Potential Barrett Scholars 2024 Projects

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The handshake job posting is at:

https://uvm.joinhandshake.com/stu/jobs/8598104

You can read more about the program at the following URL:

https://www.uvm.edu/cems/richard_barrett_scholarships

1. **<u>Project title:</u> Exploring the role of underwater soundscapes (a.k.a. hydroacoustic) in facilitating coral reef restoration**

   Project Description: Coral reef organisms (i.e., shrimp, fish) emit sounds that intermingle with background "noise" (i.e., bubbles, sand movement) that have been shown to attract fish, invertebrates, and coral larvae. By playing back the sounds of healthy reefs, larvae can be attracted to degraded sites, "kick-starting" restoration. Yet we know extremely little of who, how, and when these sounds are created. Northeastern University (NU) is deploying a series of acoustic sensors at both healthy and degraded reef sites to record acoustic signatures. This project will also help connect UVM with Jacques Cousteau's grandson's nonprofit, which will build a very impressive underwater lab called Proteus. https://news.northeastern.edu/2023/05/19/underwater-labs-co-op-experience/

   Barrett scholar's role: Collaborate with NU on data analysis. Specifically, use programming skills to explore how the acoustic signatures collected by NU personnel vary over a day or season or how sounds change with varying degrees of reef decline.

   Other details: This will be the first year of a new collaboration with NU. The project will include one undergraduate researcher from NU, who will participate in the field capture of sound data and analyses of large amounts of sensor data, as well as a faculty member at NU, Mark Patterson, with expertise in machine learning and AI approaches.

   Proposing faculty: Professors Donna Rizzo (Department of Civil & Environmental Engineering) and Brian Helmuth (Department of Marine and Environmental Sciences and School of Public Policy and Urban Affairs at Northeastern University). Email: drizzo@uvm.edu

2. **<u>Project title:</u> Assess Climate Vulnerability at Quarai Spanish Mission Complex**

   Project description: This project will result in the development of a climate vulnerability assessment of the 17th Century Quarai Spanish Mission Church in New Mexico, a stone masonry structure constructed c.1626. Quarai is located in the Salinas Missions National Monument and includes architecture associated with the mission period, cultural landscape features, and archeological deposits associated with the mission and the ancient Indigenous communities living on the site. It retains connections to living descendent communities. The site is located in a region where future climate impacts are expected to include more prolonged and more severe periods of drought, increased risk of wildland fire, more frequent extreme precipitation events, and reductions in current groundwater levels. This project will create essential baseline data needed to assess and monitor the mission church, will identify vulnerabilities associated with climate change, and will make recommendations that can be used to develop mitigation/adaptation strategies to be implemented by the Park. The Salinas project is part of a pilot conducted by the Vanishing Treasures Program of

the National Park Service, intended to develop options for climate change preparedness that will apply to other southwest parks.

Barrett scholar's role: Participate in a site visit to archaeological sites in the park by the project team, acquire climate data for the region, conduct statistical analyses of changes in rainfall extremes over time, and assist in deploying sensors to acquire site-specific data.

Other details: This project will be conducted in partnership with the Department of Anthropology at the University of New Mexico (UNM), which is in the first year of a 3-year project in the Monument. In addition to the Barrett Scholar, the project will involve students (undergraduate and graduate) from UNM.

The Quarai mission church (tall structure) with a portion of the mission Convento overlaid on ancient Pueblo construction in the foreground. This site in New Mexico, south of Albuquerque, is at an altitude of approximately 7,000 feet.

Proposing faculty: Doug Porter, Arne Bomblies, Donna Rizzo. Emails: douglas.porter@uvm.edu; abomblie@uvm.edu; drizzo@uvm.edu

3. Project title: Climate Vulnerability and the Preservation of Archaeological Sites and Landscapes in Canyon de Chelly National Monument, Part II

Project description: Canyon de Chelly National Monument, an area co-managed by the Navajo Nation and the National Park Service, encompasses one of North America's longest continuously inhabited landscapes. In this arid environment, population density varied over time, often in response to drought conditions; these were especially severe in the 13th century and may have resulted in a hiatus in the construction and use of the stone and earthen masonry alcove villages that proliferated in the canyon by the 11th century. The Navajo farmers and ranchers living in the canyon today, as well as the numerous archaeological and historical sites preserved there, are again threatened by extreme drought conditions that affect the surrounding Chuska Mountains and the potential for flash floods in the narrow canyons that make up the Monument. A Barrett scholar working on this project in 2023 deployed sensors to log changes in the water flows in the canyon and developed a 2-D Hec-RAS model for the site.

Barrett scholar's role: Participate in site visits to archaeological sites in the park by the project team, acquire climate data for the Chuska Mountains and canyon region, retrieve data from the sensors deployed in 2023, and begin to populate the hydraulic model.

Other details: This project will be conducted in partnership with the Department of Anthropology at the University of New Mexico, which is in the fourth year of an 8-year project in the Monument. In addition to the Barrett Scholar, the project will involve Anthropology students (undergraduate and graduate) from UNM, an engineering student from UC Berkeley, and interning Indigenous artists.

The Tower Complex and East Alcove of Mummy Cave (c.300-1300 C.E.), the largest of the alcove villages in Canyon de Chelly National Monument. This Barrett scholarship is focused on determining the likely impacts of climate change on this and other alcove sites in the canyon complex that comprises the Monument.

Proposing faculty: Doug Porter, Arne Bomblies, Donna Rizzo. Emails: douglas.porter@uvm.edu; abomblie@uvm.edu; drizzo@uvm.edu

4. Project title: Addressing Barriers to Electric Vehicle Home Charging to Advance Equitable Transportation Decarbonization.

Project description: There is a need to address context-specific barriers to electric vehicle (EV) adoption for disadvantaged populations in order to decarbonize passenger vehicle transportation equitably and effectively. Differences in EV adoption rates are of concern when they reflect barriers to adoption, signaling a diminished ability to adapt to a clean energy transition and when they disproportionately affect vulnerable populations. A critical obstacle faced by people with fewer economic resources is a need for more access to home charging, which brings significant benefits in terms of convenience and cost. People living in multifamily and attached homes, older homes, and renters face unique barriers to installing home chargers. This research will evaluate variation in access to home charging along sociodemographic and housing dimensions using national energy consumption survey data. Results from this research can inform policies targeting increased EV adoption for populations facing more significant barriers due to their limited access to home charging.

Barrett scholar's Role: The Barrett scholar will lead the analysis of national energy consumption data to determine the characteristics of households with lower barriers to EV

home charging. Some knowledge of programming, spatial analysis, and/or statistics is a plus, but the scholar can also learn these skills during the Barrett program.

Other details: This project is being conducted through the Transportation Research Center. The Barrett scholar will work alongside other researchers who are currently evaluating the costs of installing EV chargers in homes and the effects of home charging barriers on EV adoption. They will also work alongside a larger group of graduate and undergraduate students, researching sustainable and equitable transportation systems.

Proposing Faculty: Dana Rowangould, Ph.D. Email: Dana.Rowangould@uvm.edu

NOTE: "*The National Center for Sustainable Transportation has provided additional support for students interested in sustainable transportation research topics, including multi-modal travel, sustainable land-use and development, greenhouse gas and air quality modeling, low carbon, and zero emission fuels and vehicles, sustainable transportation planning, policy, and management strategies. Students interested in any area of sustainable transportation will automatically be considered for these additional positions. Students interested in discussing potential transportation-related research topics should contact the UVM Transportation Research Center at trc@uvm.edu."*

5. Project title: Flood-resilient Communities and Mobility in Vermont

Project description: As natural disasters increase in frequency and severity due to climate change, there is an urgent need to advance place-based knowledge about how communities can effectively respond to disasters to ensure that affected populations recover quickly and equitably. People living in rural communities face unique challenges when economic opportunities and transportation options are limited during a disaster. A flood can lead to cascading impacts lasting decades or even a lifetime. In July 2023, when heavy rainfall caused flooding in small cities, towns, and villages across Vermont, many of the economically vulnerable pockets of the Northeast Kingdom experienced flooding of homes, vehicles, and businesses. In the wake of the flood, the project team surveyed affected Vermonters living in Northern and Central Vermont. This project will qualitatively and quantitatively evaluate this data to determine the personal and institutional factors contributing to mobility resilience and personal economic recovery when a flood occurs. This research will result in strategies communities can adopt to build resilience to future flood events. This project may also include additional survey collection during the summer of 2024 to determine the longer-term effects of the floods on mobility and well-being.

Barrett scholar's Role: The Barrett scholar will lead the interview and survey data analysis in collaboration with Dr. Rowangould and Dr. Sarah Grajdura, a post-doctoral scholar with expertise in disaster resilience. Some knowledge of programming and/or statistics is a plus, but the scholar can also learn these skills during the Barrett program.

Other details: The Barrett scholar will work alongside several Transportation Research Center undergraduate and graduate students, researching various sustainable and equitable transportation topics.

Proposing Faculty: Dana Rowangould, Ph.D. Email: Dana.Rowangould@uvm.edu

NOTE: *The National Center for Sustainable Transportation has provided additional support for students interested in sustainable transportation research topics, including multi-modal travel, sustainable land use and development, greenhouse gas and air quality modeling, low carbon, and zero emission fuels and vehicles, sustainable transportation planning, policy, and management strategies. Students interested in any area of sustainable transportation will automatically be considered for these additional positions. Students interested in discussing potential transportation related research topics should contact the UVM Transportation Research Center at trc@uvm.edu.*

6. Project title: Validating Models and Satellite-Based Data Products with Localized Site Meteorological Observations for Renewable Energy Resource Assessment.

Project Description: At the early stages of wind or solar energy project development, a resource assessment campaign is conducted to understand the meteorological characteristics of a potential site. Central to this data collection phase are local surface measurements obtained by various sensor systems at the site under study. Project developers and owners increasingly leverage modeled and satellite-derived data products to combine with their local site data for enhanced decision-making intelligence. This project aims to incorporate data product validation metrics and analysis into NRG's cloud-based data platform that hosts customer site surface measurements. This will allow a user to assess the performance of any given data product for a specified geographic location with available on-site observations.

Barrett Scholar's Role: The Barrett scholar chosen for this position will work with a team comprised of data science, analytics engineering, software engineering, and product management disciplines to engage the early stages of this validation software product feature development. The individual will be responsible for 1) aggregating, with input from the team, an inventory of available data products as well as the relevant metadata essential to understanding NRG software integration strategy, 2) building and conducting a data product validation case study to understand and convey performance as compared to example local site data, and 3) compile and document for repeatability and integration the data, methodology, and analysis scripts (python) used for the investigation. For success in this role, the student should have scientific and analytic Python programming experience as well as proficiency in data analytics.

Other Details:

- This position will be supported through the Fall 2024 semester at 8 hours per week after the conclusion of the summer commitment
- Potential to result in an abstract submission and poster presentation for a prominent renewable energy industry conference in Fall 2024/Spring 2025
- Hybrid location arrangement with available workspace and team collaboration on-site at NRG's Hinesburg, VT headquarters

Proposing Project Advisor: Alexandra Arntsen, Ph.D. NRG Systems (aea@nrgsystems.com)

7. **<u>Project title:</u> Analysis, Testing, and Citing of Co-Located Hydrogen Gas Turbine, Electrolyzer, and Solar Farms at a Decommissioned Nuclear Station (Vermont Yankee Nuclear Power Station)**

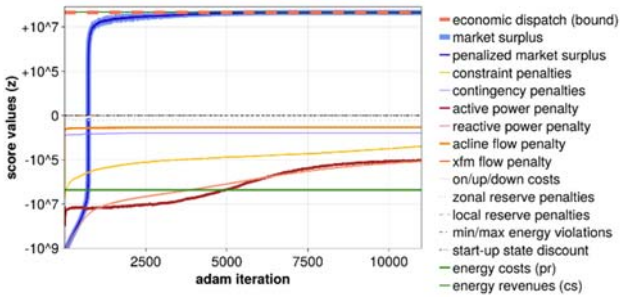
<u>Project description:</u> In 2014, the 620 MW Vermont Yankee Nuclear Power Plant was shut down. This plant provided the majority of Vermont's in-state power generation and was a vital power producer in the New England region. Today, the expensive transmission assets used to connect the power plant to the high-voltage transmission network are "stranded" (i.e., no longer utilized). Meanwhile, due to over-reliance on cheap natural gas, the New England region faces the possibility of electricity shortages in the coldest winter months. This project will consider a hydrogen turbine as a new use case for the stranded transmission assets. Paired with solar power, an electrolyzer, and on-site fuel storage, a hydrogen turbine could provide key, firm, low-carbon power capacity to the New England region, and its cost could be partially covered by the Inflation Reduction Act (IRA). However, this arrangement's feasibility and economics must be analyzed closely.

<u>Barrett scholar's role:</u> The scholar will help write a feasibility report. This report will consider the potential revenues a hydrogen power plant generates, the costs associated with its construction, land-use considerations, and applicable tax subsidies. The scholar will work with Professor Chevalier to model the hydrogen plant to understand how it can most effectively bid into the real-time energy markets and the forward capacity markets of the ISO New England region. Successful results will be published as a white paper.

<u>Other details:</u> This is a new, independent project initiated by faculty member Sam Chevalier. There will be no other graduate students involved.

<u>Proposing faculty:</u> Sam Chevalier. Email: schevali@uvm.edu

8. Project title: Using Machine Learning Optimizers to Maximally Dispatch Renewable Energy Resources in Large-Scale Power Grids



Project Description: The proliferation of renewable energy resources makes the operation and control of large-scale power networks much more challenging. Associated power system optimization problems, which include the nonlinear AC power flow equations, require powerful and robust numerical solution algorithms. Over the last decade, several efficient numerical optimizers have emerged from the field of Machine Learning (ML). One algorithm in particular, Adam, has become the optimizer of choice for a massive percentage of ML training problems (including, e.g., the training of GPT-3), solving some of the largest unconstrained optimization problems ever conceived of. Inspired by such progress, this project utilizes a parallelized Adam-based numerical solver to overcome one of the most challenging power system optimization problems: security and reserve-constrained AC Unit Commitment. The resulting solver will be tested on large-scale power system networks with massive renewable energy deployment.

Barrett scholar's role: The scholar will help design and test new computational algorithms in the Julia programming language. The scholar will run computational experiments on UVM's supercomputer, the VACC.

Other details: This ongoing project will build off Professor Chevalier's existing code base.

Proposing faculty: Sam Chevalier. Email: schevali@uvm.edu

9. Project Title: Quantifying the water quality benefits provided by restored riparian wetlands in Vermont's agricultural landscape

Project Description: Poor and declining water quality and increasing frequency of extreme flood events threaten the Lake Champlain Basin's water quality and human well-being. Restoration of riparian wetlands can help mitigate these problems by reducing downstream flooding, trapping sediment, and storing phosphorus (P). Wetlands commonly serve as nutrient sinks, but the P retention benefits of riparian wetlands on formerly farmed land are more uncertain due to potential legacy P in agricultural soils. Beyond water retention and P capture benefits, restored wetlands can provide valuable wildlife habitat and serve as recreational sites.

UVM's Nutrient Cycling & Ecological Design Lab, led by Dr. Eric Roy, studies several wetland monitoring sites in the Lake Champlain Basin, spanning a range of &me since farming and hydrologic restoration. The research aims to monitor wetland hydrology, quantify sediment and phosphorus retention, estimate the flux of dissolved P during flood events, and determine how fluxes affect overall P load reductions. Such results can be used to inform future wetland restoration designs.

Barrett scholar's role: The Barrett scholar(s) could focus on one of the following aspects of this project:

1. Analyze data from high-frequency sensors that record water level and dissolve oxygen every ten minutes for seasonal and/or site-specific trends.
2. Collect and analyze field data to understand the impacts of specific restoration designs on site hydrology and the potential for phosphorus retention.
3. Estimate hydraulic residence time using data from multiple high-frequency water level sensors deployed at different elevations across each site.
4. Quantifying P stocks in plant biomass at each site. This will include fieldwork at wetland sites in Addison County and laboratory analysis of samples collected.

Other details: Other opportunities may be related to quantifying the benefits of restored wetlands (carbon sequestration, wildlife habitat) and determining best practices for wetland restoration engineering and design.

In addition to the research, the Barrett scholar(s) will have the opportunity to interact with project stakeholders, including entities such as the USDA Natural Resources Conservation Service, landowners, and the Vermont DEC Wetlands Program.

Proposing faculty: Eric Roy. Email: eric.roy@uvm.edu

10. Project title: Employing Crushed Recycled Glass for Sustainable Infrastructure

Project Description: Most recycled glass cannot be reused as new glass. Unless practical uses are found, it lands in landfills or is left unused in piles. There is a strong potential for recycled glass to be crushed and reused as construction materials, as a substitute for sand, for example, in constructing drains, road subbases, fills, and mounds for septic systems. Sand is becoming increasingly scarce and, therefore, more expensive. Crushed recycled glass contains harmful materials such as small amounts of metals, plastics, and paper, which are difficult to determine, preventing the widespread use of recycled glass in construction. This research will involve laboratory testing of crushed recycled glass to ensure it has acceptable engineering properties compared to typical sands used in construction. The project will assess if the crushed recycled glass can replace sand entirely or partially in construction.

Barrett scholar's role: Laboratory testing (permeability and shear strength) of crushed glass samples from recycling facilities and samples produced in the lab with known amounts of deleterious contents; data analysis and synthesis

Other details: (1) Ongoing project in collaboration with Transportation Infrastructure Durability Center, Vermont Agency of Transportation, Vermont Agency of Natural Resources, and Chittenden Solid Waste District; and (2) the Barrett scholar will work alongside a graduate student engaged in this project

Proposing faculty: Professor Mandar Dewoolkar (Department of Civil & Environmental Engineering). Email: mdewoolk@uvm.edu

11. Project title: Fracture Modeling in Rocks for Carbon Storage Applications

Project Description: The objective of carbon capture and storage (CCS) is to mitigate the impacts of climate change by reducing the concentration of carbon dioxide in our atmosphere. Geological storage involves injecting carbon dioxide emitted from industrial activities into underground rock formations. In such applications, fracture analysis is necessary to ensure underground storage reservoirs' structural integrity and safety. Accurate modeling of crack propagation in CCS applications is crucial for predicting failure modes and preventing carbon leakage. This research project includes developing fracture models for anisotropic materials, such as sedimentary rocks, and assessing their predictive capabilities based on experimental data.

Barrett scholar's role: Conducting numerical simulations on supercomputers and comparing results against experimental data for anisotropic materials

Other details: This interdisciplinary project will provide the scholar with knowledge in fracture mechanics and high-performance computing, utilizing resources from the Vermont Advanced Computing Center.

Proposing Faculty: Lampros Svolos, PhD (Department of Civil & Environmental Engineering). Email: Lampros.Svolos@uvm.edu

12. Project title: Evaluating the capacity of (re)connected floodplains to attenuate floodwaters and decrease flooding impacts to downstream vulnerable communities.

Project description: As we experience increasing frequency and intensity of storms such as those that led to the July 2023 flooding here in Vermont, functioning floodplains are increasingly valued for their ability to store and detain floodwaters and decrease downstream flood power and peak stage. Floodplains are highly variable in their capacity to lessen the downstream impacts of floods, depending upon their size, position in the watershed, channel, valley gradients, land cover/use, and a history of modifications that may have disconnected channels from their floodplain. Research is needed to better understand optimal sites along river networks for floodplain restoration and conservation, considering the relative position of riverside communities. This Barrett internship will apply computational methods to quantify Vermont floodplains' existing and potential capacity to

improve flood resilience in downstream communities. There is flexibility for this Barrett project to have a regional data science focus or a more site-scale detailed hydraulic modeling focus.

Barrett scholar's role: analyzing data; computer modeling; strong proficiency in GIS, R, or Python desired; possible field data collection and/or lab work depending upon timing and interest.

Other details: This project would be connected to the ongoing research of Dr. Underwood (CEE) and Dr. Rebecca Diehl (Geography & Geosciences). The Barrett intern will have opportunities to cohort with an interdisciplinary team of graduate students, post-docs, and faculty with specialties in geomorphology, engineering, and machine learning Home | CIROH @ UVM.

Proposing faculty: Kristen Underwood, PhD, Civil & Environmental Engineering. Email: Kristen.Underwood@uvm.edu

13. Project title: Enhancing Concrete Durability Using Shrinking Chitosan Biopolymers

Project Description: Concrete, a widely utilized construction material, grapples with significant environmental concerns and limited durability. Concrete durability is crucial for reducing maintenance costs and environmental impacts. Enhancing durability reduces replacement frequency, maintenance needs, and CO2 emissions. Minimizing crack size or preventing its occurrence is vital to improving concrete's durability. This study aims to enhance concrete durability and long-term resilience by adding shrinking chitosan-based fibers in concrete to reduce cracking. The biopolymer chitosan is derived from the waste shells of crustaceans. This research will examine the performance of concrete made using various chitosan percentages via compression, freeze-thaw, and chloride penetration testing.

Barrett scholar's role: Mixing and testing concrete, analyzing data, literature review, and synthesizing the literature and laboratory investigation.

Other details: This is an ongoing project of Professors Dryver Huston (dryver.huston@uvm.edu) and Mandar Dewoolkar (mdewoolk@uvm.edu). The Barrett scholar will be paired with a graduate student working on this project.

Proposing faculty: Professors Mandar Dewoolkar (Department of Civil & Environmental Engineering) Email: mdewoolk@uvm.edu and Dryver Huston (Department of Mechanical Engineering) Email: dryver.huston@uvm.edu.