

SUSTAINABLE ENVIRONMENTS
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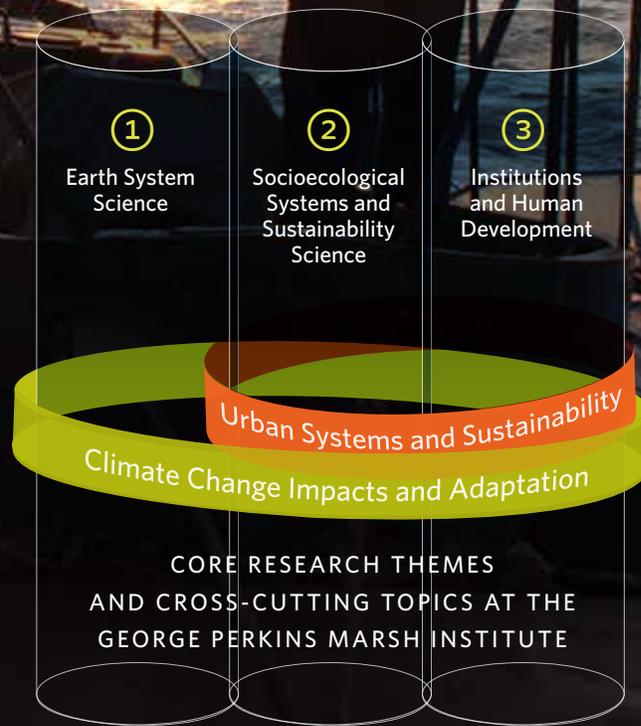
CLARK
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GEORGE PERKINS MARSH INSTITUTE

Highlights, Accomplishments and Impacts
of the George Perkins Marsh Institute
Annual Report 2015-16

GROUNDING 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 Earth System Science, ② Socioecological (or human-environment) Systems and Sustainability 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, and Urban Systems and Sustainability.



HIGHLIGHTS, ACCOMPLISHMENTS AND IMPACTS OF THE GEORGE PERKINS MARSH INSTITUTE

ANNUAL REPORT 2015-16

The George Perkins Marsh Institute is an outward-facing unit of Clark University—we focus on the information needed to solve real-world problems from a local to global scale. Our work makes a difference through advancements in basic and applied science, direct engagement with decision makers, provision of learning opportunities for students, and communication with the public. We also promote the success of other departments, centers and institutes across Clark University who share our commitment to science in the public interest.

Grants to Institute researchers support work in such wide-ranging topics as adaptation to coastal hazards, climate change impacts in the Arctic, the global carbon cycle, climate and forest fires, ecosystem service valuation, resource governance and human development, drought and water use, land systems science, and urban sustainability and welfare. External support for these and other Institute activities comes from private donations, foundations, and grants from state and federal agencies. The Institute is home to more than fifty research faculty and staff, many of whom have joint appointments with other Clark University departments.

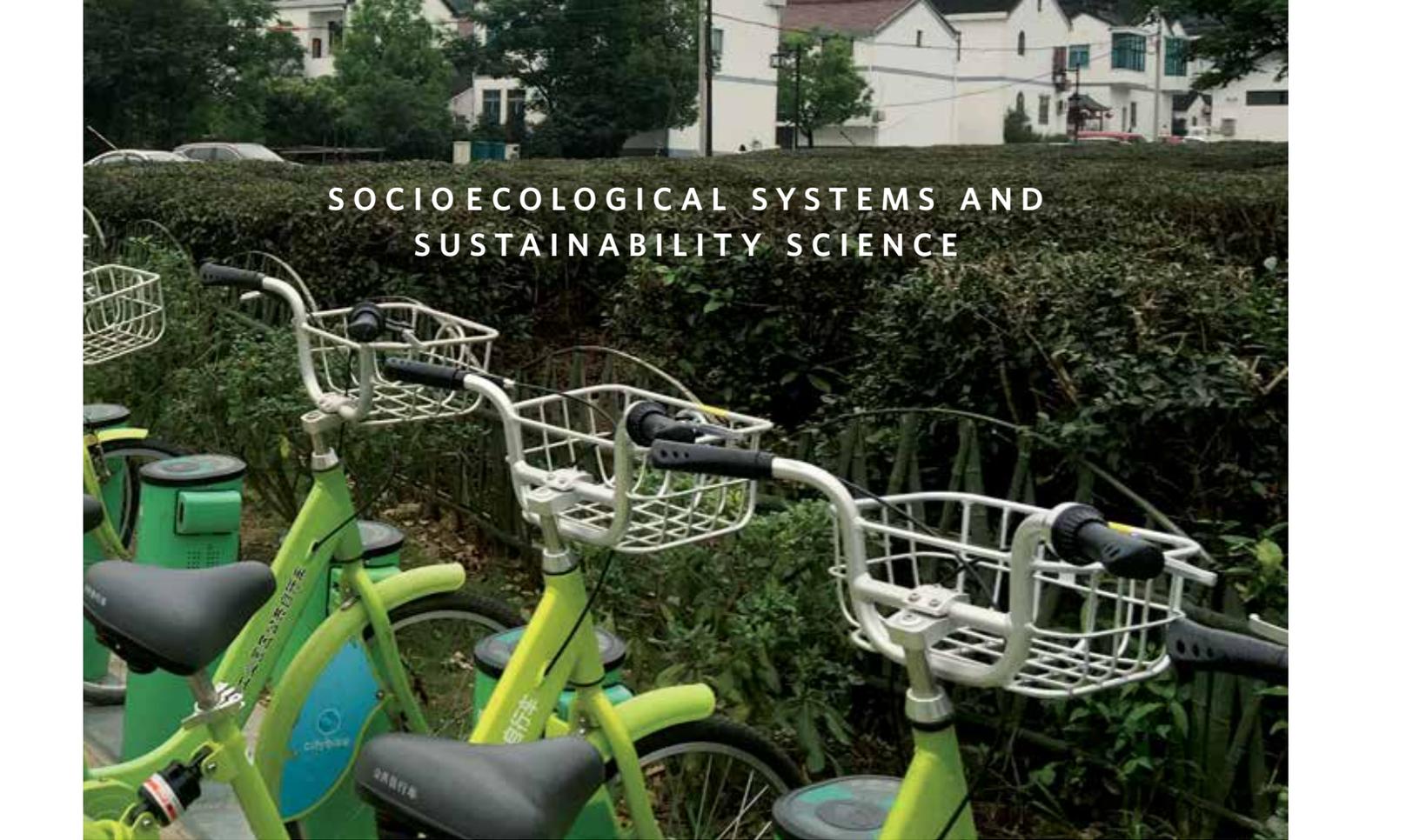
The Marsh Institute is one of the most productive hubs for research activity at the University, regularly generating approximately one-third of the University's external research funds. New research projects initiated during 2015-16 address topics including salt marsh sustainability, agricultural best management practices, urban resilience to extreme weather events, greenhouse gas fluxes, the links between women's participation in forest governance and forest outcomes, barriers and pathways to climate-smart agriculture, and the effects of mining expansion on local livelihoods in Honduras.

In addition to our funded research activities, the Institute convenes multiple workshops, conferences and seminars each year 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 groups such as the Narragansett Bay Estuary Program Steering Committee. These and other 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 is also dedicated to the provision of unique 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 central 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, education, outreach, and communication.



SOCIOECOLOGICAL SYSTEMS AND SUSTAINABILITY SCIENCE

Among the most pressing challenges facing human society are those involving relationships between human and natural systems. Climate change mitigation and adaptation are among the most complex and far-reaching of these challenges. Researchers at the Marsh Institute study ways in which natural and human systems interact in an uncertain world, and through this understanding promote more effective policy and management. Research in this area requires multidisciplinary perspectives that recognize the importance of uncertainty, risks, and resilience. 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 multidisciplinary, collaborative research project will examine 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 will also address 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?"

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 and tax bases in northeast communities respond to coastal hazards? (2) How do property values and tax bases respond to adaptation actions undertaken by states,

municipalities or homeowners/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 social science 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.

Climate Change Adaptation and Ecosystem Service Resilience in Northeast Coastal Communities: Quantifying Economic Values and Tradeoffs

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

Hazards related to a variable and changing climate are a critical problem facing northeast coastal communities. Strategies to address these challenges involve tradeoffs among development, ecosystem health, costs, and community needs. This ongoing research and engagement project seeks to assess the vulnerability of northeast coastal communities to hazards from a changing climate and evaluate how communities can best adapt to these vulnerabilities. The team is developing an economic valuation component to accompany the Nature Conservancy's Coastal Resilience modeling and visualization tool. The project quantifies the benefits realized by communities under alternative adaptation scenarios, with particular attention to choices between hardened shoreline and ecosystem-based adaptation. The project

is designed to help communities plan for sea level rise and coastal storms in a way that is most beneficial to the public. This requires strategies that protect homes and infrastructure, but that also recognize the benefits that are provided by threatened natural areas such as beaches, dunes and marshes. Project results for Old Saybrook and Waterford, Connecticut provide insight into adaptation responses that are most beneficial to the public.

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.

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 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 (www.scorai.org). SCORAI participants seek to advance and disseminate knowledge, forge connections, and contribute to policy dialogues and practices. Scholars working in the field of sustainable consumption are seeking to better understand the connections between material consumption and societal well-being 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, with sister organizations in Europe, China, and Israel. Its most recent annual workshop was held in June 2016. Vergragt is also a member of the Executive Committee for the Global Research Forum on Sustainable Production and Consumption (GRF-SPC), which brings together individuals and organizations from more than 25 countries engaged in research and its applications on the transition towards sustainable systems.

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.

Linking Coastal Adaptation 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

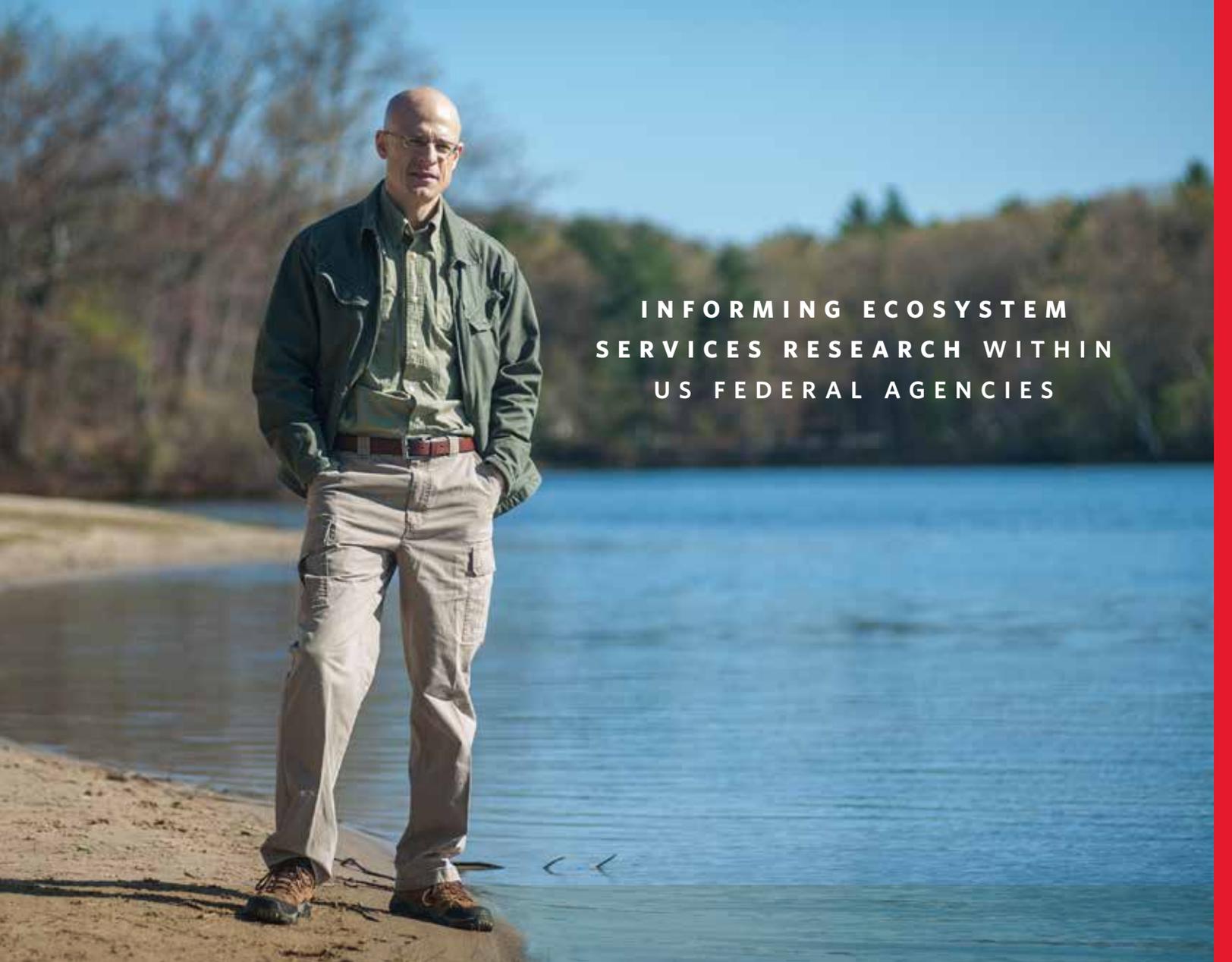
This project is an international and interdisciplinary collaboration led by Marsh Institute researchers, with collaborators at the Virginia Institute of Marine Sciences and Monash University in Melbourne, Australia. Tidal marshes are one of the most common natural features used for coastal adaptation (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 will conduct 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 to predict the value of riparian buffer enhancements in the GBE region, based on a systematic review and analysis of prior studies in the ecosystem services literature. The project draws on Johnston and Bauer's internationally recognized expertise in economic valuation and benefit transfer.



INFORMING ECOSYSTEM SERVICES RESEARCH WITHIN US FEDERAL AGENCIES

US FEDERAL AGENCIES TAKE MANY ACTIONS THAT INFLUENCE ECOSYSTEM CONDITIONS AND CHANGE THE PROVISION OF ECOSYSTEM SERVICES VALUED BY THE PUBLIC. Recent policies and guidance require federal agencies to account for effects on ecosystem services and ecosystem service values in planning and management. Yet many agencies lack the expertise to conduct high quality ecosystem services research. Marsh Institute Director Robert Johnston has engaged in a number of collaborative efforts to inform and improve ecosystem services research within the US federal government. 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 is leading 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 is contributing 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.



VISITING SCHOLAR AT MARSH INSTITUTE

During 2015-16, the Marsh Institute hosted two visiting scholars, Anne Kejser Jensen, a Ph.D. Fellow from the Department of Food and Resource Economics at the University of Copenhagen, and Liuyang Yao, a China Scholarship Council sponsored graduate student from Northwest A&F University. Ms. Jensen's research investigates the economic valuation of aquatic ecosystem services, focusing on the different direct and indirect ways that aquatic ecosystem changes influence people and what this implies for the valid calculation of economic values. For example, is water quality itself the "thing that is valued," or is water quality primarily a causal input into other outcomes that are valued, where these outcomes might

vary across different beneficiary groups? Her research provides the first systematic analysis of whether indicators of different ecological endpoints are required for different respondent groups, when using discrete choice experiments to value policy outcomes that entail biophysical changes in ecosystem services. She illustrates these issues using an empirical case study concerning preferences for water quality improvements in Danish coastal waters. Mr. Yao's research models public preferences for ecosystem services in northwest China's Heihe River Basin. Both scholars were mentored by Marsh Institute Director, Robert Johnston.

ILTER/PIE: Interactions between External Drivers, Humans and Ecosystems in Shaping Ecological Process in a Mosaic of Coastal Landscapes and Estuarine Seascapes

Principal Investigator: Robert Gilmore Pontius Jr.

Funding Agency: National Science Foundation

As part of the Plum Island Ecosystems (PIE) Long Term Ecological Research (LTER) site, this project is developing new methods to measure ways in which humans transform landscapes. These methods will allow researchers to link patterns and processes of land and other changes, providing new insights for ecosystem management. The program integrates research, education and outreach as it seeks to understand long-term interactions between human and natural systems at the land-sea interface. Integration of social science and environmental biology is crucial to comprehend how multiple stressors affect the sustainability of ecosystems. This project will evaluate how changes in management decisions and ecological systems influence, and are influenced by, organic matter and nutrient biogeochemistry.

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 complex and interdependent infrastructure. Recent disasters demonstrate not just failures in built infrastructure, but also the inadequacy of institutions, resources, and information systems to prepare for and respond to events. This interdisciplinary project will develop a diverse suite of 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 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. This work will enable characterizing how communities in Miami and other urban sites exhibit differential vulnerability to extreme events, and their resilience or adaptive capacity in the face of such events.

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.

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 (e.g. against erosion, tsunamis and storms), 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.

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.



Isabel Miranda, NOAA fellow, measuring elevation in Hawaii

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 profoundly affecting biological and biogeochemical systems 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).

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.

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 more systematically 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.

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.



Pacific-Arctic Carbon Synthesis

Principal Investigator: Karen Frey

Funding Agency: National Science Foundation

Predicting future conditions of the Arctic Ocean system requires scientific knowledge of its present status as well as a process-based understanding of the mechanisms of change. This collaborative research effort synthesizes a number of recent, upcoming, and historical datasets to create three regional carbon budgets for the Chukchi/western Beaufort Sea, the Bering Sea, and the northern Gulf of Alaska. The aim of this effort is to determine how physical forcing and biological responses control the marine carbon cycle including: (1) rates of air-sea CO₂ exchange; (2) net community production; and (3) ocean acidification effects in the contrasting shelf environments. Among the overall goals is improved understanding of how climate change will affect the regional carbon cycle. The project supports early career investigators, postdoctoral scientists, and Ph.D. students.

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 CO₂ concentrations as forest growth becomes stimulated by rising CO₂ 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



Trampers (open ocean harvesters) in Captain's Bay, Unalaska Photography © Kristen Shake

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 CO₂ 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. 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 CO₂ fluxes; (3) demonstrate a joint atmosphere- and inventory-based carbon cycle observation system; (4) explore the utility of remotely sensed atmospheric CO₂ 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 CO₂.

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 for prediction of 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. 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 the challenges facing 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.

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. 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.

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

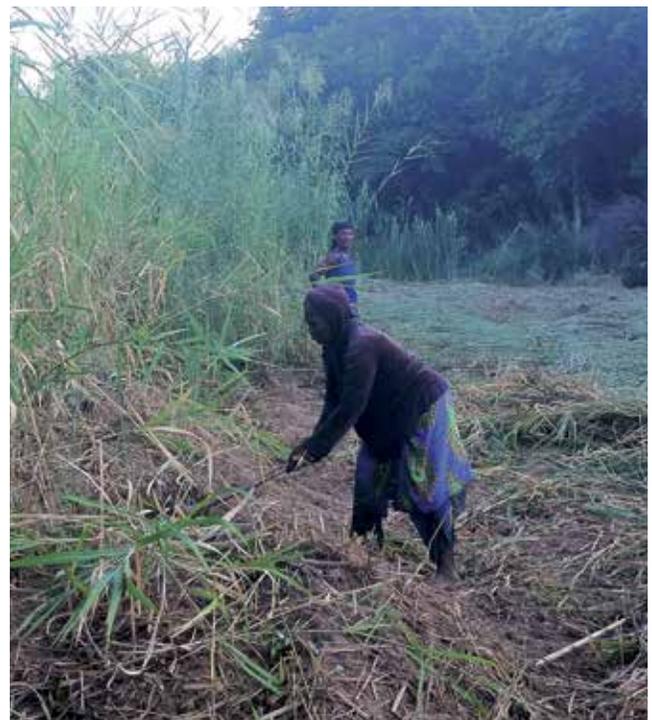
Using the Humanitarian Response and Development Lab (HURDL) Livelihoods as Intimate Government (LIG) approach, this project will build the resiliency of 264,000 people in Mali, targeting those most vulnerable to the risks of climate disasters, by helping communities identify, reinforce, and scale-up 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.

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.





Professor Laurie Ross '91, M.A. '95, with Dayanara Negron and her daughter, Jediah Russell, outside Main South Community Development Center.

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.

Shannon Community Safety Initiative: Worcester Local Action Research Partner

Principal Investigators: Laurie Ross and Ellen Foley

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 Foley 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 Ellen Foley

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 Foley: (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.

Research and Knowledge Mobilization on the Extractive Industries: Institutionalizing a Cross-Regional Network

Principal Investigator: Anthony Bebbington
Funding Agency: Social Sciences and Humanities Research Council, Canada

This project develops an interdisciplinary and cross-regional research and knowledge mobilization network on extractive industries (oil, mining, and gas). It builds upon the cooperative relationships established among a group of institutions and researchers that developed from an international academic conference held at York University in March 2009, where participants recommended the creation of a permanent forum for research collaboration and information exchange, and an international expert workshop on networking and collaborative research, held in November 2010. Professor Bebbington is involved in supervising and supporting the research carried out in Latin America, and acts as the co-chair of the working group on Constructing and Contesting Extractive Industry Governance. Doctoral students at Clark University are working with Bebbington to produce a comparative study of the genesis of the Extractive Industries Transparency Initiative (EITI) in Peru, Bolivia and Colombia, exploring how EITI emerged (or did not) in each case, the politics involved, and the role of trade and investment agreements with the US and Canada.

Tracking the Politics of Natural Resources and Inclusive Development over Time

Principal Investigators: Anthony Bebbington and Denise Humphreys Bebbington
Funding Agency: Effective States and Inclusive Development ESID Research Centre, Manchester, UK

The exploitation and governance of natural resources (i.e., mining, oil and gas extraction) offers a window onto the role of political settlements and development ideologies in shaping prospects for inclusive development, and the significance of how the core domains of accumulation, redistribution and recognition relate to each other. It is also a domain in which transnational private and public actors have special weight. This project involves country studies of the relationships between political settlements, natural resource extraction and inclusive development in Peru,

Bolivia, Ghana and Zambia, together with synthesis studies and comparative research into the politics surrounding corporate social responsibility in extractive industries in Ghana, Peru, and Zambia, and the political drivers of taxation policy surrounding mining, oil and gas in Bolivia, Ghana and Zambia.

Options for Extractive Industry Governance

Principal Investigator: Anthony Bebbington
Funding Agency: Ford Foundation

Natural resource governance is a combination of natural resource politics and management. It combines not only the immediate use of those resources but also the ways in which they are traded, taxed and turned into other forms of value. Governance processes and mechanisms interact at different scales. A natural resource governance agenda must understand these interactions in order to enhance the potential for synergies and also reduce the possibilities of unintended adverse effects. This project, working closely with doctoral students, reviews secondary materials to establish the main contours of the debate into industry governance as it currently stands. The geographical focus of the review will be on Sub-Saharan Africa, Latin America and East, South-East and South Asia. This research investigates how extractive industries can be governed so as to contribute to the goals of enhancing rights, fostering inclusive development, and adapting to climate change.

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.

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.

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.

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 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?

Governing to Maintain Legacies: Urban Governance, Policies and the Long-Term Impacts of the Olympics

Principal Investigator: Mark Davidson

Funding Agency: International Olympic Committee

Among the goals of each Olympic Games is a substantial and varied positive legacy for host city populations. But the delivery of legacies is not straightforward. Each host city must manage legacy commitments against other evolving demands. This research examines the varied ways in which recent host cities have developed institutional and policy innovations in order to deliver Olympic-related legacy commitments. The research aims to provide a comparative account of how legacies are produced over-time and across contexts. The research will report on successful methods of innovation to inform past and future host city governments.

HUMANITARIAN RESPONSE AND DEVELOPMENT LAB



Will Collier, Helen Rosko, Jane Kennery, and Sheila Onzere (above, left to right)

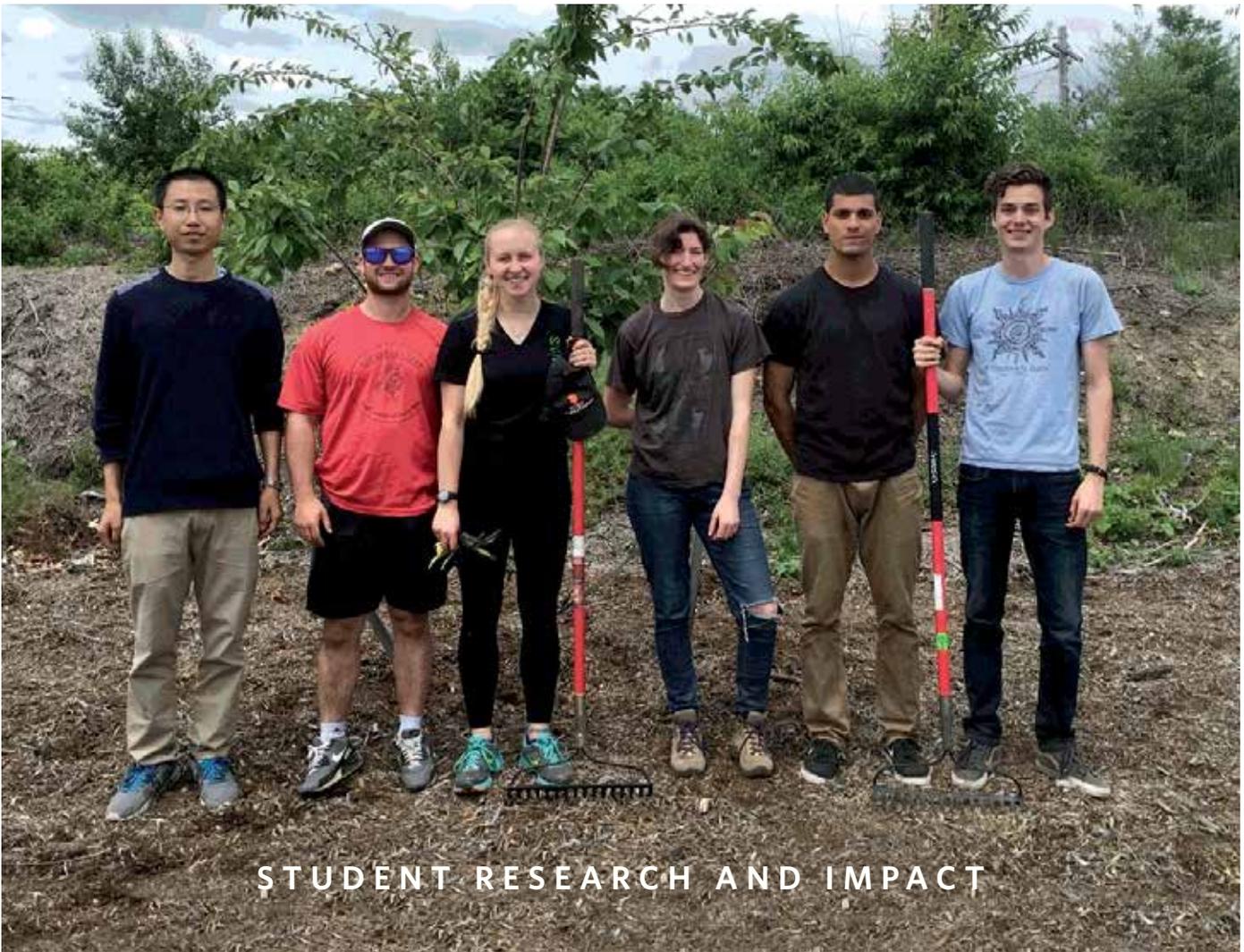
The Humanitarian Response and Development Lab (HURDL) is a development and humanitarian assistance research and implementation lab within the George Perkins Marsh Institute at Clark University. HURDL scientists and student researchers are engaged in projects that range from policy development to project 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.



Dr. Sheila Navalía Onzere

Dr. Sheila Navalía Onzere is a research scientist with HURDL. She has a PhD in sociology and sustainable agriculture from Iowa State University. Her research interests focus on livelihoods, gender, food systems, forestry, climate change, and development in sub-Saharan Africa (SSA). She has considerable experience working on international development issues in SSA. She received a fellowship from the Leadership Enhancement in Agriculture

Program to carry out fieldwork for her dissertation research while attached to The International Center for Tropical Agriculture. Dr. Onzere previously worked as the program coordinator for the Master in Sustainable Development Program at the University of Florida and as a gender specialist for the International Livestock Research Institute in Nairobi. In 2014, she was one of 20 early career scientists from around the world who were invited to attend the global Future Earth Food Systems conference. Since joining HURDL, Onzere has worked on various projects that aim to understand agricultural livelihoods and vulnerability to climate change and variability in the Sahel, as well as projects that focus on gender and forest based livelihoods in Malawi and Liberia.



STUDENT RESEARCH AND IMPACT

The George Perkins Marsh Institute is dedicated to the provision of 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 2015-16, Marsh Institute grants and endowments supported 39 graduate students, six undergraduate students, and one post-doctoral fellow. 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.

2016 Human-Environment Regional Observatory (HERO) Fellows (left to right): Zhiwen Zhu, Graduate Student Manager (PhD Geography), Eli Simonson (BA Environmental Conservation Biology '17), Savannah Sanford (BA Earth System Science '17), Emma Freud (BA Geography '17), Rishi Singh (BA Geography '17), Tyler Anderson (BA Earth Systems Science '18). Missing: Graduate Student Manager Arthur Elmes (PhD Geography).

Research Experiences for Undergraduates

Through the Research Experiences for Undergraduates (REU) program, the National Science Foundation supports active research participation by undergraduate students to analyze the causes and consequences of global environmental changes at local scales in faculty-led research projects. This ongoing program provides the opportunity for undergraduate students to conduct research in interdisciplinary and inter-institutional projects. Recent REU supplements awarded to Marsh Institute research projects have provided undergraduate research opportunities in topics such as citizen activism and neighborhood disputes, wildfires and insect infestations, suburbanization and water use, diffusion of energy technologies, socio-cultural change in South America, and transport of carbon and nutrients from terrestrial uplands to the Arctic Ocean..

Mapping Beetles, Trees, Neighborhoods, and Policies: A Multi-scaled, Urban Ecological Assessment of the Asian Longhorned Beetle Invasion in New England (HERO Project)

Principal Investigators: John Rogan and Deborah Martin
Funding Agency: National Science Foundation/Clark University
O'Connor Fund

Human alterations of the earth's surface represent one of the planet's most significant environmental changes. Built on 15 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. Fellows learn how to use research methods such as GIS, remote sensing, geostatistical modeling, interviews and focus groups. 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.



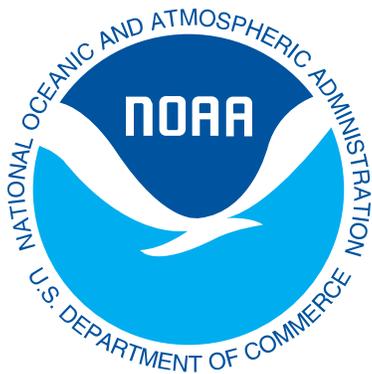
In 2016, HERO focused research in two areas. The Tree Planting Assessment uses field data collection, geoinformatics-based mapping, and ecosystem services modeling and forecasting techniques to examine how the recent tree replanting program—conducted by the Worcester Tree Initiative (WTI) and the Massachusetts Department of Conservation and Recreation (DCR)—has 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. Students presented their work at a 2016 Stakeholder Summit in Worcester.

The Polaris Project II — Amplifying the Impact

Principal Investigator: Karen Frey
Funding Agency: National Science Foundation

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, graduate student, postdoctoral researcher, and visiting faculty member. Outreach activities under this program target K-12 students and teachers, undergraduate students and faculty, and a diverse public audience. 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. 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.

HERO Fellows working with the Worcester Tree Initiative



The 2016 Marsh-Mosakowski NOAA Fellows were introduced at Clark University on May 3. From left: Isabel Miranda, '17; Robert Johnston, Director of the Marsh Institute; and Rebecca (Becca) Hadik, '17 (Kristen Sheldon, '17 is not pictured).

National Oceanic and Atmospheric Administration (NOAA) Student Fellowships

Now in its fifth 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. Three students were placed in NOAA internships during 2015-16.



Promoting Liberal Education and Effective Practice (LEEP) at the George Perkins Marsh Institute

Through the Liberal Education and Effective Practice (LEEP) program, Clark University undergraduate students combine a robust liberal arts education with authentic engagement beyond the classroom. As the home of innovative and impactful programs that provide hands-on research opportunities to students, the Marsh Institute is a central component of this pioneering program. The Institute is dedicated to the provision of applied student research opportunities, and to initiatives that engage Clark students in broader communities of practice. The Institute has also pioneered prototype



Liberal Education & Effective Practice

programs that provide a model for the way that LEEP initiatives can succeed at Clark University. An example is the NOAA Fellows program, whose exceptional success has been recognized across campus. Other Institute programs directly relevant to LEEP include the Albert, Norma and Howard '77 Geller Endowed Research

Awards that support student-initiated research, and the Institute's multiple Research Opportunities for Undergraduates (REU) opportunities supported by the National Science Foundation. Through these and other programs, the Marsh Institute provides transformative research opportunities for undergraduate students.

2016 NOAA FELLOWS AND THEIR PROJECT DESCRIPTIONS

Rebecca Hadik Political Science '17, Faculty Mentor: Amy Richter, Location: Maryland



Congressional Communications for Oceanic and Atmospheric Research (MD)

Hadik interned at the NOAA Office of Oceanic and Atmospheric Research's Formulation and Congressional Analysis Division, which develops the Office's budget and defends it to the President and Congress. As part of her internship experience, she translated scientific information for delivery to Congress and interpreted congressional actions for a scientific audience. Her tasks included editing draft reports to Congress on scientific topics, tracking legislation of interest, compiling remarks from relevant floor speeches, attending and summarizing congressional hearings and briefings, and reviewing summaries of scientific programs.

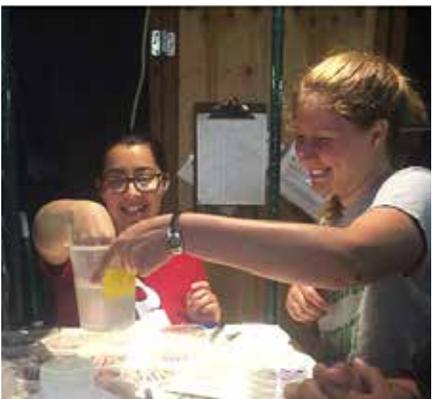
Isabel Miranda Global Environmental Studies '17, Faculty Mentor: John Rogan, Location: Hawaii



GIS Intern for NOAA's Hawaii-focused Sentinel Site Program/Habitat Blueprint and NOAA's Office for Coastal Management (HI)

Miranda participated in several projects for the NOAA Office of Coastal Management including: creating outreach materials on anchialine pools (brackish water bodies with cultural and ecological significance) in Hawaii; mapping fires in Guam to help the US Forest Service target campaigns at reducing intentional burns; and mapping data locations for the Citizen Science King Tides Project.

Kristen Sheldon Biology '17, Faculty Mentor: Deb Robertson, Location: California



Climate Effects on Physiology and Life History for Southwest Fisheries Ecology (CA)

Sheldon worked at the NOAA Southwest Fisheries Ecology Division to understand the mechanisms by which fish populations respond to environmental changes. Specifically, she investigated whether maternal or paternal effects are more important in shaping sheepshead minnow offspring's phenotype and reaction norm in response to temperature, which can be essential in understanding the adaptations of marine organisms to climate change.

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 to support other Clark undergraduate and graduate students through these annual awards. Five projects were funded during 2016.

Geography PhD Candidate Kristen L. Shake on the beaches of Unalaska Island, Alaska



2016 GELLER ENDOWED RESEARCH AWARDEES AND THEIR PROJECT DESCRIPTIONS

Bernadette Arakwiye PhD Geography '18, Faculty Mentors: John Rogan and Ronald Eastman

Monitoring Forest Loss and Degradation to Evaluate Forest Restoration Priorities in Rwanda

Gishwati-Mukura National Park (GMNP) is a conservation component of a chain of protected areas in densely populated western Rwanda. This richly biodiverse region has experienced unprecedented forest loss and degradation in the last 30 years that have resulted in major regional losses of wildlife habitat, biodiversity, and ecosystem services, as well as erosion, flooding, and major landslides that threaten the life of local populations. Increasing interests in afforestation activities aiming to reconnect

Gishwati to Mukura and to improve livelihoods, forest ecosystem health, and climate resiliency have attracted major international donors including the World Bank. However, information on spatial locations of highly suitable habitats that would increase forest cover while minimizing competition among land uses is lacking from both local ecological and communities' perspectives. This project uses remote sensing and socio-ecological field data to explore trends in deforestation, forest degradation and afforestation in GMNP, in order to evaluate sustainable forest restoration priorities.

Dylan Harris PhD Geography '20, Faculty Mentor: James McCarthy

Re-Politicizing Global Climate Change: Stories from High-Mountain Communities in Nepal and Bolivia

High-mountain populations are among the most vulnerable populations to global climate change. However, their perspectives (i.e., stories from the frontlines) are critically different from the prevailing climate change discourse, for example by discussing llama fetuses rather than carbon fluxes. By researching these alternative perspectives, this project aims to explore counter-narratives to normative climate politics, thereby carving out necessary imaginative capacities to discuss future climate

governance and policy design. Specifically, the project will utilize a mixed methods approach - a combination of traditional ecological knowledge, storytelling, and Geographic Information Systems (GIS) - to study climate change narratives in the Bolivian Andes and the Nepalese Himalayas. While similar in some ways (altitude, glaciology, etc.), there are substantive differences (religions, economies, etc.) between the two regions that offer unique stories. Together, this comparative study will provide a dynamic view of alternative approaches to global climate change policy.

Wenjing Jiang PhD Geography '18, Faculty Mentor: James McCarthy

Contemporary Agrarian Transformation in China: Ongoing Transfer of Rural Land Use Rights in a Reform Era

Transfers of land use rights, forbidden by law until 1984, are now central to China's development policies and implemented nationwide. Under current rules, local authorities formally subcontract the use rights of collectively owned rural land to villagers, which contributes to the enormous transformations of agricultural production and social relations in the countryside. How the formalization of land transfer practices takes place,

how it interacts with the politics of contemporary agrarian transformation, and what the implications are for policy-making and implementation, all require a close investigation into the ongoing practices and politics on the ground. Utilizing multiple sources of data (e.g., statistical records, participant observation, and interviews with stakeholders across levels), this project combines top-down and bottom-up perspectives to uncover the intentions behind, processes of, and outcomes from the formalization of these land transfer practices

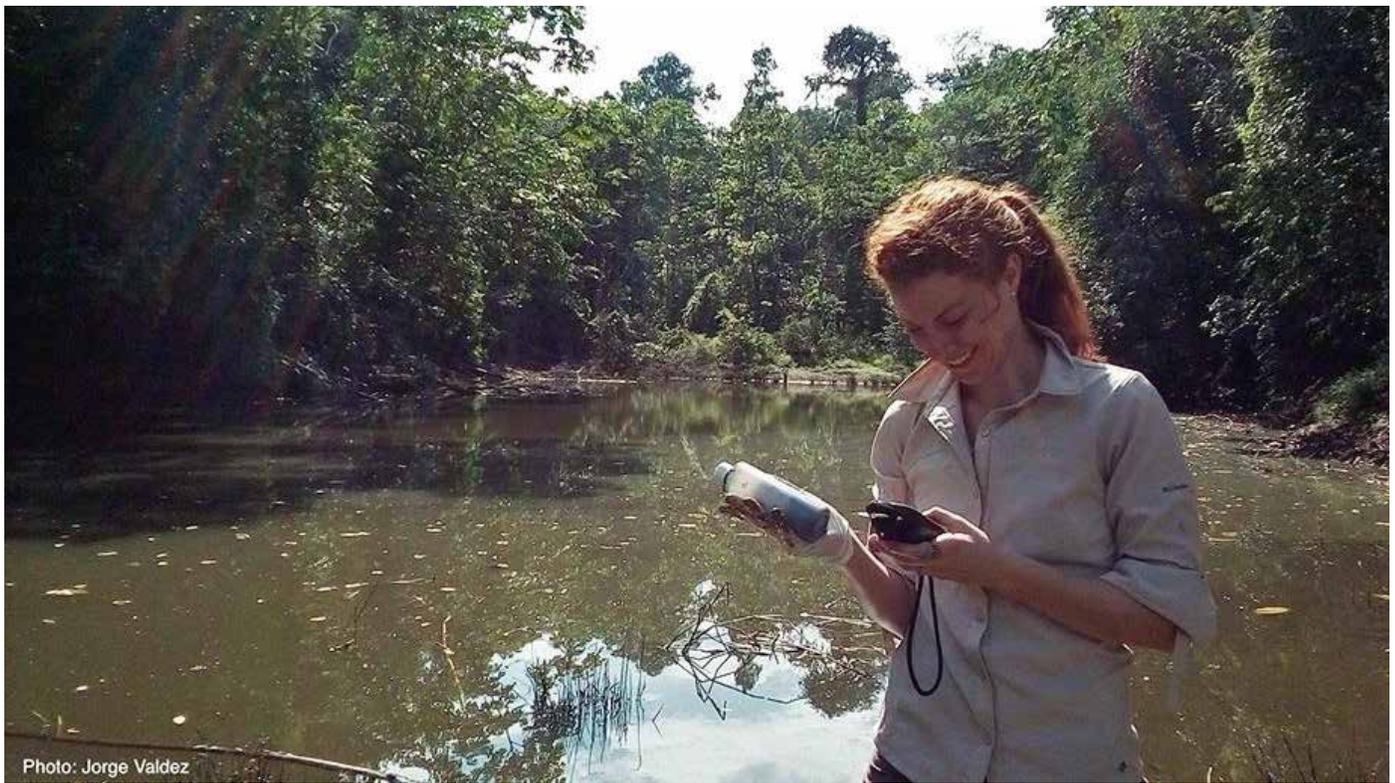


Photo: Jorge Valdez

Katherine Markham '17 analyzing water quality in Peru

Geller Endowed Research Awardees continued

Katherine Markham MS Environmental Science and Policy '17, Faculty Mentor: Florencia Sangermano

Modeling Faunal Vulnerability to Artisanal and Small-Scale Gold Mining in Madre de Dios, Peru

Peru is the world's fifth largest producer of gold, with the Madre de Dios region producing over 70% of Peru's gold. The recent rise in the price of gold has made it profitable to mine in previously unprofitable areas, such as deposits in tropical forests. Environmental threats associated with gold mining include arsenic, cyanide and mercury pollution of air, water, and soil. Using maps of artisanal and small-scale mines and data on species geographic distribution, this project will identify changes in the landscape

related to mining activities and relate these changes to species biodiversity and composition in the surrounding landscape. In-situ verification of map accuracy and interviews of local stakeholders about changes in land-use and their perceptions surrounding wildlife and biodiversity will be conducted. This international collaborative research will improve our understanding of the species and regions that could be affected by increased mining activities. Results may lead to changes in land use practices and conservation efforts and impact policy decisions concerning mining in areas of high biodiversity.

Kristen Shake PhD Geography '17, Faculty Mentors: Karen Frey and Deborah Martin

(Un)frozen Boundaries: Examining the Role of Sea Ice in the Socio-legal Dynamics of the Bering Sea Pollock Fishery

Sea ice is a dynamic element of the greater Arctic marine ecosystem. Its changing physicality influences a variety of socio-cultural processes, such as the extraction of living resources, the vitality and propagation of those resources in the marine environment, maritime activity, subsistence hunting activities, and search and rescue operations. Changes to the spatial extent of sea ice presents challenges for international law and no internationally agreed upon legal regime for sea ice currently exists. This is

particularly problematic in the Bering Sea where recent increases in the seasonal spatial extent of sea ice could present a hazard to fishing vessels, threaten the sustainability of an economically viable marine fishery, and intensify debates over maritime boundaries. Using legal archival analysis, document analysis, and semi-structured interviews, this project will investigate the linkages between dynamic sea ice, pollock fishery resources, and ocean law within the Bering Sea.



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 2015-16 included:

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

Anthony Bebbington was elected to the Board of Directors of Oxfam America in June 2016.

Robert J. Johnston serves on the US EPA Science Advisory Board (SAB). During 2015 he also served on the SAB Scientific and Technological Achievement Awards (STAA) Committee.

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

Robert J. Johnston served on the National Research Council (National Academy of Sciences) Committee on the Practice of Sustainability Science: The Landscape Perspective.

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 serves on the Management Committee and Scientific Advisory Committee for the Narragansett Bay Estuary Program.

Rinku Roy Chowdhury serves on the Scientific Steering Committee of the Global Land Project.

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

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. The Marsh Institute Working Papers Series also provides a mechanism to release new and important research findings while they undergo formal peer review. 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:

Dana Marie Bauer and colleague Ian Sue Wing's paper "The macroeconomic cost of catastrophic pollinator declines," recently published in *Ecological Economics*, estimates the global value of pollination ecosystem services to be \$127-152 billion, mostly due to indirect effects on non-agricultural (e.g., chemical inputs and processed food) sectors. Results were used by the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) Assessment Report on Pollinators, Pollination and Food Production.

Anthony Bebbington was among 43 co-authors collaborating on *A Hundred Key Questions for the Post-2015 Development Agenda*, which presents the results of a four-month consultative and participatory exercise that addresses the need to articulate and better align the research interests and priorities of academics and practitioners working on international development in a post-2015 framework.

Timothy Downs and colleague Nikita Golovko recently published "Integrative education for climate-change resilience x sustainable development transformations" in a special issue of the *International Journal of Global Warming* focused on Climate Change Education.

Robert J. Johnston and co-authors published "Ecosystem services indicators: Improving the linkage between biophysical and economic analyses, in the *International Review of Environmental and Resource Economics*. The paper provides guidance on identification and use of indicators in ecosystem service valuation.

Nathan Mietkiewicz and **Dominik Kulakowski** recently published the paper "Relative importance of climate and mountain pine beetle outbreaks on the occurrence of large wildfires in the western US" in the journal *Ecological Applications*. Results point to climate, not beetles, as the main culprit of wildfires, suggesting new approaches to managing forests and preventing wildfires.

R. Gilmore Pontius Jr. and colleagues co-authored the paper "SimiVal, a multi-criteria map comparison tool for land-change model projections" in *Ecological Modelling and Software* that identified the major dimensions of land-cover maps that ought to be evaluated, and devised a Similarity Validation tool to test models using these metrics.

Christopher Williams is serving as a lead author (chapter on Forests) for the United States Carbon Cycle Science Program interagency partnership report 2nd State of the Carbon Cycle Report (SOCCR-2). The report is focused on the scientific understanding of North American carbon cycle stocks and fluxes, in the context of and interactions with global scale budgets and climate change impacts in managed and unmanaged

systems, identifying uncertainties and rising opportunities for improving measurements and projections in the carbon cycle.

Deborah Woodcock and colleagues recently published "The Piedra Chamana Fossil Woods" in the *International Association of Wood Anatomists Journal*. The report presents results from an in-depth investigation of a petrified forest in northern Peru that includes anatomical descriptions of the fossil woods and identifications of the fossil taxa in order to understand more about the forest, its paleoenvironment, and forest history in the highly biodiverse New World tropics.

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:

Edward Carr received the US Department of Agriculture's Abraham Lincoln Honor Award for Contributions to Global Food Security for his role as a lead author of the 2015 report on Climate Change, Global Food Security, and the US Food System.

Robert J. Johnston was awarded the Henry Schapper Visiting Fellowship from the Australian Agricultural and Resource Economics Society (AARES).

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.



"The Path to a Climate-Friendly and Socially Just Transportation Future"

Albert, Norma and Howard '77 Geller Endowed Lecture, co-sponsored by the Mosakowski Institute for Public Enterprise

KRISTINA EGAN

Director, Transportation for Massachusetts



"Conserving Small Natural Features with Large Ecosystem Functions"

DANA MARIE BAUER

Assistant Director and Research Scientist,
George Perkins Marsh Institute, Clark University



"Protracted Circumstances of Refugee Displacement: Making Homes in Limbo?"

ANITA H. FABOS

Associate Professor, Department of International Development, Community, and Environment, Clark University



"Those Gendered Outcomes Aren't Bugs, They're Features! Transitioning Mali's Agro-meteorological Advisory Program from Humanitarian Assistance"

EDWARD CARR

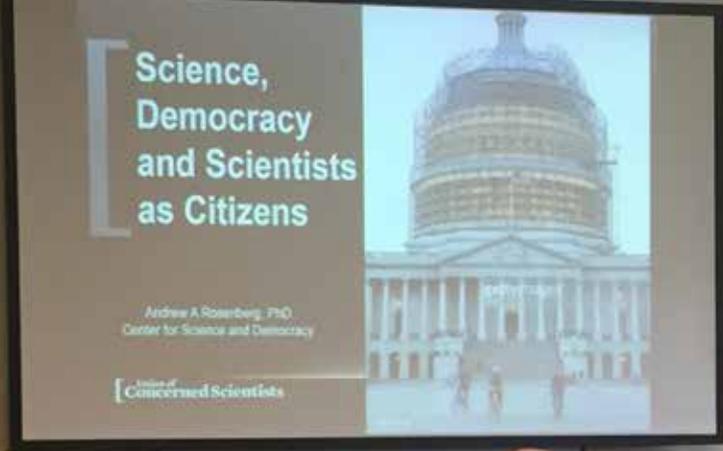
Director and Professor, Department of International Development, Community, and Environment, Clark University



"The Economics of Sea Level Rise, Coastal Vulnerability and Adaptation: Choices and Tradeoffs in New England"

ROBERT J. JOHNSTON

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



"Speculative Wonder at the World's End"

Co-Sponsored with the Graduate School of Geography Colloquium Series

LAURA OGDEN
Associate Professor, Department of Anthropology, Dartmouth College



"Willful Ignorance: The Mismeasure of Uncertainty"

HERBERT I. WEISBERG
President, Causalytics, LLC



"Science, Democracy and Scientists as Citizens"

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

ANDY ROSENBERG
Director, Center for Science and Democracy, Union of Concerned Scientists



"Multi-Capitalism: The Future of Corporate Sustainability Standards"

ALLEN WHITE
Vice President and Senior Fellow, Tellus Institute



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 internet resources. The staff provide exceptional and personalized research assistance. More than 2,500 students, faculty, and others visited the library this past year.



The George Perkins Marsh Institute Steering Committee, 2015-16

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; Director, Environmental Science Program

Karen Frey

Associate Professor, Graduate School of Geography

Robert Goble

Research Professor, George Perkins Marsh Institute

James Gomes

Director, Mosakowski Institute for Public Enterprise

Deborah Martin

Professor, Graduate School of Geography

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

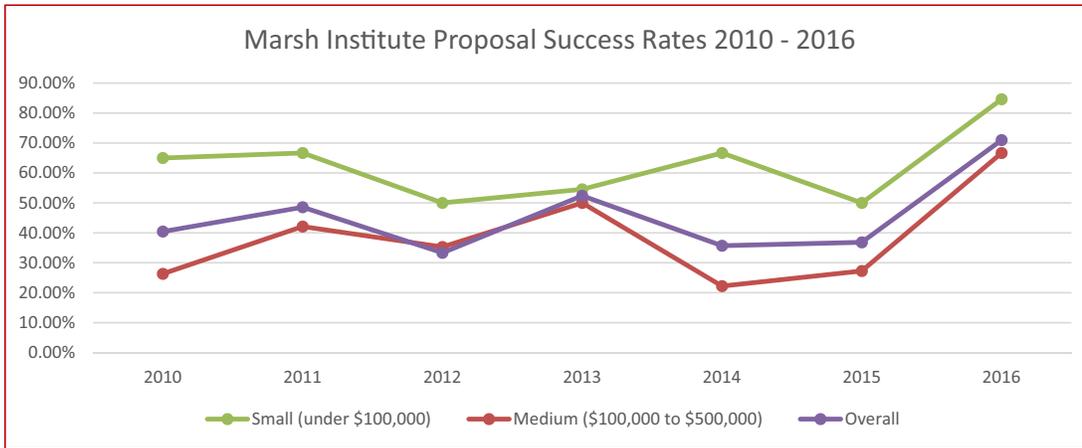
EX-OFFICIO MEMBERS

Robert J. Johnston

Director, George Perkins Marsh Institute

Nancy Budwig

Associate Provost and Dean of Research



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 2016, the Institute maintained approximately \$8.5 million in current grants, covering 42 active projects. Ten of these are components of large-scale, multi-institutional research projects each exceeding \$1 million in total funding.

The Institute has an excellent success rate with research proposals. For fiscal year (FY) 2016, the Institute's overall success rate was 71%. For medium proposals (\$100,000 - \$500,000), the success rate was 67%, while for smaller proposals (<\$100,000), the success rate was 85%. During FY 2016, the Marsh Institute was awarded new grant funds totaling \$4.1 million. The average award amount was \$186,480 per grant, an increase of 76% over FY2015.

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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