George Perkins Marsh Institute

Highlights, Accomplishments, and Impacts

2023 Annual Report

Promoting Sustainable Environments for the Public Good

Informing Solutions to Global Change

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 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, vulnerability, mitigation, and adaptation.

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 scientists 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).
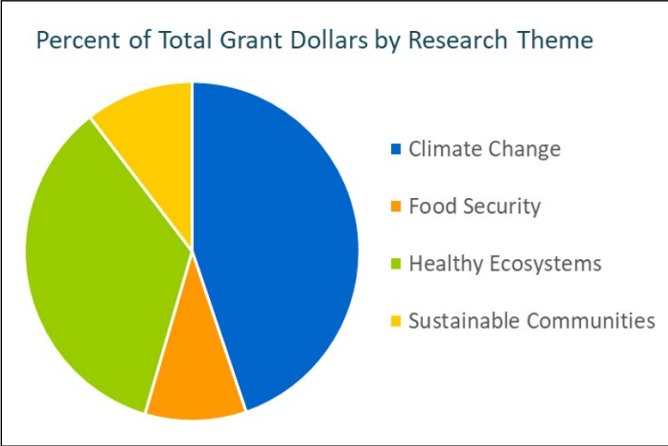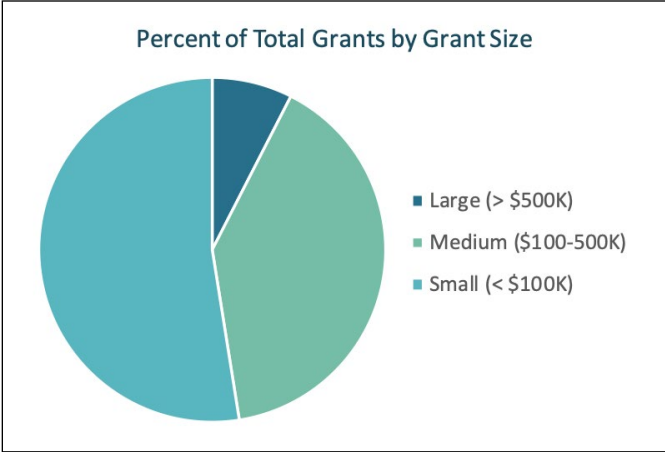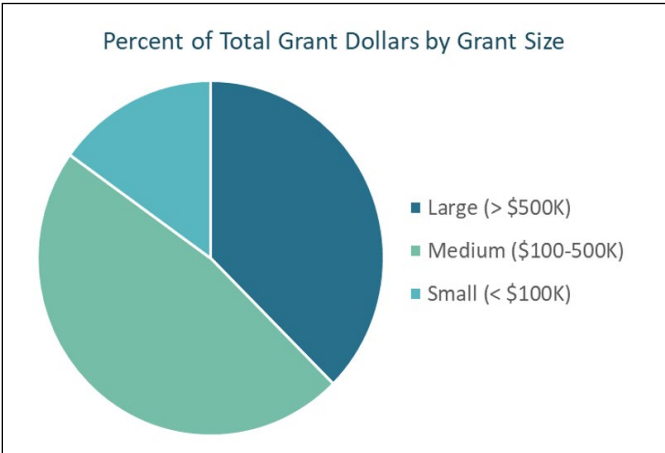
Among the facilities, offices, and centers that comprise the Marsh Institute is the Jeanne X. Kasperson Research Library, whose holdings include one of the most extensive research collections in North America on risks, hazards, and global environmental change. We are also home to the Humanitarian Response and Development Lab (HURDL), the Center for the Study of Natural Resource Extraction and Society, and the Blackstone Watershed Collaborative. 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 Clark Labs. 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 **$9.6 million in current grants,** covering **47 active projects:** 28 grants for small (under $100,000) projects, 15 grants for medium ($100,000 - $500,000) projects, and 4 for large (over $500,000) projects. Six grants are components of large-scale, multi-institutional research projects, each exceeding $1 million in total funding. During FY2023, the Institute was awarded $2.9 million in new grants, with an average size of $170,524 per grant. The Institute's overall proposal success rate was around 69%, with higher success rates for small (89%) and medium (100%) grants.

Percent of Total Grant Dollars by Grant Size

- Large (> $500K)
- Medium ($100-500K)
- Small (< $100K)

Percent of Total Grants by Grant Size

- Large (> $500K)
- Medium ($100-500K)
- Small (< $100K)

Percent of Total Grant Dollars by Research Theme

- Climate Change
- Food Security
- Healthy Ecosystems
- Sustainable Communities

Broken down by research theme, projects related to climate change impacts and adaptation represent 45% of total grant funds, while projects related to healthy ecosystems provide another 35% of grant funds. The largest number of projects are related to climate change impacs and adaptation.
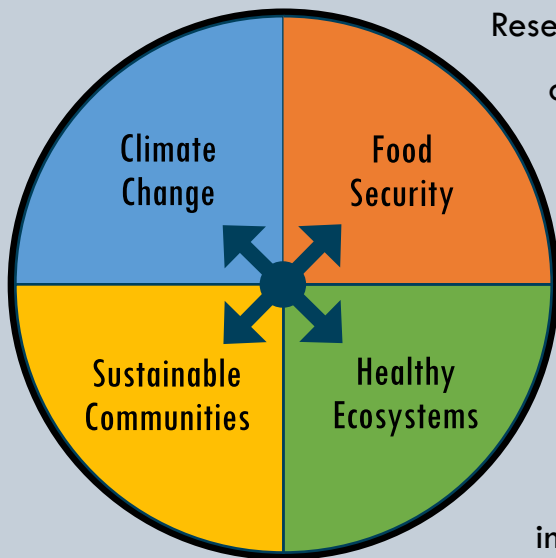
Research at the Marsh Institute addresses some of the most critical issues facing society today. Research topics fall under one or more broad themes related to sustainable natural and human systems: **(1) Climate Change Impacts and Adaptation, (2) Local and Global Food Security, (3) Healthy and Viable 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 2023** address topics such as: assisting USAID's global climate adaptation strategies, facilitating Cambodia's participation in a voluntary carbon market, studying the interactions among forest fuels, fires, and bark beetle outbreaks, examining the expansion of irrigated agriculture as a climate adaptation strategy, investigating the benefits of traditional crop mixtures and indigenous agroecological knowledge, predicting the effects of public campaigns that promote reductions in residential fertilizer use, characterizing the change in coastal mangrove habitat resulting from ongoing shrimp farming, and identifying the factors that drive the persistence of early education and care (EEC) deserts and the barriers families face when attempting to access formal, high-quality EEC.

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, **Ed Carr** 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. **Lyndon Estes** is creating a Cambodian national forest regrowth dataset that will support the country's participation in one of the world's largest voluntary carbon markets programs. **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. **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 working with The Nature Conservancy to develop decision-support tools for evaluating climate change mitigation opportunities across the U.S. and Canada. 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.
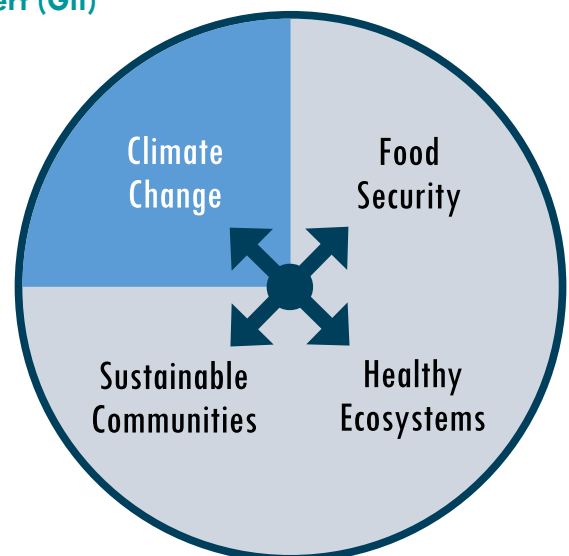
USAID Climate Adaptation Support Activity— Climate Risk Profile Updates

Principal Investigators: Edward Carr, Cynthia Caron, 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.

Xochimilco, a municipality in southern Mexico City, contains the last vestiges of indigenous Aztec floating gardens — or chinampas — a farming and transport system. Still producing food today, the centuries-old canal system is shrinking due to climate change and population-induced water scarcity, and has become polluted due to tourism. (Mexico photos courtesy of Ravi Hanumantha)

Jurisdictional Forest Carbon Support

Principal Investigator: Lyndon Estes
Funding Agency: TerraCarbon

Nature-based solutions are important for addressing climate change, improving the availability and quality of freshwater, and protecting biodiversity. REDD+ provides a framework that governments can follow for reducing greenhouse gas emissions from deforestation and forest degradation, as well as increasing forest conservation, sustainable management of forests, and enhancement of forest carbon stocks. This project supports the development of the Cambodian REDD+ activity data for one of the world's largest voluntary carbon markets program, the Verified Carbon Standard (VCS) Program. Project work includes the creation of a national forest regrowth dataset, the improvement of existing classifications in key regions, and the review of standard operating procedures developed by partner TerraCarbon, an advisory firm that helps develop carbon offset projects to fund nature-based climate solutions.

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

Nā Pali Coast State Wilderness Park on Kauai Island, Hawaii

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.

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.

Pacific RISA: Building International Adaptation and Resilience to Changing Climate in the Pacific Islands

Principal Investigator: Abby Frazier
Funding Agency: Center for Cultural and Technical Interchange Between East and West

This project describes combined extreme events and the related implications for hazard prediction, impact assessment, and adaptation planning in Hawai'i and the US-Affiliated Pacific Islands (USAPI). The research entails an investigation of current knowledge, through an examination of literature and interviews with stakeholders, and culminates in the writing of a review paper that contextualizes the compound and correlated extreme events for tropical Pacific Islands. This effort will catalog, characterize, and prioritize combined extreme events in

Hawai'i and the USAPI. Specifically, it will identify and classify the various event types, explain the rationale, review key examples, and include a discussion of climate variables and their spatial and temporal dependencies. Events will be categorized geographically and by sector to help inform future research and application needs.

Routine Monitoring of Climate in the State of Hawai'i: Establishment of State Climate Divisions

Principal Investigator: Abby Frazier
Funding Agency: National Weather Service (NWS)

Basic climate summaries and historical climate analyses produced by the National Centers for Environmental Information (NCEI) do not include the state of Hawai'i, largely because Hawai'i is the only state that does not have assigned climate divisions. This project will develop the analytical approach to produce climate divisions for Hawai'i with regional groupings analogous to the contiguous United States' climate division records. Rainfall in Hawai'i exhibits a number of extremes that include some of the wettest locations on earth, and short-term extreme events that rival national extreme values. Extreme drought events also regularly affect the state. Given the strong spatial climate gradients in Hawai'i, careful analysis is needed to develop appropriate climate regions that characterize the state's spatial and temporal variability. This information is required to better understand climate variability and change, and to include Hawai'i within NCEI's suite of state and national climate products. The production of climate divisions for Hawai'i will support development of a robust monitoring and forecasting framework, enhancing seasonal forecasting at NWS and monitoring through NCEI.

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.

Professor Karen Frey (Geography) holds a "hitchhiker" jellyfish that was accidentally pulled up on an instrument in the Chukchi Sea. Jellyfish populations are increasing in these regions as a consequence of human activities, including warming seawater due to anthropogenic climate change.

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 will address 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?

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.

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.

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.

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

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

The Brazilian Cerrado is one of the most important and threatened ecosystems in the world in terms of carbon fluxes, water resources, biodiversity, and social diversity including indigenous and other traditional communities. Agricultural expansion has become central to the Cerrado's regional development and global food security, with western Bahia state being one of the most active agricultural frontiers worldwide. However, climate change is altering the dynamics of agricultural production in the region whereby a hotter and drier climate is driving an increase in irrigation to guarantee the viability of large-scale commercial agriculture. 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 with accompanying software 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.

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 maps concerning 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.

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's aim is to provide 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 on 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 albedos (or reflectivity) 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.

Avoided Deforestation as a Climate Opportunity in the U.S.

Principal Investigator: Christopher Williams
Funding Agency: The Nature Conservancy

Forests are a globally-significant store of carbon, but this store is vulnerable to release from disturbance processes such as harvesting or fires that contribute to global warming. At the same time, intact forests serve as a major offset to rising CO_2 concentrations as forest growth becomes stimulated by rising CO_2 levels, enabling forests to absorb about one third of annual carbon emissions from fossil fuels and land use change. The balance of these processes is constantly changing and it varies widely from region to region. Expanding upon previous work in the New England states, this project will provide the data, scientific analyses, and communications needed for quantifying the full climate impacts (e.g., carbon emissions and forgone carbon sequestration) of potential forest loss in the conterminous U.S. This project will also extend the work to include the albedo-induced radiative forcing and associated CO_2 equivalent emissions that would be caused by avoiding forest conversion.

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.

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, **Robert Johnston** is investigating how the public perceives northeast U.S. shellfish aquaculture, and how new operations can be developed in ways that maximize public support. Other threats to food security result from the agricultural use of pesticides and other chemicals, with acute and chronic effects on agro-ecosystem services. For example,

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.

Climate Change

Food Security

Sustainable Communities

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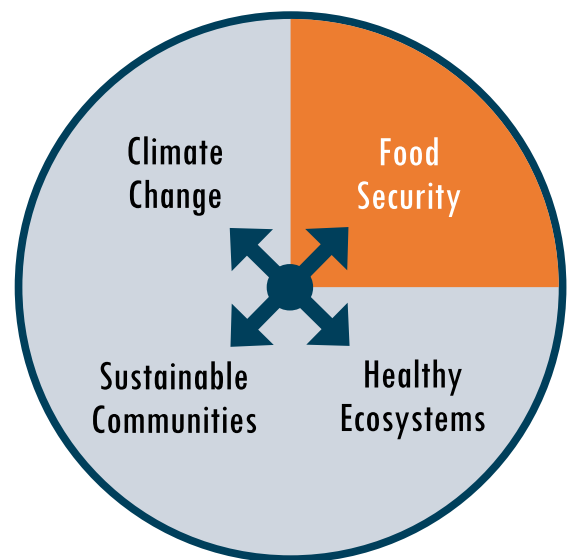
Informing Conservation Program Targeting for Cost-Effective Integrated Pollinator-Pest Management

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.

Enabling Crop Analytics at Scale: AGData Acceleration Facility

Principal Investigator: Lyndon Estes
Funding Agency: Farmerline and TetraTech

Smallholders in Africa often lack access to the information that can help boost their productivity and resilience to climate change. One key reason for this is the absence of data that accurately map where croplands are and what crops are grown on them. Making such maps is challenging because it requires the ability to use satellite imagery to accurately map the boundaries of smallholders' fields over large areas. This project will provide the cropland and crop type mapping capabilities that will allow provisioning of new agricultural extension services to farmers in Ghana, and demonstrate the ability to extend such services to Tanzania.

High Resolution Crop Analytics

Principal Investigator: Lyndon Estes
Funding Agency: World Food Programme

Partnering with Cloud to Street PBC, a flood mapping and intelligence company, this project uses complex machine learning methods and advanced cropland analytics to generate 3-meter high-resolution cropland datasets for the Republic of Congo. The work will initially focus on the Likouala, Cuvette, and Plateaux regions.

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.

Marsh Institue Director Robert Johnston (left) and Research Scientist Tom Ndebele (right) develop an online survey to understand public preferences for water quality improvements in New England.

Advancing Southern New England Shellfish Aquaculture through an Engaged Public and Next Generation Tools

Principal Investigator: Robert Johnston
Funding Agency: NOAA, National Sea Grant

The largest sector of the U.S. marine aquaculture industry is molluscan shellfish (e.g., oysters, clams and mussels), which accounts for more than 50% of total production. A large number of shellfish operations are concentrated within Connecticut, Rhode Island and Massachusetts, where significant growth potential exists and support where stakeholder efforts this important U.S. food production sector. One of the challenges facing future growth of the shellfish aquaculture industry in this region is siting aquaculture operations in the face of negative public perceptions and concerns highlighted by the media about environmental impacts and human use conflicts. Although in some cases these perceptions may be grounded in personal experience or accurate information, in other cases they may be motivated by a misunderstanding of the science or a past inability of aquaculture stateholders to speak to the concerns relevant to the public. This project examines public values and support for prospective shellfish aquaculture expansion programs that could be enacted region- or state-wide, as determined by alternative development strategies. The analysis also considers the systematic effect of different types of information on this support, and how values and perceptions differ across resident groups. The goal is to characterize how state and regional efforts to promote shellfish aquaculture can be designed and communicated in ways that best match residents' preferences—and hence optimize public support and value.

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. Through a combination of literature review and field research, 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. Specifically, 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.

Grains growing in a field in the Wollo region of Ethiopia (photo by Morgan Ruelle)

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 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. **Johnston** is also working with an international team of researchers to understand the damages caused by marine plastic pollution and identify the benefits of international cooperation. **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. Through these and other projects, Marsh Institute researchers are helping to maintain healthy ecosystems and conserve the supply of critical ecosystem services.

Climate Change

Food Security

Sustainable Communities

Healthy Ecosystems
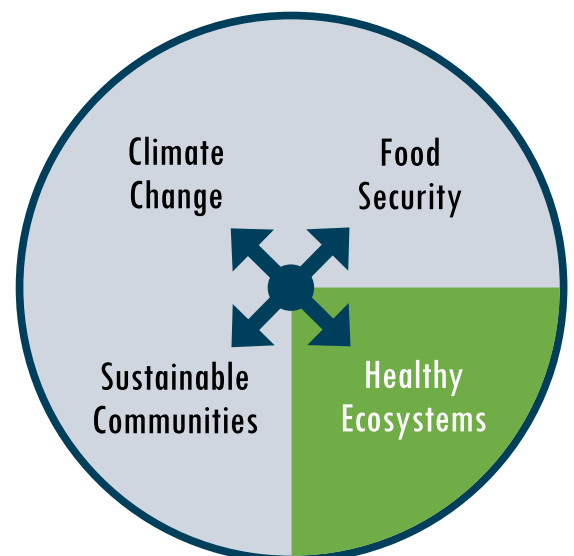
Marsh Institute Assistant Director Dana Bauer, recent graduate Lily Sartorius (BA Economics and International Development), and project team member Gwen Hoang (PhD Psychology, University of Oklahoma) meeting with farmers in the Red River Basin to discuss irrigation water use and voluntary adoption of conservation measures.

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 will be 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.

Collaboratively Restoring the Hardest Working River in America

Principal Investigator: Stefanie Covino
Funding Agency: U.S. Environmental Protection Agency

The Blackstone River's health and history are inextricably intertwined with its role as the birthplace of the Industrial Revolution. Plans at all levels prioritize restoration in this heavily impacted watershed. In addition, advocates have worked for decades to create fish passage, and there is finally traction with The Nature Conservancy creating permit-ready designs. However, without local capacity or training available, we lack practitioners to advance these complicated projects and there is little outreach or community buy-in to ensure lasting success. This project has two primary goals: (1) the Blackstone Watershed Collaborative will host a dam removal training workshop for ~150 participants, to share best practices, resources, and funding opportunities, and (2) the Collaborative will organize a series of technical stakeholder working group meetings for tribes, federal agencies, dam owners, and others working to advance fish passage.

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 will work 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 will collaborate 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 will develop 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.

The Economics of Marine Plastic Pollution: What are the Benefits of International Cooperation?

Principal Investigator: Robert J. Johnston
Funding Agency: Economic and Social Research Council

Plastic pollution is a global phenomenan with significant impacts on the marine and coastal environment. The physical properties and uncertainties associated with marine plastic, combined with the transboundary nature of the problem and a lack of international markets for control, has led to a lack of effective global actions to address the challenge. The aim of this research is to provide new insights on the economic damages associated with global marine plastic, the costs of reducing this pollution problem, and the net benefits of international coordination. The project, involving collaborators from University of Stirling, University of Glasgow, and Plymouth Marine Laboratory, is organized around four research questions: (1) What is the probable spatial distribution and movement of marine plastic and what are the associated ecological impacts? (2) What are the economic damage costs associated with marine plastic? (3) What are the costs of reducing both the stock and the flows of plastic into and within the marine North Atlantic environment? (4) What are the economic benefits of different levels of international cooperation in emissions reductions, and what does this imply about incentives to cooperate?

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 will develop and evaluate next-generation tools designed to meet these challenges. To develop these methods, the project team will leverage 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 will also evaluate 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.

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.

Land Use Change, Ecosystem Resilience, and Zoonotic Spillover Risk

Principal Investigator: Florencia Sangermano
Funding Agency: National Science Foundation

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

SUSTAINABLE COMMUNITIES AND GOVERNANCE

Public and private institutions and governance determine whether and how people are able to achieve sustainable levels of consumption and the resilience of 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. **Stefanie Covino** is working with the Blackstone Watershed Collaborative to facilitate the adoption of green infrastructure and other nature-based water quality strategies by stakeholder communities within the watershed. **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 10 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** and **Jennifer Safford-Farquharson** are working with Together for Kids Coalition and Edward Street Child Services to identify the factors driving the persistence of early education and care (EEC) deserts in three Worcester, MA neighborhoods.

Climate Change

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Healthy Ecosystems

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 $330,000 prestigious Belmont Forum award for a project entitled "Co-creating Sustainable Food Supply Chains" (Co-SFSC). The project involves researchers and practitioners who will work to assess and transform sustainability in their local food supply chains. The work will be conducted by five teams across the globe: Germany, Sweden, Taiwan, Thailand and Turkey. Brown and Vergragt are co-organizers of the fifth International SCORAI Conference, *Transforming Consumption-Production Systems Toward Just and Sustainable Futures*, co-convened with the European Roundtable on Sustainable Consumption and Production (ERSCP) and the University of Wageningen.

Incorporating Underserved Voices to Improve Capacity and Structure in the Blackstone Watershed Collaborative

Principal Investigator: Stefanie Covino
Funding Agency: Center for Large Landscape Conservation

With its headwaters located in Worcester, Massachusetts, the Blackstone River has a reputation as a heavily developed, urbanized river. The watershed includes 29 municipalities in Massachusetts and 10 municipalities in Rhode Island. The most heavily urbanized areas are located in Worcester, MA; Woonsocket, RI; Central Falls, RI; and Pawtucket, RI, all of which are home to mapped environmental justice populations. The Blackstone Watershed is also the ancestral homeland of the Nipmuc Nation, recognized by the Commonwealth of Massachusetts as a sovereign people. The Blackstone Watershed Collaborative exists to improve the health and resilience of the Blackstone Watershed communities and help meet the increasing challenges to water quality and climate change impacts. This project will improve organizational capacity and allow the collaborative to deeply engage with under-represented populations in the watershed, including Indigenous communities such as the Nipmuc Nation. Specifically, this project will inform establishment of an inclusive governance structure, creation of a five-year fundraising plan, and establishment of a list of priority projects.

Clark students assess the structural and environmental viability of culverts in the Blackstone River Watershed.

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 will initially focus on two communities with significant environmental justice populations: Worcester, MA and Woonsocket, RI.

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, will conduct 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.

Community Change Evaluation Projects

Principal Investigator: Margaret Post
Funding Agency: JPB Foundation and Innovation Network

Community Change is an organization that promotes racial justice and equity through education and advocacy programs. This ongoing project provides an outcomes-focused evaluation of Community Change's economic justice initiative, which is funded through grants from the JPB Foundation. The evaluation includes: interviews with key informants knowledgeable about the state of the national conversation on poverty and economic justice; case studies to delve deep into local initiatives and success factors; and evaluation and learning support for strategy development.

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 Department of Conservation and Recreation (DCR) in response to the Asian Longhorned Beetle (ALB) 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 with a specific focus in the context of proximity and overlap (if any) with 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.

David Henriques '22, M.S.-GIS '23, and Galen Oettel '21, M.S.-GIS '22, planting trees at the Hadwen Arboretum.

Blackstone River Urban Tree Planting to Enhance Bird Habitat and Communities

Principal Investigator: John Rogan
Funding Agency: National Fish and Wildlife Foundation

This project engages community members and schoolchildren in learning about, establishing, and supporting urban bird habitat through hands-on tree and shrub plantings in environmental justice neighborhoods near the Blackstone River (an American Heritage River and National Heritage Corridor). Tree Equity Scores show that the cities of Central Falls and Pawtucket (Rhode Island) are significantly lower in urban tree canopy and will be increasingly burdened with the heat island impacts of climate change. Residents of these cities also have significantly less opportunities to be connected to nature. Working with Groundwork Rhode Island, the project will plant 200 trees and dozens of additional shrubs to create 6-10 bird-friendly, highly visible demonstration sites near the river, coordinate volunteer resident planting days, train high school students on tree planting and maintenance, and develop an urban bird habitat and restoration curriculum for schoolchildren in the two cities. Student researchers will also model other urban tree benefits, such as heat island mitigation and flood protection, from the new bird demonstration plantings.

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.

Equity from the Start: Data to Improve Community Conditions Shaped by Structural Racism

Principal Investigators: Laurie Ross and Jennifer Safford-Farquharson
Funding Agency: Robert Woods Johnson Foundation

High quality early education and care (EEC) ensures "equity from the start" by allowing families to work while also providing infants and young children with enriching environments for brain, body, and social development. The Child Opportunity Index (COI) centers equity and makes structural racism visible by measuring and mapping the conditions and quality of resources at the neighborhood level. Three neighborhoods in Worcester (Vernon Hill, Bell Hill, and Main South) have very low COI scores as compared to other zip codes in the city and Massachusetts. These three neighborhoods also have the highest number of infants born and the largest waitlists for subsided EEC vouchers in Worcester, making them "EEC Deserts" and a clear racial and economic justice issue. Working with Together for Kids Coalition and Edward Street Child Services, this project seeks to answer the following questions: (1) What factors drive the persistence of EEC deserts in the Vernon Hill, Bell Hill, and Main South neighborhoods? (2) What resources do families in these neighborhoods rely on to take care of their young children? (3) What barriers do families face when attempting to access formal EEC? (4) What are the systemic barriers to providing EEC in these three neighborhoods? The resulting Data Dashboard will be used by Worcester's Governance Council for Children, Youth, and Families and other stakeholders to: (1) link to statewide EEC advocacy efforts such as Common Start; (2) bring needed partners to the table; and (3) create solutions that fill EEC gaps in licensable and sustainable ways.
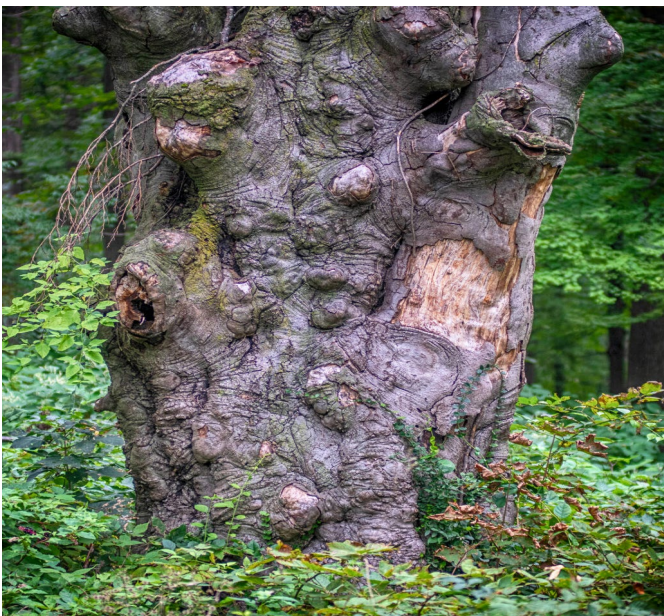
Safe and Successful Youth Initiative Project East

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 Worcester's Eastside 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.

The Marsh Institute is home to several partner facilities including research centers and labs, stakeholder education and outreach programs, and a research library all focused on supporting Clark University's extensive environmental academic and research programs, as well as the broader community, to foster local and global long-term environmental sustainability and human well-being. The **Blackstone Watershed Collaborative**—a network of nonprofits, universities, businesses, and others seeking to improve the health and resilience of the watershed—convenes stakeholders and offers technical assistance, outreach, and educational materials. The **Humanitarian Response and Development Lab** is a development and humanitarian assistance research and implementation lab that collaborates with global partners such as the World Bank and Red Cross Climate Center. The **Clark Center for the Study of Natural Resource Extraction and Society** promotes the collaborative efforts of Clark faculty and students on extractive industries, infrastructure investment, energy, and agroindustry. The **Jeanne X. Kasperson Research 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 Marsh Institute also collaborates with other research centers and labs at Clark University including **Clark Labs**, which develops innovative and customized geospatial research tools, the **Agricultural Impacts Research Group**, which focuses on how agricultural development can be achieved with lower environmental and social costs, the **Biogeosciences Research Group**, which explores how earth's biosphere responds to natural and human perturbations such as drought events and forest fires, and the **Polar Science Research Laboratory**, which investigates linkages between land surface, ice cover, oceans and the atmosphere in polar regions.

CENTERS AND PROGRAMS

BLACKSTONE WATERSHED COLLABORATIVE

The Blackstone Watershed Collaborative is a network of nonprofits, universities, businesses, and others seeking to improve the health and resilience of the watershed which spans 48 miles and 39 communities from Worcester, MA to Pawtucket, RI. The Blackstone River and its watershed have been vital to the ecological, social, and economic health of the region for centuries. Along with the Taunton River, the Blackstone provides freshwater to the Narragansett Bay downstream and supports ecological health through large intact forests and cold-water fisheries as well as thriving commercial and recreational benefits such as fishing, kayaking, and biking. Local river advocates have devoted tireless efforts to address the watershed's industrial past, ongoing urbanization, and climate change impacts. Despite this progress, work is still required to assure a healthier and more resilient watershed over the coming years.

Caleigh McLaren '22, MS ES&P '23 (left), restoration coordinator, and Stephanie Covino, MS ES&P '15 (right), program manager, at the Slater Mill Dam, one of a series of dams along the Blackstone River which inhibits the return of fish upstream to spawn and feed within the river's marshy areas. The Collaborative is working with Indigenous tribes, local agencies, and other partners to restore fish passage along the river.

The Blackstone Watershed Collaborative was established in 2021 to convene stakeholders throughout the bi-state watershed and offer technical assistance, outreach, educational materials, and networking to advance the priority goals of the *Blackstone River Watershed Needs Assessment Report*. The Collaborative acts as an umbrella organization to facilitate and coordinate the work of over 140 partner organizations including watershed associations, land trusts, universities, federal/state/local agencies, consultants, and others to share the most recent data, publications, tools, and resources. A major part of the program's effort is focused on matching priority projects with available funding.

Located in the Marsh Institute, Program Manager **Stefanie Covino** (right) leads the effort to create a thriving and sustainable Blackstone Watershed

Collaborative that supports restoration activities, develops communication and messaging, educates decision-makers, and promotes new programs and policy for the benefit of all that work, live, and recreate in the watershed. More information can be found on the program's website (www.blackstonecollaborative.org).

HUMANITARIAN RESPONSE AND DEVELOPMENT LAB

The Humanitarian Response and Development Lab (HURDL) is a development and humanitarian assistance research and implementation lab. Led by **Ed Carr**, HURDL scientists and student researchers are engaged in projects that range from policy development to project design and implementation. This diverse portfolio of activities is unified by a shared belief that the challenges we see in the Global South are products of various forms of risk and uncertainty that limit the potential for locally generated innovations that could change the lives of the poor. HURDL collaborates with many different organizations including the U.S. Agency for International Development, the World Bank, the Red Cross Climate Center, and the Climate Services Partnership, among others, creating a broad network of experience and expertise to inform its work. More information can be found on the lab's website (www.hurdl.org).

CENTER FOR THE STUDY OF NATURAL RESOURCE EXTRACTION AND SOCIETY

The Clark Center for the Study of Natural Resource Extraction and Society (Extractives@Clark) promotes the collaborative efforts of Clark faculty and students on extractive industries, infrastructure investment, energy, and agroindustry. Center research—led by Professors **Denise Humphreys Bebbington** (IDCE), **Anthony Bebbington** (Geography) and **John Rogan** (Geography)—involves policy and practical engagements with philanthropic, non-governmental, and public sector bodies. For example, research into the effects of extractive industry and large-scale infrastructure on forest cover and human rights in the Amazon, Central America, Mexico and Indonesia involved Clark researchers in direct discussions with the Climate and Land Use Alliance regarding the implications of their findings for the Alliance's work. Researchers at the Center have also worked closely with Oxfam on elements of its Extractive Industries program, advising on overall global and Latin American strategy, and conducting research designed to feed into program and policy design in Honduras, Peru and East Africa in particular. This past year, the center hosted a seminar series and a brown-bag lunch forum covering various extractives related issues. More information can be found on their website (www.extractivesatclark.org).

JEANNE X. KASPERSON RESEARCH LIBRARY

The Jeanne X. Kasperson Research Library is dedicated to higher learning and to supporting those who seek to expand their knowledge. The primary mission of the library is to support Clark University's extensive environmental research and global change programs. This includes but is not limited to programs conducted under the aegis of the Marsh Institute, the Graduate School of Geography, and the Department of Sustainability and Social Justice (SSJ). The library is committed to serving the educational functions of Clark University and the broader community in order to further research related to socio-environmental sustainability. 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. Most recently, the library became 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 holds has more than thirty-five thousand volumes related to it's focus areas, and computer and internet resources. Library Director **BJ Perkins** (insert) and other library staff provide personalized research assistance.

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 2023, Marsh Institute grants and endowments supported eight undergraduate students, thirty-six graduate students, one post-doctoral fellow, and multiple full-time, non-faculty research scientists.

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.

During the summer of 2023, the HERO team returned to tree surveying in Worcester—focusing on the Burncoat and Greendale neighborhoods that experienced extensive tree removal in 2010-2012 in response to the Asian Longhorned Beetle Outbreak. The HERO team re-surveyed the health of trees in residential yards that had been surveyed ten years prior. The work also involved interviews with residents to gauge their perceptions about tree care and neighborhood resilience. The HERO fellows

Adlai Nelson, Aaron Richmond-Crosset, and Professor Deb Martin interview a Worcester resident about tree health in her neighborhood.

presented their results to stakeholders at the end of the project. The outcome contributed important first-of-a-kind information to the Massachusetts Department of Conservation and Recreation and its partners to help with current and future tree planting efforts in Worcester, and other Greening the Gateway Cities sites.
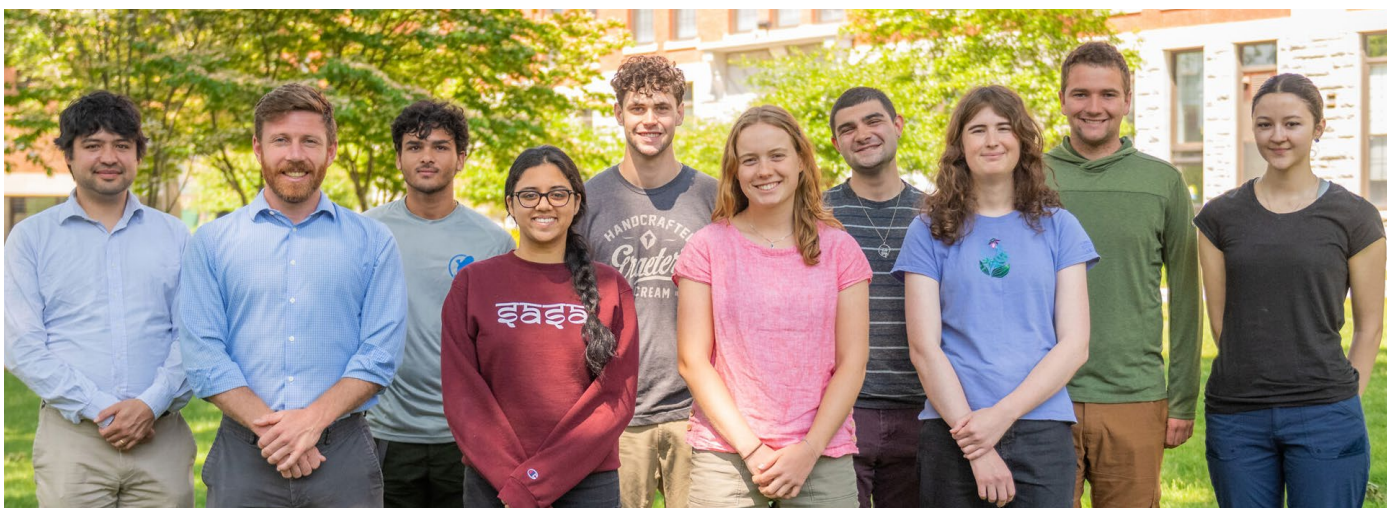
2023 HERO Fellows (left to right): Nick Geron (team manager), Jason Andrews (graduate mentor), Ramón Colón, Amritha Pai, Aaron Richmond-Crosset, Ksenia Smart, Caleb Kluchman, Adlai Nelson, Tanner Honnef, and Clio Bate.

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.

Oluwole Olakunle Ajayi (MA International Development)

Gender Equality: The Pathway to Food Systems Security, Economic Sustainability, and Ecological Preservation

Faculty Mentor: Jude Fernando
A gender approach to food security can enable shifts in gender power relations and assure that all people, regardless of gender, benefit from and are empowered by development policies and practices to improve food security. In 2017, the United States had 1.2 million female producers, accounting for 36 percent of the country's 3.4 million producers. This research project focused on women owned farms in New York, Massachusetts and Maine to improve our understanding of how these farms contribute to sustainable food security, economic interdependence, and climate change mitigation.

Josaphat Barcenas Argueta (MA International Development)

Green Economy: Its Role in Lithium Extraction and Climate Change

Faculty Mentor: Denise Humphreys Bebbington
The dilemma of pursuing extractive industry for economic growth while limiting it for sustainability has sparked many conversations and debates about current development strategies and their effects on our environment. The UN Environment Programme and other world actors have introduced "the green economy" to tackle this issue; however, these technologies are not entirely "green" as they are reliant on and create new demand for precious metals such as lithium. This research project analyzed the debates around lithium mining in Chile and the emerging socio-environmental conflicts in the local communities.

Abby Beilman (BA/MA Environmental Science and Policy)

Chromophoric Dissolved Organic Matter in the Blackstone River Watershed: Winter to Spring Transitions

Faculty Mentors: Tim Downs and Karen Frey
Chromophoric dissolved organic matter (CDOM) is the optical/viewable fraction of dissolved organic matter and can be used as a proxy for organic matter quantity and quality. Depending upon environmental conditions, CDOM can degrade to atmospheric CO_2, contributing to the production of a greenhouse gas that is an important component of ongoing climate change. This research project investigated the Winter-Spring changes in CDOM in the Blackstone River Watershed (BRW).

Andrea Cabrera Roa (PhD Geography)

Present Absences: In the Making of the Sovereign Territoriality through Indigenous Peoples in Isolation and in Initial Contact in the Peruvian Amazon

Faculty Mentors: Anthony Bebbington and Yuko Aoyama

This research used the 'Territorial Reserve Kugapakori, Nahua, Nanti and Others' and its surrounding communities, located in the Peruvian Amazon, as an emblematic case study to explore the ongoing debates among the Peruvian government, indigenous organizations, and civil society associations regarding the status of these indigenous peoples' collective rights to self-determination to remain in 'isolation' and/or to decide their own pace in initiating processes of 'contact' with the rest of society.

Pilar Delpino Marimon (PhD Geography)

Unbuilt Infrastructure Projects and the Use of Space in the Peruvian-Brazilian Border

Faculty Mentor: Anthony Bebbington

Infrastructure projects not only have impacts when they are built, they also generate impacts in their unbuilt phase. This research project examined the effects that unbuilt infrastructures have on how actors plan to use space in Western Amazonia, using the unbuilt Pucallpa, Peru – Cruzeiro do Sul, Brazil transboundary corridor as a case study. This research examined how the recurrent proposal of this corridor shaped ways in which state and non-state actors plan space for investment, protection of livelihoods, and regulation of natural resources.

Amanda Dye (BA Global Environmental Studies)

Transforming Waste Systems: An Exploration into How Urban Fungi Farming Can Reduce Waste, Address Food Insecurity in Low-Income Communities, and Provide Practical Agricultural Education

Faculty Mentor: David Hibbett

The Worcester Advisory Food Council found that the prevalence of hunger in Worcester is six times greater than the Massachusetts average and that one in three children in low-income neighborhoods live in a household that is facing food insecurity. Growing mushrooms in community gardens is one potential way to increase access to produce used in a variety of Asian and African cuisines. This project: (1) developed a method for converting cardboard waste into substrate for growing edible mushrooms, (2) revitalized a nearby community garden space for successful food production, and (3) provided educational and agricultural opportunities for local gardeners.

STUDENT RESEARCH IN HAWAI'I AND THE PACIFIC ISLANDS

Graduate student **Danielle Hall** (MSGIS '24; right) and faculty mentor Professor **Abby Frazier** (left) at a recent Pacific RISA (Research on Island Solutions for Adaptation) meeting in Hawai'i, where Hall presented her research exploring the use of a global climate dataset to predict precipitation in Guam and Tutuila. An Edna Bailey Sussman Fund Graduate Research Fellowship funded Hall's research.

STUDENT RESEARCH IN CENTRAL MEXICO

Master's students **Josaphat Barcenas-Argueta** (MS ES&P), **Milagros Becerra-Zambrano** (MS GIS), **Mattie Carroll** (MA ID), **Mónica Muñoz-Miranda** (MS GIS), **Fátima Oseida** (MA ID), **María Elena Salazar** (MS ES&P), and faculty mentor **Tim Downs** (Professor of Sustainability and Social Justice) conducting research in Mexico City and the surrounding region. The students, all fluent Spanish speakers, are spending six months in Central Mexico to explore the impacts of climate change on water supply and related social inequities.

STUDENT RESEARCH IN BRAZIL

Professor **Gil Pontius** (right) studied giant red parrots in Brazil with graduating Clark student **Nicholas Pontius** (BA '24) and incoming Clark student **Olivia Pontius** (BA '28).

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

YUKO AOYAMA
Geography

DANA BAUER
Marsh Institute

ANTHONY BEBBINGTON
Geography

ASHA BEST
Geography

HALINA BROWN
Marsh Institute

CYNTHIA CARON
SSJ

EDWARD CARR
SSJ

STEFANIE COVINO
Marsh Institute

MARK DAVIDSON
Geography

JON DENTON-SCHNEIDER
Economics

TIMOTHY DOWNS
SSJ

RONALD EASTMAN
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LYNDON ESTES
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ANITA FABOS
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SSJ

ROBERT JOHNSTON
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DOMINIK KULAKOWSKI
Geography

WILLIAM LYNN
Marsh Institute

DEBORAH MARTIN
Geography

JAMES MCCARTHY
Geography

JAMES MURPHY
Geography

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YELENA OGNEVA-HIMMELBERGER
SSJ

GUSTAVO OLIVEIRA
Geography

JIE PARK
Education

ROBERT (GIL) PONTIUS
Geography

MARGARET POST
SSJ

JOHN ROGAN
Geography

LAURIE ROSS
SSJ

RINKU ROY CHOWDHURY
Geography

MORGAN RUELLE
SSJ

JENNIFER SAFFORD-FARQUHARSON
SSJ

FLORENCIA SANGERMANO
Geography

PHILIP VERGRAGT
Marsh Institute

CHRISTOPHER WILLIAMS
Geography

DEBORAH WOODCOCK
Marsh Institute

JING ZHANG
Management

JUNFU ZHANG
Economics

MARSH INSTITUTE STEERING COMMITTEE

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

Denise Humphreys Bebbington
Research Associate Professor, Sustainability and Social Justice

Timothy Downs
Professor, Sustainability and Social Justice

Lyndon Estes
Associate Professor, Graduate School of Geography

Ellen Foley
Professor, Sustainability and Social Justice

Karen Frey
Professor, Graduate School of Geography

Robert Goble
Research Professor, George Perkins Marsh Institute

Deborah Martin
Professor, Graduate School of Geography

James Murphy
Professor and Director, Graduate School of Geography

Laurie Ross
Professor, Sustainability and Social Justice

Rinku Roy Chowdhury
Professor, Graduate School of Geography

Christopher Williams
Professor, Graduate School of Geography

EX-OFFICIO MEMBERS

Lisa Gaudette
Director, Sponsored Programs and Research

Dana Marie Bauer
Assistant Director, George Perkins Marsh Institute

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.

"Sipping from the Data Firehose: Insights from Bayesian Inference, Power Computing, and Generalization"

JEFFREY CARDILLE
Associate Professor
McGill University

"From Denial to Delay: Obstruction of Action on Climate Change"

J. TIMMONS ROBERTS
Ittleson Professor of Environmental Studies and Sociology, Brown University

"Deworming as HIV Prevention for Young Women: Evidence from Zimbabwe"

JOHN DENTON-SCHNEIDER
Assistant Professor
Clark University

"Acting on Climate Change Adaptation – When Science, Policy, and Practice Don't Align"

LISA SCHIPPER
Professor
University of Bonn

"The Climate Crisis: How Did We Get Here and What Can We Do?"

GILBERT METCALF
John DiBiaggio Professor of Citizenship and Public Service and Professor of Economics, Tufts University

"Decarbonisation and its Discontents: A Critical Justice Perspective on Four Low-Carbon Transitions"

BENJAMIN SOVACOOL
Professor in the Department of Earth & Environment, Boston University

"Sustainable and Transparent Soy Supply Chains? A Political Ecology Critique of Neo-Malthusianism and Eco-Modernization Theory"

GUSTAVO OLIVEIRA
Assistant Professor
Clark University

"Understanding Requirements for IRB Approval and Exemption Under the Revised Common Rule: How to (Without Frustration) Compose a Successful Protocol for Human Subjects Research"

ROBERT JOHNSTON
Director of the George Perkins Marsh Institute and Professor of Economics Clark University

LINDA COTE
IRB and Grants Coordinator
Clark University

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.

Edward Carr is a lead author on the Intergovernmental Panel on Climate Change's Sixth Assessment Report.

Edward Carr serves as the Climate Change Adaptation Adviser on the Global Environmental Facility's (GEF) Scientific and Technical Advisory Panel.

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

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

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

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

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

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

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

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

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

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

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

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

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 since 1925.

AWARDS AND RECOGNITIONS

Robert (Gil) Pontius was selected as a 2022-2023 Fulbright Scholar to share his expertise in analyzing digital maps with scientists, professors, and students in Porto Alegre in Southern Brazil.

Stefanie Covino was presented with the 2023 River Advocate Award from the Massachusetts Rivers Alliance.

Stefanie Covino received the John H. Chaffee Heritage Award from the Blackstone River Valley National Heritage Corridor, which honors the late Senator's legacy and recognizes individuals who have worked on projects that promote cultural heritage, environmental conservation, and the quality of life in the Blackstone River Valley.

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 colleague Balaji Parthasarathy published the chapter "Governing frugal innovation for sustainable development: The hybrid domain" in *Handbook on Frugal Innovation.*

Timothy Downs, Ravi Hanumantha (PhD), Yelena Ogneva-Himmelberger, and **Morgan Ruelle** published the chapter "Illustrating Climate-Change Resilience Engineering: Conceptual design of water supply and wastewater/stormwater system for the Mexico City-Toluca Social-Hydrological Region" in *Development Engineering in Practice: Case Studies from Around the World.*

Anita Fábos and colleagues published the article "Bridging and Breaking Silos: Transformational Governance of the Migration-Sustainability Nexus" in the *Proceedings of the National Academy of Sciences.*

Giulio Farolfi (PhD Economics) and **Robert Johnston** published the article "Understanding Public Preferences for Molluscan Shellfish Aquaculture: The Role of Production Technology and Environmental Impacts" in *Marine Resource Economics.*

Karen Frey is lead author of "Arctic Ocean Primary Productivity: The response of marine algae to climate warming and sea ice decline," a chapter in the *2023 Arctic Report Card* released by NOAA.
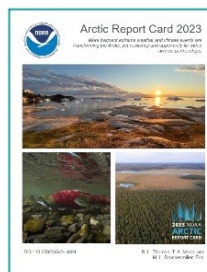
Nick Geron (Phd '23), **Deborah Martin, John Rogan,** and **Marc Healy** (Phd '23) published the paper "Resident's roles as environmental policy actors using an urban governance framework: A case study of a tree planting program" in *Cities.*

Robert Johnston, Tom Ndebele and colleagues published the article "Spatial dimensions of water quality value in New England river networks" in the *Proceedings of the National Academy of Sciences.*

Dominik Kulakowski and colleagues published the article "Reduced Fire Severity Offers Near-Term Buffer to Climate-Driven Declines in Conifer Resilience Across the Western United States" in the *Proceedings of the National Academy of Sciences.*

James Murphy and colleagues co-authored the book *The Urban Question in Africa: Uneven Geographies of Transition*, which examines the imbalanced and contested nature of the ongoing urban transition of Africa.
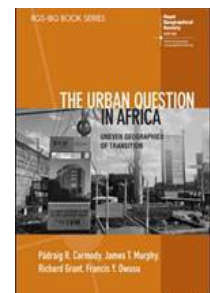
Sarah Lerman-Sinkoff (PhD '23), **John Rogan**, and colleagues published the article "Become a Gas Leak Detective! Evaluating a multigenerational citizen science program for connecting distribution pipelines to energy justice" in *Energy Research and Social Science.*

Florencia Sangermano and colleagues published the article "Protecting Brazilian Amazon Indigenous territories reduces atmospheric particulates and avoids associated health impacts and costs" in *Nature's Communications Earth and Environment.*

Deborah Woodcock presented "The Piedra Chamana Petrified Forest, Sexi, Cajamarca: A scientific resource of global importance" to the College of Engineers in Cajamarca, Peru.

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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