

SUSTAINABLE ENVIRONMENTS  
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GEORGE PERKINS MARSH INSTITUTE

Highlights, Accomplishments and Impacts  
of the George Perkins Marsh Institute  
Annual Report 2017-18

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 issues facing today's world. The Institute's research covers three core research themes linked by cross-cutting topics. Our primary research themes include: ① Socioecological (or human-environment) Systems and Sustainability Science, ② Earth System Science, and ③ Institutions and Human Development. Cross-cutting topics reflect areas of particular importance that are studied through these scientific lenses. **Recent cross-cutting topics include:** Climate Change Impacts and Adaptation, Local and Global Food Security, and Sustainable Urban and Rural Communities.



# HIGHLIGHTS, ACCOMPLISHMENTS AND IMPACTS OF THE GEORGE PERKINS MARSH INSTITUTE

## ANNUAL REPORT 2017-18

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

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

The Marsh Institute is one of the most productive hubs for research activity at the University, generating approximately 50% of the University's external research funds. New research projects initiated during 2017-18 address topics including:

- Understanding the effect of drought hazards in subsistence agriculture in sub-Saharan Africa
- Integrating real-time environmental data and crowd-sourcing to improve climate adaptation actions that enhance food security
- Examining the design and on-going development of a "smart" urban development project in Kenya
- Analyzing the land conversion impacts of a federal land quota system in China
- Assessing the impact of infrastructure and extractive industry investments on deforestation
- Developing a more accurate agricultural land cover mapping platform
- Investigating rare Eocene mangrove ecosystem fossils in Peru
- Exploring seasonal and inter-annual marine ecosystem changes in the Pacific Arctic region

External support for these and other Institute activities comes from federal, state, local and international grants, private donations, foundations, and other sources.

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

The Institute also provides research opportunities for Clark graduate and undergraduate students. Dozens of students participate in the Institute's externally funded research projects each year. Dedicated programs for student research include the NOAA Fellows summer internship program; the Albert, Norma and Howard '77 Geller Research Grants; and the Human-Environment Regional Observatory (HERO) research program in Massachusetts. 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 Research Library, whose holdings include one of the most extensive research collections in North America on risks, hazards and global environmental change. We work closely with 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), and Clark Labs.

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



## SOCIOECOLOGICAL SYSTEMS AND SUSTAINABILITY SCIENCE

Among the most pressing challenges facing human society are those involving relationships between humans and natural systems. Researchers at the Marsh Institute were among the pioneers of sustainability science, and the Institute remains a world leader in this critical area of work. This research requires multidisciplinary perspectives that recognize the importance of uncertainty, risks, and resilience. Researchers study such diverse topics as climate change impacts and adaptation, ecosystem services, urbanization, and sustainable agricultural systems. We work with decision makers to transform knowledge into action. Partnering with investigators from Clark's Graduate School of Geography, 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. Funding for work in this area comes from federal and regional agencies and foundations.

### 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. Projected rates of sea-level rise and increased human modification of coastal watersheds and shorelines may cause extensive marsh losses across the United States. This multi-disciplinary, collaborative research project examines the comparative vulnerability of salt marshes to sea-level rise in three U.S. Atlantic Coastal Long-Term Ecological Research (LTER) sites that vary with respect to sediment supply, tidal range and human impacts. The research also addresses how feedbacks from potential adaptations influence marsh vulnerability, economic benefits and costs, and practical management decisions. This collaborative, \$2 million Coastal Science, Engineering, and Education for Sustainability (Coastal SEES) project addresses the broad interdisciplinary question "How will feedbacks between salt marsh response to sea-level rise and human adaptation responses to potential salt marsh loss affect the overall sustainability of the combined socio-ecological system?"

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

Principal Investigators: Robert J. Johnston and Dana Marie Bauer

Funding Agency: National Oceanic and Atmospheric Administration

This project is an international and interdisciplinary collaboration led by Marsh Institute researchers, with collaborators at the Virginia Institute of Marine Sciences and Monash University in Melbourne, Australia. Tidal marshes are one of the most common natural features that protect 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, promoting marsh resilience. 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 develops 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 develops and illustrates 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 among multiple organizations seeking to understand the natural and social dimensions of riparian buffer management. The goal is to enhance stakeholder capacity to make informed decisions related to the protection and restoration of buffers around GBE. In support of this goal, the project conducts an integrated assessment focused on the following policy question: What are the potential regulatory and non-regulatory options for protecting and restoring buffer zones around New Hampshire's Great Bay? Marsh Institute researchers are leading the economic component of this interdisciplinary effort, applying cutting-edge methods in meta-analysis, benefit transfer and ecosystem service valuation to predict the value of riparian buffer enhancements in the GBE region.

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

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

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

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

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

This project combines coastal hazards, property value and other data with economic models to answer three questions central to northeast US coastal adaptation: (1) How do property values in northeast communities respond to coastal hazards? (2) How do property values respond to adaptation actions undertaken by states, municipalities or homeowners and developers? (3) What do results imply for future property values and tax bases in northeast communities, under alternative climate change scenarios? The study develops and applies rigorous economic methods that, when integrated with natural science data and projections on coastal vulnerability, enable stakeholders and decision makers to evaluate the property value and tax base impacts of climate change adaptation across northeastern 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 enhance the ability of communities to choose adaptations with desirable economic consequences. A workshop under this project in 2017

brought together a wide range of decision makers and stakeholders from across New England to discuss the economic aspects of coastal climate adaptation.

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

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

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

### Targeted Conservation Contracts to Enhance Agricultural Best Management Practices

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

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

to enable the design of flexible conservation contracts that can be used to optimize environmental benefits, farmer adoption, or acres enrolled. These innovative contracts will help U.S. agriculture remain competitive while balancing production and sustainable agri-environmental benefits.

### Navigating the Tradeoff between Pest Management and Pollinator Conservation

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

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



## Conserving Small Natural Features with Large Ecosystem Functions in Urbanizing Landscapes

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

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

## Promoting Sustainable Consumption Research and Action

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

Marsh Institute researchers Halina Brown and Philip Vergragt work at the forefront of sustainable consumption research. Brown and Vergragt are Founding Board Members of SCORAI, the Sustainable Consumption Research and Action Initiative, an international network of over 1000 professionals working to address challenges at the interface of material consumption, human fulfillment, lifestyle satisfaction, and technological change. For more than a decade, SCORAI network participants have advanced and disseminated knowledge and contributed to policy dialogues and practices, in order to chart pathways towards a more sustainable future. This past year, Brown and Vergragt were co-organizers of the third International Conference on Sustainable Consumption Research and Action in Copenhagen, Denmark and participated in the IPCC Conference on Cities in Edmonton, Canada, where they were part of a panel discussing sustainable consumption and cities.

## Developing and Scaling Up the Mapping Africa Active Learning Platform

Principal Investigator: Lyndon Estes  
Funding Agency: Omidyar Network

The need for both growth and reform of agriculture is particularly urgent in sub-Saharan Africa (SSA), where populations are expected to double and economies quintuple by 2050, leading to a tripling of food demand. Existing agricultural maps for SSA fail to quantify even the most basic agricultural characteristics (where and how much cropland there is), and must become much more accurate at much finer resolutions if we are to adequately

solve agriculture's challenges. This project refines and tests a methodology for a scalable, fast, and cost-effective land cover mapping platform based on a next generation machine-learning algorithm that directs human mappers (based in SSA) to collect training data over the most difficult to classify locations. Active learning produces maps that are more accurate across a broader range of agricultural types than conventional classification methods. The maps will not only distinguish agricultural from non-agricultural areas with unprecedented accuracy, but will go beyond pixel-based classifications to map individual fields. The platform will be tested in Ghana.

## Impacts of Agricultural Decision Making and Adaptive Management on Food Security

Principal Investigator: Lyndon Estes  
Funding Agency: National Science Foundation

Despite significant attention from governments, donor agencies, and NGOs, food security remains an unresolved challenge in the context of global human welfare. Technical and conceptual limits have prevented the collection and analysis of rich empirical datasets with high temporal frequency over large spatial extents necessary to investigate how changes to seasonal precipitation patterns affect food security. Working with collaborators at UC Santa Barbara and Indiana University, researchers will integrate physical models of hydrological and agricultural dynamics with real-time environmental data obtained from previously developed, novel, cellular-based environmental sensing pods and real-time reports of farmer decision making submitted via cell phones. The research addresses three critical research questions: (1) How do intra-seasonal dynamics of the environment and social systems shape farmer adaptive capacity? (2) To what extent does intra-seasonal decision making enable farmers to adapt to climate uncertainty? (3) How can intra-seasonal data improve the ability to model, predict, and improve adaptation to climate variability in ways that enhance food security?

## Integrating Crowdsourcing, in situ Sensing, and Spaceborne Observation to Understand the Sustainability of Smallholder Agriculture in African Wet Savannas

Principal Investigator: Lyndon Estes  
Funding Agency: National Aeronautics and Space Administration

Livelihoods in sub-Saharan Africa (SSA) rely heavily on small-scale farming. This dependence could deepen as SSA's wetter savannas will be increasingly farmed to meet growing food demand, while economic growth strategies promote the expansion of smallholder farming. This large-scale, smallholder-based agricultural development in a region with a highly variable climate raises two important sustainability questions: (1) Do strategies for increasing smallholders' productivity increase or decrease their resilience to climatic variability? (2) Will productivity gains minimize the amount of new land needed for agriculture? The project will use a novel approach that integrates crowd-sourcing, in situ environmental sensing, and Earth Observing satellites to achieve three main objectives: (1) identify patterns of cropland change in smallholder farms; (2) identify landscape-scale trends

in smallholder productivity; and (3) understand the relationships among changes in crop productivity, land cover, and climatic variability. The project focuses on maize farming in Zambia, a bellwether for regional agricultural development that has seen recent maize yield increases and farmland expansion.

### Understanding Cross-scale Interactions of Trade and Food Policy to Improve Resilience to Drought Risk

Principal Investigator: Lyndon Estes

Funding Agency: National Science Foundation

Food security in regions affected by drought is influenced by a complex set of interactions among hydrological, agricultural, and social systems. Previous models examining the impact of drought on food security have not incorporated food trade and food movements at fine spatial scales, yet these components are critical parts of regional food systems. In sub-Saharan Africa droughts and floods account for approximately 80% of fatalities and 70% of the economic losses that are due to natural hazards. This project's goal is to understand the effect of drought hazards in subsistence agriculture, using a novel integrative framework that merges data, models, and knowledge of drought risk and crop production, their interactions with the dynamics of trade-based and aid-based responses, and their effect on household food security and consumption. With collaborators at Princeton University, we shall address three questions: (1) What are the spatio-temporal scales of drought risk across Zambia and how does risk transfer into agricultural impacts? (2) What is the role of trade and domestic food policy on food security at local to national levels? (3) Can drought impacts be more effectively reduced by integrating an understanding of policy and food transfers into an agricultural drought early warning system?

## TRAINING RESEARCHERS AT CLARK UNIVERSITY

Recent collaborative efforts between the George Perkins Marsh Institute and the Office of Sponsored Programs and Research have provided workshops and training to enhance research productivity and impact across the University. During 2018, Marsh Institute Director Robert Johnston coordinated with Associate Provost and Dean of Research Yuko Aoyama on a workshop to enhance grant-writing skills across the University, "How to Secure External Funding: Tips for Successful Grant-Writing in Natural and Social Sciences." As Co-Chair of the University's Institutional Review Board (IRB) during 2017-18, Johnston also worked with researchers to ensure that their work met rigorous standards to protect the rights and safety of human subjects. Through these and other efforts, the Marsh Institute works to improve research success across multiple disciplines and departments.

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

Principal Investigator: Robert Gilmore Pontius Jr.

Funding Agency: National Science Foundation

Over the last 30 years, surface seawater temperatures in the Gulf of Maine have risen at three times the global average, rates of sea-level rise have accelerated, and precipitation has increased. Coupled with these changes in climate and sea level are substantial changes within the rapidly urbanizing watersheds that influence water, sediment, and nutrient delivery to marshes and estuaries. The Plum Island Ecosystems (PIE) Long Term Ecological Research (LTERR) site is developing a predictive understanding of the response of a linked watershed-marsh-estuarine system in northeastern Massachusetts to rapid environmental change. This large-scale, interdisciplinary project will test how internal feedbacks within the marsh-estuary ecosystem influence the response of geomorphology, biogeochemistry, and food webs to three major drivers: climate, sea-level rise, and human alteration of the watershed. It will address three critical questions. (1) How will the geomorphic configuration of the marsh and estuary be altered by changes in the watershed, sea-level rise, climate change, and feedbacks internal to the coastal system? (2) How will changing climate, watershed inputs, and marsh geomorphology interact to alter marsh and estuarine primary production, organic matter storage, and nutrient cycling? (3) How will key consumer dynamics and estuarine food webs be reshaped by changing environmental drivers, marsh-estuarine geomorphology and biogeochemistry? Cross-system comparisons with other LTERRs along gradients of temperature, species composition, tidal range, and sediment supply will further our understanding of long-term change in coastal ecosystems.

### FCE III — Coastal Oligotrophic Ecosystems Research

Principal Investigator: Rinku Roy Chowdhury

Funding Agency: National Science Foundation

The Florida Coastal Everglades (FCE) Long-Term Ecological Research (LTERR) 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 LTERR employs long-term datasets to determine how the amount and quality of fresh water flowing through the Everglades influences ecological processes in the coastal zone. Coupled socio-economic studies reveal how decisions about Everglades restoration influence—and are influenced by—the human history of dependence on local natural resources. This project recognizes the importance of water in the sociopolitical environment, and addresses how and why land and water use in South Florida has changed. Specifically, this project identifies the sources of sociopolitical conflicts over freshwater distribution and evaluates how solutions that improve inflows to the Everglades mediate the effects of sea-level rise on freshwater sustainability in the coastal zone.

## Urban Resilience to Extreme Weather-related Events

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

Urban areas are vulnerable to extreme weather-related events because of their location, high concentration of people, and increasingly 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 of this magnitude. This interdisciplinary project will develop a diverse suite of new methods and tools to assess how infrastructure can be more resilient, provide ecosystem services, improve social well-being, and exploit new technologies in ways that benefit all segments of urban populations. The primary research questions are 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.

## Alternative Ecological Futures for the American Residential Macrosystem

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

An apparent, but untested result of changes to the urban landscape is the homogenization of cities, such that neighborhoods in very different parts of the country increasingly exhibit similar patterns in their road systems, residential lots, commercial sites, and aquatic areas; that is, cities have now become more similar to each other than to the native ecosystems that they replaced. This research examines the ecological homogenization of the American Residential Macrosystem (ARM) and specifically investigates factors that contribute to stability and/or changes in the ARM. The aim is to determine how factors that effect change—such as shifts in human demographics, desires for biodiversity and water conservation, regulations that govern water use and quality, and dispersal of organisms—will interact with factors that contribute to stability such as social norms, property values, neighborhood and city covenants and laws, and commercial interests. The project will determine ecological implications of alternative futures of the ARM for the assembly of ecological communities, ecosystem function, and responses to environmental change and disturbance at parcel (ecosystem), landscape (city), regional (Metropolitan Statistical Area), and continental scales. Five types of residential parcels as well as embedded semi-natural interstitial ecosystems will be studied, across six U.S. cities (Boston, Baltimore, Miami, Minneapolis-St. Paul, Phoenix, and Los Angeles).

## HELPING GOVERNMENT AGENCIES INCORPORATE ECOSYSTEM SERVICES INTO DECISION MAKING



Marsh Institute Director Robert Johnston has engaged in a number of collaborative efforts to inform the ways that US federal agencies manage and account for ecosystem services (the goods and services provided by nature). This past year, Johnston was invited to speak to the National Academies of Sciences,

Engineering, and Medicine Committee on the Potential for Biotechnology to Address Forest Health, which is charged with identifying the ecological, economic and social implications of deploying biotechnology in forests. Johnston's talk "Forest Health and Biotechnology within an Ecosystem Services Framework" described how a structured ecosystem services framework can be implemented to evaluate the social effects of forest biotechnology and identify the various pathways through which benefits and costs occur. In addition, Johnston was a member of the steering committee that led a Council on Food, Agricultural and Resource Economics (C-FARE) effort to help USDA quantify the economic value of agricultural conservation-based ecosystem services, and contributed to the working group of that effort focusing on the quantification of ecosystem services related to water-quality improvements. Johnston is also a member of the steering committee of a US EPA effort (led by Paul Ringold at EPA) 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*. 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. Johnston was also part of the interdisciplinary team that created the *Federal Resource Management and Ecosystem Services Guidebook* and co-authored *Best Practices for Integrating Ecosystem Services into Federal Resource Management*, two guidance documents intended to help federal agencies respond to rules and regulations on ecosystem services and federal decision-making. He has pioneered benefit transfer methods now used worldwide to estimate the economic benefits of ecosystem services improvements. He also co-authored the 2017 paper "So You Want Your Research to be Relevant? Building the Bridge between Ecosystem Services Research and Practice," which was published in the journal *Ecosystem Services*.



Centered in expertise at Clark University's internationally recognized Graduate School of Geography, Earth System Science 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. Earth System Science research studies the connections among 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 the causes and consequences of global climate change. Work in this area is supported by major grants from the National Science Foundation, the National Aeronautics and Space Administration, and the National Geographic Society.

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

Principal Investigator: Karen Frey

Funding Agency: National Aeronautics and Space Administration

Arctic sea ice cover is undergoing tremendous change. There has been a pronounced decrease in the summer sea ice extent, an overall thinning of the ice, a lengthening of the summer melt season, and a fundamental shift to a primarily seasonal sea ice cover. Some of the greatest changes in sea ice cover have been observed in the Chukchi and Beaufort seas, where there has been substantial loss of summer ice in recent decades. These changes in the physical system are affecting biological and biogeochemical systems profoundly. 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, Cold Regions Research and Engineering Laboratory, University of Washington, and NASA Goddard Space Flight Center).

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

Principal Investigator: Karen Frey

Funding Agency: National Science Foundation

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

communities and media will ensure that both those immediately impacted and the broader public will be made aware of changes occurring in this sensitive area of the Arctic.

## The Distributed Biological Observatory (DBO): A Change Detection Array in the Pacific Arctic Region (Phase 2)

Principal Investigator: Karen Frey

Funding Agency: National Science Foundation

Within the Pacific Arctic region, the northern Bering and Chukchi Seas are among the most productive marine ecosystems. Recent shifts in seasonal sea-ice cover are having profound consequences for seasonal phytoplankton production as well as affecting intimately linked upper trophic level species, including those harvested locally for subsistence. Key uncertainties remain as to how the marine ecosystem will respond to seasonal shifts in the timing of spring sea-ice retreat and/or delays in fall sea-ice formation. The internationally coordinated Distributed Biological Observatory network provides a change detection array that allows for consistent sampling and monitoring of productivity hotspots by all participants. The overarching goal of this continuing project is to use coordinated south-to-north observations as a "space for time" strategy in which a suite of physical, biochemical, and biological measurements evaluate ecosystem change both seasonally and inter-annually over the spatially diverse latitudinal gradient. Working with collaborators from the University of Maryland, University of Washington, and Woods Hole Oceanographic Institute, specific questions for Phase 2 include: (1) Will an earlier sea-ice retreat and changes in seawater properties influence the composition of pelagic and benthic prey species that can cascade to upper trophic organisms? (2) How will plankton and the benthos change on the Pacific Arctic continental shelves with reduced sea-ice persistence over a south-to-north latitudinal basis, both seasonally and temporally? (3) What is the impact of seasonal changes in hydrography (salinity, temperature, and nutrients) on the lateral and vertical distribution of primary production and export production to the benthos?

## 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.

## Translating Forest Change to Carbon Emissions

Principal Investigator: Christopher A. Williams

Funding Agency: National Aeronautics and Space Administration

Forests are a globally significant store of carbon, but this store is vulnerable to release from disturbance processes such as harvesting or fires. At the same time, intact forests serve as a major offset to rising CO<sub>2</sub> concentrations as forest growth becomes stimulated by rising CO<sub>2</sub> levels, enabling forests to absorb about one third of annual carbon emissions. The balance of these processes is constantly changing and varies widely from region to region. National and international policies aimed at protecting forest carbon storage rely heavily on high quality, accurate reporting (called "Tier 3") that earns the greatest financial value of carbon credits and hence incentivizes forest conservation and protection. But methods for Tier 3 Measuring, Reporting, and Verification (MRV) are still in development. This project aims to quantify how much carbon is being released and taken up by each process over the entire United States using a new approach to Tier 3 MRV, involving a combination of direct remote sensing, ground-based inventorying, and computer modeling methods to track forest carbon emissions and removals at a 1 km scale. Few existing approaches seek to combine all of these sources of information. Specificity about the underlying processes driving carbon flows enables the framework to be used as a decision-support tool to help test the relative benefits of various land management strategies and to examine how today's carbon sources and sinks will trend over time.

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

Principal Investigator: Christopher A. Williams

Funding Agency: National Aeronautics and Space Administration

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

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

Principal Investigator: Christopher A. Williams

Funding Agency: National Aeronautics and Space Administration

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

## What can a 39-million-year-old Coastal Ecosystem Tell us about Climate and Earth History?

Principal Investigator: Deborah Woodcock

Funding Agency: National Geographic Society

Mangrove ecosystems are rarely represented in the fossil record because the dynamic nature of the coastal environment is not conducive to the preservation of organic remains or shelly material. The Piedra Chamana Fossil Forest in northern Peru was preserved 39 million years ago when a volcanic eruption buried coastal mangroves and nearby forests in volcanoclastic deposits. The unusual circumstances of preservation underscore the potential of the site to provide a multi-proxy record that will (1) provide a uniquely detailed picture of late middle Eocene mangrove and lowland tropical forest ecosystems; (2) contribute to our understanding of the history of the New World tropical forests and development of tropical biodiversity; (3) allow for comparison and evaluation of paleoenvironmental proxies (leaves versus woods, marine versus terrestrial, geochemical versus biological) that do not generally co-occur; and (4) serve as a rich baseline reference of the vegetation and environment in the New World tropics at a time of considerable global warmth. The project also supports interpretation and education efforts related to conservation and protection of the fossils and fossil site.



## RESEARCH TO INFORM GLOBAL CLIMATE CHANGE ADAPTATION

Global climate change affects millions of people world-wide through increased intensity and frequency of droughts, floods, pest infestations, and habitat destruction and degradation. George Perkins Marsh Institute researchers are at the forefront of science and policy efforts to inform climate change mitigation, adaptation, and long-term resilience. Edward Carr, Sheila Onzere, and Robert Goble are evaluating existing climate information services (CIS) programs in Africa with the goal of increasing the efficiency and effectiveness of future investments in CIS delivery, and ultimately increasing the number of users of CIS who benefit through livelihood practices. Karen Frey is determining the impact of thinning and retreating sea ice cover on biological productivity and biogeochemical cycling in the Pacific Arctic region. Elisabeth Gilmore is investigating the role of climate-driven human migration as an indicator of social stress, which may lead to social unrest and violence in both receiving and originating communities depending on the affected societies' resilience and adaptive capacity. Robert Johnston is comparing the vulnerability of salt marshes to sea-level rise in three Atlantic coastal sites that vary with respect to sediment supply, tidal range, and human impacts in order to understand how potential adaptations may influence marsh vulnerability, associated economic benefits and costs, and practical management decisions. Gil Pontius is exploring how internal feedbacks within the Gulf of Maine marsh-estuary ecosystem influence the response of geomorphology, biogeochemistry, and food webs to three major drivers: climate, sea-level rise, and urbanization of the watershed. Rinku Roy Chowdhury is analyzing the spatial structure and land cover components of vulnerability to climate-driven extreme events (e.g., hurricanes), 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. Christopher Williams is investigating uncertainty in current models of carbon dioxide and methane sources and sinks to produce more accurate and precise estimates that will enable the more accurate prediction of a future climate and improve climate change mitigation and adaptation. Through these and other projects, Marsh Institute researchers are helping to ensure sustainable natural, human, and engineered systems in a world threatened by a constantly changing climate.



## INSTITUTIONS AND HUMAN DEVELOPMENT

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

### 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 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's (HURDL) Livelihoods as Intimate Government (LIG) ethnographic approaches, an understanding of the connection, if any, between these differing degrees of women's participation and differences in forest outcomes will be developed. Results from this work will support calls for future work on changing/improving women's participation in forest governance.

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

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

Climate information services (CIS) involve the production and use of climate knowledge in climate-smart decisions, planning, and policy-making. Easily accessible, timely, and relevant scientific information can help society cope with current climate variability

and limit the economic and social damage caused by climate-related disturbances. The goal of this project is to increase the efficiency and effectiveness of future investments in CIS delivery, and ultimately increase the number of users of CIS who will benefit through livelihood practices. Through literature reviews, analyses of existing CIS systems, and a pilot evaluation program using the Humanitarian Response and Development Lab's (HURDL) Livelihoods as Intimate Government (LIG) approach, this project will (1) increase understanding of, and access to, knowledge on the effectiveness of current CIS programming, (2) expand the current understanding of how CIS systems function in the context of broader social, cultural, and institutional systems within which they operate, (3) increase evidence on the degree of effectiveness of CIS on livelihoods, and (4) escalate dissemination and uptake of new knowledge.

### Mali Climate Change Adaptation Activity

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

Facing an estimated 30% drop in rainfall since the 1980s, while 80% of its population earns its 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.

### Assessment and Scoping of Infrastructure and Extractive Industries in Relation to Deforestation - Part 2

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

Large-scale infrastructure and extractive industry projects have attracted significant private and public investment, with direct and indirect synergies between them. However, while the effect of roads on deforestation has been widely studied, the extent to which extractive industry affects forest cover and forest-dependent livelihoods is less clear. Although the actual footprint of operations is modest in absolute terms, the footprint of pollutant-based externalities can be far larger. In addition, the drivers of these different processes are multiple and complex. With a focus on three regions (Brazil, Mexico/Central America, and Indonesia), this project: (1) describes the recent geography of infrastructural and extractive industry investments; (2) assesses the current state of knowledge regarding the impacts of these investments on forest cover and quality, and the rights, organizations and livelihoods of forest-dependent communities; (3) examines the work different organizations are already doing on the relationships among infrastructure, extractives and forests, including what their successes and failures have been with different types of strategy; and (4) identifies feasible strategies for CLUA.

## HUMANITARIAN RESPONSE AND DEVELOPMENT LAB

The Humanitarian Response and Development Lab (HURDL) is a development and humanitarian assistance research and implementation lab within the George Perkins Marsh Institute at Clark University. HURDL scientists and student researchers are engaged in projects that range from policy development to project design and implementation. This diverse portfolio of activities is unified by a shared belief that the challenges we see in the Global South are products of various forms of risk and uncertainty that limit the potential for locally generated innovations that could change the lives of the poor. HURDL collaborates with many different organizations including the World Bank, the Red Cross Climate Center, the International Research Institute for Climate and Society, and the Climate Services Partnership, among others, creating a broad network of experience and expertise to inform its work.



Photography © Tshitshi Kalala



### Forecasting Armed Civil Conflict under Alternative Climate Change and Socioeconomic Scenarios

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

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

### 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?

### 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, and the City of Worcester, this project will develop, implement, monitor, and evaluate a plan, based on the evidence-based Office of Juvenile Justice and Delinquency Prevention Comprehensive Gang Model, to reduce gang-related criminal activity while addressing the needs of disengaged youth in the Greater Kilby-Gardner-Hammond neighborhood.

### **Safe and Successful Youth Initiative (SSYI) Project East**

Principal Investigator: Laurie Ross  
Funding Agency: City of Worcester

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

### **Shannon Community Safety Initiative: Worcester Local Action Research Partner**

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

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

### **Shannon Community Safety Initiative: Massachusetts Statewide Research Partner**

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

The Senator Charles E. Shannon Community Safety Initiative is a state-wide program designed to reduce youth and gang violence

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

### Land Conversion and Misallocation across Cities in China

Principal Investigator: Junfu Zhang

Funding Agency: Lincoln Institute of Land Policy

China is experiencing rapid urbanization, whereby large amounts of farmland at the urban edge are being converted to urban use. This is taking place in a unique institutional context in which the central government specifies the total amount of land to be converted each year and allocates quotas among different provinces, which in turn are distributed to lower-level governments. While some of this land is used to build infrastructure and public facilities, the use rights of the rest are leased to developers and businesses for very long terms (40, 50, or 70 years depending on the use type). Over the years, local governments have increasingly relied on land lease revenue to finance public spending. Whereas this land quota system is arguably the most important government policy shaping urban development

in China, little is known about the details of land conversion at the city level and still less is known about the consequences of this policy. Collaborating with Shihe Fu, Professor of Economics at Xiamen University, this research addresses two primary research questions: First, what are the important characteristics of land conversion and land finance at the city level in China? Second, does the land quota system efficiently allocate newly converted urban land across cities in China?

### Generative Urbanization in Emerging Africa? The Case of Konza Techno City

Principal Investigator: James Murphy

Funding Agency: Regional Studies Association

Africa is experiencing an urban transition that raises significant questions as to whether its economies are being transformed structurally. In Kenya, the prospects seem particularly high as the country has experienced steady growth and urbanization since the early 2000s. In response, the country's leaders are constructing Konza Technopolis, a "smart" urban development project that aims to establish industrial clusters in the information-communication technology (ICT), life sciences, and engineering sectors that will foster innovation, attract FDI, and create knowledge spillovers and other positive externalities to position Kenya favorably in high-tech industries globally. This study is examining the design and on-going development of Konza in order to assess whether such a project might spur industrial transformation in Kenya. The research will determine whether outcomes such as innovation, labor market development, industrial diversification, and urban sustainability are possible and what challenges need to be addressed to ensure Konza's success. The research will advance geographical conceptualizations of the links between urbanization and development and provide key insights for policy makers and planners.





## RESEARCH TO PROMOTE WORLDWIDE FOOD SECURITY

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



Pictured from left: Jim Gomes, Jess Strzempko, Anthony Himmelberger, Sophie Spiliotopoulos, and Karen Frey.

Photography © Lu Ann Pacenka

The George Perkins Marsh Institute provides innovative, applied research opportunities for Clark graduate and undergraduate students. Programs range from endowed awards for student-initiated research to large-scale research projects promoting student involvement and hands-on learning. Throughout 2017-18, Marsh Institute grants and endowments supported 40 graduate students, 18 undergraduate students, one post-MA research associate, and five post-doctoral fellows. In addition, Institute faculty and staff have been central to the development of the new Liberal Education and Effective Practice (LEEP) initiative. This is 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.

### National Oceanic and Atmospheric Administration (NOAA) Student Fellowships

Now in its seventh 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 the summer of 2018.

Anthony Himmelberger

Earth System Science '19, Faculty Mentor: Karen Frey, Location: Naples, Florida



**Assessing Loggerhead Sea Turtle Nesting Activity along the Cape Romano Complex Beaches**

Himmelberger interned at the Rookery Bay National Estuarine Research Reserve (NERR) in Naples, Florida where he monitored and documented sea turtle nesting and hatching activity throughout the Cape Romano beach complex. Several species of sea turtles inhabit the estuary waters within the reserve and two species nest along its beaches. Loggerhead sea turtles (*Caretta caretta*) are the most prevalent and green sea turtles (*Chelonia mydas*) are the least common. The Rookery Bay NERR has been partnering with Collier County Parks and Recreation to monitor sea turtle activity since 2005. The long-term data are used to guide the management of important sea turtle nesting beach habitat.

Sophie Spiliotopoulos

Geography '20, Faculty Mentor: Karen Frey, Location: Silver Springs, Maryland



**Identifying and Summarizing Research: Marine Mammal Life History Traits**

Spiliotopoulos interned with NOAA Fisheries in Silver Spring, Maryland where she contributed to vulnerability assessments on marine protected species. These assessments use existing life history information and expert judgement to assess exposure, sensitivity, and capacity to adapt to changing climate and other conditions. The objective of this project is to describe the current state of knowledge about marine mammal species' life history traits related to climate change vulnerability by exploring and summarizing published literature. The information compiled in this project will be used as input to the Marine Mammal Climate Vulnerability Assessment for Pacific and Arctic stocks.

Jess Strzempko

Earth System Science '20, Faculty Mentor: Karen Frey, Location: Woods Hole, Massachusetts



**Age and Growth Studies of Endangered Atlantic Salmon**

Strzempko interned with NOAA's Atlantic Salmon Ecosystems Research Team in Woods Hole, Massachusetts which monitors the emigration of Atlantic salmon smolts and studies the growth patterns in the scales from both juvenile and adult life stages of this endangered species. Scales provide a valuable record of growth in Atlantic salmon since they record patterns of growth over the lifetime of a fish, instead of providing only a snapshot of condition at one point in time. Strzempko contributed to a long-running time series of data collected from Atlantic salmon smolts and had the opportunity to develop an individual project based on new and archived scale data.





### 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 toward more sustainable outcomes. Remembering his own experience as an activist student researcher at Clark, Dr. Howard Geller (Science, Technology, and Society '77) hopes, through these annual awards, to support other Clark undergraduate and graduate students combine research with action that moves society toward sustainability. Eight projects were funded during 2018.

#### 2018 GELLER ENDOWED RESEARCH AWARDEES AND THEIR PROJECT DESCRIPTIONS

**Roopa Krithivasan** PhD Geography '20, Faculty Mentors: Rinku Roy Chowdhury and John Rogan

#### Farmer-Wildlife Conflict as Consequences and Drivers of Land System Change in the Indian Himalayas

In rural areas adjoining forests, crop damage and loss attributed to wildlife is a significant issue. This project uses a land system science framework to ask how land systems contribute to and change as a result of farmer-wildlife conflict. The research is situated in Kangra, an agriculture-dependent rural landscape in the Indian Himalayas that has undergone decades of forest conservation and plantation projects. In recent years, Kangra has

experienced increased farmer-wildlife conflict from crop-raiding monkeys, boar, and other large mammal species. Using a mixed-methods approach, this project seeks to understand the spatial relationships between the agro-forest land system and farmer-wildlife conflict, as well as the ways in which these conflicts induce farmers to adopt different land management strategies depending on their agronomic, social, and economic contexts. Understanding these interactions helps address pressing questions in land system science, and is an important step towards community resilience and sustainable land use.

**Bezawit Ayalew** BA Computer Science '19; **Tiffany Kayo** BA Computer Science/Economics '19; **Christina Zymaris** BA Computer Science/Geography '19, Faculty Mentor: John Magee

#### Reducing Food Wastage at Clark University via Food Sharing Application (ClarkEats)

This project will develop a food-share mobile application and website (ClarkEats) to support student's accessibility to food on campus while raising awareness of food waste. It will program an interface where users can post food they have left over from cooking or an event, and make that available to other students. The app may also support those who want to market and sell their food/beverages, such as through popular entrepreneurial courses. This application will be beneficial to end users by providing easily accessible food for those who need it, minimizing food waste on campus, reducing student costs on food and beverages, especially

students not on the University meal plan, and create a more environmentally aware environment on campus.





**Mario Machado** PhD Geography '20, Faculty Mentor: Rinku Roy Chowdhury

### **The Revolution within the Revolution: Understanding the Landscape and Livelihood Dynamics of the Cuban Agroecological Transition**

In an age of unprecedented abundance, we still face the enormous challenge of creating a truly sustainable, equitable food system. While industrial agriculture continues to dominate global food production, it also comes with mounting social and ecological externalities. To address these issues, many farmers have turned towards more sustainable, alternative methods such as

agroecology. This project aims to contribute new and important insights on agroecology in Cuba. Specifically, it will use both quantitative and qualitative methods to evaluate the social and ecological dimensions that such a food system transition entails for local communities. The study will integrate perspectives from the household, community and landscape scale into a framework of national agroecological transition, with the potential to inform broader re-imaginings of more equitable, sustainable food systems.

**Kayleigh McHugh** BA Biology '19; **Olivia Barksdale** BA Environmental Science '19, Faculty Mentor: John Baker

### **Recruitment Failure, Habitat Suitability, or Host Limitation: What Limits *Margaritifera margaritifera* in North-Central Massachusetts Streams?**

The freshwater pearl mussel is a globally endangered mussel species. Despite years of study and concern in Europe, little is known about the distribution, recruitment, and survival of *Margaritifera margaritifera* in North American stream systems. Recent surveys suggest that there has been little or no recruitment in many streams in recent years. However, for the first few years

of life juvenile mussels live well below the sediment surface, and thus may not be discovered in surface-oriented visual surveys that are usually conducted. The objective of this project is to determine whether the apparent recruitment problem of the freshwater pearl mussel is due to habitat or host factors. Data gathered from this recruitment study would enable conservation biologists to more appropriately use resources to regenerate this keystone species in their ecosystems. It would also allow the state to make sustainable and economic decisions on how to use the state's natural resources.

**Helen Rosko** PhD Geography '21, Faculty Mentor: Ed Carr

### **Climate Information Services for Development and Livelihoods: Investigating Adaptation Subjects in Mali**

Climate information services (CIS), broadly understood as the packaging and dissemination of climate information to targeted user populations, have been produced by the climate science community for many years. More recently, CIS have been taken up by development organizations as a means of addressing vulnerabilities associated with climate change and variability. While the development community takes a positive view of the potential of CIS to further the achievement of development goals in a

changing climate, there has been little critical attention paid to the ways in which CIS design and implementation impact the complex livelihoods decisions that characterize the lives of potential CIS users. This project seeks to fill this gap through a case study of the Mali Agrometeorological Advisory Program in Mali, West Africa. The program provides an opportunity to explore how a CIS does and does not align with its presumed users' livelihood realities. More specifically, this project seeks to understand how, through their interaction with CIS, users negotiate this information and rework their livelihoods.

Laura Sauls PhD Geography '19, Faculty Mentor: Tony Bebbington

### Constructing Territory: Regional Coalitions, International Environmental Governance, and the Quest for Development Alternatives in Mesoamerica

Indigenous and forest communities have fought for greater recognition of their rights to forests by drawing on social justice claims and scientific evidence of lower rates of deforestation in their collective lands. In Latin America, these communities now have rights to nearly 30 percent of the region's forests; however, they continue to face threats from advancing agricultural frontiers,

large-scale infrastructure, extractive industry expansion, and state efforts to maintain or re-centralize control over natural resources. To counter this trend, some indigenous and forest peoples have mobilized to assert an alternate vision of territorial governance of the world's most carbon-rich and biodiverse forests. Through collaborative research with the Mesoamerican Alliance of Peoples and Forests (AMPB), its member groups across Central America, and the NGO PRISMA, this project asks how such regional coalition-building influences forest governance in the region and, in turn, territorial identities and socio-ecological systems.

Paige Myatt MA International Development and Social Change '19, Faculty Mentors: Chuck Agosta and Mary-Ellen Boyle

### Studying the Social and Environmental Impacts of Electric Pedicabs in Worcester, MA

WooRides is a new pedicab company in Worcester that provides an eco-friendly, reliable and fun form of alternative transportation. Currently, WooRides' operating radius is greatly limited by Worcester's hills and expansive area. The addition of electric motors would effectively increase the radius in which WooRides can operate and thus serve a greater portion of the city's population. The goal of this project is to better understand

the social and environmental impacts of adding electric-powered motors to local pedicabs. Specifically, this project will answer quantitative research questions regarding the increase in range in which pedicab drivers can efficiently reach customers and the associated reduction of carbon emissions. Another aim is to answer qualitative research questions concerning the Worcester community's views on alternative eco-friendly transportation methods. To keep with WooRides' goal of producing zero-emissions in their transportation efforts, the batteries powering the motors would be charged with solar energy.





*HERO Fellows and their graduate student mentors, from left: Elizabeth Lohr '19, doctoral student Marc Healy, Yeannet Ruiz '19, Rachel Corcoran-Adams '20, Rowan Moody '20, Andrew Pagan '19, Laura Cohen '19, and doctoral student Nick Geron.*

## GREENING THE GATEWAY CITIES (HERO PROJECT)

Principal Investigators: John Rogan and Deborah Martin  
 Funding Agencies: John T. O'Connor '78 Endowed Fund for Environmental Studies; Commonwealth of Massachusetts

Built on 19 years of success, the Human-Environment Regional Observatory—Massachusetts (HERO—MA) program is a unique undergraduate-graduate-faculty collaborative that conducts research on human-environment relationships in Massachusetts. HERO Fellows analyze the causes and consequences of global environmental changes at local scales in faculty-led research projects. Each Fellow is paired with a Clark faculty mentor and other researchers on the HERO team. Among its many benefits, the HERO program provides students with opportunities to conduct, present, and publish research alongside faculty colleagues. HERO research has been funded by multiple awards from the National Science Foundation Research Experiences for Undergraduates (REU), the National Marine Fisheries Service, the Thoreau Foundation, the Commonwealth of Massachusetts, and the Clark University O'Connor '78 Fund. Since 2012, HERO Fellows have monitored the health of trees replanted in the Worcester area after one of North America's largest infestations of the Asian longhorned beetle. As data collected by HERO's undergraduates show, the Worcester Tree Initiative and Massachusetts Department of Conservation and Recreation's program to replant 30,000 trees in residents' yards has largely proven successful.

In 2017, the HERO program expanded its research goal to include cities that face a dearth of trees due to their industrial past. These cities are part of Massachusetts' Greening the Gateway Cities Program, which aims to increase tree canopy by 10 percent in high-density neighborhoods in 26 former factory towns by providing trees to residents and planting trees along city streets. In 2018, HERO Fellows worked in Chicopee and Fall River on two major projects. The Tree Planting Assessment uses field data collection, geoinformatics-based mapping, and ecosystem services modeling and forecasting techniques to examine how the recent tree replanting programs have impacted the urban forest diversity, land cover/density/configuration, land surface temperature, and various ecosystem services. The Place-Making Assessment uses interviews and focus groups to explore how the experience of tree planting programs and associated policy interventions affect neighborhood-level urban ecological vulnerabilities, environmental awareness and sense of place; and the ways in which resource managers and policy makers can implement more environmentally aware policies and build local tree and environmental stewardship. HERO Fellows presented their work at a 2018 Stakeholder Summit in Worcester and will spend the 2018-19 academic year working on individual research projects. They will present their research next spring at Clark's Academic Spree Day and at the American Association of Geographers' annual meeting in Washington, DC.



## 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 2017-18 included:

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

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

**Halina Brown** is serving on the Newton, Massachusetts Municipal Electricity Task Force which is working towards increasing the mix of locally produced renewable electricity.

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

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

**Elisabeth Gilmore** is a lead author on the Intergovernmental Panel on Climate Change's Sixth Assessment Report.

**Dale Hattis** is an ad hoc member of the U.S. Environmental Protection Agency's Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel (SAP).

**Robert Johnston** is co-Chair of the Ecosystem Science and Management Working Group of the NOAA Scientific Advisory Board.

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

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

**Robert Johnston** serves as the editor of *Resource and Energy Economics*.

**James Murphy** serves as Editor-in-Chief of *Economic Geography*, which has been owned and operated by Clark since 1925. This past year the journal reached its highest impact factor in history, placing its ranking at 3 out of 84 geography journals and 4 out of 353 economics journals.

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

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

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

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

**Christopher Williams** is a member of the North American Carbon Program's (NACP) Science Leadership Group, a multi-disciplinary research program established to study how carbon cycles through ecosystems, oceans and the atmosphere.

**Christopher Williams** was appointed leader of the Science Implementation Plan for the North American Carbon Program, a principal activity of the interagency U.S. Carbon Cycle Science Program.

**Christopher Williams** was one of only two U.S. scientists invited to participate in a science workshop and policy dialogue hosted by the International Boreal Forest

Research Association to identify key issues related to the use of boreal forests for climate change mitigation and adaptation.

**Christopher Williams** joined leaders of state and federal governments and environmental organizations for the Climate Alliance Learning Lab on Natural and Working Lands, which examined priority opportunities for meeting international climate change mitigation goals.

**Junfu Zhang** was elected president of the Chinese Economists Society and will be serving a 3-year term.

## Publications

Each year researchers at the George Perkins Marsh Institute author dozens of peer reviewed articles in top scientific journals, along with books, chapters and technical reports. These publications advance scientific methods, report empirical findings, and inform both public and private decisions. Updated lists of publications and curricula vitae can be found on the Marsh Institute research appointments website, <http://www.clarku.edu/departments/marsh/faculty/index.cfm>. The following are a few highlights:

**Halina Brown, Philip Vergragt**, and colleagues published "Why achieving the Paris Agreement requires reduced overall consumption and production" in *Sustainability: Science, Practice and Policy*.

**Robert Johnston** and colleagues published "Benefit relevant indicators: Ecosystem services measures that link ecological and social outcomes" in *Ecological Indicators*.

**James Murphy** and colleague Pádraig Carmody published "Generative urbanization in Africa? A sociotechnical systems view of Tanzania's urban transition" in *Urban Geography*.

**Robert (Gil) Pontius, Jr.** with graduate students Roopa Krithivasan and Laura Sauls and colleagues Yan Yan and Yujia Zhang published "Methods

to summarize change among land categories across time intervals" in *Journal of Land Use Science*.

**Laurie Ross** and Samantha Arsenault published "Problem analysis in community violence assessment: Revealing early childhood trauma as a driver of youth and gang violence" in the *International Journal of Offender Therapy and Comparative Criminology*.

## 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:

Clark University has been granted provisional non-governmental observer status at the United Nations Framework Convention on Climate Change (UNFCCC) which, among other benefits, allows Clark faculty and students to attend the UNFCCC Conference of the Parties (COP). Marsh Institute Director **Robert Johnston** is the designated point of contact for the university and was joined by **Elisabeth Gilmore** in the application effort.

**Halina Brown** received a Lifetime Achievement Award from the American Environmental Health and Science Foundation, one of only two recipients.

**Jacqueline Geoghegan** received an Agricultural and Resource Economics Review Fellow Award from the Northeastern Agricultural and Resource Economics Association.

**Robert Goble** was named a Fellow of the Society for Risk Analysis in recognition of his achievements related to science and public policy.

**Robert Johnston** was invited to speak to the National Academies of Science, Engineering and Medicines' Committee on the Potential for Biotechnology to Address Forest Health.

## 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.



**"Palaeohabitat Reconstruction:  
Ice-age Refugia and a New Model  
of Post-glacial Colonization in an  
Adaptive Radiation"**

**RICHARD KING**

Post Doctoral Researcher, Department of  
Biology, Clark University



**"Edible Insects Might Save the  
World: But Will We Bite Back?"**

**SØREN BØYE OLSEN**

Associate Professor, Department of Food and  
Resource Economics, University of Copenhagen



**"High Frequency, Realtime  
Sensor Networks to Improve  
Agricultural and Food Security  
Monitoring"**

**LYNDON ESTES**

Assistant Professor, Graduate School of  
Geography, Clark University



**"How Saving Time Leads to  
Destruction of Time-wealth  
and Environment"**

**ULF SCHRADER**

Professor, School of Education, Technical  
University of Berlin



**"Changes in Temperate and  
Boreal Forests Based on Three  
Decades of Landsat Imagery"**

**MARK FRIEDL**

Professor, Department of Earth and Environment,  
Boston University



**"Protect On-Farm Diversity!  
But How?"**

**KAMI SEO**

Associate Professor, School of International Politics,  
Economics and Communication, Aoyama Gakuin  
University, Tokyo

## VISITORS AT THE INSTITUTE

Each year brings new individuals and expertise to the George Perkins Marsh Institute. During 2017-18, the Marsh Institute hosted one brief and three long-term visits from international scholars.



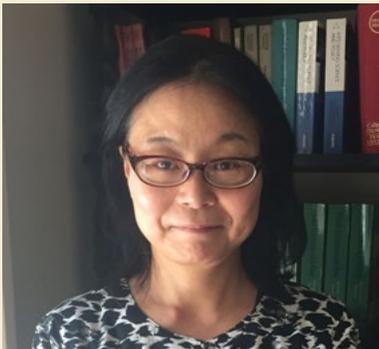
**Søren Olsen**

Søren Bøye Olsen, Associate Professor in the Department of Food and Resource Economics at the University of Copenhagen, visited the Marsh Institute in October of 2017 to collaborate with Marsh Director Robert Johnston. Dr. Olsen has several years of research experience in the economic valuation of non-marketed goods and services, participating in multiple research projects at regional, national and international levels and generating advice for policy makers. His current research focuses on understanding consumer behavior and preferences for food products. During his visit, Dr. Olsen met informally with Institute researchers and gave a seminar titled “Edible Insects Might Save the World: But Will We Bite Back?”



**Ulf Schrader**

Ulf Schrader, chair of Economic Education and Sustainable Consumption at the Technical University of Berlin, was a visiting scholar at the Marsh Institute from August 2017 to February 2018, where he collaborated with Marsh researchers Halina Brown and Philip Vergragt. His main task during this research sabbatical was preparation of a cooperative research project on “Time rebounds, time wealth, and sustainable consumption”, financed by the German Ministry of Education and Research (BMBF). While at the Marsh Institute, Dr. Schrader spoke about sustainable consumption at an informal luncheon and gave a seminar titled “How Saving Time Leads to Destruction of Time-Wealth and Environment.”



**Kami Seo**

Kami Seo, a visiting scholar from the School of International Politics, Economics and Communication at Aoyama Gakuin University (Tokyo), spent much of her year-long sabbatical collaborating with Marsh Institute Research Professor Rob Goble on research regarding the environmental risks and uncertainties associated with sustainable agriculture. Dr. Seo’s current research focuses on risks related to on-farm crop (genetic) diversity and its impact on the market for food in Japan. During her time at the Marsh Institute, Dr. Seo gave a seminar titled “Save On-Farm Diversity! But How?”



**Ewa Zawojkska**

Ewa Zawojkska, a PhD candidate and Fulbright Scholar from the Faculty of Economic Sciences at the University of Warsaw (Poland), is an emerging expert in non-market valuation. Ms. Zawojkska visited the Marsh Institute during the spring and summer of 2018, working with Marsh Institute Director Robert Johnston on multiple projects related to the economic value of environmental and natural resource improvements.



Photography © Lu Ann Pacenka

### 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 home to the Worcester Refugee Archive, a collection of local and global resources on the topic of refugee resettlement in Worcester County. In addition to journal articles, the archive contains theses, government reports, and newspaper articles dating back to the 1970s. The library has attained national and international recognition as a premier collection of research materials, and particularly of fugitive materials and unpublished literature in its areas of specialization. It provides information and 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, journals related to the library's focus areas, and computer and internet resources. The staff provide exceptional and personalized research assistance. Over 2,000 students, faculty, and others visited the library this past year.



### The George Perkins Marsh Institute Steering Committee, 2017-18

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.

#### Halina Brown

Professor Emerita, International Development, Community, and Environment

#### Edward Carr

Professor and Director, International Development, Community, and Environment

#### Timothy Downs

Associate Professor, International Development, Community, and Environment

#### Susan Foster

Professor and Chair, Biology

#### Karen Frey

Associate Professor, Graduate School of Geography

#### Robert Goble

Research Professor, George Perkins Marsh Institute

#### James Gomes

Director, Mosakowski Institute for Public Enterprise

#### Deborah Martin

Professor and Director, 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

#### Yuko Aoyama

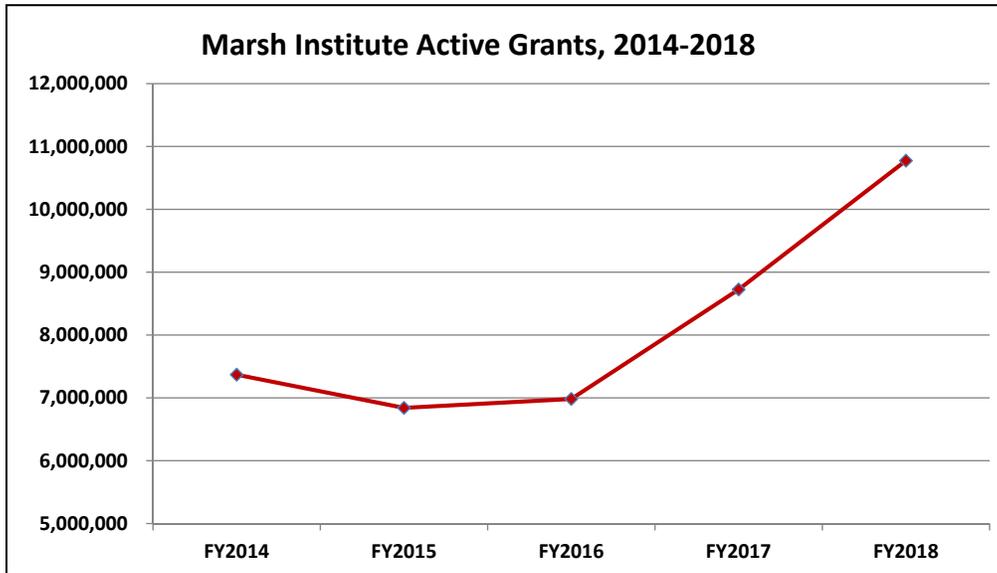
Associate Provost and Dean of Research; Professor, Graduate School of Geography

#### Robert J. Johnston

Director, George Perkins Marsh Institute

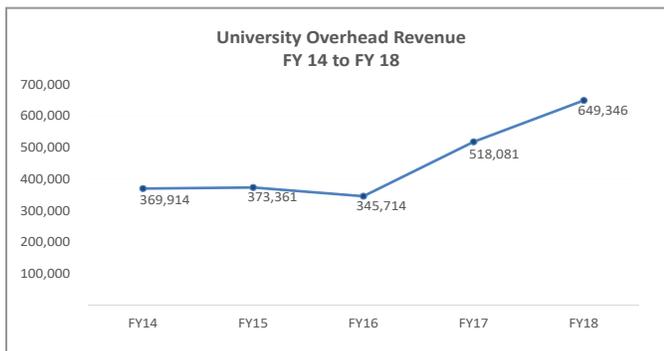
#### Dana Marie Bauer

Assistant Director, George Perkins Marsh Institute



### 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 July 2018 the Institute maintained approximately \$10.7 million in current grants, covering 34 active projects. Eleven of these are components of large-scale, multi-institutional research projects each exceeding \$1 million in total funding. During FY2018, the Marsh Institute was awarded \$2.8 million in new grants, with an average size of \$283,855 per grant, and generated more overhead revenue (facilities and administration) for Clark University than at any other year during its history.



### Service for the Greater Good

George Perkins Marsh Institute researchers serve on numerous boards and committees for regional, national and international organizations. This includes journal editorships, boards of directors, offices of regional, national and international organizations, science advisory panels, and principal roles in many other types of organizations. Through service to these groups, we contribute to scholarly pursuit and public service. More information on Marsh Institute faculty and scientists may be found on our website at [www.clarku.edu/departments/marsh/faculty](http://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](http://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.

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## 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.

## Annual Report Credits

**Dana Marie Bauer**  
Editor

**Lu Ann Pacenka**  
Design

