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Proposed Research

Successful application for The Earth Commons
Postdoctoral Fellowship at Georgetown University
https://earthcommons.georgetown.edu/research/eco-fellows/

A new history of climate and society for the Chesapeake Bay region

The Chesapeake Bay is a defining feature of the North American Atlantic Coast, and faces pressures from sea level rise (SLR), pollution from human land use, and extreme weather. Historical sources and geochemical climate proxies record hundreds to tens of thousands of years of change in the Chesapeake, and this project will analyze available archives to better understand how ecological responses to extreme climate events have changed through the Holocene. Using the framework of Degroot et al. [1, 2] to produce a history of climate and society (HCS) for the Chesapeake will require close examination and correlation between existing records including historical maps, newspaper accounts of major floods, archaeological findings, sediment cores, and stable isotope measurements from plankton and animals in the Bay. It is clear that human activity following European colonization has caused a decline in water quality and biodiversity, and an HCS approach that synthesizes historical and geological records will provide a holistic account of the connected ecological and social responses to multiple pressures. This work will be useful to communities living on the Chesapeake Bay today, to the researchers who study it, and to climate scientists developing models of SLR.

Background

The evolution of the Chesapeake began ~35 million years ago with an impact that produced a crater ~85 km in diameter off the Atlantic Coast [3]. The resulting topography influenced development of a coastal plain where the drowned Susquehanna River Valley forms a long, shallow, brackish tidal estuary. Sediments from cores taken from the Chesapeake and its shores record changes in sea level, vegetation, and shorelines over the past 10,000 years as glacial cycles and human activity shaped the Bay [4–6]. Stable isotope ratios of oxygen from single-celled marine organisms called foraminifera are faithful recorders of sea level in the oceans, and can indicate low-level stands in smaller bodies of water [7, 8]. Marine climate reconstructions use a measurement of oxygen isotopes noted as $\delta^{18}O$ to plot trends over time, with peaks and troughs in $\delta^{18}O$ corresponding, generally, to global sea levels. Additional proxies quantify changes in salinity, and pollen in sediment cores reflects vegetation on land. The Chesapeake Bay paleoclimate record shows changes in temperature and aridity consistent with global climate change patterns over geologic time, yet the rate of SLR (~4 mm/year) is four times higher than the global average due to long-term effects of glaciation on coastal elevation, known as glacial isostasy [9, 10]. For this reason, the Bay provides an analogue for ecological responses to rapid SLR as well as land clearing and agriculture.

The Chesapeake connects its tributaries to the Atlantic Ocean, and port cities on its shores depend on access to stable navigation channels. Georgetown was built at the confluence of the Potomac River and Rock Creek, where there once was a bay that could accommodate large ships. At the time of its founding in 1751, any ship could sail from Georgetown to the Atlantic Ocean via the Potomac River and Chesapeake Bay. Shipping channels began to close and trade volume dropped within decades as settlers cleared land upstream in Maryland and Virginia; massive influxes of sediment covered the deep channel beds and the river became impassible for many trade vessels. Consequently, Georgetown lost its port, and the federal government has paid to dredge the Potomac since 1833 [11]. This story presents an example of anthropogenic land use altering an ecosystem and thus requiring social adaptation, and demonstrates how feedbacks between urban development and geologic processes (i.e., sediment deposition in rivers) shape our cities.

A new regional history of ecological and social change will contextualize the present-day environment along the Potomac River and other tributaries, on the Chesapeake Bay, and on the Delmarva Peninsula. With SLR accelerating globally, an understanding of the interactions and dynamics of local topography and depositional processes, severe weather, global climate change, and ecosystem adaptations in the Chesapeake region should inform policy around land use and water quality, flood and erosion mitigation, and drought resilience.

Methods

This project will mainly use existing data from sediment cores and mollusks to contextualize climate history. Geochemical recorders, described briefly above, reflect changes in the ecosystem over time, responding to shifts in global and local sea level, precipitation, and land cover. I plan to compile published climate proxy records, map them, and determine whether there are any notable spatial gaps or opportunities for sample re-analysis. I will also use historical maps of settlements in the region to identify sites where further proxy analysis may be useful. For example, Joppa Town was active port at the seat of Baltimore County until sediment filled the estuary and tidal flats expanded into the Bay [11], but previous proxy studies do not include samples from the northwestern shores of the Bay. Exploring the marshes around the Gunpowder River near Joppa may yield new observations— the banks of creeks expose strata that may provide evidence of flooding, erosion, and soil development, and simple, manual augers can extract core samples from soft marsh terrain. Analytical methods for any cores I am able to take will depend upon what I find, potentially including measuring elemental composition of sediment, extracting plant biomarkers for stable isotope analysis, and correlating stratigraphy with other sites. Labs at the Smithsonian are equipped for this work, and my colleagues in the geochemistry community may also be available for analytical support on a modest budget.

This study will examine the past three centuries of anthropogenic influence on the Bay in particular, as well as the previous centuries of Native American interactions with the landscape, and Holocene climate records that predate human settlement. Collections held by the Smithsonian and other regional institutions could also potentially be included in this study. Oyster shells from different time periods around the Bay record human intervention in the ecosystem, growing larger in the 18th c. as more nutrients were delivered to the Bay, and later shrinking in size and population density with increased harvesting and anoxia [12]. Middens, preserved accumulations of anthropogenic garbage, typically contain oyster shells, and these are common in the region both before and after European colonization [13]. I am optimistic about the possibility of analyzing material from middens that have not been studied, and would target the search for potential samples according to historical maps and sites of particular interest.

Historical accounts of drought and flood in the Chesapeake Bay region exist for the past three centuries, and are well correlated with $\delta^{18}O$ and pollen records from the same period. There is an abundance of material for a new HCS synthesis, and working with Dr. Degroot will be essential for my success. Like most paleoclimate researchers, my training as an academic historian is limited, and I look forward to developing entirely new skills that interest me and will serve my future career. I will structure the project around the framework for HCS studies described in Degroot et al. 2021 [1], beginning from a paleoclimate perspective and moving toward environmental and social questions with guidance from other disciplines in the Earth Commons.

Broader Impacts

My dissertation work is part of a project that asks how climate change influenced hominin development more than 16 million years ago and led to the evolution of *Homo sapiens*. Interactions between people and climate are fundamental to our experience and have lasting effects on our planet. As an Earth Commons Fellow, I hope to expand my skills beyond paleoclimate and into HCS. Joining Dr. Degroot's group, which leads the field in synthesizing climatic, archaeological, and historical information, will be mutually beneficial— I will have guidance in the sensitive task of analyzing social responses to climate change, and historians in the group will have access to my knowledge of proxy systems and my network of geochemists. It can be challenging for scholars who have not directly worked with paleoclimate proxies to evaluate uncertainty and bias in published climate records, and I intend to provide efficient assistance whenever possible. I am also familiar with the R programming language and happy to help colleagues and students improve their data management, analysis, and visualization practices.

Developing a new, holistic, multi-proxy compilation for the Chesapeake Bay under the supervision of Dr. Degroot will offer opportunities for students and colleagues at Georgetown to collaborate with the Smithsonian, National Parks Service, and other institutes for ecology, archaeology, and history of the Chesapeake. Georgetown is connected to the Chesapeake by the Potomac River, and the community today is part of the larger ecosystem. Rapid changes in shoreline due to the opposing effects of locally accelerated SLR and high sedimentation rates can still cause displacement and economic loss as access to waterways disappears, as they have in Maryland's history. Understanding past interactions between SLR above the current global rate and sedimentation are important for modeling and mitigation in other low-lying coastal areas as well, and this study can serve as an example that may be applicable elsewhere. Comparing states of climate and society over time improves mitigation efforts— holistic HCS enables holistic projections that inform policy. The Earth Commons Fellowship is an ideal opportunity to explore the history of the Chesapeake Bay with the goal of learning how we can work for the region's healthy future by learning from its past.

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Mae Saslaw ***Teaching Statement***
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College-level classes should teach three fundamental practices in the context of the subject matter: Critical inquiry, research, and writing. Everyone has some curiosity about the natural world— for many of us, our first experience in critical inquiry takes the form of questions like “Why is the sky blue?” Earth science faculty are at an advantage because all of our students have been outside, interacted with the soil, and felt the weather, regardless of their origin or background. We have the opportunity to draw on their personal experiences with the planet and with climate change over time. Offering students a deeper understanding of their environment through critical inquiry enables them to interpret familiar natural phenomena as features of a greater system, situated in space and time. Paleoclimate is the history of the Earth, and my perspective as a paleoclimate scientist complements the Earth Commons focus on history of climate and society (HCS). As part of an HCS group, I will highlight paleo science research methods that are most useful for historians. For example, I might direct students to identify a geographical place of interest, conduct a literature review to learn about its geology, climate history, and human history, and propose next steps for improving or adding to the records. Students would have the freedom to emphasize whichever aspect they find most interesting and develop questions they might answer through further study and synthesis of climate and historical records.

Before I began my career as a geoscientist, I earned a BFA in Writing from Pratt Institute, an arts college in Brooklyn, NY. I plan to incorporate the methods and structures that made me a better writer into my course design wherever possible, and mentor students in good writing practices. As a creative writing undergraduate student, I wrote and re-wrote pieces containing a single, simple idea until my language and purpose were as clear to my audience as they were to me. Scientists in particular often have difficulty with writing, and it is my view that science education should focus on the craft of clear and concise sentences before expecting students to produce publication quality papers. I will introduce texts from scientists who are exceptionally skilled writers along with literary nonfiction about the natural world, discussing the ways in which people communicate science, and how students might draw upon different practices in writing scientific publications.

Entrenched pedagogy in environmental sciences involves field-based learning that assumes students are able-bodied and free to travel, and educators must make efforts to provide better experiences for students with diverse backgrounds. I had the privilege to participate in fieldwork as an undergraduate, and I learned well from traditional lectures and exercises, and I think these still serve a valuable purpose. At the same time, many students struggle unnecessarily or leave academia because a degree is ultimately not accessible to them. It is my goal to help improve access for underrepresented groups in climate science by developing courses that encourage students to approach Earth history in ways that engage their unique talents and interests. As an Earth Commons Fellow, my proposed research project on climate change in the Chesapeake Bay will require me to visit the Bay to make field observations, visit archaeological sites and cultural archives, and collect samples for geochemical analysis. I would include opportunities in an HCS syllabus for the class to join my fieldwork, with groups of students planning their own involvement. A student-led process has the advantages of steering the itinerary to places where they are most interested, and introducing them to the logistical considerations and collaborative decision-making involved in planning fieldwork for a diverse group.

As an Earth science educator, I want my students to understand the planet and its past, to learn to read landscapes and see through time. In my experience as a teaching assistant at Stony Brook and the Turkana Basin Institute Field Camp in northern Kenya, I have worked with students across anthropology, archaeology, ecology, and paleontology departments, and I learned how geological concepts are relevant to many disciplines. The canonical geology curriculum has much to offer HCS, and I look forward to teaching students to examine the connections between paleoclimate and people. I am committed to the practice of teaching and value the opportunity to work with students, faculty, and the Center for Multicultural Equity and Access at Georgetown University as I continue to strive for quality and equality in my syllabi.