George Perkins Marsh Institute

Highlights, Accomplishments, and Impacts

2024 Annual Report

Promoting Sustainable Environments for the Public Good

Informing Solutions to Global Change

On the Front Cover:

Graduate student Anna Zhu (PhD Geography) working on the chromophoric dissolved organic matter (CDOM) filtration rig. CDOM is the fraction of dissolved organic matter that absorbs light in the ultraviolet and visible ranges. Under the mentorship of Geography Professor Karen Frey, Zhu is studying the crucial role of light transmittance on the biogeochemical cycle and energy flows of arctic marine ecosystems.

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 an understanding of global environmental change and how we can safeguard the natural and social systems that support human livelihoods. Our primary research themes 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 risk, 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. We seek equitable and just solutions to real-world problems and work directly with practitioners to implement those solutions from local to global scales. 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. Other programs focused on 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).

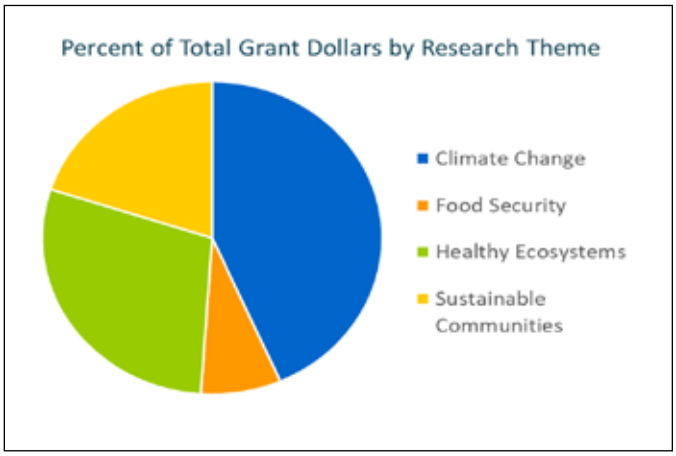
Among the facilities that comprise the Marsh Institute is the Jeanne X. Kasperson Research Library, whose holdings include one of the most extensive research collections in North America on risks, hazards, and global environmental change. We work closely with departments and schools across Clark University, including the Graduate School of Geography, the Department of Sustainability and Social Justice (SSJ), the Department of Economics, and the Center for Geospatial Analytics. As of 2025, the Institute will become a key part of the new School of Climate, Environment, and Society at Clark University.

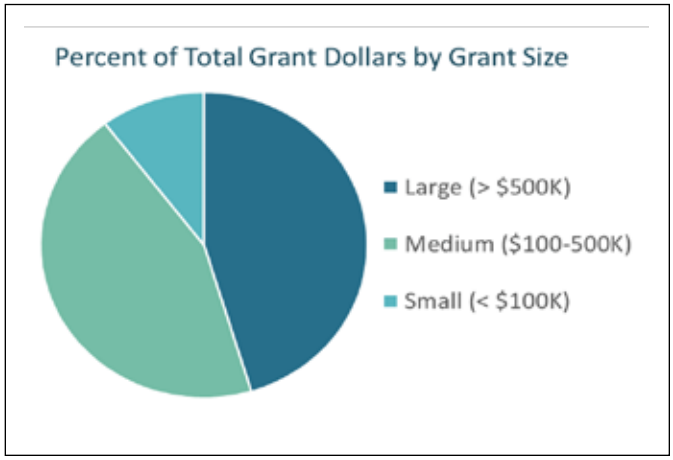
This annual report highlights some of the recent areas in which the George Perkins Marsh Institute is making a difference through environmental research, engagement, education, outreach, and communication.

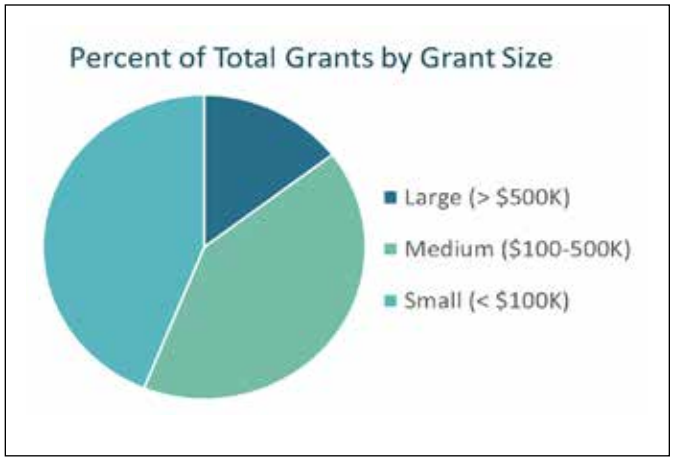
Robert J. Johnston, Director

GRANTS AND REVENUES

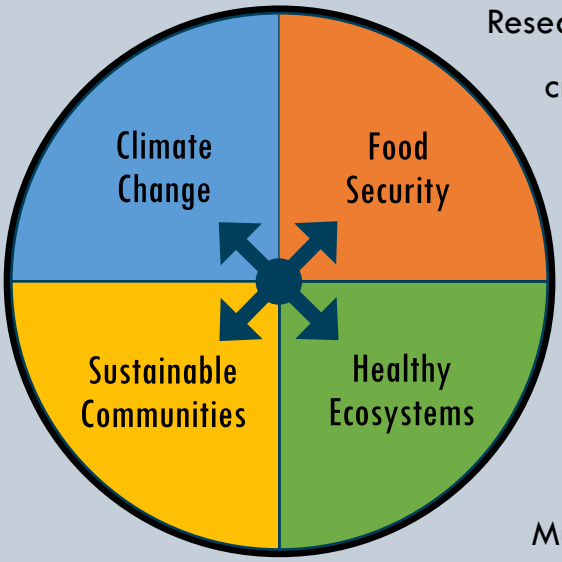
A large portion of Clark University's external grant funding is generated by the Marsh Institute, in coordination with our partners in the Graduate School of Geography, the Department of Sustainability and Social Justice, and the Department of Economics, among others. This past year, the Institute maintained approximately **$11.7 million in current grants,** covering **41 active projects:** 18 grants for small (under $100,000) projects, 17 grants for medium ($100,000 – $500,000) projects, and 6 for large (over $500,000) projects. Four grants are components of large-scale, multi-institutional research projects, each exceeding $1 million in total funding. During 2024, the Institute launched $3.4 million in new grants, with an average size of $342,7000 per grant.







Broken down by research theme, projects related to climate change impacts, mitigation, and adaptation represent 43% of total grant funds, while projects related to healthy ecosystems provide another 29% of grant funds. The largest number of projects are related to climate change impacts, mitigations 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:

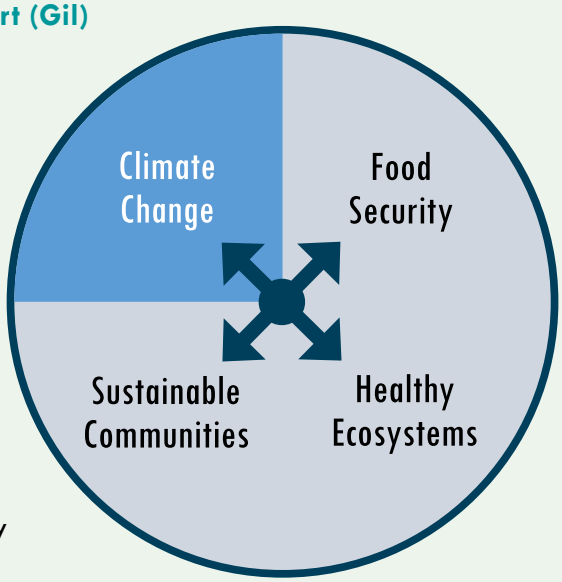
(1) Climate Change Impacts, Mitigation, and Adaptation, (2) Local and Global Food Security, (3) Healthy and Viable Ecosystems, and (4) Sustainable Communities and Governance.

Much of the research at the Institute is interdisciplinary in nature, and conducted by large teams with collaborations among Clark researchers as well as with researchers from other institutions around the world. Many projects focus on the analysis of policies and programs that impact the health and well-being of integrated human and natural systems. The scale of these projects ranges from local neighborhoods to regional watersheds to whole countries and the entire globe. **New research projects initiated during 2024** address topics such as: evaluating coastal communities' capacity for climate adaptation, analyzing the social and environmental impacts of Peruvian mega-port development, assisting USAID's global climate adaptation strategies, improving responses to childhood trauma, collaboratively restoring the Blackstone River, examining the impact of urban development on tree survival, examining feedbacks among rural food production and urban food security, exploring the climate-food-urbanization nexus in Sub-Saharan Africa, supporting at-risk youth in Worcester, and improving water quality in Long Island Sound.

RESEARCH PROJECTS

CLIMATE CHANGE IMPACTS 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 livelihoods. For example, **Cynthia Caron** and colleagues are producing country-level Climate Risk Profiles for the U.S. Agency for International Development to assist the agency's climate adaptation strategies. **Tim Downs** and colleagues are combining innovative technologies and stakeholder engagement to co-create research and education capacities that allow for comparing 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 situations 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. **Robert Johnston** and colleagues are evaluating the contribution 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. **Christopher Williams** is updating the National Forest Carbon Monitoring System to support the efforts of land trusts and other conservation organizations. 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.



USAID Climate Adaptation Support Activity—Climate Risk Profile Updates

Principal Investigators: Cynthia Caron (Project PI), Lyndon Estes, Abby Frazier, Yelena Ogneva-Himmelberger, Morgan Ruelle
Funding Agency: U.S. Agency for International Development

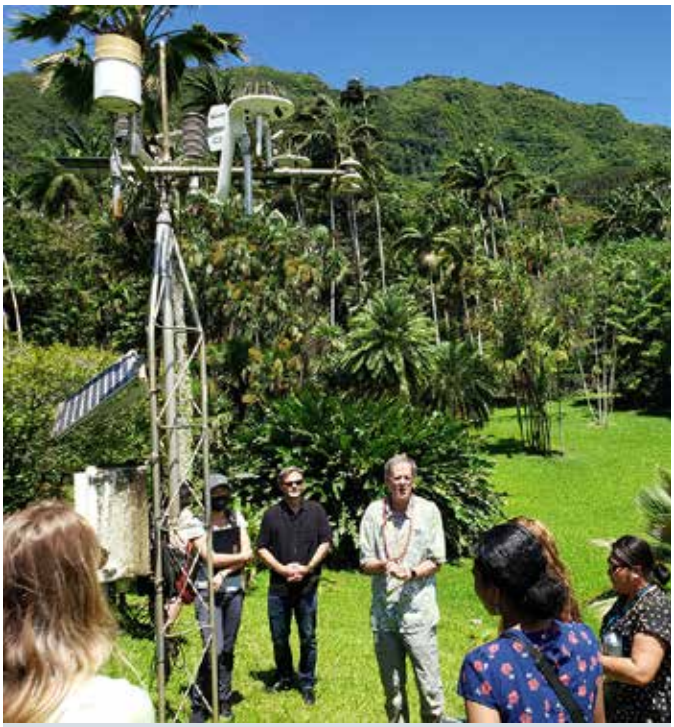
The Climate Adaptation Support Activity (CASA) program supports USAID/Washington and USAID Missions to implement the Agency's ambitious Climate Strategy and the President's Emergency Plan for Adaptation and Resilience (PREPARE) initiative. To support CASA, Clark University researchers, through a partnership with Tetra Tech ARD, are providing technical assistance and other support to: (1) increase actionable information that supports the design and implementation of impactful climate change adaptation approaches, interventions, and systems shifts; (2) identify strategic and forward-looking climate change adaptation and resilience approaches that support sustainable, scalable, and innovative adaptation, monitoring, evaluation, research, and learning; (3) expand and provide inclusive capacity strengthening, convening, and coalition building that supports impactful climate change adaptation action; and (4) support CASA programmatic planning and implementation. This phase of the long-term project focuses on production of 39 country Climate Risk Profiles that will improve decision-making around climate adaptation needs and opportunities.

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: National Science Foundation

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, and thus increase the water scarcity used to justify them in the first place. This project uses a planned 3-fold-expansion water supply 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.

Tim Downs (far right) and the project team on a field visit to Tlahuac, Central Mexico.



from the Pacific Drought Knowledge Exchange project check on one of the 30 Hawai'i Mesonet climate stations they have installed around the islands, with 70 more to go.

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 will expand the HDKE project to include additional stakeholders and collaborations 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.

Translating Existing Model Results to Aid in Resource Management Planning for Future Precipitation Extremes in Hawai'i and Southeast Alaska

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

The USGS Pacific Islands and Alaska Climate Adaptation Science Centers have supported the development of high-resolution future climate model projections for the steep-gradient watersheds of Hawai'i and Southeast Alaska. However, these model results are currently not accessible to resource managers in user-friendly formats, and no clear descriptions of the data or uncertainty are available. In partnership with the University of Alaska at Fairbanks, University of Hawai'i at Manoa, and other stakeholders, this project will co-develop a joint Hawai'i-Alaska website to make existing modeling results more accessible for resource managers who need to incorporate climate change projections into their planning and outreach efforts. The project will also co-produce new standardized hydro-meteorological products that will help address the uncertain future of precipitation extremes.

Drought Early Warning and Response in Hawai'i – Expanding and Enhancing Stakeholder-Driven Drought Products and Services

Principal Investigator: Abby Frazier
Funding Agency: National Oceanic and Atmospheric Administration

The National Integrated Drought Information System (NIDIS) has worked collaboratively to build an important foundation for understanding drought in Hawai'i and US-Affiliated Pacific Islands (USAPI). The Pacific Drought Knowledge Exchange (PDKE) collaborative: (i) brings together relevant agencies and stakeholders for meaningful engagement and collaborations in the Pacific; (ii) explores knowledge co-production with land stewards and resource managers including the delivery of tailored climate data products; (iii) provides easier access to drought and climate information and data sources for a wide range of private, Native Hawaiian, Pacific Islander and agency based stewards and managers; (iv) enhances quality and scope of information available to users; (v) improves capacity for knowledge delivery and technical assistance; and (vi) fosters a more collaborative information transfer environment. This project will develop a formalized, centralized structure for drought research and knowledge exchange designed to support ongoing and future drought related work in Hawai'i and USAPI.

The Distributed Biological Observatory (DBO)—A Change Detection Array in the Pacific Arctic Region, 2019-2024

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

The Pacific Arctic Region (PAR) is experiencing major reductions in seasonal sea ice and increases in seawater temperatures. A key uncertainty is how the marine ecosystem will respond to these shifts. Recent observations indicate these changes are linked to shifts in species composition and abundance, as well as northward range expansions in higher trophic predators (e.g. gray and humpback whales, and commercially harvested fish). There is also evidence of negative impacts on ice-dependent species such as walruses. Some distribution shifts may be driven by changes in lower trophic level productivity that cascade into higher trophic levels. Spatial changes in carbon production and export to the sediments are additional observations that have grown out of recent sampling efforts. An international consortium of scientists has implemented a coordinated Distributed Biological Observatory (DBO) that undertakes selected biological measurements at multiple trophic levels, simultaneously collected with hydrographic surveys (salinity, temperature, and nutrients) and satellite observations. The DBO approach provides multiple repeat sampling each year and new, more seasonally continuous data on the status and developing trends for the PAR ecosystem. This continuing project addresses questions such as: (1) Will earlier sea ice retreat and changes in seawater hydrographic properties influence the composition of pelagic and benthic prey species, and how will upper trophic organisms be affected? (2) What is the impact of seasonal changes in hydrography on the lateral and vertical distribution of primary production and export production to the benthos? (3) What will be the ecosystem responses to latitudinal changes in environmental drivers and can we forecast the biological response to components of the food web through ecological modeling?

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 LOADEST (Load Estimator software) modeling of dissolved organic carbon for rivers globally and across the Arctic.

Professor Karen Frey (Geography) conducts research on board the CCGS Sir Wilfrid Laurier.

Impacts of Increased Light Transmittance on Ocean Heating, Primary Productivity, and Carbon Cycling Across a Pacific Arctic Continental Shelf Gradient

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

Seasonal sea ice in the Pacific Arctic Region (PAR) has declined significantly, with large portions of this region becoming ice-free by mid-summer. This Pacific Arctic sector is also among the most biologically productive marine ecosystems in the world and acts as an important sink and perhaps seasonal source of carbon. Although sea ice is a dominant feature in these shelf environments at high-latitudes, we are only beginning to understand how changes in sea ice (through its influence on light, seawater temperature, salinity, and nutrient availability) will specifically affect ecosystems in these regions. This project adds new optical measurements of light transmittance through the upper ocean water column across a continental shelf gradient to an existing suite of observations on the Synoptic Arctic Survey cruise to the central Arctic Ocean. The research will: (1) test the hypothesis that light transmittance increases with declines in sea ice cover and varies with light absorbing impurities in the water column, and (2) utilize the optical measurements to elucidate questions surrounding vertical heat distribution in the water column, primary productivity, and the photodegradation of dissolved organic matter.

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. Importantly, 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.

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.

View of the Tuolumne River in the Sierra Nevada Mountain Range. By Antandrus, CC BY-SA 3.0, Https://commons.wikimedia.org/w/index.php?curid=4452388

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. Yet, researchers still 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.

NFCMS Update and Carbon Assessment for Forest Conservation Planning and Action

Principal Investigator: Christopher Williams
Funding Agency: Open Space Institute

Climate change can disrupt wildlife habitat and other natural amenities supported by land trusts and other conservation organizations. However, these organizations require good data upon which to base their land protection decisions. This project is updating the National Forest Carbon Monitoring System (NFCMS) to establish a data timestamp for 2020, or the most recent possible date, in order to better represent contemporary carbon stocks and expected future sequestration. The project ensures the dataset better represents present conditions viewed by users on the ground. Doing so will support greater applicability and build confidence from the user community. The project also uses the USGS LCMAP (Land Change Monitoring, Assessment, and Projection) dataset to identify areas of recent forest gain that were missed (and treated as non-forest) in the earlier version.

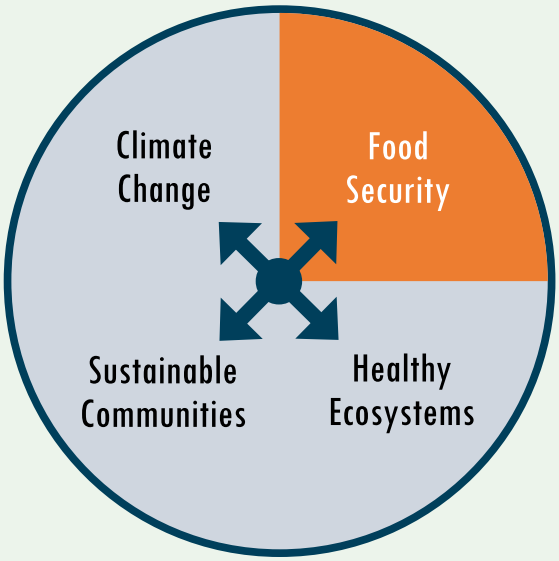
Applied Science to Catalyze Natural Climate Solutions

Principal Investigator: Christopher A. Williams
Funding Agency: The Nature Conservancy and The Bezos Earth Fund

Climate change is a global problem that will require both reductions in new greenhouse gas emissions and removal of existing gases from the atmosphere. This project provides the data and decision-support tools needed to quantify the albedo component of assessments evaluating climate change mitigation opportunities from reforestation, avoided deforestation, and forest management. The project draws upon prior research in the U.S. and Canada, refining the methods to expand the analysis to a global scale. The research will sample a global atlas of satellite-derived surface reflectivity2 defined for specific land cover types, combine these with climatology data on snow cover, solar radiation, and radiative kernels to compute the global scale radiative forcing that would result from forest cover conversions representative of deforestation and reforestation opportunities in a given area, and relate these radiative forcings in terms of global warming potential. Datasets will be delivered to The Nature Conservancy for integration into products, tools, and web platforms, and the project team will aid in integration and associated communications. Scientific findings will inform the identification of areas of opportunity where changes in forest cover or forest composition are expected to yield net climate benefits.

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 includes the use of machine learning and crop analytics to accurately map the location of cropland and particular crops in order to facilitate 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. 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 agricultural 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. However, growers differ in their knowledge of the impacts of pesticide exposure on pollination services and differ in their willingness to adjust management practices to address these impacts. These differences likely depend on the particular cropscape within which the grower operates. 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) How aware are growers of the different pathways through which pollinators are exposed to pesticides? (2) 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? (3) 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 federal, state, and local pollinator conservation programs?

Linkages and Interactions between Urban Food Security and Rural Agricultural Systems

Principal Investigator: Lyndon Estes
Funding Agency: National Science Foundation

Meeting urban food demand due to population growth, changing food consumption patterns, and the vulnerability of food production to environmental variability present future challenges. Globalization and international trade of food and commodities are key aspects of how urban areas will meet future food demand. But urban areas exhibit different levels of connectivity to international, regional, and local food systems. Most urban food security research has focused on large metropolitan areas, despite the reality that significant numbers of urban residents live in small to moderate sized urban places. New research is needed to understand what types of urban places are most vulnerable to impacts of local and regional crop production, and what type of urban agglomerations can mitigate those impacts through food imports from distant areas. This project evaluates the impacts of environmental variability on rural agricultural production and how this affects urban food security, and, in turn, how urban population growth affects the demand for local and regional agricultural production, as measured through food trade and other flows. This large-scale interdisciplinary research partnership involves collaborators from University of Arizona, University of California Santa Barbara, and University of Illinois at Urbana-Champaign. Marsh Institute researchers are responsible for characterizing rural agricultural production using remote sensing, and modeling the land use impact of different urbanization scenarios.

A Region-Wide, Multi-Year Set of Crop Field Boundary Labels for Sub-Saharan Africa

Principal Investigator: Lyndon Estes
Funding Agency: Lacuna Fund

This project builds upon previous work, using satellite imagery to accurately map the boundaries of smallholders' fields over large areas and accurately label these crop fields covering two mapping regions in Western/Central Africa and Eastern/Southern Africa. It will develop and prepare the labelling platform for use, and provide technical support and guidance to project partners on how to use the platform.

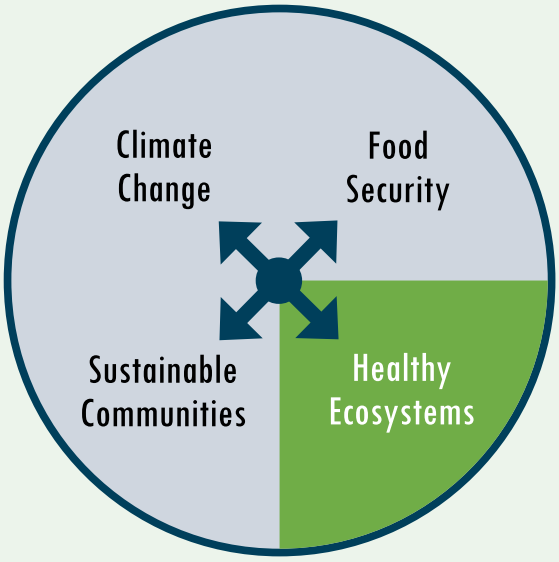
Investigating Underutilized Traditional Crop Mixtures for Nutritional Yield, Climate Resilience, and Soil Regeneration

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. Ecosystem services include provisioning of food, water, and energy, purification of air and water, and protection from natural hazards, among many 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 using radar technologies to map the Amazon's forest-agriculture interface. **Robert Johnston** is investigating solutions to the widespread problem of nitrogen runoff from residential lawns 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 focus of this project is on water systems in areas with extensive agricultural use, but 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.

Culvert Assessment and Prioritization for Ecological and Social Resilience in the Blackstone Watershed

Principal Investigator: Stefanie Covino
Funding Agency: Anonymous Foundation

The Blackstone Watershed Collaborative is a network of organizations and individuals working to improve health and resilience of the watershed. This project supports the Collaborative's culvert training and assessment initiative to assist local communities and organizations in the watershed to understand and assess culvert (road-stream crossing tunnels) replacement or removal-and-restoration to improve ecological and social benefits. The project includes offering two-day fieldwork trainings and organizing volunteer participants and key professionals to assess approximately 200 culverts in the Blackstone Watershed, with a focus on the high-quality habitat of coldwater fisheries located in the Douglas-Sutton-Northbridge (Massachusetts) region. The Collaborative is working closely with diverse organizations and municipal partners to prioritize top culvert management actions for ecological and social improvements, provide comprehensive outreach materials, and identify potential funding sources for implementation.

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.

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

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

Environmental programs and policies cost billions of dollars per year. 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. Recognizing the need to quantify these and other non-market benefits, environmental economists have devoted considerable effort to the development and application of a range of non-market valuation (NMV) techniques. These have varying strengths and weaknesses and different techniques are suited to estimating different types of non-market values. This project is developing a rigorous framework for selecting the most appropriate approach to handling 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 more than $5 billion 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. To develop these methods, the project team is leveraging advances in online, interactive map-based survey architecture, together with novel approaches for stated-preference survey design, Bayesian econometrics, 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.

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 entirely 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. The project is also evaluating the ways in which targeted behavior-change campaigns for residential lawn care influence nitrogen loads to LIS areas proximate to environmental justice (EJ) communities, and whether fertilizer use by wealthier households might have disproportionate effects on EJ communities. Results will be used to provide actionable guidance for targeting behavior-change campaigns.

Spatially Explicit Ecosystem Service Benefit Transfer for Policy Evaluation: An Integrated Biophysical and Meta-Analytic Approach

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

The USDA spends over $5 billion annually on conservation programs to enhance ecosystem services that promote agricultural sustainability, often targeting benefits such as water quality and aquatic ecosystem services. While the biophysical impacts of these programs can be estimated using established models, the economic benefits are generally unknown. Addressing this shortcoming requires practical, reliable and cost-effective benefit transfer methods explicitly designed for large-scale ecosystem service valuations. Meta-regression models are increasingly used in benefit transfers, and these models can be specified to link directly to biophysical models that predict policy outcomes. Despite this promise, further methodological advances are required if meta-regression models are to be used widely for large-scale ecosystem service valuations. This project will develop and evaluate an integrated biophysical and meta-analytic benefit transfer model designed to estimate spatially explicit ecosystem service benefits from large-scale agricultural conservation policies, while addressing limitations of prior benefit transfer approaches. The new approach, based on Bayesian locally weighted meta-regression modeling, will be demonstrated using case studies of conservation programs that enhance aquatic ecosystems.

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.

Florencia Sangermano and ETH BiodivX team leader David Dao gather data in the Brazilian Atlantic Forest.

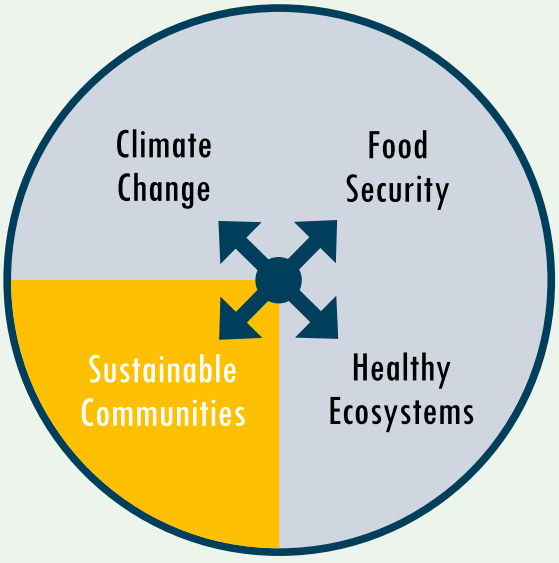
Multi-Temporal Analysis and Determination of Mangrove Cover in the Coastal Region of Ecuador

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.

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 populations to social upheavals and environmental change. 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. **Denise Humphreys Bebbington** and **John Rogan** are assessing the social and biophysical implications of a proposed mega-port in the Peruvian Amazon. **Margaret Post** is evaluating a program that promotes racial and maternal birth equity in low-income communities. **John Rogan** and **Deborah Martin** are assessing the survivorship, condition, and growth of trees planted over ten years ago in Worcester, Massachusetts. **Rogan** is also working with Groundwork Rhode Island to implement a science-based tree planting and forest restoration initiative in several environmental justice areas along the Blackstone River. **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.



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.

Advancing Green Infrastructure in the Blackstone Watershed: Identifying Municipal Priorities, Workshopping Solutions, and Mapping Implementation

Principal Investigator: Stefanie Covino
Funding Agency: U.S. Environmental Protection Agency and Narragansett Bay Estuary Program

Nature-based solutions and green infrastructure, such as the planting of trees for cooling and the use of roadside vegetation to mitigate pollutant runoff, are nothing new. However, many Blackstone Watershed communities are still not including nature-based solutions as a priority for new developments at the scale or frequency of what is possible. This project seeks to build long-term relationships with community stakeholders to identify local goals that can be addressed through nature-based solutions and remove barriers to implementation. The Blackstone Watershed Collaborative will provide technical assistance and identify potential funding sources. The project is initially focusing on two communities with significant environmental justice populations: Worcester, MA and Woonsocket, RI.

The Blackstone Watershed Collaborative organized a paddle on the Blackstone River in September 2024. Photo: Stefanie Covino.

Rags to Rags: The Effects of the New Poor Law across Three Generations

Principal Investigator: Jon Denton-Schneider
Funding Agency: Economic History Association

Budget cuts are common during times of fiscal austerity and often include substantial reductions in welfare spending. In developed economies, the withdrawal of income support for poor families can have wide-ranging consequences in the short run, including increasing poverty and criminal activity as well as worsening health and educational outcomes. However, our understanding of the long-run effects is generally limited to an assessment of those adults who were children when the programs began. Therefore, despite the prevalence of income support programs in the developed and developing worlds, we generally lack the data to study their effects on the health and well-being of the low-income population across its life course and into subsequent generations. The implementation of the Poor Law Amendment Act of 1834 in England and Wales offers a unique opportunity to fill this gap in our knowledge. This project uses historical data to examine the short and long run effects associated with the elimination of income support programs.

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

Principal Investigator: 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 broadly 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.

Evaluating the Base Building and Birth Justice Components of the Community Power to Build Health Equity Initiative

Principal Investigator: Margaret Post
Funding Agency: Center for Evaluation Innovation

Community power is the ability of communities most impacted by inequity to act together to voice their needs and hopes for the future and to collectively drive structural change, hold decision-makers accountable, and advance health equity. The Robert Wood Johnson Foundation (RWJF) supports community organizations and advocacy networks that engage in grassroots organizing, particularly with people who are low-income, of color, or youths. This project, in collaboration with the Center for Evaluation Innovation and Social Insights Research, is conducting an evaluation of RWJF's Community Power to Build Health Equity Initiative that is focused on elevating the voices of communities of color and building a broad constituency that promotes local racial equity and maternal/birth equity. As senior researcher, Dr. Post will contribute to the overall leadership and shaping of the project design and implementation, and participate in stakeholder meetings.

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.

Professor John Rogan (back center) leads a tour of the Hadwen Arboretum.

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. Specifically, 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.

Assessing the Survivorship, Condition, and Growth of Trees Planted 2010-2014 in Worcester

Principal Investigators: John Rogan and Deborah Martin
Funding Agency: Commonwealth of Massachusetts, Department of Conservation and Recreation

Over 17,000 trees were planted in Worcester by the Massachusetts Department of Conservation and Recreation (DCR) in response to the Asian Longhorned Beetle infestation between 2010 and 2014. During 2015 and 2016, the Clark University Human-Environment Regional Observatory conducted an inventory of over 1500 of the trees planted in the Burncoat and Greendale neighborhoods and reported those findings to the DCR. The first goal of this current research is to revisit those cohorts of trees, and evaluate them for survivorship, condition, and growth over the 7-8 years since the trees were last surveyed. The second goal of the project is to use remote sensing techniques to show change in land cover types from 2010 to 2023 in the area surrounding the DCR tree cohort under investigation. This research will help DCR understand the most important ecological, biophysical, and anthropogenic factors that have influenced the Burncoat and Greendale tree cohort.

Planting Resilient Riparian Forests for Water Supply and Public Health in Under-Served Communities

Principal Investigator: John Rogan
Funding Agency: U.S. Department of Agriculture

Working with several government, NGO, and community partners including Groundwork Rhode Island, this project is implementing a science-based tree planting and forest restoration initiative along a 15-mile stretch of the Blackstone River, one of 14 American Heritage Rivers and home to several drinking water supplies for a downstream city. This initiative will significantly increase tree canopy cover in environmental justice areas of three Rhode Island communities adjacent to the Blackstone by leveraging new tree planting projects via volunteers supported by municipal efforts and NGO's. The expanded tree canopy cover will reduce heat island impacts and improve public health via reduced air pollution and extreme heat as well as reduced stormwater pollution for drinking water supplies. Student researchers will conduct extensive modeling and monitoring that will help focus tree planting in areas for maximum reduction of heat island, flooding, and stormwater impacts, and will set up a monitoring system to document heat, air and water quality results. The initiative will serve as a demonstration project for many other landscapes where health equity, forest resilience, and water supply protection overlap.

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.

Safe and Successful Youth Initiative Project East

Principal Investigators: Laurie Ross
Funding Agency: City of Worcester

Worcester, Massachusetts, the second largest city in New England with a population of 183,000, exhibits many established risk factors for youth and gang violence. The goal of the Safe and Successful Youth Initiative (SSYI) Project East is to reduce gang violence and prevent gang initiation among high-risk youth ages 12-17 in Worcester's Eastside neighborhoods. By focusing on these neighborhoods and on youth ages 12-17, this project addresses a major geographical, age, and programmatic gap identified in Worcester's Youth Violence Prevention Initiative, the result of a comprehensive community gang assessment and citywide strategic planning process. SSYI Project East will bolster Worcester's Comprehensive Gang Model to direct outreach workers and case management to up to 50 youth who live on the city's Eastside, attend Worcester East Middle School, North High School or one of the city's alternative school programs, and are on the Worcester Public Schools Gang Protocol List. Clark University is the project's research partner, developing and managing a data tracking system, as well as sharing best-practice research with the rest of the project team.

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. Importantly, 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 approaches to 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.

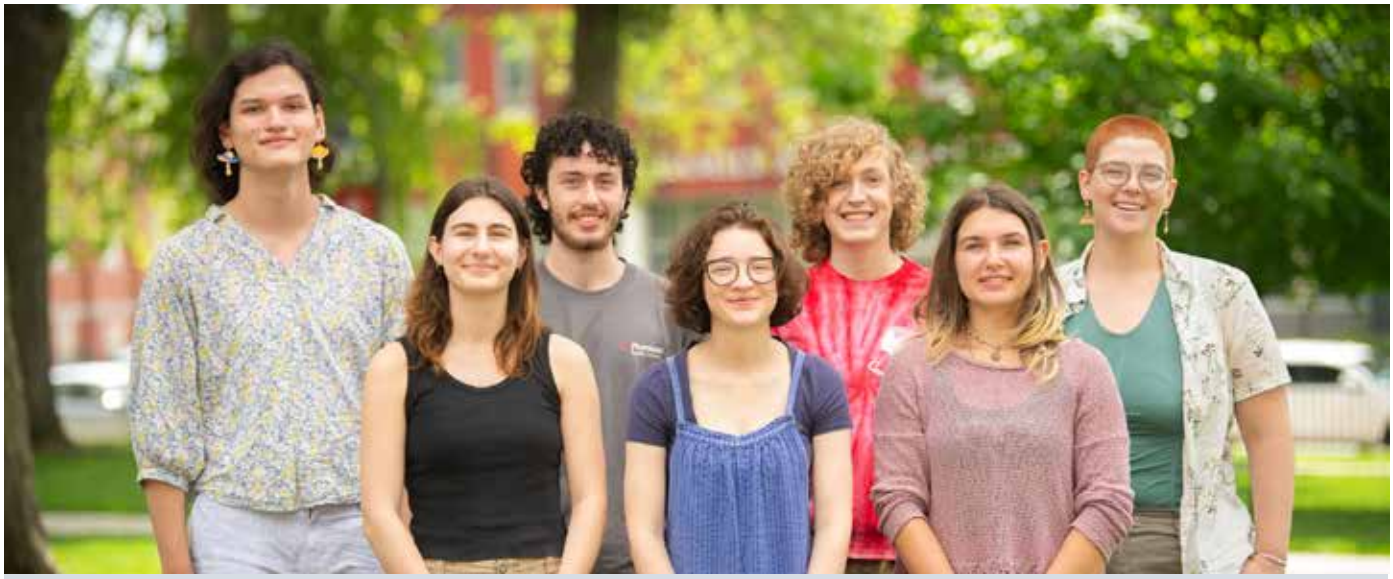
The Marsh Institute provides innovative, applied research opportunities for Clark graduate and undergraduate students. Programs range from endowed awards for student-initiated research to large-scale research projects promoting student involvement and hands-on learning, often in interdisciplinary and 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, and identifying and predicting changes in coastal vegetation in the Plum Island (Massachusetts) Ecosystem. Students are engaged in all aspects of the research from data collection and analysis through presentation and publication of results. Throughout 2024, Marsh Institute grants and endowments supported eight undergraduate students, 35 master's students, 23 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 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 Massachusetts Department of Conservation and Recreation (DCR). During the summer of 2024 the HERO team returned to tree surveying in the cities of Chelsea and Holyoke, where DCR's Greening the Gateway Cities Program first planted trees back in 2013. The team re-surveyed the health of trees in residential yards that had been surveyed previously. 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 outcome of the project contributed the first round of decadal-scale tree health information to our DCR partners. 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.

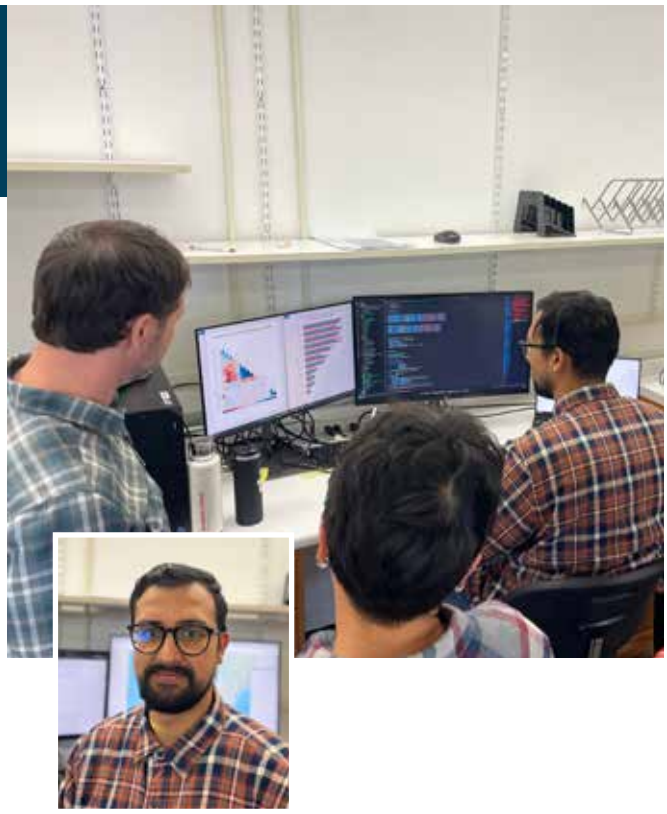
HERO student Mara Litten '26 canvassed neighborhoods in Chelsea and Holyoke to measure trees planted in 2023.



2024 HERO Fellows (left to right): Quinn Chang Martin '26, Espi Garschina-Bobrow '25, Jack Keane '25, Mara Litten '26, Aria Cranford '26, Juju Kaiser '26, and Kalon Shepard '25.

STUDENT RESEARCH IN THE SIERRA NEVADA MOUNTAINS

Graduate student **Sushil Paudel** (PhD Geography) analyzing geospatial data in Clark's Forest Ecology Research Lab. As climate change reshapes forest ecosystems worldwide, increasing wildfires stand out as one of its most dramatic consequences. In response, billions of dollars are spent annually on so-called "fuel treatments" that aim to reduce forest flammability. However, these efforts may be undermined by other climate-driven factors, such as increasing outbreaks of tree-killing insects and extreme weather that intensifies fires beyond historical norms. Under the mentorship of Geography Professor **Dominik Kulakowski,** Sushil is studying these interactions and modeling the effectiveness of forest management strategies under future climate scenarios.

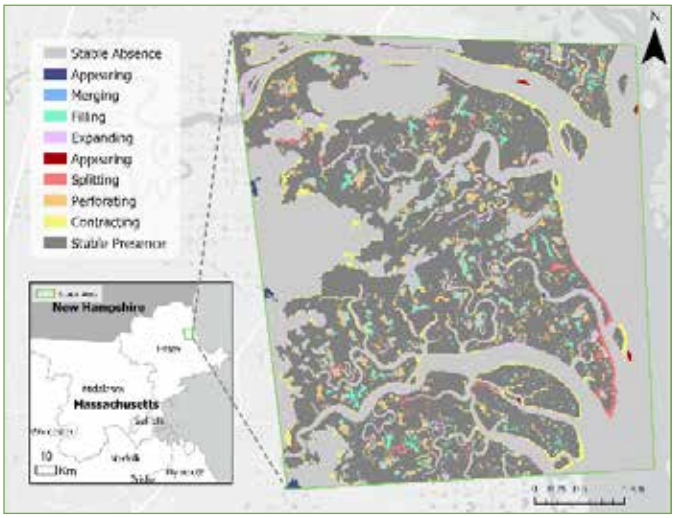


STUDENT RESEARCH IN CENTRAL MEXICO

Professor Jannice Alvarado Velázquez (UNAM), **Catalina Cuervo Maldanado** (MS ES&P), **Valeria Obregon Diaz** (MS ES&P), **Kwabena Antwi** (PhD Geography), and Professor **Timothy Downs** (Sustainability and Social Justice) conducting research in Central Mexico. Funded by a grant from the National Science Foundation's Partnerships for International Research and Education Program, the four-year interdisciplinary project involves researchers from the Department of Sustainability and Social Justice, the Becker School of Design & Technology, and the Graduate School of Geography, along with their peers at the National Autonomous University of Mexico (UNAM). Students are involved in many aspects of the project including: stakeholder interviews and workshops, geospatial and satellite data analysis, assisting communities with the installation and use of 3D-printed weather stations, and development of a virtual reality platform that allows residents and policymakers to virtually "inhabit" alternative climate futures at local and regional scales.

STUDENT RESEARCH IN THE PACIFIC ARCTIC ECOSYSTEM

Graduate student **Anna Zhu** (PhD Geography) holding a centrifuge tube containing a chlorophyll-a sample. Under the mentorship of Professor **Karen Frey** in the Polar Science Research Laboratory at Clark University, Zhu is analyzing data from seawater and sea ice samples collected on a recent scientific cruise to the Bering and Chukchi Seas. The Arctic is warming four times faster than the rest of the world since 1979, and two times faster than previously thought, resulting in dramatic changes to sea ice cover with ramifications throughout the entire marine ecosystem including impacts on commercial fishing. Zhu's research is contributing to the ongoing international consortium of scientists working on the Distributed Biological Observatory across the Pacific Arctic Region.



STUDENT RESEARCH IN THE PLUM ISLAND ECOSYSTEM

Graduate student **Aiyin Zhang** (PhD Geography) received the Robert N. Colwell Memorial Fellowship from the American Society for Photogrammetry and Remote Sensing Foundation for exceptional aptitude in the field of remote sensing, demonstrated through her research on coastal wetland transitions in response to climate change and sea level rise. Under the mentorship of Geography Professor **Robert (Gil) Pontius**, Zhang developed a new method utilizing innovative remote sensing and geospatial techniques to detect and characterize fine-scale changes in highly dynamic coastal ponds. This ground-breaking approach provides much-needed fine-scale information to land managers who require high spatial and temporal resolution information. The map shows the transition patterns of coastal salt marsh at the Plum Island Ecosystem Long-Term Ecological Research Site during the period 1971–2013.

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.

Arman Bajracharya (PhD Geography)

Land Use Land Cover Modification as Disaster Response in Sindhupalchok District: Understanding Adaptive Pathways for Double Exposure in Nepalese Communities

Faculty Mentor: Rinku Roy Chowdhury

Mountainous regions worldwide face intense biophysical hazards like landslides and floods due to their geographical location. The escalating impacts of climate change have compounded stresses on mountain communities. Meanwhile, these communities have encountered new trade and development opportunities due to economic globalization. However, this socially and geographically uneven economic integration has increased the vulnerability of community members due to dependence on external markets. This study examines livelihood and land use modifications as adaptive pathways for communities in Nepal's Hindukush Himalayas, where communities are doubly exposed to climate change and economic globalization.

Sergio Carvajal (PhD Geography)

Understanding REDD+ Beyond a Carbon-Centric Approach: Sustainable Agriculture and the Transformation of Indigenous, Peasant and Black Communities in Colombia

Faculty Mentor: Gustavo Oliveira

In recent years, the Reducing Emissions from Deforestation and forest Degradation (REDD+) initiative has received a lot of attention because of its potential to attract large-scale investment in the protection of forests and the promotion of sustainable agriculture. Although a growing literature has inquired about the social and environmental impacts of the carbon markets that REDD+ fosters, much less attention has been paid to the way in which these projects are reconfiguring agriculture. This project explores how the implementation of REDD+ is transforming the ways in which value is produced in the economy, and how those changes are impacting forest-based communities in Colombia. This research examines the transformation in labor relations and productive activities that peasant, Afro-Colombian, and indigenous communities are experiencing due to REDD+ projects, ultimately providing important input to policymakers, project developers, and environmental activists.

Sophia Hayes (BA Geography and Environmental Science)

Flood Patterns and Extractivist Geographies on Indigenous Lands in Northern Wisconsin: An Integrated Approach

Faculty Mentor: John Rogan

Indigenous lands are disproportionately impacted by the risks associated with fossil fuel infrastructure compared to non-native land. The crossing of Enbridge Inc.'s Line 5 liquid petroleum pipeline across the Bad River Reservation of the Lake Superior Tribe of Chippewa Indians in northern Wisconsin exemplifies the multifaceted risks pipeline infrastructure poses to Indigenous communities. This study assesses the risks associated with a potential rupture of Line 5 within or near the Bad River Reservation utilizing a comprehensive analysis of the ecological, economic, and socio-cultural function of the Reservation as an extension of the political identity of the Bad River Band. This project investigates the threats to environmental and hydrologic stability that Line 5 imposes on the Bad River Band and how these threats are perceived by community members.

Madeline Kroot (PhD Geography)

Contesting Energy Transitions: Understanding Community Opposition to High-Voltage Transmission Lines in Northern New England

Faculty Mentor: James McCarthy

While energy transition is often imagined in terms of new energy sources, transition also requires new transmission lines to bring new sources of electricity to existing sites of consumption. However, transmission lines have increasingly become the objects of contestation, delaying or halting plans for decarbonization. This project explores local opposition to two proposed transmission lines in northern New England, both of which intend to transmit Quebecois hydroelectricity to Massachusetts and neither of which have been built amidst intense local resistance. This project seeks to understand how power lines emerge as objects of contestation, examine divergent understandings of their prospective impacts, and trace the ways and scales at which stakeholders mobilize competing justice claims.

Al-Rauf Mahama (MA Environmental Science and Policy)

Urban Greening, Waste Reduction, and Community Well-Being: A Case Study in the Upper West Ghana for Sustainable Urban Development

Faculty Mentor: Eman Lasheen

Urbanization often leads to waste disposal challenges, with dump sites scattered across urban areas. These sites contribute to increases in local air temperature, releases of particulate matter, and emissions of greenhouse gases, all of which can impact human health. Urban greening—the process of including natural elements like vegetation via parks, gardens, and other green spaces—can address these challenges. This project uses the Upper West region of Ghana as a case study to explore the complicated relationship between waste disposal sites, urban green spaces, community well-being, and environmental sustainability. Results will be provided to local stakeholders for use in future urban planning initiatives.

Walter Poulsen (PhD Geography)

Expert Knowledge and Discourses for Solar Photovoltaic Policy and Development: Ethnographic Fieldwork at Two Industry Conferences

Faculty Mentor: Gustavo Oliveira

Solar photovoltaic (PV) energy generation is emerging as a key technology for climate mitigation. Solar PV development is accelerating across the U.S. and is driving a significant restructuring of the political economy of energy. As this development has spread, so have calls for a just transition. To achieve just energy transitions, it is imperative that we understand the processes by which policies are produced. This project will conduct ethnographic research (semi-structured interviews and participant observation) with industry practitioners and policymakers at two industry conferences, extending understandings of the actors and discourses involved at the development and planning level of the solar PV assemblage.

Prasanth Prakash Prabhu (PhD Biology)

Investigating the Genetic Underpinnings of Nitrogen Pollution Induced Trophic Transition in Wood-Decaying Mushrooms

Faculty Mentor: David Hibbett

Fungi are the primary wood decomposers in forest ecosystems. The rate of decomposition is often limited by the amount of nitrogen available in the environment, thus altering the carbon cycle. Human-derived nitrogen pollution causes changes in the nitrogen cycle and the community structure in ecosystems. Wood-decaying fungi have developed several mechanisms to overcome nitrogen limitation. This research is identifying the genetic basis of the influence of different nitrogen sources on nematode-trapping fungi. Results will provide insight into alterations in the rate of decomposition of organic matter influenced by an external nitrogen source and ultimately inform carbon cycle models that incorporate fungus-mediated decay.

Jewon Ryu (PhD Geography)

Unraveling the Impact of New Technology on Society: Challenges in Adopting EVs in Jeju Island, South Korea

Faculty Mentor: Deborah Martin

Jeju Special Self-Governing Province (Jeju), an island lying in the south of the Korean Peninsula, is the only self-governing province in South Korea. In 2012, Jeju introduced the Carbon-Free Island (CFI) Jeju Plan, a comprehensive effort to transition the island to a carbon-free environment. One long-term goal of the CFI plan was to cease new registrations for internal combustion engine vehicles after 2030, with the intention of replacing 75% of these vehicles with EVs. Despite extensive government endeavors (e.g., subsidies) to encourage the adoption of EVs, the number of registered internal combustion engine vehicles increased. This project examines technology transitions from multiple perspectives, focusing on how various actors implement public environmental policies, to understand the societal effects of new technology on carbon neutrality.

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.

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DANA BAUER
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ANTHONY BEBBINGTON
Geography

ASHA BEST
Geography

HALINA BROWN
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CYNTHIA CARON
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MARK DAVIDSON
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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
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Deborah Martin
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James Murphy
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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

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.

"The Role of Indigenous Peoples and Local Communities in Protecting Earth's Ecosystems"

SOLANGE BANDIAKY-BADJI
President and Coordinator
Rights and Resources Initiative

"Forest Ecosystem Responses to Climate Change"

SERITA FREY
Professor
University of New Hampshire

"Climate Narratives of Hope: Coral Refuge in the Red Sea"

EMAN LASHEEN
Assistant Professor
Clark University

"Considerations on Reducing Climate Change Impacts in Urban Environments"

PAUL MATHISEN
Associate Professor
Worcester Polytechnic Institute

"Climate Change and Mobility Justice"

MIMI SHELLER
Dean of The Global School
Worcester Polytechnic Institute

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. In addition, national and international awards reflect the contributions, expertise and reputation of institute scientists.

ADVISORY BOARDS AND COMMITTEES

Anthony Bebbington is a member of the National Academy of Sciences and serves on its Diversity Committee for the Human-Environment Sciences section.

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.

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.

Robert Johnston participated in the White House Statistics for Environmental-Economic Decisions Valuation Roundtable.

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.

EDITORSHIPS AND PROFESSIONAL SERVICE

Anthony Bebbington is Associate Editor at *World Development* and Editor at the *Proceedings of the National Academy of Sciences*.

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

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.

AWARDS AND RECOGNITIONS

Natalia Hasler, Christopher Williams, and colleagues received a "Top 25" award from the editorial team at Nature Communications for their research article Accounting for albedo change to identify climate-positive tree cover restoration in recognition of its value to the research community. The article, which quantifies the global climate mitigation benefit of restoring tree cover using spatially explicit data, was downloaded 23455 times, making it one of the top 25 downloaded Earth, Environmental, and Planetary Science papers published in the journal during 2024.

Florencia Sangermano and colleagues were awarded the XPRIZE Rainforest Bonus for co-developing groundbreaking inclusive biodiversity monitoring technologies in collaboration with local communities.

Aiyin Zhang (PhD Geography) received the Robert N. Colwell Memorial Fellowship for exceptional aptitude in the field of remote sensing, demonstrated through her research on coastal wetland change in response to climate change.

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 published the article "Geopolitics and geospatial strategies: the rise of regulatory supply chain controls for semiconductor GPN in Japan, South Korea and Taiwan" in *ZFW – Advances in Economic Geography*.

Timothy Downs, Yelena Ogneva-Himmelberger, and colleagues published the article "Manganese in residential drinking water from a community-initiated case study in Massachusetts" in *Journal of Exposure Science & Environmental Epidemiology*.

Anita Fábos and colleagues published the article "Micro-scale transformations in sustainability practices: Insights from new migrant populations in growing urban settlements" in *Global Environmental Change*.

Ellen Foley and colleague Tsitsi Masvawure edited the volume *Routledge Handbook of Anthropology and Global Health*.

Abby Frazier and colleagues published the article "How people, rainfall and vegetation shape tropical island fire regimes across Micronesia" in *Journal of Biogeography*.

Karen Frey and colleagues published the article "Peatlands versus permafrost: Landscape features as drivers of dissolved organic matter composition in West Siberian rivers" in *Journal of Geophysical Research: Biogeosciences*.

Natalia Hasler, Christopher Williams, and colleagues published the article "Accounting for albedo change to identify climate-positive tree cover restoration" in *Nature Communications*.

Denise Humphreys Bebbington and colleague Guido Cortez published the chapter "Tense territories: Negotiating natural gas in Weenhayek Society" in the book *Reimagining the Gran Chaco: Identities, Politics, and the Environment in South America*.

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*.

Deborah Martin published the article "A quiet influence shaping lines of inquiry: Rethinking 'cities in pursuit of economic growth'" in *Political Geography*.

James McCarthy and colleague Paprocki Kasia published the article "The agrarian question of climate change" in *Progress in Human Geography*.

James Murphy and colleague Pádraig Carmody edited the volume *Handbook of African Economic Development* and co-authored three of the book's chapters.

Robert (Gil) Pontius Jr. and colleagues published the article "Performance of CA_Markov and DINAMICA EGO models to evaluate urban risk in Antofagasta and Mejillones, Chile" in *Natural Hazards*.

Madeline Regeyene (MS '23), **John Rogan,** and **Nicholas Geron** (PhD '23) published the article "Examining local climate zones in the context of the urban heat island effect: A case study in Worcester Massachusetts" in *Remote Sensing Letters*.

Laurie Ross, Jie Park, and colleagues published the chapter "Guided emergence and the praxis curriculum: Promoting faculty learning" in the book *Towards a community of antiracist praxis: Transformative principles, practices, and resources for the classroom.*

Rinku Roy Chowdhury and colleague Darla Munroe published the article "A mature land-system science has deepened its conceptualization of environment" in *Progress in Environmental Geography.*

Morgan Ruelle and colleagues published the article "The need for more inclusive deliberation on ethics and governance in agricultural and food biotechnology" in *Journal of Responsible Innovation.*

Christopher Williams and colleagues published the article "We need a solid scientific basis for nature-based climate solutions in the United States" in *Proceedings of the National Academy of Sciences.*

Florencia Sangermano and colleagues published the article "Potential 2050 distributions of world terrestrial ecosystems from projections of changes in world climate regions and global land cover" in *Global Ecology and Conservation.*

Deborah Woodcock published the article "Wood of Qualea from the Piedra Chamana in-situ fossil forest (late Middle Eocene, Peru) and the comparative wood anatomy of Vochysiaceae and Myrtaceae" in *International Association of Wood Anatomists Journal.*

JEANNE X. KASPERSON RESEARCH LIBRARY

The Jeanne X. Kasperson Research Library supports Clark University's extensive environmental research and global change programs. An integral part of the Marsh Institute, the Kasperson Library offers one of the most extensive collections in North America on environmental risk and hazards, environment and development, and the human dimensions of global environmental change. The library also has significant holdings on the subjects of sustainable development, environmental technology, water resources, and energy policy, as well as other unique special collections such as its extensive holdings on radioactive waste management. The library is also home to the Worcester Refugee Archive, a collection of local and global resources on the topic of refugee resettlement in Worcester County. In addition to journal articles, the archive contains theses, government reports, and newspaper articles dating back to the 1970s. The library has attained national and international recognition as a premier collection of research materials, and particularly of fugitive materials and unpublished literature in its areas of specialization. It provides information and research support for university researchers; undergraduate and graduate students; visiting scholars; regional experts; federal, state, and local agencies; industry; schools; and consulting firms. The library houses more than thirty-five thousand volumes related to it's focus areas, and computer and internet resources. Library Director **BJ Perkins** and other library staff provide personalized research assistance.

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.

CLARK UNIVERSITY

GEORGE PERKINS MARSH INSTITUTE

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