



## **ANNUAL REPORT FOR AWARD # 0080381**

Bruce P Hayden ; *University of Virginia*

LTR IV: Long-Term Ecological Research on Disturbance, Succession, and Ecosystem State Change at the Virginia Coast Reserve

### **Participant Individuals:**

CoPrincipal Investigator(s) : John H Porter; Karen J McGlathery

Senior personnel(s) : Joseph C Zieman; Linda K Blum; Herman H Shugart; Iris Anderson; Nancy Moncrief; Aaron L Mills; Mark Brinson; Robert Christian; R M Erwin; Frank Day; James N Galloway; Stephen Macko; Donald Young; George Oertel; Patricia Wiberg; David E Smith; John Albertson

Graduate student(s) : Anna C Tyler; David L Richardson; Amanda Knoff; Jennifer Wu

Technician, programmer(s) : Charles R Carlson; James R Spitler; Phillip Smith

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Research Experience for Undergraduates(s) : Adriana Veloza; Samuel Diaz

Graduate student(s) : Allison Holinka

Undergraduate student(s) : Elizabeth Skane; Jessica Burton

Participants' Detail

### **Partner Organizations:**

NASA, Kennedy Space Flight Center: Personnel Exchanges

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

USFWS- US Fish and Wildlife Service: Personnel Exchanges

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

USGS Biological Resources Division: Collaborative Research; Personnel Exchanges

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.: Collaborative Research

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: Collaborative Research

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. They are involved in developing a management plan for a MAB site in the delta, and are interested in ILTER.

#### Environmental Protection Agency: Collaborative Research

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 conditions.) The consortium is coordinated by Penn State (Rob Brooks, PI) and includes other institutions such as Virginia Institute of Marine Science, Smithsonian Environmental Research Center, and the Environmental Law Institute.

#### USDA: Financial Support

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: Collaborative Research; Personnel Exchanges

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: In-kind Support; Collaborative Research

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.

### Department of Navy Naval Research Laboratory: Collaborative Research; Personnel Exchanges

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.

### Nature Conservancy: Facilities; Collaborative Research

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: Collaborative Research

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.

### Virginia Dept. of Environmental Quality: Financial Support

They continue to provide support 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.

### Northampton Co. VA Public Schools: Facilities; Collaborative Research

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: In-kind Support

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

## **Other collaborators:**

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

-- Contacts with Scientists from several countries in Southern Africa, specifically exchanges with LTER sites in southern Africa. Remote tele-connection (WEB based) instruction is in the trials phase with class offerings planned for 2002 (Hayden)

-- 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 preservation of soil organic matter in wetlands. This also involved scientists from the LTER network 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. They are involved in developing a management plan 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 CO<sub>2</sub> and CH<sub>4</sub> flux, O<sub>2</sub> consumption, DOC loss, root ingrowth of cores, molecular characterization of microbial communities, pyrolysis 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 Witwatersrand, South Africa; Robert Swap, PI, SAFARI 2000 (Southern Africa Regional Science Initiative), Department of Environmental Sciences, University of Virginia; Hank Shugart,

Leader, Global Climate Change Program, Department of Environmental Sciences, University of Virginia and participating 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 Witwatersrand; Peter Omara-Ojunga, 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 Siteo 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.

Non-LTER collaborations include:

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

## **Activities and findings:**

### **Research and Education Activities:**

Research by Virginia Coast Reserve Long-term Ecological Research Project (VCR/LTER) scientists continue to focus on our core hypothesis that ecosystem, landscape and landuse patterns within terrestrial-marine watersheds are controlled by the vertical positions of the land, sea, and of the fresh groundwater table surfaces. Coastal storms, climate change, long-term eustatic sea-level rise, and land subsidence cause variations in the elevations of these surfaces that drive ecosystem dynamics. Ecological processes, including organic matter production, 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 and land and groundwater surfaces give rise to variations in nutrient availability, primary productivity, organic matter accumulation and trophic interactions.

Continuing research focuses on collection of long-term data sets and maintenance of long term experiments started during VCR/LTER III (1994-2000). With our renewal we have initiated additional work in the lagoons, marshes and uplands of the Virginia Coast. In the lagoons we have:

1. Initiated new intensive monitoring program for Hog Island Bay and its tributaries. (Anderson, McGlathery)
2. Initiated study of the role of land use in affecting groundwater quality (base flow) in fourteen tributaries to coastal lagoons in the VCR (Anderson, McGlathery, Blum, Christian)
3. Initiated study on the role of mudflats in mediating nutrient transformations in the coastal lagoons of the LTER (Anderson, McGlathery)

4. Continued study of nitrogen transformations (nitrogen fixation, gross nitrogen mineralization, nitrification, denitrification) in the water column and sediments of Hog Island Bay (Anderson, McGlathery)
5. Started measurements using a digital fathometer integrated with global positioning system measurements to extend our bathymetric mapping to include the lagoon inland of Smith Island (Oertel, Carlson)
6. Continued studies of the surface lagoonal circulation using sequential global positioning system (GPS) locations of 'drifters.' (Oertel, Carlson)
7. Initiated development of a model to determine residence times and transport in shallow subtidal areas of Hog Island Bay (Anderson, McGlathery with collaborator Friedrichs)
8. Started measurements of grain-size distributions of the lagoon bottom in Hog Island Bay (Lawson, Wiberg and McGlathery)

In the marshes we have focused on:

1. Continued work on understanding organic matter accumulation, with particular emphasis on the ability of salt marshes to maintain themselves as the sea-level free-surface rises. (Blum, Brinson, Christian)
2. Continued experimental manipulation of marsh flooding (Brinson, Christian, Blum)
3. Continued analysis and modeling of near-surface soil moisture at a marsh-upland transition (Dusterhoff, Albertson, Wiberg)
4. Started measurements, analysis and modeling of water-table elevation and soil saturation across a marsh transect (Turaski and Wiberg)

In the uplands of the islands and mainland we have:

1. Continued with long term measurements of *Myrica cerifera* shrub production and thicket expansion on Hog Island (Young)
2. Continue measurements of vegetation for a large herbivore exclosure experiment on Hog Island (Young, Porter, Moncrief, Dueser)
3. Initiated new studies of the ecology of the *Phragmites australis* with attention to its invasion/expansion at the VCR (Young)
4. Continued analysis of a, now completed, 10 year study on fine root dynamics using minirhizotrons (Day)
5. Continuation of long-term monitoring of permanent vegetation plots in a nitrogen fertilization experiment (Day)
6. Continued monitoring of depth to freshwater free surface across Hog Island (Brinson, Day).
7. Instituted a study by a Master's student on effects and fate of nitrogen in plots fertilized 9 years previous (Day)
8. Continued vegetation biomass determinations every three years on Hog Island dunes. (Day)
9. Continued monitoring of small mammal populations (Porter, Moncrief, Brannon)
10. Initiated instrumentation of the Cobb Mill Creek Watershed in the vicinity of its outflow into Oyster Harbor at the Anheuser Busch Coastal Research Center. Continuous stream discharge measurements are being made and nutrient (N&P) concentrations are being determined in the stream and groundwater adjacent to the stream. The immediate purpose of the activity is to provide a baseline for estimation of



N-translocation from groundwater in the watersheds of the LTER into the seaside lagoons.(Mills)

11. We conducted a multi-island survey of herpetofauna (reptiles and amphibians, including both selected islands for which a species list already is available (Assateague, Chincoteague, Wallops, Parramore, Hog, Cobb, Smith) and on islands for which no survey has been published (Revel, Myrtle and Ship Shoal). (Moncrief, Brannon, collaborator Dueser)

We have also participated in cross-site and synthetic projects, including:

1. Research vegetation impacts on climate from both theoretical and observational perspectives. The results of this work were presented in a Plenary talk at the 2000 ESA/LTER All Scientists Meeting (Hayden)
2. Completed a renewed study of storminess at all LTER sites and the results were submitted for inclusion in the forthcoming Oxford University Press LTER book on climate variability. This work on storminess was also included as a contribution to the US National Climate Change Assessment: Water Sector. In addition, this work appeared the Journal of Water Resources Research. (Hayden)
3. Performed collaborative study with PIE LTER on the quality of dissolved organic nitrogen in the VCR coastal lagoons vs the PIE estuarine system. (Anderson)
4. Performed collaborative study of nitrogen cycling processes in watersheds of the Shumava ILTER, Czech Republic (Anderson)
5. Initiated an Intersite Comparison that investigates the question of organic source vs. environmental (geographic) setting on the development of microbial decay communities in coastal marshes. Decay communities developing on reciprocal crosses of litter from 9 sites with the Virginia Coast LTER are being examined with a variety of molecular techniques. At this point, all the materials have been collected from the sites, litterbags have been prepared and deployed at the 10 sites. Initial samples have been taken and are currently being analyzed at the University of Virginia and at Kennedy Space Center (major collaborators on the project). (Mills, Blum)
6. We were active participants in an LTER All-Scientists meeting workshop that has met twice and that is developing goals/guidelines for invasive species at all LTER sites (Young)
7. Enhancement of the LTER All-Site Data Catalog by adapting it to an improved search engine and improving documentation (Porter)
9. PI Erwin organized a symposium on 'Global change and waterbirds: Implications for management and conservation in the 21st century' at the 24th annual meeting of the Waterbird Society, Plymouth MA, November 2000. Nine presentations were given, with 8 invited speakers. The symposium was organized to assess our current state of knowledge on how sea level rise, ocean regime changes, and expected shifts in precipitation patterns may affect a variety of habitats and prey communities of waterbird species in different regions of the world.

The VCR Schoolyard LTER program had a successful year in that chemistry, biology and math courses used VCR LTER resources, faculty and staff to take hands-on scientific measurement in to the classroom

as well as into the field. More than 150 students benefited from this activity in the 2000-2001 academic year. In addition the SLTER teachers participated in the VCR All Scientist meeting held in January 2001. Organized by lead PI Hayden, Carlson, Smith, Blum, Porter, and Richardson offered a class for the Schoolyard LTER teachers in Northampton County, Virginia. This graduate course was focused on the scientific equipment purchased for use in the SLTER program. In addition, the class met recertification requirements for the teachers.

## Findings:

### LAGOON

Overall Objective of Research on VCR Coastal Lagoons: Perform an interdisciplinary study of watershed inputs, biological transformations and trophic status, and water residence times over diurnal, seasonal, and interannual time scales in order to determine the fate of agriculturally-derived N entering Hog Island Bay, a shallow coastal lagoon located in the Virginia Coast Reserve (VCR)

Specific Objectives: estimate groundwater inputs of nitrogen from the watershed to Hog Island Bay determine the fate of dissolved inorganic and organic nitrogen released during decomposition of macroalgae in Hog Island Bay; relate rates of biological transformations to residence time of water parcels within Hog Island Bay.

Conclusions of N-cycling studies performed in Hog Island Bay (Anderson, McGlathery):

1. Water column processes have a greater impact on water column nutrients in VCR coastal lagoons than do sediment processes. Water column metabolism resulted in uptake of ammonium during all seasons and in uptake of nitrate during most seasons. Phytoplankton biomass was low during all seasons except August, following crash of a macroalgal bloom.
2. Gross nitrogen mineralization, which ranged from 0.9 - 6.5 mmol N/m<sup>2</sup>/d, resulted in short-term turnover (< 1d) of the sediment ammonium pool; however sediment - water fluxes of both ammonium and nitrate were either negligible or directed into the sediments.
3. The ammonium produced by gross mineralization was rapidly consumed in the dark. We cannot currently distinguish between the potential mechanisms responsible for this uptake, which include coupled nitrification/denitrification, uptake by benthic microalgae, and immobilization by heterotrophic bacteria. Currently studies are in progress to attempt to determine how the mineralized ammonium is partitioned between these processes.
4. Nitrogen demand by benthic microalgae was exceeded by ammonium production in the sediments.
5. Estimates of potential nitrogen consumptive mechanisms and preliminary determinations of residence times in the shallow zones of the lagoon (performed by Carl Friedrichs and students) suggest that the lagoon is likely to retard and remove nitrogen during its transport from the uplands through the coastal lagoon to the ocean.

Preliminary results of mudflat studies conducted during summer 01:

Mudflat sediments are a negligible source of nutrients to the coastal lagoon. Most of the nutrient cycling took place in water overlying the mudflats utilizing nutrients derived from upland sources.

Preliminary results of groundwater contributions to VCR coastal lagoons: During spring and early summer concentrations of nitrate, the principal nutrient in groundwater, ranged from 30 - 800  $\mu\text{M}$  with a mean for 14 creeks of 181  $\mu\text{M}$ .

#### MARSH

Work on organic matter accumulation at VCR marshes focuses on landscape scale responses of this important ecosystem process with particular emphasis on the ability of salt marshes to maintain themselves as the sea-level free-surface rises. The work of PI Blum shows that in the mid-marsh and at the current rate of sea-level rise (0.4 cm per year) organic matter accretion rates (0.83-0.27 cm per year) are high enough that this region of the marsh can maintain the sediment surface elevation even in the absence of significant mineral sediment inputs, but that this is not the case in the low marsh (0.07-0.26 cm per year) or the high marsh (0.09-0.225 cm per year). Furthermore, there is evidence from long-term experiments that root production, the mechanism responsible for organic matter accumulation in the mid-marsh, maybe controlled by precipitation. Root production appears to be greatest when cumulative monthly rainfall during the growing season (March to September) is less than the forty-year average. Continued observation and experimentation will be necessary to confirm this finding. (Blum)

The surface organic litter layer plays an important role in controlling surface saturation conditions in low gradient, forested ecosystems. Average soil moisture during the study period along the marsh-upland transition correlated with the average water table elevation. Tidal forcing kept the average water table elevation at the high marsh end of the transect elevated while low seasonal precipitation input caused a low average water table elevation within the upland fringe. Surface soil textural heterogeneity and microtopographic influences resulted in variability in the relationship between soil moisture variance and surface elevation. Time series of water table elevations at locations along a marsh transect were used to develop cumulative probabilities of soil saturation (leading to runoff) as a function of elevation and distance from the tidal creek. A simple model of evapotranspirative water losses can explain most of the observed changes in water table elevation. (Wiberg)

Findings from flooding experiments and observations included the following (1) There is a shift in high marsh plant species from *S. patens* to *D. spicata* with disturbance and conversion from flat turf to the hollow and hummock microtopographic relief. The shift is associated with stress, physiological changes and changes in production potential. (2) The *Juncus roemerianus* community may be more resilient to disturbance than previously thought if the inundation regime remains characteristic of high marshes. (3) The water quality of stations throughout the Hog Island Bay is much more similar than

previously envisioned. Although trends are evident in that mainland creeks may have higher concentrations of some nutrients than those on Hog Island, lagoonal flushing tends to homogenize the system. (4) Nitrogen cycling within high marshes (based on marshes from VA, MA, and GA) involves more recycling and greater dependence of primary production on recycling and precipitation than low marshes. (Christian)

#### UPLAND

*Myrica cerifera* shrub thicket growth is a function of a complex set of environmental variables including environmental salinity, availability of freshwater, summer temperature and precipitation patterns. However, important biotic variables include facilitation of seedling establishment by grasses and the presence of a key actinomycete, *Frankia*, which forms root nodules and then symbiotically fixes nitrogen. (Young)

Our preliminary evidence from *Phragmites australis* indicates that this invasive weedy grass prefers a similar environmental niche (mesic swales or close to freshwater seeps). In addition it is also a strong vegetation propagator and both seeds and rhizome pieces are easily dispersed. Thus, understanding the longterm dynamics of the shrub thickets on the barrier islands is beginning to provide insight towards a better understanding of the invasion potential and mechanisms of *Phragmites australis* in the coastal environment. (Young)

Generally, aboveground biomass decreased on all dunes over a six-year period. However, the magnitude of the decrease was least on the oldest dune, where *Schizachyrium* increased. The results suggest that typical succession, with biomass increasing progressively, is not occurring on Hog Island dunes. Correlation analysis indicates that the position of the groundwater free surface may play a major role in determining aboveground biomass levels. (Day)

There were few significant changes in species composition and dominance in control permanent plots between 1992 and 1998; however, in fertilized plots, *Ammophila breviligulata* cover increased (except on the oldest dune) and *Spartina patens* cover decreased (except on the youngest dune). After seven growing seasons, results suggested more intense negative effects of competition in nitrogen-fertilized plots. Greater cover of *Ammophila* in fertilized plots suggests *Ammophila* is in a better position to compete for light with enhanced aboveground dominance. The hypothesis that, with fertilization, areas that start with different species assemblages will become more similar does not appear to be supported by our study. Diversity was lower in fertilized plots on all but the 1967 dune 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 influence plant community composition. The decline in

*Spartina* density may be at least partially attributed to development of drier conditions on the older dunes. (Day)

Minirhizotron observation tubes were used to assess the effect of nitrogen fertilization on short-term fine root dynamics in a nutrient limited, barrier island dune system. Root length elongation and mortality rates followed expected patterns with soil depth, with the highest values for both occurring in the upper 22 cm. Total % nitrogen was significantly increased by the fertilization regime and corresponded to significantly higher root elongation and mortality rates. However, mortality rates (0.61 mm cm<sup>-2</sup> day<sup>-1</sup>) greatly exceeded root length elongation rates (0.18 mm cm<sup>-2</sup> day<sup>-1</sup>) in both control and treatment plots. These results support the hypothesis that fine root turnover rates increase with nitrogen availability. The effect of N fertilization was much more pronounced on mortality rates than on root length elongation rates. This is suggestive of a belowground die back in response to nitrogen fertilization, perhaps associated with a shift in allocation to aboveground production. (Day)

For our intensive study of Cobb Mill Creek, baseflow discharges and nutrient concentrations have been examined since Nov. 2000. Using the baseflow data, we estimate N loading to the lagoon from the Cobb Mill Creek Watershed to be approximately 1.5 metric tons per year. This number will soon be refined to include the rest of the year's data and also contribution from storm events. (Mills)

During the herpetofaunal survey we recorded a total of four previously-unreported species on one or more islands during our activities on the islands: Little brown skink (*Scincella lateralis*) on Myrtle and Ship Shoal Islands; Black rat snake (*Elaphe obsoleta*) on Parramore Island; Diamondback terrapin (*Malaclemys terrapin*) on Ship Shoal Island; Leatherback sea turtle (*Dermochelys conacea*) on Cobb Island. (Moncrief, Brannon, collaborator Dueser).

#### CROSS SITE AND SYNTHESIS

The presentations at the symposium suggested that a number of changes associated with shifting ocean regimes, rainfall patterns in the interior of the U.S. and Canada, and sea level rise (e.g. at the Virginia Coast Reserve LTER site) may already be affecting many species of waterbirds and their habitats. Krill and fisheries in Antarctica and Alaska seem to be shifting, and with it, there are major implications to seabird foraging bases and declining populations of some species (e.g. Adelie Penguins). Prairie Potholes in the interior of North America are expected to dry significantly, especially in Parklands of Canada, with major implications to 7-9 species of breeding waterfowl. Shifts in the geographic distribution of some species has already occurred, with many southern species moving further north in the northern hemisphere. In coastal areas of the U.S., inundation of marshes and loss of islands appears to be occurring and in turn, limiting nesting site potential for a number of waterbird species of concern. (Erwin)

The intersite comparison that investigates the question of organic source vs. environmental (geographic) setting on the development of microbial decay communities in coastal marshes has yielded samples that are currently being analyzed, but data are not sufficient to draw any conclusions at this point. In the very near future we will complete initial analyses of a geographical comparison of phylloplane bacteria and fungi (on standing dead plants) and soil bacteria and fungal communities for the marshes of the U.S. east coast. (A paper will be presented at ISME9 at the end of August, 2001). (Mills)

### **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 demonstrations and WEB based communications. We have engaged in high school teacher training in field methods in the environmental sciences. We have included two high school students in our project surveys of watershed water chemistry observations. Undergraduate and graduate students have acted as teams on various research project during the year.

Specific investigators characterized the training aspects:

This project continues to support graduate and undergraduate students and provide training and experience for them. (Day)

This project continues to serve as the focus of research for master's students working on their degrees. Also, the VCR-LTER site is used for an all day field trip for my Wetland Ecology Laboratory. (Brinson)

The intersite comparison provided a project for an undergraduate student at Kennedy Space Center in the summer of 2001. Additional students will be added in 2002 at both KSC and UVa. The Cobb Mill Creek project supports one Ph.D. student and provided another with a collaborative project during the initial instrumentation phase. (Mills)

Graduate and undergraduate students involved in my research learn a variety of vegetation analysis techniques, both field and computer based. They also learn how to properly measure physiological parameters in the field and the environmental variables that affect them. In addition, these students develop and appreciation for and skill in the design/implementation/difficulty of field work on a remote barrier island. Perhaps most important, they develop an

intuitive appreciation for the ecological dynamics of this dynamic ecological system. Former students have become high school science teachers, received or are working on doctorates, accepted positions with government agencies, or are working in private industry. (Young)

Educational Activities: The following students took part in the above research activities: 1. Jen Wu, VIMS, M.S. student, groundwater quality 2. Frank Parker, VIMS, Ph.D. student, mudflat study, Lagoonal N cycling 3. Tami Lunsford, VIMS, M.S. student, DOM characterization, DON quality 4. Adriana Veloza, Stroudsburg University, REU student, mudflat project 5. Samuel Diaz, University of Puerto Rico, REU student, mudflat project. 6. Allison Holinka, College of William and Mary, M.S. student, mudflat project 7. Jessica Burton, University of Virginia, B.A. student, HIB monitoring, N-cycling studies 8. Sarah Lawson, University of Virginia, M.S. student, HIB N-cycling 9. Elizabeth Skane, University of Virginia, B.A student, HIB N-cycling (Anderson)

As mentioned elsewhere, much activity has been devoted to conducting workshops on network analysis. I hope that it will be used as an integrating tool for the LTER network for synthesis of both food web and nutrient cycling dynamics across sites. (Christian)

#### **Outreach Activities:**

The Schoolyard LTER program continues to be a meaningful way of increasing future public understanding.

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

The project's WWW site (<http://www.vcrlter.virginia.edu>) is publically accessible and receives substantial use. Of the 1.02 million 'hits' between March and August 2001, 884,792 were from outside the University of Virginia.

PI Christian served as the liason from the Global Terrestrial Observing System (GTOS) to the Coastal Global Oceanographic Observing System panel and subsequently the Coastal Oceanographic Observing Panel. As a result of additional perceived needs for coastal ecosystems, He will be chairing a panel to initiate a coastal initiative directly for GTOS.

PI Porter co-chairs the User Working Group for the NASA Global Change Master Directory (<http://www.globalchange.nasa.gov>) and represents the LTER program on the Biological Data Working Group of the Federal Geographic Data Committee. He is also active in LTER Network information management activities and serves on the LTER Executive Committee.

VCR/LTER investigators and students are also frequent participants in scientific meetings that are open to the public. We will not attempt to list all of the presentations made at these meetings, but instead list the activities of one investigator (Iris Anderson) and one graduate student (Amanda Knoff) whose activities are not atypical.

-----Iris Anderson -----

Invited Talk on work performed at Sumava ILTER in the Czech Republic:  
Anderson, I.C. Tobias, C.R., Macko, S.A., and  
Poth, M.A. Sources and Sinks of Nitrogen in Acidified Glacial Lakes  
and their Watersheds in Sumava National Park,  
International Workshop on Acidified Lakes in Bohemian/Bavarian  
Forests- History, Present and Future, Ceske Budejovice,  
CR, Mar 00.

Speaker for Mini School of Marine Science, offered by Virginia  
Institute of Marine Science to educate the public about marine issues,  
Richmond VA and in Newport News Va during 00-01. Talk on Shallow  
Aquatic Ecosystems (approximately 150 participants).

Participant NSF- Comparative Aquatic Research Workshop, Salt Lake  
City, Feb. 2000.

Science Advisory Committee - Georgia Coastal Ecosystems, Long Term  
Ecological Research project, NSF-LTER Program, ( 3 year term starting  
00)

-----Amanda Knoff-----

TALK: Stable Isotope Analysis of Intrapopulation, Spatial, and  
Temporal Variation of Laughing Gull (*Larus atricilla*) Diets in the  
Virginia Coast Reserve and Jamaica Bay, New York, Applications of  
Stable Isotope Techniques to Ecological Studies, Braunschweig,  
Germany, May 2000.

POSTER: Stable Isotope Analysis of Intrapopulation, Spatial, and  
Temporal Variation of Laughing Gull (*Larus atricilla*) Diets in Coastal  
Virginia (VCR-LTER) and Jamaica Bay, N.Y. All-Scientists Meeting,  
LTER, Snowbird, UT, Aug. 2000 and Kalahari Transect Workshop, Maun,  
Botswana, Oct. 2000.

TALK: Stable Isotope Analysis of Intrapopulation, Spatial, and  
Temporal Variation of Laughing Gull (*Larus atricilla*) Diets in the  
Virginia Coast Reserve and Jamaica Bay, New York Atlantic Estuarine  
Research Society, Edgewater, MD, Nov. 2000

### **Journal Publications:**

McGlathery, K. J., "Macroalgal blooms contribute to the decline of seagrass in nutrient-enriched coastal waters",  
*Journal of Phycology*, vol. 35, (2001), p. 1. Published

Anderson, I. C., K. J. McGlathery, and A. C. Tyler, "Microbial processing of reactive nitrogen in a temperate  
coastal lagoon", *Marine Ecology Progress Series*, vol. , (), p. . Submitted



- Baker, K.B. B.J. Benson, D.L. Henshaw, D. Blodgett, J.H. Porter, and S.G. Stafford, "Evolution of a Multisite Network Information System: The LTER Information Management Paradigm", *BioScience*, vol. 50, (2000), p. 963. Published
- Barimo, J.F. and D.R. Young, "Grasshopper(Orthoptera:Acrididae)-plant-environmental interactions in relation to zonation on an Atlantic Coast barrier island", *Environmental Entomologist*, vol. , (), p. . Submitted
- Barimo, J.F. and D.R. Young, "Insect-plant-environmental interactions in relation to primary succession in a coastal ecosystem", *Oikos*, vol. , (), p. . Submitted
- Berg, P. and K. J. McGlathery, "A high-resolution pore water sampler for sandy sediments", *Limnology and Oceanography*, vol. 46, (2001), p. 203. Published
- Blum, L.K. and Christian, R.R., "Below ground production and decomposition along a tidal gradient in a Virginia, U.S.A, salt marsh", *Estuaries*, vol. , (), p. . Submitted
- Brinson, M. M., and R. R. Christian, "Assessing functions of wetlands and the need for reference", *Biologia Ambientale*, vol. , (), p. . Accepted
- Brinson, M.M., "Fluvial forms and processes: A new perspective (book review)", *Ecological Engineering*, vol. 14, (2000), p. 307. Published
- Christiansen, T., P.L. Wiberg and T.G. Milligan, "Flow and sediment transport on a salt marsh surface", *Estuarine, Coastal and Shelf Science*, vol. , (), p. . Accepted
- Craig, C.L. and D.R. Young, "Physiological responses of *Phragmites australis* to flooding at variable salinities", *Wetlands*, vol. , (), p. . Submitted
- Crawford, E.R. and D.R. Young, "Comparison of gaps and intact shrub thickets on an Atlantic Coast barrier island", *American Midland Naturalist*, vol. , (), p. . Accepted
- Day, F.P., C. Conn, E. Crawford, and M. Stevenson, "Long-term effects of nitrogen fertilization on plant community structure on a coastal barrier island dune chronosequence", *Canadian Journal of Botany*, vol. , (), p. . Submitted
- Day, F.P., E. Crawford, and J.J. Dilustro, "Plant biomass change along a coastal barrier island dune chronosequence over a six-year period", *J. Torrey Bot. Soc.*, vol. 128, (2001), p. 197. Published
- Elliott, M.T. and D.R. Young, "Influence of tidal wrack and microtopography on strand species and on community composition", *American Midland Naturalist*, vol. , (), p. . Accepted
- Erwin, R.M. and B.R. Truitt, "Nowhere to hide: ground-nesting waterbirds and mammalian carnivores in the Virginia barrier island region", *Journal of Coastal Research*, vol. 17, (2001), p. 292. Published
- Franklin, R.B., D.R. Taylor, and A.L. Mills, "The influence of chemical environment and spatial separation on the distribution of microbial communities in anaerobic and aerobic zones of a shallow coastal plain aquifer", *Microb. Ecol.*, vol. , (), p. . Submitted
- Giannotti, A. L. and K. J. McGlathery, "Consumption of *Ulva lactuca* (Chlorophyta) by the omnivorous mud snail *Ilyanassa obsoleta*", *Journal of Phycology*, vol. 37, (2001), p. 1. Published
- Havens, K. E., A. C. Tyler, J. Hauxwell, S. Thomas, K. J. McGlathery , I. Valiela, J. Cebrian, A. D. Steinman, and S. J. Hwang, "Complex interactions between primary producers in shallow marine and freshwater ecosystems: Implications for community responses to nutrient stress.", *Environmental Pollution*, vol. , (2001), p. 113. Published
- Howarth, R., D. Anderson, J. Cloern, C. Elfring, C. Hopkinson, B. Lapointe, T. Malone, N. Marcus, K. McGlathery, A. Sharpley, and D. Walker., "Nutrient Pollution of Coastal Rivers, Bays and Seas", *Ecological Issues*, vol. 7, (2000), p. 1. Published
- Hutton, J. and F.P. Day, "The effect of nitrogen fertilization on short-term fine root dynamics in a barrier island dune community", *Plant and Soil*, vol. , (), p. . Submitted

- Joy, D.A. and D.R. Young, "Promotion of mid-successional seedling recruitment and establishment by *Juniperus virginiana* in a coastal environment", *Plant Ecology*, vol. , (), p. . Accepted
- Knapp, E. P., J.S. Herman, A.L. Mills, and G.M. Hornberger, "Alteration of reactive mineral surfaces in anaerobic groundwater systems", *Appl. Geochem.*, vol. , (), p. . Submitted
- Knoff, A.J., S.A. Macko and R.M. Erwin, "Diets of nesting Laughing Gulls (*Larus atricilla*) at the Virginia Coast Reserve: Observations from stable isotope analysis", *Isotopes in Environmental and Health Studies*, vol. 37, (2001), p. 67. Published
- Kopacek, J., E. Stuchlik, J. Vesely, J. Schaumburg, I.C. Anderson, J. Fott, J. Hejzlar, and J. Vrba, "Hysteresis in reversal of Central European mountain lakes from atmospheric acidification", *Water, Air, and Soil Pollution*, vol. , (), p. . Accepted
- Layman, C.A. and D.E. Smith, "Sampling Bias of Minnow Traps in Shallow Aquatic Habitats on the Eastern Shore of Virginia", *Wetlands*, vol. 24, (2000), p. 145. Published
- Lowit, M.B., L. K. Blum, and A. L. Mills, "Determining replication for discrimination among microbial communities in environmental samples using community-level physiological profiles", *FEMS Microbiology Ecology*, vol. 32, (2000), p. 97. Published
- McGlathery, K. J., "Macroalgal blooms contribute to the decline of seagrass in nutrient-enriched coastal waters", *Journal of Phycology*, vol. 35, (2001), p. 1. Published
- McGlathery, K. J., Anderson, I. C., and Tyler, A. C., "Magnitude and Variability of Benthic and Pelagic Metabolism in a Temperate Coastal Lagoon", *Marine Ecology Progress Series*, vol. 216, (2001), p. 1. Published
- Miller, W.D., S.C. Neubauer and I.C. Anderson, "Effects of sea level induced disturbances on high salt marsh metabolism", *Estuaries*, vol. 24, (2001), p. 357. Published
- Moncrief, N.D. and R.D. Dueser, "Allozymic variation in the endangered Delmarva Fox Squirrel (*Sciurus niger cinereus*): Genetics of a translocated population", *American Midland Naturalist*, vol. , (), p. . Accepted
- Mood, M.L. and D.R. Young, "Salinity tolerance for brackish and freshwater populations of *Phragmites australis*", *Journal of Applied Ecology*, vol. , (), p. . Submitted
- Neubauer, S. C., I.C. Anderson, J.A. Constantine, and S.A. Kuehl, "Sediment deposition and accretion in a mid-Atlantic (U.S.A) tidal freshwater marsh", *Estuarine Coastal and Shelf Science*, vol. , (), p. . Accepted
- Neubauer, S.C., W.D. Miller and I.C. Anderson, "Carbon cycling in a tidal freshwater marsh ecosystem: a carbon gas flux study", *Marine Ecology Progress Series*, vol. 199, (2000), p. 13. Published
- Newell, S.Y., L.K. Blum, R. E. Crawford, T.Dai, M. Dionne, "Autumnal biomass and potential productivity of salt marsh fungi from 29 to 43 north latitude along the United States Atlantic Coast", *Applied and Environmental Microbiology*, vol. 66, (2000), p. 180. Published
- Rheinhardt, R., D.F. Whigham, H. Kahn, and M. Brinson, "Vegetation of headwater wetlands in the inner coastal plain of Virginia and Maryland", *Castanea*, vol. 65, (2000), p. 21. Published
- Rheinhardt, R.R., M.C. Rheinhardt, M.M. Brinson, and K.E. Faser, Jr., "Application of reference data for assessing and restoring headwater ecosystems", *Restoration Ecology*, vol. , (), p. . Accepted
- Thomas, C. R., and R. R. Christian, "Comparison of nitrogen cycling in salt marsh zones related to sea-level rise", *Marine Ecology Progress Series*, vol. , (), p. . Accepted
- Tobias, C.R., E.A. Canuel, and I.C. Anderson, "Biogeochemical controls on nitrate reduction in groundwaters from a shallow coastal aquifer", *Estuaries*, vol. , (), p. . Submitted
- Tobias, C.R., I.C. Anderson, E.A. Canuel and S.A. Macko, "Nitrogen cycling through a fringing marsh-aquifer ecotone", *Marine Ecology Progress Series*, vol. 210, (2001), p. 25. Published
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Tobias, C.R., S.A. Macko, I.C. Anderson, E.A. Canuel, and J.W. Harvey., "Tracking the fate of a high concentration groundwater nitrate plume through a fringing marsh: A combined groundwater tracer and in situ isotope enrichment study.", *Limnology and Oceanography*, vol. , (), p. . Submitted

Tyler, A. C., K. J. McGlathery, and I. C. Anderson, "Macroalgal mediation of dissolved organic nitrogen fluxes in a temperate coastal lagoon", *Estuarine, Coastal and Shelf Science*, vol. , (), p. . Accepted

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Wijnholds, A.E. and D.R. Young, "Interdependence of the host plant, *Myrica cerifera*, and the actinomycete, *Frankia*, in a coastal environment", *Journal of Coastal Research*, vol. 16, (2000), p. 139. Published

Wu, K. W. and L. K. Blum, "Estuarine bacteria: important links to higher trophic levels", *Estuaries*, vol. , (), p. . Submitted

Layman, C. A., "Fish Assemblage Structure of the Shallow Ocean Surf-Zone on the Eastern Shore of Virginia Barrier Islands", *Estuarine, Coastal and Shelf Science*, vol. 51, (2000), p. 51. Published

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Knoff, A., S. Macko and R.M. Erwin, "Stable isotope analysis of temporal variation in the diets of laughing gulls (*Larus atricilla*) in coastal Virginia and Jamaica Bay, New York", *Coastal Waterbirds*, vol. , (), p. . Submitted

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Appolone, E., "Organic matter distribution and turnover along a gradient from forest to tidal creek" , bibl. MS thesis, Biology Department, East Carolina University, Greenville, N.C., (2000). *Thesis* Published

Buck, T., "High marsh plant community response to sea-level rise induced high marsh subsidence and ecosystem state change" , bibl. East Carolina University, Greenville, NC, (2001). *Thesis* Published

Christian, R. R., and C. Thomas, "Neuse River Modeling and Monitoring Project stage I: Network analysis for evaluating the consequences of nitrogen" , bibl. UNC-WRRI Report No. 325F. Raleigh, NC. 44 pp., (2000). *Book* Published

Christian, R. R., and D. G. Capone, "Overview of issues in aquatic microbial ecology" , bibl. ASM Press, Washington, DC., (). *Book* Accepted

of Collection: C. J. Hurst, G. R. Knudsen, M. J. McInerney, L. D. Stetzenbach, and M. V. Walter, "Manual of Environmental Microbiology, 2nd edition"

Christian, R. R., and R. E. Ulanowicz, "Network Ecology" , bibl. John Wiley & Sons, Ltd, (). *Book* Accepted  
of Collection: A. El-Shaarawi and W. W. Pierogorsch, "Encyclopedia of Environmetrics"

Christian, R.R., L.E. Stasavich, C.R. Thomas, and M.M. Brinson, "Reference is a moving target in sea-level controlled wetlands." , bibl. Pages 805-825. Kluwer, Dordrecht, The Netherlands, (2000). *Book* Accepted  
of Collection: M.P. Weinstein and D.A. Kreeger, "Concepts and Controversies in Tidal Marsh Ecology"

Craig, C.L., "Physiological responses of *Phragmites australis* to flooding at different salinity levels" , bibl. MS thesis. Virginia Commonwealth University, Richmond, VA, (2001). *Thesis* Published

Dusterhoff, S., "Controls on Near-Surface Soil Moisture Dynamics within a Tidal Marsh-Forested Upland Coastal Environment" , bibl. MS Thesis. University of Virginia, Charlottesville, VA, (2001). *Thesis* Published

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Hutton John "The effect of nitrogen fertilization on short-term fine root dynamics in a barrier island dune

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Porter, J.H., "Scientific databases" , bibl. Blackwell Science Ltd., London, (2000). *Book* Published  
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Richardson, J.L. and M.M. Brinson, "Wetland soils and the hydrogeomorphic classification of wetlands" , bibl. Lewis Publishers, Boca Raton, Florida, USA., (2000). *Book* Published  
of Collection: J.L. Richardson and M.J. Vepraskas, "Wetland Soils: Genesis, Hydrology, Landscapes, and Classification"

Roberts, S.W., "Primary production of *Distichlis spicata* and *Spartina patens* and effects of increased inundation on a salt marsh" , bibl. East Carolina University, Greenville, NC, (2000). *Thesis* Published

Weber, Rett, "An analysis of the energetic budgets of grasses to assess the effectiveness of different competitive strategies" , bibl. Old Dominion University, Norfolk, VA, (2001). *Thesis* Published

Keiss, O., "Mammalian Predator Distribution and Abundance on the Virginia Barrier Islands in Relation to Breeding Habitats of Colonial Birds" , bibl. M.S. Thesis, Department of Fisheries & Wildlife, Utah State University, Logan, UT., (2000). *Thesis* Published

## **Other Specific Products:**

### **Data or databases**

The VCR/LTER provides access to more than 75 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 biodiversity database, or extensive graphical output, such as our meteorological 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.

Data is made available via the WWW in conformance with LTER-wide data policies. As noted in the 'contributions' section, the data is widely used for research and education, with over half (58%) of the data requests coming from researchers, educators and students not associated with the VCR/LTER.

### **Physical collection (samples, etc.)**

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.

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

## **Audio or video products**

We have begun to post compressed videos of our site and research procedures on the WWW at <http://www.vcrlter.virginia.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.

They are available in RealPlayer or Windows Media Player formats on the WWW site: <http://www.vcrlter.virginia.edu/video>

## **Internet Dissemination:**

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

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 1.02 million "hits" during the period March-August 2001.

## **Contributions:**

### **Contributions within Discipline:**

#### 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.

In parallel with our measurements of biological process rates in the lagoon, a model is being developed by Dr. Carl Friedrichs (VIMS), which will relate biological process rates with residence times in various parts of the lagoon. In addition, Dr. John Albertson (University of Virginia) is developing a model to quantify groundwater inputs of nutrients to the lagoon. This study is somewhat unique since it involves an interdisciplinary team including an hydrologist (John Albertson), physical oceanographers (Carl Friedrichs and David Fugate) and biologists (Iris Anderson and Karen McGlathery).

#### MARSH

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 begun to organize 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 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. (Wiberg)

#### UPLAND

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 I have 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 maritime forest. (Young)

Ten 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. (Young)

#### **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 of network ecology. Social scientists have also used network analysis, and one of our accomplishments has been to bring awareness of the different approaches to the broader group. (Christian)

Research on ecological information management has included computer scientists. The challenges posed by ecological data provide opportunities for innovation in computer science. (Porter)

#### **Contributions to Education and Human Resources:**

As can be seen from the number of graduate and undergraduate students listed on our participant list, this project provides abundant

opportunities for training. Moreover, the inter- and multi-disciplinary nature of the research teaches the students how to operate in a collaborative environment.

During the spring semester of 2001, the LTER laboratory has been used by three classes totaling more than 40 undergraduate students. One intensive class worked at the site for 5 days straight and provided the LTER site with data on bird colony locations and structure of marsh communities along a topographic gradient.

We have, in our Schoolyard LTER program provided instruction and assistance to local teachers as well as graduate courses in assistance of their recertification. We have brought LTER research activities into the classroom had extensive contact with more than 150 students in grades 9-12.

Some typical reports from individual LTER researchers include:

'A variety of individuals have been involved with these projects including undergraduates (Alison McCombe and Ned Rubert), graduate students (Mike Lowit, Rima Franklin, and Cassandra Thomas), and technical staff (Greg Harp).' - Linda Blum

'Much of what I have learned and continue to study is used in the classroom. I now teach a course in barrier island ecology. I have trained twenty MS students and at least fifteen did thesis research on some aspect of coastal ecology. During almost every summer of my involvement with the Virginia Coast Reserve I have had REU students working on my projects. The REU program at VIMS is primarily a minority program. This summer I had a student from Columbia (Adriana Veloza) who worked with me on the mudflat component of the study and Samuel Diaz from Puerto Rico, who accompanied us on field trips. Since 1991, I have had 8 REU students work with me at the VCR. Of those, 4 were minority students, 2 hispanics, 1 Asian, 1 Indian, 4 women. In addition, I had 3 high school students, of which two were women, and one a minority. I currently have two graduate students (one Ph.D, one M.S) working at the VCR. In addition, two students have received Ph.D's in the last two years, and two have received M.S degrees.' ' -- Iris Anderson

### **Contributions to Resources for Science and Technology:**

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 the beginning of this grant in Nov. 2000, we have provided data for 100 formal requests. 42% were by VCR/LTER associated researchers, but 58% were from individuals not associated with the VCR/LTER. 27% of the total requests were for research use and an additional 27% were for classroom use. 11% of the total requests were from outside the US



including India, China, and the United Kingdom, 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.

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.

### **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, Porter, Hayden, Blum, Albertson, 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. (Anderson)

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 disturbances due to human activities in the coastal zone. (Blum)

As described elsewhere, my activities with the UN programs on observing global change along coastal ecosystems have significance for broad aspects of public welfare and environmental protection. (Christian)

### **Special Requirements for Annual Project Report:**

*Unobligated funds: less than 20 percent of current funds*

### **Categories for which nothing is reported:**

**Special Reporting Requirements**

**Animal, Human Subjects, Biohazards**



We welcome [comments](#) on this system

