detailed short-term measurements show that erosion rates vary more than an order of magnitude (0.1 m to 1.5 m per year; McLaughlin 2011). Based on a 2D model of hydrodynamics and sediment transport, we show that wave attack at the marsh boundary increases with tidal elevation until the marsh is submerged and then rapidly decreases (Fagherazzi & Wiberg 2009; Tonelli et al. 2010; Mariotti & Fagherazzi 2010). Wave energy at the marsh boundary produces a wide array of marsh edge morphologies (wave-cut gullies, terraces, overhanging root mats) that influence edge erosion rates and are related to local vegetation and sediment characteristics, and the presence of crab burrows and bivalves (Prietas & Fagherazzi 2011; McLaughlin 2011).

Nutrient processing and retention, sediment redistribution, and water temperature variations are all influenced by hydrodynamics and water residence times, and may affect the dynamics of alternative stable states in the marshes and coastal bays. We recently adopted the Finite-Volume Coastal Ocean Model (FVCOM), an open-source 3D unstructured-grid model that has a number of modules, including variable forcing (tide, wind, waves), wetting-drying, sediment transport, Lagrangian particle tracking, and water quality. We used the model to assess sediment suspension as a function of wave and tidal heights to simulate typical storm events, and calibrated it against field measurements. The results show a significantly larger effect of wave height than tidal amplitude on sediment suspension. Residence times calculated for bays with different bathymetry and coastline geometry were spatially variable within each bay, ranging from a few hours close to the channels to 2 weeks near the mainland boundary (Fig. 7).

On barrier islands, shrub expansion was not related to island area or stability (Young et al. 2007), but instead to a decrease in precipitation and increases in winter temperatures and atmospheric CO<sub>2</sub> concentrations (Zinnert et al. 2011). Analysis of recent LiDAR (Light Detection And Ranging) data showed that *Morella* has only expanded into 50% of suitable habitat (based on elevation and distance to shoreline). These shrubs may be sentinels for climate change impacts on the barrier island landscape. Long-term observations also indicate an 'upward cascade' in which predator (fox, raccoon) and small mammal populations are linked to the presence and patchiness of shrub thicket. In turn, the presence of predators on

barrier islands is negatively correlated with the abundance of ground-nesting waterbirds (Erwin et al. 2011).

Geomorphic models of barrier island change – As sea level rises, barrier islands will respond by migrating landward across the underlying substrate to higher elevations, by disintegrating if there is no longer sufficient sand volume and relief above sea level to prevent inundation, or by drowning in place. We are using a morphological-behavior model that simulates barrier island evolution and migration as a function of sealevel rise and changes in sediment supply to understand barrier island dynamics (Moore et al. 2010, 2011). Our results indicate that even though migration rates will increase with current scenarios of accelerated sea-level rise, low-lying VCR islands (e.g., Metompkin) are likely to avoid disintegration or inundation due to sufficient sand and the slope of the underlying substrate.

### **\* What opportunities for training and professional development has the project provided?**

The VCR/LTER project provided abundant opportunities for training, with at least partial support for 63 graduate students, 10 undergraduate students and 1 post-doc (see Personnel for details). Moreover, the inter- and multi-disciplinary nature of the research teaches the students how to operate in a collaborative environment. Each year, the VCR LTER supported 20 - 30 graduate students who conducted their M.S. and Ph.D. projects at the VCR site. Each summer, 3-4 undergraduate students received REU funding for 10-week research internships, partnering with a graduate student and P.I., and during the academic year 5 - 10 undergraduate students work in university laboratories of LTER P.I.s. Also, each year 1-4 local high school students were supported for 8 week internships at the VCR and work with undergraduate-graduate-P.I. teams. We have found this tiered mentoring to be extremely effective. Our Schoolyard-LTER (SLTER) program, and related activities, have helped introduce scientific concepts to K- 12 students. All high school students at Northampton High-School took an LTER-based course before they graduated, and some took more than one course. Each year, over 200 local students were exposed to LTER science. Additionally, the VCR field facility hosts 3 - 5 undergraduate classes, involving 60 - 100 students.

The Virginia County (Northampton) that houses the VCR program is one of poorest counties in the Commonwealth. It has been our experience that the majority of primary and secondary school students on Virginia's Eastern Shore have never spent significant time on the water, and few have ever ventured into the marshes or mudflats. Consequently, our involvement with this audience is very important. We involve about 200 students each year in our Schoolyard LTER program, more than half of whom are representative of women and minority groups. The VCR Program has helped outfit the science faculty at the county high school with badly needed computers, specialized software (e.g., GIS software), portable GPS units, supplies, reference material, etc.

In addition to traditional university-level education, the goals of the VCR/LTER education program are to: 1) involve and excite local school kids and teachers in marine science in general, and specifically about their local coastal barrier island system; 2) reach a broader audience of students through web-based resources; and 3) train undergraduate and graduate students through VCR research and involvement in national and internal collaborations. Our site director served as our Education and Outreach Coordinator and worked closely with local teachers and students. He also forged new education collaborations with our partners at The Nature Conservancy and colleagues at Chesapeake Experience. Our Schoolyard LTER program focused on local high schools in Northampton County and contained 3 main components: 1) curriculum development, 2) teacher training, and 3) high school student summer research internships.

1) Curriculum - We worked with science faculty at Northampton High School with the successful and popular Environmental Science II class. This class is built around water quality monitoring at 23 locations along the VCR, analogous to the water quality monitoring done as part of the VCR LTER data collection. Students learned basic laboratory techniques and are engaged in local environmental issues including: land use change and coastal eutrophication, sediment runoff, climate change and sea-level rise. SLTER support was used to purchase and maintain secchi tubes, thermometers, DO probes, refractometers, conductivity meters, and Smart Colorimeters used by the students to measure water quality parameters including: turbidity, temperature (water and air), dissolved oxygen,

salinity, nitrate/nitrite, ammonia and dissolved phosphorus. Using digital cameras and hand held gps units, also purchased for the school with SLTER support, the students take pictures of the area surrounding their monitoring sites and collect latitude and longitude positional data. They use this information along with GIS software and computers supplied with SLTER funding to create GIS maps of their study sites in order to characterize the potential impacts of varying land use patterns (i.e. agriculture, development, nature preserve, etc.) on the water quality parameters being monitored. Students use these data to analyze long-term trends in water quality criteria along the VCR. At the end of each semester the students described their methods and results in a PowerPoint presentation.

LTER staff and science faculty at Northampton High School also developed a new high school science class on Coastal Ecology. This class focused on the locally relevant human activities impacting the health, productivity and sustainability of coastal ecosystems along the VCR. We also made routine visits to Northampton High School to present guest lectures and assist in classroom instruction on such topics as GPS technology, seagrass ecology and water quality in Earth Science, Chemistry and Marine Biology classes. Finally, we hosted field trips for a variety of visiting middle and high school classes and science groups ranging in size from 10-60 students. On average, 10 school groups visited the VCR each year from the VA Eastern Shore, Virginia Beach, Norfolk, Richmond and Charlottesville.

2) Teacher training - Through our partnership with Chesapeake Experience, the VCR LTER offered 2 professional development classes for area teachers each year (Fall Migration Ecology and Coastal Bay Ecology May), with a combined enrollment of 28 teachers. These short courses provided instruction in ecology and environmental science topics centered around the Eastern Shore Barrier islands, but applicable to other VA ecosystems. The VCR LTER also hosted a new workshop for Art Teachers that linked instruction in Plein Aire painting techniques with our place-based research on salt marsh ecology. Nine teachers (4 from Northampton County) participated in the workshop, and an exhibit of the artwork and ecology essays they produced were displayed at the Barrier Islands Center Museum on the Eastern Shore and the Brown Science and Engineering Library at UVA . The success of this program has resulted in a grant awarded by the Buckner W. Clay Endowment for the Humanities, which supported 2 additional Art and Ecology workshops for public school Art teachers.

Two additional new programs were initiated in 2011-2012. In September 2011, we recruited and trained 6 local teachers (at least one teacher from every public and private school in Northampton County) to participate in the VA Oyster Gardening program. Field trips were run for 3 schools, involving over 40 local school children, to release the oysters they had grown onto local oyster reef sanctuaries. Groups from 2 other schools forged partnerships with the Chesapeake Bay Foundation to release their oysters at sanctuaries in the Chesapeake Bay.

#### **\* How have the results been disseminated to communities of interest?**

The scientific literature was the primary way the VCR/LTER disseminated information from the project. The VCR/LTER published 164 papers in scientific journals, with an additional 19 book chapters and 42 theses or dissertations. Additionally, over 160 datasets were made available via LTER data systems.

Additionally, the LTER developed links with conservation organizations, and local, state, and federal agencies through outreach efforts. The LTER has a strong partnership with TNC, and through this we addressed the important management and conservation problems that face the region. This put us in an excellent position to provide a solid, scientific foundation for making decisions related to planning, management, and ecosystem restoration. A good example of this was our collaboration with TNC (and VIMS) on the seagrass restoration in the VCR coastal lagoons. We provide key data (e.g., lagoon bathymetry) that facilitates the restoration program, and we also provide logistical support for the volunteer-driven TNC efforts on seagrass and oyster restoration.

Our Outreach/Education Coordinator was a member of the Eastern Shore Climate Adaptation Working group, a partnership between TNC, local, regional and federal agencies. He was also part of a regional committee formed to examine current zoning regulations and the potential economic and ecological impacts of developing commercial poultry production. In May 2012, the VCR LTER co-hosted a 'listening sessions' to assess local citizen responses to climate change issues with UVA's Institute for Environmental Negotiation (<http://ien.arch.virginia.edu/projects-current/virginia-sea-level-rise>).

An important part of outreach to the local community was a public seminar series hosted by the LTER and ABCRC, with monthly presentations by scientists working on the coastal barrier system. The seminar series, which began in Fall 2007 supported by a partnership between the NOAA Coastal Zone Management Program/Seaside Heritage Program, the Department of Environmental Sciences and the VCR-LTER. The purpose of the seminar series was to educate the local public about environmental research, management and restoration projects being conducted on the Eastern Shore of Virginia. Past seminar topics covered have included, seagrass ecology, barrier island history, the seaside heritage program, oyster catcher ecology, sea turtle ecology, habitat restoration in support of migratory song birds, the VA natural heritage program, salt marshes and sea level rise, oyster restoration, seagrass restoration, hypoxia and dead zones in the Chesapeake Bay, impacts of climate change on the Eastern Shore, stream and catchment hydrology, and the ecology of barrier island upland communities.

In addition to visiting classes we also hosted groups of the UVA Ecology Club, the VA Aquarium Mentoring Young Scientists program, the Eastern Shore chapter of the VA Master Gardeners and Master Naturalists programs, and the Virginia Association of Biological Sciences. Our Outreach/Education coordinate served as an instructor for the Eastern Shore chapter of the VA Master Naturalists program, lecturing on ecology, seagrass ecology, climate change, sea-level rise, and ichthyology.

VCR LTER investigators and graduate students frequently give presentations on topics of scientific interest to community groups and at scientific meetings and workshops.

### Supporting Files

Filename	Description	Uploaded By	Uploaded On
LTER 2006 Table 2.pdf	Table of observations and experiments	John Porter	02/11/2015
Figures for Significant Results and Key OutcomesFinalReport.pdf	Figures for Significant Results and Key Outcomes	John Porter	02/11/2015

## Products

### Books

Franklin, R.B. and Mills, A.L. (2007). *The spatial distribution of microbes in the environment* Springer. Dordrecht. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Perillo, G. and Wolanski, E. and Cahoon, D. and Brinson, M. (2008). *Coastal Wetlands: An Integrated Ecosystem Approach* Elsevier. Amsterdam, The Netherlands.. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Shugart, H.H. and Woodward., F.I. (2011). *Global Change and the Terrestrial Biosphere: Achievements and Challenges* Wiley-Blackwell Press. Oxford. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

### Book Chapters

Anderson, I. C. and Stanhope, J.W. and Hardison, A.K. and McGlathery, K.J. (2010). Sources and Fates of Nitrogen in Virginia Coastal Bays. *Coastal Lagoons: Critical Habitats of Environmental Change* Kennish, M. and Paerl, H.. CRC Press. Boca Raton FL. 43-72. Status = PUBLISHED; Acknowledgement of Federal Support = No ; Peer Reviewed = Yes

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Wolanski, E. and Brinson, M. and D.Cahoon and Perillo, G. (2009). Coastal wetlands: A synthesis. *Coastal Wetlands: An Integrated Ecosystem Approach* Perillo, G. and Wolanski, E. and Cahoon, D. and Brinson, M.. Elsevier. Amsterdam, The Netherlands.. 1-62. Status = PUBLISHED; Acknowledgement of Federal Support = No ; Peer Reviewed = Yes

## Conference Papers and Presentations

### Inventions

### Journals

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## Licenses

### Other Products

#### Databases.

During this grant, the VCR/LTER provided 120+ GB of data in nearly 160 separate datasets, 34 of which have a duration > 15 years. Through the use of Ecological Metadata Language (EML) 2.1 (level 5) metadata, our data can be discovered using the LTER Data Portal and other associated cataloging systems, as well as the VCR/LTER Data Catalog.

During the grant period we had 1,760 formal data requests. Not surprisingly, roughly one half of the data requests (557, 57%) came from faculty and students in some way associated with the project, almost entirely for research purposes. Researchers and students not associated with the VCR/LTER requested 419 datasets. Most (52%) were for educational use (class projects, etc.), with the remaining 48% for research uses. An additional 790 datasets were requested by automated programs using the LTER Data Access Server.

### Other Publications

#### Patents

#### Technologies or Techniques

#### Thesis/Dissertations

Martin, Joel. *A test of conditioned food aversion to control raccoon predation on the eggs of ground-nesting shorebird species on the barrier islands of Virginia.* (2007). Utah State University. Acknowledgement of Federal Support = Yes

Harbeson, Stephanie Anne. *An investigation of nutrient transfer in a restored eelgrass, Zostera marina, meadow.* (2010). University of Virginia. Acknowledgement of Federal Support = Yes

Bissett, Spencer Nathaniel. *Avian dispersal of the actinomycete Frankia across a barrier island landscape.* (2008). Virginia Commonwealth University. Acknowledgement of Federal Support = Yes

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Long, J. Bridget. *Belowground production of the mixed high marsh plant community Spartina patens and Distichlis spicata.* (2010). University of Virginia. Acknowledgement of Federal Support = Yes

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Kost, J.. *Changes in nitrogen, photosynthesis and leaf morphology in Morella cerifera leaves with increased age.* (2011). Virginia Commonwealth University. Acknowledgement of Federal Support = Yes

Brantley, Steven T.. *Consequences of shrub encroachment: linking changes in canopy structure to shifts in the resource environment.* (2009). Virginia Commonwealth University. Acknowledgement of Federal Support = Yes

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Robertson, Wendy Marie. *Diurnal Variations in Nitrate Concentrations in the Cobb Mill Creek, VA.* (2009). University of Virginia. Acknowledgement of Federal Support = Yes

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- Giordano, Juliette Christina Poletto. *Nutrient Loading and System Response in the Coastal Lagoons of the Delmarva Peninsula*. (2009). Virginia Institute of Marine Sciences. Acknowledgement of Federal Support = Yes
- Fennell, Jeremy D.. *Phragmites australis patch characteristics in relation to watershed landcover patterns on the Eastern Shore of Virginia*. (2007). Virginia Commonwealth University. Acknowledgement of Federal Support = Yes
- Lawson, Sarah E.. *Physical and biological controls on sediment and nutrient fluxes in a temperate lagoon*. (2008). University of Virginia. Acknowledgement of Federal Support = Yes
- McMillan, Brett A.. *Plant assemblage structure on "pimple" dunes at the Virginia Coast Reserve Long-Term Ecological Research site*. (2007). Old Dominion University. Acknowledgement of Federal Support = Yes
- Probasco, Paul G.. *Riparian Buffer Landscape Effects on Groundwater Flow Paths and Nitrate Occurrences in Groundwater near Streams of the Eastern Shore of Virginia*. (2010). University of Virginia. Acknowledgement of



Federal Support = Yes

Rubis, K.. *Shrubs as sentinels of ordnance contamination: using plant physiology and remote sensing to detect TNT in soils.* (2011). Virginia Commonwealth University. Acknowledgement of Federal Support = Yes

Aguiar, Amie B.. *Social and physical influences on wading bird foraging patch selection.* (2007). University of Virginia. Acknowledgement of Federal Support = Yes

Casciano, Gina Marie. *Soil fungal community patterns in a Virginia salt marsh.* (2007). University of Virginia. Acknowledgement of Federal Support = Yes

Gomez, Loreto Herraiz. *Spatial analyses and repletion of Gargathy coastal lagoon.* (2008). Old Dominion University. Acknowledgement of Federal Support = Yes

Robertson, Travis. *Spatial patterns of bacterial abundance in a seagrass restoration site on the Eastern Shore of Virginia (USA).* (2009). University of Virginia. Acknowledgement of Federal Support = Yes

Carr, J.. *Stability and resilience of seagrasses in shallow coastal bays.* (2011). University of Virginia. Acknowledgement of Federal Support = Yes

Willis, Patricia. *The effect of hydroperiod on surface elevation and sediment accumulation in Philips Creek Salt Marsh, Virginia, USA.* (2009). University of Virginia. Acknowledgement of Federal Support = Yes

Clarkson, C. E.. *The use of novel biomarkers in waterbird biology.* (2012). University of Virginia. Acknowledgement of Federal Support = Yes

Graziani, D. . *Thresholds of change in decomposition rates along a dune/swale transect on a Virginia barrier island.* (2012). Old Dominion University. . Acknowledgement of Federal Support = Yes

Hondula, Kelly L.. *Using multiple stable isotopes including deuterium to trace organic matter in a complex near-shore lagoon.* (2012). University of Virginia. Acknowledgement of Federal Support = Yes

Mozdzer, Thomas Jan. *Variation in the availability and utilization of dissolved organic nitrogen by the smooth cordgrass, *Spartina alterniflora*.* (2009). University of Virginia. Acknowledgement of Federal Support = Yes

Vick, Jaclyn. *Woody encroachment mechanisms of a symbiotic n-fixing shrub: Ecophysiology, facilitation, and resource use efficiency.* (2011). Virginia Commonwealth University. Acknowledgement of Federal Support = Yes

## Websites

Virginia Coast Reserve Long-Term Ecological Research

<http://www.vcrlter.virginia.edu>

The VCR/LTER Website provides a rich array of resources for both the researchers and the general public. These include LTER Data, publication lists, personnel lists, research highlights, full text of student theses and dissertations, photographs, videos and interactive maps.

During this grant, in addition to adding new datasets and updating long-term datasets, we made a number of improvements to the system. These included: 1) moving the web and database services from an aging Sun Unix computer to virtual Linux machines, 2) a transition of our web page to use the Drupal Content Management System and an accompanying redesign of the VCR/LTER web structure, 3) upgrade of EML to version 2.1, 4) transition to use of LTER-standard keywords and improvement of metadata editors to provide drop-down lists and automatically suggest LTER-standard keywords, 5) testing of all tabular datasets to assure that data types and ranges correspond to the metadata, and 6) expanding our field wireless network to add a network of ground-water wells and development of workflows to support them.

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## Participants/Organizations

**Research Experience for Undergraduates (REU) funding**Form of REU funding support: REU  
supplement

How many REU applications were received during this reporting period? 25

How many REU applicants were selected and agreed to participate during this reporting  
period? 10

REU Comments:

**What individuals have worked on the project?**

<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
McGlathery, Karen	PD/PI	6
Porter, John	Co PD/PI	12
Wiberg, Patricia	Co PD/PI	2
Anderson, Iris	Co-Investigator	2
Bachmann, Charles	Co-Investigator	2
Berg, Peter	Co-Investigator	2
Blum, Linda	Co-Investigator	2
Brinson, Mark	Co-Investigator	2
Christian, Robert	Co-Investigator	2
D'Odorico, Paolo	Co-Investigator	2
Day, Frank	Co-Investigator	2
Dueser, Raymond	Co-Investigator	2
Erwin, Russel	Co-Investigator	2
Fagherazzi, Sergio	Co-Investigator	2
Fuentes, Jose	Co-Investigator	2
Galloway, James	Co-Investigator	2
Macko, Stephen	Co-Investigator	2
Mills, Aaron	Co-Investigator	2

MONCRIER, Nancy	Co-Investigator	2
Moore, Laura	Co-Investigator	2
Oertel, George	Co-Investigator	2
Reidenbach, Matthew	Co-Investigator	2
Reyes, Enrique	Co-Investigator	2
Scanlon, Todd	Co-Investigator	2
Schwarzschild, Arthur	Co-Investigator	12
Shafer, Justin	Co-Investigator	6
Shugart, Herman	Co-Investigator	1
Smith, David	Co-Investigator	1
Young, Donald	Co-Investigator	2
Zieman, Joseph	Co-Investigator	2
Safak, Ilgar	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Betancourt, Christopher	Technician	12
Boyd, David	Technician	12
Buck, Christopher	Technician	12
David, Richardson	Technician	8
Fauber, Donna	Technician	12
Overman, Kathleen	Technician	12
Rodgers, Brooke	Technician	12
Battistelli, Joseph	Graduate Student (research assistant)	6
Bissett, Spencer	Graduate Student (research assistant)	6
Blecha, Staci	Graduate Student (research assistant)	6
Brantley, Steven	Graduate Student (research assistant)	6

Brenner, Owen	Graduate Student (research assistant)	6
Carr, Joel	Graduate Student (research assistant)	6
Challand, Maragaret	Graduate Student (research assistant)	6
Challard, Margaret	Graduate Student (research assistant)	6
Clarkson, Charles	Graduate Student (research assistant)	6
Cole, Luke	Graduate Student (research assistant)	6
Conroy, Patrick	Graduate Student (research assistant)	6
Fennell, Jeremy	Graduate Student (research assistant)	6
Flewelling, Samuel	Graduate Student (research assistant)	6
Funk, Clara	Graduate Student (research assistant)	6
Gomez, Loreto	Graduate Student (research assistant)	6
Graziani, Dominic	Graduate Student (research assistant)	6
Greener, Jill	Graduate Student (research assistant)	6
Gulbransen, Dana	Graduate Student (research assistant)	6
Hansen, Jennifer	Graduate Student (research assistant)	6
Harbeson, Stephanie	Graduate Student (research assistant)	6
Hardison, Amber	Graduate Student (research assistant)	6
Harrington, Christine	Graduate Student (research assistant)	6
Haywood, John	Graduate Student (research assistant)	6
Hondula, Kelly	Graduate Student (research assistant)	6
Hume, Andrew	Graduate Student (research assistant)	6
Kathilankal, James	Graduate Student (research assistant)	6
Kirwan, Matthew	Graduate Student (research assistant)	6
Koopmans, Dirk	Graduate Student (research assistant)	6

Kost, Elizabeth	Graduate Student (research assistant)	6
Kunz, David	Graduate Student (research assistant)	6
Lawson, Sarah	Graduate Student (research assistant)	6
Mariotti, Giulio	Graduate Student (research assistant)	6
Marsh, Amanda	Graduate Student (research assistant)	6
McFadden, George	Graduate Student (research assistant)	6
McFarland, George	Graduate Student (research assistant)	6
McLeod, George	Graduate Student (research assistant)	6
McLoughlin, Sean	Graduate Student (research assistant)	6
McMillan, Brett	Graduate Student (research assistant)	6
Michaels, Rachel	Graduate Student (research assistant)	6
Mozdzer, Thomas	Graduate Student (research assistant)	6
Naumann, Julie	Graduate Student (research assistant)	6
O'Connell, Michael	Graduate Student (research assistant)	6
Oster, Dana	Graduate Student (research assistant)	6
Poleto, Juliette	Graduate Student (research assistant)	6
Prietas, Anthony	Graduate Student (research assistant)	6
Probasco, Paul	Graduate Student (research assistant)	6
Rafferty, Emmett	Graduate Student (research assistant)	6
Reid-Black, Kristina	Graduate Student (research assistant)	6
Reynolds, Laura	Graduate Student (research assistant)	6
Robertson, Travis	Graduate Student (research assistant)	6
Robertson, Wendy	Graduate Student (research assistant)	6
Rubis, Kathryn	Graduate Student (research assistant)	6

Sahu, Parameswar	Graduate Student (research assistant)	6
Serebryakova, Alexandra	Graduate Student (research assistant)	6
Shiflett, Sheri	Graduate Student (research assistant)	6
Taube, Sara	Graduate Student (research assistant)	6
Vick, Jackie	Graduate Student (research assistant)	6
Voss, Christine	Graduate Student (research assistant)	6
Webster, Kirby	Graduate Student (research assistant)	6
Weinmann, Richard	Graduate Student (research assistant)	6
Whitman, Elizabeth	Graduate Student (research assistant)	6
Willis, Patricia	Graduate Student (research assistant)	6
Wolner, Catherine	Graduate Student (research assistant)	6
Anutaliya, Waen	Undergraduate Student	2
Bruno, Gavin	Undergraduate Student	2
Carlson, Charles	Undergraduate Student	2
Combs, Kendall	Undergraduate Student	2
Curtis, Ben	Undergraduate Student	6
Deemy, James	Undergraduate Student	2
Ellis, Stuart	Undergraduate Student	2
Emery, Kyle	Undergraduate Student	2
Hippert, Rachel	Undergraduate Student	2
Hoffman, Ava	Undergraduate Student	2
Long, Victoria	Undergraduate Student	2
Long, Bridget	Undergraduate Student	2
Luckenbach, Patrick	Undergraduate Student	2

McIntyre, Andrew	Undergraduate Student	2
Mische, Paige	Undergraduate Student	2
Olcott, Chris	Undergraduate Student	2
Peterson, Nancy	Undergraduate Student	2
Sherman, Arianna	Undergraduate Student	2
Starling, David	Undergraduate Student	2
Walsh, Kate	Undergraduate Student	2
Weakley, Meredith	Undergraduate Student	2
Wiles, Cory	Undergraduate Student	2
Mariner, Charlie	High School Student	6
Austin, Jared	Research Experience for Undergraduates (REU) Participant	2
Berry, Savannah	Research Experience for Undergraduates (REU) Participant	3
Pendergrass, Jessica	Research Experience for Undergraduates (REU) Participant	3
Richards, Joshua	Research Experience for Undergraduates (REU) Participant	3
Smith, Chris	Research Experience for Undergraduates (REU) Participant	3

### Full details of individuals who have worked on the project:

**Karen McGlathery**

**Email:** [kjm4k@virginia.edu](mailto:kjm4k@virginia.edu)

**Most Senior Project Role:** PD/PI

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Lead Principal Investigator, specializing in studies of seagrass

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

**John H Porter****Email:** jhp7e@virginia.edu**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 12**Contribution to the Project:** Co-PI and Information Manager**Funding Support:** NSF**International Collaboration:** Yes, China, Korea, Republic Of, Taiwan**International Travel:** Yes, Taiwan - 0 years, 2 months, 0 days**Patricia L Wiberg****Email:** pw3c@virginia.edu**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 2**Contribution to the Project:** Co-PI focusing on sedimentary processes in marshes**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Iris Anderson****Email:** ianderson@lternet.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2**Contribution to the Project:** Co-PI - Subcontract to Virginia Institute of Marine Sciences; research focuses on lagoon biogeochemistry and metabolism**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Charles Bachmann****Email:** cbachmann@lternet.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2**Contribution to the Project:** Co-PI - Naval Research Laboratory; research focuses on hyperspectral remote sensing of mainland, barrier island, marsh and lagoon systems**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Peter Berg****Email:** pberg@lternet.edu



**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on application of novel eddy correlation technique to subtidal systems to investigate benthic metabolism and groundwater fluxes

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Linda Blum**

**Email:** lblum@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on the effects of sea-level rise on marsh accretion, and bacterial community structure and intertidal and subtidal systems

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Mark Brinson**

**Email:** mbrinson@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to East Carolina University; research focuses on state change in marsh ecosystems in response to sea-level rise and disturbance

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Robert Christian**

**Email:** rchristian@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to East Carolina University; research focuses on state change in marsh ecosystems in response to sea-level rise and disturbance

**Funding Support:** NSF

**International Collaboration:** Yes, Italy  
**International Travel:** No

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**Paolo D'Odorico**

**Email:** pdodorico@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on modeling of alternate stable states in coastal lagoons

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Frank Day**

**Email:** fday@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to Old Dominion University; research focuses on plant community dynamics on barrier islands

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Raymond Dueser**

**Email:** rdueser@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to Utah State University; research focuses on small mammal genetics, population dynamics and predator-prey interactions on barrier islands

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Russel Erwin**

**Email:** rerwin@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia and U.S. Geological Survey, Biological Resources Division; research focuses on population dynamics of waterbirds

**Funding Support:** USGS

**International Collaboration:** No  
**International Travel:** No

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**Sergio Fagherazzi**

**Email:** sfagherazzi@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to Boston University; research focuses on model lagoon hydrodynamics, coastal geomorphology, and marsh accretion/erosion in response to climate change (sea-level rise, storms)

**Funding Support:** NSF

**International Collaboration:** Yes, Italy  
**International Travel:** No

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**Jose Fuentes**

**Email:** jfuentes@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on land-atmosphere carbon dioxide fluxes in marshes using tower-based eddy covariance technique

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**James Galloway**

**Email:** jgalloway@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on atmospheric nitrogen deposition, and nitrogen cycling between land, water, and atmosphere

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Stephen Macko**

**Email:** smacko@lternet.edu

**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on using isotope geochemistry to understand trophic dynamics in subtidal systems, specifically in relation to state change to seagrass system. On leave working at NSF 2008-2009.

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Aaron Mills****Email:** amills@lternet.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on groundwater hydrology and nutrient fluxes via tidal streams into lagoons, in particular on importance of denitrification in the riparian zone and stream sediments

**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Nancy Moncrief****Email:** nmoncrief@lternet.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Virginia Museum of Natural History, collaborates with Co-PI Dueser; research focuses on small mammal genetics, population dynamics and predator-prey interactions on barrier islands

**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Laura Moore****Email:** lmoore@lternet.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research on coastal geology and ecology using remote sensing. Started 2008.

**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**George Oertel****Email:** goertel@lternet.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to Old Dominion University; coastal oceanographer whose research focuses on reconstructing antecedent landscape of the VCR, hypsometry, and water residence times of lagoons

**Funding Support:** NSF**International Collaboration:** No

**International Travel:** No

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**Matthew Reidenbach**

**Email:** mreidenbach@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on sediment movements in the lagoon. Started 2008.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Enrique Reyes**

**Email:** ereyes@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to East Carolina University; research involves creating a landscape model of state change for the VCR marsh-lagoon-barrier island system in response to climate and land-use change

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Todd Scanlon**

**Email:** tscanlon@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; uses eddy covariance and laser techniques to study nitrous oxide and carbon dioxide fluxes from at the marsh-upland interface

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Arthur Schwarzschild**

**Email:** aschwarzschild@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Research Site Manager, Co-PI - University of Virginia; leads SLTER program with David Smith

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Justin Shafer**

**Email:** jshafer@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2006-2010). Advisor: Day; Thesis: Interisland variability of dune plant community structure on Virginia's barrier islands

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Herman Shugart**

**Email:** hshugart@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Co-PI - University of Virginia; terrestrial ecosystem modeling of the barrier islands

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**David Smith**

**Email:** dsmith@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Co-PI - University of Virginia; leads SLTER program with Arthur Schwarzschild, research focuses on invertebrate and fish communities in the coastal lagoons

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Donald Young**

**Email:** dyoung@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - Subcontract to Virginia Commonwealth University; research focuses on plant community dynamics on barrier islands, specifically on shrub expansion, invasive species and birds as agents of seed dispersal among islands

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Joseph Zieman**

**Email:** jzieman@lternet.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Co-PI - University of Virginia; research focuses on salt marsh chronosequence on barrier island and on nitrogen dynamics in salt marshes

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Ilgar Safak**

**Email:** isafak@lternet.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** 2010-2012. Post-Doc for PI Wiberg, working on sedimentary geology in Hog Island Bay. Supported by UVA funding.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Christopher Betancourt**

**Email:** cbetancourt@lternet.edu

**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 12

**Contribution to the Project:** 2010-. Lead programmer for PI Reyes VCR Landscape Model.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**David Boyd**

**Email:** dboyd@lternet.edu

**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Technician, responsible for boat logistics and assists with long-term monitoring

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Christopher Buck****Email:** cbuck@lternet.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 12**Contribution to the Project:** Technician, assists with long-term monitoring**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**Richardson David****Email:** dlr2n@virginia.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 8**Contribution to the Project:** Work on enhancing metadata and data products of the VCR/LTER**Funding Support:** NSF supplement 2012**International Collaboration:** No**International Travel:** No

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**Donna Fauber****Email:** dfauber@lternet.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 12**Contribution to the Project:** Fiscal Technician**Funding Support:** NSF/UVA**International Collaboration:** No**International Travel:** No

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**Kathleen Overman****Email:** koverman@lternet.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 12**Contribution to the Project:** Technician, Laboratory Manager, assists with long-term monitoring**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**Brooke Rodgers****Email:** brodgers@lternet.edu



**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Collect data maintain and operate monitoring equipment and boats at the Anheuser-Busch Coastal Research Center. (2011-2012)

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Joseph Battistelli**

**Email:** jbbattistelli@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2004-2009). Advisor: Mills; working on the effects of physical arrangement of nitrifiers in spaces at the scale of the organism on nitrification rates.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Spencer Bissett**

**Email:** sbissett@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** MS & Ph.D Student (2005-2009). MS thesis (2005-2009): Avian dispersal of Frankia for successful nodulation of Myrica seedlings. Ph.D student (2009-2014); Working with PI Young, focusing on the physiological ecology of Myrica shrub expansion in coastal environments.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Staci Blecha**

**Email:** sblecha@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student. (2006-2010) Advisor: Day; Thesis: Interisland variability in above and belowground plant biomass in interior marshes on the Virginia barrier islands

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Steven Brantley****Email:** sbrantley@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** Ph.D student (2005-2009). Advisor: Young. Dissertation: Consequences of shrub encroachment: linking changes in canopy**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Owen Brenner****Email:** obrenner@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** M.S. Student (2009-) at UVA working with PI Moore on beach dynamics.**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Joel Carr****Email:** jcarr@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** Ph.D student working with PI D'odorico (2007-2011) Dissertation title: Stability and resilience of seagrasses in shallow coastal bays**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Maragaret Challand****Email:** mchalland@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** M.S. Student (2011-) at UVA working with PI Mills on Cobb Mill Creek watershed with support from other grants.**Funding Support:** USGS**International Collaboration:** No**International Travel:** No**Margaret Challard**

**Email:** mchallard@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student working 2010-2015 with PI Mills on stream nitrogen loading and denitrification. Supported by a UVA fellowship 2010.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Charles Clarkson**

**Email:** cclarkson@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D Student (2007-2012). Advisor: Erwin; worked on waterbird population dynamics. Dissertation: Applicability of ptilochronology as a conservation tool in waterbird studies, University of Virginia

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Luke Cole**

**Email:** lcole@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. Student (2005-2011), Advisor: McGlathery; worked on the effects of seagrass restoration on nitrogen cycling and retention in coastal lagoons. Dissertation: Inputs and fluxes of nitrogen in the Virginia coastal bays: Effects of newly-restored seagrasses on the nitrogen cycle.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Patrick Conroy**

**Email:** pconroy@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student (2005-2007), Advisor: D. Smith; worked on the effects of macrophytes on invertebrate density and diversity in coastal lagoons

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Jeremy Fennell****Email:** jfennell@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** M.S. Student (2005-2007). Advisor: Young; Thesis: Phragmites australis patch characteristics in relation to watershed landcover patterns on the Eastern Shore of Virginia**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Samuel Flewelling****Email:** sflewelling@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** Ph.D student (2003-2008), Advisor: Mills; Dissertation: The hydrological control of nitrate fluxes from groundwater to streams on the Eastern Shore of Virginia.**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Clara Funk****Email:** cfunk@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** M.S. Student (2008-2010). Advisor: Scanlon; Ph.D Dissertation: Factors contributing to spatial variability of N<sub>2</sub>O fluxes in a Virginia salt marsh.**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Loreto Gomez****Email:** lgomez@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** M. S. student (2006-2008) Advisor: Oertel; Thesis: Spatial analyses and repletion of Gargathy coastal lagoon.**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

**Dominic Graziani****Email:** dgraziani@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** ODU MS student (2011-2012) Advisor: Day working on island vegetation dynamics.**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Jill Greener****Email:** jgreener@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** M.S. student working 2010-2013 with PI McGlathery on carbon cycling in seagrass.**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Dana Gulbransen****Email:** dgulbransen@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** PhD student (2008-2013). Advisor: McGlathery; working on effects of invasive macroalga, *Gracilaria vermiculophylla*, in subtidal seagrass and intertidal marsh ecosystems**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Jennifer Hansen****Email:** jhansen@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** Ph.D student (2009-) Advisor: Reidenbach. Research related to flow and sediment dynamics within seagrasses.**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Stephanie Harbeson****Email:** sharbeson@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D Student (2003-2010). Advisor: Macko; Ph.D Dissertation: An investigation of nutrient transfer in a restored eelgrass, *Zostera marina*, meadow

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Amber Hardison**

**Email:** ahardison@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. Student (2004-2009). Advisor: Anderson; working on the influence of macroalgal blooms on biogeochemical processes in coastal lagoons using a dual isotope tracer and biomarker approach

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Christine Harrington**

**Email:** charrington@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2007-2009), Advisor: Fagherazzi; working on field measurements of marsh erosion

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**John Haywood**

**Email:** jhaywood@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** MS Student; (2007-2009) working with Mark Brinson on effects of disturbance and stressors on ecological state change in tidal marshes at the VCR.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Kelly Hondula****Email:** khondula@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6

**Contribution to the Project:** 2008 worked with PI McGlathery and graduate student Laura Reynolds on seagrass demographics as an REU and subsequently did M.S. degree during 2009-2012 with PI Macko. Thesis: Using multiple stable isotopes including deuterium to trace organic matter in a complex near-shore lagoon. University of Virginia, Charlottesville.

**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Andrew Hume****Email:** ahume@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2004-2007). Advisors: Berg & McGlathery; Thesis: Dissolved oxygen fluxes and ecosystem metabolism in an eelgrass (*Zostera marina*) meadow measured with the novel eddy correlation technique

**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**James Kathilankal****Email:** jkathilankal@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2004-2008). Advisor: Fuentes. Dissertation: Carbon and Energy Flow Dynamics in a Coastal Salt Marsh.

**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Matthew Kirwan****Email:** mkirwan@lternet.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6

**Contribution to the Project:** Modeling of marsh and lagoon systems (2010-2012). USGS/BRD employee stationed at UVA.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Dirk Koopmans**

**Email:** dkoopmans@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2006-2011). Advisor: Berg; working on using the eddy correlation technique to measure groundwater fluxes into coastal waters

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Elizabeth Kost**

**Email:** ekost@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** VCU Biology MS student worked with Don Young on studies on the shrubs on Hog Island 2010-2011. Thesis: Changes in nitrogen, photosynthesis and leaf morphology in Morella cerifera leaves with increased age.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**David Kunz**

**Email:** dkunz@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2006-2008). Advisor: Brinson. Examining shorezone concept with respect to rising sea level. Includes comparisons of NC and Virginia.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Sarah Lawson**

**Email:** slawson@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2002-2008), Advisor: McGlathery & Wiberg; Dissertation: Physical and biological controls on sediment and nutrient fluxes in a temperate lagoon



**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Giulio Mariotti**

**Email:** gmariotti@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student (2008-2012), Advisor: Fagherazzi; modeling tide and wave dynamics in the coastal lagoons

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Amanda Marsh**

**Email:** amarsh@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M. S. Student (2005 - 2007), Advisor: Christian. Thesis: Effects on a salt marsh ecosystem following a brown marsh event

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**George McFadden**

**Email:** gmcfadden@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student (2009-) at UVA working with PI Mills and Herman on Cobb Mill Creek watershed. Supported by non-LTER funds.

**Funding Support:** USGS

**International Collaboration:** No

**International Travel:** No

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**George McFarland**

**Email:** gmcfarland@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student at UVA (2011-)working with PI's Mills and Herman on hydrogeochemistry of mainland creeks.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**George Mcleod**

**Email:** gmcleod@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2006-2009) Advisor: Oertel; working on data interpolation for DEM's and comparing lagoon hypsometry and repletion in Hog Island Bay, Chincoteague Bay and Magothy Bay

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Sean McLoughlin**

**Email:** smcloughlin@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student (2008-2010). Advisors: Wiberg/McGlathery; M.S. Thesis: Erosional processes along salt marsh edges on the Eastern Shore of Virginia.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Brett McMillan**

**Email:** bmcmillan@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2003-2008), Advisor: Day. Dissertation: Plant assemblage structure on 'pimple' dunes at the Virginia Coast Reserve Long-Term Ecological Research site.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Rachel Michaels**

**Email:** rmichaels@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2003-2009). Advisor: Zieman; working on the effects of *Uca pugnax* on pore water biogeochemistry and salt marsh productivity and stability in the context of sea-level rise

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Thomas Mozdzer**

**Email:** tmozdzer@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2004-2009), Advisors: Zieman & McGlathery; Dissertation: Variation in the availability and utilization of dissolved organic nitrogen by the smooth cordgrass, *Spartina alterniflora*.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Julie Naumann**

**Email:** jnaumann@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2002-2008). Advisor: Young. Dissertation: Linking physiological responses, chlorophyll fluorescence and hyperspectral imagery to detect environmental stress in coastal plants.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Michael O'Connell**

**Email:** mo'connell@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student (2003-2009), Advisor: Shugart; Dissertation: Ecohydrology of Delmarva Peninsula barrier island forests and the application of lidar to measure and monitor forest structure.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Dana Oster**

**Email:** doste@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student (2009-2011) working with PI Moore studying beach dynamics on the barrier islands.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Juliette Poletto**

**Email:** jpoletto@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2007-2009). Advisor: Anderson; Thesis: Nutrient Loading and System Response in the Coastal Lagoons of the Delmarva Peninsula.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Anthony Priestas**

**Email:** apriestas@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student (2007-2011), Advisor: Fagherazzi; working on marsh erosion and modeling feedbacks with vegetation

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Paul Probasco**

**Email:** pprobasco@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** PhD student (2006-2012). Advisors: Herman & Mills; working on denitrification in riparian zones and stream beds in coastal watersheds

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Emmett Rafferty**

**Email:** erafferty@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2007-2009); working with G. Oertel on modeling field-generated depth data to create a DEM of Magothy Bay.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Kristina Reid-Black**

**Email:** kreid-black@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student (2008-) at UVA working with PI Mills on Cobb Mill Creek watershed with support from other grants.

**Funding Support:** USGS

**International Collaboration:** No

**International Travel:** No

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**Laura Reynolds**

**Email:** lreynolds@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student (2006-2011). Advisors: McGlathery & Zieman; working on genetic basis of seagrass restoration success in coastal lagoons

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Travis Robertson**

**Email:** trobertson@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. Student (2006-2009). Advisors: Blum, McGlathery & Wiberg; Spatial patterns of bacterial abundance in a seagrass restoration site on the Eastern Shore of Virginia (USA). MA thesis. University of Virginia, Charlottesville, VA.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Wendy Robertson**

**Email:** wrobertson@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2006-2009). Advisors: Mills & UVA colleague Janet Herman; Thesis:

## Diurnal Variations in Nitrate Concentrations in the Cobb Mill Creek, VA

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Kathryn Rubis**

**Email:** krubis@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** VCU Biology MS student worked with Don Young on studies on the shrubs on Hog Island 2010-2011. Thesis: Shrubs as sentinels of ordnance contamination: using plant physiology and remote sensing to detect TNT in soils

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Parameswar Sahu**

**Email:** psahu@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2005-2007). Advisor: Scanlon; worked on nitrous oxide fluxes from marsh-upland ecosystems

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Alexandra Serebryakova**

**Email:** aserebryakova@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2007-2008). Advisor: R. Christian; working in Coastal Resource Management at ECU on a long-term data set of vegetation cover in a salt marshes to use in GIS analysis.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Sheri Shiflett**

**Email:** sshiflett@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2006-2008). Advisor: Young. Thesis: Avian seed dispersal on Virginia barrier islands: potential influence on vegetation community structure and patch dynamics.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Sara Taube**

**Email:** staube@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** MS student working 2010-2013 with PI Wiberg on sediment distribution in salt marshes. Supported by a UVA fellowship 2010.

**Funding Support:** UVA

**International Collaboration:** No

**International Travel:** No

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**Jackie Vick**

**Email:** jvick@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2005-2007). Advisor: Young. Thesis: Corticular photosynthetic dynamics for a coastal evergreen shrub: *Myrica cerifera*.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Christine Voss**

**Email:** cvoss@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student (2005-2007). Advisor: Christian; worked on network analysis of nitrogen cycling in coastal lagoons

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Kirby Webster**

**Email:** kwebster@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** PhD student (2007-2012). Advisors: Berg & McGlathery; working on measuring benthic metabolism in lagoons using eddy correlation system, with specific focus on state change from benthic algal to seagrass dominance

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Richard Weinmann**

**Email:** rweinmann@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D student (2003-2008). Advisor: Shugart; worked on water budgets of coastal watersheds.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Elizabeth Whitman**

**Email:** ewhitman@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** UVA M.S. Student (2008-2011). Advisor: Reidenbach. Thesis: Hydrodynamics affecting larval transport and settlement onto intertidal oyster reefs.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Patricia Willis**

**Email:** pwillis@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.A. Student 2007-2009; Advisor Blum. Thesis: The effect of hydroperiod on surface elevation and sediment accumulation in

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Catherine Wolner**

**Email:** cwolner@lternet.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6



**Contribution to the Project:** M.S. Student. University of Virginia. (2008-2011). Advisor: Moore. Thesis: Ecomorphodynamic feedbacks and barrier island evolution, Virginia Coast Reserve, USA

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Waen Anutaliya**

**Email:** wanutaliya@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Student at UVA working with PI Mills on Cobb Mill Creek watershed with support from other grants (2011).

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Gavin Bruno**

**Email:** gbruno@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** In 2011 worked with PI Schwarzschild. Assisted in the synoptic seagrass survey assisted with pilot study to examine impacts of sediment organic matter on eelgrass morphology and minimum light requirements.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Charles Carlson**

**Email:** ccarlso@eckerd.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Worked on preparing data for archiving and linking publications to datasets

**Funding Support:** NSF Supplement to VCRLTER 2012

**International Collaboration:** No

**International Travel:** No

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**Kendall Combs**

**Email:** kcombs@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Summer of 2012, worked on Seagrass project with PI Karen McGlathery and graduate student Laura Reynolds

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Ben Curtis**

**Email:** bcurtis@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 6

**Contribution to the Project:** 2007 worked with PI Zieman and graduate student Thomas Mozdzer on nitrogen cycling in salt marsh communities.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**James Deemy**

**Email:** jdeemy@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** VCU undergraduate, worked with Don Young on shrub-related projects in 2010

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Stuart Ellis**

**Email:** sellis@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** 2009-2010 ECU undergraduate student contributions to Haywood marsh disturbance study and independent study project on below ground organic matter (faculty advisor Christian)

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Kyle Emery**

**Email:** kemery@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** In 2011 worked with graduate student Jill Griener under the supervision of PI's McGlathery and Wiberg. Topic: Carbon sequestration in sediments of restored seagrass meadows in the coastal bays

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Rachel Hippert**

**Email:** rhippert@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** 2007 worked with PI McGlathery on seagrass restoration.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Ava Hoffman**

**Email:** ahoffman@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** UVA undergraduate, worked with Don Young on shrub-related projects in 2010.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Victoria Long**

**Email:** evsl31@gmail.com

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Worked on data entry and preparation of datasets for publication

**Funding Support:** NSF Supplement 2012

**International Collaboration:** No

**International Travel:** No

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**Bridget Long**

**Email:** blong@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** 2007-2008 worked with PI's Blum

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Patrick Luckenbach**

**Email:** pluckenbach@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** In 2011 worked with PI Schwarzschild. Assisted in the synoptic seagrass survey assisted with pilot study to examine impacts of sediment organic matter on eelgrass morphology and minimum light requirements.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Andrew McIntyre**

**Email:** amcintyre@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Summer of 2012 worked with PI Don Young on the vegetation dynamics of barrier islands

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Paige Mische**

**Email:** pmische@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** In 2010 worked with PI McGlathery and graduate student Dana Gulbransen on a project studying the ecological impacts of the invasive macroalga Gracillaria

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Chris Olcott**

**Email:** colcott@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** In 2010 worked with PI Linda Blum in studies of the effects of fertilizer additions to

below ground growth in saltmarshes

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Nancy Peterson**

**Email:** npeterson@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Worked in 2011 with graduate student Dana Gulbransen under Karen McGlathery on Potential Ecological Impacts of invasion by a non-native macroalgae

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Arianna Sherman**

**Email:** asherman@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Summer of 2012, worked on Seagrass project with PI Karen McGlathery and graduate student Laura Reynolds

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**David Starling**

**Email:** dstarling@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Worked with PI Young on studies of barrier island vegetation (2011)

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Kate Walsh**

**Email:** kwalsh@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Worked with PI Reidenbach on seagrass and oyster related research during 2010-2011.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Meredith Weakley**

**Email:** mweakley@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** In 2010 worked with PI Wiberg and graduate student Wolner on a sediment survey of Hog Island

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Cory Wiles**

**Email:** cwiles@lternet.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 2

**Contribution to the Project:** 2009-2010 ECU undergraduate student contributions to Haywood marsh study (faculty advisor, Christian)

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Charlie Mariner**

**Email:** cmariner@lternet.edu

**Most Senior Project Role:** High School Student

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Northampton HS, 2011 worked with graduate student Gulbranson on her project looking at impacts of the invasive ,macroalgae

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Jared Austin**

**Email:** jaustin@lternet.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 2

**Contribution to the Project:** VCU undergraduate, worked with Don Young on shrub-related projects in 2010

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No  
**Year of schooling completed:** Freshman  
**Home Institution:** VCU  
**Government fiscal year(s) was this REU participant supported:** 2010

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**Savannah Berry**

**Email:** sberry@lternet.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** worked with PI Reidenbach and graduate student Jenny Romanowich on clam filtration and seagrass studies

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

**Year of schooling completed:** Sophomore

**Home Institution:** UVA

**Government fiscal year(s) was this REU participant supported:** 2008

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**Jessica Pendergrass**

**Email:** jpendergrass@lternet.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** worked with PIs Christian & Blum on genetics of salt marsh cordgrass, *Spartina alterniflora*

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

**Year of schooling completed:** Junior

**Home Institution:** East Carolina

**Government fiscal year(s) was this REU participant supported:** 2008

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**Joshua Richards**

**Email:** jrichards@lternet.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Worked with graduate student Andrew Hume and PIs Berg and McGlathery on benthic metabolism in lagoons during 2007.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

**Year of schooling completed:** Sophomore

**Home Institution:** UVA

**Government fiscal year(s) was this REU participant supported:** 2008

**Chris Smith**

**Email:** csmith@lternet.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** 2007 Worked with Iris Anderson on lagoon nitrogen studies.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

**Year of schooling completed:** Junior

**Home Institution:** UVA

**Government fiscal year(s) was this REU participant supported:** 2007

#### What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Coastal Zone Management - Virginia	State or Local Government	Richmond, VA
Department of Army, U.S. Army Corp of Engineers	Other Organizations (foreign or domestic)	Washington, DC
Department of Navy Naval Research Laboratory	Other Organizations (foreign or domestic)	Maryland
NOAA National Environmental Satellite Data Information Servi	Other Organizations (foreign or domestic)	Virginia
The Nature Conservancy	Other Nonprofits	Nassawadox, VA
USGS Biological Resources Division	Other Organizations (foreign or domestic)	Reston, VA
Virginia Museum of Natural History	State or Local Government	Martinsville, VA

#### Full details of organizations that have been involved as partners:

**Coastal Zone Management - Virginia**

**Organization Type:** State or Local Government

**Organization Location:** Richmond, VA



**Partner's Contribution to the Project:**

Financial support

**More Detail on Partner and Contribution:** In 2007 a monthly public seminar series on environmental issues and research activities at the VCR-LTER was established with support by the Coastal Zone Management and Seaside Heritage Program of the Commonwealth of Virginia.

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**Department of Army, U.S. Army Corp of Engineers**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** Washington, DC

**Partner's Contribution to the Project:**

Personnel Exchanges

**More Detail on Partner and Contribution:** LiDAR expert John Anderson is supported during a sabbatical at UVA (2011-2012) and collaborated on studies of barrier island vegetation.

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**Department of Navy Naval Research Laboratory**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** Maryland

**Partner's Contribution to the Project:**

Personnel Exchanges

**More Detail on Partner and Contribution:** Co-PI Charles Bachmann was supported by, and worked at, NRL.

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**NOAA National Environmental Satellite Data Information Servi**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** Virginia

**Partner's Contribution to the Project:**

In-Kind Support

**More Detail on Partner and Contribution:** NOAA installed an operates a Climate Reference Network station at our laboratory in Oyster, VA. The resulting data provides a valuable adjunct to LTER meteorological data.

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**The Nature Conservancy**

**Organization Type:** Other Nonprofits

**Organization Location:** Nassawadox, VA

**Partner's Contribution to the Project:**

Facilities

Collaborative Research

**More Detail on Partner and Contribution:** The Virginia Coast Reserve of the Virginia Chapter of The Nature Conservancy provides access to study sites and field research facilities. They were frequent collaborators on

research projects. In 2010 they provided \$75K to assist us in a joint purchase of LiDAR data for the Eastern Shore of Virginia.

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### **USGS Biological Resources Division**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** Reston, VA

**Partner's Contribution to the Project:**

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:** Co-PIs R. Michael Erwin and Matthew Kirwan were supported by USGS/BRD and are stationed at UVA

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### **Virginia Museum of Natural History**

**Organization Type:** State or Local Government

**Organization Location:** Martinsville, VA

**Partner's Contribution to the Project:**

In-Kind Support

Personnel Exchanges

**More Detail on Partner and Contribution:** Collaboration on GIS databases of predator locations involving PI's Dueser (USU), Moncrief (VMNH) and Porter (UVA) The museum also provides physical storage of some VCR/LTER samples

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### **What other collaborators or contacts have been involved?**

YES

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## **Impacts**

### **What is the impact on the development of the principal discipline(s) of the project?**

VCR scientists contributed to theoretical advances in understanding complex non-linear dynamics of ecosystem change. Our strength is the interdisciplinary approach we take coupling geomorphology with ecological feedbacks. We built on our long-term observations and experiments to develop quantitative models of these non-linear dynamics that show the emergence of alternative stable states, separated by thresholds, in the intertidal and subtidal parts the landscape.

We developed models describing alternative stable states in the intertidal and subtidal parts of the landscape, and observed patterns in barrier island vegetation and island morphology that are consistent with bistable dynamics. The dynamics of alternative stable states have been described in inland terrestrial, freshwater, hard-bottom, and off-shore marine ecosystems, but only recently by us in soft-bottom coastal systems.

We contributed to the understanding of coastal systems through our efforts in studying the effects of sea level rise (which involves developing detailed understandings of the processes that effect accretion in marshes - both physical

and biotic, and encroachment into uplands), storm disturbance, coastal eutrophication, seagrass restoration, controls on plant production, determinants of faunal biogeography in an island system, and prediction of future state change.

#### WATERSHEDS AND LAGOONS:

Coastal lagoons are common features of the land margin, especially along the East and Gulf coasts. We hypothesized that these lagoons play an important role in retarding and transforming nitrogen during transport from land to the sea. To address this, we: (1) measure groundwater sources of nutrients to the lagoon; (2) measure rates of biological processes that remove or transform nitrogen in the waters and sediments of the lagoon; (3) compare rates of nitrogen cycling processes to physical transport across and out of the lagoon in order to determine whether the nitrogen remains in the lagoon for a sufficient length of time to allow biological processing to occur.

Our modeling and process studies indicated that the VCR lagoons receive relatively low inputs of nitrogen from the coastal watersheds compared to more eutrophic lagoons in the mid-Atlantic. Nitrogen that enters the lagoon is rapidly removed by both benthic macro- and microalgae. Our research has shown that nitrogen is retained in the sediments for a longer time than would be expected by turnover of plant biomass because nitrogen 'shuttles' back and forth between bacterial and benthic microalgal pools.

Shallow bays in the VCR and elsewhere along the US Atlantic coast experienced a dramatic state change in the 1930's when a single storm decimated seagrass populations already decimated by disease. Until recently, VCR lagoons persisted in an alternate, algal-dominated state. We found that high turbidity events in the VCR were episodic and wind driven and we estimated that average light availability over 65-87% of the lagoon bottom is suitable for seagrass recolonization. Beginning in 2007, in collaboration with Robert Orth from the Virginia Institute of Marine Science, we restored seagrass in a 509 acre 'set aside' we obtained from the Virginia Marine Resources Commission in our primary lagoon study site, Hog Island Bay. The seagrass restoration project contributed to important theoretical and applied problems related to coastal ecosystems. Our study of the coupling between biotic and abiotic processes controlling the dynamics of seagrass ecosystems has shown that: 1) The positive feedback that exists between seagrass and their light environment is strong enough to induce bistable dynamics within a limited depth range; and 2) Seagrasses within this depth range possess limited resilience, in that disturbances (high temperature events/poor growth conditions) may cause shift to stable bare sediment conditions.

MARSHES: Surface Elevation Tables (SETs) were used to quantify changes in sedimentation and subsidence that ultimately will determine the fate of marshes in the face of sea level rise. These baseline measurements at different marshes were then used in association with process-based studies focusing on the processes such as transport of material through tidal flooding, burial of organic matter and its decomposition, marsh plant production (both above and below ground) and the feedbacks on sedimentation rates, bioturbation by crabs, and even herbivory by insects to develop models aimed at predicting changes in marshes over the coming decades. Our results indicate that the on mainland marshes, the rate of accretion is generally keeping pace with sea level rise, and that specific rates are position dependent, with the upper marsh receiving less input.

BARRIER ISLANDS: Within the realm of coastal sciences, we demonstrated that barrier island plant communities are sensitive to climate change. These may serve as sentinels to climate change due to a rapid response to shoreline migration and storm related disturbances. The results increased our understanding of dynamic vegetation changes and their causes in coastal barrier island ecosystems. We established that landscape position is they key factor controlling the pattern of plant community development and production on the islands, with distance from the shore (and susceptibility to salt spray and overwash disturbance) and elevation (and distance to the groundwater) as the important factors defining landscape position. One of our most significant contributions has been to demonstrate that biotic interactions are very important in the coastal environment of the VCR, which we often define as being dominated by physical parameters. We demonstrated the importance of the presence of a soil actinomycete, *Frankia*, for the successful establishment of *Morella cerifera*.

SYSTEM-WIDE INTEGRATION: We are used two types of models to synthesize our long-term monitoring and experiments and shorter-term process studies to address the causes and consequences of state change on the VCR landscape. The goal of this modeling effort was to predict the non-linear and threshold responses of the VCR ecosystems to long-term environmental change and short-term disturbance events.

Landscape modeling: The data compiled so far have enabled tests of previously developed, but untested, conceptual models. Additionally, the data are contributing to a long-term predictive model of barrier island morphodynamics. These data will provide climate change assessments along one of the longest natural, mixed-energy barrier island systems in the world. We coined the term 'maintainer feedback' to apply to processes that maintain low elevations (in contrast to the more typically considered 'dune-builder feedback,' which leads to increases in island elevation). Our work on the maintainer feedback has improved our understanding of the role of combined physical and vegetative processes in barrier island evolution. Our ecomorphodynamic model of barrier island evolution synthesizes our work on physical and ecological barrier island processes and improves our ability to qualitatively predict future island evolution along the continuum from high islands to low islands.

Network modeling: We used ecological network analysis at the VCR to evaluate nitrogen cycling within mainland marshes and the lagoon and also the food web structure of salt marsh ponds (Dame 2005). We have expanded this effort to include states across the entire VCR landscape to provide assessments of nitrogen cycling relative to the contributions of biomass storage, recycling, physical and biotic exchanges. We also used network analysis within the ecological community via publications and workshops sponsored by NSF biocomplexity and the LTER network. Several groups within and beyond the LTER network have begun using the tools.

### **What is the impact on other disciplines?**

The studies conducted by the VCR/LTER were inherently interdisciplinary or multidisciplinary. Our studies were being performed by an interdisciplinary team of ecologists, hydrologists, biologists, and physical oceanographers. When such collaborations take place, it is not unusual that each group of scientists will gain greater insight into problems that may not be recognized within their own discipline.

With supplemental funds, we have supported work of a natural resource economist to understand public valuation of ecosystem services related to seagrass and marsh restoration. The 'willingness to pay' experiments give information on public opinions that influence policy and management decisions in the region. We have also helped develop new understandings of the tradeoffs involved in environmental conservation.

In 2011, we initiated an Artist-in-Residence Program to explore the value of the arts in communicating an understanding and appreciation of coastal ecosystems and the services they provide. Paintings from this program were on display at the local Barrier Island Center and the Science and Engineering Library at UVA.

Additionally, our workshops on network analysis exposed a broad group of scientists to the field of network ecology. Social scientists have also used network analysis, and one of our accomplishments has been to bring awareness of the different approaches to the broader group.

Research on ecological information management included computer scientists. The challenges posed by ecological data provided opportunities for innovation in computer science. Our work with development of wireless sensor networks, and processing of the massive data flows they can generate, contributed to better defining the cyberinfrastructure challenges that will confront us in coming decades. During 2006-2007 the VCR Information Manager participated in the Cyberinfrastructure-Core group and we hosted a modeling workshop that focused on the cyberinfrastructure needs of advanced ecological modeling.

### **What is the impact on the development of human resources?**

As can be seen from the number of graduate and undergraduate students listed on our participant list, this project provides abundant opportunities for training. Moreover, the inter- and multi-disciplinary nature of the research teaches the students how to operate in a collaborative environment. Each year, the VCR LTER supported 20 - 30 graduate students who conducted their M.S. and Ph.D. projects at the VCR site. Each summer, 3-4 undergraduate students received funding for 10-week research internships, partnering with a graduate student and P.I., and during the academic year 5 - 10 undergraduate students worked in university laboratories of LTER P.I.s. Also, each year 1-4 local high school students were supported for 8 week internships at the VCR and worked with undergraduate-graduate-P.I. teams. We have found this tiered mentoring to be extremely effective.

Our SLTER program, and related activities, helped introduce scientific concepts to K- 12 students. All high school students at Northampton County High School took an LTER-based course before they graduate, and some take more than one course. Each year, over 200 local students were exposed to LTER science. The VCR field facility hosted 3 - 5 undergraduate classes, involving 60 - 100 students.

### **What is the impact on physical resources that form infrastructure?**

Through our Schoolyard LTER supplement, we have been able to provide equipment such as global positioning system, taxonomic guides and water chemistry analysis kits and equipment to the Northampton Co. VA Public Schools. This program now extends from grades K-12 through the Northampton Co. elementary, middle and high schools.

Work that we did at the VCR was of interest to the Department of Environmental Quality of the State of Virginia, and in particular to the Water Conservation Districts located on the Eastern Shore. Proper management of agricultural activities and fertilization practices requires an improved understanding of nitrogen losses to the coastal lagoons via groundwater and surface water runoff.

We developed new instrumentation to conduct underwater particle image velocimetry (commonly known as PIV). Particle image velocimetry (PIV) has been used for a number of years in laboratories to measure velocity and turbulence over an area ranging from square millimeters to square meters. This system uses a laser and optics to create a laser light sheet. This light illuminates suspended particles in the flow and, using a digital camera, particle motion is recorded. With the recent development of laser diodes, powerful yet energy efficient lasers can be placed in water tight housings and submersed underwater. The system developed uses a 250 mW laser with a wavelength of 532 nm (green light). A waterproof housing has been designed to hold both the laser and optics used to spread the beam into a narrow, yet wide sheet. The housing is sealed and the laser is pulsed on and off using a magnetic switch controlled from outside the housing. Imaging of the illuminated particles is done using a high definition camcorder (Sony HDR-HC7) that can obtain images up to 60 frames per second. Both the laser and camera are attached to a rigid frame and can be deployed in the coastal ocean where suspended sediment particles are tracked.

We also developed a new instrument to measure sediment-water column fluxes in aquatic habitats, based on eddy correlation. The new technique measures fluxes under true in situ hydrodynamic and light conditions.

### **What is the impact on institutional resources that form infrastructure?**

The VCR was a primary user of the Anheuser-Busch Coastal Research Center of the University of Virginia and was integral to its success as a biological field station.

As detailed elsewhere, the VCR/LTER is also a provider of long-term, curated, data to the scientific community and general public.

### **What is the impact on information resources that form infrastructure?**

The VCR/LTER web page is widely used. Since October 2006, 5.1 terabytes of information have been downloaded by over 700,000 distinct clients. On a daily basis an average of over 3.7 gigabytes of information were transferred. However, such raw statistics can be misleading because search engines (e.g., Googlebot) make up a large number of the 'hits.' More telling is that users came from over 190 different countries or international organizations (as shown by network domains). Countries with over 100,000 requests included India, Switzerland, Netherlands, Czech Republic, Russia, Canada and China, and 32 additional countries each had over 10,000 requests. Similarly the large number of distinct hosts (550,000) reflects a wide user community.

The VCR/LTER provided 120+ GB of data in nearly 160 separate datasets, 34 of which have a duration > 15 years. Through the use of Ecological Metadata Language (EML) 2.1 (level 5) metadata, our data can be discovered using the LTER Data Portal and other associated cataloging systems, as well as the VCR/LTER Data Catalog. A more important measure of impact is datasets that are formally downloaded. These formal data requests require users to fill out a data license form. We had 1,760 formal data requests. Not surprisingly, roughly one half of the data requests (557, 57%) came from faculty and students in some way associated with the project, almost entirely for research

purposes. However, researchers and students not associated with the VCR/LTER requested 419 datasets. Most (52%) were for educational use (class projects, etc.), with the remaining 48% for research uses. An additional 790 datasets were requested by automated programs using the LTER Data Access Server.

### **What is the impact on technology transfer?**

With supplemental funds from NSF and in collaboration with The Nature Conservancy, Commonwealth of Virginia and U.S. Geological Survey, we supported the collection of high-resolution LiDAR-based elevation data for both Virginia counties located on the Eastern Shore (Northampton and Accomac). This data was made available via the VCR/LTER website and has been subsequently used for a wide array of scientific analyses related to sea-level rise. Additionally, FEMA is using this high-quality data to redraw flood maps, providing a more accurate basis for assessments of flooding and local governments are using the data to revise emergency plans.

We developed an auction-based methodology for assessing public attitudes that has subsequently received a patent (Patent No.: US 8,429,023 B2).

### **What is the impact on society beyond science and technology?**

We engaged in studies designed aid the conservation of avian fauna and better understanding of the extent and change in exotic plant species in the coastal zone in conjunction with TNC.

We worked closely with colleagues at the Virginia Institute of Marine Sciences and TNC to address issues relevant to sustainable restoration of seagrass and oysters in the VCR and in the mid-Atlantic region in general. Our models on bistable dynamics of seagrass meadows and the dependence on water depth provided useful information on regions within the VCR coastal bays that could potentially support seagrass habitats. We provided information on how the maximum depth limit for sustainable seagrass meadows could vary as a function of sediment conditions (organic content, grain size, hydrogen sulfide) and this helps managers identify areas that are most likely to support seagrass habitats over the long term. In addition, our work on hydrodynamic influences on oyster feeding and larval settlement is useful to practitioners in understanding how currents and exposure affect oyster growth and the persistence of oyster reefs.

In collaboration with the TNC, we did a retrospective analysis of long-term trends in erosion and accretion of mainland marshes throughout the VCR from the 1950's to the present. This is coupled with information on the presence of oyster reefs as a potential buffer to marsh erosion. Patterns of erosion were also overlain on maps of TNC-conserved lands to identify potential areas to study climate adaptation and the potential for marshes to transgress onto the mainland with predicted scenarios of climate change and sea-level rise.

Knowledge of the relationship between land use, nutrient contamination of groundwater, groundwater export of nutrients to coastal lagoons, and the fate of nutrients within lagoons will be of benefit to state and federal agencies charged with managing coastal resources. This knowledge will be especially important given the ongoing return of seagrasses to large areas of the coastal bays, from which they have been absent for over 70 years. The VCR lagoons are also a model system to understand the important role of plants in mediating nutrient export from coastal watersheds to the open ocean.

Linking information about variation in microbial and fungal community structure and fungal and microbially controlled processes (e.g., nitrogen-fixation, decomposition), helped predict how critical ecosystem processes will be affected by disturbances due to human activities in the coastal zone.

Activities with the UN programs on observing global change along coastal ecosystems have significance for broad aspects of public welfare and environmental protection. We helped develop the Coastal Module of GTOS to complement the Coastal GOOS program and highlights terrestrial, wetland, freshwater, and transitional ecosystems. Further and importantly it explicitly includes socio-economic components of global change in the coastal zone. This is the first significant introduction of the human dimension into the global observing systems.

Finally, the public seminar series begun in the summer of 2007 on environmental issues and research activities at the ABCRC was established with support from the Coastal Zone Management and Seaside Heritage Program of the

Commonwealth of Virginia. During the seminars, VCR/LTER researchers provided information on their research to the general public.

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## Changes/Problems

### **Changes in approach and reason for change**

Nothing to report.

### **Actual or Anticipated problems or delays and actions or plans to resolve them**

Nothing to report.

### **Changes that have a significant impact on expenditures**

Nothing to report.

### **Significant changes in use or care of human subjects**

Nothing to report.

### **Significant changes in use or care of vertebrate animals**

Nothing to report.

### **Significant changes in use or care of biohazards**

Nothing to report.