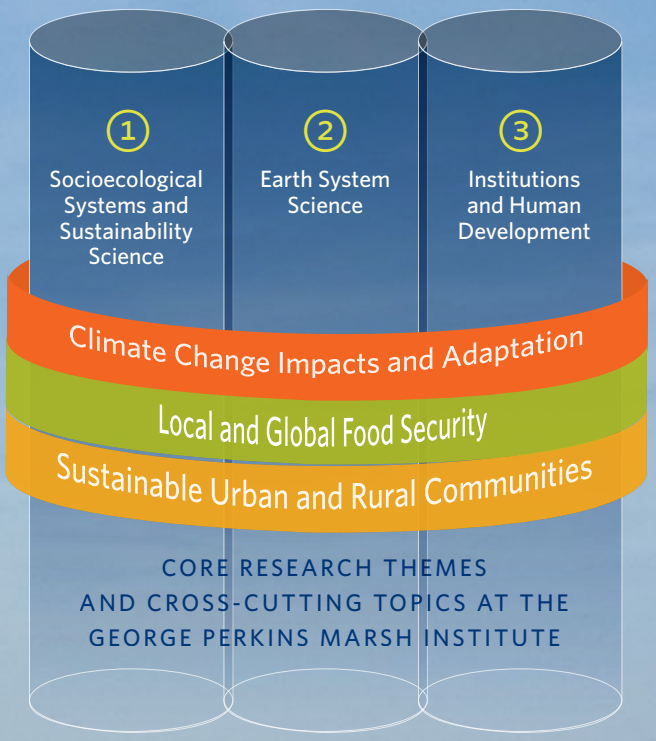
SUSTAINABLE ENVIRONMENTS
FOR THE PUBLIC GOOD

CLARK UNIVERSITY

GEORGE PERKINS MARSH INSTITUTE

Highlights, Accomplishments and Impacts
of the George Perkins Marsh Institute
Annual Report 2016-17

GROUNDED IN NEARLY A CENTURY OF APPLIED RESEARCH AT CLARK UNIVERSITY, THE GEORGE PERKINS MARSH INSTITUTE studies the socio-ecological, technical, institutional and other systems through which humans interact with their surrounding environments. Working within a collaborative agenda, the Institute coordinates resources from Clark University and elsewhere to study human transformation of the environment and responses to this change. The Institute promotes collaborative, systems-based research that challenges traditional disciplinary boundaries to address some of the most pressing challenges facing today's world. The Institute's research covers three core research themes linked by cross-cutting topics. Our primary research themes include: 1 Socioecological (or human-environment) Systems and Sustainability Science, 2 Earth System Science, and 3 Institutions and Human Development. Cross-cutting topics reflect areas of particular importance that are studied through these scientific lenses. **Recent cross-cutting topics include:** Climate Change Impacts and Adaptation, Local and Global Food Security, and Sustainable Urban and Rural Communities.



CORE RESEARCH THEMES AND CROSS-CUTTING TOPICS AT THE GEORGE PERKINS MARSH INSTITUTE

HIGHLIGHTS, ACCOMPLISHMENTS AND IMPACTS OF THE GEORGE PERKINS MARSH INSTITUTE

ANNUAL REPORT 2016-17

The George Perkins Marsh Institute studies and solves real-world problems from local to global scales. Our work makes a difference through advancements in basic and applied science, direct engagement with decision makers and the public, provision of learning opportunities for students, and science communication to multiple audiences. We also promote the success of other departments, centers and institutes across Clark University who share our commitment to science in the public interest. The Institute is set apart by its unique focus on sustainability science and social welfare as relevant to a wide spectrum of challenges ranging from pollinator declines to urban youth violence.

The Marsh Institute is home to approximately fifty research faculty and staff, many of whom have joint appointments with other Clark University departments. Grants to Institute researchers support work across a wide range of topics from examining the impacts of melting sea-ice in the Arctic to developing strategies for climate-resilient agriculture in Africa. We work with partners that range from individual farmers and households to entire communities to organizations working at national or global scales. Key themes include climate change impacts and adaptation, ecosystem service provision and conservation, human livelihood protection, and sustainable urban and rural communities.

The Marsh Institute is one of the most productive hubs for research activity at the University, regularly generating at least one-third of the University's external research funds. New research projects initiated during 2016-17 address topics that include: managing pollination and pest control in agriculture, assessing the relationship between extractive resource infrastructure and deforestation, the role of socioeconomic and climate change for armed conflicts, residential nitrogen dynamics in coupled natural-human systems, modeling responses of linked watershed-marsh-estuarine systems, preventing gang initiation among high-risk youth, exploring alternative residential landscape futures, and developing new tools to facilitate use of NASA's Carbon Monitoring System data products. External support for these and other Institute activities comes from federal, state, local and international grants, private donations, foundations, and other sources.

In addition to our funded research activities, the Institute convenes workshops, conferences and seminars involving scientists, students, stakeholders and decision makers. Institute researchers play important roles in national and international science advisory bodies such as the US National Academy of Sciences and US EPA Science Advisory Board, as well as regional boards and panels such as the Narragansett Bay Estuary Program Steering Committee and Science Advisory Board. These and other advisory, outreach and communication activities help ensure the impact of the Institute's work, and connect Institute researchers to local, regional, national and international decision-making.

The Institute also provides research opportunities for Clark graduate and undergraduate students. Dozens of students participate in the Institute's externally-funded research projects each year. Dedicated programs for student research include the Polaris Projects in the Siberian Arctic; the Human-Environment Regional Observatory (HERO) research program in Massachusetts; the Albert, Norma and Howard '77 Geller Research Grants; and the NOAA Fellows program. Building on programs such as these, the Institute plays an important role in the Liberal Education and Effective Practice (LEEP) initiative at Clark, providing expertise as well as opportunities for student research within our many communities of practice. We also support outside students and scholars who visit the Institute on a short- or long-term basis, often to work with resident researchers on collaborative research projects.

Among the facilities, offices and centers that comprise the Institute is the Jeanne X. Kasperson Library, whose holdings include one of the most extensive research collections in North America on risks, hazards and global environmental change. We work closely with numerous departments and institutes across Clark University, including the Graduate School of Geography, the Department of Economics, the Department of International Development, Community and Environment (IDCE), the Mosakowski Institute for Public Enterprise, and Clark Labs.

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.

SOCIOECOLOGICAL SYSTEMS AND SUSTAINABILITY SCIENCE

Among the most pressing challenges facing human society are those involving relationships between humans and natural systems. Researchers at the Marsh Institute were among the pioneers of socio-ecological sustainability science, and the Institute remains a world leader in this critical area of work. This research requires multidisciplinary perspectives that recognize the importance of uncertainty, risks, and resilience. Researchers study such diverse topics as climate change impacts and adaptation, ecosystem services, coastal hazards and agricultural systems. We work with decision makers to transform knowledge into action. This core research theme represents one of the largest and most diverse areas of research at the Institute, and one in which large, multi-institutional projects have been successful.

A Cross-site Comparison of Salt Marsh Persistence in Response to Sea-level Rise and Feedbacks from Social Adaptations

Principal Investigator: Robert J. Johnston
Funding Agency: National Science Foundation

Salt marshes are intertidal habitats that provide a buffer for coastal communities against sea-level rise and are valued for many other ecosystem services, including wildlife habitat, nutrient cycling, and recreation. However, projected rates of sea-level rise and increased human modification of coastal watersheds and shorelines may cause extensive marsh losses across the U.S. This multi-disciplinary, collaborative research project examines the comparative vulnerability of salt marshes to sea-level rise in three U.S. Atlantic coastal Long-Term Ecological Research (LTER) sites that vary with respect to sediment supply, tidal range and human impacts. The research also addresses how feedbacks from potential adaptations influence marsh vulnerability, economic benefits and costs, and practical management decisions.

This collaborative, $2 million Coastal Science, Engineering, and Education for Sustainability (Coastal SEES) project addresses the broad interdisciplinary question "How will feedbacks between salt marsh response to sea-level rise and human adaptation responses to potential salt marsh loss affect the overall sustainability of the combined socio-ecological system?" During 2016-17, Marsh Institute researchers led efforts to study qualitative and quantitative aspects of the ecosystem services provided by salt marshes, in coordination with partners from Florida Atlantic University and the three participating LTERs.

Linking Coastal Adaption Portfolios to Salt Marsh Resilience and Ecosystem Service Values

Principal Investigators: Robert J. Johnston and Dana Marie Bauer
Funding Agency: National Oceanic and Atmospheric Administration

This project is an international and interdisciplinary collaboration led by Marsh Institute researchers, with collaborators at the Virginia Institute of Marine Sciences and Monash University in Melbourne,

Australia. Tidal marshes are one of the most common natural features used for coastal adaptation (protecting the coast from flooding and storms), and are frequently promoted for their ability to support coastal resilience and valued ecosystem services. However, marsh resilience depends on the complex interplay of natural dynamics and human actions. The preservation of marsh transgression zones is among the most critical of these actions; transgression zones are undeveloped coastal areas that allow marshes to migrate inland as sea levels rise, hence promoting marsh resilience. Yet the effect of these zones depends on uncertain sea level rise (SLR) and natural dynamics, which determine how, when and where marshes migrate. These uncertainties and dynamics imply that diversified portfolios of adaptation actions (e.g., preserving different types of transgression zones in different areas) are best able to ensure the resilience of marsh areas and resulting social values. This project will develop tools that address a central coastal adaptation question: Considering the influence of SLR and other uncertain factors on tidal marsh resilience, how can information on biophysical dynamics and economic benefits and costs be coordinated to identify optimal, diversified portfolios of adaptation actions that best sustain marsh resilience and ecosystem service values? The project will develop and illustrate the methods and resulting insights using data from multiple Long Term Ecological Research (LTER) sites.

Exploring the Trends, Science, and Options of Buffer Management in the Great Bay Watershed

Principal Investigators: Robert J. Johnston and Dana Marie Bauer
Funding Agency: National Estuarine Research Reserve Science Collaborative

The US EPA recently designated New Hampshire's Great Bay Estuary (GBE) as an impaired waterbody, with multiple symptoms of nitrogen pollution. Sixty-eight percent of this nitrogen load originates from nonpoint sources including stormwater runoff, fertilizers, and septic systems—all of which could be mitigated through the coordinated use of buffer zones in the GBE region. Managing buffer zones wisely is also a recognized way of protecting (or avoiding) infrastructure in areas currently, or projected to be, impacted by sea level rise, coastal surge, and riverine flooding. This project is a partnership between multiple organizations seeking better understanding of the natural and social dimensions of riparian buffer management. The goal is to enhance stakeholder capacity to make informed decisions related to the protection and restoration of buffers around GBE. In support of this goal, the project conducts an Integrated Assessment focused on the following policy question: What are the potential regulatory and non-regulatory options for protecting and restoring buffer zones around New Hampshire's Great Bay? Marsh Institute researchers are leading the economic component of this interdisciplinary effort, applying cutting-edge methods in meta-analysis, benefit transfer and ecosystem service valuation to predict the value of riparian buffer enhancements in the GBE region.

Estimation of Spatially Explicit Water Quality Benefits throughout River Systems: Development of Next Generation Stated Preference Methods

Principal Investigator: Robert J. Johnston
Funding Agency: US Environmental Protection Agency

Stated Preference (SP) methods are survey-based approaches to calculate the economic value of environmental improvements, and provide the only means to measure total use and nonuse willingness to pay (WTP) for water quality change. Yet water quality has multiple characteristics that pose challenges for WTP estimation: water quality can vary spatially and temporally, the role of small streams is often under-appreciated, and water quality benefits are often realized through direct and indirect effects on other ecosystem services valued by different user and nonuser groups. This large, multi-year interdisciplinary project will develop and evaluate a next generation approach to SP valuation, Free-form Choice Experiments (FCEs). FCEs restructure the way that WTP is elicited and estimated, hybridizing traditional survey methods with online labor pool survey techniques and Bayesian econometrics. The approach is developed to estimate use and nonuse WTP for linked water quality and ecosystem service improvements across river networks. The project will advance the methods used by government agencies and others to calculate the benefit of water quality improvements to society. The project is led by Marsh Institute director Robert Johnston, with collaborators from the University of New Hampshire, Virginia Tech, and Abt Associates.

Coastal Hazards and Northeast Housing Values: Implications for Climate Change Adaptation and Community Resilience

Principal Investigator: Robert J. Johnston
Funding Agency: National Oceanic and Atmospheric Administration/Northeast Sea Grant Consortium

This project combines coastal hazards, property value and other data with economic models to answer three questions central to northeast US coastal adaptation: (1) How do property values in northeast communities respond to coastal hazards? (2) How do property values respond to adaptation actions undertaken by states, municipalities or homeowners and developers? (3) What do results imply for future property values and tax bases in northeast communities, under alternative climate change scenarios? This project develops and applies rigorous economic methods that, when integrated with natural science data and projections on coastal vulnerability, enable stakeholders and decision makers to evaluate property value and tax base impacts of climate change adaptation across northeast states and communities. The result is information quantifying the economic consequences of coastal vulnerability and adaptation. The project is implemented in coordination

with partners and communities involved in northeast coastal adaptation including the Wells National Estuarine Research Reserve (NERR), Great Bay NERR, Waquoit Bay NERR, and The Nature Conservancy in Connecticut. Project results will enhance the ability of communities to choose adaptations with desirable economic consequences. A workshop under this project during 2017 brought together a wide range of decision makers and stakeholders from across New England to discuss economic aspects of coastal climate adaptation.

Multi-scale Coupled Natural Human System Dynamics of Nitrogen in Residential Landscapes

Principal Investigator: Robert J. Johnston
Funding Agency: National Science Foundation

This $1.6 million project is a multi-year, interdisciplinary partnership between institutions including the George Perkins Marsh Institute at Clark University, the City University of New York (CUNY), Cornell University, the U.S. Forest Service Northern Research Station, the University of North Carolina, Florida Atlantic University, the University of Rhode Island, and others. Urban, suburban and exurban ecosystems are increasing in area across the U.S. There is significant concern and uncertainty about the environmental performance of these ecosystems, especially the extent to which they export nutrients to receiving waters, and how this net export is related to human behavior. Challenges are especially evident in the management of residential landscapes dominated by grass lawns. This project will apply social science theories related to institutional and behavioral change along with formal economic models of household behavior to address questions about human decision-making related to management of residential ecosystems at multiple scales (parcel, neighborhood, watershed, and municipality). These social investigations will be formally predicated on explicit results from biophysical studies of nitrogen and water fluxes. The project will address questions about how flows of information between biophysical and social science domains, either alone or in combination with other policy changes, can promote or constrain the adoption and effectiveness of measures to improve the environmental performance of urban ecosystems at these multiple scales. Results will help public and private decision-makers better understand how to manage the environmental impacts of lawns.

Targeted Conservation Contracts to Enhance Agricultural Best Management Practices

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

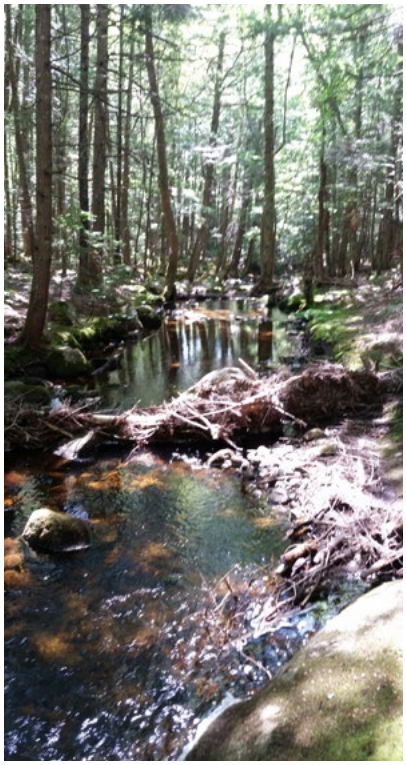
This interdisciplinary project is a partnership between economists at the Marsh Institute and both economists and agronomists at the University of Delaware. The United States spends billions on state and federal policies encouraging farmers to implement best management practices (BMPs) through conservation contracts. BMP programs seek agricultural objectives, such as increasing crop prices by reducing production, and environmental objectives, such as providing wildlife habitat. Yet existing research provides little insight on the design of more flexible BMP contracts that capitalize on farmer differences and desires to enhance cost-efficiency and agri-environmental outcomes. The goal of this project is to improve the cost-effectiveness of policies used to promote BMPs on farms in the U.S. The research will inform the development of targeted, cost-effective conservation contracts that can be used by governmental agencies to incentivize agricultural BMPs, focusing on programs to encourage the use of cover crops. It will produce information to enable the design of flexible conservation contracts that can be used to optimize environmental benefits, farmer adoption, or acres enrolled. These innovative contracts will help U.S. agriculture remain competitive while balancing production and sustainable agri-environmental benefits.

Navigating the Trade-off between Pest Management and Pollinator Conservation

Principal Investigator: Dana Marie Bauer
Funding Agency: US Department of Agriculture

Neonicotinoid insecticides ('neonics') experienced an exponential rise in use on farmland over the past two decades and are now the most widely used insecticides in the world. Unfortunately, the attributes that make neonics versatile and powerful pest management tools also make non-targeted insects vulnerable to their effects. Specifically, neonics have been implicated as a factor in sudden die-offs of managed honeybee hives and long term declines in native bee populations. Thus, farmers growing pollinator-dependent crops, which represents a large fraction of all fruits and vegetables, are confronted with a potential trade-off between two competing aspects of crop production: effective pest suppression and successful pollination. The overarching goal of this $3.6 million, 5-year project is to develop holistic pest-pollinator joint management regimes that are effective, profitable, and sustainable. Specifically, this project will: identify insecticide management strategies that simultaneously optimize pest suppression while minimizing non-target exposure to pollinators; determine the consequences of neonic exposure for honey and wild bee health; and assess the ecological and socioeconomic trade-offs among pollinators, pests, crop yield, and farm profitability resulting from alternative pest

management regimes. This interdisciplinary research partnership involves collaborators from Purdue University, Michigan State University, Ohio State University, and the University of New Hampshire. Marsh Institute Assistant Director Dana Bauer will lead the economic analysis of grower preferences, profitability, and decision-making.



Conserving Small Natural Features with Large Ecosystem Functions in Urbanizing Landscapes

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

Many landscapes have small natural features whose importance for biodiversity or ecosystem services belies their small size. Management challenges for these areas include: uncertainties over their location and contributions to ecosystem services; tensions between private property rights and public rights to environmental protection; and the spatial mismatch between the broad, regional accrual of beneficial services and the concentrated, local costs of protection. Conservation strategies are undermined by limited scientific knowledge, especially of mechanisms that link ecological and social processes. In the forested landscapes of the northeastern U.S., small, seasonally inundated wetlands (vernal pools) emerge as an excellent model system to study the dynamics of small natural feature management. This project brings together a team of ecologists and economists from multiple sub-disciplines and institutions to: (1) explore the biophysical and socioeconomic components of one type of small natural feature, vernal pools, as a coupled-systems model for management of these features; (2) improve strategies for conserving vernal pools and other small natural features with large significance; and (3) share results with local and state-level stakeholders and policy makers.

Promoting Sustainable Consumption Research and Action

Principal Investigators: Halina Brown and Philip Vergragt
Funding: Multiple Foundations and Other Grants

Marsh Institute researchers Philip Vergragt and Halina Brown are at the forefront of SCORAI, an international network of professionals working to address challenges at the interface of material consumption, human fulfillment, lifestyle satisfaction, and technological change. Vergragt and Brown, along with Maurie Cohen of the New Jersey Institute of Technology, were co-founders in 2008 of SCORAI, the Sustainable Consumption Research and Action Initiative. SCORAI network participants seek to advance and disseminate knowledge, forge connections, and contribute to policy dialogues and practices involving these interrelated issues. Scholars working in the field of sustainable consumption are seeking to better understand the connections between material consumption and societal wellbeing and to chart transition pathways toward a more sustainable future. SCORAI is the largest organizational assemblage of individuals working on sustainable consumption in North America. Vergragt and Brown contributed to a SCORAI-Europe workshop "Sustainable Consumption and Social Justice in a Constrained World" in Budapest and Vergragt was the main organizer of a SCORAI workshop "Bridging Research and Action and Policy" in Washington, D.C. The two scholars lectured extensively on topics related to sustainable consumption.

LTER/PIE: Dynamics of Coastal Ecosystems in a Region of Rapid Climate Change, Sea-level Rise, and Human Impacts

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

Over the last 30 years, surface seawater temperatures in the adjacent Gulf of Maine have risen at three times the global average, rates of sea-level rise have accelerated, and precipitation has increased. Coupled with these changes in climate and sea level are substantial changes within the rapidly urbanizing watersheds that influence water, sediment, and nutrient delivery to marshes and estuaries. The Plum Island Ecosystems (PIE) Long Term Ecological Research (LTER) site is developing a predictive understanding of the response of a linked watershed-marsh-estuarine system in northeastern Massachusetts to rapid environmental change. This large-scale, interdisciplinary project will test how internal feedbacks within the marsh-estuary ecosystem influence the response of geomorphology, biogeochemistry, and food webs to three major drivers: climate, sea-level rise, and human alteration of the watershed. It will address three critical questions. How will the geomorphic configuration of the marsh and estuary be altered by changes in the watershed, sea-level rise, climate change, and feedbacks internal to the coastal system? How will changing climate, watershed inputs, and marsh geomorphology interact to alter marsh and estuarine primary production, organic matter storage, and nutrient cycling? How will key consumer dynamics and estuarine food webs be reshaped by changing environmental drivers, marsh-estuarine geomorphology and biogeochemistry? Cross-system comparisons with other LTERs along gradients of temperature, species composition, tidal range, and sediment supply will further our understanding of long-term change in coastal ecosystems.

FCE III — Coastal Oligotrophic Ecosystems Research

Principal Investigator: Rinku Roy Chowdhury
Funding Agency: National Science Foundation

The Florida Coastal Everglades (FCE) Long-Term Ecological Research (LTER) site seeks to understand how global climate change and shifting approaches to water management affects the Florida Everglades and the 6 million residents of the region. By conducting extended-duration research in freshwater wetlands, mangrove swamps, and shallow seagrass communities of Florida Bay, the FCE LTER employs long-term datasets to determine how the amount and quality of fresh water flowing through the Everglades influences ecological processes in the coastal zone. Coupled socio-economic studies reveal how decisions about Everglades restoration influence—and are influenced by—the human history of dependence on local natural resources. This project recognizes the importance of water in the sociopolitical environment, and addresses how and why land and water use in South Florida has changed. Specifically, this project identifies the sources of sociopolitical conflicts over freshwater distribution and evaluates how solutions that improve inflows to the Everglades mediate the effects of sea-level rise on freshwater sustainability in the coastal zone.

Urban Resilience to Extreme Weather Related Events

Principal Investigator: Rinku Roy Chowdhury
Funding Agency: National Science Foundation

Urban areas are vulnerable to extreme weather related events given their location, high concentration of people, and increasingly complex and interdependent infrastructure. Recent disasters demonstrate not just failures in built infrastructure, they highlight the inadequacy of institutions, resources, and information systems to prepare for and respond to events of this magnitude. This interdisciplinary project will develop a diverse suite of new methods and tools to assess how infrastructure can be more resilient, provide ecosystem services, improve social well-being, and exploit new technologies in ways that benefit all segments of urban populations. The primary research question is how do social, ecological, and technological systems (SETS) interact to generate vulnerability or resilience to extreme weather related events, and how can urban SETS dynamics be guided along more resilient, equitable, and sustainable trajectories? Specifically, this project will analyze the spatial structure and land cover components of vulnerability to climate-driven extreme events in Miami and comparatively across other urban sites, and entails particular attention to spatially differentiated patterns of urban exposure, sensitivity and adaptive capacity in the face of extreme events such as hurricanes, floods and droughts.

Ecological Homogenization of Urban America

Principal Investigator: Rinku Roy Chowdhury
Funding Agency: National Science Foundation

Urban, suburban and exurban environments are important ecosystems and their extent is increasing in the US. The conversion of wild or managed ecosystems to urban ecosystems is resulting in ecosystem homogenization across cities, where neighborhoods in very different parts of the country have similar patterns of roads, residential lots, commercial areas and aquatic features. This project will test the hypothesis that this homogenization alters ecological structure and functions relevant to ecosystem carbon and nitrogen dynamics, with continental scale implications. The research will provide a framework for understanding the impacts of urban land use change from local to continental scales. Using datasets ranging from household surveys to regional-scale remote sensing across six metropolitan statistical areas (MSA) that cover the major climatic regions of the US, this project will determine how household characteristics correlate with landscaping decisions, land management practices, and ecological structure and functions at local, regional and continental scales. This research will improve our understanding of an important and increasingly common ecosystem type ("suburbia") and the consequences to carbon storage and nitrogen pollution at multiple scales. In addition, it will advance our understanding of how humans perceive value and manage their surroundings.

Alternative Ecological Futures for the American Residential Macrocosm

Principal Investigator: Rinku Roy Chowdhury
Funding Agency: National Science Foundation

An apparent, but untested result of changes to the urban landscape is the homogenization of cities, such that neighborhoods in very different parts of the country increasingly exhibit similar patterns in their road systems, residential lots, commercial sites, and aquatic areas; that is, cities have now become more similar to each other than to the native ecosystems that they replaced. This research examines the ecological homogenization of the American Residential Macrosystem (ARM) and specifically investigates factors that contribute to stability and/or changes in the ARM. The aim is to determine how factors that effect change—such as shifts in human demographics, desires for biodiversity and water conservation, regulations that govern water use and quality, and dispersal of organisms—will interact with factors that contribute to stability such as social norms, property

values, neighborhood and city covenants and laws, and commercial interests. The project will determine ecological implications of alternative futures of the ARM for the assembly of ecological communities, ecosystem function, and responses to environmental change and disturbance at parcel (ecosystem), landscape (city), regional (Metropolitan Statistical Area), and continental scales. Five types of residential parcels as well as embedded semi-natural interstitial ecosystems will be studied, across six U.S. cities (Boston, Baltimore, Miami, Minneapolis-St. Paul, Phoenix, and Los Angeles).

Vulnerability Assessment of Mangrove Forests in the Americas

Principal Investigator: Rinku Roy Chowdhury
Funding Agency: National Aeronautics and Space Administration

Mangrove forests are coastal wetlands that contribute to regional, continental and global biodiversity and act as biogeochemical links between upland and coastal regions of the tropics. Mangrove ecosystems provide many ecosystem services including shoreline protection, nutrient cycling, fisheries production, lumber, and habitat. However, because of their location and economic value, they are among the most rapidly changing landscapes. The greatest threats to mangroves derive from human activities such as aquaculture, freshwater diversions, over-harvesting, and urban and industrial development. The effects of sea-level rise and increased extreme climatic events may also increase the vulnerability of these ecosystems to global change. Integrating socioeconomic datasets and local surveys with multi-sensor remote sensing of mangrove use and cover change, and eco-geomorphology, this project will develop spatially explicit models of mangrove forest vulnerability to anthropogenic activity and climate change across the Americas. The team will also design a web-based platform for dissemination of project research results.

HELPING GOVERNMENT AGENCIES INCORPORATE ECOSYSTEM SERVICES INTO DECISION MAKING

Marsh Institute Director Robert Johnston has engaged in a number of collaborative efforts to inform the ways that US federal agencies manage and account for ecosystem services (the goods and services provided by nature). In 2016, Johnston co-led (along with Vic Adamowicz and David Fluharty) a report by the Ecosystem Sciences and Management Working Group of the NOAA Science Advisory Board, *An Assessment of the Use and Potential Use of Ecosystem Service Valuation in NOAA*, which provides guidance for the use of ecosystem service valuation within the agency. In addition, Johnston is a member of the steering committee that led a Council on Food, Agricultural and Resource Economics (C-FARE) effort to help USDA quantify the economic value of agricultural conservation-based ecosystem services, and contributed to the working group of that effort focusing on the quantification of ecosystem services related to water quality improvements. Johnston is also a member of the steering committee of a US EPA effort (led by Paul Ringold at EPA) that is seeking to improve the agency's ecological monitoring programs by helping them identify and measure relevant indicators of final ecosystem goods and services. A recent output of this effort is the paper "Ecosystem Services Indicators: Improving the Linkage between Biophysical and Economic Analyses" which was published in the *International Review of Environmental and Resource Economics* in 2016. Previously, Johnston was part of the interdisciplinary team that created the Federal Resource Management and Ecosystem Services Guidebook and co-authored Best Practices for Integrating Ecosystem Services into Federal Resource Management, two guidance documents intended to help federal agencies respond to rules and regulations on ecosystem services and federal decision-making. He has pioneered benefit transfer methods now used worldwide to estimate the economic benefits of ecosystem services improvements. He also co-authored the 2017 paper "So You Want Your Research to be Relevant? Building the Bridge between Ecosystem Services Research and Practice," which was published in the journal *Ecosystem Services*.

EARTH SYSTEM SCIENCE

Centered in expertise at Clark University's internationally recognized Graduate School of Geography, Earth System Science (ESS) research at the George Perkins Marsh Institute examines the structure and function of the Earth's lithosphere, atmosphere, hydrosphere, cryosphere, and biosphere, and how these systems interact. ESS research studies connections between Earth System components that are at the heart of such issues as carbon cycling, climate change, water scarcity, and the loss of biological diversity, with an emphasis on understanding and predicting global environmental changes. Of particular relevance to the Institute are causes and consequences of global climate change. Work in this area is supported by major grants from the National Science Foundation, National Aeronautics and Space Administration (NASA), and private foundations.

Observing and Understanding the Impacts of a Thinning and Retreating Sea Ice Cover on Light Propagation, Primary Productivity, and Biogeochemistry in the Pacific Arctic Region

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

Arctic sea ice cover is undergoing tremendous change. There has been a pronounced decrease in the summer sea ice extent, an overall thinning of the ice, a lengthening of the summer melt season, and a fundamental shift to a primarily seasonal sea ice cover. Some of the greatest changes in sea ice cover have been observed in the Chukchi and Beaufort seas, where there has been substantial loss of summer ice in recent decades. These changes in the physical system are affecting biological and biogeochemical systems profoundly as well. The goal of this project is to determine the impact of physical changes in the sea ice cover of the Chukchi and Beaufort seas on biological productivity and biogeochemical cycling in waters beneath and associated with this ice cover. An interdisciplinary and multi-methodological approach is being used to address this goal, including integration of field observations, satellite remote sensing, process studies, and large-scale modeling. Because of the interdisciplinary nature of this work, the project will be integrated with several ongoing projects and will leverage observations from previous and ongoing field programs. There is also a strong educational component to this research, including the training of two Ph.D. students, multiple undergraduate students, and comprehensive student involvement in research subcomponents at all involved institutions (Clark, Dartmouth, CRREL, University of Washington, and NASA GSFC).

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

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

Several regionally critical marine sites in the Pacific Arctic sector, that have very high biomass and are focused foraging points for apex predators, have been reoccupied during multiple international cruises. To track the biological response of these ecosystem hotspots to sea ice retreat and associated environmental change, an international consortium of scientists is developing a coordinated Distributed Biological Observatory (DBO) that includes selected biological measurements at multiple trophic levels. These measurements are being made simultaneously with hydrographic surveys and satellite observations. The DBO currently focuses on five regional biological hotspot locations along a latitudinal gradient. The spatially explicit DBO network is being organized through the Pacific Arctic Group, a consensus-driven, international collaboration sanctioned by the International Arctic Science Committee. This project is a US contribution to the DBO effort in the Pacific Sector. The scientific needs being met are consistent with research needs identified in the US National Ocean Policy planning effort and the NOAA strategic plan. The project serves as a contribution to the US-led Arctic Observing Network and will improve international cooperative efforts for evaluating ecosystem impacts from high-latitude climate change. Outreach to local communities and media will ensure that both those immediately impacted and the broader public will be made aware of changes occurring in this sensitive area of the Arctic.

Investigating the Influence of Sea-surface Variability on Ice Sheet Mass Balance and Outlet Glacier Behavior using Records from Disko Bugt, West Greenland

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

This collaborative research project furthers the understanding of ocean-ice-atmosphere interaction around the Jakobshavn Isbrae and Disko Bay region of west Greenland, with a particular focus on the role of sea surface temperature and sea ice variability in modulating past outlet glacier behavior and ice sheet snowfall and melt over the past two centuries. Project scientists are reconstructing past environmental conditions in the Disko and Baffin Bay region based on new glaciochemical and stratigraphic records from ice cores and geophysical studies from three sites surrounding Disko Bay. Results will complement recent glaciological studies of regional ice dynamic behavior, as well as recent paleoceanographic and glacial geologic reconstructions of conditions from this area and era. A high school science teacher is also participating in the field work and interacting with students at his school in Massachusetts as well as from the ice.

Developing Remote-Sensing Capabilities for Meter-Scale Sea Ice Properties

Principal Investigator: Karen Frey
Funding Agency: US Office of Naval Research

An increasing array of higher resolution commercial satellite assets has created the opportunity to track meter-scale sea ice properties over large areas. These satellite assets provide capabilities at high enough resolution to directly resolve features like melt ponds, floe boundaries, and individual ridges. These features have not been resolved by the majority of earlier space-based remote sensing assets, but are of substantial geophysical importance. Collecting imagery of sea ice using these assets and applying this imagery to track meter-scale processes at carefully chosen, regionally representative sites will provide an important set of data products for modeling and process studies, and permit a newly comprehensive assessment of the processes driving sea ice loss in the Arctic. This project focuses on disseminating both data and techniques developed to ensure the broadest possible impact of the work.

Toward a Circumarctic Lakes Observation Network (CALON)

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

About one-quarter of the lakes on Earth are located in the Arctic, with their origin and distribution largely controlled by the presence of permafrost, glacial history, and the regional water balance. Arctic lakes release large quantities of carbon dioxide and methane to the atmosphere and absorb up to 35% more solar energy than the surrounding tundra during summer. Lakes also play a vital role in ecosystems of the Arctic, and there is concern that biological communities and lake productivity are vulnerable to the effects of climate warming. As a first step toward developing a Circumarctic Lakes Observation Network (CALON), this collaborative project expands and integrates a network of sites across Alaska. Using in situ measurements, field surveys, and remote sensing/GIS technologies, the study provides raw data and processed images that help fill identified information gaps and facilitate knowledge sharing. This large-scale project incorporates a suite of scientific and educational objectives to promote improved observation and understanding of Arctic lakes.

Spruce Beetle and Wildfire Interactions under Varying Climate in the Rockies

Principal Investigator: Dominik Kulakowski
Funding Agency: National Science Foundation

This project examines relationships between outbreaks of spruce bark beetles and wildfire activity in coniferous forests of the Rocky Mountains. Since the early 1990s, synchronous outbreaks of native bark beetles have been occurring throughout coniferous forests of western North America, from Alaska to the US Southwest. Extensive tree mortality caused by bark beetle outbreaks is triggering major changes in forest landscapes and their ecosystem services. This collaborative research project addresses the following questions: (1) How does climatic variation affect the initiation and spread of spruce beetle outbreaks across complex landscapes? (2) How does prior disturbance by windstorm, logging, and fire affect the subsequent occurrence and severity of spruce beetle outbreak? (3) In the context of a recently warmed climate, how do spruce beetle outbreaks affect forest structure and composition? (4) How do spruce beetle outbreaks affect fuels and potential wildfire activity under varying climatic conditions? (5) How will climate change and the climate-sensitive disturbances of wildfire and spruce beetle activity affect future ecosystem services in the subalpine zone of the southern Rocky Mountains under varying scenarios of adaptive forest management? This project provides information that helps inform the management of these vulnerable ecosystems.

Translating Forest Change to Carbon Emissions

Principal Investigator: Christopher A. Williams
Funding Agency: National Aeronautics and Space Administration

Forests are a globally-significant store of carbon, but this store is vulnerable to release from disturbance processes such as harvesting or fires. 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. The balance of these processes is constantly changing and varies widely from region to region. National and international policies aimed at protecting forest carbon storage rely heavily on high quality, accurate reporting (called "Tier 3") that earns the greatest financial value of carbon credits and hence incentivizes forest conservation and protection. But methods for Tier 3 Measuring, Reporting, and Verification (MRV) are still in development. This project aims to quantify how much carbon is being released and taken up by each process over the entire United States using a new approach to Tier 3 MRV, involving a combination of direct remote sensing, ground-based inventorying, and computer modeling methods to track forest carbon emissions and removals at a 1 km scale. Few existing approaches seek to combine all of these sources of information. Specificity about the underlying processes driving carbon flows enables the framework to be used as a decision-support tool to help test the relative benefits of various land management strategies and to examine how today's carbon sources and sinks will trend over time.

Quantification of the Regional Impact of Terrestrial Processes on the Carbon Cycle Using Atmospheric Inversions

Principal Investigator: Christopher A. Williams
Funding Agency: National Aeronautics and Space Administration

The earth's terrestrial biosphere has been a strong net sink of atmospheric carbon dioxide for roughly three decades. This has slowed the rate of CO_2 accumulation in the atmosphere. The causes of this net sink and its likely evolution in the future, however, are uncertain, leading to uncertainty in future climate projections.

Photography © Sheila Onzere

This project, involving investigators from both Penn State and Clark University, applies recent advances in atmospheric inversion methodology and observational technology to study the carbon balance of North America as a whole, with emphasis on the southeastern United States. The project will: (1) reduce uncertainty in the overall continental carbon balance and especially in the southeastern US; (2) evaluate inventory estimates of southeastern US CO_2 fluxes; (3) demonstrate a joint atmosphere- and inventory-based carbon cycle observation system; (4) explore the utility of remotely sensed atmospheric CO_2 data in regional to continental scale atmospheric inversions; and (5) motivate extension of this diagnostic approach to other regions of the continent and the world. This project will advance scientific understanding of relationships between terrestrial carbon sinks and atmospheric CO_2.

Tools to Bridge the Gap between Static CMS Maps, Models, and Stakeholders

Principal Investigator: Christopher A. Williams
Funding Agency: National Aeronautics and Space Administration

From its inception, the NASA Carbon Monitoring System (CMS) has largely been organized around two activities: observation-based mapping of biomass and model-based estimation of carbon flux. Although there has been significant progress in both biomass and flux activities at various scales, several challenges hinder the use of biomass products to inform flux modeling. For example, biomass maps are often static or local scale, uncertainties are difficult to render and incorporate into models, and map products are not designed with the needs and format standards of modelers in mind. To help address these challenges, this project will develop new tools to facilitate broader use of CMS data products by (a) converting static maps of aboveground biomass and land cover to dynamic yearly maps, and (b) collaborating with modelers and stakeholders to build a convenient interface that will facilitate their use of the dynamic map results. This will add significant value to the CMS program by thoughtfully and deliberately connecting the results from various disparate projects to each other and to modeling and accounting frameworks that provide a more integrated view of carbon dynamics.

Surface Biogenic Carbon Flux Priors: Providing Priors, Analyzing Error Structures, and Reducing Parameter Uncertainties

Principal Investigator: Christopher A. Williams
Funding Agency: National Aeronautics and Space Administration

Better estimates of greenhouse gas sources and sinks are needed for climate management and to predict future climate. Atmospheric Carbon and Transport – America conducts airborne campaigns across three regions in the eastern United States to study the transport and fluxes of atmospheric carbon dioxide and methane, and to measure how weather systems transport these greenhouse gases with the overall objective of enabling more accurate and precise estimates of the sources and sinks of these gases. Biogenic surface carbon flux prior estimates are a necessary component of the regional atmospheric inversion framework utilizing aircraft data. These surface flux priors should represent realistic spatial and temporal errors in the biological fluxes emerging from parameter uncertainty, be unbiased, and encompass the truth. This project delivers surface carbon flux priors to support regional inversions centered on aircraft campaigns and analyzes prior and posterior surface carbon fluxes to identify a reduced set of model parameters that are most consistent with the aircraft data.

INSTITUTIONS AND HUMAN DEVELOPMENT

Interactions among the environments in which we live, resource governance, and the role of public and private institutions have important effects on human health, development and welfare. Institutions and governance determine whether and how people benefit from natural resources and the resilience of local populations to global change and regional upheavals. They are also critical to the opportunities available to different groups within society. Partnering with investigators from the Department of International Development, Community and Environment (IDCE), Graduate School of Geography, Department of Economics and other departments at Clark University, the Marsh Institute undertakes research to promote improved human condition, with particular emphasis on challenges related to disadvantaged populations, urban areas, resource governance, and social and environmental justice. Much of this work coordinates closely with community partners to promote positive social change.

Global Shifts in Research and Development Alliances

Principal Investigator: Yuko Aoyama
Funding Agency: National Science Foundation

This project represents an international collaborative effort between institutions in the United States and India. It examines how Multinational Enterprises (MNEs) access market intelligence by forging alliances with nongovernmental organizations (NGOs), and develops case studies of organizational innovation in emerging economies. In particular, it focuses on R&D alliances between MNEs and NGOs, analyzing global corporate R&D activities in five metropolitan areas in India. Understanding how MNEs and NGOs co-innovate, co-develop, and nurture knowledge assets—in spite of competing incentive structures, institutional objectives, and organizational cultures—requires not only new solutions to multidimensional coordination problems, but also new perspectives on market governance. The project develops a new conceptual framework that explicitly recognizes innovation as interactions between technological knowledge and market intelligence. This work provides new evidence into emerging trends in capitalism and development.

Assessment and Scoping of Infrastructure and Extractive Industries in Relation to Deforestation

Principal Investigators: Anthony Bebbington, Denise Humphreys Bebbington, and John Rogan
Funding Agency: Climate and Land Use Alliance (CLUA)

Large-scale infrastructure and extractive industry projects have attracted significant private and public investment, with direct and indirect synergies between them. However, while the effect of roads on deforestation has been widely studied, the extent to which extractive industry affects forest cover and forest-dependent livelihoods is less clear. Although the actual footprint of operations is modest in absolute terms, the footprint of pollutant-based externalities can be far larger. In addition, the drivers of these different processes are multiple and complex. With a focus on three regions (Brazil, Mexico/Central America, and Indonesia), this project will: (i) describe the recent geography of infrastructural and extractive industry investments; (ii) assess the current state of knowledge regarding the impacts of these investments on forest cover and quality, and the rights, organizations and

livelihoods of forest dependent communities; (iii) examine the work different organizations are already doing on the relationships among infrastructure, extractives and forests including what their successes and failures have been with different types of strategy; and (iv) identify feasible strategies for CLUA.

Extractive Industry, Decentralization and Development: An Andean Comparative Study

Principal Investigator: Anthony Bebbington
Funding Agency: Ford Foundation

This project enhances knowledge of the ways in which political and institutional regimes affect the extent, nature and distribution of development opportunities catalyzed by the growth of extractive industries. This was achieved through a comparison of Peru and Bolivia, and of the different taxation and redistributive regimes for hard-rock mining and hydrocarbons in the two countries. The first part of the research traces the ways in which distinct taxation and revenue distribution regimes have emerged for these two sectors in each of the countries. The second part focuses on relationships between extractive industry taxation, expenditure and the distribution of development opportunities under the market-friendly regime of Peru and the post-neoliberal regime of Bolivia. In each country, the project assesses the allocation of extractive rents between private capital and government; the geographical distribution of negative development impacts, especially in the form of environmental externalities; the geographical distribution of the rents that accrue to government; and the ways in which these rents are spent. The goal is to evaluate the role of political and institutional forces on ways in which the benefits and costs of resource extraction are distributed across society.

Women's Leadership, Agency and Voice: Promoting Gender Justice within Community-Based Tenure System

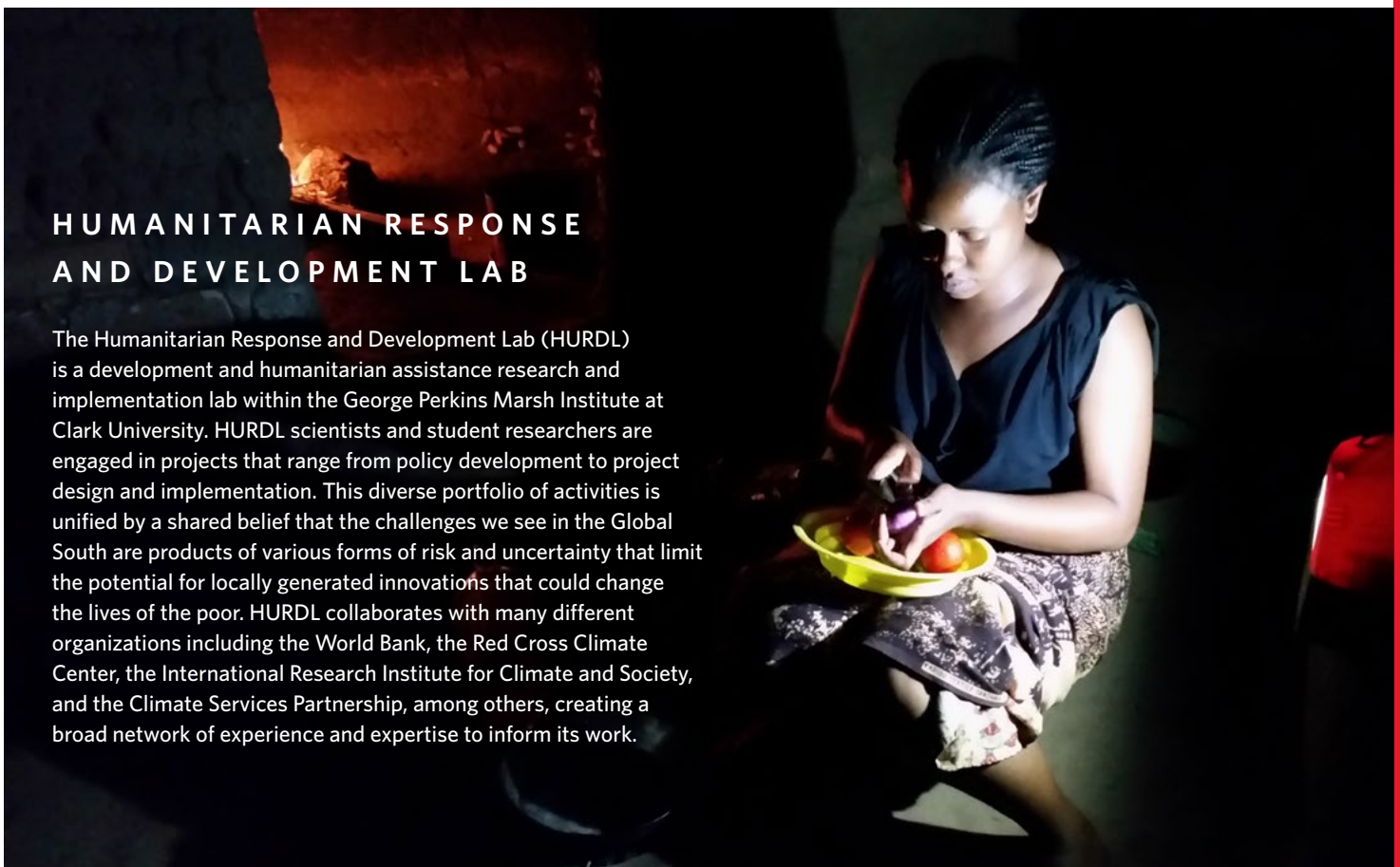
Principal Investigators: Cynthia Caron and Denise Humphreys Bebbington
Funding Agency: Rights and Resources Institute

This project explores how women gain access to and maintain control over land and forest resources in traditional community-based tenure systems, and how they participate in natural resource governance based on their multiple subject positions (i.e., as wives, co-wives, daughters, widows) in the family and community. The project asks a common set of questions across continents and contexts where different types of resources (forest, land, hydrocarbons and wildlife) must be governed together, in order to understand the complexities involving multiple resources and actors with competing interests, often enmeshed in contexts of social conflict and serious asymmetries of power. Case studies of Bolivia and Zambia focus on understanding: (1) how women experience authority and address asymmetries of power; (2) the processes through which they do so; and (3) the specific role of women's leadership and networking in promoting rights of access to land and forests.

Linking Gender-Based Violence, Gendered Forest Governance, and Forest Outcomes

Principal Investigators: Edward Carr, Sheila Onzere, Denise Humphreys Bebbington, and Cynthia Caron
Funding Agency: World Resources Institute

This project will explore the connection between different levels of women's participation in forest governance and forest outcomes.



HUMANITARIAN RESPONSE AND DEVELOPMENT LAB

The Humanitarian Response and Development Lab (HURDL) is a development and humanitarian assistance research and implementation lab within the George Perkins Marsh Institute at Clark University. 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 World Bank, the Red Cross Climate Center, the International Research Institute for Climate and Society, and the Climate Services Partnership, among others, creating a broad network of experience and expertise to inform its work.

Photography © Sheila Onzere

Gender-based violence emerges as a means by which households and communities discipline women and therefore shape their participation in forest governance, producing different levels of participation. A small number (2-3) of case study communities will be selected based on differences in the level of women's participation in forest governance. Using remotely sensed forest cover data and Humanitarian Response and Development Lab (HURDL) Livelihoods as Intimate Government (LIG) ethnographic approaches, an understanding of the connection, if any, between these differing degrees of women's participation and differences in forest outcomes will be developed. Results from this work will support calls for future work on changing/improving women's participation in forest governance.

Toward a Learning Agenda: Generating Knowledge and Evidence for Climate Information Services (CIS) Design and Implementation

Principal Investigators: Edward Carr, Sheila Onzere and Robert Goble
Funding Agency: USAID/Mercy Corps

Climate information services (CIS) involve the production and use of climate knowledge in climate-smart decisions, planning, and policy-making. Easily accessible, timely, and relevant scientific information can help society cope with current climate variability and limit the economic and social damage caused by climate-related disturbances. The goal of this project is to increase the efficiency and effectiveness of future investments in CIS delivery, and ultimately increase the number of users of CIS who will benefit through livelihood practices. Through literature reviews, analyses of existing CIS systems, and a pilot evaluation program using the Humanitarian Response and Development Lab (HURDL) Livelihoods as Intimate Government (LIG) approach, this project will (1) increase understanding of, and access to, knowledge on the effectiveness of current CIS programming, (2) expand the current understanding of how CIS systems function in the context of broader social, cultural, and institutional systems within which they operate, (3) increase evidence on the degree of effectiveness of CIS on livelihoods, and (4) escalate dissemination and uptake of new knowledge.

Pathways to Climate Smart Agriculture in Africa

Principal Investigators: Edward Carr and Sheila Onzere
Funding Agency: USAID/Integra

Population growth requires a concomitant increase in food production, and this issue is particularly acute in sub-Saharan Africa where a changing climate threatens to negatively affect crop productivity and increase yearly variability. This necessitates greater adoption of strategies and approaches that increase production sustainability and adaptive capacity of farming systems to climate change, and mitigate agriculture's contribution to global greenhouse gas emissions. Despite perceived benefits, the uptake of climate-smart agriculture (CSA) has been slow. The purpose of this project is to conduct a rigorous and systematic analysis of existing evidence on the adoption barriers and incentive structures around CSA practices in sub-Saharan Africa, with a view to providing recommendations for USAID policy and programming. This study intends to answer the following questions: What is known about the main barriers to adoption of CSA practices? What incentives are proven effective in increasing uptake of CSA practices? How should USAID program CSA activities differently in order to ensure greater success of our investments?

Mali Climate Change Adaptation Activity

Principal Investigators: Edward Carr and Sheila Onzere
Funding Agency: USAID/Chemonics

Facing an estimated 30 percent drop in rainfall since the 1980s, while 80 percent of its population earns their livelihood from farming, Mali remains particularly vulnerable to the impacts of climate change. The Mali Climate Change Adaptation Activity (MCCAA) aims to share weather information more effectively and create community-driven systems that can better respond to climate variability. The program also increases the adoption of locally appropriate solutions to climate variability and change by communities and households. This project provides technical assistance in the development and implementation of activities, which will: strengthen the capacity of stakeholders' access and use of climate data and decision-support tools; assess the effectiveness and promote effective adaptive strategies; and contribute to reducing socioeconomic barriers to adopting adaptive strategies.

Building Resiliency and Adaptation to Climate Extremes and Disasters (BRACED)

Principal Investigators: Edward Carr and Sheila Onzere
Funding Agency: UK DFID/International Relief and Development

Using the Humanitarian Response and Development Lab (HURDL) Livelihoods as Intimate Government (LIG) approach, this project will build the resiliency of 264,000 people in Mali, targeting those most vulnerable to the risks of climate disasters, by helping communities identify, reinforce, and scale-up their unique adaptive capacities. Through community-led disaster risk management, BRACED will strengthen social cohesion, climate-adapted livelihoods, and natural resource management. Project interventions will be developed around a community planning process that includes: risk management; climate smart agriculture technologies; collective management of productive assets and savings; support for creation of micro-enterprises by women; strengthening integration of local climate change adaptation priorities by the local government; sustainable community management of natural resources; and promotion of energy-efficient household technologies.

The Scale of Governance in the Regulation of Land: Community Land Trusts in the Twin Cities

Principal Investigator: Deborah Martin
Funding Agency: National Science Foundation

Community land trusts are private, not-for-profit organizations which own land in trust for a particular community defined by membership and geographical boundaries. They offer long-term renewable leases for the use of that land to members, who in turn own the homes built on that land. Using voluntary, contractual mechanisms that are compatible with existing legal

RESEARCH TO PROMOTE WORLDWIDE FOOD SECURITY

A changing climate, population growth, natural hazards, regional conflicts, and degradation of ecosystem services are among the changes that threaten food security in many regions across the globe. These threats are particularly severe in the developing world. George Perkins Marsh Institute researchers are at the forefront of efforts to help ensure food security worldwide. Edward Carr, Sheila Onzere and others at the Humanitarian Response and Development Lab (HURDL) coordinate with partners such as the World Bank, USAID, and the Red Cross Climate Center to promote climate-smart agriculture in Africa. New Marsh Institute researcher Lyndon Estes' work investigates the drivers and impacts of agricultural change, with a particular focus on Sub-Saharan Africa. His recent work includes the development of sensor networks to understand changing rainfall patterns and relationships to farmers' planting and harvesting decisions. Marsh Institute researcher Rinku Roy Chowdhury's work on mangrove vulnerability to anthropogenic activity and climate change contributes to our understanding of the tradeoffs among coastal aquaculture development and provisioning of wild fisheries habitat in the tropics. Other types of threats to food security result from agricultural use of pesticides and other chemicals with both acute and chronic effects on agro-ecosystem services. For example, Marsh Institute Assistant Director Dana Bauer is working with multi-disciplinary teams to evaluate tradeoffs between pest management and pollinator preservation in US agriculture. Through these and other projects, Marsh Institute researchers are helping to ensure the resilience of the agricultural systems upon which human societies depend.

frameworks, community land trusts disrupt the often taken-for-granted direct relationship between individual landowners (whether corporations or citizens), their properties, and regulatory agencies / governments. They offer an institutional structure that allows individuals to "opt out" of certain parts of the land market — reconfiguring the homeowner relationship to property and governments — in exchange for a long-term commitment to participate in an organization which owns and thus possesses many controlling rights to the use of the land around and under individual homes. By examining the legal and social dimensions of community land trust-governed common property in a major metropolitan area (the Twin Cities region of Minnesota), this project highlights how the meanings of community and property can be negotiated through public and private institutions at multiple scales. This research explores the following question: What are the relationships between the geographic scale of a community land trust, its engagements in regional land governance (including interactions with other non-profit and government agencies), and its geographical identity?

DEVELOPING A WORCESTER REFUGEE ARCHIVE

The Jeanne X. Kasperson Research Library is home to the Worcester Refugee Archive, a collection of research papers, agency reports, news articles, non-published posters/analyses, and other materials related specifically to the recent history of refugee resettlement within the city of Worcester. In addition to dozens of journal articles, dissertations/theses, agency reports, and hundreds of newspaper articles dating back to the late 1970s, the collection also includes books and papers providing general background information on refugee and forced migrant populations. The archive supports the active research of Clark University faculty, students, and post-docs, as well as scholars from other institutions within Worcester, across Massachusetts, and beyond. This research contributes to the improvement of policies and programs targeting these vulnerable populations. The archive is also a valuable resource for the local community to access material relating to the experience of refugees in Worcester and the organizations that support them.

Shared Worlds 2015

Principal Investigator: Anita Fabos
Funding Agency: Society for the Psychological Study of Social Issues (SPSSI)

Worcester is the leading destination for refugees being resettled by the federal government in the state of Massachusetts. Both refugees and settled populations face challenges in creating and recreating safety, security, and social cohesion in the wake of demographic change such as refugee resettlement. While access to services for newcomers remains an important part of a city's positive integration strategy, designing policy approaches to support the well-being of newcomers and social cohesion for changing cities is less straightforward. This project will use focus groups to examine the relationships between refugees and their neighbors in Worcester, and the effect these relationships have on sense of belonging and well-being. Participants will include US and foreign-born Worcester community residents from a variety of sectors including faith-based organizations, educational institutions, the community of Worcester seniors, refugee and immigrant organizations, the healthcare sector, and other residents and stakeholders in the city of Worcester.

Forecasting Armed Civil Conflict under Alternative Climate Change and Socioeconomic Scenarios

Principal Investigator: Elisabeth Gilmore
Funding Agency: US Department of Defense

The impact of climate change on conflict is complex as the pathways are likely indirect and conditional. Changing weather patterns and other physical processes associated with climate change can amplify common drivers of armed conflict, such as economic underperformance, food insecurity, and human displacement, but these effects will vary because the immediate and long-term impacts of climatic shocks depend on the affected societies' resilience and adaptive capacity. This project investigates the joint role of socioeconomic and climate change for forecasts of future armed conflicts. Currently, migration as an indicator of social stress, which may then lead to social unrest and violence in both receiving and originating communities, is being evaluated by eliciting experts' mental maps of the potential pathways.

Geographic Analysis of the Territorial Overlap between Extractive Industries and Livelihoods in Honduras

Principal Investigators: John Rogan, Nicholas Cuba, and Ben Fash
Funding Agency: Oxfam America

The growth of extractive industries, particularly mineral extraction, in Honduras stands to change patterns of resource access and use that are central to agricultural and indigenous livelihoods, as well as conservation efforts. Extractive operations typically occupy a small area relative to other land uses such as agriculture or forestry, yet they may trigger tremendous, diffuse changes to land systems through unlocking access to land and resources via construction of associated infrastructure, movement of large amounts of overburden rock, and leakage of leaching agents or sulfuric acid. This project seeks to investigate the potential effects that the expansion of mining, leading to increased competition for access to

and control over land and water, will have, or is likely to have, on peoples' livelihoods in Honduras. Through geographic mapping, the project will explicitly visualize existing and potential overlaps in agricultural lands, indigenous lands, protected areas, watersheds and mining concessions in Honduras. Tracing the implications of territorial change for mining activities on livelihoods at different spatial scales will provide important insights for exposing the indivisibility of poverty and inequality. In addition, the project incorporates qualitative fieldwork to analyze the socio-ecological impacts and relations in communities near existing and proposed mines.

Greater Kilby-Gardner-Hammond Neighborhood Gang Violence Reduction Initiative

Principal Investigators: Laurie Ross, Ellen Foley, and Yelena Ogneva-Himmelberger
Funding Agency: US Department of Justice (Byrne JAG Program)/ Main South Community Development Corporation

The Byrne Criminal Justice Innovation Justice Assistance Grant (BCJI - JAG) program was created to develop and implement place-based, community-oriented strategies to transform distressed communities into communities of opportunity. The Greater Kilby-Gardner-Hammond neighborhood of Worcester is perceived to be "gang territory" by area youth. Over 40% of the population is under the age of 24, unemployment is high, and median income is low. Only 13.7% of the population has obtained a college degree and 34.6% have not obtained a high school diploma. The public school system is also met with challenges including language access barriers and low reading levels. In collaboration with the Main South CDC, the Worcester Boys and Girls Club, the Worcester Police Department (WPD), and the City of Worcester, this project will develop, implement, monitor, and evaluate a plan, based on the evidence-based Office of Juvenile Justice and Delinquency Prevention Comprehensive Gang Model, to reduce gang-related criminal activity while addressing the needs of disengaged youth in the Greater Kilby-Gardner-Hammond neighborhood.

Safe and Successful Youth Initiative (SSYI) Project East

Principal Investigator: 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—which was 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 will be 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, Straight Ahead Ministries, the Worcester Community Action Council, and the Worcester Youth Center, 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.

Shannon Community Safety Initiative: Massachusetts Statewide 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 is a state-wide program designed to reduce youth and gang violence in cities across Massachusetts. The initiative supports regional and multidisciplinary approaches through the implementation of the Comprehensive Gang Model, an evidence-based and intentional integration of prevention, intervention, suppression, organizational change, and community mobilization strategies. This multidisciplinary approach includes law enforcement initiatives such as hot spot analysis and anti-gang task forces, coordinated reentry programs for young adults and juvenile offenders, and education and employment programs for high-risk youth. As the Statewide Youth Violence Research Partner, investigators Ross and Safford-Farquharson: (1) identify emerging best practices in the literature related to youth and gang violence; (2) collaborate with individual Shannon CSI sites; (3) analyze information collected through quarterly reports and produce statewide summary reports and a comprehensive report on the impact of Shannon CSI; and (4) provide training and technical assistance on the Comprehensive Gang Model.

NEW FACES AT THE INSTITUTE

Each year brings new individuals and expertise to the George Perkins Marsh Institute. This year, the Institute added critical expertise in climate change adaptation and civil conflict, low-carbon energy technologies, integrated assessment modeling, agricultural land-use change, food security, environmental economics, and sustainable agriculture.

Lyndon Estes

Lyndon Estes is an environmental scientist who investigates the drivers and impacts of agricultural change, with a particular focus on Sub-Saharan Africa. He conducts his research using new Earth Observation technologies and a range of modeling techniques, and works within inter-disciplinary projects that involve economists, geographers, hydrologists, climatologists, and computer scientists. Prior to joining Clark's Graduate School of Geography, Estes worked as a research scientist in Princeton University's Woodrow Wilson School and Department of Civil and Environmental Engineering and spent several years working in protected area management and environmental consulting in Southern Africa. He holds a Ph.D. in Environmental Science from the University of Virginia. Estes' current research is funded by grants from NASA and the National Science Foundation.

Elisabeth Gilmore

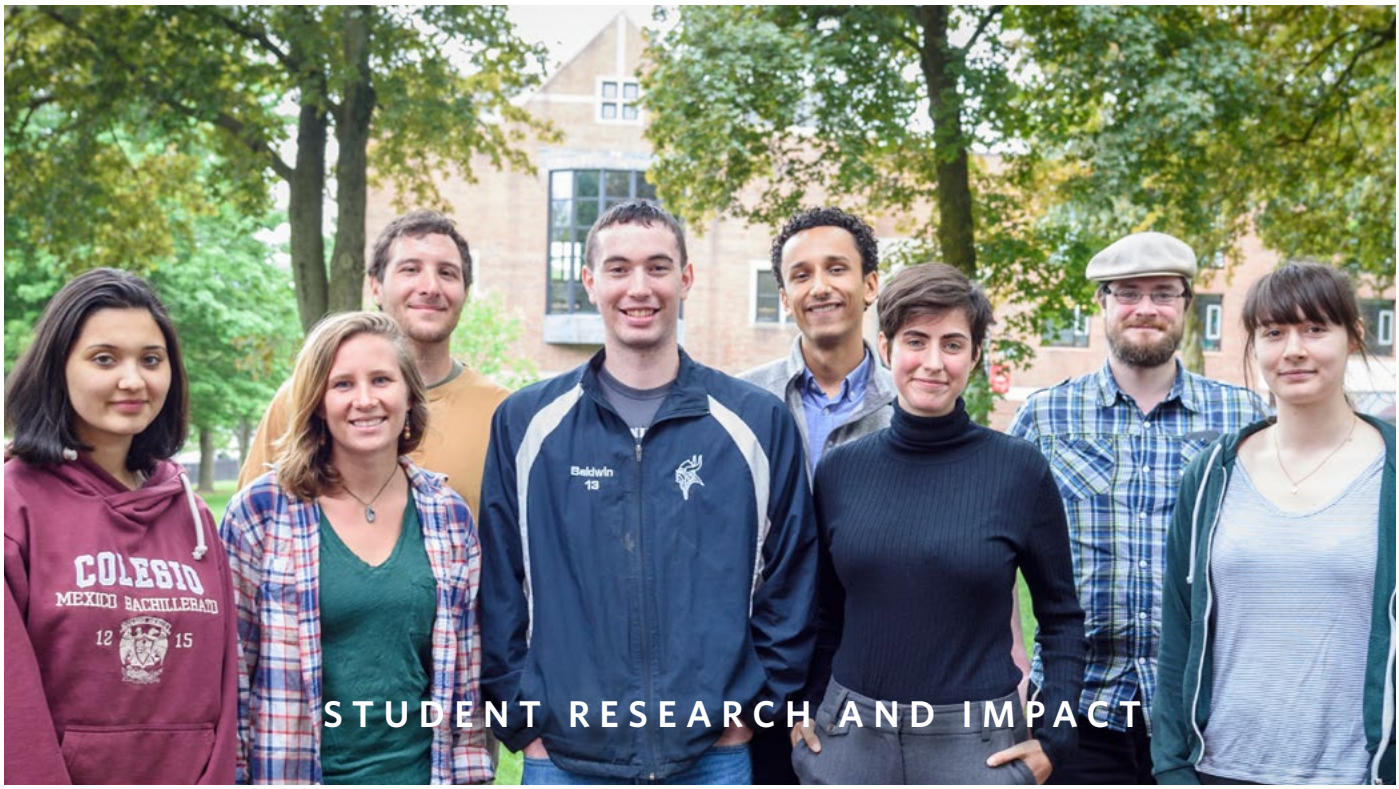
Elisabeth Gilmore is an Associate Professor of Environmental Science and Policy in the Department of International Development, Community and Environment. Her research focuses on three related streams: (1) quantifying and forecasting the economic and societal impacts of climate change, specifically the potential for civil conflict and social unrest; (2) evaluating the economic and security implications of novel low carbon energy technologies; and (3) integrating scenarios and modeling tools, specifically integrated assessment models, for decision-making and regulatory analysis. Gilmore joins Clark from the School of Public Policy at the University of Maryland, College Park. She holds a dual Ph.D. in Engineering and Public Policy and Chemical Engineering from Carnegie Mellon University (CMU). Her research has been funded by grants from the U.S. Department of Defense, U.S. Environmental Protection Agency, and the Canadian National Science and Engineering Research Council.

Abigail Kaminski

Abigail Kaminski is a new Research Associate at the Marsh Institute with expertise in geographic information systems, spatial econometrics, and survey-based research. Her most recent work involves collaborating with an NSF-funded interdisciplinary team working to ensure the health and safety of Maine and New Hampshire beaches and shellfish beds. Her prior research includes an examination of access to healthy foods in Worcester, MA and an investigation into the socioeconomic factors influencing homeowner landscape decision-making. She holds an M.S. in Resource Economics and Policy from the University of Maine and a B.A. double major in Economics and Geography from Clark University. Kaminski is collaborating with Marsh Assistant Director Dana Bauer on research related to the conservation of ecosystem services.

Tom Ndebele

Tom Ndebele is a new postdoctoral researcher at the Marsh Institute with expertise in environmental economics, non-market valuation, and survey design. Ndebele comes to the Institute from the University of Waikato in New Zealand, where he worked to developed novel methods for ecosystem service and non-market economic valuation. His dissertation work evaluated tradeoffs made by consumers when choosing between renewable and non-renewable electricity sources. Ndebele is collaborating with Marsh Director Robert Johnston to develop novel methods for ecosystem service valuation (focusing on aquatic ecosystems and water quality), and to evaluate tradeoffs made in residential landscaping and lawn care, major projects funded by the U.S. Environmental Protection Agency and the National Science Foundation.



STUDENT RESEARCH AND IMPACT

The HERO team of Clark University and University of Massachusetts, Amherst (left to right): Meyru Bhanti (Environmental Conservation Biology '18), Hannah Cormey (Global Environmental Studies '18), Ben Breger (Landscape Architecture, UMass), Eli Baldwin (Geography '19), Miles Weule Chandler (Geography '18), Sonny Kremer (Landscape Architecture, UMass), Joseph Mogel (Mathematics and History '18), and Gemma Wilkens (Economics '18). Missing from photo: graduate research assistants Arthur Elmes (PhD, Geography), Marc Healy (PhD, Geography), and Zhiwen Zhu (MS Geographic Information Science for Development and Environment).

The George Perkins 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. Throughout 2016-17, Marsh Institute grants and endowments supported 31 graduate students, 17 undergraduate students, and two post-doctoral fellows. In addition, Institute faculty and staff have been central to the development of the new Liberal Education and Effective Practice (LEEP) initiative, Clark University's pioneering model of higher education that links a deep and integrated undergraduate curriculum with opportunities to put knowledge into practice in order to prepare students for remarkable careers and purposeful, accomplished lives.

Greening the Gateway Cities (HERO Project)

Principal Investigators: John Rogan and Deborah Martin
Funding Agency: John T. O'Connor '78 Endowed Fund for Environmental Studies

Built on 18 years of success, the Human-Environment Regional Observatory—Massachusetts (HERO—MA) program is a unique undergraduate-graduate-faculty collaborative that conducts research on human-environment relationships in Massachusetts. HERO Fellows analyze the causes and consequences of global environmental changes at local scales in faculty-led research projects. Each Fellow is paired with a Clark faculty mentor and other researchers on the HERO team. 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 the National Science Foundation Research Experiences for Undergraduates (REU), the National Marine Fisheries Service, the Thoreau Foundation, and the Clark University O'Connor '78 Fund. Since 2012, HERO Fellows have monitored the health of trees replanted in the Worcester area after one of North America's largest infestations of the Asian longhorned beetle. As data collected by HERO's undergraduates show, the Worcester Tree Initiative and Massachusetts Department of Conservation and Recreation's program to replant 30,000 trees in residents' yards has largely proven successful.

In 2017, the HERO program expanded the research goal to include cities that face a dearth of trees due to their industrial past: Holyoke, Chelsea and Revere. These cities are part of Massachusetts' Greening the Gateway Cities Program, which aims to increase tree canopy by 10 percent in high-density neighborhoods in 26 former factory towns by providing trees to residents and planting trees along city streets. The Tree Planting Assessment uses field data collection, geoinformatics-based mapping, and ecosystem services modeling and forecasting techniques to examine how the recent tree replanting programs have impacted the urban forest diversity, land cover/density/configuration, land surface temperature, and various ecosystem services. The Place-Making Assessment uses interviews and focus groups to explore how the experience of tree planting programs and associated policy interventions affects neighborhood-level urban ecological vulnerabilities, environmental awareness and sense of place; and how resource managers and policy makers can implement more environmentally aware policies and build local tree and environmental stewardship. For the first time, the program collaborated with Theodore S. Eisenman, assistant professor of landscape architecture at the University of Massachusetts at Amherst, and two of his students. HERO Fellows presented their work at a 2017 Stakeholder Summit in Worcester and will spend the 2017-18 academic year working on individual research projects. They will present their research next spring at Clark's Academic Spree Day and at the American Association of Geographers' annual meeting in New Orleans.

The Polaris Project II — Amplifying the Impact

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

The unifying theme of the Polaris Project is the transport and transformation of carbon and nutrients as they move with water from terrestrial uplands to the Arctic Ocean. Research conducted by the Polaris team of faculty and students will make fundamental contributions to the scientific understanding of this topic. The Polaris Project II seeks to amplify the impact of Polaris I (Rising Stars in the Arctic). The three objectives of Polaris II are to: (1) train the next generation of Arctic researchers; (2) advance scientific understanding of the Arctic; and (3) expand public awareness of the feedbacks between the Arctic and the global climate system. These objectives will be accomplished through a multi-faceted effort that includes a summer field course/research experience in the Siberian Arctic, a series of on-campus arctic-focused courses, and a wide range of outreach activities. While undergraduate students remain the primary focus of Polaris II, participation in the annual field course was expanded to include a K–12 teacher, a graduate student, a postdoctoral researcher, and a visiting faculty member. Polaris II offers a unique experience in undergraduate research that will inspire and prepare a new generation of arctic researchers. Furthermore, it will convey the importance of the Arctic to the public and to policymakers, providing them with the knowledge they need to make informed decisions.

National Oceanic and Atmospheric Administration (NOAA) Student Fellowships

Now in its sixth year at Clark University, this program offers qualified undergraduate students paid summer field internships in National Oceanic and Atmospheric Administration (NOAA) labs and offices nationwide. The program was developed jointly by the George Perkins Marsh Institute and the Mosakowski Institute for Public Enterprise, in partnership with scientists and managers from NOAA. This competitive program offers Clark students the opportunity to conduct hands-on research relevant to real-world challenges in applied ocean and atmospheric science, policy, and science communication. Clark faculty mentors provide students with guidance and communication during the internship and promote connections between the internship and the student's academic program. Four students were placed in NOAA internships during the summer of 2017.

The 2017 Marsh-Mosakowski NOAA Fellows — The Clark Silver Spring interns got a photo in front of the NOAA wave pool. From left: Tyler Anderson, '18; Anika Kreckel '18; and Carly Robbins, '18 (Alexis Stabulas, '18 is not pictured).

Tyler Anderson

Environmental Science '18, Faculty Mentor: Chris Williams, Location: Maryland

Rapid Bathymetry for Safer Navigation: Developing an Automated Process

Anderson interned at NOAA Headquarters in Silver Spring, MD as part of a team that is automating the process to obtain water depth from satellite data in order to complement traditional surveys. Knowledge of water depth or bathymetry is critical for coastal navigation and management. Hurricanes and winter storms can move channels and shoals, posing a risk to navigation. Many remote areas of the U.S. and the world have limited or extremely old surveys. Satellite data can offer a rapid way to provide an assessment of water depth for these places. Anderson evaluated data from multiple satellite products to determine which approaches provide the best estimates of bathymetry, as well as turbidity and other water quality outcomes.

Anika Kreckel

Economics '18, Faculty Mentor: Dana Bauer, Location: Maryland

Advancing Integration of Natural Capital Principles into American Businesses

Kreckel interned at NOAA's Office of the Chief Economist on multiple projects related to the integration of natural capital into the planning and operations of private business. Natural capital is another term for the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, and minerals) that combine to provide benefits to people. Every business affects and depends on natural capital to some degree and will experience risks and/or opportunities associated with these relationships. Kreckel assisted with the development of a framework to define the Ocean Economy that will help businesses evaluate their relationship to marine natural capital. The internship provided many opportunities to attend conferences and symposiums in Washington, D.C. that discussed the importance of business support to mitigate climate change. Back at Clark this fall, Kreckel remains engaged with a small group of individuals from NOAA, Conservation International, and The Natural Capital Coalition (NCC), working to develop an Oceans Supplement to the Natural Capital Protocol. This has been integrated with her Clark studies through a linked independent study with Marsh Director Robert Johnston.

Carly Robbins

Geography '18, Faculty Mentor: Florencia Sangermano, Location: Maryland

Finding Harmful Algae with High Resolution Satellite

Robbins interned at the National Ocean Service's Stressor Detection and Impact Division at NOAA Headquarters in Silver Spring, MD, where she assessed the potential of high resolution satellite data to detect harmful algal blooms within small lakes in northern Florida. NOAA lacks information on bloom conditions in these smaller lakes due to their satellite data having too coarse of a spatial resolution and an absence of ground truth data to validate satellite measurements. To determine how well the high resolution satellite could detect and quantify algal blooms, Robbins conducted a matchup between new high resolution satellite data and existing lower resolution satellite data that was previously found to detect harmful algae accurately.

Alexis Stabulas

Environmental Science '18, Faculty Mentor: John Baker, Location: Massachusetts

Endangered Species Act – Listed Species Tracking

Stabulas interned at the NOAA Fisheries Greater Atlantic Regional Fisheries Office and Protected Resources Division, which is responsible for protecting marine mammals and threatened/endangered species. She provided research and technical assistance on several projects within the Endangered Species Act (ESA) consultation team, summarizing and interpreting programmatic data and assisting with the development of an ESA-listed species tracking geodatabase and the creation of a map user guide. The final mapping products will be published online, improve interagency efficiency, and help educate the public on the best available science and information regarding threatened and endangered species.

Albert, Norma and Howard '77 Geller Endowed Research Awards

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 including practical improvements that can move society towards more sustainable outcomes. Remembering his own experience as an activist student researcher at Clark, Dr. Howard Geller (Science, Technology, and Society '77) hopes, through these annual awards, to support other Clark undergraduate and graduate students combine research with action that moves society toward sustainability. Four projects were funded during 2017.

Photography @ Yifan Cai

2017 GELLER ENDOWED RESEARCH AWARDEES AND THEIR PROJECT DESCRIPTIONS

Yifan Cai PhD Geography '19, Faculty Mentor: Yuko Aoyama

Variegated Green Capitalism and the Decentralized Developmental State: a Case Study on the Low-speed Electric Vehicle (LSEV) Industry in Shandong, China

China is rapidly emerging as one of the world's green superpowers in a wide range of sectors including green transportation; in 2015, it became the world's largest and fastest-growing electric vehicle (EV) market. More than half of the EVs sold in China are low-speed electric vehicles (LSEV), which are produced by entrepreneurial start-up firms. While existing research on sustainable transitions in China has predominantly focused on the role of the state and its public sectors, little attention has been paid to the bottom-up approach and the role of the private sector. The objective of this project is to shed light on green capitalism driven by bottom-up sustainable entrepreneurship against the background of the Chinese developmental state's top-down approach to sustainability. Using a case study of the LSEV industry, this research will analyze: (1) strategies used by LSEV firms to achieve technological leapfrogging goals in niche markets, (2) the role of the state at the subnational level in the development of the LSEV industry, and (3) the relationships between the top-down and bottom-up approaches to sustainable development for the LSEV case. This research aims at offering a nuanced account of the governance framework of sustainable development at different scales of the Chinese developmental state.

Janae Davis PhD Geography '20, Faculty Mentor: Edward Carr

Toward a Framework for Decolonizing Integrated Conservation and Development Projects in South Africa

Over the last few decades, models of protected area management have shifted from those with centralized regimes known for displacing and marginalizing indigenous peoples to participatory schemes that link rural peoples' economic development to environmental protection. Yet, reconciling conservation and development has proven to be difficult. Scholarly research has shown that most of these Integrated Conservation and Development Projects (ICDPs) often fail to reduce poverty and tend to worsen inequalities. This research seeks to understand how ICDPs can reconcile conservation and development by creating equitable and beneficial relations around labor. This case study will examine the dimensions of labor that shape the operationalization of ICDPs associated with nature-based and cultural tourism in South Africa's Northern Cape Province. It will specifically focus on the labor of the ǂKhomani San people who are targets of ICDPs, yet who struggle to realize significant benefits from these projects. This participatory research aims to work with the local community to foster knowledge and dialogue that will support more equitable and beneficial outcomes.

Photography @ Carlos Dobler-Morales

Carlos Dobler-Morales PhD Geography '19, Faculty Mentors: Rinku Roy Chowdhury and John Rogan

Drought in the New Rurality: Transformation of the Rural Landscape of the Yucatán and its Implications under a Changing Climate

Patterns of tropical precipitation are expected to change substantially over the 21st century. Preliminary climatological analysis indicates the southern Yucatan has already begun to experience changes in the form of less and more variable rainfall. Unpredictable and drier conditions threaten most sources of subsistence and income of local smallholder households. Despite these changes, over the last decade, land-use in the region has been experiencing a shift from traditional agricultural systems to follow two distinct trajectories: one characterized by more intensive agriculture, and another based on strict conservation of forest cover. Agrarian policy subsidizing the modernization-technification of slash-and-burn practices, as well as conservation instruments restricting forest clearance, contribute to the gradual replacement of a formerly heterogeneous and highly dynamic landscape for one that is temporally more stable and spatially more segregated. What remains to be known is how this transitioning landscape and the livelihoods in it will be affected by increasingly drier conditions and unpredictable rainfall. This research seeks to understand how processes of agricultural intensification and desintensification in the southern Yucatán are happening, and to investigate how such processes could amplify or ameliorate the vulnerability of smallholders to drought in the region.

Alex Moulton PhD Geography '20, Faculty Mentor: James McCarthy

Managing Resources in Jamaica's Blue and John Crow Mountains National Park

Community based resource management (CBRM) has been discussed in conservation and resource management circles, and debates have intensified as conservation and development have become integrated in responses to global environmental change. These debates indicate that CRBM must provide social, economic and ecologically sustainable outcomes. This project examines CBRM in Moore Town in Jamaica's Blue and John Crow Mountains National Park (BJCM), a World Heritage Site. Given the rich biodiversity of BCJM, the reliance on small-scale farming in the community, and generally high levels of rural poverty in Jamaica, Moore Town is a good case study through which CBRM can be examined with respect to all three measures of sustainability. This research project seeks to understand the structure and outcome of CBRM in Moore Town. Using a combination of qualitative and quantitative methods, this project will examine the institutional arrangement in the community in order to understand perceptions, effects, and implications of resource management in Moore Town and for environmental governance more generally.

Photography © Lu Ann Pacenka

PANELS, AWARDS AND ACCOMPLISHMENTS

George Perkins Marsh Institute researchers are internationally recognized for their expertise and are called upon frequently to serve on scientific boards, committees and panels. Authored and edited publications advance the state-of-the-science in many fields, and each year the contributions of our faculty and staff are recognized by national and international awards.

Advisory Boards and Committees

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 national and international policy guidance. Examples during 2016-17 included:

Anthony Bebbington is a member of the United States National Academy of Sciences (elected 2009).

Anthony Bebbington serves on the Board of Directors of Oxfam America.

Halina Brown is serving on the Newton, Massachusetts Municipal Electricity Task Force which is developing a purchasing plan that will allow the city to procure better electricity prices and to increase the mix of locally produced renewable electricity.

Karen Frey was appointed by the National Academy of Sciences to serve on the Marine Working Group of the International Arctic Science Committee (IASC). Only two U.S. scientists were appointed to this prestigious group.

Dale Hattis was recently appointed by the U.S. Environmental Protection Agency as an ad hoc member of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel (SAP).

Dale Hattis served on EPA's Science Advisory Board Risk and Technology Review Screening Methods Review Panel.

Robert J. Johnston serves on the US EPA Science Advisory Board (SAB), as well as the Scientific and Technical Achievement Awards (STAA) Committee of the SAB.

Robert J. Johnston is a member of the Ecosystem Science and Management Working Group of the NOAA Scientific Advisory Board.

Robert J. Johnston is a member of the Council on Food, Agricultural and Resource Economics (C-FARE), Steering Committee on Assessing the Value of Conservation-Based Ecosystem Services for the USDA.

Robert J. Johnston served on the Five-Year Economics and Human Dimensions Science Program Review panel for the National Oceanic and Atmospheric Administration (NOAA) Northwest Fisheries Science Center.

Robert J. Johnston serves on both the Steering Committee and Scientific Advisory Committee for the Narragansett Bay Estuary Program.

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

Robert J. Johnston served on the 2016 and 2017 Review Panels for The National Academies of Sciences, Engineering, and Medicine Gulf Research Program.

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

Rinku Roy Chowdhury is a member of the International Long-Term Ecological Research (LTER) Committee.

Philip Vergragt is a member of the Coordination Working Group of the Future Earth Knowledge Action Network of Systems of Sustainable Consumption and Production (FE KAN SSCP).

Christopher Williams joined the North American Carbon Program's (NACP) Science Leadership Group, a multidisciplinary research program established to study how carbon cycles through ecosystems, oceans and the atmosphere.

Publications

Each year researchers at the George Perkins 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. Updated lists of publications and curricula vitae can be found on the Marsh Institute research appointments website, http://www.clarku.edu/departments/marsh/faculty/index.cfm. The following are a few highlights:

Yuko Aoyama, with colleague Balaji Parthasarathy of the International Institute of Information Technology, published the book *The Rise of the Hybrid Domain: Collaborative Governance for Social Innovation*, which explores possibilities for new governance structures that blend social and economic missions and advance the livelihoods of the poor in the Global South.

Dana Marie Bauer is part of an international group of researchers investigating the disproportionate ecological importance of small natural features, unique environmental elements that provide significant ecological and economic impacts. The 37 researchers from 11 countries published a Special Issue on Small Natural Features in the journal *Biological Conservation*.

Halina Brown and Philip Vergragt, along with colleague Maurie Cohen of the New Jersey Institute of Technology, published the book *Social Change and the Coming Post-Consumer Society*, which explores the relevant processes of social change and identifies effective interventions for enabling a transition beyond the present energy- and material-intensive consumer society.

Robert J. Johnston is the lead author of "Contemporary Guidance for Stated Preference Studies" published in the *Journal of the Association of Environmental and Resource Economists*. The article offers best-practice guidance for stated preference studies used to inform decision-making and policy analysis.

Philip Vergragt and Halina Brown are lead authors of the report *Fostering and Communicating Sustainable Lifestyles: Principles and Emerging Practices*, which sets out a strategy roadmap for fostering and communicating sustainable lifestyles. The report, an end product of a United Nations Environment Program (UNEP) funded project, is illustrated by cases from around the world.

Awards and Recognitions

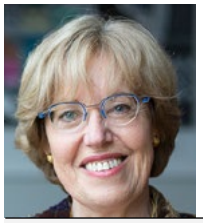
National and international awards reflect the contributions, expertise and reputation of Marsh Institute scientists. Recent national and international awards received by Marsh researchers include the following:

Anthony Bebbington was recently awarded a $2.8 million Australian Laureate Fellowship from the Australian Research Council. The project entitled "Mining and Society in a Changing Environment: Pathways to Sustainability" will conduct a systematic comparative analysis of mining activities across Latin America, Australasia, and South-East Asia, drawing on political ecology, sustainability science, indigenous geography, and geographic information science.

Laurie Ross received the Katharine F. Erskine Award by the YWCA, which honors women for outstanding achievement in their profession, community, and commitment to the YWCA's mission of eliminating racism, empowering women, and promoting peace, justice, freedom and dignity to all.

GEORGE PERKINS MARSH INSTITUTE SEMINARS

Each year the Marsh Institute sponsors formal lectures and seminars that expose faculty and students to contemporary research. These include lectures conducted as part of the George Perkins Marsh Institute/Jeanne X. Kasperson Seminar Series, as well as periodic Marsh Distinguished Lectures. The Institute also coordinates multiple endowed lecture series. These include the Albert, Norma and Howard '77 Geller Endowed Lecture Series, and the Debra I. and Jeffrey A. Geller Endowed Lecture Series. Both of these endowments support lectures related to the environment and sustainability. Institute events are also designed to provide a foundation for future research collaborations.



"Unsustainable Consumption: History and Future"

HALINA BROWN

Professor of Environmental Science and Policy, Department of International Development, Community, and Environment, Clark University

"Book Talk: The Rise of the Hybrid Domain"

YUKO AOYAMA

Professor and Henry J. Leir Faculty Fellow of Geography, Clark University

"Navigating Clark University's IRB: How to Plan your Human Subjects Research and Get it Approved"

JAMES ELLIOTT

Professor, English Department and Chair, Clark University Institutional Review Board (IRB), Clark University

"Preparing for Mass Relocation from Disasters"

VICKI BIER

Professor, Department of Industrial and Systems Engineering, University of Wisconsin-Madison

"Navigating Clark University's IRB: How to Plan your Human Subjects Research and Get it Approved"

ROBERT J. JOHNSTON

Director, George Perkins Marsh Institute and Professor, Department of Economics, Clark University

Photography © Lu Ann Pacenka

"Pathways from Climate Change to Armed Conflict and Social Unrest"

ELISABETH GILMORE
Assistant Professor, Department of International Development, Community, and Environment, Clark University

"The Ability of Tree-Rings to Represent Soil Moisture in Eastern US Forests: Challenges from Changing Climatic Conditions"

Debra I. and Jeffrey A. Geller Endowed Lecture

JUSTIN MAXWELL
Assistant Professor, Department of Geography, Indiana University

"Waters People Value"

Albert, Norma and Howard '77 Geller Lecture, co-sponsored with the Mosakowski Institute for Public Enterprise and the Economics Department

JULIE HEWITT
Associate Director for Economics in the United States Environmental Protection Agency's Office of Water

"Is the Greenland Ice Sheet Melting Away?"

Debra I. and Jeffrey A. Geller Endowed Lecture, co-sponsored with the Graduate School of Geography Colloquium Series

ASA RENNERMAIM
Assistant Professor of Geography, Rutgers University

Jeanne X. Kasperson Research Library

One of the integral parts of the Marsh Institute, 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 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 is developing the Worcester Refugee Archive, a collection of local and global resources on the topic of forced migration. 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 crucial research support for university researchers; undergraduate and graduate students; visiting foreign scholars; regional experts; federal, state, and local agencies; industry; schools; and consulting firms. The library currently has more than thirty-five thousand volumes, three hundred journals, and computer and internetresources. The staff provide exceptional and personalized research assistance. More than 2,500 students, faculty, and others visited the library this past year.

B.J. Perkins, Director, Jeanne X. Kasperson Research Library

The George Perkins Marsh Institute Steering Committee, 2016-17

Steering Committee members are chosen to represent the diversity of the 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.

Anthony Bebbington
Higgins Professor of Environment and Society; Director, Graduate School of Geography

Halina Brown
Professor, Department of International Development, Community, and Environment

Edward Carr
Professor and Director, Department of International Development, Community, and Environment

Timothy Downs
Associate Professor, Department of International Development, Community, and Environment

Susan Foster
Professor and Chair, Department of Biology

Karen Frey
Associate Professor, Graduate School of Geography

Robert Goble
Research Professor, George Perkins Marsh Institute

James Gomes
Director, Mosakowski Institute for Public Enterprise

Samuel Ratick
Professor, Graduate School of Geography; Professor, Department of International Development, Community and Environment

Rinku Roy Chowdhury
Associate Professor, Graduate School of Geography

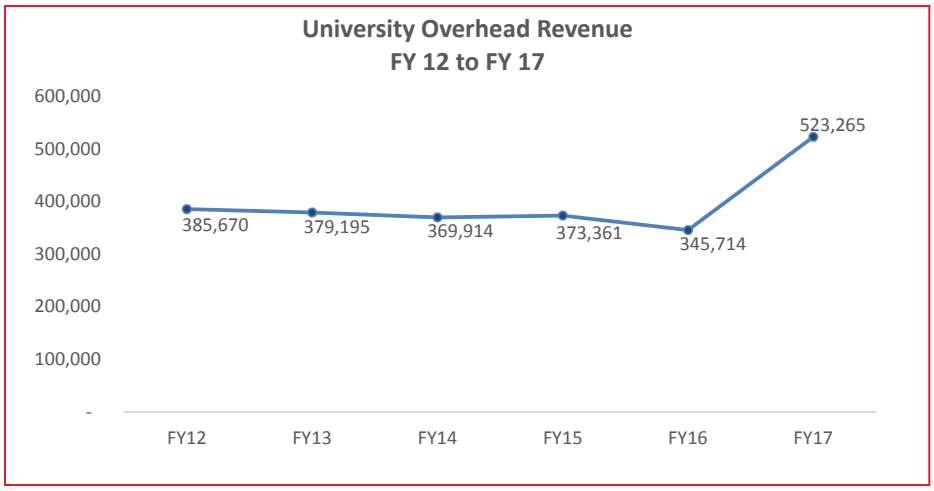
Christopher Williams
Associate Professor, Graduate School of Geography

EX-OFFICIO MEMBERS

Deborah Martin
Interim Dean of Research, Professor, Graduate School of Geography

Robert J. Johnston
Director, George Perkins Marsh Institute

Dana Marie Bauer
Assistant Director, George Perkins Marsh Institute



In addition to direct revenues that support research activity, George Perkins Marsh Institute grants provide indirect or overhead revenues that support general university operations.

Grants and Revenues

A significant portion of Clark University's external grant funding is generated by the Marsh Institute, in coordination with our partners including the Graduate School of Geography and the International Development, Community, and Environment Department. As of August 2017, the Institute maintained approximately $8.7 million in current grants, covering 35 active projects. Eleven of these are components of large-scale, multi-institutional research projects each exceeding $1 million in total funding. During FY2017, the Marsh Institute was awarded $1.1 million in new grants, with an average size of $125,568 per grant, and generated more indirect (facilities and administration) funding for Clark University than at any other year during its history.

Service for the Greater Good

George Perkins Marsh Institute researchers serve on numerous boards and committees for regional, national and international organizations. This includes journal editorships, boards of directors, offices of regional, national and international organizations, science advisory panels, and principal roles in many other types of organizations.

Through service to these groups, we contribute to scholarly pursuit and public service. More information on Marsh Institute faculty and scientists may be found on our website at www.clarku.edu/departments/marsh/faculty.

Sharing Our Knowledge

The Marsh Institute is dedicated to research of consequence that engages with partners to promote sustainability and social welfare. Among the Institute's primary goals is the dissemination of knowledge through workshops, seminars and other sponsored events. For more information on events at the Marsh Institute, visit: www.clarku.edu/departments/marsh/news/new.cfm.

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.

Want to know more?

Information on these and other activities at the Marsh Institute may be found on our website or feel free to contact us.

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GEORGE PERKINS MARSH INSTITUTE

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