Potential Barrett Scholars 2023 Projects

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1. Project Title: Measuring and Mitigating Heat Microclimates in Northern Environments

Project Description: Built environment infrastructure including buildings, roads and other paved surfaces lead to warmer local microclimates that can have a significant impact on human health, air and water quality, energy consumption and ecosystem wellbeing. Ongoing research on this topic includes measuring heat distribution in small and rural communities over time and under variable weather conditions; investigating alternative and novel material and design solutions to mitigate heat microclimates; and understanding the practitioner and public perception of the risk of adverse heat health impacts and behavior based mitigation strategies.

Proposing Faculty: Elizabeth Doran (Elizabeth.Doran@uvm.edu)

2. Project Title: Nature-based Solutions to Address Nonpoint Source Nutrient Pollution

Project Description: Nutrient pollution primarily from excess phosphorus (P) and nitrogen (N) originating from human activity distributed across the landscape can lead to adverse water quality conditions including eutrophication and harmful algal blooms (HABs) in downstream water bodies. Ongoing research on this topic includes mapping the distribution and function of natural communities in river corridors and floodplains and, modeling adoption of best management practices in river corridor, forest and agricultural systems.

Proposing Faculty: Elizabeth Doran (Elizabeth.Doran@uvm.edu)

3. Project Title: *Reusing recycled glass in sustainable construction practices*

Project Description: Majority of recycled glass cannot be reused as new glass. Unless practical uses are found, it lands in landfills or 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. Sand is becoming increasingly scarce and therefore more expensive. The crushed recycled glass has some deleterious materials such as small amounts of metals, plastics and paper, amounts of which are difficult determine, preventing widespread use of recycled glass in construction. This research will develop laboratory procedures to determine deleterious material content in crushed recycled glass to support more use of it as a substitute for sand.

Barrett scholar's role: Laboratory testing on crushed glass samples produced in lab with known amounts of deleterious contents and crushed glass samples obtained from recycling facilities; 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: Mandar Dewoolkar (Mandar.Dewoolkar@uvm.edu)

4. Project Title: Enzymatic Stabilizers for Reclaimed Stabilized Base Projects

Project Description: Rehabilitation of existing pavement structures is a primary objective in many roadway constructions projects in New England (NE) region. Reclaimed stabilized base (RSB) with an appropriate stabilizing agent is an appealing option for many rehabilitation projects. Traditional stabilizers such as cement, lime, and calcium chloride entail some disadvantages (e.g. chemical reactions that might lead to disintegration of bonds). An alternative to the traditional stabilizers is using enzymatic stabilizers (e.g. terrazyme, bio-grouting) or a combination of an enzyme with traditional stabilizers in RSB leading to an improved stabilization outcome. The overarching goal of this project is to evaluate the effectiveness of enzymatic stabilizers in RSB projects in Vermont and the NE region.

Barrett scholar's role: Laboratory testing on prepared and cured specimens in lab with predetermined additive content; data analysis and synthesis

Other details: Ongoing project in collaboration with Transportation Infrastructure Durability Center, Vermont Agency of Transportation; the Barrett scholar will work alongside a graduate student engaged in this project.

Proposing Faculty: Ehsan Ghazanfari (eghazanf@uvm.edu)

5. Project Title: Rail bed infrastructure using wireless passive sensing

Project Description: Assessment and monitoring the health of railbed structures is an essential aspect of extending the service life of transportation infrastructures. Intrusion of fines from the subgrade or surface leads to ballast fouling and consequently impairs track drainage and adversely affects serviceability. This project focuses on using embedded and passive wireless sensing to meet practical needs of railbed monitoring. Signatures from these sensors, once interrogated, can be tracked over time to detect fouling and thus non-destructively assess and monitor the integrity of the railbed. This project will conduct a series of controlled experiments to characterize the response of the sensing device when embedded in a ballast stack. The ballast will be fouled with different levels of coal dust having different levels of moisture. The response data will be used to develop inverse models to extract railbed fouling from measured device responses.

Barrett scholar's role: Laboratory testing of sensors embedded in ballast stack with different levels of coal dust and moisture; data analysis and synthesis

Other details: Ongoing project in collaboration with Transportation Infrastructure Durability Center, Vermont Agency of Transportation

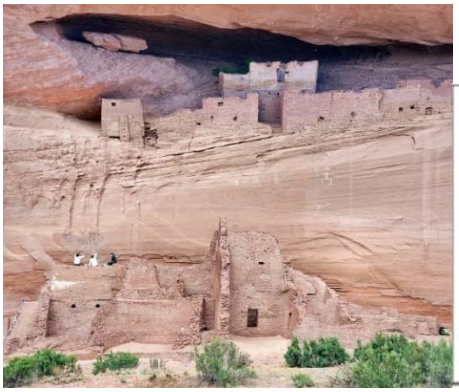
Proposing Faculty: Ehsan Ghazanfari (eghazanf@uvm.edu)

6. Project Title: Climate Vulnerability and the Preservation of Archaeological Sites and Landscapes in Canyon de Chelly National Monument

Project Description: Canyon de Chelly National Monument, an area co-managed by the Navajo Nation and the National Park Service, encompasses one of the longest continuously inhabited landscapes in North America. 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 historic 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.

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, and begin to evaluate climate vulnerabilities in those watersheds.

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 also involve Anthropology students (undergraduate and graduate) from UNM, an engineering student from UC Berkeley, and interning Indigenous artists.



White House (c.1000-1280 C.E.), one of the alcove villages in Canyon de Chelly National Monument. Note the use of white and yellow washes in the embellishment of plastered surfaces in Upper and Lower alcoves, as well as for figural paintings on the rock face.

Proposing Faculty: Doug Porter (douglas.porter@uvm.edu) and Donna Rizzo (drizzo@uvm.edu)

7. Project Title: Sustainable and Equitable Rural Transportation

Project Description: The need for a holistic understanding of rural travel behavior has never been greater or more urgent. Transportation is the largest source of greenhouse gas (GHG) emissions in the US, and transportation GHGs are particularly significant in small and rural (S&R) communities. A significant body of research that seeks to predict how policy interventions can reduce GHGs from transportation is largely focused on urban areas, despite notable differences in the physical and social contexts found in rural versus urban areas. Consequently, existing research provides limited insight into how to leverage investments, technology, and policies to influence travel behavior and reduce GHGs while supporting economic vitality and equity in S&R communities. This research will analyze a large spatially and temporally detailed vehicle travel dataset to evaluate the effects of a policy strategy on sustainable and equitable travel in Vermont.

Barrett scholar's Role: The Barrett scholar will select one policy strategy to focus on for their evaluation. Potential policy strategies that can be evaluated include expanding broadband internet access, funding electric vehicle adoption incentives, building electric vehicle charging stations, putting a price on carbon in transportation fuels, or land use planning. 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 part of an ongoing collaboration at the Transportation Research Center. The Barrett scholar will work alongside several graduate students conducting related research.

Proposing Faculty: Dana Rowangould (Dana.Rowangould@uvm.edu)

8. Project Title: Investigating the conversion of wastewater from Cabot Creamery into beneficial products

Project Description: Dr. Matt Scarborough's Environmental Microbiome Engineering Research Group is interested in mentoring a Barrett Scholar on a project investigating the conversion of wastewater from Cabot Creamery into beneficial products, such as biogas and fertilizers. The scholar would assist with the operation of bench scale bioreactors and perform nutrient analyses and test recovery processes on digested wastewater. The student would be mentored by a graduate student and Dr. Scarborough.

Proposing Faculty: Matt Scarborough (Matthew.Scarborough@uvm.edu)

9. Project Title: investigating the potential to convert food waste to beneficial products at on-farm anaerobic digesters

Project Description: Dr. Matt Scarborough's Environmental Microbiome Engineering Research Group is interested in mentoring a Barrett Scholar on a project investigating the potential to convert food waste to beneficial products at on-farm anaerobic digesters as a means to manage organic wastes in Vermont. There are currently 14 on-farm anaerobic digesters in Vermont and sludge from 9 of these digesters will be used to perform biomethane potential tests with mixtures of food waste. Microplastics in the food wastes will also be assessed.

Proposing Faculty: Matt Scarborough (Matthew.Scarborough@uvm.edu)

10. Project Title: Dispersive clay and phosphorus project

Project Description: Many farmed soils in the Lake Champlain Basin are dominated by clays that have the potential to disperse in runoff, transporting sediment-bound phosphorus off of fields and into waterways. The extent to which this dispersion transports P through subsurface tile drainage is unknown. This project will involve assisting with collection of intact soil cores from agricultural fields in Addison County and setting up and executing a mesocosm flow-through column study. Sediment and P concentrations will be measured in inflows and outflows, as well as various soil parameters. Project will involve both field and lab work.

Proposing Faculty: Joshua Faulkner (Joshua.faulkner@uvm.edu)

11. Project Title: Greenhouse gas emissions from agriculture

Project Description: Agricultural soils have the potential to be a source or a sink of GHGs, depending on management practices and climatic conditions. It is unknown how Vermont soils are performing related to climate change mitigation as a function of typical and alternative management on farms. This project would involve assisting with intensively monitoring soils and GHG emissions from fields within the Champlain Basin under two different suites of management practices. Data would contribute to larger multi-state multi-year project. Project will involve field work and data processing and analysis.

Proposing Faculty: Joshua Faulkner (Joshua.faulkner@uvm.edu)

12. Project title: Vehicle Electrification Impacts on Air Quality, Climate, Health and Equity

Project description: The transition to electric vehicles is expected to substantially reduce greenhouse gas and toxic air pollutant emissions from motor vehicles. These emission reductions would improve air quality along roadways and in cities and also help address global climate change. However, concerns have been raised by community groups and researchers about the pace and geography of the transition to electric vehicles. Will the electricity used to charge electric vehicles increase air pollutant and greenhouse gas emissions from fossil fueled power plants? Will rural, lower income and communities of color share in the benefits of electrification if they can not afford or are unable to use electric vehicles? What are the public health and climate implications of a slower than expected transition to full electrification of the US vehicle fleet?

Barrett scholar's Role: The Barrett Scholar(s) will join a team of TRC graduate and REU students collecting data, creating models and building online data dashboards to evaluate the above questions. Students will select one research question that most interests them and focus on developing new modeling and data analysis tools to evaluate it over the summer. There are opportunities to focus on Vermont and US scale projects. Students can expect to learn how to use EPA vehicle emission and air quality modeling software and the R programming language.

Other details: This project is part of an on-going TRC project sponsored by the Environmental Defense Fund (https://www.edf.org/) and is anticipated to receive additional funding support from the US EPA this spring. There are opportunities to begin or continue work on this project as an REU student.

Proposing Faculty: Greg Rowangould (gregory.rowangould@uvm.edu)

13. Project title: Post construction monitoring of a Low-Tech Process-Based River Restoration Site

Project description: Beavers used to be much more prevalent across Vermont's landscape, actively building dams, felling trees, and distributing woody debris in low-gradient

headwater streams. Collectively, these natural materials represented important structural elements in streams, slowing flood velocities, storing sediment, and providing important instream and riparian habitat. As uplands were cleared of forest and beavers were trapped for pelts in the 1700s and 1800s, these important flood resiliency, water quality and habitat functions of headwaters were diminished. To restore these functions and focus on cost-effective approaches that let nature do the bulk of the recovery work, Low-tech Process-Based Restoration (LTPBR) techniques have been implemented in recent years on smaller streams.

LTPBR techniques have tremendous potential to (i) support key riparian habitats; (ii) reduce downstream delivery of sediment and nutrients to receiving waters, and (iii) improve flood resiliency in downstream communities by storing floodwaters in the headwaters. However, these approaches are new, and there is uncertainty regarding the effectiveness of LTPBR structures, and typically resources are not available for post-construction monitoring because restoration funds are limited.

Barrett scholar's Role: This Barrett internship would focus on a recently-implemented LTPBR site at the Button Farm in Colchester, Vermont. The intern would design a monitoring protocol to address one or more of the following research questions:

- How is the channel evolving over time?
- What types of structural elements are effective in advancing/accelerating the channel evolution process?
- What kinds of flow velocities are typical in the channel during small and large flows?
- What kind of plant community is re-establishing in the restored river valley? And what are the relative success rates of planted vs. volunteer species?
- At what rate are structures mobilized and relocated by the river and where are they ultimately relocated to?

Proposing Faculty: Kristen L. Underwood, PG, PhD (Kristen.Underwood@uvm.edu)

14. Project title: Quantifying Floodwater Attenuation Capacity of a Conserved Floodplain

When rivers are well-connected to their floodplains, floodwaters can spill over the channel banks and fill the floodplain to dissipate energy. Floodwaters often carry suspended sediments and nutrients, such as phosphorus, which may be captured and stored in the floodplain, improving water quality in downstream receiving waters and preventing harmful algal blooms. Because of these important services, floodplains have been identified for conservation and restoration to increase flood resiliency and improve water quality in Vermont communities. However, floodplains are highly variable in their capacity to attenuate floods, depending upon their size, the shape and characteristics of the floodplain landforms (geodiversity), vegetation community, and how well the floodplain is connected to the channel.

In 1998, previously farmed lands along two reaches of the Lewis Creek were donated to the Town of Starksboro, Vermont – Cota North and Cota South – and the Town conserved these lands with the Vermont Land Trust. Original conservation goals included improving habitats and recreation along these reaches, and the town would like to better understand the flood resiliency benefits of these parcels. The capacity of these reaches to attenuate floodwaters has not been investigated to date, and it is expected that this capacity has gradually increased as the river channel is no longer actively managed (i.e., straightened, armored, bermed) and has been allowed to freely migrate and rebuild its connection to the floodplain over the past 24 years.

In support to the Town of Starksboro and its conservation partners, this Barrett internship will focus on field measurements, remote sensing, and geospatial analyses (in GIS) to address the following research questions:

- How have the floodplain conditions (land use, land cover, vegetation) at the Cota parcels changed over time?
- How has the channel planform changed over time?
- How has the degree of channel-floodplain connection changed over time?
- Can remote sensing methods be used to quantify the "geodiversity" of floodplain surfaces?
- Can geodiversity of floodplain surfaces be linked to measures of floodwater velocity and stream power measured with a hydrodynamic model?

Barrett scholar's Role: This Barrett intern position would also provide support to the UVM research team to conduct detailed channel surveys of the Cota reaches that will be used build a two-dimensional hydrodynamic model (2DHECRAS) to simulate flows through this reach. Researchers at UVM have installed temporary flow monitoring stations at the Cota lands, and data from these stage-discharge relationships will be available to calibrate the model. This calibrated 2DHECRAS model will then be available to simulate flows through the channel and floodplain and acquire measures of velocity, stream power and inundation duration.

Research team members: Rebecca M. Diehl, PhD; Juli Scamardo, PhD (Dept Geography & Geosciences).

Proposing Faculty: Kristen L. Underwood, PG, PhD (Kristen.Underwood@uvm.edu)

15. Project title: Dairy waste remediation for food technology

Project description: The goal of this project is to reduce the environmental impact of dairy processors by creating a waste water treatment technology that remediates nutritious byproducts. The objectives are to collect dairy biowaste, create a protein and plant-based gel, and manufacture the gel as a new food technology. The mission of the project is to improve global food security through the valorization of dairy waste by designing and manufacturing nutritious biomaterials as food products.

Barrett scholar's role: writing protocols, collecting and analyzing data, writing a report on the data; working close with other student researchers.

Proposing faculty: Rachael Floreani (Matt Scarborough as secondary advisor) floreani@uvm.edu

16. Project title: Spatial Uncertainty Quantification on Environmental Monitoring Mobile Networks

Project Description: Environmental monitoring usually relies on static (spatially fixed) monitoring stations. More versatile and mobile data acquisition platforms (aerial and water vehicles with specific sensing capabilities) enhance these fixed stations with the information needed for a reliable spatial description of some regions of interest. This project aims to characterize and quantify the uncertainty of the spatial estimation together with the positional uncertainty originating from the mobile network.

Barrett scholar's role: Apply the uncertainty quantification methodology to data sets and assess the performance of the method for spatial data reconstruction.

Proposing faculty: Luis A. Duffaut Espinosa (lduffaut@uvm.edu)

17. Project title: Computational Thermal Analysis of Graphene for Geothermal Energy Collection

Project description: Graphene is a promising sustainable material for many applications ranging from semiconductors to geothermal energy collection thanks to its ultra-high electrical and thermal conductivity. One of the sources of graphene can be from any carbon-rich waste stream. Although being an ideal energy transport medium due to the high thermal conductivity in its pristine form, the single-layer and bi-layer graphene are prone to structural defects, which may influence their thermal properties. Hence, understanding the role of these defects in graphene heat transfer will lead to better material usage. Using molecular dynamics analysis will provide insights from the atomistic perspective, which deepens our understanding of the mechanism of thermal transport in graphene, thus aiding further facilitation and adoption of graphene into those sustainable material technologies vital to our environment.

Barrett scholar's role: Developing and running computational model (LAMMPS) on fundamental thermal properties of graphene with defects to understand the role of defects in thermal transport in graphene. Disseminate the research result at a professional conference, such as the Material Research Society Fall meeting in Boston in the Fall.

Proposing faculty: Dr. Jihong Ma (Jihong.Ma@uvm.edu)