Annual Report for Period: 08/2004 - 08/2005
Submitted on: 08/16/2005
Principal Investigator: McGlathery, Karen .
Award ID: 0080381
Organization: University of Virginia
Title:
LTER IV: Long-Term Ecological Research on Disturbance, Succession, and Ecosystem State Change at the Virginia Coast Reserve

Project Participants

Senior Personnel

Name: Hayden, Bruce
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Porter, John
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: McGlathery, Karen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Zieman, Joseph
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Blum, Linda
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Shugart, Herman
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Anderson, Iris
Worked for more than 160 Hours: Yes
Contribution to Project:
Subcontract through VIMS

Name: Moncrief, Nancy
Worked for more than 160 Hours: Yes
Contribution to Project:
support from Virginia Museum of Natural History

Name: Mills, Aaron
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Brinson, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:
Subcontract through East Carolina University

Name: Christian, Robert
Worked for more than 160 Hours: Yes
Contribution to Project:
Subcontract through East Carolina University

Name: Erwin, R
Worked for more than 160 Hours: Yes
Contribution to Project:
Salary support by USGS/BRD as part of field station at UVA. USGS/BRD employee

Name: Day, Frank
Worked for more than 160 Hours: Yes
Contribution to Project:
Subcontract to Old Dominion University

Name: Galloway, James
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Macko, Stephen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Young, Donald
Worked for more than 160 Hours: Yes
Contribution to Project:
Subcontract to Virginia Commonwealth University

Name: Oertel, George
Worked for more than 160 Hours: Yes
Contribution to Project:
Subcontract to Old Dominion University

Name: Wiberg, Patricia
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Smith, David
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Albertson, John
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Fuentes, Jose
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Smith, David
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: McGlathery, Karen
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Schwarzschild, Arthur
Worked for more than 160 Hours: Yes
Contribution to Project:

Graduate Student

Name: Tyler, Anna
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Richardson, David
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Knoff, Amanda
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wu, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: May, Mindi
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Morrison, Sandra
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Lawson, Sarah
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: White, Jessica
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Zinnert, Julie
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Rounds, Rachel

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Parker, Frank
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Dame, Bo
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Keusenkothen, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Barr, Jordan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Rosinski, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Russell, Kristina
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Chauhan, Meetan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Herod, Devon
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Turaski, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Dusterhoff, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Lunsford, Tami
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Holinka, Allison
Worked for more than 160 Hours: No
Contribution to Project:

Worked on mudflat project

Name: Lowit, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Blum

Name: Thomas, Cassondra
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Blum

Name: Willis, Patricia
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Blum

Name: Dame, James
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Christian

Name: McMillan, Brett
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Day

Name: Barnes, Diane
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI McGlathery

Name: Thomsen, Mads
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI McGlathery

Name: Battistelli, Joseph
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Mills

Name: Franklin, Rima
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Mills

Name: Galavotti, Holly
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Mills

Name: Vandever, Jeffrey
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Oertel

Name: McGoff, Nicola

Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Zieman

Name: Michaels, Rachel
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Zieman

Name: Mozdzer, Thomas
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised by PI Zieman

Name: O'Connell, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kozak, Amber
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Floyd, Amanda
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Holzer, Kimberly
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Flewelling, Samuel
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Naumann, Julie
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Long, Matthew
Worked for more than 160 Hours: No
Contribution to Project:

Name: Brantley, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:
Major professor: Donald Young

Name: Fuest, Jaime
Worked for more than 160 Hours: Yes
Contribution to Project:
Major professor: Donald Young

Name: Fennell, Jeremy

Worked for more than 160 Hours: Yes
Contribution to Project:
Major professor: Donald Young

Name: Casciano, Gina
Worked for more than 160 Hours: Yes
Contribution to Project:
Advisor: Linda Blum

Name: Cole, Luke
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Conroy, Patrick
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Hume, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Hardison, Amber
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Vick, Jaclyn
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: O'connell, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:
Advisor: Shugart

Undergraduate Student

Name: Skane, Elizabeth
Worked for more than 160 Hours: No
Contribution to Project:

Name: Burton, Jessica
Worked for more than 160 Hours: No
Contribution to Project:

Name: Jiron-Murphy, Claudia
Worked for more than 160 Hours: No
Contribution to Project:

Technician, Programmer

Name: Carlson, Charles

Worked for more than 160 Hours: Yes
Contribution to Project:
Site Manager

Name: Spitler, James
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Smith, Phillip
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Overman, Kathleen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Restein, Jason
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Patrick, Brannon
Worked for more than 160 Hours: No
Contribution to Project:
Supported by the Virginia Museum of Natural History for work on the fauna of the islands and mainland

Name: Reynolds, Rene
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Mace, Joshua
Worked for more than 160 Hours: Yes
Contribution to Project:

Other Participant

Research Experience for Undergraduates

Name: Veloza, Adriana
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: Stroudsburg University
Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree
Fiscal year(s) REU Participant supported: 2000
REU Funding: REU supplement

Name: Diaz, Samuel
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Junior
Home Institution: Other than Research Site
Home Institution if Other: University of Puerto Rico
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2000
REU Funding: REU supplement
Name: Robinson, Jaime
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2002
REU Funding: REU supplement
Name: Quigley, Katherine
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2002
REU Funding: REU supplement
Name: Woodworth, Laurel
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2002
REU Funding: REU supplement
Name: van Montfrans, Schuyler
Worked for more than 160 Hours: Yes
Contribution to Project:
working with Kim Holzer/McGlathery

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2004
REU Funding: REU supplement
Name: Conroy, Patrick

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Kim Holzer/McGlathery

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2004

REU Funding: REU supplement

Name: Snyder, John

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Tom Mozdzer/Zieman

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2004

REU Funding: REU supplement

Name: Turner, Jason

Worked for more than 160 Hours: Yes

Contribution to Project:

working with Sarah Lawson/McGlathery and Pat Willis/Blum

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2004

REU Funding: REU supplement

Organizational Partners

NASA, Kennedy Space Flight Center

Collaborative comparative studies between the Virginia Coast and the Merritt Island National Wildlife Refuge

USFWS- US Fish and Wildlife Service

Merritt Island: Collaborative, comparative project between the Virginia Coast and the Merritt Island National Wildlife Refuge in Florida.

Eastern Shore: PI Donald Young is working to develop a management plan to control invaisive populations of fennel (Foeniculum vulgare) and Japanese honeysuckle (Lonicera japonica) in a 100-acre old field. Invaisive plant species are an increasing threat to wildlife reserves, especially in coastal environments, and most refuges have no management plans. We have developed a proposal for a three-year experimental study with treatments of fire, herbicide, mowing and shrub plantings. Results from this study will be used to develop a management plan for the entire 100 acres.

USGS Biological Resources Division

USGS scientist R. Michael Erwin holds a joint faculty appointment at the University of Virginia and collaborates extensively on faunal studies on the Virginia Coast.

PI's Blum and Mills have worked on a collaborative, comparative project between the Virginia Coast and the Merritt Island National Wildlife Refuge in Florida that includes USGS as a partner.

Florida St John's Water Management Dist.

PI's Blum and Mills have worked on a collaborative, comparative project between the Virginia Coast and the Merritt Island National Wildlife Refuge in Florida that includes the St. John's Water Management District as a Partner.

University of Buenos Aires

PI Mark Brinson has been working with Dr. Patricia Kandus, University of Buenos Aires, who visited the VCR site. She is part of a wetland ecology group in UBA biology department working on remote sensing of the Parana River Delta in Argentina. The are involved in developing a management plant for a MAB site in the delta, and are interested in ILTER.

Environmental Protection Agency

The Atlantic Slope Consortium, a group funded by an EPA STAR grant, will be working in the connection between watersheds and coastal estuaries. Primary contacts are through Mark Brinson at East Carolina University (ECU is a member of the consortium and will be conducting evaluations of watershed-estuarine coupling and condtions.) The consortium is coordinated by Penn State (Rob Brooks, PI) and includes other institutions such as Virginia Institute of Marine Science, Smithsonian Environemtal Research Center, and the Environmental Law Institute.

USDA

PI Iris Anderson is working under a USDA -National Research Initiative, Competitive Grants Program with a grant to study physical vs. biological process rates in VCR coastal lagoons

Czechoslovak Academy Science

PI Iris Anderson has been working with the Hydrobiological Institute - Academy of Sciences, Czech Republic on a collaborative study in the Shumava International LTER site.

NASA/Goddard Space Flight Center/Wallops Flight Facility

The VCR/LTER has been designated as a MODIS Validation Site, so NASA has been making available MODIS and other remote sensing data for the site. An Aeronet Sun Photometer has been hosted at the VCR/LTER. It uses changes in solar radiation to quantify atmospheric aerosols.

Participation as a EOS Land Validation core site has provided the VCR/LTER with numerous satellite images (ETM+, IKONOS).

Department of Navy Naval Research Laboratory

PI John Porter has been collaborating with NRL researchers Charles Bachman and Tim Donoto on remote sensing of land cover on the Virginia barrier islands. PI Robert Christian has is working with this research group on identifying areas of marsh die-off.

Nature Conservancy

Many of our research sites are owned by the Virginia Coast Reserve of The Nature Conservancy. We have also collaborated with them on a variety of projects ranging from landscape ecology of colonial waterbirds, to predator populations, to restoration of dredge spoil sites.

US Army Corps of Engineers

Army Corps of Engineers - They have expertise in sensing leaf optical properties which allows us to identify the presence and degree of stress in plants and, hopefully, the cause of the stress. We are evaluating the use of corresponding measurements of leaf reflectance and fluorescence as indicators of leaf/plant physiological responses to stress. We hope to refine the remote sensing technologies to make large-scale generalizations across the landscape. Low diversity coastal communities (i.e., shrub thickets, Spartina marsh) are ideal for scaling-up to the landscape level.

Virginia Dept. of Environmental Quality

They continue to provide support to PI Donald Young for vegetation monitoring on the Swash Bay dredge spoils. The longterm goal of the project is to eradicate or control Phragmites australis at the sites and return the landscape to native flora and fauna.

As part of a NOAA-funded grant to VA DEQ for a Coastal Management Program, PI Donald Young is defining the expansion of the invaisive reed Phragmites australis on the Eastern Shore and on the barrier islands. In addition to mapping we are evaluating spatial variations in Phragmites density, height and flowering. Response to fire on Parramore Island is also included. The results will assist land managers in determining the invaision potential of Phragmites in other coastal habitats.

Northampton Co. VA Public Schools

Through the Schoolyard Long-term Ecological Research supplement we have been interacting intensively with the Northampton County VA public schools. Students have been used to collect water quality and biological data at a number of sites.

Global Terrestrial Observing System

The VCR/LTER is one of the Terrestrial Ecosystem Monitoring Sites participating in GTOS.

City of Greenville, NC

VCR/LTER PI Robert Christian serves as chair of the Environmental Advisory Commission and is a member of the Comprehensive Planning Committee

Global Ocean Observing System

PI Robert Christian works with both GOOS and GTOS on remotely-sensed monitoring of ocean and terrestrial systems, including the Virginia Coast.

Italian International LTER

PI Robert Christian collaborates with a large number of researchers at coastal sites of the Italian Long-Term Ecological Research Network.

American Type Culture Collection

PI Linda Blum has been collaborating with Dave Emerson of ATCC on studies of the microbial communities on the Virginia coast.

Old Colorado City Communications

They have provided wireless networking equipment and expertise to the VCR/LTER, allowing us to link our island research sites with the Internet at high (2 MBS) rates of speed.

NOAA - Climate Research Network

NOAA has established and maintains a Climate Reference Network (CRN) climate monitoring station adjacent to the LTER Meteorlogical Station in Oyster VA. Data from the NOAA station is used to validate LTER meteorological data.

Virginia Marine Resources Commission

Other Collaborators or Contacts

We have collaborated extensively with researchers at other LTER sites. This includes:

-- Meryl Amber at the Georgia Coastal Ecosystems LTER has been collaborating with PI Robert Christian on the topic of areas of high vegetation mortality within salt marshes.

-- James T. Morris and Robert Ulanowicz collaborated with PI Christian on a book chapter on Network Analysis, an outcome of LTER Network workshops associated with the 2003 All Scientists Meeting.

-- James Gosz and Scott Collins of the LTER Network Office and Sevilleta LTER, respectively, have been collaborating with PI Hayden on the role of hydrocarbon emmissions from vegetation and the impact of these gases on local climate. This work was supported by an NSF supplement. This included the deployment of temperature sensors in the spring of 2004.

-- Three Taiwanese scientists (Chau Chin Lin, Sheng-Shan Lu and Meei-ru Jeng) visited the VCR/LTER in January 2004 to collaborate with PI Porter on the development of ecological information systems for international LTER work. In addition, during the spring of 2005 Meei-ru Jeng spent 3 months working with the LTER Information Manager in Charlottesville.

-- Paul Hanson of the University of Wisconsin collaborated with PI Porter on organizing Wireless Networking Workshops at the 2003 LTER All Scientists Meeting and the 2004 Ecological Society of America meeting. Presentations from the workshops are available at: http://www.vcrlter.virginia.edu/~jhp7e/wireless.

-- Contacts with Scientists from several countries in Southern Africa, specifically exchanges with LTER sites in southern Africa. Remote teleconferencing instruction was offered during 2002 with participants from Mozambique, Botswana and South Africa (Macko)

-- collaborations through workshops. PI Christian organized 2 workshops on network analysis through LTER (one at Snow Bird and one at ECU) and have received support for another (jointly with Alan Covich at Colorado State U.). More collaborations resulted from a biocomplexity workshop on network analysis. The list of collaborators contacts is extensive. They include individuals from other LTER sites, social scientists, and ecologists from outside the LTER network from the USA and abroad. (Christian)

-- Another collaborative effort from a cross-site LTER workshop focused on preseration of soil organic matter in wetlands. This alos involved scientists from the LTER netaork and outside. (Christian)

-- Drs. Jiri Kopacek, Vera Straskrabova, and Jarda Vrba, Hydrobiological Institute, Czech Academy of Sciences --collaborative study of nitrogen cycling processes in mountain lakes of the Sumava ILTER (Anderson, Macko)

-- Dr. Hana Santruckova, University of South Bohemia - collaborative study of N-cycling processes in watersheds of the Sumava ILTER (Anderson)

-- Dr. Rudolph Jaffee, Florida International University, Collaborative study of DOM quality in the VCR coastal lagoons and in PIE estuaries (Anderson)

-- Dr. Charles Hopkinson, Marine Biological Laboratory, PIE LTER, intercomparison of dissolved organic nitrogen dynamics in PIE (Anderson)

-- University of Georgia and Georgia Tech, GCE-LTER, intercomparison of groundwater/saltmarsh interactions (Anderson)

-- FCE-LTER, Collaborative study of dissolved organic
matter quality (Anderson)

-- James T. Morris (PIE LTER) co-hosted Organic matter workshop held at Virginia Institute of Marine Science, July 26, 01 (Anderson)

-- Dr. Patricia Kandus, University of Buenos Aires, visited the VCR site. She is part of a wetland ecology group in UBA biology department working on remote sensing of the Parana River Delta in Argentina. The are involved in developing a management plant for a MAB site in the delta, and are interested in ILTER. (Brinson)

-- PI Blum has been an active participant in cross LTER Organic Matter Workshops organized by Jim Morris. The goal of these workshops has been to compare organic matter accumulation in wetland sediments and the mechanisms controlling OM accumulation and to plan a series of experiments that include controlled laboratory incubations and reciprocal transplants of soil cores. Measurements might include CO2 and CH4 flux, O2 consumption, DOC loss, root ingrowth of cores, molecular characterization of microbial communities, pyrolosis GCMS and nutrient characterization of organic matter composition (new
production and old SOM). (Blum)

-- Blum is PI on NSF funded cross-site comparison study to examine the relative importance of local abiotic conditions vs. organic matter on microbial communities associated with decaying marsh grass and mangrove litter. Collaborators include: Gary King, Univ. of Maine Chuck Hopkinson, PIE LTER John Hobbie, PIE LTER Randy Chambers,
College of William and Mary Mike Reiter, Delaware State Univ. Bob Christian, East Carolina Univ. Jim Morris, Univ. South Carolina, NIN Steve Newell, GCE LTER Jay Garland, Dynamac Corp, NASA Mike Roberts, Dynamac Corp, NASA Joy Boyer, FCE LTER

-- Collaborative project with NASA Kennedy, USFWS, USGS,and State of Florida's St. John's Water Management District - working on comparison of the contribution of primary production and decomposition to organic matter accumulation and the effect on salt marsh sediment surface elevation changes between VCR and Merritt Island National Wildlife Refuge. Collaborators include: Ross Hinkle, Dynamac, Corp. Kelly Gorman, NASA Ron Brockmeyer, St. John's Water Management District Don Cahoon, USGS Mark Epstein, USFWS (Blum, Mills)

-- We have also had active contacts with African researchers interested in establishing International LTER sites. With an NSF supplement we hosted a workshop 'SOUTHERN AFRICA VIRGINIA NETWORKS AND ASSOCIATIONS - SAVANA I' Nov. 6-10, 2000. The purpose of the workshop was to explore scientific research topics, to share information about broad institutional collaboration, and to identify

demonstration projects that would lay the foundations for a regional environmental research and teaching infrastructure. The workshop participants identified three demonstration projects: (1) a collaborative distance learning project initially including WITS, the University of Eduardo Mondlane, and UVA; (2) an ecology and sustainable resource management station on the Mozambique coast; and (3) a collaborative ecological research station in the eastern Lowveld/Limpopo River basin that joins three existing stations in South Africa and Mozambique. Co-Convenors of the workshop were Harold Annegarn, Atmosphere and Energy Research Group, University of Witswatersrand, South Africa; Robert Swap, PI, SAFARI 2000 (Southern Africa Regional Science Inititative), Department of Environmental Sciences, University of Virginia; Hank Shugart, Leader, Global Climate Change Program, Department of Environmental Sciences, University of Virginia and participanting scientists were Pauline Opha Dube, Department of Environmental Sciences, University of Botswana; Bane Marjanovic, Director, Sasol Centre for Innovative Environmental Engineering, Department of Civil Engineering, University of Witswatersrand; Peter Omara-Ojungu, Dean, School of Science, University of Venda; Lars Ramberg, Director, Harry Oppenheimer Okavango Research Center, University of Botswana, Maun; Francisco Vieira, Dean, School of Science, Universidade Eduardo Mondlane, Mozambique; 'Diran Makinde, Dean, School of Agriculture, Rural Development, and Forestry, University of Venda; Stephen Macko, Workshop Program Chair, Department of Environmental Sciences, UVA; Paul Desanker, Coordinator, Miombo Network, UVA; and Mike Garstang, Bruce Hayden (Director, Virginia Coastal Reserve NSF LTER), Christelle Hely, Don Clark, Lufafa Abel, and Sam Alleaume, all faculty members in the Department of Environmental Sciences, UVA, and 13 graduate students.

-- In May 2001, African scientists Susan Ringrose, Luisa Santos, Rui Brito, and Almeida Sitoe visited the VCR/LTER. They toured the research site and met with VCR/LTER PI's and information specialists to discuss issues surrounding the creation and operation of LTER sites.

-- In July 2002, VCR/LTER PI's Zieman, Macko, Porter and Shugart participated in a series of meetings in Mozambique, South Africa and Botswana. These included participation in the Ecological Long-term Observatories of Southern Africa (ELTOSA) meeting (an International LTER regional group), Information Management training in Maputo, Mozambique, presentations on ecological information management to the staff of Kruger National Park in South Africa and a series of meetings with university administrators at a variety of South African universities.

Non-LTER collaborations include:

-- We have collaborated with Jay Austin (Old Dominion University), Dave Fugate and Karl Friedrichs (Virginia Institute of Marine Sciences) on the development and testing (using automated drifters) of a hydrodynamic model for Hog Island Bay.

-- We are collaborating with Dr. Donald Stillwell of Virginia Tech on the use of autonomous underwater vehicles to measure oxygen concentration in the lagoon. This will give us access to data on ecosystem metabolism that is otherwise difficult to get.

-- Boise State University - Dr. Steve Novak along with Dr. Greg Plunkett (VCU) and PI Don Young are collaborating on an integrated project (genetics, populaton biology, and physiological ecology) to assess the invasion potential of Phragmites australis on the Eastern Shore of Virgina. (Young)

-- Dr. Randy Chambers, Director Keck Laboratory, College of William and Mary - study of nutrient cycling processes in mudflats of the VCR (Anderson)

Dr. Carl Friedrich, Virginia Institute of Marine Sciences. Collaboration with Anderson on modeling studies of particle transport and residence times in Hog Island Bay (Anderson)

-- Dr. Mandy Joye, University of Georgia and Dr. Carolyn Ruppel, Georgia Tech, Groundwater flow at the salt marsh interface (Anderson)

-- Matt Jones, National Center for Ecological Analysis and Synthesis. Collaboration on testing of Ecological Metadata Language. (Porter)

-- Dr. Raymond Dueser, Utah State University, Barry Truitt, The Nature Conservancy. Mammalian predators often have severe negative effects on colonial-nesting waterbirds such as gulls, terns and shorebirds. These effects may vary with predator and prey species and with habitat, but often are extreme for introduced predators on islands. The raccoon (Procyon lotor) and red fox (Vulpes vulpes) are frequently implicated on islands. Based on both long-term anecdotal accounts and 20 years of breeding bird counts, most beach- and dune-nesting colonial waterbird populations have declined in recent decades on the Virginia barrier islands. It has been proposed that much of this decline is attributable to expanding distributions and increasing abundances of raccoons and red foxes. Direct effects such as nest depredation have been observed repeatedly but relatively infrequently over the past 20 years. We have been working to determine more directly the effects of mammalian predators on nesting waterbirds. There appeared to be a real effect of mammalian predators on nesting colonial waterbirds (in the form of reduced bird abundance) even in the absence of apparent effects (in the form of signs of depredation) in a given year. These results support the

contention that mammalian predators have had a significant long-term effect on colonial-nesting waterbirds on the Virginia barrier islands despite the infrequency of observed direct effects. This study represents a highly effective partnership among The Nature Conservancy, the Virginia Museum of Natural History, the Virginia Department of Environmental Quality and the VCR-LTER Program.(Moncrief, Porter)

We collaborated in 2002 with Dr. Ronald A. VanDenBussche, Department of Zoology, Oklahoma State University, in an (mtDNA)analysis of the phylogeography of raccoons on the Virginia barrier islands and the adjacent the Delmarva Peninsula (Moncrief).

-- Peter Arzberger of the University of California, San Diego collaborated in 2004 and 2005 with PI Porter on publications and workshops related to wireless networking of ecological research sites.

-- Bob Orth and Elizabeth Canuel(Virginia Institute of Marine Sciences), and Sergio Fahgarazzi (Florida State University have been collaborating on research related to the ecological status of bays, seagrass reintroduction and bay circulation during 2004 and 2005.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

See attached file

Findings: (See PDF version submitted by PI at the end of the report)

See attached file

Training and Development:

We have engaged in training at all levels of education. At the graduate level we have a large number of students who participate in the research conducted at the VCR/LTER. A smaller number of undergraduate student REUs participate in research, while a larger number of undergraduates experience the LTER site through class field trips. In the K-12 area we are engaged in taking hands on science into the classroom in the area of field measurements using state-of-the-art equipment. This involves classroom teaching on the part of VCR scientists, field demonstartions and WWW-based communications.

The VCR/LTER continues its efforts in the area of graduate education. During 2004-2005 three Ph.D and six M.S. students completed their thesis work at the VCR/LTER.

Some specific training and development activities were:

With additional funding from the Virginia Environmental Endowment we have been developing K-12 class activities using island-based webcams. The web site is at http://ecocam.evsc.virginia.edu.

Our investigations of sea-level rise and its wetland impacts provide many opportunities for visiting scientists all over the world to come and consult on the long-term project and to learn how to install and monitor the SETs. PI Erwin and his USGS colleagues Don Cahoon and J. Lynch have a network of SETs in many US states, and in many other countries at present that have been used for such training.

The VCR/LTER hosted for three months in the spring of 2005 an information manager-in-training from the Taiwan Ecological Research Network. During her stay she was taught to use content management systems, PHP and PERL CGI programming, Internet mapping (Mapserver)and relational databases (MySQL). The VCR/LTER Information Manager spent an additional week in Taiwan working with the TERN information management group on defining a strategy for future development and participated in an international workshop for the East Asia Pacific region, providing talks on LTER Site Information Management and Ecological Metadata Language.

Outreach Activities:

The Schoolyard LTER program continues to be a meaningful way of increasing future public understanding, now serving elementary, middle

and high schools in Northampton County, VA.

During the past year we have worked with The Nature Conservancy on issues of landscape dynamics, surveys of bird populations and on the extent of invasive species.

From 2003-2008, PI Erwin will serve on a seven-member National Science Panel that oversees a large, long-term San Francisco Bay Salt Pond Restoration program. The role is one of oversight over the development of a Science and Monitoring plan, and its implementation.

PI Robert Christian continues to be active with the Italian International LTER program. Christian has served as the Chair of the Expert Panel for development of the Coastal Module of UN's Global Terrestrial Observing System. Relatedly, he has served on the team to write the report for the Coastal Theme of the Integrated Global Observing Strategy. Additionally, he is program co-chair for the 2005 Estuarine Research Federation meeting and President-elect of the Estuarine Research Federation. He also serves on the Scientific and Technical Advisory Committee of the Albemarle Pamlico National Estuaries Program.

While PI Stephen Macko continues to be active in African ILTER efforts. He, Porter, Shugart and student A. Knopf participated in the southern African ELTOSA workshop in Mozambique in July 2002.

Nancy Moncrief used distributional data collected from the multi-island surveys in a Teacher Re-Certification class that she teaches through the University of Virginia at the Roanoke Higher Education Center. She reviewed processes such as extinction and colonization and concepts such as succession, habitat complexity, and carrying capacity. Typically, there are 20-30 K-12 teachers in this course each year. Her work at VCR/LTER was featured in an article about me that appeared in VMNH's popular publication The Virginia Explorer, published in May 2002.

Don Young was appointed to the Governor's Advisory Board of Soil Scientists and Wetlands Professionals. We will be developing guidelines for certifying professionals as wetlands ecologists.

Images from the VCR/LTER WWW site have appeared in a number of publications for the general public. These include Chesapeake Life Magazine, UVA Insights and the Eastern Shore Post.

The VCR/LTER WWW site (http://www.VCRLTER.virginia.edu)is widely used. We average over 8,500 requests for information resulting in over 290 MB of downloads each day. Educational users accounted for 17% of all requests, while commercial users or educational users using a commercial network provider accounted for 49%. A complete web statistics report is available at: http://www.vcrlter.virginia.edu/analog/.

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Web/Internet Site

URL(s):

http://www.VCRLTER.virginia.edu

Description:

This WWW site serves as the "file cabinet" for the VCR/LTER Project - both for researchers within the project and external scientists. It provides access to a wide array of information products derived from the grant including data, searchable bibliographies, full text of proposals and theses and dissertations. The site is heavily used with over 8,500 requests served on the average day.

Other Specific Products

Product Type:

Data or databases

Product Description:

The VCR/LTER provides access to more than 100 formally documented data sets. They are listed on the WWW at: http://www.vcrlter.virginia.edu/data.html. They include physical, biological, geographical and model data sets. Some data sets also support sophisticated queries, such as our biodiverisity database, or extensive graphical output, such as our meterlogical and tide data sets. In addition to the formal data sets we provide a wealth of textual and graphical material resulting from research at the VCR/LTER.

Sharing Information:

Data is made available via the WWW in conformance with LTER-wide data policies. The data is widely used for research and education, with over half of the data requests coming from researchers, educators and students not associated with the VCR/LTER both within the US and internationally.

Product Type:

Physical collection (samples, etc.)

Product Description:

In collaboration with the Virginia Museum of Natural History, we have established a sample archive for the VCR/LTER. This includes mammalian tissue samples, as well as soil, and water. To date, collections at the Virginia Museum of Natural History include more than one thousand traditional skin and skeletal preparations of 18 species of mammals from more than 40 locations on the Virginia barrier islands and southern Delmarva Peninsula. Ninety-nine percent of these specimens are accompanied by frozen tissue samples (heart, liver, kidney, and skeletal muscle). Also, intensive long-term live-trapping data were collected for 3 island sites and 3 sites on the adjacent mainland for a five-year period. In conjunction with that study, non-invasive tissue samples (earclips) were collected from more than two thousand individuals of three species of rodent.

Sharing Information:

These samples are available through standard loan procedures of the Virginia Museum of Natural History.

Product Type:

Audio or video products

Product Description:

We provide online access to over 350,000 images of ecological research activities and sites at http://www.VCRLTER.virginia.edu/images, http://www.vcrlter.virginia.edu/gallery and an large number of database-accessible webcam images at: http://ecocam.evsc.virginia.edu.
This includes several compressed videos of our site and research procedures on the WWW at http://www.vcrlter.virgina.edu/video. These are not 'production quality' videos, but aid in the orientation researchers who may be interested in conducting research at the VCR/LTER.

Sharing Information:

Images are available in standard Internet formats (.jpg and .gif) at http://www.VCRLTER.virginia.edu/images/ , http://www.vcrlter.virginia.edu/gallery and http://ecocam.evsc.virginia.edu.
They are available in RealPlayer or Windows Media Player formats on the WWW site: http://www.vcrlter.virgina.edu/video

Product Type:

Teaching aids

Product Description:

We provide live Webcams viewing research sites of the Virginia Coast Reserve LTER. These are used by K-12 students to view these remote islands.

Sharing Information:

Cameras and time series of images can be viewed at: http://www.VCRLTER.virginia.edu/wwwcam/ and at http://ecocam.evsc.virginia.edu/

Contributions

Contributions within Discipline:

We have continued to contribute 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), coastal eutrophication, controls on plant production, and determinants of faunal biogeography in an island system.

LAGOON

Coastal eutrophication has been recognized as an increasing problem in areas such as the East and Gulf coasts of the U.S. Symptoms of eutrophication include blooms of phytoplankton, which when they decompose may reduce available oxygen in the water; blooms of harmful algae that are toxic to fish, shellfish, and occasionally humans; blooms of macroalgae that cause die-backs of sea grasses which are vital to maintaining populations of many fish and crabs. Eutrophication generally results from export of excess nutrients from land, in particular nitrogen. Sources of nitrogen include agriculture, septic tanks, waste water treatment plants, industry, and atmospheric deposition of nitrogen derived from automobiles, power plants, and other industrial sources. Nitrogen from these sources is most often transported to coastal waters in shallow groundwater and in surface water runoff.

Coastal lagoons are common features of the land margin, especially along the East and Gulf coasts. We have hypothesized that these lagoons play an important role in retarding and transforming nitrogen during transport from land to the sea. Our study of the Virginia Coast Reserve lagoonal system has been designed to: (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. The biological studies described in this report are being performed jointly by Iris Anderson, VIMS, and Karen McGlathery, University of Virginia.

Our preliminary results support our hypotheses that: (1) nitrogen entering the lagoon is rapidly removed by both benthic macro- and microalgae. The bloom of macroalgae that results in early summer crashes during mid-summer, releasing much of the nitrogen as dissolved inorganic and organic nitrogen. The sediments act to rapidly remove the nitrogen released to the water column by a combination of mechanisms including immobilization by benthic microalgae and coupled nitrification - denitrification. We are currently attempting to determine how the nitrogen released during decomposition of the macroalgal bloom is partitioned between the various potential consumptive mechanisms.

Our conclusions regarding the importance of macroalgae in influencing the dynamics of nutrient movements within the lagoon helps to explain the role of the lagoon as an active mediator between mainland nutrient sources (e.g., agricultural fields) and the coastal ocean. The recent discovery that the dominant macroalga in the lagoon is an exotic (rather than its native congener), will be important to understanding long-term changes in the lagoon's characteristics.

MARSH

Surface Elevation Tables (SETs) are used at numerous VCR/LTER research sites to quantify subtle changes in sedimentation that ultimately will determine the fate of marshes in the face of sea level rise. These baseline measurements at different marshes are 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), bioturbation by crabs and even herbivory by insects to develop models aimed at predicting changes in marshes over the coming decades. Our preliminary results indicate that the rate of acretion are position dependent, with the upper marsh receiving less input.

Recent work on microbial communities in the marshes and tidal creeks at the VCR (as well as 9 other coastal systems as part of a cross-site comparison study) contribute to our understanding of what abiotic and biotic factors determine microbial community structure and the scales over which microbial communities vary. Linking information about variation in microbial community structure and microbially controlled processes (e.g., nitrogen-fixation), will allow prediction of how critical ecosystem processes will be affected by disturbance. (Blum)

We have continued to work with a small group to compare the ways in which salt marshes, mangroves and coral reefs respond to sea-level change and are perceived to respond to sea-level change. This synthesis promises to be valuable. (Christian)

The work culminating in the masters theses of Scott Dusterhoff (under supervision of Albertson and Wiberg) and Steven Turaski (supervised by PI Wiberg) has applied instrumentation and models most commonly used in studies of fields and forests to marshlands. Measurements of soil moisture (using TDR), water table elevation, soil texture and topography were used to characterize near surface soil moisture dynamics and runoff potential across a marsh-upland transect at Phillips Creek Marsh, VCR-LTER. Models of soil moisture (Richards equation) and evapotranspiration were successfully used to investigate controls on soil moisture and water table level, including soil texture, elevation, root density in addition to precipitation, tidal inundation and etc.

One of PI Robert Christian's major commitments for the last couple of years has been to encourage and promote the use of network analysis within ecology. Network analysis is a modeling tool (really an accounting tool for data. These data must be organized in a network form of interactions aomong system compartments) These efforts have come to some fruition via publications and workshops sponsored by NSF biocomplexity and the LTER network. Now several groups within and beyond the LTER network have begun using the tools. Jim Morris at U. South Carolina and PI Christian have collaborated on large number (>1,000) compartment networks, randomly generated but following perscribed rules. We have found some distribution dependent and independent attributes of food webs. This work will be continued at a workshop on Network Analysis at the LTER All Scientists Meeting in Sept. 2003.

UPLAND

The results of this work to date have increased our understanding of dynamic vegetation changes and their causes in coastal barrier island ecosystems. New cross site and cross species analyses are linking meteorological and climatological drivers to plant production. This analysis is revealing complex patterns showing that all species and sites do not respond similarly to meteorological drivers.

To date, 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. Most importantly PI Donald Young, demonstrated the importance of the presence for a soil actinomycete, Frankia, for the successful establishment of Myrica cerifera. Myrica usually is usually the first woody species to establish in these environments. Once established, Myrica rapidly forms extensive thickets in coastal environments. These thickets are excellent indicators of island stability and may be precursors to the establishment of maritme forest.

Fourteen years of research in shrub thicket ecology has provided excellent background and experience for studying the potential for invasive species in coastal environments. This is especially true for the weedy grass, Phragmites australis. Populations of Phragmites are establishing and rapidly expanding throughout the VCR as well as in coastal environments of the mid-Atlantic region. Phragmites often establishes in habitats similar to those of shrub thickets. The detailed understanding of the ecology of P. australis with respect to nutrient uptake and competitive relationships provide a basis for predictions regarding its ultimate distribution.

Studies of island-dwelling organisms, such as those underway at VCR, have long played an important role in testing ecological and evolutionary theory about patterns and processes related to distribution and abundance of species and genetic variation within and among natural populations. The Virginia coast is a highly dynamic, frequently disturbed landscape, and the Virginia barrier islands are the only undeveloped barrier system on the Eastern seaboard. As such, this system affords a unique opportunity to study phenomena associated with island systems, including fragmentation of habitats and populations, local extinction, dispersal, and colonization, which are also important issues in conservation biology. The relative isolation of the islands also provides an excellent opportunity for assessing the roles of paracitism and disease in overall vertebrate population dynamics.

At the global scale, PI's Hayden and Fuentes have continued work, in collaboration with the Sevilleta LTER site, on the gaseous and particulate emissions from vegetation and its role in the dynamics of the lower atmosphere. Information about these non-CO2 emissions has increased the awareness of the ecological community as to the diversity of feedbacks from the biosphere to the atmosphere. Our topographically stratified measurements of annual temperature show a coincidence of vegetation zonation with abrupt temperature gradients.

Contributions to Other Disciplines:

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

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

Research on ecological information management has included computer scientists. The challenges posed by ecological data provide opportunities for innovation in computer science. Our work with development of wireless sensor networks, and processing of the massive data flows they can generate, contributes to better defining the cyberinfrastructure challenges that will confront us in coming decades. (Porter)

In association with educators (and with additional support from the Virginia Environmental Endowment) we have been exploring the use of wireless web cameras for use in K-12 science education. (Smith, Porter)

Connections between storminess at the Virginia Coast Reserve LTER and variations at the El Nino frequency have proved negative. In addition, General Circulation Models (The Hadley Model) indicate no changes in storminess at the VCR out as far as 2085 (Hayden).

Contributions to Human Resource Development:

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.

We have, in our Schoolyard LTER program provided instruction and assistance to local teachers as well as graduate courses in assistance of their recertification. During 2005, we have brought LTER research activities into the classroom had extensive contact with more than 200 students in grades 9-12.

From Jan 1, 2003 through July 2005, the LTER laboratory has been used by four college classes totaling more than 60 undergraduate students.

PI Nancy Moncrief continues to use distributional data collected from the multi-island surveys in a Teacher Re-Certification class that she teaches through the University of Virginia at the Roanoke Higher Education Center. She reviews processes such as extinction and colonization and concepts such as succession, habitat complexity, and carrying capacity. Typically, there are 20-30 K-12 teachers in this course each year. Additionally, she has developed a K-12-level activity that illustrates various island biogeography principles. She distribute it through Teacher Recertification courses and workshops.

PI John Porter continues to contribute to training efforts in the area of Ecoinformatics. He participates annually in the training efforts of the Resource Development Initiative for Field Stations (RDIFS), which trains information managers at biological field stations. He co-taught a one week short course on ecological databases for participants from the Organization of Biological Field Stations in October 2002. Internationally, he co-taught a two day course on ecological information management in Maputo Mozambique in July 2002. He taught a session on site information management and Ecological Metadata Language (EML) at the East Asia Pacific LTER meeting in Beijing in July 2005.

Contributions to Resources for Research and Education:

Our WWW site (http://www.vcrlter.virginia.edu) provides access to a wide variety of information in text, graphical and video forms. Data are frequently downloaded for use by classes and researchers at institutions not associated with the VCR/LTER. Since January 2002, our web site has distributed 375 gigabytes of information to over 370,000 different client computers. The site averages over 8,500 'hits' per day throughout that period. A detailed summary can be found at: http://www.vcrlter.virginia.edu/analog/index.html

Through the web server, we have provided data for 659 formal requests, since 10/1/2000, with 151 requests in the last year. 21% were by VCR/LTER associated researchers, but 79% were from individuals not associated with the VCR/LTER. 66% of the total requests were for research use and an additional 44% were for classroom use. Many requests were from outside the US including the United Kingdom, China, Indonesia, Chile, Australia, Germany, India and the Netherlands, among others.

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 are currently doing at the VCR is of much 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. The major source of nitrogen to VCR coastal lagoons is agriculture. 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.

During 2004-2005 high school students monitored water quality at 21 sites on a bi-weekly basis. They also did quarterly testing of soil characteristics at the same sites. Through the SLTER supplement, this year we were able to upgrade water quality and soil testing kits, provide up-to-date global positioning system units (incorporating WAAS technology).

Contributions Beyond Science and Engineering:

We have 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 The Nature Conservancy. (Erwin, Moncrief, Porter, Hayden, Blum, Young)

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 probable return of seagrasses to large areas of the coastal bays, from which they have been absent for over 70 years.(Anderson, McGlathery)

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

Activities with the UN programs on observing global change along coastal ecosystems have significance for broad aspects of public welfare and environmental protection. One of the greatest potential contributions from PI Christian's work at the VCR LTER are to the global observing systems and the ability to detect and assess global change in coastal ecosystems. The Coastal Module of GTOS is being developed 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. (Christian)

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Context:

Research by the Virginia Coast Reserve (VCR) LTER project scientists continues to focus on our core hypothesis that ecosystem, landscape and land use patterns within terrestrial-marine watersheds are controlled by the vertical positions of the land, sea, and freshwater groundwater table surfaces. Coastal storms, climate change, long-term eustatic sea-level rise and land subsidence cause variations in elevations of these surfaces that drive ecosystem dynamics. Biotic feedbacks within ecosystem states also influence the responses to external stressors. Ecological processes, including organic matter production and species extinction and colonization, alter the rates of erosion and sediment deposition and thereby alter land and water table surface elevations. Short-term episodic events and long-term systematic trends in sea level, land and groundwater surfaces give rise to variations in nutrient availability, primary productivity, organic matter accumulation and trophic interactions.

In LTER I (1987-1992), we began with the hypothesis that ecosystem dynamics in the VCR are driven by large-scale events and processes such as coastal storms and sea level rise. The concept of abrupt ecosystem change (state change) and slow progressive change (succession) as emergent properties driven by these large-scale events and processes was added in LTER II (1992-1994). In LTER III (1994-2000), we developed the concept that changes in the relative elevations of the free surfaces (land, sea, groundwater table) controlled state change and ecosystem dynamics. Our current proposal (LTER IV; 2000-2006) focuses on hypsometry as a synthetic framework for integrating research in the VCR landscape.

Activities:

Continuation and augmentation of long-term experiments and core monitoring activities have comprised a large part of our activities for the year. These core activities include tracking of changes in ecological states in relation, collection of groundwater, meterological, and tidal data, monitoring watershed nutrient inputs into coastal lagoons via tidal streams, monitoring transects in the coastal lagoons for water quality, primary production, and benthic biodiversity, monitoring terrestrial vertebrate populations (birds and mammals), measuring the effect of manipulation of sea level on marsh communities, modeling hydrodynamics and transport in coastal lagoons.

<u>Lagoon</u>:

Our research for the VCR coastal lagoons continues to be on the linkages between watershed land use and the impacts of nutrient loading on the lagoon ecosystem, and on the return of the foundation species, Zostera marina (eelgrass). In order to assess the fate and transport of nutrients across the landscape, our studies relate nutrient inputs to processing by primary producers and consumers and physical transport within the lagoon. Our models of hydrodynamics and sediment resuspension set the state for the planned large-scale recolonization of seagrass in Hog Island Bay and other lagoons in the VCR.

Continuing Activities

The specific research activities that we are continuing to do to characterize patterns and processes in the watersheds and lagoon are detailed below.

We continue to monitor the two long-term water quality transects in the VCR lagoons, one of which was added last year. The transects represent the gradient from mainland – lagoon – barrier island – ocean inlet in two bays that represent different water land use and nutrient loading rates. We couple measurements of water quality (nutrient concentrations, light availability, suspended solids) to estimates of primary producer (benthic algae, phytoplankton) at each site. This year we have added measurements of invertebrate biomass and diversity to the lagoon survey (see below in *New Activities*). (Blum, McGlathery, Christian)

To estimate groundwater nutrient loading during baseflow to the coastal lagoons, we are monitoring 14 tributaries that drain watersheds of differing land use across the VCR landscape. (Mills, Anderson). This year we have added stilling wells to 3 sites to capture storm flow nutrient inputs (see below in *New Activities*). (Anderson)

New Activities

To augment our long-term monitoring program of the effects of watershed land use on water quality in the VCR coastal lagoons, we have instrumented 3 tidal streams that represent different levels of nutrient loading with stilling wells. Continuous monitoring of these wells along with rainfall measurements provide the data input for a hypsometric model to separate baseflow from surface water runoff into the streams. Nutrient samples are also being taken simultaneously to estimate nutrient flux during episodic rainfall events. (Anderson)

We have added sampling of benthic and pelagic invertebrates to our quality sampling along the 2 mainland-ocean transects. For both sediment infauna, and pelagic epifauna, we will be recording abundance and species diversity of the major taxonomic groups. We are particularly interested in the relationship between benthic fauna and the biomass of bloom-forming macroalgae. These data will serve as a baseline for changes in faunal abundance and diversity as the system undergoes a state change to a seagrass-vegetated lagoon. (McGlathery, Smith)

We are continuing our investigations of macroalgal communities in Hog Island Bay, in particular their role in nutrient cycling and trophic dynamics within the bay. We have focused on the role of the abundant polychaete, *Diopatra cuprea*, as a 'foundation' species, facilitating macroalgal distribution in Hog Island Bay, particularly the invasive species *Gracilaria vermiculophylla*.

We are extending our work on the relationship between sediment resuspension and light availability in Hog Island Bay to understand the effects of different primary producers

(seagrass, macroalgae, benthic microalgae) on sediment resuspension and nutrient release to the water column. The work will be done using Gust erosion chambers that allow us to manipulate sheer stress at the sediment surface in sediments vegetated by the different types of benthic plants. (Wiberg, McGlathery)

Macroalgae serve as a large, temporary reservoir for carbon and nitrogen in lagoonal systems, particularly those that are impacted by increased nutrient loading from the coastal watershed. To quantify the various short- and long-term fates of the carbon and nitrogen bound within macroalgal tissue, we are monitoring sediment and water column parameters along a cross-lagoon transect during the macroalgal bloom and crash cycle. In addition, we are tracing the fate of macroalgal carbon and nitrogen during a simulated macroalgal bloom and crash using dual isotope tracer and biomarker techniques in an outdoor mesocosm experiment. (Anderson)

We are applying a numerical model developed for the Venice Lagoon to Hog Island Bay that calculates tidal currents, wind wave heights, bottom shear stresses caused by the waves, and influence of wind stresses on the flow field. The model couples a hydrodynamic finite element module based on the shallow water equations with a finite volume module that accounts for the generation and propagation of wind waves. The wave module solves the wave action conservation on the same triangular mesh used in the hydrodynamic module, thus correctly reproducing the physical relationships between waves and tide propagation. The model is specifically designed for intertidal environments basins with irregular bathymetry characterized by deep channels, emergent salt marshes, and extensive tidal flats. A module specifically computes the transport parameter at the bottom, thus highlighting areas in erosive regime. We hope to build on this framework to develop a more integrated picture of controls on turbidity in Hog Island Bay, the effect of vegetation on the lagoon bottom, residence time and circulation. We also plan to link this model to the biogeochemical measurements made by McGlathery and Anderson to understand the flux of watershed nutrients through the lagoon to the coastal ocean (Wiberg with collaborator Fagherazzi).

In addition, we are combining field data and GIS techniques to develop protocols for understanding flushing characteristics in coastal bays. NWI and hydrographic data are used to develop hydro-hypsographic curves for hydraulic turn-over analysis. Lagrangian data are then used to calibrate repletion patterns of exchange. (Oertel)

We collected approximately 1000 samples of primary producers through higher trophic level fish during the summer of 2004 to examine trophic relationships by stable isotope analyses in seagrass meadows in South Bay that have been restored by seeding within the last 5 years. The dominant invertebrates (crabs, shrimp, amphipods and isopods), plant material (seagrass and algae) and overlying water were sampled for stable isotopes of carbon, nitrogen, and sulfur (^{13}C, ^{15}N, and ^{34}S) to estimate the influence of primary producers in the diet of resident species. Carbon and nitrogen isotopic signatures of gut contents of fish have been analyzed and compared to isotopic signatures of muscle tissue in each respective fish. (Macko)

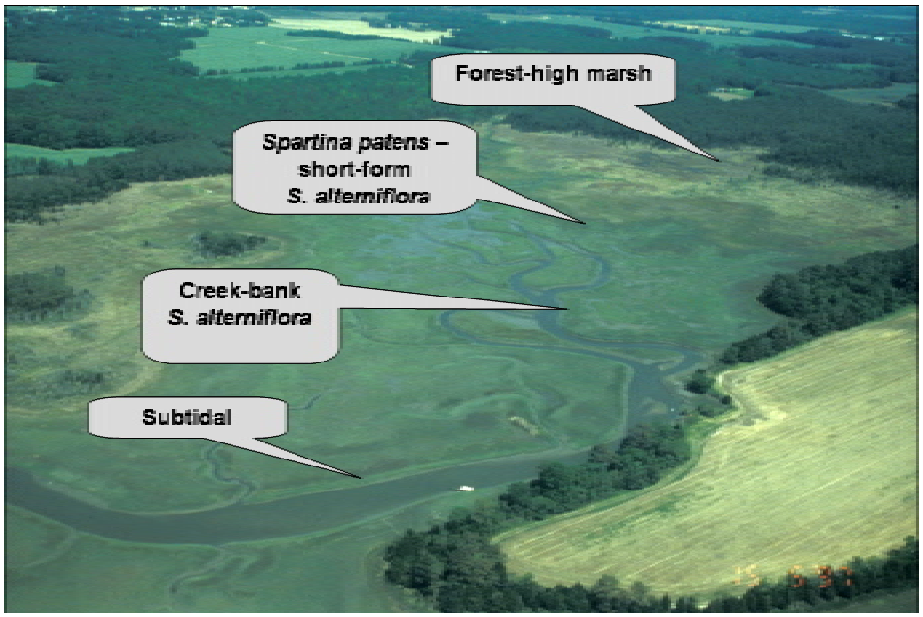
In collaboration with Pier Luigi Viaroli (University of Parma, Italy) we are investigating nutrient cycling and ecosystem metabolism of coastal lagoons using network analysis. We are developing models for Hog Island Bay, which receives relatively low nutrient loading from the agricultural watershed, and the Lagoon of Venice, which is a heavily eutrophic lagoon. (Christian, McGlathery, Anderson)

Marsh:

Research in wetlands at the VCR focuses on the question of how the interaction between the land, freshwater, and sea-level results in state change by examining the way in which biological and physical processes affect the geomorphology within states. We continue to focus our efforts on long-term measurements of marsh biomass and community change, sediment accretion in relation to sea level rise, groundwater levels, and marsh food web dynamics. Of particular interest is the occurrence of marsh die-off in parts of the VCR landscape, a phenomenon that has occurred throughout the eastern seaboard.

Continuing Activities

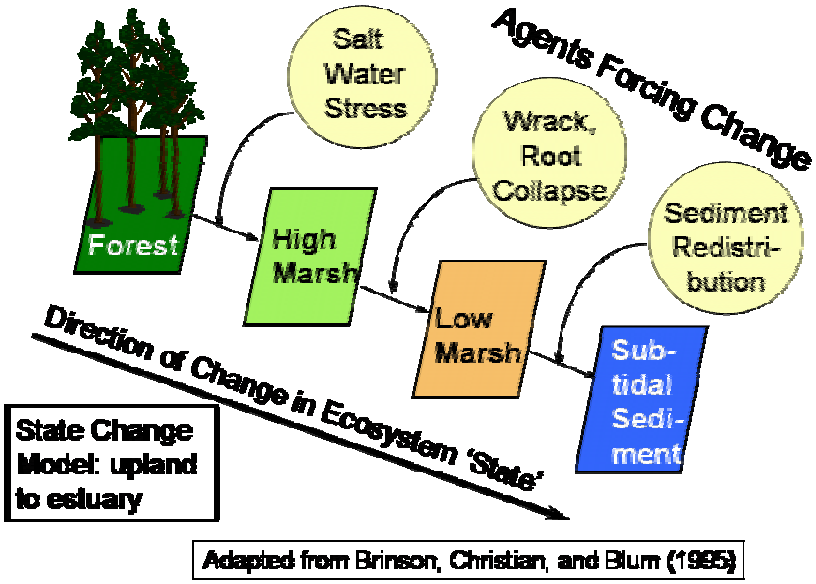
At the landscape scale, we continue our monitoring of peak standing crop of marshes and marsh die-off. This regional study gives us a framework for applying our understanding of the relationship of the free surfaces to state change in the marshes. We are also continuing our more detailed monitoring of marsh biomass and community structure in permanent plots at one marsh site. (Brinson, Christian, Blum)



Habitat/innundation zones in Phillips Creek Marsh, a principal VCR/LTER research site.

We are also continuing our long-term inundation experiment to test the effects of simulated sea-level rise on marsh biomass, community structure and nutrient cycling.

Experimental plots are being used to examine the effect of more frequent tidal inundation on high marsh plant communities. (Christian)



Adapted from Brinson, Christian, and Blum (1995)

At the Phillips Creek study site, our work on trophic interactions focuses on creating food web networks for high marsh ponds. We are also monitoring changes in groundwater levels in the salt marsh and surrounding uplands at this site, and tracking salt marsh accretion due to root production and sediment accumulation. (Christian, Brinson, Blum)

From these activities, we have established a series of long-term measurements to examine the rates of change in the following parameters (Christian, Blum, Brinson):

- peak salt marsh grass standing stock at a regional scale
- salt marsh surface elevation
- accretion of sediments on the salt marsh
- salt marsh accretion due to root production
- high salt marsh community change
- groundwater levels

We are examining questions about the spatial and temporal distribution of microbial communities in wetland sediments to understand what factors controlling rates of organic matter accumulation and nutrient processing. (Blum)

New Activities

During spring 2004 we observed significant areas of salt marsh grass die-off in a single marsh. Plots were established in 2004 to track the extent of the die-off and to monitor recovery or state change within the die-off areas. We continue to monitor the die-off areas. New die-off was observed in another marsh in spring 2005. Plots to monitor the die-off were established and

are being monitored. Reciprocal transplant experiments were initiated in May 2005.

The biotic feedback of fiddler crab (*Uca* spp.) burrowing activity may influence the state change in marsh ecosystems in response to sea-level rise. We are studying how changes in tidal inundation due to an increase in relative sea-level will affect the pathways of organic matter oxidation and the overall pore water chemistry of salt marsh sediments with the presence of fiddler crab burrows. These processes will have an impact on *Spartina alterniflora* production and organic matter buildup, in response to sea-level rise. (Zieman)

The distribution of the non-native grass Phragmites australis has increased significantly in VCR marshes in recent years. We investigated the physiological mechanisms that might be responsible for P. australis expansion, including higher photosynthetic efficiency and the direct uptake of dissolved organic nitrogen. (Zieman)

We have begun a new collaboration with Chip Bachman (Naval Research Lab) and Elijah Ramsey (USGS) to use aerial photography to measure marsh community change and estimate regional marsh plant biomass at broad scales than our current ground-based measurements allow. Long-term measurements and experiments will continue and serve as ground-truth measurements for remote sensing measurements. This effort addresses the core area of primary productivity, in addition to providing information about within state biological process rates and state change.

Another new collaboration is with Gene Turner (LSU) to examine the effect of temperature and nutrients on rates of organic matter accumulation began in May 2005. Experimental sites are located in Louisiana, South Carolina (NIN), Virginia (VCR), and Massachusetts (PIE). The results of these experiments contribute to understanding the core of primary production (belowground), organic matter accumulation and nutrient dynamics at broad geographic scales in salt marshes.

Terrestrial:

Our activities in the terrestrial portions of the VCR landscape continue to focus on increasing our understanding of the relationship between the groundwater and land free surfaces, and how this relationship influences patterns of nutrient cycling and primary production. We have also continue to study the effects of Hurricane Isabel, which occurred in September 2003, on small mammal populations as a result of flooding and habitat loss, and on the invasion of the marsh grass *Phragmites australis* on some of the islands.

Continuing Activities

Monitoring of long-term plots, sites, transects and groundwater wells continues annually on Hog Island. PI Frank Day has quantified spatial/temporal variations in fertilized and unfertilized plots on the grass dominated dunes across the Hog Island chronosequence.

These are related to fluctuations in groundwater wells. PI Don Young has compared spatial variations is *Myrica cerifera* shrub thicket annual shoot growth at four locations representing a variation in thicket age and exposure. We have continued the monitoring of small mammals with live traps along Hog Island transects and have developed a digital photographic record of habitats and disturbances on Hog Island (PI Porter in collaboration with Ray Dueser, Utah State University).

During 2004-2005 we have also done a major rebuilding of VCR/LTER meteorological and tide stations. The Phillips Creek meteorological station was completely destroyed by flooding caused by Hurricane Isabel in late 2003. It has now been rebuilt using a new tower and instruments and new documentation created. We are continuing our 15-year record of monitoring deposition of atmospheric nitrogen via wet deposition at the new meterological site. Precipitation samples are collected weekly and analyzed for the major chemical constituents (including SO_4^{2-}, Cl^-, NO_3-, NH_4^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, and H^+). A new tide station was installed in early 2005 on the dock of the Anheuser Busch Coastal Research Center (ABCRC).

New Activities

On a shorter-term basis, numerous projects have been either completed or initiated in support of the long-term activities. Brett McMillan, an ODU doctoral student working with Frank Day, is focusing his dissertation work on vegetation dynamics on "pimples" (small dunes with highly zonated vegetation). Attempts to utilize ground-penetrating radar to map groundwater levels and root architecture and biomass will be attempted this summer. Steven Brantley, VCU doctoral student with Don Young, continues to quantify spatial variations in litter production and leaf area index for *Myrica* shrub thickets on Hog Island. In conjunction with the annual shoot growth measurements, the results will be used to estimate ANPP variations. Jaime Fuest, a VCU MS student working with Don Young, completed a comparison of variations in insect herbivores abundance, herbivory damage, and plant abundance on dunes across the Hog Island chronosequence. Stable isotope analyses, linked individual grasshopper species to preferred diets and locations on the island.

Small mammal trapping on Ship Shoal and Myrtle islands was conducted in the summer and fall of 2004 and the summer of 2005 to determine changes in the fauna of the island driven by extensive flooding and habitat loss during Hurricane Isabel. Sample collection activities during trapping have been expanded to include fecal and blood samples aimed at identifying wildlife diseases. In addition, VCR PIs (Porter, Erwin) have collaborated with Shawn Padgett of the College of William & Mary on a digital image database that tracks use of a nest tower by Peregrine Falcons. Images are captured every 10 minutes from three cameras located in, or near the box. The images are transferred via a wireless network connection to UVA where they are archived. Thus far over 18,000 individual images have been captured.

A three-year assessment of the invasive grass, *Phragmites australis*, is in the final year. This is a collaborative project between VCU and the Virginia Departments of

Environmental Quality and the Natural Heritage Program. Over 1,400 patches have been mapped on the barrier islands and Eastern Shore of Virginia. Special attention has been give to Parramore Island, where fire and Hurricane Isabel have created increased disturbance that may facilitate Phragmites expansion. This summer, a random subset of the patches has been sampled to determine the percentage of native vs. the introduced, invasive genotype. Julie Naumann, VCU doctoral student, has initiated a field based student of variations in plant stress and leaf fluorescence to remotely assess the physiological condition and potential for expansion of individual patches of *Phragmites* the Virginia Coast Reserve. (Young)

Graduate student Michael O'Connell is investigating the effects of site water conditions on barrier island (Assateague Island, MD and Parramore Island, VA) vegetation, and - characterizing ecosystem vulnerabilities to environmental forcing factors such as sea level rise, climate change and geomorphologic change. Measurement of vegetation biophysical properties related to canopy structure and leaf area is accomplished with a unique small-footprint, airborne, scanning *lidar* (Light Detections and Ranging) system. Field sampling documents forest structural components including Plant Area Index (PAI), verifies remotely sensed data, and describes site water availability. Freshwater availability, geomorphic, and vegetation assemblage gradients identified by field observation will be tested for correlation with patterns in PAI and other pertinent vegetation measures like height, basal area, and biomass to assess sensitivities and predict future changes. This novel combination of remotely sensed properties and field environmental data will be developed to investigate fundamental physiological interactions (such as water and foliar area in transpiration) and characterize and monitor effects of environmental change on island vegetation.

Thus far, one EAARL (Experimental Advanced Airborne Research Lidar) survey has been completed of the entire upland portion of Parramore Island on August 26, 2004. Cooperators at the USGS are currently processing these data for basic information like first-return and last-return position layers (approx. 1m horizontal and 11cm vertical resolution) as well as time-resolved intensity waveforms for the eventual analysis of vegetation structure. No further Lidar surveys of Parramore are planned, however, there is a possibility that the Virginia end of Assateague Island will be surveyed this fall.

In May of this year, he installed four automatic water-level recorders (recording water table position points every hour) at critical upland locations that are in or near the established long-term vegetation monitoring plots of Shugart. These data will provide for a characterization of on-site water availability and the development of gradient analyses.

Information Management:

The principal activities in the area of Information Management, have been the development of rich Ecological Metadata Language (EML) metadata and a new web site for the VCR/LTER. During late 2004 we developed a program which extracts the information needed to populate and EML document from metadata in our existing database. It includes most of the elements needed to reach "level 5" status in the best

practices guide written by the LTER Information Management Committee. Starting in July 2005, our metadata is available in the KNB Metacat system.

The new web page uses a content management system to facilitate management. In a content management system, page contents are stored in a relational database (MYSQL) and used to populate the pages "on the fly." Our system is a hybrid, with some web pages generated from the database and others in a static form more suitable for archival storage.

The new VCR/LTER Home Page:

Findings

Lagoon:

Nutrient cycling and trophic relationships

We continue to focus much of our research in Hog Island Bay on the influence of benthic algae on nutrient cycling processes and their influence on the fate and transport of watershed nutrient inputs. In the absence of large seagrass populations, macroalgae and benthic macroalgae are the dominant primary producers in the system. This year we discovered using molecular techniques that the dominant taxa, *Gracilaria*, which comprises up to 90% of the macroalgal biomass in the lagoon is an alien species, *G. vermiculophylla*, not the native species, *G. verrucosa*, we previously thought. In light of this discovery we are refocusing our work on *Gracilaria* to understand why this species is such a successful invader, compared to the less successful alien, *Codium fragile*. Our work shows that the widespread dominance of *G. vermiculophylla* in Hog Island Bay can be attributed to traits that make it resistant to stresses that normally occur in coastal lagoons, including desiccation, burial, grazing and low light conditions due to sediment resuspension. We have found that the abundant polycheate, *D. cuprea,* facilitates algal persistence, particularly that of the alien *Gracilaria*, by providing a stable substrate retaining algae against hydrodynamic forces such as tidal flushing and storm surge. We plan to investigate the distribution of *G. vermiculophylla* throughout the VCR lagoons. (McGlathery and students)

In general, macroalgae serve as a large, although temporary, sink for nutrients entering the lagoon from the coastal watershed. Knowing the fate of these plant-bound nutrients is key to understanding how nutrients are retained and transformed as the pass through the lagoon to the coastal ocean. This information also serves as a baseline as the system undergoes a state change to a seagrass-vegetated lagoon. Our results indicate that water quality and sediment characteristics reflect seasonal changes in macroalgal abundance. As macroalgal senesce, nutrient and chlorophyll concentrations in the water column increase and dissolve oxygen concentrations decrease. This suggests that the macroalgae are important in regulating nutrient availability in the lagoon, and likely outcompete phytoplankton during the summer growing season. (Anderson and McGlathery, graduate student Amber Hardison)

Our continuing studies on sediment resuspension show that at high densities macroalgae prevent advective exchange of nutrients and limit sediment resuspension. These ongoing studies will address the effects of state change within the lagoon to compare the effects of macroalgae, benthic microalgae, and seagrass on sediment resuspension and advective fluxes of nutrients from the sediment to the water column. Differences in sediment characteristics and susceptibility to resuspension suggest that there will be different mechanisms of advective nutrient exchange between the sediment and water column at different sites in the lagoon, either desorption from suspended particles or porewater exchange. (Wiberg, McGlathery; graduate student Sarah Lawson)

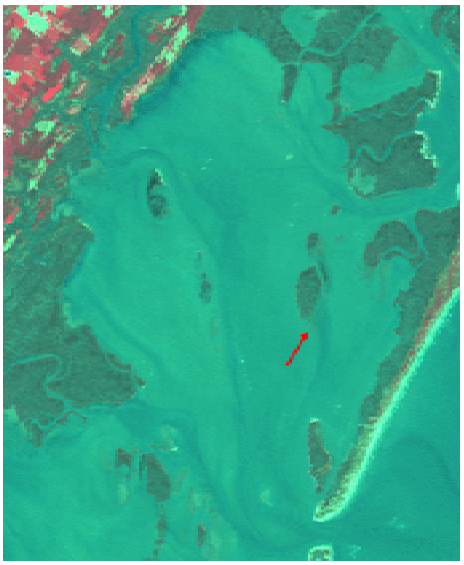
Seagrass recolonization

The seagrass, *Zostera marina*, declined precipitously in the coastal lagoons of the VCR in the 1930s due to the pandemic wasting disease and a destructive hurricane in 1933. Natural recovery occurred in coastal bays north of the VCR, with over 7300 ha vegetated by 2004. However, no natural recovery occurred in the VCR lagoons, until a small isolated plot was found several years ago, presumably due to the distance of the lagoons from potential donor beds and/or restricted exchange with ocean currents that could bring rafting reproductive shoots carrying viable seeds. We have been working with our colleague Bob Orth (Virginia Institute of Marine Sciences) to understand the trophic consequences of newly recolonized seagrass beds in South Bay in the VCR, and are intiating a large-scale restoration effort in our main study lagoon, Hog Island Bay. This successful recolonization gives us an unprecedented opportunity to understand the key role of *Z. marina* as a 'foundation' species in the coastal lagoons, and the landscape-level consequences of an ecosystem state change from a muddy-bottom to a vegetated lagoon. This state change potentially returns the system to a similar state as occurred at the turn of the century when seagrasses provided key ecosystem services, including providing a habitat and food source for the bay scallop (*Argopecten irradians*) and the brant (*Branta bernicla*), both of which disappeared after the loss of the seagrass in the 1930s. (McGlathery)

To guide our efforts for recolonization in Hog Island Bay, we have used a model that predicts light availability at the sediment surface and indicates areas in the bay that are suitable habitat for seagrasses (PIs Wiberg and McGlathery, graduate student Sarah Lawson). The model predicts sediment suspension and light availability from waves and currents. In Hog Island Bay, and likely in similar shallow coastal lagoons especially those lacking sediment stabilization by benthic vegetation, wind-driven sediment suspension is the dominant control on light availability. Waves and currents in the bay responded strongly to wind forcing, with bottom stresses from wind driven waves dominant for 88% of the modeled area for the late fall period and 56% of the modeled area for the summer period when wind speeds were lower. The influence of wind events, through both waves and wind-driven currents, was greatest on the shallow flats that are potentially suitable habitat for seagrass. Based on the modeled average light availability at the sediment surface, 22% more of the modeled area was suitable habitat for seagrass in summer (87%) than in late fall (65%) when wind speeds were higher. This study shows that because of the episodic nature of wind events and the spatially variable nature of sediment suspension, conventional methods of examining light availability, such as fair-weather monitoring or single in-situ recorders do not adequately represent light conditions for benthic plants.

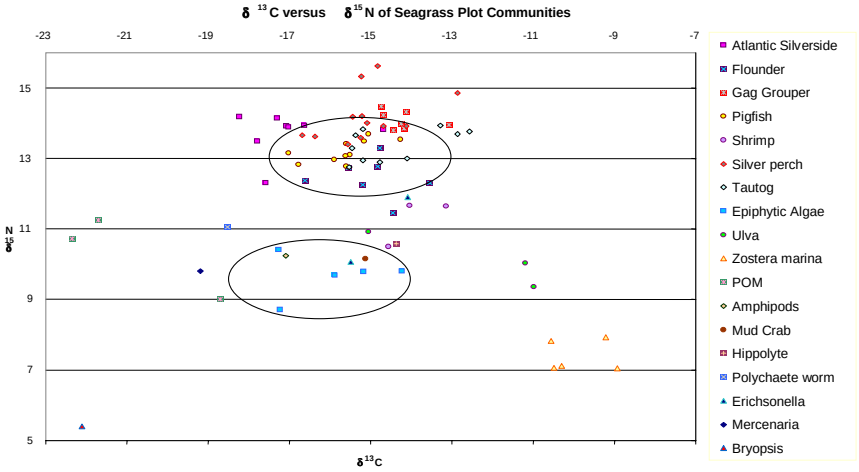
We used the model of light attenuation based on sediment resuspension to identify potential sites in Hog Island Bay for seagrass recolonization experiments. In Fall 2004, we surveyed these sites, and much to our surprise we found a small patch of naturally-occurring seagrass that we estimated to be about 1 year old. This is excellent validation of our model. At this site and one additional site nearby, we set out test plots with seagrass seeds. These seeds germinated and the seedlings have survived through the first

growth season. We have recently negotiated with the Virginia Marine Resource Commission to set aside 400 acres in Hog Island Bay for the seagrass recolonization experiments. We will set out another set of test plots in the seagrass conservation set-aside, and assuming these too are successful, we will begin large-scale recolonization experiments in Fall 2006.



Location of naturally-occurring seagrass found in the fall of 2004. A 162 ha conservation set-aside will be located nearby.

We have also examined trophic relationships by stable isotope analyses in seagrass meadows in South Bay that have been restored by seeding within the last 5 years (PI Steve Macko, graduate student Stephanie Harbeson). Isotopic signatures from prey and predators associated with the two habitats provide an important basis for tracking changes through time as seagrass habitats expand and become more dominant components of VCR lagoons. The primary producers *Z. marina*, epiphytic algae and macroalgae were found to be isotopically distinct, thus allowing for source differentiation. The bulk isotopic values indicate that the isopod *Erichsonella sp.*, amphipods and mud crabs from the seagrass meadows are possible dietary sources for many of the fish captured at these sites. The tissues of nearly all were isotopically enriched compared to their gut contents, indicating probable linkages to the nutritional base of the restored meadows. The effect of plot age on carbon isotopic signature of fish is also being analyzed. The $\delta^{13}C$ varied between fish captured in plots restored in 2001 versus those restored in 2002. Variation in isotopic signature is inconsistent among different species, however, indicating that plot age does not have a simple relationship to the $\delta^{13}C$ of animals in the restored seagrass community. The influence of the habitat on the potential prey species is likely variable, with some being highly dependent on the seagrass, while others appear to be less influenced. As the system undergoes a state change to a seagrass-vegeated bottom, it is likely that seagrass primary production will become an important source of nutrition for a variety of species, including those that are commercially or recreationally harvested such as blue crabs and various fish species.



Isopods (*Ericsonella attenuata, Idotea sp.*) Amphipods, mud crabs, and epiphytic algae are prey for fish. Several fish species are encompassed within one level of trophic enrichment for carbon and nitrogen.

Hydrodynamics

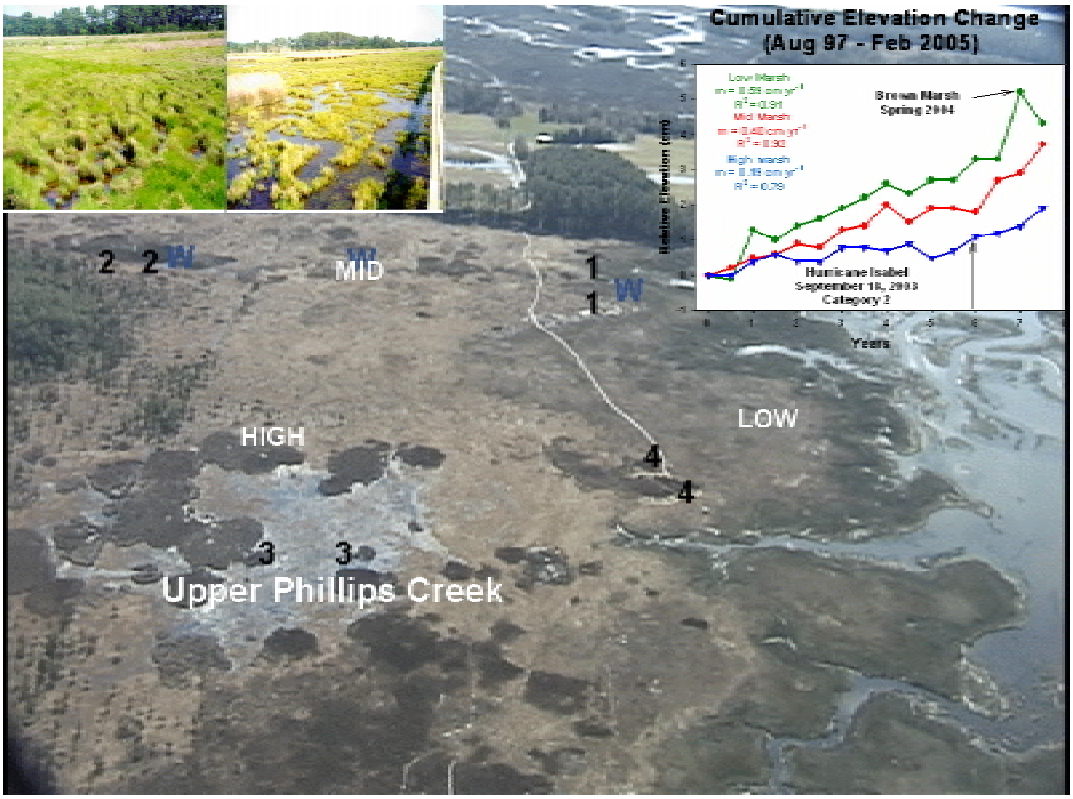
We have found that a strong relationship exists between hierarchies of antecedent topography, hydrohypsography and the flushing of coastal bays. Bays can be categorized by using a combination of hydraulic turn over and percent of repletion penetration.

Marsh:

Blum and students are finding out more on the significant role that fungi play in decomposition of standing dead marsh plants. Fungi have been recognized as having a significant role in decomposition of standing dead marsh grass and in trophic dynamics on stand dead marsh plants. They also form a mycorrhizal association with some marsh grasses and as such may be important in marsh plant growth. Generally, conditions in salt marsh sediments have been viewed as unfavorable for the growth of filamentous higher fungi. However, our recent studies in marsh surface sediments indicate an abundance of filamentous higher fungi at levels similar to those in terrestrial soils. Abundances are higher in monotypic stands of *Juncus roemerianus* than in the mixed *Spartina patens* community and differences are also found depending on flooding frequency. Such differences belie the simplicity in community composition of higher plants, and suggest that fungi may play important roles in other ecosystem functions such as plant decomposition, nutrient cycling, and trophic dynamics that has been thus far overlooked by salt marsh ecologists.

Our results from the inundation experiment of the high marsh show surprisingly little effect of flooding over 6 years in two sites. In the third site there was an effect from the disturbance of having a border around the plots. This third site is developing hollows and hummocks and a replicate site is also showing differentiation from other sites.

The Sediment Elevation Table measurements, now in their 7^{th} year, show evidence of insufficient accretion in the high marsh to match the rate of rising sea level.



Locations of Sediment Elevation Tables in Phillips Creek Marsh. Photographs in the upper left show changes in marsh cover. The graph in the upper right shows the cumulative elevation change at different locations.

Our work on the non-native grass P. australis showed that this species, as well as the native *Spartina alterniflora*, can take up dissolved organic nitrogen (DON) at directly, at rates that are between 8-20% of ammonium uptake rates. This is the first documentation of DON assimilation in marsh plants, and is similar to the findings that marine algae and tundra plants can utilize DON. *P. australis* had significantly higher photosynthetic rates than the native grasses under similar conditions, and this photosynthetic efficiency provides a possible mechanism that contributes to the invasion success of this species. (Zieman, McGlathery; graduate student Mozdzer)

Terrestrial:

After seven growing seasons, results from the permanent plots suggested more intense negative effects of competition in nitrogen-fertilized plots. Greater cover of *Ammophila* in fertilized plots indicates *Ammophila* is in a better position to compete for light with enhanced aboveground dominance. Diversity was lower in fertilized plots on all but the dune formed in 1967 and diversity decreased most dramatically in fertilized plots on the oldest dune. The increase in total density with fertilization as diversity decreased, coupled with the shifting composition of *Ammophila* and other dominants, appears to

support the interspecific competitive exclusion hypothesis. Changes in the positions of free surfaces (groundwater level in particular) appear to be the primary influence on plant community composition. On the dune pimples, environmental data, such as depth to water table, height above marsh, aspect, soil texture, and total C:N are being used with ordination techniques, primarily canonical correspondence analysis (CCA), to quantify their relationship with species distribution patterns. Preliminary analyses suggest a strong influence of elevation and water availability on species distribution. Addition of more variables, such as nutrients will help explain finer differences in species composition.

After fourteen years of quantifying annual shoot growth in *Myrica cerifera* shrub thickets, several patterns have emerged. Shoot growth decreases as thickets age, with highest growth rates occurring as individual shrubs initial merge to form an enclosed thicket. Similar to the results for the long-term plots on the grass covered dunes, annual growth is strongly influenced by summer precipitation patterns with the lowest values for all sites occurring during years with significant summer drought. Island position is also important. Thickets located in the central portions of Hog Island show less fluctuation in shoot growth over the years of measurement. Presumably these thickets are less exposed to salt spray and wind damage and have greater access to stored groundwater during periods of drought.

Four methods to determine LAI were compared across *Myrica cerifera* shrub thickets. Traditional allometric modeling was considered to provide the best estimates of LAI. Light attenuation and annual litter production estimates of LAI were similar to the allometric estimates. Although measurement with an LI-COR integrating radiometer is rapid and non-destructive, the instrument continually underestimated LAI relative to the other three methods. Depending on position on the island landscape and age of the thicket, shrub LAI may vary from 6 to 11 as estimated with allometric relationships. These values are much higher than previously assumed (e.g. 4). These accurate LAI estimates will increase the predictability of water, carbon, and other nutrient stoichiometric analyses at the landscape level. In addition, as the landscape is changed from grass dominated swale to shrub thicket, LAI at least doubles. The increased LAI, especially when considering physiological differences between grass and *Myrica* shrubs, will significantly increase evapotranspiration. Thus, some landscape units may remain grass dominated because limited groundwater availability will not support the increased demand associated with the higher shrub LAI.

Collaboration with Sandford Feldman at the Center for Comparative Medicine at UVA to examine wildlife disease has been successful. Collection of samples of feces and blood from small mammals on Myrte, Ship Shoal, Mink and Hog Islands indicates the presence of *Salmonella* infections in some individuals. This could have important implications for population dynamics, as *Salmonella* can be fatal in mice and rats, especially at young ages. Tests for *Shigella* (commonly associated with shellfish), parainfluenza viruses, coronaviruses, pathogenic mycoplasmas, reovirus-3 and *Campylobacters* were negative.

Based on collaborations begun at the 2003 LTER All-Scientists Meeting, a cover story in BioScience (Porter et al. 2005) detailed how wireless networking technologies are

expanding the basis of data collection in ecology, and how use of such technology might be expanded. Such technologies are widely used at the VCR/LTER, with network links extending to Hog, and Cobb Islands, over 20 km off the coast. The article included images of extensive flooding at the VCR/LTER captured by digital cameras during a major storm.

Images captured automatically by wirelessly networked cameras.
The first shows southern Hog Island during a non-storm time.
The second shows the same view during Hurricane Isabel,
showing the extensive flooding.

Mike O'Connell's work with remote sensing of barrier island vegetation has some preliminary results. Inspection of the coincident high-resolution CIR digital imagery has shown that much of the *pinus taeda* canopy on Parramore Island was defoliated at the time of the EAARL survey. This is likely the result of decline due to the island-wide fire in August 2002, followed by Hurricane Isabel in September 2003, and the infestation of weakened stands by bark beetles. Mike O'Connell is coordinating with Chip Bachmann of the Naval Research Lab to start looking at available spectral datasets in the last few years to try to determine the progression of mortality.