George Perkins Marsh Institute

Highlights, Accomplishments, and Impacts

2025 Annual Report

Promoting Sustainable Environments for the Public Good

Informing Solutions to Global Change

On the Front Cover:

2025 Geller Student Research Awardees (clockwise from upper left)
Daley O'Keefe (PhD Biology), Beatrice Altopp (BA/MA Biology), Anna Zhu (PhD Geography),
Ana Lucia Araujo Raurau (PhD Geography), and Wiktoria Golemo (BA Biology).
See pages 24 through 26 for descriptions of the students' research.

DIRECTOR'S STATEMENT

The George Perkins Marsh Institute at Clark University is dedicated to research on one of the most fundamental questions confronting humankind:

How Can We Sustain Natural and Human Systems Amidst Profound Global Change?

Human actions are causing profound transformations of integrated systems at unprecedented speeds and scales. Through complex feedback processes, these changes pose direct threats to the sustainability of natural and social systems, and lead to deep uncertainties for decision-making. Building on Clark University's legacy of leadership in geography, economics, development, urban studies, geospatial analytics, and natural resource governance, the Institute provides the translational knowledge and integrative collaborations needed to understand and sustain these systems. We promote collaborative, evidence-based research that challenges traditional disciplinary boundaries to address some of the most pressing issues facing today's world.

Work at the Marsh Institute is oriented around a set of primary research themes that include **(1) Climate Change Impacts, Mitigation, and Adaptation, (2) Local and Global Food Security, (3) Healthy and Viable Ecosystems,** and **(4) Sustainable Communities and Governance,** with cross-cutting emphasis on risks, hazards and vulnerability.

The Marsh Institute is one of the most productive hubs for research and funding at Clark University, regularly generating approximately half of all external research funds received by the university. The Institute coordinates expertise from the university and elsewhere to study human transformation of the environment and responses to these changes. This work seeks to understand environmental and social change from local to global scales, and how society can best safeguard the natural and social systems that support human welfare and livelihoods. External support for these and other Institute activities comes from federal, state, local and international grants, private donations, foundations, and other sources.

The Marsh Institute is also dedicated to the provision of research opportunities for Clark undergraduate and graduate students. Dozens of students participate in the Institute's research projects each year. Other programs to support student research include the Human-Environment Regional Observatory (HERO) research program and the Albert, Norma and Howard '77 Geller Student Research Grants.

The Marsh Institute makes a difference through advancements in basic and applied science, engagement with decision-makers, and communication with the public. We develop new ways to study, understand, and model socio-ecological systems. We work directly with decision-makers to inform policy. We coordinate workshops, conferences, and seminars that connect scientists, students, stakeholders, and policy makers. We also host visiting scholars to promote cross-institutional collaborations. Institute researchers play important roles in national and international science and policy advisory bodies. The Institute also represents Clark University in its role as a recognized non-governmental observer organization with the United Nations Framework Convention on Climate Change (UNFCCC).

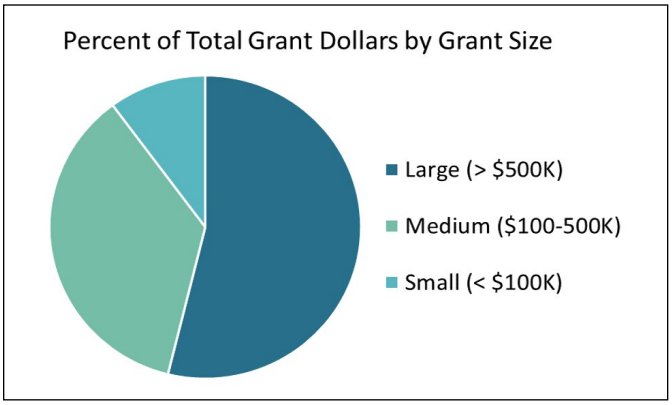
We work closely with departments and schools across Clark University, including the Graduate School of Geography, the Department of Sustainability and Social Justice (SSJ), the Department of Economics, and the Center for Geospatial Analytics. In 2025, the Institute became a key part of the new School of Climate, Environment, and Society at Clark University, and has played a central role in the school's inaugural year.

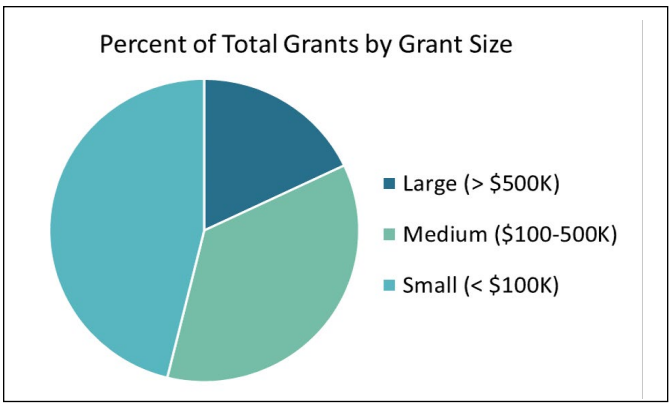
This annual report highlights some of the recent areas in which the George Perkins Marsh Institute is making a difference through environmental research, engagement, education, outreach, and communication.

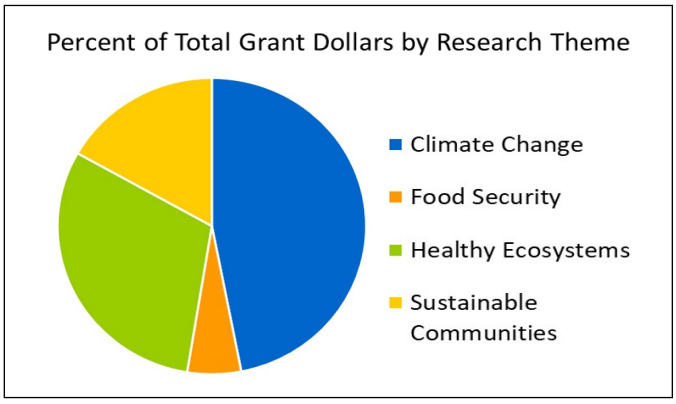
Robert J. Johnston, Director

GRANTS AND REVENUES

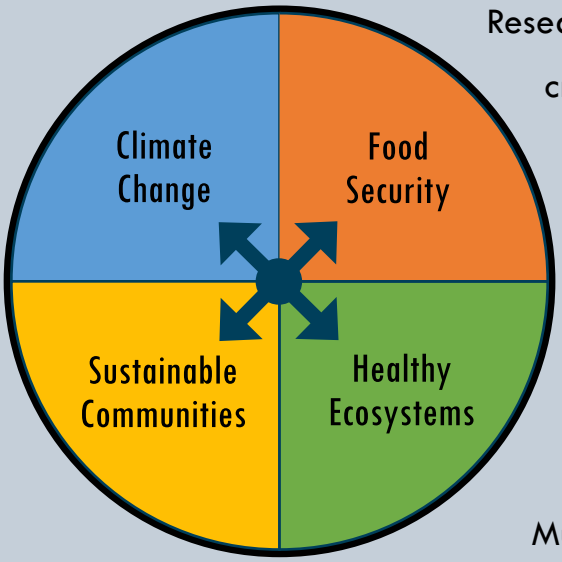
A large portion of Clark University's external grant funding is generated by the Marsh Institute, in coordination with our partners in the Graduate School of Geography, the Department of Sustainability and Social Justice, and the Department of Economics, among others. This past year, the Institute maintained approximately **$11.3 million in current grants,** covering **39 active projects:** 18 grants for small (under $100,000) projects, 14 grants for medium ($100,000 – $500,000) projects, and 7 for large (over $500,000) projects. Seven grants are components of large-scale, multi-institutional research projects, each exceeding $1 million in total funding. During 2025, the Institute launched $2.2 million in new grants, with an average size of $136,608 per award.







Disaggregated by research theme, projects related to climate change impacts, mitigation, and adaptation represent 47% of total grant funds, while projects related to healthy ecosystems provide another 31% of grant funds. The largest number of projects are related to climate change impacts, mitigation, and adaptation.



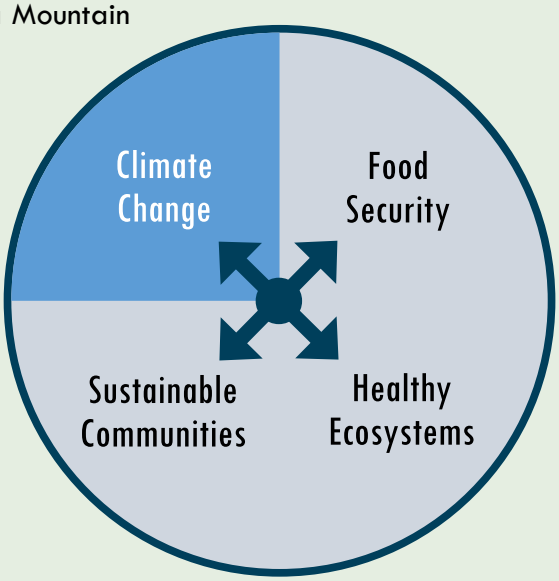
Research at the Marsh Institute addresses some of the most critical issues facing society today. Research topics fall under one or more broad themes related to sustainable natural and human systems, including: **(1) Climate Change Impacts, Mitigation, and Adaptation, (2) Local and Global Food Security, (3) Healthy and Viable Ecosystems, and (4) Sustainable Communities and Governance.**

Much of the research at the Institute is interdisciplinary in nature, and conducted by large teams with collaborators from Clark University and other institutions around the world. Many projects study policies and programs that impact the health and well-being of integrated human and natural systems (also called socio-ecological systems). The scale of these projects ranges from neighborhoods to countries to the entire globe. **New research projects initiated during 2025** address topics such as: mapping hunting pressure in Southern Arizona's Altar Valley, characterizing the co-occurence of multiple extreme climate events in the Pacific Islands, investigating the contribution of mixed cropping practices to the nutritional value of school food programs in Kenya, examining the land market and ownership factors leading to regeneration of forests in Eastern Africa, improving methods for measuring forest-based carbon emissions, supporting at-risk youth in Worcester, and improving water quality in Long Island Sound.

RESEARCH PROJECTS

CLIMATE CHANGE IMPACTS, MITIGATION, AND ADAPTATION

Global climate change affects every living organism on the planet through cascading effects such as an increased intensity and frequency of droughts, floods, forest fires, pest infestations, and habitat destruction and degradation. Marsh Institute researchers are at the forefront of science and policy efforts to inform climate change mitigation, adaptation, and long-term resilience to sustain ecological systems and human welfare. For example, **Tim Downs** and colleagues are combining innovative technologies and stakeholder engagement to co-create research and education capacities that compare alternative climate/development scenarios in Central Mexico. **Abby Frazier** is collaborating with researchers across the state of Hawai'i to share knowledge and data regarding local and regional drought to inform stakeholder actions and policy decisions. **Karen Frey** is quantifying the impact of thinning and retreating sea ice on biological productivity and biogeochemical cycling in the Pacific Arctic. **Natalia Hasler** and **Christopher Williams** are working with the Nature Conservancy and other partners to develop new methods for measuring the avoided carbon emissions caused by forest conservation and reforestation. **Robert Johnston** and colleagues are evaluating the effect of engagement and capacity building on communities' ability to adapt to climate-driven hazards. **Dominik Kulakowski** is studying the interactions among forest fuels, fires, and bark beetle outbreaks under different climate change scenarios in the Sierra Nevada Mountain Range. **Robert (Gil) Pontius** and **Gustavo Oliveira** are examining the expansion of irrigated agriculture as a form of adaptation to climate change in the Cerrado biome region of Brazil. Through these and other projects, Marsh Institute researchers are helping to ensure sustainable natural and human systems in a world threatened by a rapidly changing global climate.



Co-creating Research and Education Capacities to Understand, Visualize, and Mitigate Climate-Change Impact Cascades and Inequities in Central Mexico

Principal Investigators: Timothy Downs (Project PI), Cynthia Caron, Paul Cotnoir, Abby Frazier, Karen Frey, Yelena Ogneva-Himmelberger, Rinku Roy Chowdhury, Morgan Ruelle, and Terassa Ulm
Funding Agency: NSF and Private Investors

In a rapidly urbanizing and climate-changing world, inter-basin water supply megaprojects are on the rise, with energy, greenhouse gas, and water injustice implications. These projects are subject to perverse positive feedbacks such that they increase climate change, while increasing the water scarcity used to justify them in the first place. This project uses a planned water supply expansion program for Mexico City as the urgent impetus to co-create a new frontier in climate-change impact science, policy analysis and education. Participatory GIS and collaborative System Dynamics Modeling are paired to make impact cascades (i.e., multiple climatic and non-climatic impacts occurring simultaneously and interacting across sectors and regions) and social inequities spatially explicit. Results are then combined with eXtended Reality (XR) technology to visualize and compare alternative climate/development scenarios that diverse stakeholders can inhabit virtually. The project will also co-create research-based courses for U.S. and Mexico-based students, as well as enhance community engagement, to facilitate integration of the research with public education.

Improving the Availability and Accessibility of Climate Data and Information for Users in Hawai'i, American Sāmoa, and Guam

Principal Investigator: Abby Frazier
Funding Agency: U.S. Geological Survey

Changes in Earth's climate are increasingly affecting natural resources in Hawai'i and on many other Pacific Islands and territories. Increasing temperatures, decreasing rainfall, and more intense droughts and severe storms are just some of the challenges faced by resource managers. The need for high-quality reliable climate data and translated products that can be used to proactively plan for changing environmental conditions has never been greater. Working with partners through the Pacific Islands Climate Adaptation Science Centers, this project co-creates several new datasets and knowledge products to be utilized by researchers, resource managers, educators, and the community at large. The research addresses four primary objectives: (1) analyze how participatory climate change scenario planning can be used to inform management plans; (2) improve data availability in American Sāmoa and Guam including the development of high-resolution historical rainfall maps; (3) develop cyber-infrastructure on the Hawai'i Climate Data Portal (HCDP) to make Guam and American Sāmoa rainfall maps available for streamlined visualization and download; and (4) work with local partners and community leaders to co-produce climate knowledge products.

Tim Downs (far right) and the Clark University project team meeting with partners in Central Mexico.

Scaling up the Hawai'i Drought Knowledge Exchange

Principal Investigator: Abby Frazier
Funding Agency: U.S. Forest Service

Collaborations among scientists and managers are needed to effectively address drought in Hawai'i. The Pacific Islands Climate Adaptation Science Center's Hawai'i Drought Knowledge Exchange (HDKE) project piloted three sets of formal collaborative knowledge exchange between researchers and managers to co-produce customized, site specific drought data products to meet the needs of each partner. This project expands upon that work to meet the needs of a larger number of resource managers across the state. Objectives include: (1) streamlining the process of drought knowledge co-production and exchange to support an expanded group of stakeholders; (2) continuing to demonstrate good aspects of a knowledge exchange (e.g., easier access to drought and climate information and data sources; better and more comprehensive information) and (3) co-produce site-specific climate syntheses. This project will improve the capacity of managers to learn from each other in planning for climate change, variability, and drought.

Collaborative Research: The Distributed Biological Observatory (DBO) – A Change Detection Array in the Pacific Arctic Region, 2025-2030

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

The northern Bering and Chukchi Seas are among the most productive marine ecosystems in the Arctic and are important carbon sinks and seasonal sources of organic materials. Recent shifts in sea ice cover are having profound consequences for seasonal phytoplankton production as well as affecting upper trophic level species, including species harvested locally for subsistence. In short, many organisms (from microzooplankton to top predators) are changing their distribution, migration routes and foraging patterns. Key uncertainties remain as to how the marine ecosystem will respond to seasonal shifts in the timing of spring sea ice retreat and/or delays in fall sea ice formation. This long-term project addresses the following questions: (1) Will an earlier sea ice retreat and changes in seawater hydrographic properties (salinity, temperature, and nutrients) influence the composition of pelagic and benthic prey species, and how will that affect the resiliency of the system and upper trophic level organisms? (2) How do seasonal changes in hydrography affect the distribution of primary production and export production to the benthos? (3) What will be the ecosystem responses to changes in environmental drivers, and can we forecast the biological response in the food web through ecological modeling? (4) How will biophysical changes in the Pacific Arctic Region impact upper trophic level species and thereby disrupt food security for coastal communities?

Ella Christie (BS Environmental Science) collecting water samples during a scientific cruise in the Arctic.

Remote Sensing of River Carbon Fluxes to the Ocean

Principal Investigator: Karen Frey
Funding Agency: National Aeronautics and Space Administration

Working collaboratively with researchers at Northeastern University, this project will develop remote sensing data and modeling of dissolved organic carbon for rivers globally and across the Arctic. The goal is a suite of products that better quantify water flows and carbon export from land-to-sea, both within the US and globally.

SCI Climate Science

Principal Investigator: Natalia Hasler
Funding Agency: The Nature Conservancy

The Nature Conservancy's Climate Science team uses climate information and climate risk assessments to inform and support conservation and adaptation planning that promotes resilience for people and nature. To help this effort succeed, global maps that enable consistent avoided forest conversion carbon accounting are needed. Avoided forest conversion offers the second highest climate mitigation potential (behind reforestation) of the 20 natural climate solution pathways, and could deliver over forty percent of total emissions reductions at $< \$10$ per ton CO_2e. Low-cost solutions are critical for the rapid transition to the low-carbon economies needed to meet climate goals. This project will improve upon prior approaches to forest conversion carbon accounting by incorporating albedo impacts on local and global climate in generating estimates. The new and improved data will be incorporated into naturebase.org, a publicly available natural climate solution web platform.

Evaluating Social, Economic and Environmental Outcomes of Community-Based Coastal Adaptation Engagements: An Integrated Economics and Machine-Learning Framework

Principal Investigator: Robert Johnston
Funding Agency: National Oceanic and Atmospheric Administration

Coastal communities face compound hazards due to elements such as sea-level rise, increased frequency and intensity of extreme weather, flooding, heat, drought, and human development. Amidst these challenges, public and private organizations have developed public engagement and capacity-building programs to help support adaptation planning and implementation that meet community goals, support social welfare and equity, enhance ecosystems and services, reflect credible science, and engage a diversity of community groups. Despite common beliefs that engagement and capacity-building improve adaptation outcomes, there is a lack of systematic evidence on performance, including impacts on social, environmental and economic outcomes. This project will develop a novel analytical framework and quantitative approach to evaluate and predict the extent to which heterogeneous engagement and capacity-building activities enhance communities' capacity to progress towards transformative adaptation. Results will be used in coordination with partners and stakeholders to provide guidance for effective engagement and capacity-building, targeted to community characteristics.

How Do Bark Beetle Outbreaks, Tree Regeneration, and Climate Determine Fuel Treatment Longevity?

Principal Investigator: Dominik Kulakowski
Funding Agency: U.S. Bureau of Land Management

As climate change continues, forests are increasingly affected by multiple types of disturbances over short periods. Notably, outbreaks of bark beetles have been widespread and affect fire regimes in complex ways. While much research has examined how susceptibility to outbreaks depends, in part, on the same attributes that are manipulated by fuel treatments, less attention has been placed on how those outbreaks, in turn, affect the long-term efficacy of fuel treatments. Conversely, fire severity (which is modulated by fuel treatments) also affects susceptibility to outbreaks. Full accounting of the interactions among fuel treatments, outbreaks, and fires under an altered climate is lacking, setting the stage for unpredicted outcomes. Using the montane forests of the Sierra Nevada Mountain Range as a case study, this project seeks to understand: (1) effects of fuel treatment and climate on fire severity; (2) how post-treatment fires and bark beetle outbreaks interact to determine longevity of fuel treatments; and (3) how fuel treatments, fires, and bark beetle outbreaks interact to determine cumulative tree mortality, regeneration, and vegetation conditions. The study will model interactions among fuel treatments, fires, and bark beetle outbreaks under climate change scenarios.

Coastal communities face threats from climate-driven storm surge and sea-level rise.

LTER-PIE: The Impact of Changing Landscapes and Climate on Interconnected Coastal Ecosystems

Principal Investigator: Robert Gilbert Pontius Jr.
Funding Agency: National Science Foundation

This project extends ongoing research at the Plum Island Ecosystems (PIE) Long Term Ecological Research (LTER) site. The overall objective of the long-term project is to develop a predictive understanding of the responses of a linked watershed-marsh-estuarine system in northeastern Massachusetts to rapid environmental change. Clark University's role in the project is to create time series land cover maps for the coastal wetland and to analyze the changes in geomorphology, vegetation, and wildlife habitat in the context of an urbanizing landscape and climate-induced sea-level rise. Previous work shows that advancements in remote sensing technology allows for finer spatial resolutions, providing more details concerning map patches at individual time points, but also causes challenges in characterizing changes over time because seasons, storms, and tides all cause fluctuations that are now captured by remote imagery. This project addresses how to evaluate the configuration of landscape dynamics across various time intervals using newly developed methods and data available from the National Agriculture Imagery Program. The project will also develop new computer programs that allow for the application of these new methods to any landscape.

Gustavo Oliveira examining irrigated cotton production in the Brazilian Cerrado.

Irrigation as Climate-Change Adaptation in the Cerrado Biome of Brazil Evaluated with New Quantitative Methods, Socio-Economic Analysis, and Scenario Models

Principal Investigators: Robert Gilbert Pontius Jr. and Gustavo Oliveira
Funding Agency: National Aeronautics and Space Administration

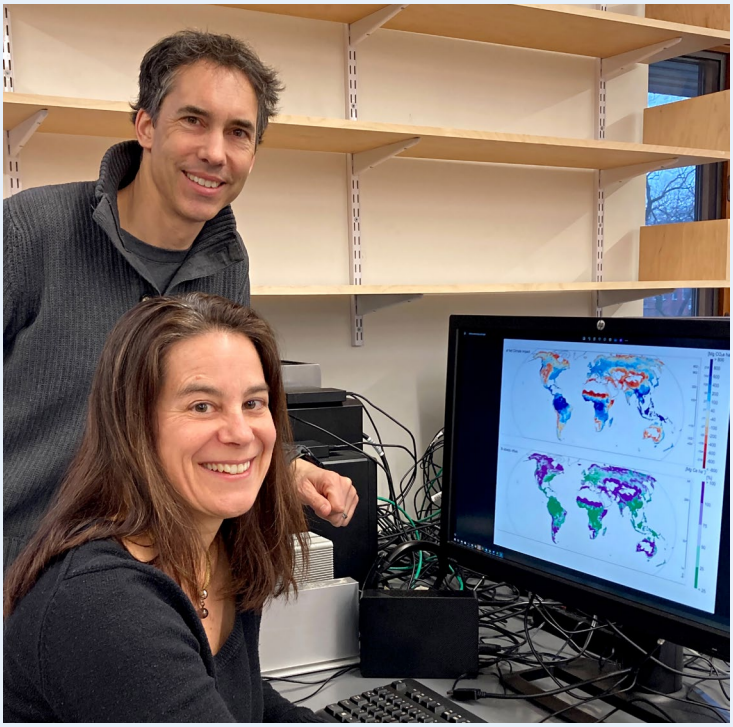
The Brazilian Cerrado is one of the most important and threatened ecosystems in the world in terms of carbon fluxes, water resources, biodiversity, and social diversity including indigenous and other traditional communities. Agricultural expansion has become central to the Cerrado's regional development and global food security, with western Bahia state being one of the most active agricultural frontiers worldwide. However, climate change is altering the dynamics of agricultural production in the region whereby a hotter and drier climate is driving an increase in irrigation to guarantee the viability of large-scale commercial agriculture. Researchers poorly understand the manner and extent to which this form of adaptation is taking place. This project investigates land change in the Cerrado biome region and has three main objectives: (1) develop generally applicable methods to quantify and analyze land change and its associated socio-economic drivers and impacts, (2) examine the expansion of irrigated agriculture as a form of adaptation to climate change, and (3) develop spatially explicit scenario models that inform policies concerning agrarian development, water use, and climate change adaptations for the Cerrado, with implications for other savannah and semi-arid biomes worldwide.

Avoided Forest Conversion as a Climate and Conservation Opportunity in the United States

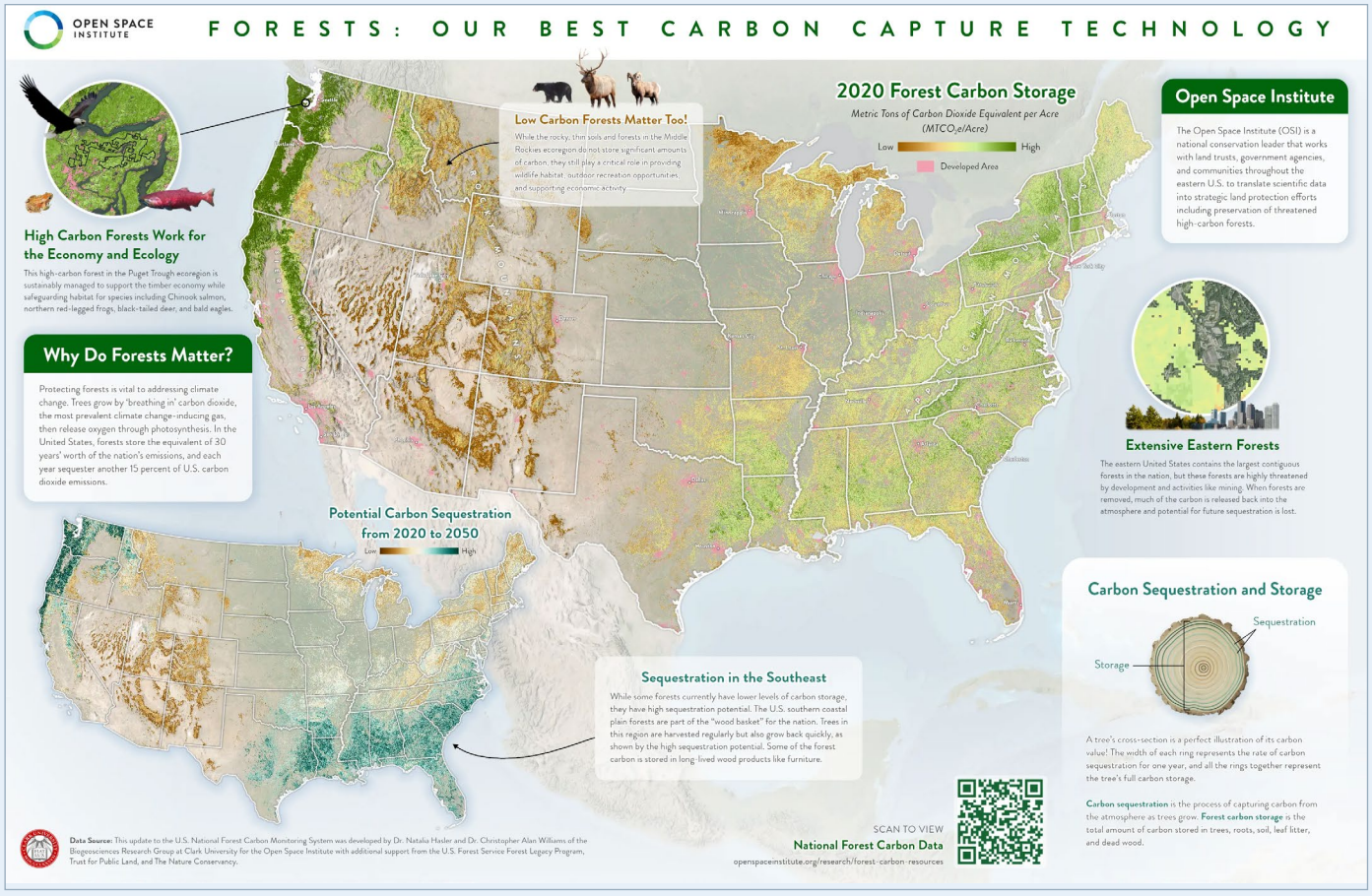
Principal Investigator: Christopher A. Williams
Funding Agency: Open Space Institute

Avoiding forest conversion contributes to biodiversity conservation and climate change mitigation, with substantial benefits to wildlife and human sustainability. This project aims to support measurable positive impacts by identifying and mapping hotspots of deforestation (forest conversion), linking these hotspots to drivers of land use change, developing a forest loss tracking interface, and examining the efficacy of different kinds of measures being taken to avoid forest conversion. This project will develop robust methodologies for measuring, monitoring, and calculating avoided forest conversion impacts and related carbon emissions.

AWARDS AND RECOGNITIONS

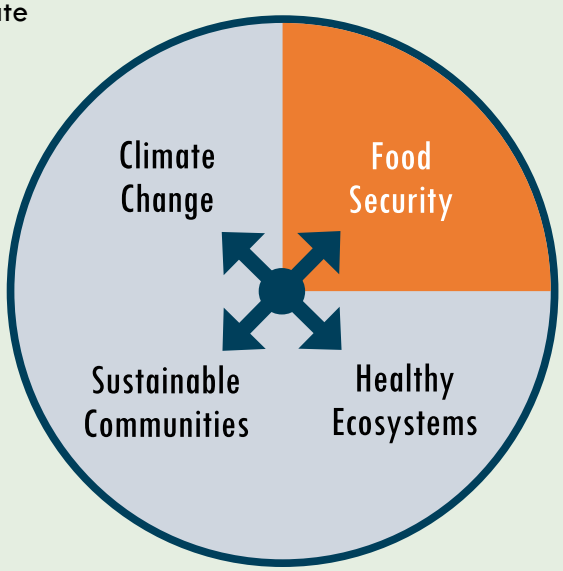


Natalia Hasler's and **Christopher Williams'** data analysis and visualization was selected as a finalist in ESRI's 2025 Storytelling Map Gallery Competition. The map, titled *Forests: Our Best Carbon Capture Technology*, illustrates the importance of forests to climate goals. It visualizes updated National Forest Carbon Monitoring System datasets that were developed by Clark University under contract from the Open Space Institute to support conservation organizations and state and federal agencies in targeting forest conservation for the greatest climate benefits. The cartographic goal of this design was to communicate forest carbon concepts in a clear and approachable way to a wide audience.



LOCAL AND GLOBAL FOOD SECURITY

Population growth, shifting consumption, regional conflicts, degradation of ecosystem services, natural hazards, and a changing climate are among the factors that threaten food security across the globe. Marsh Institute researchers are at the forefront of efforts to help ensure food security worldwide. These threats are particularly severe in the developing world. For example, **Lyndon Estes'** interdisciplinary and multi-institutional collaborative work investigates the drivers and impacts of agricultural change, with a particular focus on sub-Saharan Africa. His recent work in collaboration with **Hamed Alemonhammad** includes the use of artificial intelligence, machine learning, and crop analytics to accurately map the location of cropland and particular crops in order to facilitate locally-beneficial agricultural extension services. **Morgan Ruelle** is investigating the potential benefits of traditional crop mixtures and indigenous agroecological knowledge as climate adaption strategies focused on providing stable crop yields and enhancing soil quality. His recent work examines the contributions of mixed cropping practices to improve nutrition in local school food programs. Different challenges can confront sustainable food production in developed countries. For example, threats to food security result from the agricultural use of pesticides and other chemicals, with acute and chronic effects on agro-ecosystem services. **Dana Bauer** is working with multi-disciplinary teams to evaluate the biophysical and socio-economic conflicts and tradeoffs among pest management and pollination services in U.S. agriculture. Through these and other projects, Marsh Institute researchers are helping to ensure the resilience of the agricultural and food systems upon which societies depend.



Informing Conservation Program Targeting for Cost-Effective Integrated Pollinator-Pest Management

Principal Investigator: Dana Marie Bauer
Funding Agency: U.S. Department of Agriculture

Recent declines in both managed and wild pollinators have been attributed in part to habitat loss and pesticide exposure. Thus, growers of pollinator-dependent crops are confronted with potential on-farm tradeoffs between effective pest control and successful pollination. This project will first develop an integrated pollinator-pesticide cropscape typology that places each county in the continental U.S. along a pollinator risk-reward gradient. The research will then conduct grower surveys in select cropscapes to answer the following questions: (1) Will provisioning of information regarding the damages of pesticides and the benefits of pollinator habitat offer enough private incentive for growers to change their management practices or are additional policies or programs, such as payments for habitat conservation, warranted? (2) How do differences among growers and cropscapes vary across the U.S. and how can we use this information to guide cost-effective spatial targeting of pollinator conservation programs?

Country-Scale Field Boundary Mapping Using Advanced AI Models Applied to Multi-Source High-Resolution Satellite Imagery

Principal Investigators: Lyndon Estes and Hamed Alemonhammad
Funding Agency: National Aeronautics and Space Administration

Agriculture, one of the largest drivers of terrestrial habitat loss and climate change, is fundamental to human health and well-being, and plays a critical role in socio-economic development. To understand how agricultural systems are changing, it is necessary to map field boundaries at national to regional scales on an annual basis. This task requires remote sensing, which has recently seen tremendous gains in the ability to map individual fields due to increasing availability of high-resolution imagery and advances in artificial intelligence. To improve the ability to map small fields over large areas, this research will: (1) examine whether field boundary labels developed on VHR (very high resolution) imagery improves a boundary-aware model's ability to delineate in HR (high resolution) imagery, (2) quantify how many VHR-based labels are needed to optimize HR-based field boundary delineation, and (3) demonstrate the ability of VHR-improved models to generate a seven-year series of country-scale field boundary maps in Ghana, Zambia, and Tanzania, and use them to analyze agricultural change. This project will improve methods for tracking and understanding the nature and impacts of widespread agricultural change.

Integrating Regenerative Mixed Cropping Practices for Enhanced Nutritional Security and Climate Resilience in Kenyan School Feeding Programs

Principal Investigator: Morgan Ruelle
Funding Agency: Rockefeller Foundation

Kenya's school feeding program provides hot, nutritious meals to students, boosting attendance, nutrition, and educational outcomes while also stimulating local economies by sourcing food from smallholder farmers, supporting climate resilience through drought-tolerant crops, and empowering women and youth. Regenerative mixed cropping practices focus on mimicking natural ecosystems to rebuild soil health, enhance biodiversity, and improve water cycles, using techniques like no-till farming, cover crops, agroforestry, and polyculture (planting multiple crops together), all to reduce synthetic inputs and create resilient, productive farms. Working with partners at The New York Botanical Garden, this project investigates the potential benefits of integrating regenerative mixed cropping practices, including their contributions to improved nutrition in school food programs, their ability to provide stable yields under an increasingly variable climate, and their role in maintaining and enhancing soil quality. Clark University graduate students will combine summer field work in Kenya with spatial data analysis to address research questions focused on traditional agroecological knowledge, plant and soil management, and cultural foodways.

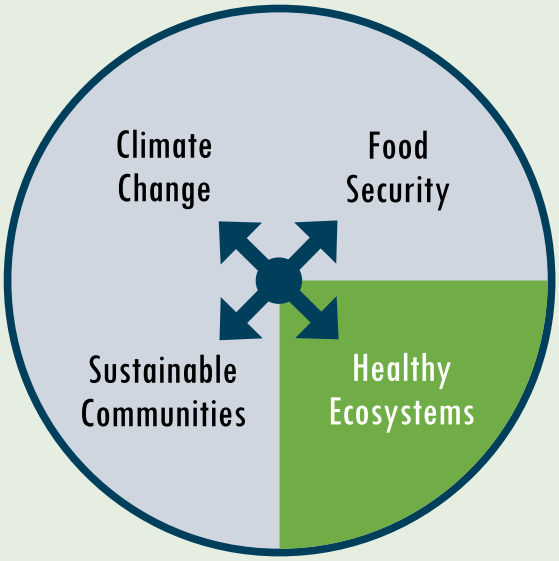
Investigating Underutilized Traditional Crop Mixtures for Nutritional Yield, Climate Resilience, and Soil Regeneration

Principal Investigator: Morgan Ruelle
Funding Agency: Rockefeller Foundation

Working with partners at The New York Botanical Garden, Cornell University, Addis Ababa University, and Wollo University, this project investigates the potential benefits of traditional crop mixtures, including: (1) their contributions to the nutritional status of mothers and infants suffering from micronutrient deficiencies, (2) their ability to provide stable yields under an increasingly variable climate, and (3) their role in maintaining and enhancing soil quality. Clark University's role in the project focuses on farmers' indigenous agroecological knowledge, including agronomic practices related to crop mixtures and their use in traditional foodways. Interviews with farmers in North and South Wollo, Ethiopia will examine their understanding of the role of crop mixtures in crop rotation, soil regeneration, and climate adaptation, and determine what farmers have learned about the performance and value of crop mixtures. The project includes cross-training of students among the partner institutions.

HEALTHY AND VIABLE ECOSYSTEMS

Healthy and productive ecosystems, and the plethora of services they provide, are crucial for sustaining human well-being and livelihoods. Ecosystem services include provisioning of food, water, and energy, purification of air and water, and protection from natural hazards, among others. However, many ecosystems across the globe are being threatened by a changing climate, together with anthropogenic activities such as overuse of natural resources, conversion of natural land covers to impervious surfaces, and inadequate waste disposal. Marsh Institute researchers are at the forefront of science and policy efforts to manage and protect ecosystems and the ecosystem services they provide. For example, **Dana Bauer** and colleagues are integrating social and ecological models to assess the potential of financial incentives for voluntary water conservation as a strategy for reducing conflict in water-scarce regions. **Lyndon Estes** is examining the land market and ownership factors that are leading to regeneration of forests in Eastern Africa. Estes is also using radar technologies to map the Amazon's forest-agriculture interface. **Robert Johnston** is investigating solutions to the widespread problem of nitrogen runoff and leaching from residential properties in urban and suburban landscapes in Long Island Sound. **John Rogan** and **Florencia Sangermano** are characterizing the change in coastal mangrove habitat in Ecuador due to shrimp farming during a 23-year period (1999-2021) and identifying potential regions for mangrove conservation. Sangermano is also evaluating the effects of habitat loss on small mammals functional diversity and the associated risk of disease spillover to humans in the Brazilian Atlantic Forest. Through these and other projects, Marsh Institute researchers are helping to maintain healthy ecosystems and conserve the supply of critical ecosystem services.



Conservation Incentives and the Socio-Spatial Dynamics of Water Sustainability

Principal Investigator: Dana Marie Bauer
Funding Agency: National Science Foundation

Disputes over scarce water resources are common worldwide and there is a growing interest in voluntary incentives (e.g., payments offered to water users) as a strategy for reducing conflicts. Incentive-based programs hold promise, but uncertainties remain regarding how state and non-state environmental organizations may implement them. Efficient and effective implementation requires strategic allocation of financial incentives across space and time. Collaborating with colleagues from multiple institutions (University of Oklahoma, Florida International University, George Mason University, University of Nebraska, and Texas A&M), this project investigates how interactions among social, hydrological, and biological spatial dynamics affect the sustainability of human-freshwater systems operating under incentive-based conservation. Integrated socio-ecological modeling is being used to investigate sustainability dilemmas typical of water-limited river basins worldwide, leading to a set of key insights for understanding and managing these systems. The findings have the potential to transform understanding of the ways in which conservation incentives might enhance the sustainability of a wide range of integrated human-natural systems.

Urban-Based Domestic Land Investors and Rural Tree Cover Gain in Eastern Africa

Principal Investigator: Lyndon Estes
Funding Agency: National Science Foundation

Many developing governments state in their climate change mitigation pledges that they intend to use funding to benefit rural citizens; however, shifts in land markets may result in reduced land ownership by rural residents. Linkages between land markets and gains in planted tree cover need to be studied to mitigate such unintended policy consequences, which may in turn lead to migration and food insecurity. Collaborating with researchers at Middlebury College, this project examines factors that lead to the regeneration of forests in developing regions in Eastern Africa. In particular, the research examines the extent to which forest regrowth arises from the purchases of rural property by urban landowners, who may use the properties to cultivate tree crops. Using a combination of satellite imagery and ethnographic methods, researchers will discern the extent to which forest regrowth is attributable to these rural-to-urban land sales. An ethnographic analysis of landowner priorities further elucidates the determinants of tree cover gain across multiple spatial and temporal scales. This research contributes to the management and stewardship of forests in regions targeted by conservation efforts.

Unlocking the Power of NISAR for Mapping the Amazon's Forest-Agriculture Interface

Principal Investigator: Lyndon Estes
Funding Agency: NASA Jet Propulsion Laboratory

NISAR is a joint Earth-observing mission between NASA and the Indian Space Research Organization. Clark University researchers are collaborating with NASA's Jet Propulsion Laboratory and other organizations to help guide development of the methods for participatory calibration and validation of the SAR (synthetic aperture radar) mapping efforts. Specific tasks include: (1) developing data that can be used to create calibration and validation samples for upload to Collect Earth Online (CEO), an open-source system for viewing and interpreting high-resolution satellite imagery; (2) creating CEO samples; and (3) preparing tutorials for sample interpreters.

Coupled Prediction of Residential Fertilizer Use and Nitrogen Loads to Long Island Sound: An Integrated Targeting Tool for Nitrogen-Reduction Behavior Change Campaigns

Principal Investigator: Robert J. Johnston
Funding Agency: New York Sea Grant

Non-point sources account for approximately 60% of nitrogen loading in Long Island Sound (LIS) and residential lawn fertilizer has been among the most difficult of these sources to reduce. In response, policymakers and other stakeholders have proposed behavior-change campaigns to promote lawn practices that reduce fertilizer use. However, the potential effect of these efforts on nitrogen loads in LIS is unknown. Even if the number of households influenced by a campaign can be identified, not all households fertilize equally, not all fertilizer applications have the same impact on nitrogen loads, and not all households react similarly to behavior-change campaigns. Working with colleagues at University of Connecticut, University of Maryland, and University of Miami, this project is developing an integrated model that links parcel-level behavioral predictions for residential fertilizer use with nitrogen load models to accurately predict the nitrogen loading impacts of behavior changes in specific coastal areas throughout Connecticut and New York. Results will be used to provide actionable guidance for targeting behavior-change campaigns, and include the newly developed Lawn Fertilizer Outreach Targeting Tool, available at https://s.uconn.edu/nfert.

Reducing Non-Point Source Nitrogen Loads from Residential Septic Systems: Identifying Barriers and Opportunities for Large-Scale Water Quality Improvements

Principal Investigator: Robert J. Johnston
Funding Agency: Connecticut Sea Grant

Residential septic systems are a primary source of nitrogen loading to nearby water bodies, which can negatively impact water quality. Collaborating with researchers at University of Connecticut, University of Maryland, and University of Miami, this interdisciplinary project will develop a generalizable framework and integrated, spatially-explicit economic-behavioral-hydrological model to inform the design and targeting of programs to reduce Long Island Sound non-point source nitrogen loads from residential onsite wastewater treatment systems. This work will significantly advance public understanding of opportunities and barriers to reduction of nitrogen from residential parcels, provide a tool that predicts household adoption of alternative onsite wastewater treatment technologies under alternative programs and scenarios, and identify how programs can be optimally designed for cost-effective nitrogen-load reduction. The framework and tool will be illustrated via an application to coastal counties and municipalities within the Long Island Sound watershed, and will be generalizable to other regions.

Benefits and Costs of Non-Market Valuation Methods for Environmental Management

Principal Investigator: Robert J. Johnston
Funding Agency: Australian Research Council

Environmental policy makers and managers can be assisted in their decisions by information on the community's preferences for environmental outcomes and actions. Ideally, this information will be expressed as monetary values (i.e., nonmarket values expressed as willingness to pay or willingness to accept) as this allows comparison of benefits and costs of environmental projects, and comparisons of alternative environmental benefits which would otherwise be incommensurate. Examples of these "non-market" benefits include existence values for threatened species, amenity values of urban wetlands, and the value of recreation in natural places. This collaborative project with the University of Western Australia is developing a rigorous framework for selecting the most appropriate approach to handling non-market valuation (NMV) information gaps for particular management or policy decisions. The aim of this research is to assist decision makers in three ways: (1) by demonstrating quantitative analyses to support a range of decisions about NMV methods; (2) by developing heuristics about when particular methodological choices are more likely to be preferred; and (3) by assisting decision makers to think through these decisions in a more sophisticated and complete way.

Integrating Locally-Weighted Meta-Regression and Machine Learning to Capture Spatial Complexity in Multi-Scale Benefit Transfers

Principal Investigator: Robert J. Johnston
Funding Agency: U.S. Department of Agriculture

The USDA spends more than $5 billion per year on conservation to enhance environmental quality, ecosystem services and agricultural sustainability. The biophysical impacts of these programs (e.g., on soil retention and water quality) are relatively well understood and can be estimated using standard modeling approaches. Yet the economic benefits of these programs remain unknown, and credible information on non-market benefits is particularly lacking. Despite a rich literature on valuation of non-market goods, the methods are often difficult or impractical to use. Large-scale, applied valuation of this type almost universally requires benefit transfer (BT); yet BT methods to support reliable large-scale valuation are inadequately developed, particularly for applications such as resource conservation and water quality improvements with widespread, diffuse impacts. USDA and its partners hence struggle to produce credible estimates of non-market conservation benefits. Addressing this major gap, this project is developing standardized BT procedures designed to support valid and reliable BTs for spatially heterogeneous, large-scale environmental changes due to resource conservation.

Next Generation Choice Experiment Architecture for Spatially-Explicit Agricultural Conservation and Ecosystem Service Valuation

Principal Investigator: Robert J. Johnston
Funding Agency: U.S. Department of Agriculture

The USDA spends billions of dollars annually on conservation programs to enhance environmental quality, ecosystem services and agricultural sustainability. Yet credible information on economic (and particularly non-market) benefits is often lacking, particularly for heterogeneous conservation practices that occur over large spatial scales. Current economic valuation methods are challenged by the individualized and spatially heterogeneous ways that people understand, use, and value ecosystem services over different spatial scales, posing questions for the validity and credibility of benefit estimation. This project is developing next-generation tools designed to meet these challenges. The project team is leveraging advances in online, interactive map-based survey architecture, together with novel approaches for stated-preference survey design, machine learning, and integrated assessment modeling. The approach will be demonstrated using a case study of conservation and aquatic ecosystem service improvements over the state of Virginia, but will be generalizable to other applications.

Elise Beier (MS Environmental Science & Policy) locates evidence of illegal hunting near a wildlife pond. (Photo by Florencia Sangermano)

Multi-Temporal Analysis and Determination of Mangrove Cover in the Coastal Region of Ecuador

Principal Investigators: John Rogan and Florencia Sangermano
Funding Agency: Ecuador Camara Nacional de Acuacultura

With growing global populations, demand for protein and more specifically seafood is expected to increase. As wild fisheries already face over-exploitation, aquaculture offers one solution to help meet growing demand while maintaining wild stocks and supporting healthy ocean ecosystems. However, in some cases, aquaculture can result in habitat destruction, water pollution, the spread of diseases to wild populations, and a lower quality product. This project seeks to characterize the change in coastal mangrove habitat in Ecuador during a 23-year period (1999-2021) resulting from ongoing shrimp farming. The study will identify areas of mangrove gains and losses and propose potential regions for mangrove conservation.

Mapping Potential Hunting Pressure in Santa Margarita Ranch

Principal Investigator: Florencia Sangermano
Funding Agency: Santa Margarita Ranch, Inc.

Santa Margarita Ranch, located in Southern Arizona's Altar Valley watershed, is bordered by the Baboquivari Mountains and Tohono O'odham Nation Reservation to the West, Mexico to the South, and the Buenos Aires National Wildlife Refuge to the East. The region is home to approximately 700 species, including the endangered black-footed ferret and the vulnerable southern long-nosed bat. Large predators including cougars, bobcats, and coyotes, as well as large game species such as javelina, mule deer, and white-tail deer, are present in the area. The region is open for recreational access under the landowner compact land rules (Arizona Game and Fish), and recreational hunting is used as a management tool to control populations of deer. This project will assess potential hunting pressure in Santa Margarita Ranch through the generation of accessibility maps considering access from motorized vehicles, on horseback, and foot. Preferred hunting habitats will be integrated to identify areas that hunters commonly frequent. Access with and without proposed closed access and commission-approved closures will be produced to identify the spatial impact of those measures.

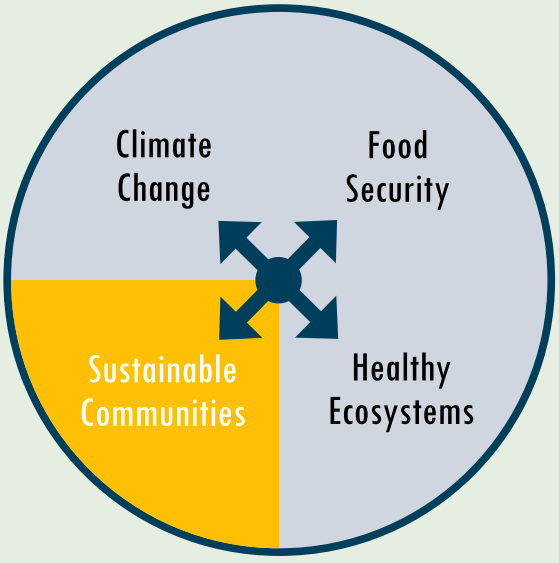
Land Use Change, Ecosystem Resilience, and Zoonotic Spillover Risk

Principal Investigator: Florencia Sangermano
Funding Agency: National Science Foundation

Biodiversity loss is one of the most severe global environmental problems caused by habitat loss, leading to functional diversity changes and profound cascading effects on the abundance, composition, and ecology of fauna and flora. These changes affect species interactions and ecological function and services, with impacts that can reach human health and well-being, primarily through changes in disease regulation services. The Brazilian Atlantic Forest is a hotspot for biodiversity and rodent diversity, with most rodent species considered pathogen reservoirs or hyper reservoir species, making the area a hub for future emerging infectious diseases. This project: (1) evaluates the effects of habitat loss on small mammals' functional diversity (i.e., community composition and interaction network structure), and assesses their effect on pathogen spillover risk throughout the Brazilian Atlantic Forest; and (2) evaluates the effects of forest restoration on the recovery of this functional diversity and reduction of spillover risk.

SUSTAINABLE COMMUNITIES AND GOVERNANCE

Public and private institutions and governance determine whether and how people are able to achieve sustainable levels of consumption and the resilience of human populations to social upheavals and environmental change. By studying institutions and governance, Marsh Institute researchers seek to promote improved human condition across the globe, with particular emphasis on challenges related to disadvantaged populations, and social and environmental justice. Much of this work coordinates closely with community partners to promote positive social change. For example, **Halina Brown** and **Philip Vergragt** continue their founding work with the Sustainable Consumption Research and Action Initiative, a network of practitioners focused on facilitating the transition to a more sustainable society by focusing on patterns of consumption. **John Denton-Schneider** is investigating cost-effective national-level policy interventions that accelerate structural transformations from agriculture to manufacturing and services in developing countries, leading to increased agricultural production, reduced disease spread, and improved health conditions. **Denise Humphreys Bebbington** and **John Rogan** are assessing the social and biophysical implications of a proposed mega-port in the Peruvian Amazon to inform local decision making. **Margaret Post** is evaluating a program that promotes racial and maternal birth equity in low-income communities, and investigating how non-profit organizationns can foster community leadereship and civic participation. **Laurie Ross** is creating a culturally-responsive and coordinated trauma response system to address challenges with implementing strategies that reduce the trauma associated with youth gun and knife incidents in Worcester, MA. Ross and **Jennifer Safford-Farquarson** are providing strategic research support and program evaluation of a Worcester city-wide gang violence prevention and intervention program.



Promoting Sustainable Consumption Research and Action

Principal Investigators: Halina Brown and Philip Vergragt

Marsh Institute researchers Halina Brown and Philip Vergragt work at the forefront of sustainable consumption research. Brown and Vergragt are Founding Board Members of SCORAI, the Sustainable Consumption Research and Action Initiative, an international network of close to 1400 researchers and practitioners committed to advancing sustainability by focusing on societal patterns of consumption. SCORAI recognizes that technological innovation alone is insufficient to achieve sustainability; changes are required in societal institutions, cultures, and economic systems. SCORAI's mission is to facilitate a transition to a more sustainable society by generating knowledge that impacts discourse and supports change agents. SCORAI recently won a prestigious Belmont Forum award for a project entitled "Co-creating Sustainable Food Supply Chains" (Co-SFSC). The project involves researchers and practitioners who are working to assess and transform sustainability in their local food supply chains. The work is being conducted by five teams across the globe: Germany, Sweden, Taiwan, Thailand and Turkey.

Eradicating the Disease of the Empty Granary: Health, Structural Transformation, and Intergenerational Mobility in West Africa

Principal Investigator: Jon Denton-Schneider
Funding Agency: United Nations University

Although structural transformation – the movement of workers from agriculture into manufacturing and services in cities – is a key component of economic development, its microeconomic foundations are not well-understood. However, recent empirical work has shown that scientific breakthroughs such as genetically engineered soybeans or massive irrigation infrastructure projects can lead to structural transformation by increasing agricultural productivity. Notably, however, these examples relied on developments that are likely beyond the capabilities of many of the lowest-income countries. This project seeks to answer the question: Are there more cost-effective national-level interventions that can increase agricultural productivity and thus accelerate structural transformation in developing economies? The question will be answered through a case study analysis of the (near) eradication of Guinea worm disease in West Africa beginning in 1990.

Analysis of the Potential Social and Environmental Impacts of the Chancay Mega-Port and Large-scale Landscape Change in the Peruvian Amazon

Principal Investigators: Denise Humphreys Bebbington and John Rogan
Funding Agency: Gordon and Betty Moore Foundation

The proposed development of the US$ 3.6 billion Chancay Multipurpose Port Project in Peru will establish the largest, deep-water port on South America's Pacific Coast. This new mega-port will generate impacts in the surrounding city and adjacent areas due to increased economic activity. However, it is the capacity of the port to move massive amounts of bulk cargo—including from and across the western Amazon—that makes it imperative to identify and analyze broader risks and impacts. This project seeks to assess the implications of the Chancay mega-port project as a driver of habitat change in the Peruvian Amazon. A multi-disciplinary team of researchers, based in Peru and the US, will analyze access infrastructure and trade corridor development associated with the mega-port, identify legal and regulatory gaps, and inform decision-making processes. Research insights will be disseminated to affected stakeholders through roundtables, seminars, publications, and social media. This project contributes to regional efforts to improve transparency and strengthen infrastructure governance with the goal of preserving conservation areas and Indigenous territories in the Peruvian Amazon.

Centering Organizers in Power Building Evaluation for California Health Equity

Principal Investigator: Margaret Post
Funding Agency: The California Endowment

The California Endowment supports programs that expand access to affordable, quality health care for underserved individuals and communities and promote fundamental improvements in the health status of all Californians. It is important that these programs are periodically evaluated to ensure goals are being met. Working with partners at Grassroots Solutions, this project documents the learning practices of community organizers and develops guidance for how funders and evaluators can transform their learning partnerships with organizers. Project team members are engaging in data gathering and analysis including learning circle facilitation, literature review, and resource mapping, as well as conducting sensemaking workshops with organizers, funders, and evaluators. A final learning brief and reflection session will be shared with The California Endowment.

Studying How Hybrid Organizations Build Community Leadership and Strengthen Democratic Processes that Improve Community Well-Being

Principal Investigator: Margaret Post
Funding Agency: Robert Woods Johnson Foundation

Establishing and sustaining locally-rooted, civic institutions that equip community members with civic skills and the power for effective participation in the policy arena can promote a healthier democracy. However, little attention has been paid to the multi-entity nonprofit form, including a focus on how their governance structures and activities produce outcomes consistent with their missions of widening civic participation and generating changes that benefit local communities. This project seeks to fill the gap in what is known about the structure, function, and impacts of those organizations that combine nonprofit structures to achieve these goals by adding capacity for advocacy, lobbying, and other forms of political and civic engagement. Specifically, the research examines how 501(c)(3)-(c)(4) hybrid organizations: (a) mobilize grassroots participation, (b) impact policy, and (c) influence economic and governing structures through the engagement of communities that have experienced chronic disinvestment, economic inequality, and isolation. The project's goal is to explain how this form of a nonprofit organization can advance public good and community well-being by fostering community leadership and engaging with governing bodies.

Safe and Successful Youth Initiative 2025

Principal Investigators: Laurie Ross and Jennifer Safford-Farquharson
Funding Agency: City of Worcester

The City of Worcester was awarded funding from the Commonwealth of Massachusetts' Safe and Successful Youth Initiative (SSYI) to provide services that support young men and women aged 17-24 who are likely to be perpetrators or victims of serious violence. The Worcester Department of Health & Human Services, Worcester Police Department, and other partners will use the funds to strengthen and expand programs that aid in outreach, case management, education, behavioral health, employment, and job skills. Clark University is the project's research partner who will: (1) analyze data from the SSYI CRM system to generate data reports for partner organizations, (2) facilitate monthly case manager meetings to review data reports, address challenges, and establish and monitor performance goals, and (3) ensure state reporting compliance.

Resilient Worcester

Principal Investigator: Laurie Ross
Funding Agency: UMass Memorial Hospital

Since launching the Worcester Youth Violence Prevention Initiative in 2015, gun and knife incidents involving young people under 25 have declined 31% in the city and arrests of young people have declined 68%. Despite these impressive accomplishments, youth gun and knife incident data suggest Worcester's work is not complete. Recognizing that cumulative experiences of trauma in childhood correlate with later risk behavior and poor health outcomes, the Governance Council has implemented three interventions to address the impacts of trauma as early and effectively as possible: Handle with Care, Youth Crisis Response Team, and the Hub. These strategies permit timely, age- and risk-level appropriate responses to violence and other traumatic incidents, the interruption of retaliatory violence, and the reduction in long-term negative impacts of trauma on child development and family wellbeing. However, four sets of reasons the downstream trauma responses are not functioning as intended have been identified. Referred to as 'pain points', these challenges indicate the need for an aligned, trust-filled, culturally responsive, coordinated upstream to downstream trauma response system. This project strives to create this system.

Shannon Community Safety Initiative: Worcester Local Action Research Partner

Principal Investigators: Laurie Ross and Jennifer Safford-Farquharson
Funding Agency: Massachusetts Executive Office of Public Safety and Security

The Senator Charles E. Shannon Community Safety Initiative (Shannon CSI) supports regional and multi-disciplinary approaches to combat gang violence through coordinated programs for prevention and intervention. These multi-disciplinary approaches include, but are not limited to, law enforcement initiatives such as anti-gang task forces and targeting of enforcement resources through the use of crime mapping; focused prosecution efforts; programs aimed at successful reintegration of released inmates and youth from juvenile detention; and programs that provide youth with supervised out-of-school activities. Working in partnership with the City of Worcester, the Worcester Police Department, the Boys & Girls Club of Worcester, and other community organizations, Ross and Safford-Farquharson serve as the Shannon CSI Local Action Research Partner for Worcester, providing strategic research support and program evaluation of city-wide gang violence prevention and intervention.

CENTER FOR THE STUDY OF NATURAL RESOURCE EXTRACTION AND SOCIETY

Clark faculty and student research on extractive industries, infrastructure investment, energy, and agroindustry has become increasingly vibrant over the last decade, and the Clark Center for the Study of Natural Resource Extraction and Society serves as a space for this research community to grow and flourish. The Center seeks to deepen Clark's collaboration and engagement with civil society organizations, researchers, and public interest bodies around the world. Core collaborations over the last five years have been with Oxfam, Ford Foundation, the Climate and Land Use Alliance, among others, and a range of research and civil society centers in the Andes, Central America and Indonesia. Under the leadership of **Denise Humphreys Bebbington** (Sustainability and Social Justice) and **John Rogan** (Geography), the Center is committed to cross-disciplinary research on resource extraction, with a particular focus on theory and methodology coming from political ecology, development studies, landscape ecology, and geospatial analysis. Through meetings, seminars, panel discussions, and workshops, the goal of the Center is to broaden the definition of natural resource extraction and better understand its shape, dynamics and consequences under a variety of environmental and governance contexts at local and global scales. In 2025, the Center received funding from the Ford Foundation to support its mission.

The Marsh Institute provides innovative, applied research and experiential learning opportunities for Clark graduate and undergraduate students. Programs range from endowed awards for student-initiated research to large-scale research projects promoting student involvement and hands-on experiential learning, often in interdisciplinary and multi-institutional settings. Among these programs, the annual **Albert, Norma and Howard Geller '77 Endowed Research Awards** support student-initiated research projects that advance our understanding of natural resource and environmental sustainability and develop practical improvements that move society toward more sustainable outcomes. Each year, the **Human-Environment Regional Observatory (HERO) program** provides funding for a cohort of select undergraduate students to engage in research on human-environment relationships in New England. For eight weeks during the summer, HERO Fellows conduct hands-on research under the mentorship of Clark University faculty and graduate students. **Faculty-led research projects** involving students cover a range of topics including: investigating climate change impacts on marine ecosystems in the Pacific Arctic region, developing a scalable and cost-effective agricultural land-cover mapping program in sub-Saharan Africa, surveying farmers across the U.S. about their conservation practices, modeling water supply and wastewater-sanitation systems for the Mexico City Basin, surveying homeowners in Long Island Sound regarding their lawn care practices, identifying and predicting changes in coastal vegetation in the Plum Island (Massachusetts) Ecosystem, and many others. Students are engaged in all aspects of the research from data collection and analysis through presentation and publication of results. Throughout 2025, Marsh Institute grants and endowments supported 12 undergraduate students, 11 master's students, 17 doctoral students, and multiple full-time, non-faculty research scientists and project managers.

STUDENT RESEARCH

HUMAN-ENVIRONMENT REGIONAL OBSERVATORY

Built on over 20 years of success, the Human-Environment Regional Observatory (HERO) program is a unique undergraduate-graduate-faculty collaborative that conducts research on human-environment relationships in New England. Under the mentorship of faculty advisors **Deborah Martin** and **John Rogan**, HERO Fellows analyze the causes and consequences of global environmental changes at local and regional scales. Among its many benefits, the HERO program provides students with opportunities to conduct, present, and publish research alongside faculty colleagues. HERO research has been funded by multiple awards from various foundations and government agencies, most recently the John T. O'Connor '78 Fund. During the summer of 2025 the HERO team returned to tree surveying in the city of Leominster, where the Massachusetts Department of Conservation and Recreation (DCR) Greening the Gateway Cities Program first planted trees back in 2016. The team re-surveyed the health of trees in residential yards and public streets that had been surveyed previously, and helped DCR plant more trees. The work also involved interviews with residents and community partners to gauge their perceptions about the successes and challenges associated with the Greening the Gateway Cities Program. The project's findings will help DCR refine and improve their tree species selection in the context of planting site variability, and build upon their existing communication strategies in partnership with the communities they collaborate with throughout Massachusetts.

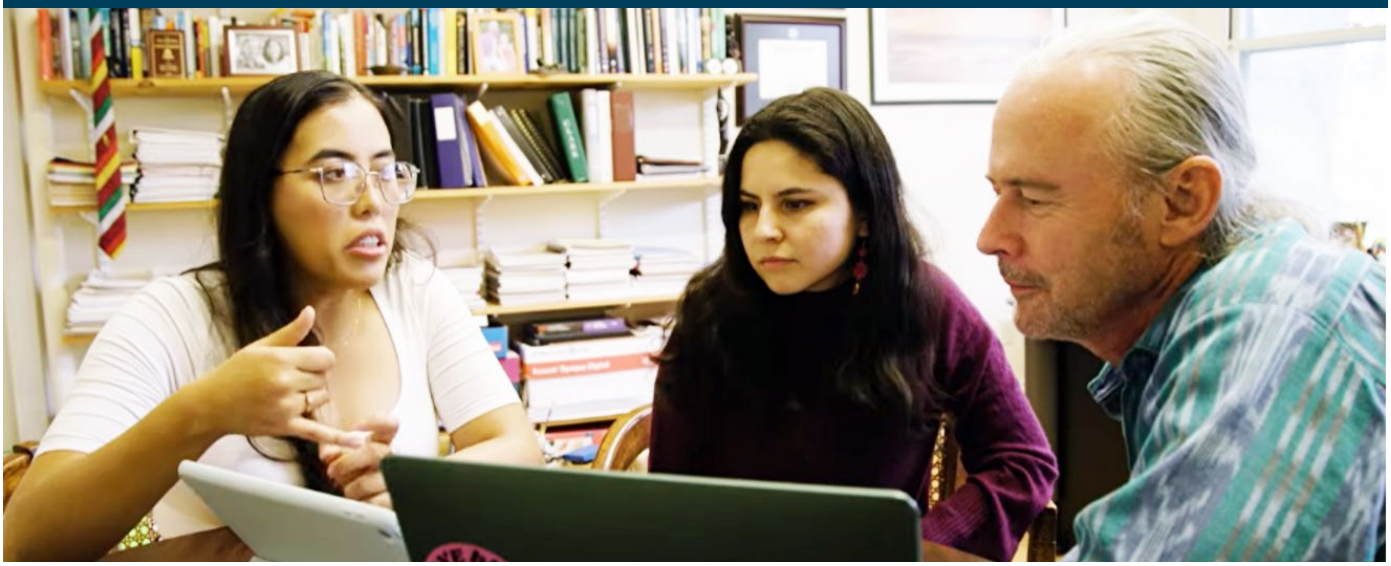
HERO Fellows planting trees in Leominster.

2025 HERO Fellows (L-R): Ph.D. student Robert Moore, Jamie Young '27, Alicen Civilikas '26, Abigail Riseman '26, Aidan Humphreys '26, Julia Head '26, Nate Kidd '26, and Ph.D. student Aidan Caron.

STUDENT RESEARCH IN THE BRAZILIAN CERRADO REGION

Rowan Compton ('25, MS GIS) left, and **Antonio Fonseca** (PhD Geography) taking a selfie, with irrigation equipment in the background. Brazil's soybeans require a lot of water to grow, and industrial farms have relied on irrigation to adapt to climate change, pumping out water from rivers and aquifers. The students are conducting research on land use and water scarcity in the Brazilian Cerrado region under the mentorship of Geography Professors **Robert (Gil) Pontius** and **Gustavo Oliveira**. In addition to collecting GPS data points for mapping the crop fields that rely on pivot irrigation, Antonio and Rowan interviewed farmers and other community members regarding their observations about changes in the landscape due to large-scale agriculture and pivot irrigation.

STUDENT RESEARCH IN CENTRAL MEXICO



Catalina Cuervo Maldanado (MS Environmental Science & Policy), **Valeria Obregon Diaz** (MS Environmental Science & Policy), and Professor **Timothy Downs** (Sustainability and Social Justice) discussing the students' research conducted in Central Mexico. Catalina is investigating climate-induced water quality impacts in a local reservoir, comparing data from water samples collected in 2025 to historical data from 2005. Valeria is investigating local community perceptions of health impacts due to climate change.

STUDENT RESEARCH IN THE PACIFIC ARCTIC ECOSYSTEM

Morgan Lehman (PhD Geography), **Ella Christie** (BS Environmental Science), **Anna Zhu** (PhD Geography), and Professor **Karen Frey** (Geography) aboard the CCGS Sir Wilfrid Laurier during a recent scientific cruise to the Bering and Chukchi Seas. The Arctic is warming at a rate four times faster than the rest of the world, with potential impacts on the entire ecosystem. The students collected hundreds of seawater samples, which were brought back to Frey's Polar Science Research Lab and analyzed for numerous biogeochemical components, including chlorophyll, suspended particulate matter, dissolved organic matter, and algal assemblages.

STUDENT RESEARCH IN SOUTHERN ARIZONA'S ALTAR VALLEY

Professor **Florencia Sangermano** (Geography), **Elise Beier** (MS Environmental Science & Policy), Luis Solorzano (Director of Environmental Science, Santa Margarita Ranch), and **Adlei Nelson** (MS GIS), conducting research near the Baboquivari Peak in Southern Arizona. The students examined hunting logs, interviewed ranchers, catalogued evidence of illegal hunting, and generated accessibility maps in order to assess potential hunting pressure on the Santa Margarita Ranch, which subsequently led to an access plan that facilitates protection of both wildlife and grasslands of this fragile ecosystem.

GELLER ENDOWED STUDENT RESEARCH AWARDS

Coordinated by Marsh Institute Assistant Director **Dana Bauer**, The Albert, Norma and Howard '77 Geller Endowed Research Awards support student-initiated research projects that advance our understanding of natural resource and environmental sustainability. Remembering his own experience as an activist student researcher at Clark, Dr. Howard Geller (Science, Technology, and Society '77) hopes to support other Clark students combine research with action that moves society toward sustainable outcomes.

Beatrice Altopp (BA/MA Biology)

Determining the Ecosystem Services of Dung Beetles Across an Urbanization Gradient in Worcester, MA

Faculty Mentor: Erin McCullough

Dung beetles play an integral role in maintaining healthy ecosystems. They provide a variety of important ecosystem services including degrading dung, aerating and restoring nutrients to the soil, supporting plant growth, reducing pathogens that harm livestock, and increasing seed dispersal. While most research has focused on dung beetles' contribution in agricultural settings, they are also essential for the functioning of forest ecosystems. Human disturbance in urban forests may impact dung beetle populations. The goal of this project is to characterize the diversity, abundance, and distribution of dung beetles along gradients of disturbance and urbanization in the city of Worcester, and quantify how these factors influence the ecosystem services that they provide. This research will provide insight into how to protect dung beetle communities and broaden public awareness of dung beetles in central Massachusetts.

Ana Lucia Araujo Raurau (PhD Geography)

Are Indigenous Territories in Amazonia Enough to Support Indigenous Peoples Well-Being?

Faculty Mentor: Lyndon Estes

While Indigenous Territories of Amazonia are increasingly recognized for their contributions to forest conservation, recent studies have raised questions about their capacity to support Indigenous Peoples' livelihoods and well-being. Among these challenges, land scarcity—defined as a decline in available or accessible land suitable for agricultural conversion—has emerged as a critical issue affecting Indigenous communities. Using semi-structured interviews with key stakeholders, this study aims to explore how two distinct enclosure processes contribute to land scarcity: (1) the allocation of unsuitable land endowments to Indigenous communities, and (2) the State's implementation of strict forest conservation arrangements. This research aims to provide a more comprehensive understanding of how territorial constraints play a significant part in reducing the availability and access to land within Indigenous communities. The Ucayali basin in Peru serves as a case study region.

Ricardo Barbosa, Jr. (PhD Geography)

The Sustainability Politics of Brazil's Selective Digital Agriculture Regulation

Faculty Mentor: Max Ritts

Digital agriculture, also known as smart farming or e-agriculture, is the use of digital technologies (e.g., data mining, machine learning, artificial intelligence) to improve agricultural production by collecting and analyzing data to help farmers make better decisions about planting, irrigation, fertilization, and pest control. Brazil's agribusiness sector ranks second globally in digital agriculture adoption, with proponents touting enhanced productivity and environmental sustainability. Yet, digital agriculture's selective regulatory landscape in Brazil is shaped by agribusiness influence, raising questions about the true extent of sustainable practice and equitable inclusion of all farmers. This research will investigate state-driven selective regulation through a combination of document analysis and in-situ fieldwork to understand both visible regulatory practices and the subtler mechanisms of purposeful inaction.

Wiktoria Golemo (BA Biology)

Identifying Evolved Microbial Adaptive Climate Change Responses in Native and Invasive *Medicago Polymorpha*

Faculty Mentor: Chandra Jack

Many crops have a narrow tolerance for sodium chloride (salt) intake, thus climate-induced salinization has the potential to impact global food security. Some plants, particularly legumes, form symbiotic relationships with rhizobia (soil-dwelling, plant-growth-promoting bacteria) which enhance plant wellness and may help to mitigate the adverse effects of high salinity environments. This research will investigate whether Burr clover (*Medicago polymorpha*) plants inoculated with rhizobia are less impacted by salt. In addition, because Burr clover grows in both coastal and non-coastal environments, this research will test whether native plants that evolved in the coastal environment are less susceptible to salt-induced stress than invasive plants found in non-coastal environments. Results from this research could assist farmers in adapting to environments exacerbated by climate change.

Chris Lamb (PhD Geography)

Climate-Driven Critical Mineral Development and Indigenous Livelihoods in Canada

Faculty Mentor: Max Ritts

In anticipation of growing global demand for lithium, cobalt, nickel, and rare earth minerals—all of which are essential for the development of renewable energy technologies—Canada released its critical mineral initiative in 2022. However, mining and exploration for critical minerals is likely to have disproportionate impacts in Indigenous communities, as targeted mineral deposits lie mostly in northern regions, such as the Hudson Bay Lowlands, home to the James Bay Cree. While Canada's critical mineral strategy includes a mandate for cooperation with Indigenous communities to ensure mutual benefits from mining development, insufficient attention has been paid to the social and environmental costs these communities face. This research aims to shed light on these developments and to situate this within broader political economic and geopolitical framings.

Vanchy Li (PhD Geography)

Multi-Scale Analysis and Risk Assessment of Mosquito Oviposition in San Pedro de Jujuy, Argentina

Faculty Mentor: Florencia Sangermano

Dengue, a mosquito-borne disease, is recognized as a significant public health issue in Argentina. Vector control, reducing the possible areas for mosquito to breed, remains the essential method for preventing dengue. This study will utilize remote sensing technology to create mosquito oviposition risk maps in San Pedro de Jujuy, a city in the northeast of Argentina. On-site fieldwork will provide critical validation data. The project aims to produce more precise maps of dengue vector oviposition locations at various time scales, enabling the implementation of more effective, targeted, and sustainable vector control measures in this region. This project will strengthen collaboration with the Universidad Nacional de Jujuy and can serve as a pivotal study for dengue epidemic research, with the potential to expand to other similar cities in Latin America.

Daley O'Keefe (PhD Biology)

The Expansion of *Myrmica Rubra:* The Ongoing Invasion of the European Fire Ant

Faculty Mentor: Kaitlyn Mathis

Invasive species account for much of global biodiversity loss. However, not all invasive species are created equally. *Myrmica rubra* is an understudied invasive species in New England and parts of Canada that alters the insect community in dramatic ways, especially by decreasing the abundance and diversity of endemic ant species. Currently our understanding of the *Myrmica rubra* range is woefully outdated. The northern edges of the known range have yet to be investigated, and are likely moving northward due to climate change, hindering our understanding of the true extent of this invasive species. This study aims to: (1) determine the current outer range of *Myrmica rubra*, and (2) determine how this ant is changing local ant biodiversity. Better knowledge of this species range and ecosystem effects will help determine how important it is to control their spread.

Anna Zhu (PhD Geography)

Understanding and Monitoring Phytoplankton Dynamics in the Bering and Chukchi Seas

Faculty Mentor: Karen Frey

Seasonal sea ice cover is extremely important for Arctic Ocean ecosystems. As primary producers, phytoplankton serve as the base of the food web. Phytoplankton are extremely important in the Bering and Chukchi Seas where there are relatively short food chains, acting as major food sources for regional fauna. Furthermore, with changing environmental conditions, harmful algal blooms are becoming an emerging threat to all levels of the food chain. Even small changes in phytoplankton community structure can have cascading effects for upper trophic levels, including humans. This research project will process and analyze of a set of phytoplankton samples from the August 2024 R/V Sikuliaq scientific cruise using an Imaging Flow Cytobot (IFCB).

The Marsh Institute is home to scholars from a variety of social and natural science disciplines, including anthropology, chemistry, computer science, ecology, economics, education, engineering, geography, geospatial sciences, history, hydrology, management, political ecology, physics, and sociology.

YUKO AOYAMA
Geography

DANA BAUER
Marsh Institute

ANTHONY BEBBINGTON
Geography

ASHA BEST
Geography

HALINA BROWN
Marsh Institute

CYNTHIA CARON
SSJ

MARK DAVIDSON
Geography

JON DENTON-SCHNEIDER
Economics

TIMOTHY DOWNS
SSJ

LYNDON ESTES
Geography

ANITA FABOS
SSJ

ELLEN FOLEY
SSJ

ABBY FRAZIER
Geography

KAREN FREY
Geography

JACQUELINE GEOGHEGAN
Economics

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ROBERT GOBLE
Marsh Institute

WAYNE GRAY
Economics

NATALIA HASLER
Marsh Institute

DENISE HUMPHREYS BEBBINGTON
SSJ

ROBERT JOHNSTON
Marsh Institute

DOMINIK KULAKOWSKI
Geography

WILLIAM LYNN
Marsh Institute

DEBORAH MARTIN
Geography

JAMES MCCARTHY
Geography

JAMES MURPHY
Geography

TOM NDEBELE
Marsh Institute

YELENA OGNEVA-HIMMELBERGER
SSJ

GUSTAVO OLIVEIRA
Geography

JIE PARK
Education

ROBERT (GIL) PONTIUS
Geography

MARGARET POST
SSJ

JOHN ROGAN
Geography

LAURIE ROSS
SSJ

RINKU ROY CHOWDHURY
Geography

MORGAN RUELLE
SSJ

JENNIFER SAFFORD-FARQUHARSON
SSJ

FLORENCIA SANGERMANO
Geography

PHILIP VERGRAGT
Marsh Institute

CHRISTOPHER WILLIAMS
Geography

DEBORAH WOODCOCK
Marsh Institute

JING ZHANG
Management

JUNFU ZHANG
Economics

MARSH INSTITUTE STEERING COMMITTEE

Steering Committee members are chosen to represent the diversity of the Marsh Institute's research areas and include some of the most prominent researchers at Clark University. Members are also chosen based on a history of involvement with the institute and a dedication to its continued success.

Denise Humphreys Bebbington
Research Associate Professor, Sustainability and Social Justice

Timothy Downs
Professor, Sustainability and Social Justice

Lyndon Estes
Associate Professor, Graduate School of Geography

Ellen Foley
Professor, Sustainability and Social Justice

Karen Frey
Professor, Graduate School of Geography

Robert Goble
Research Professor, George Perkins Marsh Institute

Deborah Martin
Professor, Graduate School of Geography

James Murphy
Professor and Director, Graduate School of Geography

Laurie Ross
Professor and Director, Sustainability and Social Justice

Rinku Roy Chowdhury
Professor, Graduate School of Geography

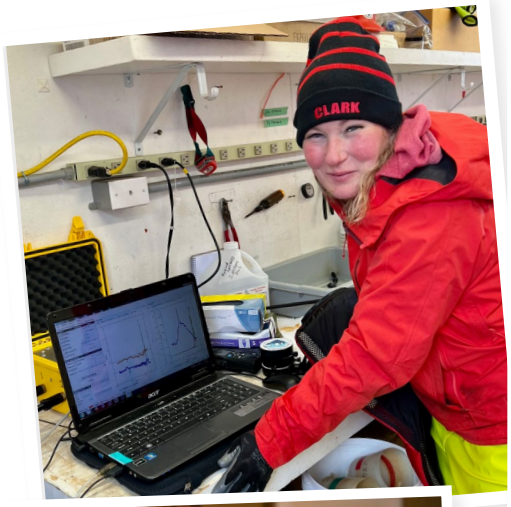
Christopher Williams
Professor, Graduate School of Geography

EX-OFFICIO MEMBERS

Dana Marie Bauer
Assistant Director, George Perkins Marsh Institute

Jennifer Hanselman
Associate Provost and Dean of Research

Robert J. Johnston
Director, George Perkins Marsh Institute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PANELS, EDITORSHIPS AND OTHER AWARDS

The international expertise of Marsh Institute researchers is reflected in their presence on top-level science advisory boards and committees, as well as invitations to provide regional, national and international policy guidance. National and international awards further reflect the contributions, expertise and reputation of institute scientists.

ADVISORY BOARDS AND COMMITTEES

Anthony Bebbington is a member of the National Academy of Sciences.

Halina Brown is chairperson of Newton (Massachusetts) Citizens Commission on Energy and **Philip Vergragt** co-chairs the Newton Task Force on Electric Vehicles, both part of the Newton Climate Action Plan.

Halina Brown is a member of the Board of Directors of the Massachusetts Climate Action Network.

Abby Frazier leads the Hawai'i and U.S.-affiliated Pacific Islands chapter of the U.S. Global Change Research Program's Fifth National Climate Assessment.

Karen Frey serves as Vice Chair of the Marine Working Group of the International Arctic Science Committee (IASC). Only two U.S. scientists were appointed to this prestigious group.

Denise Humphreys Bebbington serves on the Advisory Council of the CASA SocioEnvironmental Fund.

Robert Johnston serves on the Senior Advisory Board of the Connecticut Sea Grant College Program.

Robert Johnston serves on the Steering Committee and Scientific Advisory Committee of the Narragansett Bay Estuary Program.

Robert Johnston serves on the Advisory Group for the International Whaling Commission, providing guidance on the socio-economic values of cetaceans' contributions to ecosystem functioning.

James Murphy was elected Corresponding Member of the Section of Technical Sciences at the Royal Academy of Overseas Sciences in Belgium.

James Murphy was appointed an Associate Researcher for ICLAC: Impacts of China in Latin America and the Caribbean.

Robert (Gil) Pontius serves on the Scientific Advisory Committee of MapBiomas.

Rinku Roy Chowdhury is a lead author of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' Global Assessment Report.

Rinku Roy Chowdhury is co-chair of the Scientific Steering Committee of the Global Land Programme.

Christopher Williams is leader of the Science Implementation Plan for the North American Carbon Program.

Christopher Williams is a member of the Science Advisory Board of the European Union's Integrated Carbon Observation System.

EDITORSHIPS AND PROFESSIONAL SERVICE

Halina Brown and **Philip Vergragt** are co-editors of the Routledge-SCORAI book series *Studies in Sustainable Consumption*.

Abby Frazier and **Florencia Sangermano** joined CES Dean **Lou Leonard** representing Clark University at COP30 in Belem, Brazil.

Karen Frey is an Associate Editor of the *Journal of Geophysical Research: Biogeosciences*.

Robert Johnston serves as Editor of *Resource and Energy Economics* and serves on the editorial boards of the journals *Coastal Management* and *Journal of Environmental Economics and Policy*.

James Murphy serves as Editor-in-Chief of *Economic Geography,* which has been owned and operated by Clark University since 1925.

James Murphy delivered the annual Richard Murphy lecture (no relation) at the University of New Mexico, speaking about urban transitions and the challenges for achieving more sustainable, adaptable, and resilient cities in Africa.

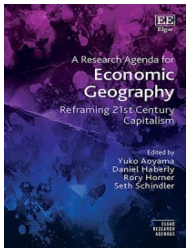
Christopher Williams served as a panelist and subject matter expert at New York Climate Week.

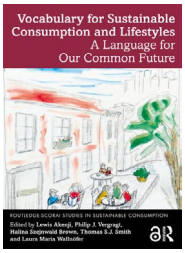
Deborah Woodcock gave an invited lecture to the Friends of Fossil Forests, a newly formed international organization promoting research on fossil wood and conservation of fossil forests around the world.

RECENT BOOKS AND OTHER PUBLICATIONS

Each year researchers at the Marsh Institute author dozens of peer reviewed articles in top scientific journals, along with books, chapters and technical reports. These publications advance scientific methods, report empirical findings, and inform both public and private decisions.

Yuko Aoyama and colleagues edited the book *Research Agenda in Economic Geography: Reframing 21st Century Capitalism*. Aoyama authored the chapter "Reframing Globalization: the rise of supply chain diplomacy."





Halina Brown, Philip Vergragt and colleagues edited the book *Vocabulary for Sustainable Consumption and Lifestyles: A Language for Our Common Future*.

Cynthia Caron published the book chapter "The work and lives of agricultural workers" in *Routledge Handbook of Contemporary Sri Lanka*.

Mark Davidson and graduate student **Samuel Cooper** published the article "Assessing climate risk bond disclosure in ten at-risk US municipalities" in *Finance and Space*.

Lyndon Estes and colleagues published the article "To enhance sustainable development goal research, open up commercial satellite image archives" in *Proceedings of the National Academy of Sciences*.

Ellen Foley published the article "Commentary on over-looked spaces: theorizing surveillance-care in reproductive health" in *Medical Anthropology*.

Abby Frazier and colleagues published the article "Broadening diversity, equity, accessibility, and inclusion in the process and development of climate assessments" in *Climatic Change*.

Ravi Hanumantha, Yelena Ogneva-Himmelberger, Morgan Ruelle, Karen Frey, Timothy Downs, and colleague Marisa Mazari published the article "Using geospatial analysis to model present and future water balance: the case of Mexico-Lerma-Cutzamala Hydrological Region" in *Water Resources Research*.

Graduate student **Tanner Honnef** and **Robert (Gil) Pontius** published the paper "Best practices for applying and interpreting the total operating characteristic" in *International Journal of Geo-Information*.

Robert Johnston and colleagues published the article "Cooperative agreement between countries of the North Atlantic Ocean reduces marine plastic pollution but with unequal economic benefits" in *Communications Earth & Environment*.

Robert Johnston and colleagues published the article "The value of value: The benefits of improved decision making informed by non-market valuation" in *Journal of Environmental Economics and Management*. The article received the Quality of Research Discovery Award from the Australasian Agricultural & Resource Economics Society.

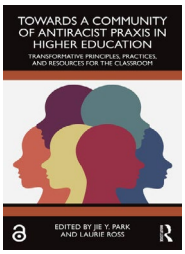
James McCarthy published the article "To own the land is to own the sunlight: the significance of land tenure for solar power" in *Sustainability Science*.

James Murphy and colleagues published the article "Exploring the economic geographies of sustainability transitions: Commentary and agenda" in *Economic Geography*.

Gustavo Oliveira and colleagues published the article "Equity in unilateral value chain policies: A monitoring framework for the EUDR and beyond" in *Forest Policy and Economics*.

Robert (Gil) Pontius Jr. and graduate student **Antonio Fonseca** published the article "A GIS method to summarize changes among classes during a time series with an application to land cover in Western Bahia, Brazil" in *Transactions in GIS*.

Margaret Post and colleague Robert Kleidman published the article "The scholarship and practice of community organizing: An assessment, vision, and call to action" in *Community Organizing Journal*.



Laurie Ross and **Jie Park** edited the book *Towards a Community of Antiracist Praxis in Higher Education: Transformative Principles, Practices, and Resources for the Classroom*.

Morgan Ruelle and colleagues published the article "Mixed teff (*Eragrostis tef, Poaceae*) cultivation and consumption among smallholder farmers in South Wollo Zone, Ethiopia" in *Journal of Ethnobiology and Ethnomedicine*.

Florencia Sangermano and colleagues published the article "Temporal and spatial analysis of urban heat in the City of Cordoba, Argentina" in *The Journal of Climate Change and Health*.

Christopher Williams and colleagues published the article "Spatial resolution for forest carbon maps" in *Science*.

Christopher Williams and colleagues published the article "Accounting for albedo in carbon market protocols" in *Nature Communications*.

Deborah Woodcock and colleagues published the article "The Eocene Piedra Chamana Fossil Forest of Sexi, Peru: A prospectus for research and conservation" in *Acta Palaeobotanica*.

Graduate student **Aiyin Zhang** and co-authors **Robert (Gil) Pontius, Thomas Bilintoh, Florencia Sangermano,** and **John Rogan** published the article "DynamicPATCH: method and software for spatially explicit dynamic patch transition characterization" in *Landscape Ecology*.

JEANNE X. KASPERSON RESEARCH LIBRARY COLLECTION

The Jeanne X. Kasperson Research Library Collection is an extensive collection of books related to environmental risk and hazards, environment and development, and the human dimensions of global environmental change.

The Kasperson collection also includes holdings in international development, water resources, technology, energy policy, and sustainability. The primary mission of the collection is to support Clark University's extensive environmental research programs. This includes but is not limited to programs conducted under the aegis of the School of Climate Environment and Society, the George Perkins Marsh Research Institute, the Graduate School of Geography, and the Department of Sustainability and Social Justice.

In 2025, the Jeanne X. Kasperson Research Library Collection was moved to the Robert H. Goddard Library. All books will be made available to the Clark community at the conclusion of the relocation. Questions about the collection may be addressed to library@clarku.edu.

We thank BJ Perkins, former Director of the Kasperson Research Library, for her many years of dedicated service to our students and researchers.

MARSH INSTITUTE SEMINAR SERIES

Each year, the Marsh Institute sponsors formal lectures and seminars that expose faculty and students to contemporary research on human-environment interactions, foster rich discussions, and catalyze future research. These seminars include the George Perkins Marsh Institute/Jeanne X. Kasperson Library Seminar Series, the Albert, Norma, and Howard '77 Geller Endowed Lecture Series, and the Debra I. and Jeffrey A. Geller Endowed Lecture Series.

TEFERI ABATE ADEM
Yale University

Vernacular Explanations of Rainfall Variability and Cascading Agrarian Shocks in Wollo, Northeastern Ethiopia

LESLEY-ANN DUPIGNY-GIROUX
University of Vermont

Hyperlocal Climate Services: Reflections of a State Climatologist

JENNY GOLDSTEIN
Cornell University

Starting with Solutions: A Global Political Ecology of Algae Innovation

DARLA MUNROE
Lincoln Institute of Land Policy

What is Land Policy?

GUSTAVO OLIVEIRA
Clark University

Spaces of Contestation over Water Resources in an Irrigation Frontier in Brazil

ADAM ROMERO
University of Washington

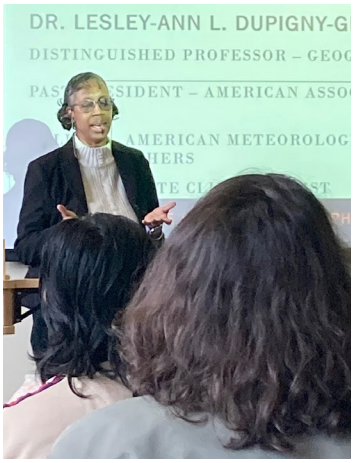
Cartels, Quality, and the Problem of Too Much Food in Post-WWII California

EDSON SEVERNIN
Boston College

Carbon Rollercoaster: A Historical Analysis of Decarbonization in the United States

JAMIE SHINN
SUNY College of Environmental Science and Forestry

Engaging the Technocrat: Bridging Critical and Applied Research in West Virginia



About George Perkins Marsh

George Perkins Marsh (March 15, 1801–July 23, 1882) was an American diplomat, scholar of languages, and designer of buildings including the Washington Monument. As a congressman in Washington, Marsh helped to found and guide the Smithsonian Institution. He is considered by many to be America's first environmentalist. Over one hundred and sixty years ago he warned of our destructive ways in an insightful book *Man and Nature*. He was the first to raise concerns about the large-scale detrimental impact of human activities on the environment. The conventional idea held by geographers of the day was that the physical aspect of the earth was entirely the result of natural phenomena, mountains, rivers, and oceans.

You Can Help

The George Perkins Marsh Institute is devoted to the use of science to inform policy and motivate positive change. We also train the scientists and environmental leaders of tomorrow. Your donation to the Marsh Institute allows us to continue our mission — promoting sustainable environments for the public good. Make your tax-deductible contribution to the Marsh Institute through the Clark Fund and join our community of scholars. Please specify the George Perkins Marsh Institute as the designation for your Clark Fund donation. If you would like to discuss ways that your gift can make a difference, please contact our Director, Robert J. Johnston.

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