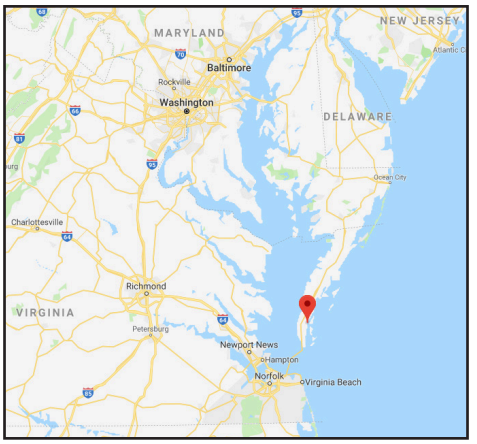
Virginia Coast Reserve LTER

Photo credit: Erika Zambello / U.S. LTER

The Virginia Coast Reserve (VCR) LTER program is based in the vast and undeveloped Virginia Coast Reserve, a coastal barrier system comprised of intertidal marshes, shallow coastal bays, and barrier islands. Research at the site is dedicated to understanding how sea-level rise, storms, and temperature extremes cause ecosystem transitions, and how state change in one ecosystem can propagate across the landscape through coupled dynamics. Over its history, the program has advanced state change theory for ecosystems dominated by foundation species, including feedbacks that either maintain or facilitate transitions, and leading indicators of tipping points. Through integrated studies of ecological and physical processes that include long term observations, experimental data, and mechanistic models, VCR LTER researchers are global leaders in predicting the impacts of climate on coastal ecosystems. Addressing the complexity and interdependence of ecosystems on the landscape is a critical frontier in projecting long term responses and resilience to climate change.



Between 2008-2018:

42 investigators

22 institutions represented

135 graduate students

Coastal

Principal Investigator:

Karen McGlathery

University of Virginia

Est. 1987

Funding Cycle:

LTER VII

NSF Program:

Biological Sciences / Division of Environmental Biology

Key Findings

Restoration returns 'blue carbon' stores. A 20-year landscape-scale experiment at VCR LTER was the first to show the role of restoration in reestablishing carbon burial in seagrass meadows, which matches natural systems after a decade. Virginia Coast Reserve scientists authored the international protocol through Verified Carbon Standards for issuing seagrass restoration carbon offset credits on the voluntary market. Carbon stored in sediments and sequestered in seagrass biomass is vulnerable to marine heatwaves that are projected to increase. [Products 1-3]

Climate change shifts grasslands to shrublands. Over the last 30 years, nearly half of the upland area on the barrier islands has changed from grassland to shrub thickets, similar to transitions observed in other drylands. For coastal systems, this transition is driven by regional climate (higher winter temperatures, lower precipitation) and shrub feedbacks on microclimate (warmer winter and cooler summer temperatures). Shrub thickets may reduce the ability of islands to build upward and migrate landward in response to sea-level rise and storms. [2,7]

Sea-level rise and storms can cause marsh loss. Long term VCR LTER and comparative studies define a threshold sea-level rise rate beyond which marshes cannot keep pace and drown. An early warning indicator of this state change is an increase in recovery time following flooding disturbances. Storms cause marsh loss by erosion in proportion to wave energy at the marsh edge. Smaller, more frequent storms, not hurricanes, are responsible for most marsh erosion, and this can be reduced by adjacent oyster reefs and seagrass meadows that attenuate waves. [4-6]

Coastal change is accelerating. Historically, this undeveloped landscape has been a shifting mosaic; a new 30-year retrospective now shows directional change and accelerating ecosystem loss. Barrier island upland area has declined by a third, and island marsh loss due to storm overwash has increased, especially in the last decade. Feedbacks between vegetation and sediment transport determine barrier island dune shape, and this affects island migration and the long term resilience of islands to storms. [8-10]

Photo credits: Gordon Campbell At Altitude Gallery (bottom left); Erika Zambello (top and bottom right)

Synthesis

International collaboration. Scientists from VCR LTER have led national and international collaborations, involving multiple LTER and non-LTER sites, on marsh vulnerability to sea-level rise and storms, carbon sequestration, and barrier island dynamics in response to climate drivers. These collaborations leverage the near pristine nature of the VCR landscape and inform strategies for nature based solutions to climate change in coastal systems globally. Two synthesis books have been edited by VCR LTER scientists on barrier island dynamics and ecogeomorphology of tidal marshes.

Partnerships

University of Virginia | NOAA | U.S. Geological Survey | U.S. Department of Agriculture | U.S. Fish and Wildlife Service | Department of the Interior | Office of Naval Research | Sea Grant | Virginia Game and Inland Fisheries | The Nature Conservancy | Nutrient Network (NutNet) | AmeriFlux

Novel technologies. Virginia Coast Reserve LTER scientists have pioneered two novel technologies and partner with national and international collaborators to disseminate their use. The aquatic eddy covariance method continuously measures benthic metabolism. High resolution in-situ techniques measure turbulent flow and mixing.

Photo credits: Gordon Campbell at Altitude Gallery (top); Michael Cornish (bottom)

Data Accessibility

The VCR provides over 230 datasets, 53 of which have a duration of 10 years or longer. Data are provided to the research community via the site data catalog, the Environmental Data Initiative repository, and DataONE. Datasets have been downloaded over 29,000 times since 2012. The VCR LTER has been an active participant in LTER-wide data initiatives, and led the creation of the LTER Controlled Vocabulary and code-generation services.

Broader Impacts

Science literacy for diverse K-12 students. Field and classroom experiences provided by VCR LTER reach every student in the region, all from majority-minority Title 1 schools, at least twice before graduation. Water quality monitoring, watershed exploration, and meaningful educational watershed experiences with regional partners parallel VCR LTER studies and train students in observation, data collection, and analysis.

Environmental humanities. Combining arts and humanities with place-based ecology is a signature of the VCR LTER. The practice of observation provides a shared foundation for VCR LTER's long running Art and Ecology professional development program. In collaboration with the University of Virginia, VCR LTER is launching the Environmental Humanities Conservatory. Sonifying long term data brings together music, ethics, and science to establish a trans-disciplinary community focused on coastal change.

Photo credit: Erika Zambello

Coastal resilience decision support. The 30-year partnership between VCR and The Nature Conservancy (TNC) is a model for data-informed management and resilience planning. Together with TNC, VCR LTER has developed the open access Coastal Resilience Mapping Tool using VCR long term data and models. Staff and researchers from VCR LTER participate in implementing the University of Virginia-led Resilience Action Feasibility Tool to help Virginia localities improve resilience to flooding and other coastal storm hazards.

Teacher training. Professional development workshops in coastal ecology, art and ecology, and oyster restoration provide teachers with place-based outdoor experiences, curriculum development, classroom resources, and sustained partnerships. Each year VCR LTER engages more than 50 teachers who reach about 8,000 students in the Mid-Atlantic region.

Top Products

1. McGlathery, KJ et al. 2012. Recovery trajectories during state change from bare sediment to eelgrass dominance. **Marine Ecology Progress Series.** doi: 10.3354/meps09574
2. Oreska, MPJ et al. 2017. Seagrass blue carbon accumulation at the meadow-scale. **PLOS One.** doi: 10.1371/journal.pone.0176630
3. Carr, JA et al. 2012. Stability and resilience of seagrass meadows to seasonal and interannual dynamics and environmental stress. **Journal of Geophysical Research.** doi:10.1029/2011JG001744
4. Kirwan ML et al. 2016. Overestimation of marsh vulnerability to sea level rise. **Nature Climate Change.** doi: 10.1038/NCLIMATE2909
5. van Belzen, JJ et al. 2017. Vegetation recovery in tidal marshes reveals critical slowing down under increased inundation. **Nature Communications.** doi: 10.1038/ncomms15811
6. Leonardi, NN et al. 2016. A linear relationship between wave power and erosion determines salt-marsh resilience to violent storms and hurricanes. **PNAS.** doi: 10.1073/pnas.1510095112
7. Huang, H et al. 2018. Non-linear shift from grassland to shrubland in temperate barrier islands. **Ecology.** doi: 10.1002/ecy.2383
8. McGlathery, KJ et al. 2013. Nonlinear dynamics and alternative stable states in shallow coastal systems. **Oceanography.** doi: 10.5670/oceanog.2013.66
9. Zinnert, JC et al. 2019. Connectivity in coastal systems: barrier island vegetation influences upland migration in a changing climate. **Global Change Biology.** doi: 10.1111/gcb.14635
10. Durán Vinent, O and LJ Moore. 2015. Barrier island bistability induced by biophysical interactions. **Nature Climate Change.** doi: 10.1038/nclimate2474