
EPA
United States
Environmental Protection
Agency
STAR
2013 FELLOWSHIP AWARDEES RESEARCH PORTFOLIO

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
RESEARCH AND DEVELOPMENT

Research Partners,

Since accepting the position as the Director for the National Center for Environmental Research, I have had the opportunity to be a part of EPA's initiatives and commitment in supporting the growth of our emerging environmental workforce—and I am pleased to welcome our 2013 EPA STAR Fellowship awardees to this esteemed group.

Each year, students from across the country compete for STAR Fellowships. These awards not only represent the academic fortitude of each student in their dedication to expanding their technical careers, but also the continued excellence of their institutions for nurturing and encouraging the minds of our Nation's rising scientists and environmental experts.

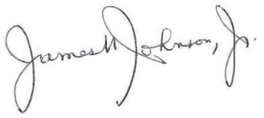
This portfolio highlights each award, which was based not only on the fundamental scientific merit of the individual research but also on the potential contribution to EPA's research programs and, ultimately, to addressing the Nation's environmental challenges.

This Portfolio is organized according to EPA's relevant research areas: Air, Climate and Energy; Chemical Safety for Sustainability; Emerging Environmental Approaches and Challenges; Human Health Risk Assessment; Safe and Healthy Communities; and Safe and Sustainable Water Resources.

The research within these areas is both diverse and high impact, with such topics as tribal-related research, indoor air pollution, impacts of climate change, drinking water contamination, impacts of sustainable landscape design, exploration of non-conventional wastewater treatment systems, and many more.

Along with previous EPA STAR cohorts, the 2013 STAR Fellows are poised to make a difference in their scientific communities and our united mission to sustain and protect our environment and public health. Please join me in congratulating the 2013 class of STAR Fellowship awardees.

EPA's National Center for Environmental Research



James H. Johnson, Jr., Ph.D.

EMERGING ENVIRONMENTAL APPROACHES & CHALLENGES

EMERGING ENVIRONMENTAL APPROACHES & CHALLENGES

Environmental Innovation

The environment and the economy are really both two sides of the same coin. If we cannot sustain the environment, we cannot sustain ourselves.

– *Wangari Maathai*

Hanna Breunig

Investigating Spatial Sensitivity in Life Cycle Assessment: A Method for Assessing Large-Scale Technology Deployment

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Project Officer: Brandon Jones
Project Period: 8/15/2014–8/15/2016
Project Amount: $84,000
Environmental Discipline: Civil/Environmental Engineering

Bio

Hanna Breunig received her B.S. in Environmental Engineering from Cornell University (New York). In 2011, she received her M.S. in Environmental Engineering from the University of California, Berkeley, and was admitted into the department's Ph.D. program. Since then, her research has contributed to advancing impact assessment methodology for emerging energy technologies, including carbon sequestration and fuel cells. Her current research explores how opportunities and barriers to managing the wastes of emerging technologies as resources vary regionally.

Synopsis

Environmental technologies are designed under green engineering principles to provide solutions that mitigate the negative effects associated with societal growth. However, the capability of a technology to achieve an environmental goal can vary regionally and temporally. This research evaluates how local management decisions affect the environmental, social and economic outcomes of nation-scale investments in emerging energy technologies.

Keywords: carbon management, life cycle assessment, spatial analysis

Objective(s)/Research Question(s)

The goal of this research is to develop a reproducible method for assessing technology deployment using spatial data to understand the implications of local operational decisions. The research will ask two integrated questions: (1) How do local by-product management decisions affect the environmental, social and economic outcomes of nation-scale investments in energy technologies like CO_2 capture, utilization and sequestration? (2) What spatial sensitivity must a life cycle assessment (LCA) methodology achieve in order to detect these effects?

Approach

LCAs of carbon capture and management technology deployment will be completed within locally and regionally scaled scenario analyses using new geographical approaches. The research includes the following specific aims: (1) a continued literature review; (2) the development of a method for generating a geographic information system database of life cycle inventory and effects; (3) the development of a method for weighting effects in a spatially meaningful manner; (4) the application of experimental method to carbon-capture waste and agriculture waste management scenarios and the comparison of the results with traditional LCA; (5) uncertainty assessment; (6) the vetting and dissemination of results through conferences and open access journals.

Expected Results

One significant expected outcome of this research is the identification of nexuses of spatial variables, indicating hot spots for profitable industrial development that overlap with regions that have traditionally stressed human or ecosystem health. These areas may require unique regulatory considerations to make alternative by-product management scenarios with lower human or ecosystem health effects more cost-effective.

Potential to Further Environmental/Human Health Protection

This research explores the potential of LCA as a prospective decision-making tool. This innovative approach to conducting regionalized LCA in a scenario analysis could present a salient answer to the call for uncertainty management in emerging technology analysis. A method that quantifies triple bottom-line tradeoffs will introduce a new standard in modern practices for deploying green technology. Subsidy allocations, environmental justice initiatives and regulatory developments would have a new scientific platform on which to base adaptive decisionmaking.

Molly Katherine MacLeod

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Project Period: 9/2/2014–9/2/2016
Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Molly MacLeod's interest in pollination ecology and conservation has taken her from her native Maine to Vermont, Colorado, South America and Central America. She received her undergraduate degree in Biology from Marlboro College (Vermont) in 2008 and is now a fourth-year Ph.D. student in Ecology and Evolution at Rutgers University. Her current work uses an experimental pollinator restoration to explore questions about plant-pollinator networks and the restoration of both ecosystem service-providing bees (crop pollinators) and rare bee species.

Synopsis

Many pollinator species need conservation because they are rare; others require protection because of their value to the ecosystem service of crop pollination. Plant-pollinator networks are a tool that can facilitate the convergence of these two conservation approaches, but variation in the relative abundance of plants or pollinators may influence the measurement of network patterns. This research is using an abundance-controlled field experiment to inform pollinator conservation and to explore the ways in which plant-pollinator interactions change across time.

Keywords: biodiversity, ecosystem services, pollinators

Can Both Ecosystem Service Providers and Rare Species Be Restored With the Same Plants? An Experimental Approach Using Plant-Pollinator Networks

Objective(s)/Research Question(s)

Plant-pollinator networks can facilitate the convergence of biodiversity and ecosystem services-based approaches to conservation, but apparent network patterns may be driven by skewed species abundance distributions. This research will use an experimental approach to networks to meet the following objectives: (1) Experimentally test the attractiveness of 17 native plant species, in single-species plots, to rare and key ecosystem service-providing (crop-pollinating) bees, determining whether both groups prefer the same plants; (2) identify annual variation in the network structure and in the identity of core generalist plant or bee species; (3) determine whether variation in partner identity is driven by bee-foraging preferences or by species abundance distributions; and (4) explore the role of species abundance distributions on the outcome of simulated species extinctions from pollination networks.

Approach

In the field experiment, pollinators have been collected from 102 monospecific plots of 17 plant species over three field seasons. The plant species are established in equal relative abundance, thus removing a sampling effect driven by a skewed plant species abundance distribution and allowing a direct measurement of pollinator preference. To meet the first research objective, rare and ecosystem service-providing (ES) bee species were defined using independent databases on the bees of the region. Mixed models were used to determine whether plant species varied in the abundance of rare or ES bees, and a rank correlation tested whether plant species that attract a high (or low) abundance of rare bees also attract high (or low) abundance of ES bees. Statistical models will determine the role of species abundance distributions in apparent annual network variation and on the simulation of species extinctions.

Expected Results

This research will expand on preliminary results that suggest that rare and ES bee species are separate sets of species that have similar preferences that are not due to plant species abundance alone. The research will explore changes in the plant-pollinator network over time. It is expected that (1) network structure, including the identity of 'core' generalist plant or bee species, will be similar across years, indicating that the same plant species can be used to restore rare and ES bee species, and that these plant species will be important across years despite any annual changes in the bee community. (2) Apparent annual variation in pairwise interactions ("rewiring") will be driven more by species abundance distributions than by actual changes in preferences. (3) The relative importance of generalist and specialist species to network robustness to species loss will be driven more by relative abundance than by diet breadth.

Potential to Further Environmental/Human Health Protection

This work will contribute to EPA's Pollinator Protection Plan and will identify methods for conservation of both rare species and key ES species with the same management actions and will develop educational tools to broadly communicate the results. The results will inform the design of existing and future pollinator restorations mandated by the Pollinator Protection Research Act of 2007 and funded by the U.S. Farm Bill. Although Farm Bill programs are not explicitly intended as ES or rare species conservation programs, they can serve both purposes if suitably designed. The multiyear experimental approach also will facilitate the development of novel educational tools for landowners to design pollinator restoration that accounts for and minimizes temporal fluctuations in the populations of the target species.

Christopher M. Rea

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Project Period: 9/20/2014–9/20/2016
Project Amount: $84,000
Environmental Discipline: Sociology

Bio

Christopher Rea is a doctoral candidate in sociology at the University of California, Los Angeles. He graduated from Clark University (Massachusetts) with a B.S. in physics (2006) and an M.A. in teaching (2007). After teaching high school, Chris returned to graduate school to study the politics, economics and policy of environmental protection. His research focuses on institutional emergence and market-oriented modes of environmental protection.

Synopsis

Over 800 wetland mitigation banks covering at least a half-million acres now pepper the United States conservation landscape. Despite their proliferation, little is known about why these institutional innovations have proliferated or how well they work as conservation tools. This research sets out to understand how wetland mitigation banks have developed, how and where they proliferate and how these and similar institutions are transforming the way habitat is protected in the United States.

Keywords: conservation, innovation, wetlands

Institutional Innovations in Environmental Regulation: The Rise of Market-Oriented Approaches to Wetland Conservation in the United States

Objective(s)/Research Question(s)

This research is guided by three closely coupled research questions: (1) How and why do market-oriented institutions for protecting habitat, like wetland mitigation banking, emerge where they do; (2) how do these novel regulatory institutions work in social, political and ecological terms; (3) how well do these institutions work as social and ecological tools for protecting the environment?

Approach

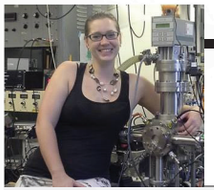
This research focuses on species conservation banking and wetland mitigation banking in the United States, along with habitat pooling in Germany, to understand the sociopolitical, economic and ecological conditions that give rise to market-oriented approaches to conservation. Archival, ethnographic and quantitative data on habitat types, protected species, land use change, economic growth and development were collected, along with data on crucial but less obvious drivers of institutional innovation: environmental litigation, social movement activism, regulatory and administrative policy and practice, and tools and techniques for quantifying natural capital and ecosystem services. By exploiting regional variations in these elements and situating them in historical context, analysis teases out the processes that lead to the development of institutions like wetland mitigation banking and helps assess their social, political and ecological utility.

Expected Results

Substantial preliminary research suggests that key drivers of the development of species conservation banking were creative efforts to more thoroughly regulate land development, heightened levels of litigation over environmental statutes and efforts of environmental regulators and ecological entrepreneurs to promote policy solutions consonant with market logics. Pure "demand," on the other hand, in the form of high levels of development overlapping with high levels of sensitive habitat, does not seem to be enough to promote the formation of species conservation banks. It is likely that similar factors will figure prominently in explanations for the development and functioning of wetland mitigation banks in the United States.

Potential to Further Environmental/Human Health Protection

With the U.S. population expected to grow by roughly 100 million people in the next 50 years, land development pressures will continue to be a central threat to ecosystems that not only provide habitat to countless species, but also supply critical ecosystem services that human populations depend upon, such as water filtration, flood protection and carbon sequestration. Developing innovative and cost-effective solutions to these problems of conservation is of paramount importance. This research explicitly aims to understand how market-oriented regulatory institutions like wetland mitigation banking serve (or fail to serve) these purposes; how and why they should (or should not) be embraced as social, political and economic tools for conservation; and the ways such institutions can be improved and their growth encouraged where they provide robust social and ecological benefits.



Sandra Elizabeth Spencer

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Analytical Chemistry

Bio

Sandra Spencer graduated from the University of Texas at Arlington in 2010, earning a B.S. in Chemistry, minor in Mathematics as well as a B.S. in Biochemistry, minor in Spanish. She is currently studying at the University of North Carolina at Chapel Hill, working on her Ph.D. in Analytical Chemistry. Her research interests include developing real-time methods for the analysis of organic aerosols; the mass spectrometry analysis will have future uses in applications ranging from biomass burning to chemical and biochemical warfare. After earning her Ph.D., Sandra plans to pursue a career as a professor at a research university.

Synopsis

Analysis of organic and biological aerosol particles is of the utmost importance for applications including global warming, pollution, forensics, human health and bioterrorism. This research is directed toward developing methods for real-time analysis of organic and biological aerosols. Special interest is taken in instrumentation that is rugged and durable to facilitate future development of field-deployable instruments.

Keywords: ambient ionization, mass spectrometry, organic aerosol

Real-Time Analysis of Organic and Biological Aerosols

Objective(s)/Research Question(s)

Current commercial aerosol mass spectrometers are not capable of performing compound identification of analytes in complex samples in real-time. This project is developing ambient ionization techniques to use in conjunction with tandem mass spectrometry for identification of compounds in and fingerprinting of aerosols and bioaerosols.

Approach

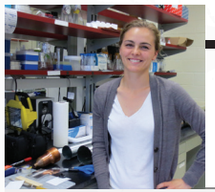
A custom-built quadrupole ion trap mass spectrometer will be used to develop methods for the analysis of organic and biological aerosols. An aerodynamic lens will be used to focus aerosol particles into the mass spectrometer vacuum system. To break apart the aerosol particles and volatilize the compounds within for ionization, the particles are impacted on a heated probe. A nitrogen laser will be used to break apart any biological material in the aerosol particles. Glow discharge chemical ionization, a nearly universal ionization technique for gaseous compounds, will generate ions from the compounds in the aerosol particles. Organic aerosols from pyrolyzed cellulose will be investigated as a model for organic aerosols and both gram-negative and gram-positive bacteria will be used to model bioaerosols.

Expected Results

Once the instrumentation and methods have been rigorously tested with the model compounds, aerosols and bioaerosols of interest may be fingerprinted. It is expected that compounds in organic aerosols will be identified. However, it will not be necessary to identify the individual compounds in the bioaerosol, as each type of bacteria is expected to have a unique mass spectrometric fingerprint. The instrument designed and optimized over the course of this research will provide a basis for future instruments designed as rugged, field deployable aerosol and bioaerosol mass spectrometers.

Potential to Further Environmental/Human Health Protection

Real-time analysis of organic and biological aerosols has applications for real-time air quality monitoring. Additionally, the instrumentation developed during the course of this project can be used as a field deployable instrument for chemical and biochemical warfare agents.



Jennifer Therkorn

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Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Jennifer Therkorn received a B.S. in Biology from Lehigh University (Pennsylvania) in 2009 and an M.P.H. from the Rutgers School of Public Health in 2011. That same year, she started a Ph.D. program at Rutgers in Environmental Science, with research interests in bioaerosol exposure assessment. Her current research involves designing and developing the first passive air sampler for bacteria, molds and pollen that eliminates the need for external power and an air pump.

Synopsis

This research aims to develop the first biological air sampler that does not need an air pump. Instead, a polarized substrate housed inside a 3D-printed holder will electrostatically attract airborne particles, offering a more practical, cost-effective solution than currently available pump-based samplers. The sampler will increase capacity to detect and study such issues as airborne mold and pollen patterns affected by global climate change, air quality, agricultural pathogens and bioterrorism.

Keywords: bioaerosol, biological pollutants, passive environmental sampling

Development and Evaluation of a Novel Passive Bioaerosol Sampler

Objective(s)/Research Question(s)

The main objective of this research is to design, build and validate the performance of a novel passive sampler for airborne biological particles (i.e., bioaerosol) that can operate without external power and an air pump.

Approach

Since airborne biological particles tend to carry electrical charge due to dispersion processes and metabolic activity, a polarized substrate with negatively and positively charged sides will be used to electrostatically attract airborne particles of both polarities. A laboratory wind tunnel and calm-air settling chamber will be used to simulate various environmental conditions to optimize sampler collection efficiency. A streamlined analysis procedure will be developed to estimate airborne bacteria and fungi concentrations using flow cytometry. Optimized sampler performance will be validated against currently available pump-based samplers through field testing.

Expected Results

Expected results of this research include development, performance validation and eventual commercial development of the first passive bioaerosol sampler. A passive sampler will be more versatile, widely deployable and cost-effective than currently available pump-based samplers. Environmental and human health protection will be directly furthered through the development and application of a passive bioaerosol sampler, as it will increase capacity to monitor, detect and study airborne biological particles.

Potential to Further Environmental/Human Health Protection

Airborne biological particles are ubiquitous indoors and outdoors, and they contribute to a wide spectrum of adverse environmental health effects, such as allergic respiratory diseases caused by bacteria, molds and pollens, spread of infectious diseases like tuberculosis, and crop loss due to fungal pathogens. The unique advantages of the sampler will directly increase human health and environmental protection capabilities through such applications as monitoring spread of antimicrobial-resistant microorganisms, global climate change research, agricultural protection, occupational health and safety sampling, increased capacity for community participatory research and outreach and homeland security.

Cara Rose Touretzky

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Project Officer: Gladys Cobbs
Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Chemical Engineering

Mitigating the Role of Buildings in the Environmental Impact of the Energy Supply Chain

Bio

Cara received a B.S. in Chemical Engineering, magna cum laude, from the University of Delaware in 2011, with minors in economics, mathematics and chemistry. She then started a Ph.D. program at The University of Texas at Austin, where she is working in the Chemical Engineering department. Her research is focused on novel techniques for modeling and control of large-scale systems, with a particular focus on buildings and controlling their energy use.

Synopsis

Commercial and residential buildings consume more than 60 percent of the electricity generated in the United States, and their energy needs fluctuate over the course of a day. Producers satisfy the peak load using old and inefficient generation facilities for a few hours each day. This research aims to flatten the electricity demand from buildings using advanced control strategies and to capture the effects of the reductions in peak demand on the operation of power plants.

Keywords: building systems and modeling, energy efficiency, model predictive control

Objective(s)/Research Question(s)

Leveling the energy demand of buildings over the course of the day can eliminate the need for extra electricity generation facilities, thus reducing pollutant production. There is ample opportunity for this because of the glaring inefficiencies in the current operation of residential and commercial buildings, which can be mitigated through advanced control technology.

Approach

Traditional building control approaches are reactive in nature and do not take into account the vast amount of information available about the building. By anticipating the effects of occupant actions and weather on a building, proactive decisions can be made for the operation of its HVAC system and energy storage devices. A model-based controller capable of satisfying occupant comfort requirements while minimizing energy use will be designed. Large-scale simulations of entire neighborhoods operating under the new control paradigm will reveal the cumulative effect of the smart controllers on the total demand placed on the electric grid.

Expected Results

This work will result in a general modeling framework and associated controller that can be easily tailored for use in any building. The large-scale simulations will demonstrate how a properly designed local energy management system can be used on a mass scale for overall demand-flattening. Ultimately, this will aid in the development of coordination strategies among the controllers to ensure peak grid load reduction and avoid shifting peak consumption to a different time.

Potential to Further Environmental/Human Health Protection

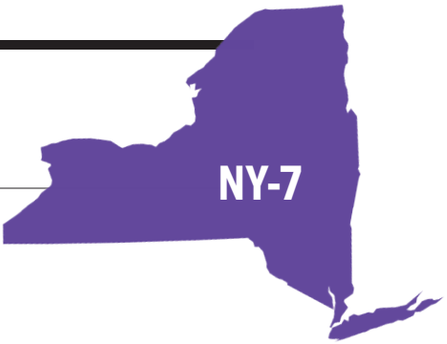
Quantifying the decrease in peak demand from buildings on the electric grid will enable a study of the subsequent discontinuation of certain, lower efficiency power plants. The associated decrease in pollution emissions from these power plants will help to improve air quality in many regions of the United States.

EMERGING ENVIRONMENTAL APPROACHES & CHALLENGES

Technology has continued to bring the world closer
together and increased the horizons of
each individual as never before.
– *Rohan Kar*

Information Science

Zoé Augustina Hamstead



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Project Period: 8/25/2014–8/25/2016
Project Amount: $84,000
Environmental Discipline: Social Ecology

Bio

Zoé Hamstead is a Ph.D. student at the Milano School of International Affairs, Management and Urban Policy at The New School in New York City, where she studies relationships between social and ecological systems in urban landscapes. She holds a Master's of City and Regional Planning from the University of North Carolina, Chapel Hill, where she studied regional water quality management. Her current research uses geospatial and temporal modeling approaches to examine patterns of ecosystem services in New York City.

Synopsis

Dense urban landscapes are characterized by high demand for scarce and often inequitably distributed environmental resources. Thus, cities face a unique set of challenges in providing adequate levels of ecosystem services, such as heat reduction, storm water management and access to recreational green spaces. Using spatial-temporal modeling, this project will examine how spatial patterns of ecosystem services in New York City emerge from changes in urban structure over time and will identify implications for socially just sustainability planning.

Keywords: ecosystem services, sustainability planning, urban structure and planning

A Spatial-Temporal Approach for Understanding Social-Ecological Dynamics of Urban Structure and Ecosystem Services

Objective(s)/Research Question(s)

While numerous studies have modeled broad processes of land use and land cover change along urban peripheries, relatively few have studied fine-scale changes to urban structure within densely urbanized landscapes where over half of the human population now resides. This research will use a spatial-temporal modeling approach to explore how social-ecological dynamics drive changes in urban structure and will explicitly link those changes to ecosystem services and spatial planning strategies in New York City. Three primary questions drive this research: (1) What are the major social-ecological drivers of changes in urban ecosystem services and the resulting spatial patterns? (2) How do urban structure change processes interact with sustainability planning strategies to inhibit or support these strategies? (3) Are there synergies and tradeoffs across space between different ecosystem services and patterns of ecosystem services across socioeconomic indicators?

Approach

The first stage of this project will involve developing a cellular automata model for describing the drivers and processes of urban structure change in New York City. Using land cover, land use, transportation infrastructure, zoning, socioeconomic and other available spatially explicit data, key drivers and processes through which urban structure change has happened historically will be represented and projected into the future. The second stage will focus on linking urban structure change to ecosystem services, such as heat mitigation, and examining how spatial planning strategies influence the spatial distribution of these services in relation to vulnerable populations.

Expected Results

There is a growing recognition that human proximity to open spaces where ecological processes occur can be essential for the consumption of particular ecosystem services, such as recreation or heat mitigation, and that these services are often inequitably distributed. Moreover, the dense urban landscapes in which most of the world's population resides present a particularly challenging context for generating and sustaining ecological processes that promote health and well-being because they often are characterized by land scarcity and competing interests over how land is used. This research will build an intra-urban structure change model that explicitly links urban structure change dynamics to environmental outcomes and planning strategies. Expected results include a dynamic model that illustrates processes through which urban structure change has happened historically, projects future change under status quo and alternative planning scenarios and examines the consequences of change on ecosystem services. This approach will allow analysis of spatial tradeoffs and synergies among multiple ecosystem services under different scenarios and the distribution of services across socioeconomic variables.

Potential to Further Environmental/Human Health Protection

The outcomes of this research are applicable to urban sustainability policies aimed at increasing and enhancing ecosystem services that help to mitigate heat-related illnesses, managing water quality and providing publicly accessible open spaces that enhance mental and physical well-being.

Imran Anees Sheikh

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Project Period: 8/21/2014–8/21/2016
Project Amount: $84,000
Environmental Discipline: Other Engineering

Bio

Imran Sheikh received a B.S. in Biomedical Engineering from the University of Wisconsin, Madison in 2003. In 2010 he received an M.S. from the Energy and Resources group at the University of California, Berkeley, where he is currently a Ph.D. student. His research interests include using information technology and emerging data sources like smart meters and internet-connected thermostats to better target energy-efficiency investments.

Synopsis

About 40 percent of energy used in the United States is used in buildings, and a wide body of evidence suggests there are both large opportunities and significant barriers to making buildings more energy efficient. This research aims to analyze data from emerging data sources like smart meters and smart thermostats to reduce those barriers and target efforts where large energy savings are likely. Targeted efforts could lead to more effective investments in efficiency projects and reduced energy use and related emissions.

Keywords: building systems and modeling, energy efficiency, smart meter

Identifying Residential Energy Efficiency Opportunities with Temperature and Energy Use Data

Objective(s)/Research Question(s)

About 40 percent of energy used in the United States is used in buildings, and a wide body of evidence suggests there are both large opportunities and significant barriers to making buildings more energy efficient. Combining data from smart meters, weather stations, and internet-connected thermostats will allow a better understanding of how energy is used in buildings. Using these emerging data sources to develop and apply algorithms can give insight into the likely efficiency opportunities that exist for specific customers.

Approach

Energy use in homes will be characterized by analyzing patterns of temperature and energy use and creating regression-based metrics that relate to how buildings use energy. These metrics will, in theory, relate to physical properties of buildings such as insulation, solar gain, or air conditioner efficiency. Looking at distributions of these metrics for buildings of similar size and in a similar climate should make it possible to identify particularly inefficient buildings. An understanding of the distribution of these metrics will allow quantification of the savings potential that would result from improving the efficiency of buildings in the tail of the distribution.

Expected Results

The goals of this research are to develop methods that make it possible to use emerging data sources to identify residences with a high potential to save energy, quantify the expected savings and assess the types of energy efficiency projects that are most likely needed. With these aggressive goals in mind, it is important to recognize that a wide variety of factors (that are not directly observed) contribute to energy use, including behavior, appliance types, design and building systems. Using only smart meter and temperature data it will be impossible to give perfectly accurate, specific recommendations of actions that should be taken. However, the results of this research will allow utilities and their partners to begin to create more effective energy efficiency programs by identifying and engaging those consumers where large energy savings are likely. Analysis of these emerging data sources at scale could create a foundation for new residential efficiency business models that remove some of the barriers to investment in energy efficiency projects.

Potential to Further Environmental/Human Health Protection

This research could lead to improved energy efficiency at scale in the residential sector and therefore decrease demand for electricity and the associated emissions that come from electricity generation. Combustion for power generation leads to emissions of a wide range of pollutants that cause health problems, and since major emission sources from electricity generation are often in economically distressed areas, reducing electricity generation through improved efficiency is particularly important to those communities.

What you do makes a difference, and you have to decide what kind of difference you want to make.

– *Jane Goodall*

EMERGING ENVIRONMENTAL APPROACHES & CHALLENGES

Synthetic Biology for Environmental Purposes

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Chemistry

Bio

Michelle Legaspi received her B.S. in Chemistry from the University of Florida in 2010. As an undergraduate, she gained an appreciation for chemical ecology by analyzing plant defense mechanisms during insect herbivory with the U.S. Department of Agriculture. She is now a Ph.D. candidate in the Chemistry department at Yale University, researching the biodegradation of synthetic polymers by fungi to facilitate the development of bioremediation methods for plastic and rubber waste.

Synopsis

Plastic and rubber materials have become an essential part of modern life. However, since they are cheap, versatile and resilient, there is a massive buildup of plastic and rubber waste in the environment. New methods of degrading these resilient wastes are needed. Since certain types of plastic and rubber are held together by the same chemical bonds found in natural plant polymers, this research investigates the ability of fungi that live inside plants to degrade synthetic plastic and rubber.

Keywords: biodegradation, bioremediation, fungi

Bioremediation of Plastic and Rubber by Endophytic Fungi

Objective(s)/Research Question(s)

The massive and rapid accumulation of plastic and rubber waste is a problem that be ignored. While there has been an enormous boom in synthetic polymer production, methods of treating these materials after disposal have not been able to keep up. Therefore, this research is investigating alternative methods of dealing with plastic and rubber waste. Since several types of plastic and rubber contain the same chemical bonds that are found in natural plant polymers, specific attention is given to the ability of endophytes, organisms that grow symbiotically inside plants, to degrade synthetic plastic and rubber.

Approach

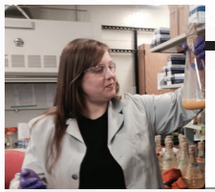
The endophytic fungus *Pestalotiopsis microspore* has previously been identified in the degradation of the plastic polyester polyurethane. This fungus secretes a small enzyme that is responsible for plastic degradation; the study will look for unique enzymatic characteristics by comparing this enzyme to other polyester-degrading enzymes. Large collections of endophytes from Ecuador will be screened for degradation of different plastics and rubbers using visual clearance assays, staining of degradation products, gel permeation chromatography and scanning electron microscopy. This screen will include, but not be limited to, plants that produce copious amounts of latex, the starting material for natural rubber. The genomes of any potential polymer-degrading candidates will be sequenced and searched for possible novel genes that encode plastic- or rubber-degrading enzymes.

Expected Results

Endophytes collected in the Amazon rainforest, one of the most biodiverse places on earth, are a relatively untapped source of biological and chemical diversity. In this biodiverse ecosystem, the active evolutionary race requires organisms to utilize chemical innovation in order to outcompete their rivals and survive, possibly yielding novel natural products and unique enzymatic activity. Screens from the vast collection of Ecuadorian endophytes should identify fungi that are capable of plastic and rubber degradation, potentially using unique methods of degradation or novel polymer-degrading enzymes.

Potential to Further Environmental/Human Health Protection

Since synthetic polymers can remain intact for hundreds of years and certain materials can leach toxic chemicals into the environment, plastic and rubber waste accumulation has become a global threat to the environment and human health. It is imperative to investigate practical and sustainable methods of plastic and rubber waste disposal. Investigating the bioremediation potential of endophytic fungi will lead to a better understanding of the organisms and enzymes that could be used to degrade synthetic plastic and rubber waste.



Sara Shields-Menard

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Project Period: 8/18/2014–8/18/2016
Project Amount: $84,000
Environmental Discipline: Microbiology

Bio

Sara Shields-Menard earned a B.S. in Biological Sciences in 2006 and an M.S. in Environmental and Marine Biology in 2010 from Nicholls State University in Thibodaux, Louisiana. She then assisted a research project responding to the British Petroleum oil spill at that university before starting a Ph.D. program at Mississippi State University in 2011. Her research interests include environmental microbiology and biotechnology, bioremediation and renewable fuels. Currently, Sara's research involves using different contaminants to promote lipid accumulation in an oleaginous bacterium.

Synopsis

Oleaginous microbes are those that accumulate more than 20 percent of their biomass as lipids, which can be converted into biodiesel. Current biodiesel feedstocks account for 60–75 percent of total biodiesel production costs, creating a need for cheaper and more sustainable alternatives. The potential to couple the utilization of diverse substrates with microbial lipid accumulation offers a unique approach to alternative fuels. This research will investigate the ability of the bacterium *Rhodococcus rhodochrous,* known for bioremediation, to use waste sources as a feedstock for lipid accumulation.

Keywords: biofuel, bioremediation, oleaginous microbes

Characterization of Lipid Accumulation by *Rhodococcus rhodochrous* Grown on Waste Substrates

Objective(s)/Research Question(s)

Current biodiesel feedstocks, such as crop oils, account for 60–75 percent of total biodiesel production costs; however, undesired waste streams are plentiful and often contain sources of carbon that can be degraded by bacteria. Oleaginous microbes are those that accumulate more than 20 percent of their biomass as intracellular lipids, which can be converted into biodiesel. This research will investigate the ability of the bacterium *R. rhodochrous*, known for bioremediation of contaminants, to use waste sources as a feedstock for lipid accumulation.

Approach

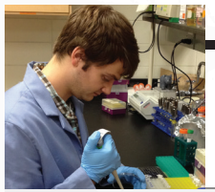
The growth and lipid accumulation of *R. rhodochrous* will be investigated when cultivated in a minimal salts medium supplemented with model lignocellulosic sugars and inhibitors, including glucose, xylose, acetic acid, furfural and phenolic lignin compounds. Cell dry weight measurements will determine growth and survival in these substrates, and gas chromatography and sugar analysis will show if the substrate has been consumed by *R. rhodochrous*. Lipid accumulation will be observed using transmission electron microscopy and quantified by lipid extraction. Genomic sequencing and proteomic analysis of *R. rhodochrous* will give us further insight at a molecular level into growth and lipid accumulation.

Expected Results

The potential to couple the utilization of diverse substrates with lipid accumulation in *R. rhodochrous* offers a promising approach to alternative fuels. Due to the diverse metabolism of *R. rhodochrous*, growth and survival in the various substrates is expected. Lipid accumulation will be observed in transmission electron microscopy images and is likely to occur in cultures containing glucose. The inhibitors could potentially reduce lipid yields; however, conversion of those inhibitors into less toxic compounds could prove useful for other commercial applications.

Potential to Further Environmental/Human Health Protection

The unstable price of oil, growing environmental concern of fossil fuel overuse and increasing government awareness have brought alternative energy solutions to the forefront of multidisciplined scientific research. Oleaginous microbes offer a unique advantage in producing lipid for biodiesel feedstock because of their ability to grow on diverse substrates in a controlled environment, resulting in a sustainable source of biodiesel feedstock. Characterization of lipid accumulation by *R. rhodochrous* grown on waste sources is a critical step in repurposing potential environmental contaminants into a sustainable fuel alternative.



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Project Amount: $84,000
Environmental Discipline: Chemical Engineering

Bio

Andrew Younger received a B.S. in Molecular Genetics from the University of Rochester (New York) in 2011. He then worked as a research assistant at the Wyss Institute for Biologically Inspired Engineering at Harvard Medical School. In 2012, he enrolled as a Ph.D. student at Northwestern University in the Interdepartmental Biological Sciences graduate program. His current research involves engineering cell-based biosensors for environmental applications.

Synopsis

Many ground water contaminants and other environmental pollutants are hard to detect without expensive detection kits that contain harsh and toxic chemicals. This project involves synthetic biology approaches to engineer biosensing organisms to detect and report on toxic environmental contaminants. This research would allow for more sensitive and environmentally friendly pollutant testing based on synthetic cellular biosensors compared to the chemical based kits.

Keywords: groundwater, sensors, synthetic biology

Engineering Cell-Based Biosensors for the Detection of Environmental Pollutants and Toxins

Objective(s)/Research Question(s)

The primary objective is to determine if cell-based biosensors can rapidly and reliably detect environmental pollutants and toxins.

Approach

To determine if cell-based biosensors can rapidly and reliably detect environmental pollutants and toxins a platform biosensor technology will be developed. This involves using synthetic biology approaches to engineer metabolite-actuated transcription factors that respond to environmental toxins. A modular protein-based biosensor will be designed to bind specific toxins and regulate expression of a genetic program integrated into the microbial host. This requires the engineering of both the ligand binding and DNA binding domains of the synthetic transcription factor that will be the cornerstone of this cell-based device. A microbe will then serve as the testing device to determine if environmental toxins or pollutants are present, in a safe and environmentally friendly manner that does not require harsh chemical testing reagents.

Expected Results

Once built, the cell-based biosensor is expected to be able to detect low levels of a given toxin or pollutant and give a visible output signal. This will be accomplished by linking the detection mechanism to the production of a fluorescent protein that can be detected by the naked eye. In this way, the culture of cells will simply change color if an unsafe level of the toxin or pollutant is present in the water that is being tested. The microbes will be self-contained in the testing kit and will be unable to survive outside the confines of the kit to prevent unwanted environmental release.

Potential to Further Environmental/Human Health Protection

A cell-based synthetic biosensor could provide a novel and environmentally friendly way of sensitively detecting pollutants and toxins in ground water, a way that does not require harsh chemical testing kits. This will allow rapid and safe testing of water found in wetlands, sewage treatment centers and agricultural or industrial run-off.


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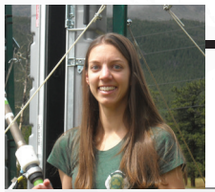
The truth is: the natural world is changing. And we are totally dependent on that world. It provides our food, water and air. It is the most precious thing we have and we need to defend it.

–David Attenborough

Clean Air



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Project Amount: $84,000
Environmental Discipline: Atmospheric Chemistry

Bio

Ashley Evanoski-Cole attended Susquehanna University (Pennsylvania) and received a B.S. in Chemistry in 2009. She then received an M.S. in atmospheric science in 2012 from Colorado State University. Continuing in the same program, Ashley is now working toward her Ph.D. Her research interests include atmospheric chemistry and air quality. Her current research investigates nitrogen deposition in national parks.

Synopsis

Atmospheric nitrogen deposition can contribute to high levels of nitrogen in the environment, leading to detrimental effects on ecosystems. Current routine monitoring does not capture all significant components of total nitrogen, often leading to an underestimation of nitrogen deposition. This research will obtain detailed measurements of all important components in total nitrogen deposition in sensitive ecosystems located in national parks in the western United States.

Keywords: ammonia, nitrogen cycling and deposition, organic nitrogen

Characterizing Total Atmospheric Nitrogen Deposition in National Parks in the Western United States

Objective(s)/Research Question(s)

Atmospheric nitrogen deposition contributes to excess nitrogen loadings in the environment, which can lead to water and soil acidification, toxic conditions for aquatic plant and animal life and other detrimental effects. However, not all compounds that contribute to nitrogen deposition are currently routinely monitored, including ammonia and organic nitrogen, so the total nitrogen deposition is often underestimated. This research will investigate nitrogen deposition, including measurements of ammonia and organic nitrogen, to gain a comprehensive understanding of total nitrogen deposition.

Approach

For this study, total nitrogen deposition will be measured in national parks, such as Rocky Mountain National Park and Grand Teton National Park. In intensive field campaigns, both dry and wet deposition will be determined. The analysis of precipitation samples and real-time measurements of nitrogen species in gases and particles will provide detailed information on total deposition. Measurements will include all routinely measured components of nitrogen, as well as ammonia and organic nitrogen. In addition, meteorological information will enable analysis of emissions, source transport and deposition processes of the nitrogen components.

Expected Results

Previous studies have estimated that organic nitrogen contributes an average of 30 percent of the total atmospheric nitrogen deposition. Ammonia also can contribute a significant amount to the total nitrogen deposition, depending on meteorological conditions, so the hourly measurements of ammonia in this study will provide more detailed information than what is routinely measured. The comprehensive quantification and characterization of total atmospheric nitrogen obtained in this research will provide a more detailed description of all important components of nitrogen deposition and how they affect different locations.

Potential to Further Environmental/Human Health Protection

A better understanding of the sources of atmospheric nitrogen deposition will lead to better calculations of the total nitrogen loading to a specific environment, which is important to understanding the environmental impact of nitrogen deposition in sensitive ecosystems. Additionally, identifying the main contributors to nitrogen deposition—as well as their trends and sources—will provide the information needed for policymakers to form air pollution controls to reduce nitrogen deposition in areas that are significantly affected by increasing nitrogen.

Cesunica Ivey

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Environmental Discipline: Environmental Engineering

Bio

Cesunica Ivey received two B.S. degrees, in Mathematics (Fort Valley State University, 2008) and in Civil Engineering (Georgia Tech, 2010). She also earned an M.S. in Environmental Engineering (Georgia Tech, 2011). Cesunica entered the Ph.D. program in environmental engineering at the Georgia Institute of Technology in 2012. Her research interests include developing and applying data assimilation techniques for improved air quality data and evaluating emissions inventories used in air quality models.

Synopsis

The proposed work will investigate new modeling approaches for improving estimates of source impacts on fine particulate matter, which quantify the estimated contribution of pollution sources to ambient concentrations. Results will include multiyear source impact estimates over the continental United States. These estimates can serve as human exposure surrogates in epidemiological analyses that investigate links between air pollution exposure and adverse health outcomes.

Keywords: air pollution, data assimilation, source apportionment

Large-Scale Application of $PM_{2.5}$ Source Identification and Control, with an Emphasis on Health Impacts

Objective(s)/Research Question(s)

In recent studies, such adverse health effects as worsening of cardiovascular and respiratory diseases have been linked to human exposure to ambient fine particulate matter, or particles with an aerodynamic diameter of 2.5 microns or less. Sources of fine particulate matter include diesel and gasoline-powered engines, solvent and metal industries, power plants, agricultural activities and biomass burning. This research project will investigate which particulate matter sources have the greatest impact on ambient particulate matter concentrations over the continental United States.

Approach

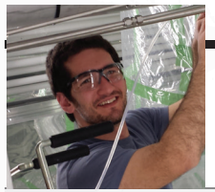
A multistep data assimilation approach will be implemented to generate estimates of $PM_{2.5}$ source impacts. A chemical transport model will be used to simulate $PM_{2.5}$ concentrations and source impacts for 20 unique source categories over the continental United States for a 5-year period (2005–2009). The results will be assimilated with ground- and satellite-based observations of $PM_{2.5}$ using a novel nonlinear optimization approach. Other model inputs include national emissions estimates of $PM_{2.5}$ and meteorological observations.

Expected Results

$PM_{2.5}$ source impacts will be identified for the years 2005–2009 over the continental United States with 36-km spatial resolution. Spatial trends will be determined for the United States for nine climate regions (e.g., southeast, northwest, Ohio River Valley, upper plains, etc.), as different regions are affected by different sources. Temporal trends will be analyzed for each region, such as weekday, weekend, holiday and seasonal trends. This work will provide a detailed assessment of the source impacts on fine particulate matter for the United States.

Potential to Further Environmental/Human Health Protection

The results of this work can be used in epidemiological studies that seek to determine correlations between human exposure to ambient particulate matter and the development or worsening of adverse health conditions. This work will aid policy makers determine which particulate matter sources are of greatest concern at the local and regional scales.



Jordan Edward Krechmer

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Environmental Discipline: Atmospheric Chemistry

Bio

Jordan Krechmer received his A.B. degree in German and Physics from Bowdoin College in 2007. He then spent a year in Germany on a Fulbright Fellowship. After returning to the United States he worked as an Applications Scientist in the chemical industry for 4 years before beginning his Ph.D. in Atmospheric Chemistry at the University of Colorado, Boulder in 2012. His research focuses on the development of mass spectrometric instrumentation to study atmospheric organic aerosols.

Synopsis

Atmospheric organic aerosols cause disease and have a large impact on climate, but much is unknown about how they form and change over time. This project proposes to develop specialized chemical instrumentation to measure large molecular gases that can form aerosols under certain conditions. The particular aim is to understand this system in places where natural emissions (from plants) and anthropogenic emissions (from power stations, cars, etc.) mix, such as in the Southeastern United States.

Keywords: air pollution, biological pollutants, organic aerosol

Development of an Ion Mobility Chemical Ionization Mass Spectrometer (IMS-CIMS) for the In-Situ Analysis of Secondary Organic Aerosol

Objective(s)/Research Question(s)

This work aims to develop instrumentation to quantify extremely low volatility organic compounds (ELVOCs) produced by the oxidation of biogenic emissions. This is an important first step to determine the contribution of these ELVOCs to the mass of secondary organic aerosol formed in heavily forested environments.

Approach

To quantify ELVOCs, this research will develop and characterize a novel mass spectrometer that utilizes a nitrate ionization source and an ion mobility component. The nitrate ion selectively clusters with extremely oxidized organics, enabling the detection of ELVOCs in ambient air with extremely high sensitivity. This instrument will then be deployed in the field in the Southeastern United States and at selective atmospheric smog chambers to explore these chemical systems. Data analysis will then identify and quantify these oxidized species and determine how much of them are forming aerosol under certain atmospheric conditions.

Expected Results

It is expected that ELVOCs play a role in the production of organic aerosol in areas with large amounts of vegetation. The exact size of this role is critical, however, and will depend on the type and quantity of biogenic emissions, as well as weather conditions and levels of anthropogenic pollution. Results from this research will help identify specific markers of different types of chemistry and aerosol. These results could help explain the observed gap between measured secondary organic aerosol and the amount predicted from aerosol computer models.

Potential to Further Environmental/Human Health Protection

The development and use of this unique instrumentation will improve understanding of the composition of both anthropogenic pollution and natural emissions. It also will enhance knowledge of how that pollution changes over time in "clean" environments. Due to effective pollution controls over the last several decades, this "clean" regime is becoming more common and understanding its characteristics will become more important as more Americans live in similar environments.

Brett Brian Palm

CO-2

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Atmospheric Chemistry

Bio

After receiving a B.A. in Chemistry from Dartmouth College (New Hampshire) in 2009, Brett Palm continued his studies in a Ph.D. program in atmospheric/analytical chemistry at the University of Colorado at Boulder. He enjoys the challenges of taking field measurements of the atmosphere and is interested in using those measurements to better understand how anthropogenic activities influence the chemistry of the atmosphere. He is currently studying secondary organic aerosol formation and aging.

Synopsis

Secondary organic aerosol (SOA) formation and aging have an important impact on air quality and climate, but remain poorly understood. The goal of this research is to provide constraints to SOA models by measuring SOA formation potential of ambient air using an oxidation flow reactor and comparing results to the SOA formation predicted by current models. These experiments will lead to better models that can be used to design more effective policies to reduce anthropogenic effects on air quality and climate.

Keywords: field campaign, organic aerosol, oxidation flow reactor

Laboratory and Field Studies of Secondary Aerosol Formation and Aging Using a Flow Reactor

Objective(s)/Research Question(s)

The sources, formation and aging of secondary organic aerosol (SOA) in the atmosphere are not well constrained, yet this information is critical for regional and global models. This research aims to evaluate the current knowledge of SOA sources (biogenic and anthropogenic) and to quantify the amount and chemistry of SOA formation as a function of oxidant exposure.

Approach

Ambient air at several internationally collaborative field campaigns will be oxidized in the Potential Aerosol Mass (PAM) oxidation flow reactor and analyzed using a broad suite of gas- and particle-phase instrumentation. In a mass closure experiment, the amount of SOA formed from oxidation of ambient air will be compared to the amount of SOA predicted using laboratory-derived aerosol yields of the known aerosol precursor gases measured in the ambient air. Also, the chemical properties of SOA (e.g., atomic O:C ratio) will be investigated as a function of oxidant exposure.

Expected Results

The measurements of real-time SOA formation in the flow reactor provide a bridge between the information obtained from the various particle-phase and gas-phase measurements that take place at collaborative field campaigns. This abundance of information will be leveraged to explain or identify gaps in knowledge about which gases form SOA and in what yields. By comparing SOA formation from ambient air with and without anthropogenic influence, this research will shed light on how human activity is influencing the chemistry of the atmosphere.

Potential to Further Environmental/Human Health Protection

The ability of models to predict future climate and the impact on air quality of aerosols depends critically on the ability to set parameters for the underlying chemistry of SOA formation, as well as spatial knowledge of SOA sources. This research aims to provide better constraints to these models, so that policy experts can use them to design well-informed, effective climate change mitigation strategies.

Nicole Katherine Scharko

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Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Nicole Scharko received a B.S. in environmental science from DePaul University (Illinois) in 2007. From 2007 through 2009, she taught math and science in Tanzania as a Peace Corps volunteer. In 2012, she received an M.S. in environmental science from Indiana University, Bloomington. Since 2012, Nicole has been a graduate research assistant in the environmental science Ph.D. program at that same institution, where she is studying how heterogeneous chemistry on surfaces affects air pollution. Her dissertation research focuses on characterizing both daytime and nighttime sources of the gas nitrous acid.

Synopsis

Nitrous acid (HONO) is a trace gas that contributes to the formation of ground-level ozone, a respiratory irritant and a greenhouse gas, by serving as a source of the hydroxyl radical, the most reactive oxidant in the atmosphere. Current atmospheric models under-predict daytime HONO concentrations measured in the field. By identifying and understanding the chemical mechanisms that form HONO, during both the daytime and the nighttime, the parameters associated with these mechanisms may be measured and implemented into models to improve the accuracy of air quality predictions.

Keywords: nitrogen dioxide, nitrous acid, photochemistry

Understanding Nitrous Acid Sources on Atmospherically Relevant Surfaces

Objective(s)/Research Question(s)

Despite the importance of HONO, little is known about the mechanisms by which it is formed. Daytime HONO formation is of particular interest because current atmospheric models under-predict daytime HONO concentrations measured in the field. There is speculation that daytime HONO may stem from nocturnal mechanisms. The objectives of this study are to characterize daytime and nocturnal sources of HONO by measuring key parameters, such as reaction efficiencies and uptake coefficients. These parameters are essential for accurate air quality predictions.

Approach

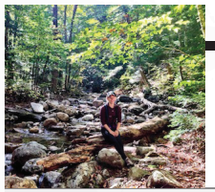
The project will study a potentially important daytime source of HONO by monitoring the formation of gas phase nitrogen dioxide and HONO from the photolysis of nitric acid and nitrate adsorbed to environmentally relevant surfaces (components of soil, suspended particulate matter and aerosols). Photochemical reaction chambers and flow tubes will be used to study the kinetics and mechanism of this chemistry. Three instrumental techniques will be used: Fourier transform infrared spectroscopy to study oxides of nitrogen adsorbed to surfaces and emitted into the gas phase; chemical ionization mass spectrometry to measure HONO emitted from the surfaces into the air; and cavity-enhanced absorption spectroscopy to measure gas phase nitrogen dioxide and HONO simultaneously. Thermal sources of HONO also will be examined by quantifying the amount of HONO generated by the hydrolysis of nitrogen dioxide on soil as a function of relative humidity, nitrogen dioxide concentration and temperature.

Expected Results

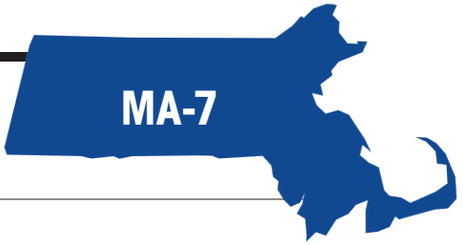
The kinetics and mechanisms associated with production of HONO from nitrate photolysis on environmentally relevant surfaces will provide important insights into the mechanism of a potentially important daytime source of HONO. As for the nocturnal source, hydrolysis of nitrogen dioxide on surfaces has been attributed to the accumulation of HONO during the night. Uptake coefficients for nitrogen dioxide on soil and the individual components of the soil will be determined; the approach taken will provide a way to eliminate confounding factors associated with studying such complex systems and allow more precise study of the mechanism of HONO production. The approach is unique because previous methods of studying these problems have been limited to working under vacuum and in the absence of air and water. This work is expected to yield more atmospherically relevant results that can be used for predictions of air quality and climate.

Potential to Further Environmental/Human Health Protection

Understanding mechanisms of HONO formation, during both the daytime and nighttime, will improve the atmospheric chemistry models used by policy-makers to create effective air quality control strategies. Effective policy that saves lives and reduces health care costs associated with exposure to air pollution is possible only when the model results are correct for the right reasons.



Katherine Rose Travis



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Project Amount: $84,000
Environmental Discipline: Atmospheric Chemistry

Bio

Katherine R. Travis received a B.S. in Engineering Science from Smith College (Massachusetts) in 2008. She then worked as an air quality scientist for CDM-Smith from 2008 to 2011 in Southern California. She started a Ph.D. program in Environmental Science and Engineering at Harvard University in 2011. Her research interests include ozone chemistry and the relative contributions of anthropogenic versus natural sources to ozone levels in the United States. Her current research involves better understanding of ozone production in the Southeastern United States using the GEOS-Chem chemical transport model, constrained by observations of ozone precursors from the 2013 NASA SEAC4RS campaign.

Synopsis

Ground-level ozone pollution is a serious public health and environmental concern in the United States. EPA is considering tightening the ozone air quality standard for better protection of human health and welfare. However, it is unclear to what extent uncontrollable background ozone would hinder achievement of a lower standard. This research focuses on improving understanding of background ozone in the United States using the GEOS-Chem chemical transport model.

Keywords: ozone, GEOS-Chem, NAAQS

Improved Understanding of North American Background Ozone

Objective(s)/Research Question(s)

Ozone pollution is a serious public health concern in the United States. Background ozone is not directly measurable and thus must be calculated from global chemical transport models (CTMs). There also are significant differences between CTMs in estimates of background ozone, which is very problematic for air quality policy. This research will evaluate the following hypotheses: (1) that background ozone in the United States can be elevated by a combination of influences including stratospheric intrusions, lightning, wildfires and foreign pollution; and (2) that improvements in CTM resolution, wildfire plume chemistry, biogenic emissions chemistry and anthropogenic emissions inventories can significantly improve the ability to quantify the ozone background, its variability and its contribution to National Ambient Air Quality Standards (NAAQS) exceedances.

Approach

After focusing on ozone production in the United States during the spring and summer of 2013, this project will use a new continental-scale version of GEOS-Chem with high horizontal resolution nested dynamically within the global model to develop a uniquely consistent representation of global and regional processes contributing to background ozone. High resolution is important for characterizing nonlinear chemistry, pollution plumes and local source variability. Nesting within a global model is critical for representing sources and transport outside North America. Key goals to achieve a successful model representation of U.S. ozone during this period include improved wildfire representation and better-constrained chemistry of species emitted by vegetation, both areas of disagreement among CTMs. The results will be evaluated with a variety of surface ozone measurements and satellite observations, as well as the recent NASA SEAC4RS aircraft campaign in the southeast United States.

Expected Results

This work will lead to significant improvement in (1) understanding the factors controlling background ozone in surface air over the United States, (2) quantifying this background for air quality policy application and (3) identifying exceptional events that might be considered exempt from the ozone NAAQS. This work will add to the understanding of background ozone over North America and assist the regulatory community in setting and achieving ambient air quality goals. The research on background ozone will uniquely connect air quality and climate issues. Through the work of the broader GEOS-Chem and atmospheric chemistry community, the capability of Earth System models will be enhance to better consider atmospheric chemistry as an agent for climate and biogeochemical forcings and feedbacks.

Potential to Further Environmental/Human Health Protection

This research will result in an improved understanding of North American background ozone. It will support regulatory development at both the EPA and state air quality agencies to better protect human health and welfare.

Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has.

–Margaret Mead

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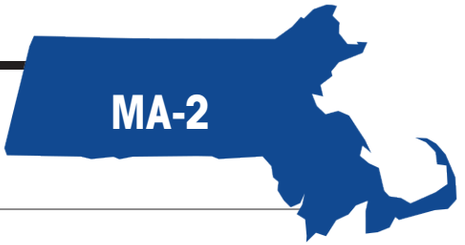
Global Change

Arnold Patrick Behrer



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Project Period: 8/1/2014–8/1/2016
Project Amount: $42,000
Environmental Discipline: Resource Economics

Bio

Patrick Behrer graduated cum laude from Harvard University in 2010 with a B.A. in economics. Following that he spent a year in New Zealand as a Fulbright Fellow. Upon his return from New Zealand he began a Master's program in natural resource economics at Colorado State University. His research interests lie in the valuation of ecosystem services and the institutional or programmatic design necessary to fully integrate the value of these services into a modern economy. In the fall he will continue this research as a Ph.D. student at Harvard University.

Synopsis

Payments for Ecosystem services (PES) programs are a new option to help preserve the environment. Reduced Emissions from Deforestation and Degradation (REDD+) schemes are a well-known version of PES programs that seek to reduce carbon emissions and global warming associated with land change. One challenge of these programs is encouraging participation among landowners. This research will examine how different economic and social factors interact with program design to facilitate increased participation in REDD+ programs.

Keywords: deforestation, ecosystem services, REDD+

Modeling Participation in Payments for Ecosystem Services Programs: A Discrete Choice Model of Participation in REDD+

Objective(s)/Research Question(s)

REDD+ programs have the potential to increase human welfare and reduce the contribution that deforestation makes to global carbon emissions. It will only do so, however, if individuals participate in the programs. The objective of this project is to identify the features of programs that make individuals more likely to participate.

Approach

The research will take place in the context of nine REDD+ pilot programs in Tanzania. These programs have been put into place by different conservation nongovernmental organizations (NGOs) and each has distinct program features, allowing an examination of how the individual program features interact with village- and individual-level characteristics to determine participation. Data will be collected from the NGOs on their individual program features and combined with socioeconomic data from the villages and individuals that have chosen to participate. This combined data set can then be fed into a discrete choice econometric model to tease out the effects of changes in specific programmatic elements relative to the mean level of base characteristics.

Expected Results

Previous research on conservation programs indicates that payments must cover the opportunity cost of participation. This cost varies greatly as the distance from main cities increases. As a result, programs that target financing at villages at greater distance from main cities are likely to have the highest participation levels. However, the distance from cities also increases the importance of in-kind benefits as access to standard markets declines. Therefore, the most successful programs are likely to be those that create an effective mix of monetary and in-kind payments to participants and are able to target these payments to areas outside of major cities.

Potential to Further Environmental/Human Health Protection

REDD+ is important in its own right but it also serves as a model for other PES programs. If a framework for success in creating general PES programs can be developed based on this research, it will greatly expand effectiveness of PES programs. This, in turn, should generate greater environmental conservation and a more secure supply of natural capital.

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Project Period: 9/2/2014–9/2/2016
Project Amount: $84,000
Environmental Discipline: Terrestrial Ecology

Bio

John Berini received a B.S. in Conservation Biology from the University of Minnesota in 2007 and an M.S. in Ecology and Evolutionary Biology from the University of Michigan in 2010. In 2011, he began a Ph.D. program in Conservation Biology at the University of Minnesota. His research interests include feeding ecology and its link to demography. His current research focuses on how climate change is affecting moose behavior and demographics in Minnesota.

Synopsis

While the correlation between increasing temperatures and the decline of moose in Minnesota is well documented, there is an urgent need to develop a mechanistic understanding of how animals interact with changing landscapes. The proposed research addresses this need by synthesizing various sources of spatiotemporal data (e.g., stable isotopes, secondary metabolites) to provide landscape-scale, spatially explicit predictions of habitat use and demographic trends of moose in a dynamic environment.

Keywords: climate change, foraging behavior, habitat use and loss

Climate Cascade: Linking Temperature, Phytochemistry and Vertebrate Demographics

Objective(s)/Research Question(s)

Moose are an important ecological component of the boreal ecosystem, are notoriously heat intolerant and are at the southern edge of their circumpolar distribution in northern Minnesota. Although the relationship between increasing temperatures and the decline of moose in Minnesota is well documented, it is critical to identify the precise mechanisms underlying this relationship in order to understand how large herbivores will respond to continued warming. This study investigates the potential impact of climate change on moose at the southern edge of their bioclimatic envelope by addressing the following questions: How do increasing temperatures affect forage quality? How do increasing temperatures affect forage selection by moose? How does habitat quality affect the demographics of the moose population?

Approach

Plant samples will be collected from a controlled warming experiment, in which 10 different tree species important to the boreal ecosystem have been grown since 2008 under three different temperature regimes: ambient, ambient +2 °C and ambient +4 °C. These samples will be analyzed to determine how the number and concentration of different plant secondary metabolites vary as a function of temperature. Similar analyses will be conducted on forage samples collected from more than 60 semipermanent plots located throughout northeastern Minnesota—a region that spans a 5 °C summer temperature gradient and includes multiple disturbance types (e.g., clear cuts, burns, etc.) and ages. Changes in ambient temperature also will be recorded at each plot at 2-hour intervals throughout the duration of the study. Forage and moose tissue samples will be analyzed for stable isotopes of carbon and nitrogen, and these data will be used to estimate diet composition with a series of Bayesian mixing models. Moose tissue samples have already been collected from more than 150 radio-collared animals as part of a parallel study being conducted by the Minnesota Department of Natural Resources (MNDNR). Finally, the annual aerial survey data collected by the MNDNR will be used to estimate changes in spatially explicit demographic rates and population growth rates as a function of different temperature regions, disturbance types, disturbance ages and forage quality. Finally, general linear models will be used to investigate the effects of temperature, disturbance type and age and forage quality on population vital rates and to determine if any one variable is overwhelmingly responsible for the decline of moose in Minnesota.

Expected Results

There is an urgent need for a mechanistic understanding of how animals interact with changing landscapes. Using the declining Minnesota moose population as a case study, this research addresses that need by synthesizing multiple sources of spatiotemporal data to provide landscape-scale, spatially explicit predictions of habitat use and demographic change. By investigating the chemical response of numerous tree species that play a critical role in the structure and function of the boreal ecosystem, this study investigates how the physicochemical landscape may be altered by present and future climate change. The demographic data provide unique insights into how a keystone herbivore may be altering its habitat-use behavior as a result of these changes and how these behavioral changes may, in turn, be affecting landscape-scale population growth.

Potential to Further Environmental/Human Health Protection

While this research directly addresses questions of management concern, it also advances the understanding of how climate change affects animal populations by investigating how increased temperatures are affecting forage quality, how animals mitigate environmental stress, and how behavior and landscape context affect diet and, consequently, population demographics. The transformative power of this project is that it will link the diet and habitat use of individuals to population demographics and the spatial and temporal variations in the biotic properties of the environment.

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Environmental Discipline: Ecology

Bio

Reuben Biel received a B.A. in Biology from Colby College (Maine) in 2010. In 2011, he started a Ph.D. program at Oregon State University's Department of Integrative Biology. His research examines relationships between ecological communities and processes, biophysical processes and ecosystem services. His dissertation research specifically explores interactions between coastal sand dune ecology and geomorphology and their combined influence on coastal protection during extreme storms.

Synopsis

Beachgrass plays an important role in building coastal dunes and providing protection against storms. However, few have investigated how climate change may affect beachgrasses and the subsequent effect on coastal hazards. This research will examine the effects of climate change on invasive beachgrass distribution and abundance in the Pacific Northwest, beachgrass's effect on dune shape (e.g., height, width) and the relationship between beachgrass density and flooding and erosion hazards.

Keywords: climate change, coastal protection, sand dunes

Coastal Vulnerability Amidst Climate Change: The Dual Effects of Altered Biogeomorphology and Variable Seas on Pacific Coast Dunes

Objective(s)/Research Question(s)

To better approach this overarching question, this project will (1) determine the relationship between climate, sand characteristics, vegetation and dune shape (i.e., height, width) in Pacific Northwest coastal sand dunes; (2) model how future climate conditions in the Pacific Northwest may modify coastal dune shape; and (3) project how altered dune shape, sea level rise and possible variations in storminess will affect coastal vulnerability to flooding and erosion.

Approach

To explore the relationship between climate, sand, vegetation and dune shape, sand dune vegetation density and topography were measured at 124 locations throughout Oregon and southern Washington in 2012 and in 2014. To better determine the influence of temperature on beachgrass abundance and morphology, this project comprises a year-long warming experiment at Hatfield Marine Science Center (Newport, Oregon) to measure growth and competition between the two dominant, invasive beachgrasses, *Ammophila arenaria* and *Ammophila breviligulata*. These data will be used to model how dune shape and dune grass distributions and abundances may be altered under changing temperatures in the Pacific Northwest. XBEACH and other coastal hazard models will be used to assess how projected foredune shape, sea level rise and variations in storminess may affect future coastal vulnerability to flooding and erosion.

Expected Results

Dune shape varies along the coast. In southern Washington, dunes are typically shorter and wider and are dominated by *A. breviligulata*, while Oregon dunes are often taller and narrower and dominated by *A. arenaria*. It is likely that the differences in both beachgrass distributions and differences in regional sand supply predominantly control dune shape, but the underlying cause for the differences in beachgrass distribution remain unknown. Nevertheless, *A. arenaria* dunes, due to their taller stature, may provide greater protection against dune scarping and shoreline recession during major storms. Even so, rising temperatures, stronger storms and sea level rise may present a significant threat to coastal areas, either indirectly by altering beachgrass distribution or abundance or directly by causing increased erosion and flooding.

Potential to Further Environmental/Human Health Protection

Beaches and dunes are valuable resources, providing habitat, recreational and tourism opportunities, coastal protection and many other uses. Rising temperatures, sea level rise and changing storm patterns threaten both the dune habitat itself and nearby coastal communities that depend upon beaches and dunes, both for providing tourism and recreation and for protecting homes and infrastructure against storms and tsunami. This research will better enable coastal communities and coastal managers to anticipate future conditions and better create resilient communities amidst climate change.

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Project Amount: $84,000
Environmental Discipline: Marine Sciences

Bio

Josh Breithaupt has a B.A. in English from Wheaton College (Illinois) and an M.S. in Environmental Science from the University of South Florida, St. Petersburg. He began work on a Ph.D. in Chemical Oceanography at the University of South Florida College of Marine Science in August 2012. He is interested in biogeochemical processes in coastal wetlands, with a focus on mangrove carbon cycling. His principal research objective is to quantify carbon burial and sediment accumulation rates in the coastal Everglades over the past 100 years.

Synopsis

Coastal wetlands convert carbon dioxide into organic carbon and can bury it in the soil for hundreds or thousands of years. In the past century the Everglades have been affected by sea level rise, tropical storms and reduced freshwater input. This research uses dated soil cores to examine the quantity and source of carbon buried in the coastal Everglades in this period. Analyzing past responses to change will help predict responses to future sea level rise, climate change and restored freshwater flow.

Keywords: carbon storage, climate change, sea level rise

Organic Carbon Burial Rates in the Coastal Everglades: An Ecosystem-Scale Assessment of Spatio-Temporal Variability

Objective(s)/Research Question(s)

The main objective of this research is to understand how environmental influences (including extensive anthropogenic alteration of south Florida hydrology, sea level rise and numerous tropical storms and hurricanes) contributed to changes in the rates of sediment accumulation and carbon burial in the coastal Everglades in the 20th century. The majority of coastal Everglades soils are either organic peat or carbonate mud, both of which can be ephemeral given the right environmental conditions. Distinguishing whether apparent rate changes in the record should be dominantly attributed to mechanisms of delivery or mechanisms of degradation is a key question. Quantifying the fractions of soil organic carbon that originate with seagrass, algae, phytoplankton, marsh, or mangrove material is needed to assess whether a change in the type of carbon buried throughout the estuary has changed over the period of interest.

Approach

This research utilizes soil cores collected from a variety of mangrove and marsh environments along the Shark, Harney and Broad Rivers, which drain the southwestern coastal Everglades. Soil cores are being radiometrically dated using Pb-210 and Cs-137 to determine rates of sediment accretion, as well as the mass accumulation of various constituents, including organic and carbonate carbon and nutrients (nitrogen and phosphorous). These accretion and accumulation records will then be related to historical records of freshwater flow, sea level rise and storm occurrences. Differentiating the respective contributions of (a) production or delivery and (b) preservation or destruction will be done by comparing, in each core, fluxes of potentially ephemeral sediments with fluxes of stable and refractory sediments. Using a multi–end-member mixing model, nutrient ratios (C:N:P) and stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) will be used to identify different vegetation contributions (seagrass, algae, phytoplankton, marsh and mangrove) to soil organic matter throughout the estuary. Collaborative work with members of the South Florida Water Sustainability and Climate and Florida Coastal Everglades Long-term Ecological Research programs will be vital to synthesize these data into the larger scope of hydro-economic considerations.

Expected Results

Coastal carbon burial rates are controlled by many factors, including those related to local hydrology, such as salinity, water depth and inundation time. The historical reduction in freshwater supply to the coastal Everglades—increasing salinity and reducing water depth—is likely to have had the greatest impacts in the upper estuary, leading to lower overall carbon burial rates. Conversely, sea level rise and storm influences (such as mangrove mortality and surge-scouring and deposition of sediments) are likely to have had the greatest impact in the lower estuary, leading to increased carbon burial rates. The fraction of mangrove carbon in the soil is expected to be greatest mid-estuary, with increasing contributions from seagrass in the lower estuary and marsh grasses in the upper estuary.

Potential to Further Environmental/Human Health Protection

By providing a broad spatial assessment of how the Everglades landscape has responded to environmental influences over the past century, this research will assess regions within the study area that may be most vulnerable to future change. This information will be important to both the National Park management charged with protecting an essential national resource and the ecologists and fisheries managers working in these changing habitats. Additionally, by constraining the influence of freshwater flow on historical carbon burial throughout the region, this research will equip ecosystem managers and policymakers with data to better evaluate how to sustainably allocate freshwater in view of future ecological, societal and agricultural needs.

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Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Heather Mae Briggs received a B.S. from the University of Nevada, Reno, and an M.S. from the University of Michigan. Heather is currently pursuing a Ph.D. from the Environmental Studies department at the University of California, Santa Cruz. She has been exploring the intricacies of pollinator-floral interactions, from both insect and plant perspectives, for more than 12 years. Her Ph.D. research focuses on the effect of pollinator species loss on ecosystem function.

Synopsis:

Pollinator species are at risk of local and global extinction from human activities and from global climate change. This research will combine a modeling approach with empirical field studies to evaluate pollinator network resilience under future climate change scenarios.

Keywords: climate change, network models, pollinators

Pollinator Losses and Plant Function: An Assessment of Pollination Network Resilience in the face of Climate Change

Objective(s)/Research Question(s)

Pollinator species are increasingly at risk of local and global extinction from the effects of human activities, including habitat loss, introduction of alien species and global climate change (GCC). Specifically, GCC is projected to disrupt the overlap in plant flowering time and pollinator emergence/foraging activity, leading to potentially mismatched interactions between both plants and animals. While it seems intuitive that GCC could reduce plant reproduction through a reduction in visitation from pollinators, recent work based on pollination networks actually suggests that plant communities will be highly resilient, meaning that plants will be resistant to linked extinctions (plant extinctions that result from pollinator extinctions) when faced with GCC. The simulation models that generate these predictions of resilience are based on a number of implicit assumptions, namely that any insect that happens to visit a flower is an effective pollinator of that plant species. A wide range of studies, however, have shown that many flower visitors are ineffective at pollinating plant species they visit, and some actually reduce plant reproduction. This work will take a two-pronged approach of modeling combined with empirical field studies to evaluate the importance of this assumption to the conclusion that pollinator networks are resilient. Furthermore, this work will evaluate pollinator network resilience under future climate change scenarios.

Approach

This project includes the following tasks: (1) Build a pollination network model for an empirical pollination network using existing long-term data sets; (2) set parameters for estimates of the directionality of plant-pollinator interactions (positive and negative); (3) assess network resilience to linked extinctions by comparing networks with a more realistic assignment of positive to negative interactions to those with only positive interactions; and (4) assess resilience to linked extinctions under climate change scenarios by comparing network models that include an assignment of interaction directionality to those that do not.

Expected Results

Pollination networks with more realistic characterization of the effectiveness of plant-pollinator interactions will exhibit substantially less resilience relative to previous network studies. Incorporating a more realistic distribution of interaction direction (negative or positive) should predict more realistic "extinction cascades," in which pollinators, as well plants, go extinct, leading to the extinction of more plants. Such cascades cannot occur when all interactions are considered positive, as a single link will be enough to maintain a plant-pollinator interaction; therefore current models may be overestimating predictions of resilience. Furthermore, global climate change will impact such realistically characterized networks more dramatically than those predicted by current models.

Potential to Further Environmental/Human Health Protection

The idea that plant-pollinator networks are highly resilient to pollinator species losses has been so broadly adopted by the ecological research community that it can almost be considered a paradigm. If relaxing one key assumption of those simple models changes the results, it could have a major effect on the way that ecologists, environmental policymakers and land managers think about plant-pollinator networks and their resilience to environmental changes. This work will provide a strong basis for improved predictive models that will be useful in anticipating likely changes in pollination services and designing strategies to maximize ecosystem resilience.

Emily Yvonne Campbell

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Project Amount: $84,000
Environmental Discipline: Aquatic Ecology

Bio

Emily Campbell earned a B.S. in Ecology from Humboldt State University (California) in 2006. The following year, she entered a Master's program in Entomology at Michigan State University and graduated in 2010. She is now pursuing a Ph.D. in Fisheries Science at Oregon State University and is researching climate influences on the development and phenologies of salmon and their invertebrate prey in Alaska streams. She is passionate about salmon ecology, entomology and science education.

Synopsis

Climate change will likely shift the timing of periodic life cycle events (phenology) of salmon, which can have cascading effects on entire ecosystems. This research will use a space-for-time design to examine climate influences on the phenologies of salmon and their invertebrate prey in thermally variable streams in Alaska, a region particularly susceptible to climate change. Empirical data will be used to develop predictive climate models to best manage and protect future salmon populations.

Keywords: climate change, salmon, phenology

Linkages Between Climate Change and the Phenologies of Juvenile Salmon and Their Invertebrate Prey in Streams

Objective(s)/Research Question(s)

Climate change will likely shift the timing of important salmon and invertebrate life history events, such as emergence, due to their temperature-dependent metabolism. This study will consider three integrated aspects of climate and phenology: (1) climatic influences on the phenology of a predator (juvenile salmon); (2) consequences of climatic influences on fitness-related characteristics, including salmon size at age, growth and condition; and (3) linkages between the phenologies of juvenile salmon predators and their invertebrate prey.

Approach

A space-for-time experimental design will address these objectives through a comparative study of coho salmon predators and their invertebrate prey in six hydroclimatically variable streams on the Copper River Delta, Alaska. In the field, emerging salmon fry and invertebrates in these systems will be detected from April through November. Sequential ID tags will allow tracking of salmon growth rates in the field among streams. The spatial and temporal variation in thermal profiles among and within streams will be mapped. In the laboratory, salmon otoliths (calcium carbonate ear stones) will be extracted to determine exact age, gut contents will be analyzed to determine which invertebrate taxa salmon are consuming, and salmon muscle tissues will be analyzed for total percent lipid content, an important determinant of over-winter survival. Empirical data collected during this study also will be used in developing a bioenergetically based simulation model that will allow exploration and understanding of a more complete range of potential climate effects on juvenile coho salmon.

Expected Results

Emergence timing is hypothesized to be under strong selection in salmonids and to be very sensitive to climate. Earlier salmon emergence is expected in streams with relatively warmer temperatures in the winter due to greater degree day accumulation for developing salmon eggs. Furthermore, in streams with less thermal variation, there should be strong selection for more synchronous emergence to match the most ideal timing of emergence. Thus, emergence should be less variable in more predictable systems. Juvenile salmon are critically dependent on the timing of prey availability. Thus, the timing of juvenile emergence may be strongly associated with greater prey availability. Climate change may create a phenological mismatch, in which case a predator becomes decoupled in time with its prey. This research will provide data about the potential for phenological decoupling to occur between Alaskan salmon and their invertebrate prey, which is likely given that these streams are particularly susceptible to climate change impacts.

Potential to Further Environmental/Human Health Protection

Salmon are of vital economic, ecological and cultural importance to human communities. Alaska is one of the last regions along the Pacific Northwest that still has salmon returns near historic levels, and yet this same region is predicted to show the greatest changes in climate. This study will provide novel data on climatic influence on salmon demography and phenology, which will be used to construct predictive climate models to best manage and protect future salmon.

Sarah Corman Crosby

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Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Sarah Crosby earned her B.A. in Biology from Tufts University in 2006 and an M.Sc. in Oceanography from The University of Rhode Island in 2009. She then began a Ph.D. in Ecology and Evolutionary Biology at Brown University. She is a coastal ecologist and is primarily interested in human and climatic impacts on salt marsh ecosystems. Her current work explores how marsh-building plants will respond to rising temperatures and how this and other factors affect marsh persistence with sea level rise.

Synopsis

Salt marshes are among earth's most productive ecosystems, providing many benefits to people, such as food provision and storm protection. Specialized plants build the habitat that provides these services. This research investigates how growth and reproduction of an important salt marsh plant (smooth cordgrass) will respond to rising temperatures. It will improve understanding of how marshes will respond to climate change and where they may be lost with sea level rise.

Keywords: phenology, salt marsh, sea level rise

Spartina alterniflora in a Changing Climate: Implications of Rising Temperatures for Salt Marsh Persistence

Objective(s)/Research Question(s)

This research considers how the phenology and growth of an ecosystem engineer will respond to rising temperatures and how these changes will alter ecosystem function and persistence. It focuses on three sets of questions: (1) What patterns of growth occur along a temperature gradient in the salt marsh species *Spartina alterniflora*, and how will rising temperatures affect plant contributions to marsh elevation? (2) How does reproduction in *S. alterniflora* vary on multiple spatial scales, and how does flowering affect growth? (3) Where are salt marshes currently keeping pace with sea level rise, and how might that change under the sea level rise rates predicted for the future?

Approach

To answer the first question about growth and temperature, the project uses field surveys, a transplant experiment and a greenhouse common garden experiment with marshes and plants from along a latitudinal gradient on the U.S. East coast. The second question is being addressed with multiscale field surveys, biomass collection and field and laboratory experiments. A literature review and meta-analysis will explore marsh elevation change and identify where marshes are keeping pace and where they are likely to keep pace in the future.

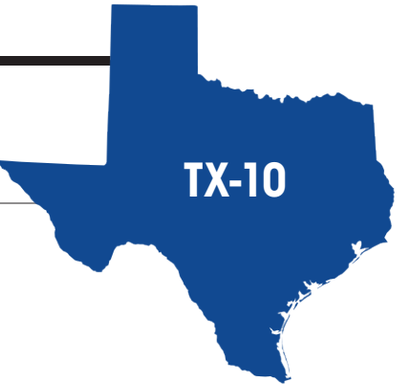
Expected Results

Plasticity in growth is expected to occur in response to warming. As a result of these shifts, drowning is likely to lead to greater marsh loss. It also is expected that flowering phenology cues the timing of biomass allocation. Within-marsh patterns of timing and density of flowering will likely show an effect of temperature on marsh plant seed output. Finally, this work is likely to demonstrate that the majority of currently existing salt marshes will not be able to keep pace with projected rates of sea level rise.

Potential to Further Environmental/Human Health Protection

Salt marshes are an invaluable part of sustainable, livable communities on U.S. coasts, providing ecological and economic benefits far beyond the shoreline, such as food provision, water filtration and protection from storms. Marsh drowning due to insufficient elevation is possible with climate change, but the rate and likelihood are unclear. This research will meaningfully expand understanding of these issues. *S. alterniflora* is a foundation species, critical to marsh persistence. Generating data on temperature effects and the current status of marsh elevation gain will improve the ability to select areas for protected status and manage expectations of future services on local and regional scales.

Nathan Fine



Managing Nitrosamines in Amine Scrubbing for Post-Combustion Carbon Capture

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Project Amount: $84,000
Environmental Discipline: Chemical Engineering

Bio

Nathan Fine earned a B.S. in Chemical Engineering from Washington University in Saint Louis (Missouri) in 2011. The following year, he began research at the University of Texas, where he currently works on the environmental sustainability of carbon capture with amine scrubbing.

Synopsis

Fossil-fueled power plants represent the single largest global source of CO_2 emissions. Carbon capture from these sources is one of the main targets for eliminating these emissions and mitigating climate change. Amine scrubbing is currently the leading industrial technology for carbon capture from these point sources, but harmful emissions from the solvent itself may negatively affect the environment. This research focuses on the accumulation and emissions of nitrosamines, a carcinogenic byproduct that forms in amine scrubbing when the amine solvent comes into contact with NO_x contaminants in the flue gas.

Keywords: amine scrubbing, carbon management, nitrosamine

Objective(s)/Research Question(s)

This research seeks to identify how nitrosamines form and decompose in amine scrubbing. It also will attempt to determine what factors can be controlled to limit nitrosamine accumulation and what the impact of nitrosamine emissions is on the environment.

Approach

Nitrosamine formation and decomposition will be studied through bench-scale experiments that mimic absorber and stripper conditions. Specifically, simulated flue gas with nitrogen oxides will be sparged through amine solutions and analyzed for absorbed species. The solution will then be heated to stripper temperatures ranging from 120 °C to 150 °C to analyze for nitrosamine content. Final results will be modeled for conditions at the pilot plant and compared to current data from the pilot plant. The model will then be refined based on any discrepancies between pilot-plant and bench-scale results. The final model will give an expected nitrosamine concentration based on the amine scrubber and the inlet flue gas. This concentration can be used by EPA and the industry to help set regulations on nitrosamine emissions and determine process conditions.

Expected Results

Nitrosamine formation will be dominated by NO_2 absorption into the amine as nitrite. The nitrite will then travel to the stripper, where it can react with the amine to form nitrosamines. NO is not expected to be reactive, so eliminating NO_2 from the NO_x emissions should drastically reduce nitrosamines. Nitrite also might be able to form directly from amine oxidation. Thus, amine scrubbers running with a NO_x-free flue gas might still have small amounts of nitrosamines. Nitrosamines should decompose in the stripper, leading to a steady-state concentration, in which formation from NO_2 balances with decomposition. The steady-state nitrosamine concentration can then be used to determine the environmental impact of nitrosamine emissions from the amine scrubber, either through volatile nitrosamine loss or through solvent spills.

Potential to Further Environmental/Human Health Protection

Amine scrubbing is currently the preferred technology for carbon capture from pilot plants, and the first-generation carbon capture units are likely to be amine scrubbers. Recognizing the harmful byproducts formed during amine scrubbing will ensure that these units are industrially hygienic and keep the population around these plants healthy.

Kyrstin Fornace

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Environmental Discipline: Earth Sciences and Oceanography

Bio

Kyrstin Fornace received a B.S. in chemistry from the Massachusetts Institute of Technology (MIT) in 2009 and began a Ph.D. program in chemical oceanography at the MIT/Woods Hole Joint Program in Oceanography in 2010. Her interests include paleoclimatology, organic geochemistry and the global carbon cycle, as well as science education and communication. Her current research is focused on the interactions between climate change and the terrestrial carbon cycle over the past 20,000 years in the South American tropics.

Synopsis

Organic carbon produced by plants can be stored on land in soils, wetlands, or river sediments for days to millennia before release as carbon dioxide or transport by rivers to the ocean. Climate change can alter this storage time, in turn affecting atmospheric carbon dioxide concentration. This research will assess how terrestrial carbon storage at two tropical sites responded to climate changes over the past 20,000 years by analyzing the ages of plant molecules in ocean and lake sediments.

Keywords: carbon cycling, climate change, radiocarbon

Exploring the Impacts of Past Climate Change on Terrestrial Carbon Storage in the South American Tropics

Objective(s)/Research Question(s)

The aim of this research is to characterize changes in the terrestrial storage time of plant-derived organic carbon during periods of distinct climate conditions over the last 20,000 years at two tropical South American sites, Lake Titicaca (Peru/Bolivia) and Cariaco Basin (Venezuela). These two sites have had very different climate histories since the last glacial period, allowing exploration of the effects of both hydrologic and temperature variability on the terrestrial carbon cycle in the tropics.

Approach

Compound-specific radiocarbon analysis of vascular plant biomarkers in marine and lacustrine sediment cores will be used to determine the difference in age between these biomarkers and the sediment deposition age, which reflects the storage time of plant-derived organic carbon on land before transport to the sediment. Although terrestrial organic carbon is comprised of a wide variety of different compounds, the specific biomarkers to be used—leaf wax compounds—are found in soil and fresh leaf litter and thus serve as proxies for both labile and refractory subsets of biospheric organic carbon. Sediment deposition ages will be determined by radiocarbon dating of aquatic biomarkers that are produced and rapidly exported to the sediment. Approximately 10 sediment horizons from the late glacial period to the present will be targeted for analysis. These particular horizons will allow investigation of the impact of temperature increase and changes in precipitation from the glacial period to the Holocene, long-term precipitation trends during the Holocene and the effects of abrupt shifts in precipitation during the last deglaciation on terrestrial carbon storage.

Expected Results

The results of small-scale studies have shown that warmer and wetter conditions tend to decrease the average storage time of organic carbon on land, both through faster respiration in the soil and increased erosion and river transport. The relationship between climate and the terrestrial carbon cycle in a large catchment area is likely more complex due to the many different processes operating within the catchment. However, by comparing trends in the terrestrial storage time of plant biomarkers at two sites with different climate histories, the imprints of past climate change might be identified. In the tropics, where precipitation changes tend to be more extreme than changes in temperature, hydrologic variability may be the key driver of changes in the terrestrial carbon cycle at both sites.

Potential to Further Environmental/Human Health Protection

Future climate change will likely have profound impact on human society, as well as on the global carbon cycle. Understanding the connection between climate change and the terrestrial carbon cycle is crucial for predicting future climate trends and shaping international policy on greenhouse gas emissions. This research will inform such efforts by providing the perspective of the impact of large climate changes in the past.

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Environmental Discipline: Environmental Engineering

Bio

Drew Gower received a B.S. degree from the University of Virginia, where he majored in Environmental Sciences and minored in Mathematics. He then served as a Peace Corps volunteer in Burkina Faso before completing an M.S. in Geology from the University of Wisconsin, Madison. Drew is now pursuing a Ph.D. in Civil and Environmental Engineering from Princeton University, where he is investigating the impact of climate change on irrigated agricultural systems in central Kenya.

Synopsis

Around Mt. Kenya, rainfall follows seasonal and geographic patterns that limit the water available to residents throughout much of the year. During these times, farmers rely on snowmelt-fed river water delivered by irrigation cooperatives; however, climate change and population growth threaten the sustainability of such systems. This project will use socio-hydrologic models to predict how water availability in the Nanyuki Catchment will change and to propose strategies to face this challenge.

Keywords: ecohydrology; food security; water resources

Climate Change Impacts on Snowmelt-Dependent Agricultural Systems Near Mount Kenya

Objective(s)/Research Question(s)

The objective of this project is to address the following questions: What is the extent and spatial distribution of river water abstractions in the Nanyuki Catchment? How might climate change affect water availability and livelihoods in the area? What factors will affect the resilience of dryland agricultural systems generally?

Approach

A socio-hydrologic model of the Nanyuki Catchment will be constructed by joining together three separate components: a hydrologic model of the catchment, an agent-based model of agricultural water use and a crop growth model. The combined model will then be calibrated using available rainfall and river flow records, dry season evapo-transpirative fluxes estimated from satellite imagery and agricultural yield data. Once calibrated, the model will be used to investigate the results of changes to climate and water demand on agricultural yields. Finally, the agent-based model will be coupled to a conceptual hydrologic model and used to evaluate the yields that could be expected in a general irrigated dryland catchment under a range of geographic, administrative and land use conditions.

Expected Results

The catchment-specific modeling efforts will produce management strategies to balance water availability for upstream and downstream users. Such strategies may take the form of recommendations for river withdrawal limits based on the time of year or recent climate history. These also could include recommendations for such infrastructure investments as wells, rainfall-harvesting systems and irrigation canals at different locations along the river system that would allow users to optimize the available resources unique to that area. The results of the generalized modeling efforts, though not relevant to a specific location, will take the form of recommendations on the appropriate structure of community irrigation systems in different types of dryland environments.

Potential to Further Environmental/Human Health Protection

On a larger scale, this project will be of interest to water resource managers in other dryland regions that are currently dependent on local "water towers" like Mount Kenya. As climate change begins to affect these areas, they, too, will need to reconsider longstanding water-sharing agreements that no longer provide an equitable partitioning of resources. Disseminating the results to interested parties around the world will help advance sustainable solutions to water management problems and protect the environment and agricultural communities in the face of a changing climate.

Kelly Lynn Gravuer

Maintaining Ecosystem Function Under Climate Change: Understanding and Managing Plant-Soil Microbe Community Dynamics

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Project Officer: Gladys Cobbs
Project Period: 9/29/2014–9/29/2016
Project Amount:
Environmental Discipline: Ecology

Bio

Kelly received her B.S. from Brown University (Rhode Island), where she researched dispersal and genetics of a rare plant. As a Fulbright Fellow in New Zealand, she examined determinants of plant invasion. She then synthesized rare plant data to inform management and policy as Research Botanist at NatureServe. Her current research explores using plant ecological theory to understand soil microbial responses to global change, integrating these with plant responses to predict ecosystem-level consequences.

Synopsis

Human well-being depends on services provided by ecosystems, including water purification, food production and nutrient cycling. This research uses precipitation manipulations to understand how climate change could affect ecosystem services in California grasslands. By exploring differences in how plants and soil microbes respond and by investigating how results may depend on soil type, it also seeks to identify patterns that may improve predictions across ecosystems, enabling humans to better adapt.

Keywords: climate change, grasslands, ecosystem function

Objective(s)/Research Question(s)

Current and predicted changes in climate are likely to affect many of the ecosystem services that support people's quality of life, including water purification, soil fertility and forage production. By improving the ability to predict effects at the local and landscape levels, mitigation and adaptation actions can be targeted to more effectively maintain these services. Focusing on ecologically important California grasslands, this research asks several questions: (1) How will predicted precipitation change affect the ecosystem functions that support critical ecosystem services? (2) Does soil type or nutrient status need to be considered in landscape-scale predictions of these effects? (3) Do the functional traits of the co-occurring soil microbial and plant communities that provide these ecosystem functions respond similarly to climate change? To what degree might they be decoupled by predicted changes?

Approach

Precipitation manipulations have been implemented across a northern California grassland, and this research measures ecosystem functions, including decomposition potential (soil enzyme activity), nitrogen mineralization, nitrification and soil carbon storage. Experimental treatments have been replicated across three distinct soil types and crossed with a nutrient addition treatment to investigate the sensitivity of ecosystem functional responses to these factors. The project will explore potential mechanisms of these impacts using a plant-microbial functional trait framework. Specifically, it assesses soil microbial community composition with DNA-based approaches and estimates a functional trait of bacteria (resource response as indicated by rRNA gene copy number) using phylogenetic methods. These data will be compared to corresponding plant community measures to determine response similarity and decoupling.

Expected Results

All of the measured ecosystem functions are expected to be greater in wetter plots, although different pathways of organic matter decomposition (activities of different soil enzymes) may not all be affected equally. The magnitude of these responses is likely to depend significantly on soil type and nutrient status, such that characterizing these dependencies should improve the ability to predict landscape-level changes in ecosystem functions. Soil microbial functional trait responses will likely be similar in direction to those of plant communities, but more temporally variable, with greater responses at times of greater soil moisture effects. This result may highlight the importance of changes in the timing and magnitude of precipitation for soil communities, to a degree that would not be apparent from aboveground observations.

Potential to Further Environmental/Human Health Protection

This work should improve the ability to predict the impact of climate change on key ecosystem functions and services, such as nutrient cycling and plant productivity, in California's grasslands. In addition, employing a functional trait framework to understand plant and microbial responses will facilitate the use of these results to understand potential responses of other ecosystems. Ultimately, this research will highlight where efforts to mitigate and/or adapt to these effects can best be focused to maintain the ecosystem services on which people depend.

Rebecca Hernandez

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Earth Sciences

Bio

Rebecca R. Hernandez earned her B.A. in geography from the University of California, Los Angeles in 2004 and an M.S. in biology from California State University, Fullerton in 2009. Currently, Rebecca is a fourth-year Ph.D. candidate in the Environmental Earth Systems Science Department at Stanford University and scientist in residence at the Department of Global Ecology at the Carnegie Institution for Science. Rebecca's work examines processes where human and natural systems interact and those that elucidate the functioning of the Earth system.

Synopsis

The successful expansion of solar energy, particularly for utility-scale solar energy (USSE) systems (> 1 megawatt), is dependent on a quantitative understanding of how solar energy may augment, reduce or interact with drivers of climate change. This research will use a multidisciplinary strategy to elucidate mechanisms to increase the land-use efficiency and technical potential of USSE. Results can be used to maximize the economic, energetic and environmental returns on investments in solar energy.

Keywords: environmental compatibility, renewable energy, solar power

Minimizing Climate Change Impacts and Feedbacks: Multidisciplinary and Strategic Utility-Scale Solar Energy Development

Objective(s)/Research Question(s)

Renewable energy is on the rise, largely to reduce individual and domestic dependency on fossil fuels and to mitigate the impact of climate change. The generation of electricity from sunlight directly (photovoltaic, or PV) or indirectly (concentrating solar power) over the last decade has been growing exponentially in the United States and globally. This research seeks to determine the impact of climate change on renewable energy systems, as well as the environmental consequences of USSE systems as a climate mitigation strategy.

Approach

Interactions among climate change, land use and land cover change (a major driver of global environmental change) and USSE development will be explored using a multidisciplinary approach. Specifically, this project will seek to (1) quantify the land-use efficiency (Wm-2) of USSE installations and identify technologies and development strategies that minimize land-use efficiency; (2) assess the capacity-based and generation-based solar energy technical potential within a solar energy hotspot (i.e., California) and compare results with current patterns of land use and land cover change—an overlooked constituent of greenhouse gas emissions—associated with USSE development; and (3) use a global climate model to simulate several climate change scenarios to determine where solar energy capacity for PV schemes—the most widely deployed technology type—may lower due to increasing surface temperatures (which reduce panel efficiency) and where it will be maximized at the global-scale.

Expected Results

Three findings from this research are likely: (1) the land-use efficiency of USSE will be modulated by technology, land ownership and power plant array design; (2) generation-based solar technical potential of USSE will meet energy consumption demand when developed within environmentally compatible areas; and (3) crystalline silicon PV module capacity will be reduced in regions around the globe—including deserts of the southwest United States, northern Africa, the Middle East and Australia—in response to increases in global-mean surface temperature projected for the 21st century. Capacity is likely to increase in a few regions, including, central-western South America, western China and Mongolia. Based on results from the comparison of the spread of members from the uncorrected and corrected Coupled Model Intercomparison Project Phase 5 ensemble, the uncertainty arising from internal climate system variability is likely to be smaller than the uncertainty arising from climate model formulation.

Potential to Further Environmental/Human Health Protection

Solar energy has several positive aspects—reduced air pollution and greenhouse gases, stabilization of degraded land, increased energy independence, job opportunities, acceleration of rural electrification and an improved quality of life in developing countries—that make it particularly attractive in many regions of the world. This body of research will provide novel and exigent information that can be employed to (1) mitigate climate change by maximizing USSE efficiency through the strategic and spatially explicit planning of USSE installations, (2) identify and reduce land use and land cover change effects—including air pollution—on ecosystems associated with USSE development and (3) better understand the projected impact of climate change on solar energy potential.

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Project Amount: $84,000
Environmental Discipline: Aquatic Systems Ecology

Bio

Joanne Heslop received a B.S. from the University of Nevada, Reno, in Ecohydrology and Environmental Studies in 2011. The following year, she began the graduate program in Geophysics at the University of Alaska, Fairbanks, studying methane production in a thermokarst (permafrost thaw) lake. Her current research examines permafrost organic matter qualities to predict methane production in lakes.

Synopsis

This study focuses on the nature and quality of organic matter substrates used by microbes to produce methane, a potent greenhouse gas, in sediments of thermokarst (permafrost thaw) lakes. The research examines a modern thermokarst lake in Alaska and the remains of ancient lakes in Siberia that are visible in cross sections along river cut banks. This work will provide new information about which organic matter pools in the thermokarst landscape are most susceptible to greenhouse gas production as permafrost thaws in a warming climate.

Keywords: methane, permafrost, soil organic matter

Modeling Potential Methane Production in Thermokarst Lakes from Permafrost Soil Organic Matter Composition

Objective(s)/Research Question(s)

Variability in soil organic matter (SOM) qualities and characteristics influences the proportion of permafrost carbon that can be processed into greenhouse gases. This research project will quantify methane production potentials in a thermokarst-lake landscape and examine if SOM compounds and characteristics can be used as predictors of anaerobic carbon cycling potentials.

Approach

The first phase of research examines samples from a 5.9-m long lake core and 40-m deep permafrost tunnel at Vault Lake, Fox, Alaska. Samples will be analyzed for their soil organic matter (SOM) properties and composition and incubated to measure anaerobic methane production potentials. SOM characteristics will be correlated with methane production potentials to determine which factors serve as predictors of methane production. The second phase of research will examine paleo-thermokarst lake profiles in a yedoma exposure near Cherskii, Russia. SOM characteristics will be analyzed and used to estimate methane emissions from a paleo-thermokarst lake environment using the determined correlations.

Expected Results

Soil organic matter (SOM) characteristics and composition can be used as an accurate predictor of methane production potentials in thermokarst-lake environments. SOM quantity and quality will vary with depth and location along the profiles and the differences will be reflected in the methane production potentials. It is expected methane production potentials will be highest in samples with high concentrations of labile SOM. Estimating methane emissions from SOM composition data will allow for better estimates about the potential effects of thawing permafrost in Earth's changing climate in both paleo-thermokarst lake profiles and thermokarst lakes in the present and future.

Potential to Further Environmental/Human Health Protection

Climate change represents a major threat to human health and community well-being through increased weather extremes, changes in storm and hydrologic patterns and changes in the range and ecology of diseases. The addition of greenhouse gases to the atmosphere, including the potent greenhouse gas methane, contributes to climate change. Improving and refining the understanding of methane production from natural environments, in addition to anthropogenic emissions, will help model the future climate scenarios.

Ashley Larsen

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Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Ashley Larsen received a B.S. in Ecology and Evolutionary Biology from the University of Michigan in 2008 and an M.A. in Economics from the University of California, Santa Barbara (UCSB) in 2012. She is currently a doctoral student at UCSB in Ecology, Evolution and Marine Biology. Her research interests lie at the intersection of the ecology and economics of food systems. Her dissertation focuses on the drivers of pesticide use, using large-scale statistical analyses.

Synopsis

Agrochemicals have important negative effects on human and environmental health, and it is crucial to identify the drivers of their variability. This project applies statistical analyses of large data sets to understand how land use and weather influence the variability in pesticide use across space and time, as well as how climate change may modify the current uses. This research will help identify where damaging levels of pesticides are likely to occur, both now and in a changing climate.

Keywords: climate change, land use, pesticides

What Drives Pesticide Use, and How Will Quantity and Distribution of Pesticide Use Be Modified by Climate Change?

Objective(s)/Research Question(s)

The goals of this research are to address whether landscape simplification drives insecticide use and to identify what explains year-to-year variation in insecticide and pesticide use in the United States. It also seeks to predict how climate change will influence the amount of pesticides being used.

Approach

Data to address the above questions will come from several sources and at several spatial scales, ranging from national-scale data at the county level (e.g., USDA Census of Agriculture) to refined crop data at 30-m pixel resolution (i.e., National Agricultural and Statistics Service Cropland Data Layer). Crop data will be combined with refined pesticide data, weather data and climate projections. This longitudinal data set will be analyzed using econometric techniques, primarily fixed effects models, to address the above three objectives.

Expected Results

Research indicates that insecticide use is highly variable across time and thus it is likely that climate change will modify the distribution and intensity of insecticide and pesticide use. Very few studies have addressed the impact of climate change on pesticide use, and those that have were conducted at the state level. Thus, the sign and magnitude of the expected results from the study proposed here are largely unknown.

Potential to Further Environmental/Human Health Protection

The combination of long-term and fine-scale analyses conducted during this project will provide unprecedented insight into how climate change is likely to alter pesticide use. This information will better enable scientists, policy-makers and the public to mitigate the negative effects of pesticide use on human and environmental health.

Caitlin Irene Looby

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Environmental Discipline: Ecology

Bio

Caitlin Looby received a B.S. in Molecular and Cellular Biology at the University of Connecticut and an M.S. at Kean University (New Jersey). In 2012, she started a Ph.D. program in Ecology and Evolutionary Biology at the University of California, Irvine. Broadly, she is interested how microbial communities are structured in tropical ecosystems. Her current research is investigating the effect of decreased precipitation on microbial communities and biogeochemical cycling in a tropical montane cloud forest in Costa Rica.

Synopsis

Tropical montane cloud forests (TMCF) are biodiversity hot spots within the tropics and are characterized by persistent low-level cloud cover. Climate change is exposing these ecosystems to drier conditions due to the rise of the cloud layer. Few studies have investigated the soil community's response to climate change, especially within cloud forests. This work will determine how microbial communities and decomposition are affected by, and possibly augmenting, climate change in the tropics.

Keywords: climate change, decomposition, soil biome

Decreasing Precipitation in Tropical Montane Cloud Forests: Belowground Responses and Their Effect on Global Climate Change

Objective(s)/Research Question(s)

TMCF are biodiversity hot spots within the tropics and are characterized by persistent low-level cloud cover. Unfortunately, climate change is exposing these ecosystems to drier conditions due to the rise of the cloud layer. Few studies have investigated the soil community's response to elevation and climate change, especially within TMCF, fostering a lack of understanding of how tropical regions will respond to and possibly augment global climate change. This research will utilize an elevation gradient in a TMCF in Costa Rica to determine how belowground communities and decomposition are affected by climate change.

Approach

An elevation gradient will be used on the Pacific Slope of the Cordillera de Tilarán within the Monteverde Cloud Forest Reserve in Costa Rica. A soil translocation experiment will be performed along this gradient to simulate the effects of the rising cloud layer on belowground communities, decomposition and microbial-associated CO_2 emissions. Soil will be translocated from higher to lower elevations. This soil will be placed in nylon membrane bags that prevent the colonization of local fungi, but allow the passage of nutrients, water and organic compounds. Controlling for the colonization of new fungi will demonstrate how fungi from higher elevations will respond to the rising cloud layer. To determine how fungal communities and decomposition will change due the rising cloud layer, fungal diversity and enzymatic activity will be measured after 6 months and 1 year. Fungal diversity will be determined by high-throughput sequencing. Extracellular enzyme assays will be performed on these samples to determine the efficiency of fungal-associated decomposition.

Expected Results

Such site characteristics as elevation, temperature and precipitation exert a strong influence on decomposition rates; decomposition decreases exponentially with increasing elevation. Decreases in precipitation due to the rising cloud layer result in a greater distinction between dry and wet seasons. This increased seasonality leads to more intense drying and rewetting cycles and, thus, increased microbial turnover. This may increase decomposition within these forests and increase the release of CO_2 into the atmosphere, potentially accelerating the pace of climate change. This research directly tests how temperature and moisture affect fungal community structure and decomposition by translocating soil. Moreover, this approach will allow an experimental determination of how the rising cloud layer will influence CO_2 emissions by microbes during decomposition. Decreased precipitation and increased temperatures may result in increased fungal-associated enzymatic activity, increased decomposition and increased CO_2 emissions from microbes.

Potential to Further Environmental/Human Health Protection

TMCF offer natural shifts in temperature and soil moisture, making them ideal systems to assess how environmental changes are influencing important ecosystem processes, like decomposition. Any changes in decomposition may have consequences for CO_2 emissions and global climate, as tropical ecosystems have a disproportionate influence over global C cycling. Results from this research will deliver a comprehensive understanding of how decreased precipitation can influence fungal communities, decomposition and microbial-associated CO_2 emissions.

Aurora Alexandra MacRae-Crerar

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Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Aurora MacRae-Crerar received a B.A. in Biology from Barnard College, Columbia University, in 2007. She then worked as a laboratory manager and technician at the University of Pennsylvania, where she studied plant development and transcription factor movement. In 2009, Aurora entered the university's Ph.D. program in biology, with a concentration in ecology. Her research focuses on soil microbial ecology within the context of global climate and land-use change.

Synopsis

Soil, which is teeming with microbes, is the foundation of a healthy terrestrial ecosystem. What are the effects of climate and land-use change on soil microbial diversity? To investigate this question, this research uses DNA sequencing to explore shifts in bacterial communities of the Mongolian steppe, which exhibits some of the greatest temperature increases in the world. Investigating these shifts is crucial for understanding soil health in the face of global change.

Keywords: climate change, land use, soil biome

Global Change From the Ground Up: Soil Microbial Diversity in a Climate and Land-Use Change Experiment

Objective(s)/Research Question(s)

Soil and the myriad microbes it contains are the foundation of ecosystem processes, but how these ecosystems respond to global change is unknown. Global change includes shifts in both climate and land use. This research uses DNA sequencing to investigate if and how soil microbial communities respond to treatments that simulate climate and land-use change—including temperature, moisture and grazing. Results will be examined for evidence of microbial sentinels that may act as indicators of soil health and predictors of impending change.

Approach

In collaboration with the PIRE Mongolia Project, fieldwork has been done in northern Mongolia at an International Long-Term Ecological Research site near Lake Hövsgöl, where significant changes in climate and grazing status have been observed. Soil samples were collected in three habitats at this site: forest, steppe and riparian. Within the steppe, samples were collected over the course of 4 years (2009–2012) from control areas and areas that included grazing and climate manipulation treatments along a topographical gradient. Samples were sequenced by the Earth Microbiome Project, allowing the identification and quantification of soil bacteria. Bioinformatic analysis investigating the patterns seen across treatments and the relationship of patterns to environmental variables is underway.

Expected Results

Despite the innate heterogeneity of the soil, distinct bacterial communities should be represented in each experimental treatment. The climate manipulation treatment, which both warms and dries the soil, is expected to decrease bacterial diversity. The grazing treatment is expected to stimulate decomposition and the availability of heterogeneous substrates, allowing a projected increase in bacterial diversity. A combination of both treatments could likely result in relatively intermediate levels of bacterial diversity.

Potential to Further Environmental/Human Health Protection

Biological diversity generally strengthens desirable ecosystem states by increasing ecosystem resilience. Identifying the factors that contribute to soil microbial diversity is key to understanding soil health, which is the foundation of healthy terrestrial ecosystems.

Jeremiah Patrick Marsicek

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Project Amount: $84,000
Environmental Discipline: Earth Sciences

Bio

Jeremiah Marsicek received a B.S. in Physical Geography from the University of Wisconsin, Madison in 2008. He earned an M.S. in Geology at the University of Wyoming in 2011 and immediately began a Ph.D. program in the same department at that institution. His research interests include paleoclimatology and current rates of global change. His present research examines how past abrupt changes affected natural resources and human civilizations.

Synopsis

To understand the effects of 21st-century warming, scientists must understand the processes that control Earth system change. The past 11,500 years have included abrupt climatic changes, but the physical processes underlying Earth system responses are unclear. This project will generate a temperature reconstruction of this period, allowing examination of system responses to abrupt change and assessment of potential consequences for natural resources and human society under continued warming.

Keywords: climate change, fossil pollen, Holocene

Abrupt Climate Change in the Northern Mid-Latitudes Circa 5 ka: Pollen-Inferred Evidence for Hemispheric-Scale Climate Change

Objective(s)/Research Question(s)

This project will not only place the recent global climate change in a long-term context, but will also investigate three primary questions related to possible abrupt changes in the climate system: (1) What relationships exist between rapid climate, hydrologic and ecosystem changes? When evaluated across the Northern Hemisphere, paleoclimatic reconstructions could be used in tandem with hydrologic and ecologic data sets to evaluate whether or not climate-resource relationships were linear, as well as what rates and magnitudes of climate change produced the various local resource changes. Ecosystem changes (e.g., fires, pathogens) may produce important abrupt shifts without direct climate influences, but climate may be vital for sustaining the outcome, or ecosystem responses to climatic changes may be linear (e.g., fast climate changes producing fast ecosystem changes). Either scenario has implications for mitigation and adaptation. (2) At what scale could even modest climatic forcing produce abrupt climate changes? Mapping the extent and rates of temperature changes in the Northern Hemisphere can help evaluate the linkages between climate forcing and extent of abrupt regime shifts. Understanding these scales could provide critical information for planning for potential future changes. (3) What role can intrinsic variability and feedbacks play in amplifying modest external forcing to produce abrupt changes? Changes in the ocean-atmosphere system or in vegetation-atmosphere feedbacks could have been critical in the mid-Holocene, and these should have produced detectable spatial patterns of change. Understanding the roles of such feedbacks in the past could be useful for anticipating changes and effects in the future.

Approach

This research will generate temperature data for the Holocene by using fossil pollen from trees and shrubs that have been preserved in lake sediments. Past temperatures will be reconstructed using modern vegetation-temperature relationships, which will be applied to fossil data to achieve temperature estimates from the past. A calibration data set has been compiled for both North America and Europe, and well-dated fossil pollen records exist for both continents, providing an opportunity to generate a temperature record for the last 11,000 years. Using these data sets in tandem with hydrologic and ecologic data sets will allow investigation of Question 1. Once the temperature records for both continents are generated, the spatial patterns of abrupt changes will be evaluated as a means to test Questions 2 and 3. It also will be critical to generate a Northern Hemisphere temperature reconstruction for comparison with climate model output, including a paleoclimate model output.

Expected Results

Expected outcomes of this work are climate reconstructions, analyses and maps of patterns of abrupt changes, as well as evaluations of the linkages among abrupt ecosystem collapses across the Northern hemisphere during weak Holocene forcing. These results will be useful for anticipating climate change and its effects on ecosystem services.

Potential to Further Environmental/Human Health Protection

Reconstructing temperature changes over geological time allows placing recent and future warming in a long-term context to understand the processes involved and the potential for abrupt changes and other "surprises." The Holocene provides useful empirical examples of change in ecosystems, species and natural resources like water in a warm world. Global climate change in the near future will result in changing distribution, health and functionality of the ecosystems on which humans rely; informed management and conservation strategies are critical in maintaining ecosystem services.

Carly Rae Muletz

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Environmental Discipline: Biological Sciences

Bio

Carly Muletz received a B.S. in Biology (dual major in Spanish) from Frostburg State University (Maryland) in 2007. She received an M.S. in Biology from James Madison University (Virginia) in 2011, with research focusing on assessing environmental augmentation of antifungal bacteria to mitigate amphibian disease. She is currently at the University of Maryland, College Park in Biological Sciences conducting Ph.D. research on how temperature influences the structure and function of amphibians' resident skin bacteria and disease outcome of the amphibian host.

Synopsis

The microbiome associated with animals can protect their hosts from disease. However, climate change is expected to alter microbial communities, and it is unclear how the host-associated microbiome will change and how this will affect host disease susceptibility. This laboratory study will elucidate the predictability of amphibian hosts' bacterial community structure and how threats (disease and climate change) are likely to affect bacterial and amphibian biodiversity.

Keywords: amphibians, microbiome, wildlife disease

The Thin Line Between Health and Disease: Determining the Effects of Climate Change on Amphibians' Skin Microbial Communities

Objective(s)/Research Question(s)

Objective 1: Determine how different temperatures (13 °C, 17 °C and 21 °C) affect the skin bacterial community on red-backed salamanders, *Plethodon cinereus*, and their susceptibility to disease over time. Objective 2: Determine how exposure to a fungal pathogen (*Batrachochytrium dendrobatidis*, Bd, implicated in worldwide amphibian decline) affects the skin bacterial community on *P. cinereus* over time. Objective 3: Determine if there is a relationship between changes in the skin bacterial community due to temperature and disease susceptibility.

Approach

A laboratory experiment will be conducted with 84 red-backed salamanders, using temperature (13 °C, 17 °C, 21 °C) and disease treatments (pathogen+, pathogen-) in a full factorial design ($n = 14$ per treatment). All salamanders will be swabbed at collection (Day 0) and thereafter at each swabbing event (every 2 weeks) until the end of the experiment at Day 100. The mass and length of each individual will be measured at each swabbing event to determine salamander body condition. On Day 40, all salamanders will be exposed either to the fungal pathogen Bd or to a sham following standard procedures. DNA will be extracted from swabs to determine Bd infection load (using quantitative PCR) and bacterial diversity (using high-throughput sequencing of the 16s rRNA gene). The QIIME pipeline and several packages in R will be used to perform multivariate analyses.

Expected Results

As temperature increases, it is expected that the number of bacterial species will decrease, including anti-Bd bacteria, selecting for only a subset of the bacterial taxa with higher temperature optima (homogenization), which will increase in abundance. Functionally important anti-Bd bacteria will be identified from a database of bacteria found on salamander skin that kill Bd in culture. As temperature increases, salamander susceptibility to Bd infection is expected to increase (in pure culture, Bd typically grows similarly between 13 and 21 °C). Salamander susceptibility to Bd infection and associated disease will be determined by comparing salamander body condition, survival and pathogen load among treatments. Increased salamander susceptibility to Bd infection is expected to correlate to a reduction in (entire and anti-Bd) bacterial richness and abundance. It is assumed that temperature does not affect salamander immunity, because research indicates that Bd paralyzes amphibians' immune responses regardless of temperature.

Potential to Further Environmental/Human Health Protection

Knowing how woodland salamanders and their associated bacteria will respond to temperature changes and pathogen exposure, especially in hotspots of biodiversity like the Appalachian Mountains, is important for planning management actions and understanding how ecosystem functions may change. Knowing how bacterial community structure influences disease outcome in amphibians is important for developing a broader understanding of how resident bacteria on animal hosts (including humans) influence disease outcome of the host.

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Project Amount: $84,000
Environmental Discipline: Ecology and Ecosystems

Bio

Gordon Ober received his B.S. in Ecology and Evolutionary Biology from the University of Connecticut in 2009. Shortly after, he began working at Yale University as a research assistant in human genetics. Gordon started a Ph.D. program in Ecology and Ecosystems Science at the University of Rhode Island in the fall of 2011. His research interests include climate change and community ecology. His current research investigates how ocean acidification and other environmental factors affect the structure and function of coastal marine communities.

Synopsis

Ocean acidification has decreased oceanic pH and is projected to have a profound impact on marine organisms and communities. Acidification is one of many environmental factors influencing coastal ecosystems. This research investigates how acidification, in conjunction with other stressors, affects species' fitness as well as the interactions between species at multiple trophic levels. It provides insight into the structure and function of coastal communities in the future.

Keywords: algal blooms, community ecology, ocean acidification

Impacts of Elevated CO_2 and Nutrients on Marine Communities and Trophic Interactions

Objective(s)/Research Question(s)

Increases in atmospheric carbon dioxide (CO_2) are directly linked to decreasing oceanic pH. More acidic oceans are detrimental to calcifying organisms like corals and shellfish, but for primary producers like algae, CO_2 is necessary for photosynthesis. As the base of many coastal marine food webs, algae support diverse and productive communities. Impact at this level of the food web will likely ripple outward and affect many other species. This research aims to determine how ocean acidification, or increased CO_2, in conjunction with increased nutrients, is affecting algae and the species they support. This project takes an ecosystem approach to understanding the impact of climate change, investigating how multiple species at multiple trophic levels are responding to change and how their interactions are changing.

Approach

This project focuses on coastal communities found in Narragansett Bay, Rhode Island. In a series of laboratory-based mesocosm experiments two local species of algae (*Gracilaria verimuculophylla*, an invasive red alga, and *Ulva rigida*, a native green alga) are exposed to increased CO_2, simulating acidification, and increased nutrients. By measuring growth, tissue quality and productivity the experiments will determine the fitness of both species and their competitive ability. Experiments will be run multiple times using different levels of CO_2, based on Intergovernmental Panel on Climate Change projections, to determine the range of responses. In subsequent experiments a common, herbivorous marine snail and omnivorous crab will be added to experimental mesocosms along with the algae. Snail feeding rates, feeding preferences and overall changes in behavior will be monitored over the course of the experiment. Performing experiments using multiple trophic levels will provide insight to how communities will be shaped and will function under future climate conditions.

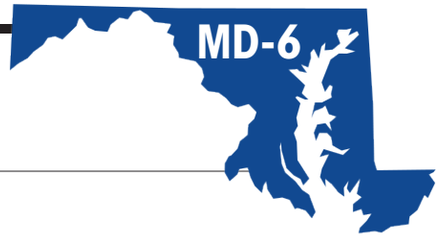
Expected Results

Projected ocean acidification will be detrimental to the fitness of calcifying organisms, such as coral and shellfish, but non-calcifying algae should reap the benefits of increased CO_2 by maximizing photosynthetic activity. Different algal species will respond differently to increases in CO_2, however, due to differences in life history and the presence or absence of a carbon-concentrating mechanism. Both species of algae are expected to see increases in growth, tissue quality and productivity under treatment conditions, but *G. vermiculophylla* will likely see significantly greater increases due to its ability to access CO_2 from the water column. When environmental stressors are combined an additive, if not synergistic, effect is expected on the growth of both species of algae. Due to stress from acidification, herbivores will feed less frequently on algae but their feeding preference will shift from *U. rigida* to *G. vermiculophylla*. Herbivores are expected to be more likely to flee under acidification stress and the presence of a predator, therefore further aiding the growth of algae by removing consumer pressure. Communities will see shifts in dominant algal species and reduced effects from herbivores, ultimately leading to less diverse and less productive ecosystems.

Potential to Further Environmental/Human Health Protection

Coastal zones are of great economic importance. Keeping these ecosystems diverse and functioning will be challenged by anthropogenic climate change. Many algal species are expected to thrive under future climate conditions, blooming more frequently and replacing calcifying organisms and leading to oxygen-poor waters, hypoxic events and even fish kills. These blooms are detrimental not only to ecosystem health, but also to local economies. Understanding the response of species within a community is key in understanding how ecosystems will function in the future.

Crystal Eloma Romeo



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Project Officer: Gladys Cobbs
Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Crystal is a Ph.D. candidate in the Marine Estuarine Environmental Sciences (MEES) Program at the University of Maryland at College Park. She graduated from Spelman College (Georgia) in 2006 with a B.S. in Environmental Science and Kennesaw State University (Georgia) in 2010 with a Master of Public Administration. Her research interests include environmental science, environmental health and climate change impact assessment on chronic diseases. Her prior experiences include extensive laboratory research in environmental remediation and catalyst products, with years of regulatory compliance in ambient air monitoring, radiation protection and environmental health.

Synopsis

The impact of climate variability and change on chronic human health is one of the least researched areas of climate change impacts assessments. With the likely rise in extreme heat events and chronic diseases, it is necessary to identify the unknown effects of extreme heat events on chronic human health. This research aims to quantify the risks that climate variability and change may create for individuals with asthma and other chronic respiratory diseases.

Keywords: chronic respiratory diseases, climate change, exposure

Association Between Climate Extremes and Chronic Respiratory Diseases Among a Nationally Representative Sample of the U.S. Population

Objective(s)/Research Question(s)

Due to the projected increase in extreme heat events and the likely rise in chronic diseases, such as asthma, it is necessary to identify the unknown effects of extreme heat events on the status of chronic human health. This issue is important because a small increase in the risk will have a significant effect on morbidity rates and healthcare costs; this will, in turn, worsen the public health burden that chronic diseases present. This project aims to develop empirical models—climate-extreme exposure metrics—that can quantify the risks that climate variability and change may create for individuals with respiratory diseases. The central hypothesis is that increased exposure to the extreme hot days contributes to the exacerbation of chronic respiratory diseases.

Approach

This study will examine the impact of long-term anomalous warming events—which may lead to changes in both biotic and anthropogenic air pollution—on asthma and emergency department visits for asthma, hay fever and chronic bronchitis. The aims are (1) to develop and validate a location-specific heat-related climate metric to characterize place-based exposure to anomalous warming events for use in exposure assessment and epidemiological studies on climate variability and change, using the years 1960–1989 as a baseline; and (2) to develop an empirical model of the heat-related climate metric (frequency of extreme hot days) that identifies the relationship between long-term exposure to anomalous warming events and chronic respiratory health outcomes. The working method is to link data by merging the heat-related climate metric to respondents in the National Health Interview Survey (NHIS). The linked data set will enable (1) an investigation of the relationship between climate variability and change on chronic respiratory diseases among the U.S. population and (2) an analysis of extreme hot-day exposure disparities among demographic (i.e., children and older adults) and socioeconomic groups.

Expected Results

The results of this study will provide a validated data set that has the monthly total number of extreme hot days for each county in the United States for the time period of 1960 to 2010. The linkage of the exposure metric to the NHIS for the years 1997–2010 should show (1) the association between heat and chronic respiratory diseases and (2) the variation in the distribution of exposure to extreme hot days. This will provide a national assessment of chronic respiratory diseases associated with anomalous warming events, based on observed data.

Potential to Further Environmental/Human Health Protection

In a changing climate, sustainable and resilient communities are vital for safeguarding the health of vulnerable populations, including children and older adults. The results of this study can substantiate the mobilization of community groups, coerce the policy-making process, and assist with the implementation of adaptation and mitigation tools to aid vulnerable and susceptible populations with combating the negative externalities of climate change. The statistical model will provide a predictive equation to enhance the robustness of climate prediction and economic models in quantifying the unaccounted impacts and costs of climate change. The methods developed from this study will be widely applicable for future studies linking other parameters, such as precipitation, to other diseases of concern.

Cybelle Tenaya Shattuck

Sustainability at the Community Level: The Role of Faith-Based Organizations

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Project Period: 9/2/2014–9/2/2016
Project Amount:
Environmental Discipline: Behavioral and Social Sciences

Bio

Cybelle Shattuck has B.A. and M.A. degrees in Religious Studies from the University of California, Santa Barbara, and an M.S. in Natural Resources and Environment from the University of Michigan. She is enrolled in the Ph.D. program at the University of Michigan's School of Natural Resources and Environment. Her research interests include community-level sustainability initiatives, collaborative processes, environmental justice and the role of religion in shaping environmental behavior. Her current research focuses on faith-based efforts to mitigate climate change.

Synopsis

U.S. religious organizations are increasing efforts to advocate for climate change mitigation, adopt conservation behaviors and promote environmental justice, but little is known about the empirical experience of faith-based environmental activities. This research uses cross-case analysis of 17 congregations with exemplary sustainability initiatives to explore factors that facilitate or hinder success. The results will help improve policies and programs to support similar initiatives.

Keywords: climate change, environmental justice, faith communities

Objective(s)/Research Question(s)

Climate change—which affects traditional faith-based efforts to improve human health, mitigate poverty and redress social inequity—is inspiring religious organizations to advocate for clean air and water, restore ecosystems and conserve resources. This project seeks to understand the empirical experiences of faith-based environmental efforts within communities. Through what motivations and processes do congregation-level sustainability initiatives emerge? What factors facilitate and/or hinder implementation of these initiatives? What environmental and community outcomes are perceived to have been achieved through these initiatives? The results will provide insights into the role of religion and faith communities in motivating environmental behavior.

Approach

In-depth case analyses will be conducted detailing the history, motivations, conservation strategies, enabling factors, challenges and outcomes achieved by 17 congregations that have notable sustainability initiatives. Criteria for case study site selection required that congregations be engaged in sustainability initiatives with multiple activities (energy and resource conservation, promotion of conservation behavior for the faith organization and members, environmental advocacy) and duration of at least 4 years. Individual case study reports will be developed for each site using data from semistructured interviews, historical documents and onsite observations. The case studies will be coded and compared to identify common themes, key similarities and significant characteristics.

Expected Results

Currently, no systematic studies examine why particular activities arise in specific faith communities, what factors contribute to the durability and efficacy of some faith-based sustainability initiatives, or what outcomes emerge from those initiatives. Comparing these 17 cases in which faith communities have implemented and maintained sustainability initiatives will provide a better understanding of the motivations and processes through which such initiatives emerge. Preliminary analysis suggests that successful initiatives follow similar processes of organizational innovation that integrate sustainability into faith-community social norms, thereby creating expectations for collective and individual behavior. The congregations undertaking these initiatives are reducing resource consumption and improving local environmental conditions while also increasing their organizational membership. The data and analytical framework developed for this project are adaptable for future research into environmental behavior by members of faith-based organizations.

Potential to Further Environmental/Human Health Protection

More Americans belong to religious groups than any other type of voluntary association and faith communities play an important role in facilitating the kind of social transitions that are necessary as the nation responds to climate change. This research has potential to provide models of practice that may help faith communities seeking pathways to respond to climate change, as well as informing policies and programs intended to promote more environmentally sustainable behaviors. The data also will be used to develop workshops to assist faith leaders in implementing sustainability initiatives within their congregations.

Joel Sholtes

CO-2

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Hydrology

Bio

Joel is pursuing a Ph.D. in Civil Engineering at Colorado State University, Fort Collins—a veritable melting pot of river science. His research focuses on sediment transport in rivers and methods to link changes in hydrology due to climate change to geomorphic change in rivers. Prior to coming out west, he studied and worked in the muddy rivers of the Southeast.

Synopsis

Rivers in many environments adjust to their incoming flow regime and sediment supply so that over time they develop a "quasi-equilibrium" form. Climate change and land use change can alter both the flow regime and the sediment supply of a river. This work will characterize the sensitivity of the sediment balance in a river to changes in flow and sediment as a function of stream type and location within a watershed. It will help identify vulnerable aquatic habitat within a watershed.

Keywords: environmental change, rivers, sediment

Drainage Scale Dependency of River Sensitivity to Environmental Change: Tools for Planning Under Uncertainty

Objective(s)/Research Question(s)

At the most general level, this research explores river responses to changes in the drivers of flow and sediment supply. Findings will help understand how scale influences this response or sensitivity; that is, where within a watershed are streams and rivers most sensitive to environmental change?

Approach

To study river sensitivity to change, the project first considers qualitative and semiquantitative river response models, which indicate the direction of channel response as a function of changes in the drivers of flow and sediment, as well as the current flow and sediment regime. It uses a sediment continuity model implemented at various points within case study watersheds to characterize the sensitivity of the sediment balance to changes in flow regime and sediment supply. The flow regimes and sediment loads to these models (e.g., increase flow variability or curtail flood peaks) will be perturbed to analyze how sensitive the sediment balance is at various points within a watershed. This work will be conducted in both snowmelt-driven and convective precipitation-driven watersheds.

Expected Results

EPA has called for a "strategic" and "systems" approach to identify priority watersheds for protection and restoration, highlighting a lack of understanding of the geography of sensitive and resilient zones within a watershed as a key research gap. This research will produce a framework that addresses the research and decision tool needs by identifying the magnitude and scaling behavior of geomorphic sensitivity to environmental change within a watershed and by creating a methodology that can be used in other settings to identify river sensitivity to environmental change.

Potential to Further Environmental/Human Health Protection

This work will help managers target limited watershed protection and restoration resources. As a general tool, the model can be applied at various points within a watershed representing similar geomorphic settings. This framework also can help managers identify which river settings and drainage scales may not meet their designated uses in the future due to habitat alteration and sedimentation caused by environmental change.

Bronwen Stanford

Mitigating the Impacts of Climate Change on Plant Communities Through Wetland Restoration Design

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Project Period: 9/30/2014–9/30/2016
Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Bronwen Stanford grew up in Washington State and received her B.A. from Stanford University in 2008. After graduation she worked for four years at the San Francisco Estuary Institute in Richmond doing historical ecology research. In 2012, she began a Ph.D. program in Environmental Studies at the University of California, Santa Cruz. Her research interests include restoration effectiveness and promoting the resilience of ecological systems to global change.

Synopsis

To investigate the impact of climate on restored and natural wetlands, this research will monitor plant species assemblages at a series of constructed and natural vernal pools for 3 years. How habitat complexity and connectivity with other pools affect species persistence will be analyzed across years. Understanding whether higher habitat complexity is linked to higher species persistence will help manage diverse, resilient vernal pools under climate change.

Keywords: biodiversity, resilience, restoration

Objective(s)/Research Question(s)

The objectives of this project are to evaluate (1) the short-term resilience of plant and invertebrate communities to climate stress at different scales of physical heterogeneity, (2) the ability of restored wetland habitats to support plant and invertebrate communities with resilience similar to that of natural habitats and (3) the importance of connectivity and local vs. landscape controls on restoration outcomes.

Approach

The persistence of plant and invertebrate communities will be compared in natural and restored/constructed vernal pool complexes over a 3-year period. Persistence across 3 years of variable climate will act as a proxy for resilience to climate change over the longer term. For each pool and each vernal pool complex, physical heterogeneity and species richness will be surveyed for an effect of connectivity and physical habitat complexity on the persistence of biological communities over time. Comparisons of species persistence and physical heterogeneity between the constructed and natural pools will be used to evaluate the effectiveness of this restoration technique. The impact of surrounding land use and potential dispersal sites on community composition and turnover also will be evaluated.

Expected Results

A correlation is expected between low temporal turnover of species (high persistence) in a group of pools and the physical heterogeneity of that group. Plant communities in constructed pools are expected to show lower resilience and lower physical heterogeneity than natural pools, affecting the ability of species to persist over time under changing climatic conditions. Higher persistence of a species within a portion of the wetland complex could contribute to resilience throughout the complex through dispersal of species to other pools. Finally, lower species richness is expected in more simplified pools.

Potential to Further Environmental/Human Health Protection

This project has the potential to help inform wetland mitigation guidelines to create systems that are more resilient to climatic stress. Precisely targeted, empirically based guidelines such as the ones this study seeks to inform have the potential to result in more efficient restoration spending and healthier, more resilient, vernal pool ecosystems. A more complete knowledge of the factors that confer long-term resilience will help ensure the creation and protection of those wetlands that best support functioning assemblages of species under a changing climate and, thus, best support the local communities dependent on the flood protection and water filtration that these wetlands provide.

Sarah Rachel Waldo

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Project Period: 8/15/2014–8/15/2016
Project Amount: $84,000
Environmental Discipline: Environmental Science and Engneering

Bio

Sarah Waldo received her B.S. in Environmental Science from Colorado College in 2009. She started a Ph.D. program with the Laboratory for Atmospheric Research at Washington State University in 2010. Her research interests include sources and fates of reactive nitrogen in the atmosphere, greenhouse gas budgets of systems and the interface between science and policy. Her current research looks at fluxes of nitrous oxide and carbon dioxide over farmland using micrometeorological methods.

Synopsis

Agriculture can contribute to climate change mitigation by sequestering carbon dioxide (CO_2) in soils via buildup of soil organic matter. At the same time, farmland is a large source of the greenhouse gas nitrous oxide (N_2O), due in part to the use of nitrogen fertilizers. This research monitors the greenhouse gas balance of several wheat cropping systems in the Pacific Northwest to better understand the relationship between climate, management practices and emission or sequestration of CO_2 and N_2O.

Keywords: agriculture, greenhouse gasses, nitrous oxide

Greenhouse Gas Fluxes Over Cereal Cropping Systems in the Inland Pacific Northwest: Measurements to Support Climate Change Mitigation and Adaptation

Objective(s)/Research Question(s)

The objectives of this research are (1) to develop an optimal system for continuous, long-term, field-integrated N_2O monitoring; (2) to determine the balance of CO_2 and N_2O fluxes at several sites and how these fluxes co-vary with site conditions; (3) to determine if certain management practices can be implemented to simultaneously reduce N_2O emissions and increase carbon sequestration.

Approach

A network of micrometeorological towers at five different sites across the Inland Pacific Northwest measures fluxes of CO_2, water vapor and energy. This project has established collection, processing and quality control/quality assurance procedures for these data sets. The research will now focus on improving the monitoring of N_2O fluxes using the flux gradient technique, as well as relaxed eddy accumulation to complement measurements made with automated static chambers at two sites. These micrometeorological techniques are needed because they do not disturb the soil surface and because they take field-scale integrated measurements. The data sets will be analyzed for trends related to soil temperature and moisture, fertilization and tillage type. The results from both the CO_2 and N_2O monitoring will be used to evaluate a field-scale cropping systems model.

Expected Results

The results from this research will provide a baseline of CO_2, N_2O and water vapor fluxes for wheat cropping systems in the Inland Pacific Northwest. Comparing results from sites with contrasting climates and management practices will give insight into how these variables affect the carbon, nitrogen and water cycles at agricultural sites. Specifically, comparing N_2O emissions at paired conventional-tillage and no-tillage fields will give growers more information to aid in their decision whether or not to switch to no-till.

Potential to Further Environmental/Human Health Protection

Temperature and rainfall patterns in this region are projected to change in the coming decades, with potentially significant effects on crop yields and management practices. In addition, the demand for food is projected to keep increasing as population grows. Food productivity needs to be maintained or increased without increasing the greenhouse gas footprint of agriculture. Because of these factors there is a great need for empirically based information on the carbon, nitrogen and water budgets of cropping systems.

Suzanne Marie Young

Effects of Climate Change on Waterborne Human Pathogens and Antibiotic Resistant Bacteria

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Project Officer: Gladys Cobbs
Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Suzanne received her B.A. from Barnard College (New York) in 2007 and her M.A. from Queens College (New York) in 2011. She collaborated with local advocacy organizations for her research studying sewage contamination in the Hudson River and also worked for an environmental policy nonprofit in New York City. She is pursuing her interests in the ecology of waterborne pathogens in the Department of Integrative Biology at the University of South Florida.

Synopsis

Waterborne pathogens are a major threat to public health and can be affected by global climate change. Antibiotic-resistant pathogens are a growing concern and may respond differently than nonresistant pathogens under variable environmental conditions. This research focuses on the effects of biotic and abiotic environmental factors that influence the disease dynamics of waterborne pathogens.

Keywords: antibiotic-resistant bacteria, climate change, waterborne pathogens

Objective(s)/Research Question(s)

The investigation of how temperature variability affects zoonotic and waterborne human pathogens can establish a mechanistic understanding of the abiotic drivers of disease outbreaks and can be used to better predict hotspots where future disease outbreaks will occur.

Approach

Water snakes will be infected with zoonotic waterborne pathogens and exposed to shifts in environmental temperatures. Experiments will be conducted in environmental chambers and incubators in the laboratory. Pathogen loads and fecal shedding will be quantified over time. Also, hosts will be injected with bacteria carrying resistance genes, and the rates of gene transfer within hosts will be quantified. In addition, the clinically relevant hospital-acquired bacteria vancomycin-resistant enterococci (VRE) will be studied in terms of aquatic ecology—how the bacteria persist and survive in varying biotic and abiotic environmental conditions.

Expected Results

Based on previous research, infected hosts will have higher resistance to pathogen infection when they remain at a constant environmental temperature. Results should support the metabolic theory of ecology, that microbial metabolism is faster than that of larger organisms. Transmission rates of antibiotic resistance genes are expected to increase with environmental temperature shifts. Results will establish a relationship between temperature variability and resistance gene functions, which can contribute to future public health measures aimed at the problem of antibiotic resistance. Antibiotic resistance determinants should have a cost to fitness, burdening on other metabolic functions within pathogens, and resistant pathogens will be less successful when adapting to environmental stress.

Potential to Further Environmental/Human Health Protection

The results of this research may be applied to human populations affected by variability in temperatures and can help in preparing strategies to mitigate future disease outbreaks, including predicting when and where they may occur.

AIR, CLIMATE & ENERGY

A clean environment is a human right like any other. It is therefore part of our responsibility towards others to ensure that the world we pass on is as healthy, if not healthier, than when we found it.

– Dalai Lama

Green Energy/Natural Resources Production & Use

Julian Lamy

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental Science and Engineering

Bio

Julian Lamy finished his B.A. in both Economics and Mathematics at the University of Maryland, College Park in 2008. After graduation, he worked for several years at an economic consulting firm on a wide range of projects in the electricity sector. His work included economic modeling of environmental policies, litigation support and strategy consulting for various energy companies. In August 2011, he entered the Ph.D. program in Engineering and Public Policy at Carnegie Mellon University. His research focuses on the economics of renewable energy projects, primarily onshore wind, and how policy can help reliably integrate such projects into the electricity grid.

Synopsis

Wind power could help reduce pollution from conventional power plants. However, wind power generation is highly variable. Furthermore, many of the best wind resources are far away from load centers and thus require transmission investment. Primarily focusing on the Midwest, this research uses economic optimization models to identify optimal siting locations of wind farms to reduce variability effects, minimize capital costs, address accessibility challenges and maximize environmental benefits.

Keywords: energy efficiency, energy storage and transmission, wind power

Integrating Remote Wind Resources: An Environmental and Economic Analysis of Technology and Siting Options

Objective(s)/Research Question(s)

Wind power could help reduce pollution from conventional power plants. However, since wind does not necessarily blow whenever power is needed, it creates greater variability in power supply. Furthermore, many of the best wind resources are in areas far away from load centers and thus require transmission investment. Illinois is a unique area to study these issues. Illinois' renewable goals require about 10 gigawatts of new wind projects by 2025—approximately double the current installed wind capacity in the entire Midwest region. Illinois is located in an area with reasonable wind resources and also is near states with the best onshore wind potential in the United States. It is therefore a perfect case to study where to build wind resources, how to address the variability and accessibility challenges and how these decisions affect the environmental benefits of displaced emissions.

Approach

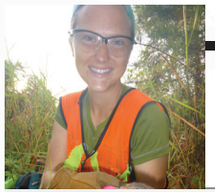
The first stage of this research will investigate the economics of using electric energy storage, such as batteries, to reduce transmission requirements when accessing remote wind farms. This research will use a case study of a farm in North Dakota that delivers power into Illinois. The second stage will use an economic optimization model to assess whether it is more economical to build wind farms in Illinois (local) or in other states (remote) where wind resources might be better to meet Illinois' renewable energy goals. This analysis will include an assessment of aggregate variability effects to the grid as a result of the new wind farms, as well as a comparison of transmission costs necessary to build farms in different states. For the last stage of this research, the same model will incorporate the environmental benefits of reduced emissions as a result of increased wind power and assess how these benefits may vary depending on where the wind farms are located.

Expected Results

Using electric energy storage to reduce transmission capacity would likely be economical only for low costs of storage technologies. The proposed model can estimate the maximum cost of energy storage in order to replace transmission. Preliminary results show that the required storage cost is far below even optimistic future cost projections of storage technologies. For optimal siting decisions, even with higher transmission costs, the higher capacity factors and lower variability of farms in states west of Illinois would likely justify building some capacity outside of Illinois to meet with Illinois' renewable energy targets. Preliminary results suggest that this is the case. Regarding environmental benefits, the majority of existing power plants in the Midwest rely on burning fossil fuels. Therefore all states in the region should realize significant environmental benefits from building wind farms. Based on previous research in this area, it appears that the highest carbon reductions would result from building wind farms in states west of Illinois.

Potential to Further Environmental/Human Health Protection

This research will help society move toward a more renewable-based and sustainable power generation mix in the most economical way possible. Both policymakers and those in the energy industry will benefit from understanding the role that energy storage might play in integrating remote renewables. This analysis also will help decision makers structure the future electricity market in their choice of where to build wind power. Finally, this research will help policymakers evaluate the best approaches to reduce greenhouse gas emissions and criteria air pollutants in the area studied. Even though the study focuses on Illinois, the lessons learned from this analysis can help energy system planning worldwide.



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Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Angela Larsen received a B.S. in Biology with a minor in Conservation Biology from the University of Wisconsin, Stevens Point. She earned an M.S. in Biology at Grand Valley State University (Michigan) where she investigated small mammals and gypsy moths. Currently she is a Ph.D. student in Environmental Health Science with a dissertation minor in Statistics at the University of North Carolina, Greensboro. Her research examines mechanisms that link rodent behavior to potential changes in rodent populations and communities, within a landscape producing forest-based biofuels.

Synopsis

This research focuses on behavioral changes at the individual rodent level that link to population and community levels in an area where switchgrass was planted as a biofuel. It seeks to understand what mechanisms at the individual level affect populations and communities to address concerns at population and community levels. In particular, this is of interest when the overall goal is to produce and harvest a biofuel in a way that promotes biodiversity sustainability.

Keywords: biofuel, rodent behavior, switchgrass

How Do Behavioral Alterations Drive Population and Community Dynamics of Rodents Associated with Intercropping Switchgrass in Pine Stands

Objective(s)/Research Question(s)

Anthropogenic changes to the environment have the potential to alter individual behaviors, life histories and population- and community-level dynamics, but mechanisms that link individual responses to population and community changes are not well understood. This research posits that population and community dynamics will differ between control and intercropped stands, driven by alterations in individual rodent habitat selection (home range size and suitability), communication (amount of ultrasonic vocalizations, or USVs) and reproduction. This research will investigate changes in an area where switchgrass is intercropped in loblolly pine plantations, changes occurring at individual, population and community levels and will assess links between changes in individual behaviors and changes at population and community levels.

Approach

Rodents in Kemper County, Mississippi, will be trapped on land owned and managed by Weyerhaeuser Company within stands established and maintained by Weyerhaeuser and Catchlight Energy LLC. Radio telemetry on individual cotton rats (*Sigmodon hispidus*) will estimate home ranges and identify nest sites where thermal video and acoustic recording devices will be deployed. Vegetation surveys will be conducted at all trapping stations and identified nest sites. Data analyses will use non-metric dimensional scaling and analysis of variance models to compare dependent variables within and among treatment plots and multiple regressions to predict population and community differences from individual changes in behavior.

Expeted Results

Individual cotton rat home range areas are expected to decrease where grasses are abundant; subsequently, these individuals are likely to interact with USVs more frequently using. Populations whose individuals have smaller home ranges and interact more are expected to have higher survival, recruitment and reproduction rates and therefore higher abundances. Plots with abundant grass cover are expected to be dominated by populations of herbivorous species and to have the lowest rodent diversity. Also, individual behaviors (home range size, microhabitat variables within home ranges and amount of USVs) are likely to be important predictors of population- and community-level changes.

Potential to Further Environmental/Human Health Protection

Conclusions of this study will allow a more complete understanding of the extent that habitat changes initially affect individual rodents in forest production landscapes and how those changes lead to population- and community-dynamic alterations. This study will provide necessary data to make management recommendations regarding biofuel feedstock production while maintaining a diverse and stable ecosystem. This may be the first study to use behavioral conservation methods to investigate rodent individuals, populations and communities.

Tera Emilie Lewandowski

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Project Amount: $84,000
Environmental Discipline: Forestry

Bio

Tera Lewandowski received a B.S. degree in Biological Sciences from the State University of New York (SUNY) at Buffalo in 2006 and an M.S. degree in Conservation Biology at SUNY College of Environmental Science and Forestry in 2009; she entered a Ph.D. program in Forestry at the University of Wisconsin, Madison in 2010. She is interested in the biotic and abiotic interrelationships in soil. Her current research concerns the long-term effects of forest biomass harvesting on soil organic carbon cycling.

Synopsis

The goal of this research is to understand the long-term effects of forest biomass harvesting on soil organic carbon (SOC) and provide data on how to sustainably manage forests to maximize woody biomass removal for economic benefits, while addressing climate change and greenhouse gas emission mitigation through carbon storage in forest soils. The project will use soil fractionation techniques to determine the amount of SOC in labile, fast-cycling and slow-cycling pools in surface and subsurface soil.

Keywords: aspen biomass harvesting, carbon storage, soil organic matter

Effects of Intensive Biomass Harvesting Practices on Long-Term Soil Organic Carbon Dynamics

Objective(s)/Research Question(s)

This fundamental research project leverages a long-term study that was established nearly 20 years ago: the USDA Forest Service Long Term Soil Productivity (LTSP) project. Treatments consist of three levels of biomass removal and two levels of compaction in a 3-by-2 factorial completely randomized design with an unharvested control, for a total of seven treatments. The overall objective of this research is to determine the effects of organic matter removal via intensive wood harvest and soil compaction on SOC pools in surface (0–10 cm) and subsurface (20–30 cm) mineral soil two decades after biomass harvest.

Approach

In this research, surface and subsurface soil from each replicate of the seven treatments will be used to examine long-term SOC dynamics following biomass harvests of varying organic matter removal and soil compaction intensities. No consensus yet exists regarding these effects because identifying changes due to management can be difficult when looking at the entire, heterogeneous, SOC pool. Therefore, to trace C fluxes through the soil matrix, this project separates labile, fast-cycling and slow-cycling SOC pools by using physical and size/density fractionation techniques. The fractionation procedure isolates the mineral-free light fraction (f-LF), occluded light fraction (o-LF), and mineral-associated or high-density fraction (HF). The f-LF includes plant detritus that is mainly free of mineral particles, has experienced a minimal amount of microbial degradation and is considered unprotected and easily degradable. The o-LF forms through the fragmentation and degradation of f-LF materials and the association of these materials with mineral particles to form aggregates. As organic matter within aggregates continues to decompose, microbially processed C bound to minerals accumulates to form the HF.

Expected Results

In general, increasing the intensity of biomass removal is expected to result in decreases in the SOC pool size in surface and subsurface soils compared with control treatments. Biomass harvesting affects all of the organic inputs to the soil system, including aboveground debris and belowground organic C sources of fine root turnover, rhizodeposition and mycorrhizae. Additionally, biomass harvesting can influence the flux of new C into surface and subsurface soil, "priming" the soil microbial community, resulting in accelerated decomposition of stabilized old C and reduced SOC mean residence time. Increasing harvest intensity will likely decrease the SOC pool size. It is further hypothesized that harvesting on Spodosol sands will result in the accumulation of organic C compounds in subsurface mineral soil. In Spodosols, the dominant soil-forming process is podsolization, the elluviation of soluble organic compounds from surface layers into deeper soil. Harvesting on Spodosols leads to accelerated podsolization and accumulation of recent organic C compounds in subsurface mineral soil. Therefore, biomass harvesting at the Huron site will likely accelerate the accumulation of C in subsurface soil. It is also expected that soil compaction treatments will increase SOC pools in sandy soils. Sites with higher aboveground productivity will have more belowground C inputs than low productivity sites.

Potential to Further Environmental/Human Health Protection

While intensive biomass harvesting will be beneficial economically through contributions to the U.S. energy portfolio and socially to rural communities, the potential effects on SOC storage are unclear and could either help or hinder environmental goals. Therefore, empirical data is needed to assess whether biomass harvesting causes soil C stocks to be released at higher-than-anticipated flux rates. The manipulative treatments used in the LTSP provide an exciting and unique opportunity to leverage the long-term investment in the ongoing study and experimentally assess long-term effects of aspen biomass harvesting on SOC dynamics.

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Project Officer: Gladys Cobbs
Project Period: 8/25/2014–8/25/2016
Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Kimberly Mighell received her B.S. in Biology from the University of North Texas in 2011. After internships with the Field Museum and the Smithsonian Tropical Research Institute, she began a Ph.D. program in Ecology and Evolutionary Biology at Tulane University. Her interests include endophytes, tropical agroecosystems and conservation of cryptic biodiversity. Her current research involves the endophytic ecology of the green energy crop *Jatropha curcas*.

Synopsis

Jatropha is a green-energy crop grown around the world, although little is known about its microbial ecology. Microbial endosymbionts (endophytes) can benefit host plants by increasing their health and productivity while deterring pests. This project studies jatropha's native microbiome, documenting benefits to and mechanisms of microbial-induced effects on the health and productivity of jatropha, and it applies principles learned to increase the sustainability of green-energy agroecosystems.

Keywords: acroecology, biofuel, endophytes

Endophytes as a Tool for Increasing Productivity and Health of *Jatropha curcas* Agroecosystems

Objective(s)/Research Question(s)

Endophytes have been shown to increase primary productivity, shape plant architecture, increase disease resistance and deter herbivores. This research aims to increase the sustainability of the green-energy crop via jatropha endophytes, in relation of pathogens, plant primary productivity and other endophytes. The purpose of this research is to elucidate how endophytes can improve the health and productivity of a green-energy agricultural ecosystem in small, tropical jatropha farms.

Approach

Endophytic bacteria travels through the plant via vascular tissue. This research will examine the in planta dispersal and establishment of endophytic bacteria to assess the spatial distribution and effects of bacterial strains. It will compare primary productivity and seed production, as well as disease resistance and herbivory of endophyte-treated and endophyte-free plants. Common garden plots throughout central Panama will give insight into the impact of natural environmental conditions and biotic interactions. Greenhouse experiments will allow treatment with specific abiotic and biotic conditions, paralleling and complementing plot trials and allowing description of precise mechanisms.

Expected Results

It is predicted that different bacterial endophytes will disperse and establish in different niches in planta. These bacterial communities will have different spatial impacts on plant architecture, primary productivity. Likewise, it is predicted that certain endophyte strains will have a strong effect on primary productivity and will increase the seed yield of its host's plants. It is expected that endophyte-inoculated plants will be less susceptible to disease. Each of these effects will likely be influenced by particular bacterial strains found within the native range of jatropha.

Potential to Further Environmental/Human Health Protection

By using the native microbiome of jatropha, this research will develop ways improve the health and productivity of jatropha agroecosystems. These finding can be applied and have the ability to improve the ecological, economic and social sustainability of green-energy agriculture.

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Project Amount: 42000
Environmental Discipline: Environmental Engineering

Bio

Maia Tatinclaux received her B.S. in Natural Resource Management from the University of Delaware in 2006. She spent 2 years in the Peace Corps in Cameroon and later worked at the EPA's Office of Pesticide Programs. In 2012, Maia began a Master's of Science program in Environmental Engineering at the University of Maryland, College Park. Her research evaluates the application of sediment microbial fuel cells for use as a waste-to-energy wastewater treatment technology.

Synopsis

The mechanical aeration of wastewater, called activated sludge, is used for the removal of organic matter from wastewater after it has undergone initial sedimentation. While this process is very energetically costly, organic matter is estimated to inherently contain significant amounts of energy. This research explores using sediment microbial fuel cells to anaerobically extract energy from wastewater during its treatment.

Keywords: sediment microbial fuel cell, waste-to-energy, wastewater treatment

The Evaluation of Microbial Fuel Cells to Provide Energy-Efficient Wastewater Treatment as Part of a Master's Program in Environmental Engineering

Objective(s)/Research Question(s)

Sediment microbial fuel cells use the oxidation of organic matter found in ocean sediments by bacteria paired with the reduction of oxygen in overlying water to extract energy. This research aims to see if these fuel cells can be configured to operate using organic matter found in wastewater and atmospheric oxygen. It also will explore alternatives to platinum as a catalyst for oxygen reduction in microbial fuel cells.

Approach

This study takes a two-phase approach at evaluating sediment microbial fuel cells for conventional wastewater treatment. First a laboratory-scale study will determine the best electrode materials to use to optimize fuel cell performance in wastewater. Next, a pilot-scale reactor will be tested under continuous flow conditions onsite at Blue Plains Advanced Wastewater Treatment Plant. In both phases, treatment efficiency and power production will be evaluated.

Expected Results

Based on published literature, the expectation is that these fuel cells will generate relatively low power, but could achieve high rates of organic matter removal with retention times as low as 8 hours. Generally, power production tends to increase with wastewater flow, but the increase in flow rate sacrifices overall treatment.

Potential to Further Environmental/Human Health Protection

Finding energy-positive methods for wastewater treatment would significantly reduce a community's carbon footprint. Additionally, energy-saving wastewater treatment methods could potentially be easier to implement in developing countries, where sanitation can be cost-prohibitive.


CHEMICAL
SAFETY FOR
SUSTAINABILITY

CHEMICAL SAFETY FOR SUSTAINABILITY

Green Engineering/ Building/Chemical Products & Processes/Materials Development

The first rule of sustainability is to align with natural forces, or at least not try to defy them.
Paul Hawken

Jamal Malik

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Project Amount: $84,000
Environmental Discipline: Chemistry

Bio

Jamal Malik received a BA. in chemistry from Macalester College in 2009. That fall, he began his doctoral studies at The Scripps Research Institute in La Jolla, CA. His research interests include the kinetics of catalytic organometallic reactions and development of waste-free transformations. His current research is studying unified reactivity paradigms of copper-catalyzed reactions.

Synopsis

Copper-catalyzed azide/alkyne cycloaddition (CuAAC), a chemical reaction discovered in 2001, has gained prominence largely through its embodiment of the principles of green chemistry. Despite its wide acceptance as a reliable method for molecular stitching in a variety of environments, little is understood about why and how it is effective. This project will use real-time reaction-tracking techniques to determine its mechanism and apply that knowledge toward creating an improved class of new catalytic reactions.

Keywords: catalysis, earth-abundant metals, green chemistry

Mechanistic Investigations of Copper-catalyzed Azide/Alkyne Cycloadditions

Objective(s)/Research Question(s)

CuAAC embodies the principles of green chemistry: it generates no byproducts, operates with a catalytic amount of an abundant earth metal (copper) and thrives in a variety of challenging conditions, including complex biological environments. Despite its widespread adoption, little is understood about the origin of the exceptional effectiveness of this reaction. This research project will employ real-time investigations of the mechanism of CuAAC, will provide insights into the fundamental interactions of coinage metals with carbon-carbon triple bonds and will apply this knowledge to creation of other environmentally benign reactions.

Approach

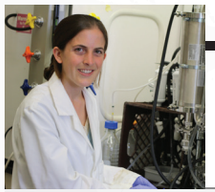
This research uses heat flow reaction calorimetry as the primary method of reaction monitoring, which tracks the energy absorbed or emitted from reactions over time. These data will be manipulated to elucidate information about the reaction, including rate dependence on reactant concentrations, robustness of the catalyst and effect of electronic substitutions on acetylenes. Comparison of data between similar reactions will illustrate how much behavior of the catalyst is "universal" and how much is unique to the CuAAC.

Expected Results

The kinetic information derived from these studies of the CuAAC is expected to add to current understanding of how organic molecules interact with common metals and improve the ease of use and performance of CuAAC for practitioners in other scientific fields. It should also provide insight into reactivity patterns that will allow creation of complementary green reactions that serve a wider base of scientists.

Potential to Further Environmental/Human Health Protection

Discovery of similar low-waste chemical transformations can significantly lower the carbon footprint from major industrial sources, broaden the possibilities for biological linkages and pave the way for greener polymers. The conversation about chemical synthesis can be changed from "Can we make these specific bonds at any cost?" to "With this powerful set of green reactions, what can we accomplish?"



Catherine May Spirito

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Project Amount: $84,000
Environmental Discipline: Bio-Environmental Engineering

Bio

Catherine Spirito received a B.S. in Civil Engineering from McGill University (Quebec) in 2010. The following year, she began studies at Cornell University in Biological and Environmental Engineering. In the fall of 2012, she enrolled in an M.S.-Ph.D. program in that department. Her research interests include bioenergy and biochemical production from organic waste materials. Her current research focuses on using high-throughput sequencing and bioinformatics tools to explore the microbial communities present in these anaerobic bioreactor systems.

Synopsis

Anaerobic fermentation processes can be used to convert organic wastes into useful fuels and chemicals. Recently, a bioprocess was developed in which undefined mixed microbial communities were shaped to convert organic wastes to a six-carbon chain carboxylic acid, which can be upgraded to a fuel additive. To ensure the stability of the system, this research will use high-throughput sequencing and bioinformatics tools to explore the effect of accidental perturbations on the reactor microbiome.

Keywords: bioinformatics, mixed culture, n-caproic acid

Using High-Throughput Bioinformatics to Investigate the Stability of a Newly Developed Anaerobic Fermentation Bioprocess

Objective(s)/Research Question(s)

A newly developed anaerobic bioprocess is capable of taking dilute ethanol (i.e., undistilled cellulosic ethanol) and using it as a source of carbon energy and reducing equivalents to upgrade short-chain carboxylic acids (i.e., acetic and n-butyric acid which are present in food waste leachate) to medium-chain carboxylic acids (i.e., n-caproic acid), which are more energy dense and easier to separate from solution. The objective of this research is to investigate the stability of this system by performing a detailed time series study to link the effect of specific perturbations to specific changes in microbial community structure and performance.

Approach

To investigate the effect of perturbations on microbial community structure and performance, several 5-L continuously-stirred bioreactors will be fed with soluble substrates and designed to promote formation of n-caproic acid. All conditions will be kept the same in the reactors with the exception of the perturbations (i.e., hydrogen partial pressure changes and pH stress) that will be imposed on the system. Continuous time series monitoring of both reactor performance and microbial community structure (i.e., via high-throughput sequencing tools) will allow the stability of the system to be examined.

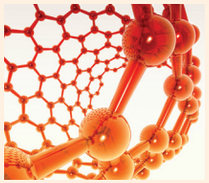
Expected Results

Through the use of different statistical, visualization and modeling methods for this time series data, correlations can be explored between reactor performance and the microbial community structure. This will increase the understanding of the stability of the n-caproic acid production system in response to perturbations and allow researchers to see what microbial community characteristics contribute to reactor stability.

Potential to Further Environmental/Human Health Protection

Currently, there is a need for further research and development of bioprocesses that can take organic wastes—such as food, yard and agricultural wastes—and convert them into useful fuels and chemicals. Use of waste for these purposes can circumvent the consumption of fossil fuels while reducing the amount of waste ending up in landfills. This research seeks to optimize a laboratory-scale process capable of converting organic wastes to a useful chemical, which will help to pave the way for industrial scale-up of this technology.

CHEMICAL SAFETY FOR SUSTAINABILITY



People who are crazy enough to think they can change the world are the ones who do.

– Steve Jobs

Nanotechnology

Megan Creighton

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Project Amount: $84,000
Environmental Discipline: Chemical Engineering

Bio

Megan Creighton is currently a Ph.D. candidate in engineering at Brown University and a trainee of the Superfund Research Program. She completed her undergraduate studies in chemical engineering and Latin American studies at the University of New Hampshire in 2010, as the recipient of the Industry Scholarship. Her research interests include investigating the impact of carbon nanomaterials on both human health and the environment.

Synopsis

Potential applications for graphene-family nanomaterials (GFNs) are growing more rapidly than the body of knowledge regarding their implications. Increased use and production of such materials consequently suggests an increased likelihood of unintended occupational, consumer and environmental exposures. This project focuses on the relation between the risks of such exposures and specific material properties so that, once understood, these properties can be intelligently exploited for function and safety.

Keywords: graphene, nanomaterials, risk assessment

Carbon Nanomaterials as Environmental Sorbents: Friend or Foe?

Objective(s)/Research Question(s)

This study is based on the hypothesis that the high aspect ratio and large surface area of GFNs will pose a unique inhalation exposure risk that is not yet properly understood, which may include impairment of the lung's immune defense mechanisms. This research must be carefully validated, as the high surface area and adsorptive properties inherent in graphene-based and other carbon nanomaterials will lead to in vitro assay results that are difficult to interpret correctly.

Approach

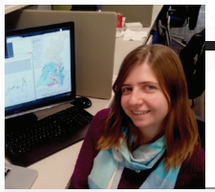
This project will focus on a suite of carbon nanomaterials whose physical properties (such as overall geometry, lateral dimension and/or aspect ratio and surface chemistry) span those of the most common commercially available products. Carbon materials are well-known sorbents for organic compounds in aqueous phases, and the increased surface area associated with nano-scale dimension compounds this inherently strong adsorptive capability. This can significantly alter the profile of their surrounding milieu by, for example, removing essential micronutrients or molecular probes used in in vitro assays. These same interactions also can mediate initial contact with macromolecules, including hydrophobic residues in proteins. Such interactions can lead to protein unfolding, which jeopardizes the structure and therefore the performance of a given protein molecule. The adsorptive interface is only one example of GFN behavior in biological systems; these carbon nanomaterials also can form physical barriers and exhibit antioxidant properties. This study also will investigate the effects of particle size and geometry, which will have implications in cellular interactions (such as recognition and uptake) as well as the transport, deposition and exposure pathways relevant for a given material.

Expected Results

This research will improve the body of knowledge used in determining the safety of GFNs. Understanding the primary influences guiding the interactions of these materials with their surroundings will lead to the enhancement of research methods and advance the quality of environmental inquiry regarding GFNs. This will eventually lead to more accurate information for environmental decisionmaking, allowing the safe and sustainable development and incorporation of GFN technology into society.

Potential to Further Environmental/Human Health Protection

This research will help correlate GFN characteristics with certain behaviors in biological systems, which will differ from those of the traditional toxicants from which common risk assessment methods developed. This work will advance the quality of environmental inquiry regarding GFNs by providing guidance on how to avoid misinterpretation of common procedures used to assay these materials, identify the predominant methods of interactions with a variety of species present in a biological environment (including proteins and reactive oxygen species), and allow design criteria that minimize risk.



Amy Lauren Dale

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Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental Risk Assessment

Bio

Amy Dale received a B.S. in Bioinformatics from the University of Pittsburgh (Pennsylvania) in 2011. She is now pursuing a joint doctoral degree in the Departments of Engineering and Public Policy and Civil and Environmental Engineering at Carnegie Mellon University. Her research focuses on developing models to describe the fate of potentially toxic metal and metal oxide nanoparticles released to the environment during the manufacture, use, or disposal of nanotechnology-enabled products.

Synopsis

Antimicrobial consumer goods containing nano-sized metal or metal oxide particles, or nanoparticles, are a fast-growing use of nanotechnology. Many of the metals used in these nanoparticles are environmentally toxic. This research focuses on mathematical models to assess the risk associated with nanoparticles that escape into the environment during a product's life cycle. Particular focus is placed on the importance of capturing chemical transformations and nanoparticle-sediment interactions.

Keywords: metal contamination, nanomaterials, risk assessment

A Model of the Transformations of Metal and Metal Oxide Nanoparticles in Freshwater Sediments: Exploring Critical Uncertainties and the Role of Sediments in Nanoparticle Risk Assessment

Objective(s)/Research Question(s)

This research employs computer simulations to describe the movement and transformation of potentially toxic metal and metal oxide nanoparticles once they are released to the environment during the manufacture, use, or disposal of antibacterial consumer goods produced by the emerging nanotechnology industry. These simulations focus on the strong association of nanoparticles with suspended sediments and soils, which facilitates their accumulation in river and lake beds. The models are used to explore the effect that natural variability in environmental conditions—such as stream flow, temperature, oxygen availability and pH—has on the toxicity, bioavailability and persistence of metal and metal oxide nanoparticles and their reaction by-products in sediment beds and overlying surface waters.

Approach

This research focuses on the development of two mathematical models to investigate the fate of three highly reactive nanoparticles—zinc oxide, copper oxide and silver—in terrestrial and aquatic environments. The first model, which is highly detailed and small in scale, focuses on the chemical transformations that nanoparticles and their reaction by-products (metal ions) undergo in the river beds and lake beds where they are expected to accumulate once released to the environment. The second model, which links an adaptation of the Chesapeake Bay Program Phase 5 Watershed Model to the U.S. EPA's water quality model WASP7, is a watershed-scale simulation that is informed by the sediment model and is designed to describe the fate of nanoparticles released to the James River basin in Virginia. Features of the model include geospatial information on the location and discharges of all permitted sewage treatment plants in the watershed; hourly rainfall patterns over a 20-year period; daily estimates of stream flow; data on agricultural and urban land use in the watershed; and a detailed description of sediment transport on the land surface and in the river network.

Expected Results

This work will predict the ultimate location, concentration and form of silver, zinc oxide and copper oxide nanoparticles released to surface waters and sediments. Predictions will indicate whether the nanoparticles will be present in toxic forms at high enough concentrations to be of concern. Overall nanoparticle mobility in the environment is expected to be low, and most environmental toxicity will likely be observed in the sediments or at the sediment-water interface. Nanoparticle risk will depend heavily on such site-specific factors as pH, oxygen availability and sulfide availability. Nanoparticle concentrations in the stream will depend heavily on stream flow due to the impact of flow on sediment transport. Uncertainty analysis will be used to determine which uncertainties in model inputs have the greatest effect on model predictions, which will help prioritize future research.

Potential to Further Environmental/Human Health Protection

This research aims to advance the emerging field of nanoparticle fate and transport modeling by adapting modeling frameworks historically developed for "conventional" or non-nano pollutants, such as metal salts and pesticides. These models will be used to shed light on the environmental transformation, toxicity and bioavailability of reactive metal and metal oxide nanoparticles under a wide range of environmental conditions. Results will be used to inform public policy and risk management decision making for this emerging class of potential environmental pollutants.

Benjamin Alex Wender

Anticipatory Life Cycle Assessment for Emerging Nanotechnologies

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Project Amount: $84,000
Environmental Discipline: Civil/Environmental Engineering

Bio

Ben Wender received a B.S. in Physics from Hampshire College (Massachusetts) and now researches life cycle assessment (LCA) in the School of Sustainable Engineering and the Built Environment at Arizona State University. He collaborates with scholars from social, environmental and physical sciences to develop LCA models of promising nanotechnologies and identify opportunities for environmental improvement early in research and development.

Synopsis

Research policy organizations recommend applying LCA to nanotechnology; however, current practices are best suited for optimizing existing industries instead of guiding emerging technologies.This research develops anticipatory LCA methods that use uncertain fate, transport, toxicity and manufacturing inventory data to identify the greatest uncertainties and opportunities for life cycle environmental improvement of nano-enabled batteries.

Keywords: nanomaterials, life cycle assessment, lithium ion batteries

Objective(s)/Research Question(s)

Lithium ion batteries (LIBs) are increasingly used in electric vehicles and transportation applications, which has drawn attention to the significant economic and safety risks associated with LIBs' overheating. One promising solution is to use solid electrolytes derived from ceramic nanowires that afford similar performance and obviate charge-discharge regulating electronics. The life cycle environmental tradeoffs of this marketable technology are unknown and being shaped by decisions made today, which presents an opportunity to use LCA to influence the research agenda toward nano-enabled batteries with reduced impacts.

Approach

This research brings together a network of researchers from materials science, social science, environmental engineering and industrial ecology to develop and apply forward-looking LCA models that are robust under uncertainty. To overcome the shortage of data characteristics of nanotechnologies this research employs a suite of prospective modeling tools, including scenario development, thermodynamic modeling and global stochastic sensitivity analysis within a life cycle framework. These methods may identify the greatest data uncertainties and prioritize investments of research resources that result in the greatest life cycle environmental improvements.

Expected Results

Applying LCA early and literately in research and development (R&D) of nano-enabled batteries will provide materials researchers with environmental criteria to consider alongside technical and economic metrics of technology readiness. Integrating environmental criteria into R&D decisions may result in development of nano-enabled batteries with decreased environmental burden. Additionally, anticipatory LCA will provide a collection of best practices for LCA of nanotechnology and build a framework that is broadly applicable to other emerging technologies.

Potential to Further Environmental/Human Health Protection

Engaging R&D decision makers with broader environmental concerns helps to transcend retrospective identification, regulation and mitigation of environmental impacts. This research has the potential of protecting human and environmental health from emerging threats by building a holistic framework that can guide development of emerging technologies toward environmentally preferable outcomes.

CHEMICAL SAFETY FOR SUSTAINABILITY

Plans to protect air and water, wilderness and wildlife,
are in fact plans to protect man.
– Stewart Udall

Pesticides and Toxic Substances

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Project Amount: $84,000
Environmental Discipline: Zoology

Bio

Devaughn Fraser received a B.S. in Integrative Biology from the University of California, Berkeley in 2003. She immediately pursued research on a variety of conservation-based studies before beginning a doctoral program at UCLA. She currently studies bat-mediated agricultural pest control in California and the effects of landscape-level insecticide use on free-ranging bats.

Synopsis

Bats provide important ecosystem services in the form of agricultural insect pest control. However, there may be an important trade-off in the use of toxic insecticides, which may harm bat populations and reduce the value of these services over the long term. This research will help evaluate the magnitude of this trade-off by quantifying the value of bat-mediated pest control in California almond orchards through dietary characterization, while simultaneously evaluating the health and reproductive effects of chronic exposure to insecticides on free-ranging bats.

Keywords: agriculture, bats, insecticides

Modeling Exposure Risk and Determining Effects of Cholinesterase-Inhibiting Insecticides on Bats in Central California Agricultural Ecosystems

Objective(s)/Research Question(s)

This research addresses several questions: What are bats in agricultural areas eating and what proportion of their diet consists of economically important agricultural pests? How are health and reproduction in free-ranging bats affected by landscape-level insecticide use? What is the long-term trade-off, economically and environmentally, of using toxic insecticides that may be harmful to bats and other wildlife that provide important pest control services?

Approach

Bats are sampled while foraging in almond orchards located across a gradient of landscape-level insecticide-use applied to the surrounding 64-km^2 area. Standard measurements include assessment of age and reproductive condition and a count of external parasites. Blood samples from two focal species, the big brown bat and the pallid bat, are analyzed for immune-response capabilities, and blood parasites are counted in blood smears. Prey DNA is extracted from guano and sequenced; coronavirus RNA is extracted from big brown bat guano and sequenced to characterize diversity and prevalence. On each night of capture, insects are sampled to assess dietary diversity and abundance relative to resource base. Acoustic monitoring stations characterize the relationship between pest abundance and bat foraging activity. Radio-telemetry tracks a subset of captured big brown bats to their roost locations to characterize their foraging range and behavior, and a maternity colony is monitored for emergence counts of the colony size and pre- and post-parturition. An exposure risk model is being developed based on insecticide residues detected on prey for a week following a spray. Combined with landscape level-analysis of ChE inhibitor applications and bat foraging behavior and dietary analysis, this model will predict exposure risk for multiple species of bats with differing foraging strategies (i.e., gleaning from ground or vegetation versus apprehending prey in the air).

Expected Results

Broadly, chronic exposure to anticholinergic insecticides is expected to compromise immune function and reproduction in bats; high insecticide use is likely to limit resource availability to bats; and exposure risk will depending on a species' prey preference and foraging strategy. The following specific findings are predicted: (1) Big brown and pallid bats captured in high-input areas (HIAs) will have higher prevalence and infection intensities of parasites and reduced constitutive immune capabilities, and they will be more frequently ChE-inhibited than bats in low-input areas (LIAs). (2) There will be a lower ratio of reproductive to nonreproductive females in HIAs, causing frequently exposed populations to have a lower annual growth rate than populations in LIAs. (3) Insect diversity will be lower in HIAs than in LIAs. Bat foraging activity and bat diversity also will be lower in HIAs. (4) The reduced dietary diversity in HIAs will lead to greater resource partitioning between sympatric species and between age-classes within species, potentially leading to species exclusion and lower bat diversity. (5) Pallid bats, which glean from vegetation and the ground, will have greater exposure risk than big brown bats, which catch prey in flight.

Potential to Further Environmental/Human Health Protection

Understanding bat activity around agricultural areas and the influence of pest control strategies on bat populations will guide management to maximize pest control while protecting insects' natural predators and reducing the use of chemical pesticides. Quantifying exposure risk to bats will aid in EPA evaluations of risks to non-target wildlife. Furthermore, understanding the relationship between bat health and viral diversity for potentially zoonotic pathogens can help reduce this risk to humans by reducing the use of immunotoxic insecticides. Overall, this study addresses the ecological effects of insecticides on economically valuable insectivores and encompasses the three pillars of sustainability: the economy, society and the environment.

Morgan Elizabeth Gilmour

Assessment of Contaminant Load and Its Relationship to Foraging in a Marine Top Predator

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Project Amount: $84,000
Environmental Discipline: Oceanography and Environmental Toxicology

Bio

Morgan Gilmour received a B.S. in Wildlife and Conservation Biology from the University of Rhode Island in 2005. After graduating she worked as a field assistant for eight avian research and conservation projects in the United States, the Caribbean and Mauritius. Morgan received an M.S. in Biology from Bucknell University (Pennsylvania) in 2011. Currently she is researching the role of contaminants and foraging ecology of tropical seabirds for her Ph.D. project in Ocean Sciences at the University of California, Santa Cruz.

Synopsis

Ocean and atmospheric currents transport nutrients and harmful contaminants, such as mercury and pesticides, throughout the sea. This research will assess contaminants in the ocean via a biomonitor of the oceanic environment: seabirds. Sampling two species, boobies and frigatebirds, for contaminants, the project will track the birds with GPS tags to estimate key foraging areas and to relate contaminants with these areas. These data also are important for humans and such fish as tuna and sardines.

Keywords: contaminants, mercury, organochlorines

Objective(s)/Research Question(s)

This research will test the hypothesis that foraging strategies of frigatebirds and boobies reflect seasonal fluctuations in available prey and local oceanographic conditions, resulting in colony-specific variations in contaminant loads and foraging behaviors. This hypothesis will be tested by (1) assessing the contaminant loads of heavy metals (such as mercury) and organochlorines (such as DDT and its metabolites) of several populations of two seabirds, boobies (*Sula spp.*) and frigatebirds (*Fregata spp.*); (2) identifying important foraging areas with GPS-tracking tags; and (3) relating the seabirds' contaminant loads with their diets and regional foraging locations.

Approach

Contaminant loads in seabirds will be assessed by sampling blood from breeding seabirds in several colonies. The blood will be tested for mercury and such organochlorines as DDT; these contaminants affect breeding behaviors and also can be lethal to birds. The sampled seabirds will be fitted with GPS-tracking tags to record foraging trips as the birds search for fish at sea. These data will allow identification of important foraging areas to these birds and determination of important foraging behaviors and characteristics that may help explain how these birds find food. The contaminant and tracking data will be combined to estimate whether these foraging areas contain harmful contaminants for these seabirds, fish and humans.

Expected Results

Mercury and organochlorines, such as DDT and PCBs, are highly volatile at low latitudes that exhibit warm temperatures. As warm air travels to cooler temperatures, the ocean becomes a sink for atmospheric organochlorines and mercury, and their concentrations increase with latitude. It is expected that (1) birds foraging in more northern areas that exhibit cooler sea-surface temperatures will exhibit higher contaminant loads than birds that forage in warmer waters; and that (2) due to anthropogenic uses of organochlorines and mercury in agriculture and industrial processes, birds that forage closer to coasts will exhibit higher contaminant loads than birds that forage further from human settlements.

Potential to Further Environmental/Human Health Protection

Boobies and frigatebirds typically eat sardines, anchovies and squid—the same fish eaten by both humans and many large sport fish, like tuna. Sampling contaminant loads in these birds will help to create an accurate picture of the types of contaminants that humans and commercially important fishes are exposed to in the oceanic environment. Information from this study can be used to create and support policy decisions for protected resources, risk assessment with fisheries operations and restoration of habitats.

HUMAN HEALTH RISK ASSESSMENT

HUMAN HEALTH RISK ASSESSMENT

If we are to go on living together on this earth,
we must all be responsible for it.
– *Kofi Annan*

Public Health

Brandon Emil Boor

Infant Inhalation Exposure to Indoor Air Pollutants while Sleeping and Crawling

University of Texas, Austin (TX)
Email: bboor@utexas.edu
EPA Grant Number: FP917652-01-0
Project Officer: Gladys Cobbs
Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental Science and Engineering

Bio

Brandon Boor is a doctoral candidate at The University of Texas, Austin, in the Department of Civil, Architectural and Environmental Engineering. He holds a B.S. degree in Mechanical Engineering from York College of Pennsylvania and an M.S.E. degree in Environmental and Water Resources Engineering from The University of Texas, Austin. He has received a Fulbright grant to Finland and a National Science Foundation Graduate Research Fellowship. His research interests include indoor air quality, human exposure assessment and the fate and transport of airborne particles. His current research is aimed at investigating infant exposure to indoor air pollutants as they sleep and crawl.

Synopsis

Infants are vulnerable to the adverse health effects of environmental toxins and are often disproportionately exposed to indoor air pollutants. Infants spend a considerable amount of time sleeping and engaged in near-floor activities indoors, such as crawling. This research will explore infant exposure to chemicals released from crib mattresses and investigate how infants can be exposed to the diverse spectrum of pollutants found in floor dust through crawling-induced particle resuspension.

Keywords: indoor air quality, particle resuspension, sleep microenvironment

Objective(s)/Research Question(s)

The objectives of the proposed research are to (1) evaluate crib mattresses as a source of volatile organic compounds (VOCs) and plasticizers and identify the unique attributes of human exposure in the sleep microenvironment; (2) develop a full-scale crawling robot that can simulate the locomotion of a crawling infant to investigate the mechanisms of crawling-induced resuspension of settled floor dust particles; and (3) evaluate near-floor infant exposure to airborne particles.

Approach

This first phase of this work will evaluate the emissions of VOCs from a collection of 20 new and used infant crib mattresses and identify phthalate and alternative plasticizers in crib mattress covers. Chamber experiments will determine VOC area-specific emission rates under different thermal conditions, as well as breathing zone concentrations. Material-phase concentrations of plasticizers will be determined through solvent extractions and analysis via gas chromatography-mass spectrometry. Target plasticizers include bis (2-ethylhexyl) phthalate (DEHP); bis (2-ethylhexyl) isophthalate (iso-DEHP); diisononyl phthalate (DINP); diisononyl cyclohexane-1, 2-dicarboxylate (DINCH); and di (2-ethylhexyl) adipate (DEHA). A literature review will identify the unique attributes of exposure to pollutants in infant and adult sleep microenvironments and provide a comprehensive overview of pollutants found in mattresses and mattress dust. The second phase of this research involves designing and constructing a full-scale (~ 8 kg) crawling robot that can simulate the locomotion of a crawling infant. Microcontrollers will control servo motors and actuators will drive each limb. The robot will simulate two common crawling techniques: a belly crawl and a hands-and-knees crawl. An optical particle sizer will be mounted on the top of the robot for mobile sampling of breathing-zone particle concentrations (300 nm to 10 µm). Full-scale experiments will be conducted in a large environmental chamber. Particle resuspension will be quantified through the resuspension rate metric, and exposure will be quantified through the intake fraction metric. The effect of flooring type (carpeted vs. hard flooring), dust loading (1–10 g/m^2), particle size and crawling motion will be evaluated. In thehe third phase the crawling robot will be deployed in different indoor environments for field measurements of near-floor particle concentrations. In addition to mobile monitoring of resuspended fine and coarse particles, ultrafine particles also will be measured with a scanning mobility particle size.

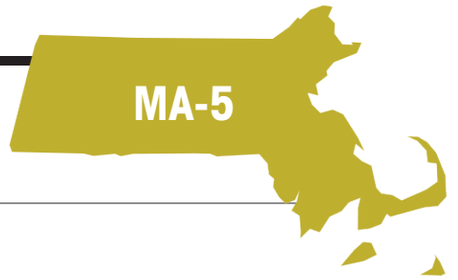
Expected Results

This research will help to characterize infant crib mattresses as a source of VOCs and plasticizers in the sleep microenvironment. The crawling robot will be used to determine size-resolved particle resuspension rates, breathing-zone concentrations and intake fractions in both controlled chamber experiments and field measurements. The breathing-zone concentrations will be used to model an infant's daily inhalation dose of particles while engaged in near-floor activities and the fraction of particles that deposit in various regions of the lung.

Potential to Further Environmental/Human Health Protection

The infant sleep microenvironment is a critically important, yet understudied, indoor space. This research will help to better understand how crib mattresses contribute to an infant's cumulative exposure to various chemicals and the health consequences of this particular product. Some phthalate plasticizers are endocrine-disrupting compounds, and repeated and prolonged infant exposure while sleeping (through inhalation and dermal contact with the mattress cover) is of particular concern. Furthermore, little is known about the process by which infants stir up settled dust particles as they engage in near-floor activities. This research will help determine how crawling-induced resuspension contributes to an infant's daily exposure to fine and coarse particles. The crawling robotic sampling platform developed in this research also will serve as a useful tool for future work on characterizing the fungal and bacterial composition of resuspended dust particles.

Clifton Dassuncao



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Project Officer: Gladys Cobbs
Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Public Health Sciences

Bio

Clifton Dassuncao received a B.S. in Environmental Engineering from the Massachusetts Institute of Technology in 2009. He then worked for an environmental consulting company on projects assisting EPA's Office of Water. He obtained an M.S. in environmental health from the Harvard School of Public Health and remained to pursue a doctorate. His research interests are environmental influences on infectious disease dynamics and modeling the transport and effects of environmental contaminants on human health.

Synopsis

Perfluoroalkylated Compounds (PFCs) are a broad class of highly persistent manmade chemicals that have been produced in large quantities since the 1940s and are today commonly used in consumer products, such as food packaging. Exposure to PFCs has been associated with immunotoxicity, metabolic changes and developmental disorders. The overarching goal of this research is to characterize exposure risks associated with PFCs by modeling data from human serum, marine animals and the environment.

Keywords: exposure, immunotoxicity, perfluoroalkylated compounds

Exposure and Risk Assessment of Perfluoroalkylated Compounds

Objective(s)/Research Question(s)

This research will provide insight into which individual PFCs are accumulated and/or metabolized in biological systems and the time periods for accumulation and elimination in human populations, thereby highlighting which compounds are likely to contribute the greatest risk in the future. This can help inform the chemical manufacturing industry on future production choices that will minimize effects on human and biological health. Exposures in the U.S. population presently include food packaging and household items, which can be regulated by product phase-outs; however, increasing accumulation of PFCs in marine ecosystems means that contributions from seafood are likely to increase in the future, and these are not easily controllable without dietary interventions. The research will directly contribute to improved risk assessment methods for immunotoxicity in children by bolstering knowledge of the exposure assessment.

Approach

This research will leverage extensive epidemiological data collected since 1985 from unique prospective birth cohorts with more than 1000 individuals in the Faroe Islands in the North Atlantic. These communities receive most of their toxicant exposure from marine food (pilot whale) consumption, show a wide range of exposure levels and are well suited to provide insight into future exposure profiles of U.S. individuals. The study will compare PFC production data, historical pilot whale tissue samples and human serum samples from multiple birth cohorts to identify trends and environmental timescales associated with transport and biological accumulation of these compounds. It will estimate benchmark dose responses for each compound and link a stochastic exposure model to a physiologically based pharmacokinetic (PBPK) model to estimate risk to human populations.

Expected Results

The research is expected to identify which PFCs present the greatest risk now and in the future given observable trends in biological samples. These compounds will likely have specific stereochemical properties that make them more persistent and bioaccumulative in the environment. The major present exposure sources to PFCs for the U.S. population will likely be household products, food packaging and drinking water, but contributions from marine foods are expected to increase over time.

Potential to Further Environmental/Human Health Protection

This research will provide insight into which individual PFCs are accumulated and/or metabolized in biological systems and the time periods for accumulation and elimination in human populations, thereby highlighting which compounds are likely to contribute the greatest risk in the future. This can help inform the chemical manufacturing industry on future production choices that will minimize effects on human and biological health. Exposures in the U.S. population presently include food-packaging and household items, which can be regulated by product phase-outs; however, increasing accumulation of PFCs in marine ecosystems means that contributions from seafood are likely to increase in the future, and these are not easily controllable without dietary interventions. The research will directly contribute to improved risk assessment methods for immunotoxicity in children by bolstering knowledge of the exposure assessment.

Anobha Gurung

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Project Period: 8/27/2014–8/27/2016
Project Amount: $84,000
Environmental Discipline: Public Health Sciences

Bio

Anobha Gurung received a B.A. in Geography and a Certificate in Geographic Information System from the University of Colorado, Denver in 2008. In 2010, she completed her M.S. in Environmental Science and started doctoral work at the Yale School of Forestry and Environmental Studies. She is interested in understanding the interaction between exposure to environmental stressors and social factors that determine human health in growing Asian cities. Her research examines traffic exposure and human health burden, with characterization of susceptibility factors in Kathmandu Valley, Nepal.

Synopsis

Air pollution has been linked to various human health impacts, with the majority of evidence based in Western cities. The air pollution impact in Asian cities is likely to differ due to higher air pollution levels and differences in environment, health status and population characteristics. This project will investigate exposure to traffic-related air pollution and human health burden, with characterization of susceptibility factors in urban areas of the Kathmandu Valley, Nepal.

Keywords: air pollution, exposure, health

Susceptibility to Exposure from Traffic-Related Air Pollution and Human Health Burden in Kathmandu Valley, Nepal

Objective(s)/Research Question(s)

This research will investigate exposure to traffic-related air pollution and human health burden with characterization of susceptibility factors (e.g., age) in urban areas of the Kathmandu Valley in Nepal, one of the fastest urbanizing nations in South Asia. It will identify important social and environmental variables, as well as explore methodologies suitable for understanding exposure and health in growing Asian cities like Kathmandu.

Approach

Long-term data have been collected from six major hospitals: ambient particulate matter with aerodynamic diameter less than 10 µm (PM_{10}), weather, and demographic information from the 2010 Census. These data will be analyzed to understand the association between PM_{10} exposure and the risk of cause-specific hospital admissions. Population vulnerability based on age, gender, home location, and socioeconomic status to hospitalization from PM_{10} will be identified. A land use regression model will help understand traffic exposure for urban residents in Kathmandu Valley. To develop the model, four NO_2 sampling campaigns for each season will be conducted at 135 sites, in addition to meteorological and environmental (e.g., land use, road network) data collection. The traffic exposure model developed will be used to determine exposure for school children and for the general population, as well to highlight issues of environmental injustice.

Expected Results

The association between short-term PM_{10} exposure and the risk of cause-specific hospital admissions will be determined for Kathmandu Valley, Nepal, with characterization of susceptibility factors (e.g., age, home location). A map of annual average NO_2 exposure will be created for urban areas in Kathmandu Valley. The proportion of the total population and school children exposed to high traffic-related air pollution and associated neighborhood features will be determined. Resulting maps will showcase issues of environmental injustice. Important variables, methods for exploring exposure to traffic-related air pollution in places like Kathmandu and ways a model developed in Western cities can be applied to growing cities in Asia will be identified.

Potential to Further Environmental/Human Health Protection

Spatiotemporal traffic exposure patterns and factors linked with high exposure are critical for future epidemiological studies, and for developing policy related to land use, road design, air pollution control and human health protection. This study highlights issues of environmental justice and susceptibility, helping to define high-risk groups, suggesting strategies for effective human health protection. Based in a developing country, one with a different socioeconomic status and environmental background than the United States, this study also strengthens the scientific evidence describing the complex relationship among traffic exposure, human health and social factors. Overall, the study is policy relevant, increases awareness, encourages future work and contributes to well-informed decisions to protect environment and human health.

Margaret Mae Kovach

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Project Period: 8/19/2014–8/19/2016
Project Amount: $84,000
Environmental Discipline: Geography

Bio

Margaret Kovach received a B.S. in Biology from the University of North Carolina, Chapel Hill in 2008. In 2010, she obtained her M.S. in Geography by investigating the spatial patterns of societal effects from inland-moving tropical cyclones. Currently, Margaret is in the Geography Ph.D. program at the University of North Carolina at Chapel Hill. Her research interests include environmental health, climatology and understanding how the environment affects spatiotemporal patterns of disease. Her current research explores heat vulnerability in North Carolina by investigating the climate thresholds that lead to increases in heat-related illness.

Synopsis

Heat is the leading cause of weather-related death in the United States. This project focuses on identifying the local- to regional-scale patterns of heat-related illness and the climate thresholds that control these patterns. Climate thresholds are identified for different time periods, ages, genders and spatial locations. Ultimately, this project will identify at-risk locations and population-specific climate thresholds, which can be integrated into an early heat warning system.

Keywords: early warning systems, heat health risk, urban climate

Identifying Climate Thresholds for Heat-Related Illness in North Carolina

Objective(s)/Research Question(s)

The objective of this research is to identify climate thresholds that lead to increases in emergency department visits for heat-related illness. Climate thresholds represent climate values (e.g. temperature, heat index, humidity) beyond which heat-related illness emergency department admissions increase significantly. Climate thresholds will be identified for separate categories of age and gender for multiple populations across North Carolina to determine the differential impact of heat stress.

Approach

Heat-related illness is measured using all 113 emergency departments across the state of North Carolina, allowing for complete spatio-temporal cover from 2007 to 2012 at the ZIP code level. Heat-related illness emergency department visits also are linked to daily weather stations, census data and land cover data to investigate different locations (i.e., urban locations, areas with large amounts of crop land, locations with a high percentage of the population living poverty, etc.). Generalized additive models will relate heat-related illness to climate variables to smooth the data for climate threshold calculation. Climate thresholds will be calculated objectively for each climate variable, using an automated routine that compares the similarity of heat-related illness rates above and below climate values iteratively across a wide range of potential threshold values. Heat-related illness incidence also is mapped with demographic, land cover and socioeconomic variables to identify potential risk for heat-related illness. Risk factors are identified through a geographic information system framework and regression techniques, such as spatial regression and multilevel modeling.

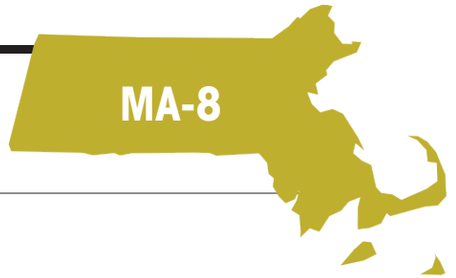
Expected Results

The research hypotheses proposed in this project suggest significant variability in heat-related illness across different populations and within different time periods. Areas with high heat-related illness incidence will be locations in which one or more demographic groups are unable to adapt to heat, either due to lower socioeconomic status, increased physical exposure to heat (e.g. high numbers of an outdoor work force) or a land cover that retains heat (e.g., developed land, certain agriculture fields). Climate thresholds will vary significantly across the state of North Carolina depending on the demographic, spatial location and season. For instance, the climate threshold for the elderly population will be lower than for younger demographics because of their inability to thermoregulate as efficiently. Additionally, the shape (i.e., linear vs. nonlinear) of these thresholds will vary, since slight temperature changes affect elderly more than the younger demographic.

Potential to Further Environmental/Human Health Protection

General circulation models of climate change project extreme heat events to increase in severity, duration and intensity, placing future populations at greater risk for adverse health effects. This motivates the need to understand risk locations and population-specific climate thresholds, which can be integrated into an early heat-warning system and targeted public health interventions. Such measures are needed since heat-related illness is easily preventable with adequate warning and appropriate education and response.

Rebecca L. Laws



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Project Officer: Gladys Cobbs
Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Epidemiology

Bio

Rebecca Laws is a Ph.D. student in the Department of Environmental Health at the Boston University School of Public Health (BUSPH), specializing in environmental epidemiology and exposure assessment. She previously received a Master of Public Health degree from BUSPH and a B.S. in Biology from Duke University. Her current research involves investigating potential environmental and occupational causes of an epidemic of chronic kidney disease of unknown etiology among Nicaraguan workers.

Synopsis

In Central America, an epidemic of chronic kidney disease (CKD) of unknown etiology has been described among young, male agricultural workers. Although many occupational and nonoccupational causes have been hypothesized (e.g., heat stress, exposure to heavy metals), the etiologic agent remains unknown. This research aims to characterize the type of kidney damage, evaluate occupational factors and investigate the role of metals exposure in a cohort of Nicaraguan workers in the sugarcane, mining, stevedoring and construction industries.

Keywords: chronic kidney disease, metal contamination, Mesoamerican nephropathy

Investigating an Epidemic of Chronic Kidney Disease in Western Nicaragua

Objective(s)/Research Question(s)

The objectives of this project are to (1) evaluate repeated measures of biomarkers of kidney injury and CKD among sugarcane workers by investigating differences by job task; (2) determine whether there is evidence of kidney injury and CKD among miners, construction workers and stevedores who have never worked in the sugarcane industry; and (3) characterize biomarkers of exposure to nephrotoxic heavy metals (i.e., cadmium, lead, uranium, arsenic) and examine the association with biomarkers of kidney damage.

Approach

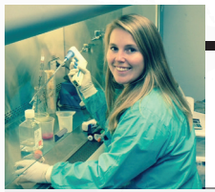
A cohort of Nicaraguan workers in the sugarcane, mining, stevedoring and construction industries was previously recruited and sampled for blood and urine. Sugarcane workers representing seven different job categories were sampled twice, before and at the end of the 6-month harvest season; workers in other industries were sampled once. Exposure will be assessed in two different, but complementary, ways. First, because the causal agent is unknown, job category will be used as a surrogate for exposure. Various job categories in the sugarcane industry are quite different in terms of potential exposure to hypothesized causal agents (i.e., heat stress, agrichemicals), so identifying which jobs have the greatest risk of kidney injury during the harvest season will provide information about which occupational factors may be important. Second, biomarkers will be used to quantify exposure to nephrotoxic heavy metals (lead, cadmium, arsenic, uranium). Kidney damage will be assessed by analyzing serum samples for creatinine (used to estimate glomerular filtration rate) and by analyzing urine samples for creatinine, albumin, neutrophil gelatinase-associated lipocalin (NGAL) and interleukin-18 (IL-18). The urine analytes NGAL and IL-18 are considered novel markers of tubular injury. Linear regression models will be used to evaluate predictors of kidney injury, estimated glomerular filtration rate and metals exposure. All data will be analyzed using SAS statistical software.

Expected Results

Among sugarcane workers, biomarkers of kidney damage are expected to increase during the harvest season and to be different by job category, suggesting an occupational component to the disease. Workers in other industries also are likely to have elevated biomarkers of kidney injury, indicating that CKD is affecting nonagricultural workers in the region. Exposure to heavy metals is predicted to be different by job category and positively associated with biomarkers of kidney damage. Finally, low proteinuria and high tubular marker levels area expected, indicating that the kidney disease is tubulointerstitial and not glomerular in nature.

Potential to Further Environmental/Human Health Protection

The epidemic of CKD in Central America is a severe public health crisis. The very limited access to renal replacement therapy in the region means that the majority of people diagnosed with CKD will die. This research will provide valuable information about the type of kidney damage and the potential causes of the CKD epidemic, with public health implications that will likely extend to other affected regions outside of Nicaragua.



Elizabeth Ann Stanford

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Project Officer: Gladys Cobbs
Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Biochemistry

Bio

Elizabeth Stanford received a B.S. in Biology and a B.A. in Anthropology from Union College (New York) in 2009. The following fall she enrolled in a Public Health program with a focus in Environmental Health at Boston University School of Public Health. After receiving her M.P.H. in 2012, Elizabeth entered the Ph.D. program in Molecular and Translational Medicine at Boston University. Her research interests include the impact of environmental exposures on cancer progression and stem cell biology, as well as the translation of her work to stakeholders including regulatory agencies and the public at large.

Synopsis

It is postulated that exposures to environmental chemicals play a role in inducing and exacerbating breast cancer. Many environmental pollutants associated with breast cancer activate an environmental chemical receptor, the aryl hydrocarbon receptor (AHR). When activated, the AHR initiates changes within normal breast cells that can lead to aggressive breast cancer. This research aims to explore the role of the AHR in the control of a lethal subset of cells termed breast cancer stem cells.

Keywords: aryl hydrocarbon receptor, breast cancer, environmental pollutants

The Effect of an Environmental Chemical Receptor on Breast Cancer Stem Cell Development, Function and Maintenance

Objective(s)/Research Question(s)

Recent studies suggest a role for AHR activation by environmental chemicals in breast cancer initiation and invasion. The AHR also is a known regulator of various stem cell lineages, suggesting a possible role for the AHR in generating chemotherapy-resistant, metastatic cancer stem cells. The mechanisms through which the AHR effects these outcomes are unknown. This research will focus on defining the functional relevance of AHR activation by environmental chemicals to breast cancer stem cell (BCSC) development and function.

Approach

Although representing only a small percentage of the whole tumor, BCSCs are believed to be extremely resistant to chemotherapeutics and, thereby, to be responsible for the recurrence and lethal spread of cancer cells after treatment. Preliminary data indicate that activation of the AHR by various environmental chemicals contributes to the development and/or maintenance of BCSCs. This research will compare the ability of a series of environmental AHR activators, including environmental pollutants found to be associated with breast cancer risk in population-based, epidemiological studies, to increase the number of BCSC-like cells and to drive the emergence of more aggressive, drug-resistant cells. Subsequently, a "snapshot" will be developed of the genetic changes occurring after human breast cancer cells are exposed to environmental AHR stimulators, to map out the genetic mechanisms through which these chemicals influence BCSC development and/or survival.

Expected Results

Based on preliminary findings from a variety of assays evaluating the effect of environmental AHR activators on human cancer cells, it is highly likely that the AHR is controlling the breast cancer stem cell population. These results will help create an invaluable platform for studying AHR signaling in a unique and critical cancer cell subset. Breast cancer stem cells are resistant to chemotherapeutics and responsible for metastasis formation, the cause of death in the majority of breast cancer patients. Collectively, these data will determine the extent to which environmental AHR ligands influence nominal signaling pathways in breast cancer stem cells, helping to elucidate the impact of chemical exposures on cancer malignancy.

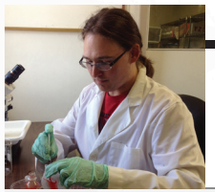
Potential to Further Environmental/Human Health Protection

Understanding the contribution of the AHR to development and/or maintenance of breast cancer stem cells will increase understanding of the basic molecular biology of this important cancer cell subset and will help assess the likelihood that environmental chemicals play a role in BCSC development and/or survival. This work represents an important next step in building the argument toward breast cancer prevention through elimination of environmental AHR activators.

HUMAN HEALTH RISK ASSESSMENT

Environmental pollution is an incurable disease.
It can only be prevented.
– *Barry Commoner*

Risk Assessment and Risk Management



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Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental Toxicology

Bio

Dan Dawson received his B.S. and M.S. degrees in Wildlife Ecology and Conservation from the University of Florida in 2004 and 2007, respectively. Before starting his Ph.D. work at Texas Tech University in 2012, Dan worked for the State of Texas in different capacities—as an environmental regulator, an extension assistant and a scientific researcher. His research interests include using ecological modeling to address human-environmental conflicts. His current research involves modeling spatially explicit disease-vector population dynamics and disease risk.

Synopsis

Mosquito-borne disease is a complex problem that exists on a global scale. Responses to mosquito-borne disease risk are usually reactive and can involve wide-scale chemical applications. However, mitigation efforts that are proactive and consider spatial variability in risk may be more efficient and effective. This research focuses on developing predictive models of mosquito-borne disease risk as a function of mosquito population dynamics in spatially heterogeneous landscapes.

Keywords: disease risk, modeling, mosquitoes

Management of Mosquito-Borne Disease Risk Through Spatially Explicit Simulation Modeling

Objective(s)/Research Question(s)

The mitigation of mosquito-borne disease risk is often reactive and frequently accomplished through wide-scale chemical application. However, environmental and anthropogenic influences on mosquito populations interact, making mosquito-borne disease risk spatially heterogeneous across a landscape. The objective of this research is to develop and test spatially explicit models of mosquito population dynamics and disease risk that consider both environmental factors and mosquito-control activities.

Approach

This research will be accomplished in several stages. First, mechanistic population dynamic models for mosquito vectors will be created that explicitly consider both environmental (e.g., temperature, habitat) and anthropogenic (e.g., mosquito control) factors. Next, models will be integrated into a geographic information system (GIS) to simulate and evaluate their behavior in a spatially explicit environment. Last, these spatial models will be adapted to an actual landscape, potentially the high plains of Texas, and compared and evaluated for their reliability and predictive ability in a real-world environment.

Expected Results

The control of mosquitoes can be costly, involving the purchase of chemicals, the operation of equipment and vehicles and many personnel hours of work. In addition to these monetary costs, there are unknown ecological costs associated with the release of pesticide chemicals into the environment. The expected results of this research are GIS-based tools that may be used by mosquito-control authorities to predictively inform their activities, so that they may be more efficient and effective at accomplishing their goals of reducing disease risk and/or nuisance problems.

Potential to Further Environmental/Human Health Protection

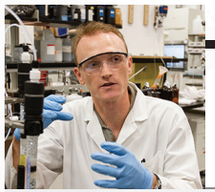
This research will provide guidance to mosquito-control authorities in the form of GIS-based modeling tools that will help predict where mosquito control can be applied to most effectively reduce disease risk under varying conditions, thereby protecting human health. Furthermore, by increasing the efficiency of these efforts, the use of resources and pesticides can be fine-tuned which help will reduce risks to ecological systems.


SAFE &
SUSTAINABLE
WATER RESOURCES

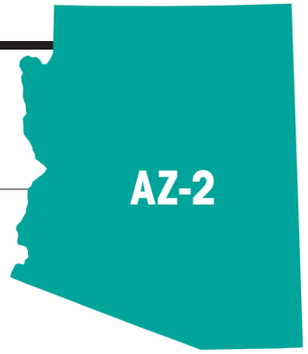
SAFE & SUSTAINABLE WATER RESOURCES

Anyone who can solve the problems of water
will be worthy of two Nobel prizes—
one for peace and one for science.
–John F. Kennedy

Drinking Water



James McKay Gifford



Simultaneous Removal of Inorganic Pollutants by Sorbents for Small Drinking Water Systems

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Project Period: 8/21/2014–8/21/2016
Project Amount: $84,000
Environmental Discipline: Civil/Environmental Engineering

Bio

Mac Gifford is dedicated to becoming a leader in water resource engineering. He earned a B.S. in Civil Engineering from the University of Arizona. He then worked in consulting engineering for 5 years, designing water infrastructure. He returned to graduate school at Arizona State University earning an M.S. in Environmental Engineering, with a certificate in Sustainable Technology and Management. He now pursues a Ph.D., researching drinking water treatment.

Synopsis

Drinking water treatment in small rural communities is challenging because they often lack the expertise needed to remove multiple contaminants. The goal of this research is to develop the science and technology of removing multiple inorganic pollutants, such as hexavalent chromium, arsenic and nitrate. Novel, simple-to-operate sorbents will use iron hydroxide or titanium dioxide nanoparticles within an anion exchange resin to improve drinking water quality in small systems.

Keywords: drinking water, simultaneous removal, small systems

Objective(s)/Research Question(s)

This research proposes to develop the science and technology of sorption processes for simultaneous removal of such inorganic pollutants as hexavalent chromium, arsenic and nitrate. It seeks to develop testing protocol and evaluation methodology, create new sorbents and mechanistically understand how the simultaneous removal occurs.

Approach

A protocol will be developed for evaluating simultaneous removal capacity using batch equilibrium testing, packed-bed column testing and pilot well-head testing of existing sorbents in waters containing mixtures of pollutants. New sorbents will be created by forming metal nanoparticles made of iron hydroxide or titanium dioxide within the porous structure of anion exchange resins. The synthesis of these sorbents will be optimized using the testing protocol and other physical characterization. Mechanistic explanations will describe how simultaneous removal occurs in the metal nanoparticle-infused sorbents.

Expected Results

It is suspected that existing sorbents have limited capacity to remove multiple pollutants, indicating a need for new, better-performing, options. It is expected that metal nanoparticles will add a high capacity to remove a second pollutant without a significant loss in capacity for the original target pollutant of the anion exchange resin. This will demonstrate that simultaneous removal of pollutants can be cumulative or synergistic and need not be competitive. The model describing the pollutant removal should indicate how diffusion or the number of reactive sites limits the new sorbents. It could then predict the performance of any metal-infused ion exchange sorbent given specific water quality parameters, allowing preliminary screening of treatment options without expensive laboratory or pilot testing.

Potential to Further Environmental/Human Health Protection

Small rural communities face challenges in providing clean drinking water due to few source water options, lack of specialized personnel and the need to meet multiple treatment objectives. These very small systems represent around 80% of contaminant level violations, but the people they serve are entitled to a clean water supply. A single, simple-to-use sorbent process with simultaneous treatment capacity may reduce human exposure to inorganic contaminants in these small communities.

Nadine Kotlarz

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Project Officer: Gladys Cobbs
Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental Engineering

Bio

Nadine Kotlarz received her B.S. in Environmental Engineering from Lehigh University in 2007. She taught seventh grade for 2 years in Chicago and then developed energy efficiency workshops as a junior engineer for Shaw Environmental. She began her graduate studies in environmental engineering at the University of Michigan in 2011. Her research interests include investigating the link between bacteria in tap water and bacterial infections in immunocompromised persons.

Synopsis

Municipally treated tap water contains diverse bacterial communities, which can lead to severe illness in elderly and immunocompromised individuals. This research proposes to investigate the spatial distribution of bacterial communities in premise plumbing along the drinking water flow path to the tap. The goal is to better understand what physical, chemical and biological factors control the presence of opportunistic pathogens in premise plumbing and to define the risk that drinking water poses as a source of bacterial infections in immuno-compromised individuals.

Keywords: drinking water, opportunistic pathogens, premise plumbing

Biogeography of Drinking Water Bacteria Along a Premise Plumbing Flow Path

Objective(s)/Research Question(s)

Most of the U.S. population receives municipally treated drinking water, which contains diverse bacterial communities that are safe for the majority of healthy individuals, but can result in severe illness in elderly and immunocompromised individuals. This research will determine the relative importance of environmental selection and dispersal limitation in shaping the bacterial communities in tap water, assess the degree to which opportunistic bacterial species are found in tap water and identify the physical, chemical and biological conditions that favor their growth in premise plumbing.

Approach

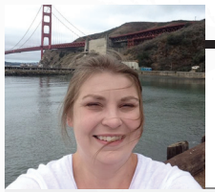
Water and biofilm samples will be collected along the drinking water flow path from the distribution system to the tap in premise plumbing (e.g., at the kitchen faucet aerator, in the hot water heater, at the showerhead). Culture-independent, next-generation DNA sequencing technology will be used to characterize the bacterial community dynamics in premise plumbing and determine under what physical and chemical conditions opportunistic bacterial groups (e.g., *Pseudomonas, Mycobacterium*) are found at highest abundance. Occupancy-abundance relationships will be generated to investigate whether the abundance of certain bacterial groups in premise plumbing can be explained by their abundance in the distribution system.

Expected Results

Overnight stagnation of drinking water in premise plumbing is expected to favor the formation of bacterial communities with less diversity which will be more susceptible to invasion by opportunistic bacterial species. Plugs of drinking water that sit stagnant near flush points (e.g., faucet aerators, showerheads) and which come into contact with biofilms at the flush points will represent distinct environments that result in higher counts of opportunistic bacterial species. Locations of reduced disinfectant and higher temperature along the flow path, for example in pipes located near heating units, will result in increased counts of opportunistic bacterial species and virulence factors.

Potential to Further Environmental/Human Health Protection

More waterborne disease outbreaks in the United States are attributed to opportunistic microbes that persist and grow in premise plumbing than to pathogenic microorganisms leaving the drinking water treatment plant. Determining the conditions that favor growth of opportunistic bacteria in premise plumbing and the critical points of human exposure to opportunistic bacterial species is necessary to develop novel strategies to mitigate the risk of opportunistic bacterial infection for immunocompromised individuals.



Amie Elizabeth Norton

Heterogeneity in the Response of Platinum/Polymer Hybrid Films to Aqueous Perchlorate

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Project Period: 8/25/2014–8/25/2016
Project Amount: $84,000
Environmental Discipline: Chemistry

Bio

Amie Norton received a B.S. degree in Chemistry from the University of Missouri in 2009. That fall, she started a Ph.D. program in Chemistry at the University of Cincinnati. Currently, Amie is developing luminescent sensors for the detection of hazardous anions in drinking water, such as perchlorate. Her research interests are luminescent platinum (II) complexes, sensor development and methods for loading platinum (II) complexes into porous materials. Her current research focus on developing a low-cost platinum (II) sensor for the detection of perchlorate in drinking water, at relevant EPA levels.

Synopsis

Despite the importance of monitoring anion levels in the environment, the rapid, onsite and low-cost detection of certain anions (e.g., oxyanions) with high selectivity and sensitivity remains a significant challenge. EPA-approved methods for perchlorate are expensive and cumbersome in the field, and current portable methods are unproven in the field. The focus of this project is to develop assessment tools to characterize and quantify the occurrence of contaminants in drinking water.

Keywords: drinking water, perchlorate, sensors

Objective(s)/Research Question(s)

A platinum hybrid film can detect perchlorate; at 0.1 ppb, the emission from the films changes to an intense red color due to formation of a unique platinum salt. However, the underlying chemistry is not understood well enough to optimize this technology. At concentrations and solution volumes where the amount of platinum in the film exceeds the amount of available perchlorate, the films still exhibit a measureable response. Those films show luminescent hot spots, suggesting a surprising heterogeneous distribution of a platinum perchlorate salt. The focus of this research is to characterize the platinum and perchlorate distribution in perchlorate-exposed films and identify the role of the polymer in perchlorate uptake from solution.

Approach

Red luminescent hot spots appear when the amount of perchlorate in solution is less than the amount of platinum in a film. The working hypothesis is that the distribution of perchlorate and/or platinum in these films is heterogeneous. To test this idea, the luminescence from films will be imaged. Intensity histograms (from Matlab) will be used to map the heterogeneity and identify patterns in distribution of hot spots (e.g., near edges or wrinkles in the film). Subsequently, inductively coupled plasma mass spectrometry (ICP-MS) will be used determine the platinum and chlorine content in the yellow and red luminescent sections. The influence of the polymers on perchlorate uptake will be determined initially by investigating films without CPG particles or platinum salt. The hypothesis is that perchlorate has a tendency to partition into the polymer film and therefore contributes to the sensitivity of this system. The partition coefficient will be determined by using an ion-selective electrode (or ICP-MS for low concentrations) to measure perchlorate concentration in solution (csol). The concentration in the film (cfilm) will be inferred from the difference between the initial concentration and csol. The resulting distribution coefficients (K_d=cfilm/csol) will provide a measure of partitioning.

Expected Results

To broadly disseminate the results and enhance scientific understanding, an open website will be created showing video clips of the response of platinum salts to anions. Through collaboration with a local high school, students in science classes (grades 8–12) will have hands-on experience with these hybrid materials. In one planned activity, students will test the colorimetric/luminescence response on water samples that they will collect in the greater Cincinnati area. The plan is to engage students in the process of documenting their activities (e.g., video clips) and posting these on the website. This project is expected to promote science literacy among the students, as well as among any other visitors to the website. A workshop will be held for rising 9th graders to spend a week in the laboratory preparing their own sensors for hazardous anion in drinking water. Finally, the research is expected to benefit society as a whole, primarily through enabling new technologies, which will promote better drinking water quality. This technology can be expanded to other anions such as nitrate. Also this work can be expanded to the vapochromic work already done in the laboratory at the University of Cincinnati. In addition, what is learned is expected to lay the foundation for strategies for designing highly sensitive, selective, easily used, inexpensive, rapid and portable luminescence-based sensors for aqueous anions, such as perchlorate. Pacific Northwest Laboratory is expected to use this material to detect TcO_4^-, a radioactive water contaminant.

Potential to Further Environmental/Human Health Protection

This project will move toward developing a sensor for the onsite detection of perchlorate using a sensitive and selective platinum complex. This project also will engage high school students to make them more aware of environmental hazards and possible solutions.

Patrick Owen Saboe

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Project Amount: $84,000
Environmental Discipline: Chemical Engineering

Bio

Patrick Saboe graduated from the University of New Haven (Connecticut) in 2011 with a B.S. in Chemical Engineering and is pursuing a Ph.D. in Chemical Engineering at Pennsylvania State University. He has interned at the Mascaro Center for Sustainable Innovation at the University of Pittsburgh and was a visiting researcher at Harvard Medical School in the Walz Laboratory of Electron Microscopy, where he researched the permeability of aquaporin proteins. His current research interests include utilizing two-dimensional (2-D) crystals of channel proteins for applications in water treatment.

Synopsis

Drinking water supplies are challenged by scarcity, contamination, population growth and industrial demands. Emerging contaminants have been identified as difficult to remove by traditional membrane technologies. The development of biomimetic membranes for desalination may offer solutions to the challenges facing fresh water supplies. This research will examine how to integrate proteins found to efficiently filter water at the cellular level into robust synthetic membranes for large-scale water treatment.

Keywords: biomimetic membranes, desalination, two-dimensional crystals

Water Purification and Desalination Using Two-Dimensional Crystals of Channel Proteins

Objective(s)/Research Question(s)

The goal is to develop an efficient bio-inspired membrane technology for sustainable water filtration. It is driven by the high permeability and selectivity of biological water channel proteins, including aquaporins and outer membrane proteins. This project will focus on incorporating high-density 2-D crystals of channel proteins into synthetic block copolymer membranes.

Approach

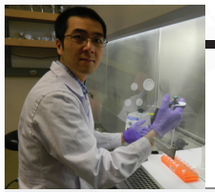
In this project, channel proteins will be crystallized within block copolymer membranes to provide functional and stable material for water filtration. Channel proteins, such as Aquaporin 0 and Outer membrane protein F, are known to form well-ordered 2-D crystals within lipid membrane. Membrane protein compatible block copolymers such as the di-block polybutadiene-polyethyleneoxide polymer provides a stable alternative to sensitive lipid molecules. High-density protein crystals in block copolymers will be characterized by electron microscopy and atomic force microscopy. The permeability and selectivity of the 2-D crystals will be monitored using a laboratory scale filtration setup.

Expected Results

The results of this project will demonstrate the feasibility of forming functional hybrid protein/polymer 2-D materials for water purification. The results will provide fundamental information regarding the design of protein-compatible polymers and will define the permeability and selectivity of the designed membranes for scaled-up systems. Structural information and data on the long-term stability of the membranes will be gained from the work.

Potential to Further Environmental/Human Health Protection

Biological membrane proteins with high selectivity are optimum for the removal of emerging contaminants such as endocrine-disruptor compounds, personal care products and pharmaceutically active compounds. The developing low-energy biomimetic membrane technology will promote water recycling and linked renewable energy operating systems.



Peiran Zhou

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Project Period: 9/24/2014–9/24/2016
Project Amount: $84,000
Environmental Discipline: Environmental Engineering

Bio

Peiran Zhou received his B.E. in Environmental Engineering from Sichuan University in Chengdu, China, in 2010. In 2012, he received his M.S. degree from the University of Washington and started a Ph.D. program in Environmental Engineering at the University of Washington. His research interests are water quality and public health. His current research is to use sunlight to generate reactive oxygen species during chlorine photolysis and thus improve chlorine disinfection.

Synopsis

Chlorine is inexpensive and effective for most waterborne pathogens. However, it is not effective for some pathogens, such as *Cryptosporidium parvum*. The cryptosporidiosis outbreak in 1993 led to substantial shifts to more expensive alternative disinfectants, such as ozone. This research uses sunlight to generate a more powerful combination of disinfectants, i.e., ozone and hydroxyl radical, in the chlorine solution and thus provide an effective and cheap way of enhancing the effectiveness of chlorination.

Keywords: chlorine, disinfection, drinking water

Sunlight-Driven Photolysis of Chlorine to Reactive Oxygen Species for Enhanced Inactivation of Chlorine-resistant Microbial Pathogens

Objective(s)/Research Question(s)

This research will investigate the use of chlorine photolysis as a sustainable approach to enhancing the effectiveness of chlorine-based disinfection processes. It also will generate data sets of inactivation rate constants and CT values (disinfectant exposure) required for the inactivation of selected chlorine-resistant pathogens—i.e., *Mycobacterium avium*, Coxsackievirus B5 (CVB5) and *C. parvum*—during the sunlight-chlorine disinfection process and will enable modeling and optimization of the chlorine photolysis process, with the ultimate objective of facilitating practical implementation.

Approach

The first stage of the research will use *Bacillus subtilis* spores as a model chlorine-resistant microorganism to validate and optimize the sunlight-chlorine disinfection process by changing irradiation time, initial chlorine concentration, pH, etc. The second stage of the research will apply the optimized treatment condition to inactivate chlorine-resistant pathogens (*M. avium*, CVB5 and *C. parvum*) and generate data sets of inactivation rate constants and CT values of selected microorganisms.

Expected Results

The key outcomes of the research will include (1) validation and optimization of the sunlight-chlorine disinfection approach to determine its effectiveness for inactivation of chlorine-resistant microbial pathogens in real water matrices and (2) generation of data sets of inactivation rate constants and CT values of *M. avium*, CVB5 and *C. parvum* inactivation by the proposed process under a wide variety of conditions (e.g., changes in solar irradiation, temperature and pH).

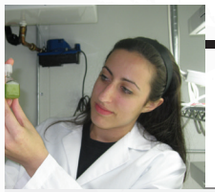
Potential to Further Environmental/Human Health Protection

The proposed water treatment approach could provide a simple, effective, inexpensive and sustainable water disinfection process to inactivate chlorine-resistant pathogens. More important, this can provide a revolutionary way to produce safe drinking water in point-of-use applications, such as backpacking, military operations and emergency water treatment following natural disasters.

With every drop of water you drink,
every breath you take, you're connected to the sea.
No matter where on Earth you live.
– *Sylvia Earle*

SAFE & SUSTAINABLE WATER RESOURCES

Water Quality—Coastal and Estuarine Processes



Rachel Golda

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Project Officer: Gladys Cobbs
Project Period: 9/29/2014–9/29/2016
Project Amount: $84,000
Environmental Discipline: Environmental Science and Engineering

Bio

Rachel Golda received her B.S. in Biology from Saint Martin's University (Washington) in 2010. She received her M.S. in Environmental Science and Engineering from Oregon Health and Science University (OHSU) in 2011. She is currently pursuing doctoral studies in the same field at OHSU. Her research interests include algal toxins and emerging environmental problems. Her current research explores the effect of ocean acidification on toxin production by harmful marine algae.

Synopsis

Although negative effects of individual human-driven environmental problems are well characterized, interactions between these problems and other environmental challenges remain largely unexplored. This research proposes to define linkages between the anthropogenically mediated problem of ocean acidification and the natural environmental challenge of harmful marine algal blooms. Special attention will be given to how ocean acidity affects toxin production and life cycle changes in toxic algae.

Keywords: chemostat, harmful algal blooms, ocean acidification

Elucidating the Role of Ocean Acidification in Estuarine Phytoplankton Dynamics

Objective(s)/Research Question(s)

Increased stress resulting from environmental pressures has been shown to increase toxin production in harmful marine algae. This project utilizes a novel autonomous algal culturing system to study the effect of the emerging environmental stressor of ocean acidification on algal toxin production and to determine what drives these effects on an intracellular level.

Approach

A novel autonomous pHstat/chemostat system will be designed and built to mimic the conditions of ocean acidification in a laboratory environment. The pHstat will maintain varying degrees of environmental acidity for extended periods of time, allowing determination of possible long-term ecosystem effects. Relationships between algal toxin levels and cell stress, and between toxin levels and environmental acidity, will be identified. The effects of environmental acidity on cellular processes and reproduction also will be determined, which will elucidate how this relates to toxin production.

Expected Results

Increased algal toxin production has been related to physiological stress induced by environmental pressures. Increased environmental acidity, such as that which is exhibited during ocean acidification, has been shown to cause stress in a number of marine microbes. It is therefore likely that increased ocean acidity will cause a concurrent increase in algal toxin production. As a measure of acidity, pH has been shown to exert direct control on the cell cycle of all living creatures. Toxin production in algae has been directly linked to the cell cycle. It is therefore likely that ocean acidification exerts a damaging effect on organisms at the intracellular level and can directly influence the behavior of the organism by controlling progression of the cell cycle and, thus, cellular processes and reproduction.

Potential to Further Environmental/Human Health Protection

Knowledge gained from this research may be used to develop predictive models of algal toxin distribution in coastal environments. This research also can be used to elucidate previously unknown collateral damage of interactions between emerging environmental problems. This knowledge will allow ecosystem managers to take a more aggressive approach in limiting human exposure to algal toxins, and it will be of great use to policymakers in assessing environmental and human health risks associated with emerging environmental problems.

Mary Rose Gradoville

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Project Period: 9/29/2014–9/29/2016
Project Amount: $84,000
Environmental Discipline: Oceanography

Bio

Mary Rose (Rosie) Gradoville received a B.A. in Biology from Barnard College, Columbia University (New York), in 2010. She went on to study microbial oceanography at Oregon State University, where she received her M.S. degree in the College of Earth, Ocean and Atmospheric Sciences in 2013. Rosie is currently a Ph.D. student at Oregon State; her research interests include marine carbon and nitrogen cycling, microbial processes and ocean acidification.

Synopsis

The last several years and decades have witnessed declines in Pacific Northwest natural oyster populations and larval oyster success in hatcheries. These declines have been linked to both ocean acidification and infection by the marine bacterium *Vibrio tubiashii,* a known shellfish pathogen. This research proposes to investigate how oceanic conditions affect the abundance and toxicity of *V. tubiashii* in its free-living state, as well as possible linkages between ocean acidification and *V. tubiashii* virulence.

Keywords: ocean acidification, Oregon estuaries, V. tubiashii

Environmental Controls of the Abundance, Growth and Toxicity of the Known Shellfish Pathogen *Vibrio tubiashii*

Objective(s)/Research Question(s)

Vibriosis outbreaks in recent years have been devastating to Northwest oyster stocks and hatchery success. This research aims to investigate the biogeochemical and oceanic conditions controlling the abundance, growth and pathogenicity of the bacterium *V. tubiashii*.

Approach

The environmental controls of *V. tubiashii* growth and toxicity will be examined using a combination of observational fieldwork and laboratory experiments. In the laboratory, optimal conditions for growth and toxicity will be characterized by monitoring *V. tubiashii* isolates subjected to treatments of varying temperature, CO_2 and O_2 regimes. In the field, the abundance and toxicity of *V. tubiashii* in local Oregon estuaries and coastal waters will be measured. Field sampling will focus on Netarts Bay, Yaquina Bay and transects off the Oregon coast; sampling will target the coastal upwelling season, with time points across the tidal cycle. Through all of these experiments, the abundance of *V. tubiashii* will be determined through quantitative polymerase chain reaction as well as traditional plating methods, and toxicity will be determined through oyster larvae toxicity assays. Data generated from laboratory and field experiments will relate the abundance and toxicity of *V. tubiashii* to biogeochemical regimes and local physics.

Expected Results

The study will use multiple approaches to determine the environmental regulation of *V. tubiashii* growth and virulence. Preliminary environmental sampling and manipulative experiments suggest that *V. tubiashii* abundances in the Northwest may be linked to climatic conditions within the California Current upwelling regime; however, the scarcity of existing data make this suggestion speculative. This research will use controlled experiments to test how seawater chemistry affects *V. tubiashii*, then correlate *V. tubiashii* abundance and toxicity with environmental conditions in Oregon estuaries and coastal habitats. It is hypothesized that high *V. tubiashii* abundances are associated with specific oceanic conditions, such as strong upwelling followed by positive temperature anomaly, and that *V. tubiashii* and environmental conditions (such as ocean acidification) synergistically induce larval mortality.

Potential to Further Environmental/Human Health Protection

Vibriosis outbreaks in recent years have been devastating to oyster stocks and hatchery success in the Northwest, and these events have been sporadic and unpredictable. The knowledge gained from this research could be used by hatcheries to predict the risk of vibriosis from a combination of current ocean conditions and easily monitored parameters of incoming seawater (e.g., pCO_2, temperature). More broadly, a mechanistic understanding of the forcing of *V. tubiashii* and the synergistic impact of ocean acidification and vibriosis on larval development would be valuable to nascent oyster restoration projects ongoing on the West coast.

Emily Bonnell Graham

CO-2

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Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Emily Graham received a B.S. in Biology from the University of North Carolina at Chapel Hill in 2009. In 2012, she earned an M.S. specializing in Biogeoscience from the Environmental Studies Program at the University of Colorado at Boulder, and she is now pursuing a doctoral degree in the same program. Her current research interests are in the interplay of microbial and biogeochemical factors in regulating ecological processes such as nutrient and pollutant cycling.

Synopsis

Chemical cycling of mercury pollution within freshwater wetlands can lead to the bioaccumulation of methylmercury in plants and animals, yet the relative roles of biological and chemical factors in regulating mercury cycling are not well understood. This research will apply microbiological and geochemical techniques to investigate methylmercury production along vegetation gradients within a contaminated estuary at the base of Lake Superior. The results should increase understanding of mercury methylation and help mitigate human exposure to toxic methylmercury levels.

Keywords: microbiology, Great Lakes, mercury

Biotic and Abiotic Controls Over Mercury Methylation in the St. Louis River Estuary: An Examination of Seasonal and Vegetative Influences

Objective(s)/Research Question(s)

Methylmercury is a potent neurotoxin that strongly bioaccumulates in plant and animal tissue, exposing humans to high levels of toxicity through fish and rice consumption, a significant economic and human health concern in the Great Lakes region. Most environmental mercury contamination originates from fossil fuel combustion and mining activity and is deposited into ecosystems in a relatively harmless inorganic form. Microbial methylation within anoxic sediments, however, converts inorganic pollutants into methylmercury, dramatically increasing mercury's bioavailability. Yet, the role of biotic and abiotic factors in mercury cycling is not well understood. This project will use a suite of molecular microbiological techniques to unravel the controls over mercury cycling along seasonal and spatial gradients within the Lake Superior National Estuarine Research Reserve (LSNERR) in Superior, Wisconsin.

Approach

Microcosm incubation experiments will be used to determine the controls over mercury methylation in the St. Louis River Estuary. Within these incubations, dissolved organic matter (DOM) concentrations and characteristics will be manipulated across vegetative gradients to examine the impact of changing DOM source matter and loadings on mercury methylation while changes in microcosm chemistry are monitored using standard biogeochemical techniques. Next-generation sequencing of the 16S rRNA gene will elucidate changes in the relative abundance of key microbial community members that affect mercury methylation.

Expected Results

The relative abundance and diversity of sulfate-reducing bacteria, iron-reducing bacteria and methanogens, as well as the concentrations, stoichiometries and speciation of sulfur, iron and carbon in St. Louis River sediments are expected correlate with rates of mercury methylation. Vegetated areas are expected to experience higher rates of mercury methylation than unvegetated zones due to differences in microbial communities and organic matter content and chemistry; however, the effect of DOM additions on mercury methylation and microbial community structure should be more pronounced in unvegetated microcosms, because mercury methylation in these microcosms should be carbon-limited. Correlations between microcosm chemistry, DOM characteristics, microbial communities and mercury methylation should help elucidate differences in the factors regulating mercury methylation across vegetative gradients.

Potential to Further Environmental/Human Health Protection

This project will aid the remediation of aquatic heavy metal pollution in an environmentally sensitive and economically important area. The results of this study should add to mechanistic understandings of the geochemical and microbial factors that regulate mercury methylation and in turn, aid in preserving clean water, protecting human food supplies and mitigating exposure to mercury toxicity.

Hannah Joy-Warren

The Role of Changing Polar Phytoplankton Communities in Global Carbon Cycling

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Project Period: 9/22/2014–9/22/2016
Project Amount: $84,000
Environmental Discipline: Oceanography

Bio

Hannah Joy-Warren completed her B.Sc. in Geophysical Sciences at the University of Chicago in 2012, after which she spent a year working as a research assistant at Woods Hole Oceanographic Institution. In 2013 she began a Ph.D. program at Stanford University, where she is studying phytoplankton community dynamics under changing nutrient regimes in the polar regions. She is especially interested in understanding the role phytoplankton play in global biogeochemical cycling.

Synopsis

While Harmful algal blooms (HAB) often threaten environmental health, the genus *Phaeocystis*, which includes HAB species, plays a unique ecological role in global carbon (C) cycling. *Phaeocystis* is especially efficient at removing C from surface waters, thus enhancing air-sea CO_2 exchange. Whether *Phaeocystis* is harmful or beneficial depends on its distribution and abundance, which is regulated in part by nutrient availability. Understanding these dynamics will help us understand global C cycling.

Keywords: carbon cycling, harmful algal blooms, polar regions

Objective(s)/Research Question(s)

Harmful algal bloom (HAB) species pose both an environmental and human health threat. Some species of *Phaeocystis* are considered HAB species due to their large, productive blooms and subsequent oxygen depletion during cellular degradation. *Phaeocystis* is found throughout the world's oceans and its large blooms contribute substantially to global carbon cycling, however the biogeochemical dynamics that mediate *Phaeocystis* populations are not yet fully understood. This research will help to understand the mechanisms, including light and nutrient availability, that govern whether *Phaeocystis* populations dominate the natural phytoplankton assemblage in polar regions.

Approach

This research will be conducted through fieldwork in the Arctic and Antarctic during the phytoplankton growing season. Fieldwork will include analysis of the natural phytoplankton communities and measurements of physiological parameters through both field population measurements and shipboard incubation experiments. Field data will be coupled with satellite remote sensing. This will provide a greater spatial and temporal perspective on the contribution of *Phaeocystis* to global biogeochemical cycling.

Expected Results

Phaeocystis is an environmentally and biogeochemically important genus that differs from other phytoplankton groups (such as diatoms) in its nutrient requirements, thereby playing a different role in the ecosystem. *Phaeocystis* can uptake more carbon per unit of phosphorus than the globally averaged phytoplankton carbon-to-phosphorus uptake ratio. As a result, *Phaeocystis* is uniquely efficient at removing carbon from surface waters, thus enhancing air-sea carbon dioxide exchange. Nutrient availability affects the distribution of different phytoplankton species and alters the community composition. Given the different nutrient requirements for *Phaeocystis* and diatoms, a different community composition could have a large effect on local and global biogeochemical cycling and, more specifically, the carbon cycle.

Potential to Further Environmental/Human Health Protection

Understanding *Phaeocystis* population dynamics and its role in global biogeochemical cycling is essential to understanding the changing carbon cycle. With increasingly rapid changes occurring in the polar regions, it is essential to understand how natural phytoplankton communities will respond and how this response will further alter global carbon cycling and, more generally, global biogeochemical cycles.

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Project Period: 7/1/2014–7/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental and Water Science

Bio

Aric Mine received a B.S. in Geology from Rensselaer Polytechnic Institute (New York) in the spring of 2009 and began a Ph.D. program at the University of Chicago the following autumn. His research interests focus on nutrient cycling in aquatic ecosystems and the role of microbes in regulating biogeochemical cycles. Aric's current research addresses microbial phosphorus cycling and its link to carbon cycling and carbon export in marine, riverine and lacustrine systems.

Synopsis

High nutrient concentrations in the Mississippi and Atchafalaya Rivers lead to annual "dead zones" in the Gulf of Mexico. This study aims to understand the role of phosphorus in enhancing production in the Mississippi-Atchafalaya River basin and the Gulf of Mexico. The stable isotope composition of phosphate oxygen will be measured in a series of river water samples and laboratory culture experiments to reveal this measure's utility for tracking nutrient loading in the Gulf of Mexico.

Keywords: nutrients, phosphorus, stable isotopes

Phosphate Oxygen Isotope Ratios as a Tracer of Nutrient Cycling in the Mississippi River and the Gulf of Mexico

Objective(s)/Research Question(s)

The Mississippi River constitutes a significant flux of nutrients to the Gulf of Mexico where hypoxia is routinely observed. When coupled with other nutrient measurements, the $\delta^{18}O$ of orthophosphate, P_i, will yield a detailed account of nutrient dynamics within the Mississippi and extending into the gulf. This includes examination of how such systems evolve toward hypoxic conditions and their significance for ecosystems and coastal nutrient budgets. As riverine water enters the gulf, patterns in nutrient cycling, nutrient limitation and carbon fluxes may shift.

Approach

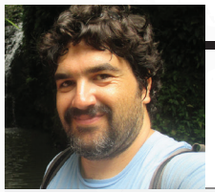
The proposed measurements on $\delta^{18}O_p$ in Mississippi River should enable tracking of Pi cycling, both within the river and as this river plume spreads into the Gulf. The sampling campaign will focus on measuring phosphate source isotopic compositions, their seasonal variation and the ways in which biological cycling modifies the isotopic composition along the river flow and into the Gulf. In conjunction with culture experiments, this work will provide a stronger mechanistic understanding of the links between measured $\delta^{18}O_p$ and P_i turnover rates and mechanisms, applicable both to the study of Gulf hypoxia and to all aquatic ecosystems.

Expected Results

A Mississippi River Atchafalaya River Basin assessment of biological nutrient cycling will determine the coupling between nutrient availability, limitation and the fate of organic carbon. The $\delta^{18}O$ value of P_i has substantial potential for tracking P_i turnover in an economically and environmentally significant region where excessive nutrient loading has led to devastating hypoxic events. This work will identify nutrients limiting and/or co-limiting primary production, determine rates of nutrient cycling and target strategies for mitigating hypoxia and nutrient loading.

Potential to Further Environmental/Human Health Protection

Identifying the effects of nutrient loading in the Mississippi River and Gulf of Mexico will provide insights toward agricultural runoff and widespread hypoxic events, which have devastating impacts on fisheries and water quality in the river and gulf. This work will provide a mechanistic link between nutrient dynamics in the Mississippi River and the Gulf of Mexico and evolution toward annual dead zones in the gulf.



Raphael David Ritson-Williams

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Project Officer: Brandon Jones
Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Zoology

Bio

Raphael earned an M.S. in Biology at the University of Guam, where he became intrigued with coral reefs and their diverse inhabitants. Raphael continued reef research while working at the Smithsonian Marine Station in Fort Pierce, Florida. This research experience exposed him to many of the management issues that threaten coral reefs throughout the tropics. Raphael wants to determine the factors that most threaten coral reefs to better inform society on the appropriate actions that can mitigate near-shore habitat destruction.

Synopsis

Corals provide the foundation for thousands of creatures in coral reefs, but much is not understood about how these habitats will respond to future stressors. Using next-generation sequencing, all of the genes involved in stress response will be quantified for corals exposed to different water quality. This project will test corals' ability to survive near-shore pollution and climate change and the corresponding impact these stressors have on coral genotypic diversity.

Keywords: adaptation, coral reef, climate change

Acclimatization of Coral Populations to Local and Global Stressors: Can Corals Adapt to Future Threats?

Objective(s)Research Question(s)

Locally, near-shore reef ecosystems are stressed and threatened by a suite of changes associated with human development, including large-scale agriculture, deforestation and stream channelization. At the global scale, seawater temperature and acidity are changing rapidly throughout the world's oceans. An outstanding question in environmental biology is whether habitat-building marine organisms can physiologically respond to this suite of stressors, and whether different populations can tolerate local degradation of water quality.

Approach

This experiment is designed to better understand how the physiological stress response of corals varies among individuals and populations. Using modern genetic tools, including next-generation sequencing, the gene expression (RNA-seq) of individual corals from multiple populations will be quantified. The gene expression of individual corals will be tested in response to multiple stressors: sedimentation, elevated seawater temperatures and those two stressors in combination. This series of experiments will reveal how corals respond to multiple stressors (individually and together) and also how this response might vary among different populations, revealing genetic architecture that might allow some coral genotypes to persist on future reefs.

Expected Results

This research is designed to use modern genetic techniques to answer three fundamental questions: (1) Can corals survive individual stressors by regulating their physiology? (2) Do corals have a different response to stress when challenged by multiple stressors at the same time? (3) Do different populations of corals have different mechanisms of response to stressors (a signal of adaptation)? The results of this research will inform managers about which stressors most threaten the persistence of corals, giving them a hierarchy of stressors that must be mitigated to ensure coral survival. In addition, this research will provide important data on whether corals can adapt locally, which is potentially an important mechanism for corals to persist in degraded habitats.

Potential to Further Environmental/Human Health Protection

Society relies on coral reefs for many ecosystem services, including a coastal buffer from storm surge, habitat for fish that humans eat and a source of sustainable revenue from tourism. As increased human development threatens near-shore marine communities, it is critical to mitigate the activities that most threaten the persistence of coral reefs. This research will provide crucial data on which stressors most threaten corals, for improved management of these diverse and important habitats.

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Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Matthew Whalen attended the College of William and Mary (Virginia), where he received a B.S. in biology and anthropology in 2006 and an M.S. in marine science in 2011. Now an ecology Ph.D. candidate at the University of California, Davis, Matt is studying how environmental variation modifies relationships between biodiversity and ecosystem functioning. His current research investigates how phytoplankton and filter feeder diversity influence water quality in a variable flow environment.

Synopsis

Biodiversity is known to enhance ecosystem functions valuable to people, yet biodiversity is changing due to human activities. This project will investigate how diversity of phytoplankton and filter feeders influences estuarine water filtration rates. Algal blooms can negatively affect coastal communities, through overproduction or the presence of toxic species; this research will contribute to understanding forces affecting the probability and severity of harmful algal blooms.

Keywords: biodiversity, ecosystem function, harmful algal bloom

Biodiversity of Native and Invasive Suspension Feeders Affects Water Quality and Potential for Harmful Algal Blooms

Objective(s)/Research Question(s)

The processes that generate harmful algal blooms are likely to involve a suite of interactions between competing algal species and their consumers. Understanding how diversity and environmental variability influence the development of harmful algal blooms will lead to better management of coastal ecosystems. This research will explore how biodiversity and water flow variability interactively determine water quality.

Approach

This research will use a suite of experiments and molecular techniques to explore how biodiversity and water flow influence filtration rates and phytoplankton coexistence in Northern California marine-fouling communities. Using a replicated array of recirculating flow chambers, phytoplankton and invertebrate filter feeder species diversity will be manipulated, as will water flow variability, to determine how these factors influence rates of biological filtration and the persistence of a variety of cultured phytoplankton species. Additionally, high-throughput DNA sequencing will be used to characterize phytoplankton communities from water column samples and from the guts of filter feeders.

Expected Results

The impact of diversity on water filtration and harmful algal blooms is expected to depend on trophic level and environmental variability. Harmful algal blooms are often dominated by a single algal species, which could result from environmental tolerance, competitive exclusion or resistance to predation. However, dominance by single, potentially harmful, algal species may be restricted by environmental variability and competitor diversity. Meanwhile, water filtration is expected to be more efficient with increasing diversity of filter feeding animals, potentially benefiting unpalatable or toxic species by alleviating competition with more palatable algae. Biodiversity could increase or decrease the likelihood and severity of harmful algal blooms, depending on the toxicity of bloom-forming algae.

Potential to Further Environmental/Human Health Protection

Results from this research will constrain evaluation of the ecosystem service of water filtration derived from fouling organisms, whose diversity in many regions is increasing due to biological invasions. Molecular techniques will provide early detection methods for aquaculture and fisheries managers to monitor phytoplankton communities and harmful algal blooms.

Access to water is a common goal. It is central in the social, economic and political affairs of the country, African continent and the world. It should be a lead sector of cooperation for world development.

– Nelson Mandela

SAFE & SUSTAINABLE WATER RESOURCES

Water Quality—Hydrogeology and Surface Water

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Project Amount: $84,000
Environmental Discipline: Geochemistry

Bio

Keaton Belli graduated with highest honors from the Georgia Institute of Technology in 2010 with a B.S. in Earth and Atmospheric Sciences. After a summer of field work and completing his undergraduate research, he began working on his Ph.D. at the Georgia Institute of Technology in the laboratory of his undergraduate advisor. His research interests revolve around developing sustainable solutions for global clean water and sanitation issues by using the symbiosis between humans and microbes.

Synopsis

For nuclear energy to compete with fossil fuels as a viable energy source, it must pose a minimal risk to the environment and public health. Developing successful remediation strategies to clean up existing or potential uranium contamination represents a fundamental step in this direction. This project will investigate the kinetic and thermodynamic controls of microbial and geochemical processes that determine the fate of uranium in contaminated subsurface aquifers.

Keywords: bioremediation, metal-reducing bacteria, uranium bioreduction

Kinetic and Thermodynamic Controls of Enzymatic Uranium Reduction in the Presence of Iron Oxide as a Competitive Terminal Electron Acceptor

Objective(s)/Research Question(s)

Uranium bioreduction—a bioremediation strategy that utilizes native metal-reducing bacteria in the subsurface to sequester and immobilize uranium as insoluble, reduced uranium minerals—is a cost-effective remediation strategy to address uranium-contaminated groundwater associated with nuclear facilities. The ability to predict the fate of uranium and the success of uranium bioreduction, however, is complicated by multiple reduction mechanisms and a lack of understanding regarding the specific geochemical conditions that promote either chemical or biological uranium reduction. This research will identify the kinetic and thermodynamic constraints that control uranium bioreduction and clarify the contribution of chemical and biological uranium reduction mechanisms across a wide range of geochemical conditions.

Approach

Shewanella putrefaciens, a model metal-reducing bacteria capable of respiration on uranium and iron oxides, will be used in laboratory pure-culture incubations to identify the kinetic and thermodynamic constraints that favor either uranium or iron reduction across a range of geochemical conditions (e.g., pH, concentration of carbonate, calcium and ferrous iron). A mutant strain of *S. putrefaciens*, which is capable of iron reduction but is unable to reduce uranium, will be used to distinguish between biological uranium reduction (bioreduction) and abiotic reduction of uranium by ferrous iron, a product of iron oxide respiration. Because traditional analytical techniques used to measure uranium provide limited insight to the reduction mechanism, a novel electrochemical technique developed as part of this research will be used to quantify aqueous uranium speciation in incubations and delineate the roles of chemical and biological reduction pathways during uranium immobilization.

Expected Results

Uranium bioreduction is observed concomitantly with microbial iron reduction during large-scale field studies and laboratory incubations. Although the decrease in dissolved uranium concentrations is often attributed to biological uranium reduction, abiotic uranium reduction pathways likely also play an important role in uranium sequestration and immobilization, especially when respiration of iron oxides is more thermodynamically favorable than uranium respiration. Pure culture incubations with both wild-type and mutant metal-reducing bacteria combined with nontraditional analytical techniques will provide several lines of evidence to support the significance of multiple mechanisms of uranium reduction.

Potential to Further Environmental/Human Health Protection

Uranium represents a significant threat to both environmental and human health; therefore, cost-effective, efficient remediation strategies are needed to deal with existing uranium contamination from the Cold War Era. Additionally, as governments recognize the environmental and economic consequences of a fossil fuel-based energy sector and look to nuclear energy as an alternative energy source, reliable remediation strategies are necessary to ensure safe energy production for posterity. This research will further understanding of the biogeochemistry of uranium, which is necessary to accurately model the mobility of uranium in dynamic subsurface environments.

Keith Bouma-Gregson

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Project Amount: $84,000
Environmental Discipline: Aquatic Ecology

Bio

Keith Bouma-Gregson is a Ph.D. student in the Department of Integrative Biology at the University of California, Berkeley. He came to Berkeley after completing an M.S. degree at the University of Michigan, researching sustainable aquaculture in China. He is an aquatic ecologist studying aquatic food webs and how algae affect ecosystem function and nutrient cycling in rivers and lakes. Currently, his research focuses on the ecological and public health effects of toxic cyanobacteria in California rivers.

Synopsis

In mediterranean climates, algae in rivers are important food for aquatic organisms and are fundamental to nutrient cycling. Under certain conditions, toxic algae, called cyanobacteria, bloom in rivers threatening public health. This research will investigate the environmental conditions causing harmful algal blooms in California rivers. Identifying environmental thresholds that transform nontoxic algal communities into harmful algal blooms will help river managers maintain healthy rivers.

Keywords: cyanobacteria, harmful algal blooms, toxins

When Do Good Algae Go Bad? Flow and Nutrient Thresholds for Harmful Algal Blooms Down a River Network

Objective(s)/Research Question(s)

Harmful algal blooms are often associated with lakes, estuaries, or the coastal ocean. However, toxic cyanobacteria have been detected in California rivers and implicated in dog deaths in Northern California. These toxic algae grow on rocks in the riverbed, posing a public health threat and degrading aquatic ecosystem health. This research will investigate the environmental conditions causing harmful algal blooms in California rivers. What are the environmental thresholds that cause harmful algal blooms? How resilient to shifting into a toxic state are nontoxic algal assemblages in rivers? Do invertebrate grazers inhibit or promote the growth and spread of toxic cyanobacteria?

Approach

The research will be based on experimental field manipulations and surveys of flow, nutrients and macroinvertebrates in the Eel River in Northern California. Mini-flumes will be deployed in the river to increase or decrease the flow conditions over an algal assemblage. Algal biomass, toxin concentrations and species abundance data will be collected to document how algal assemblages respond to flow alterations. In addition, fine-scale flow measurements will be made with an acoustic Doppler velocimeter to study how hydraulic bed shear stress affects cyanobacterial accrual on the riverbed. Nutrient diffusing substrates also will be deployed to measure how nutrient concentrations affect colonization rates and growth of toxic cyanobacteria. Finally, the density of invertebrate grazers will be manipulated to determine if invertebrate grazing facilitates or inhibits toxic algal growth.

Expected Results

Low river flows are expected to increase the growth rates of toxic cyanobacteria. It is expected that cyanobacteria will not be able to accrue biomass in high-energy water because the force of the water will scour the fragile filaments off the riverbed. The effect of nutrients on toxic algae is expected to be species specific, because some toxic cyanobacteria can fix atmospheric nitrogen but others cannot. Invertebrate grazers often avoid cyanobacteria, consuming diatoms instead. If grazers are consuming other algal taxa, this could release toxic cyanobacteria from competition and increase cyanobacterial growth rates.

Potential to Further Environmental/Human Health Protection

This research will identify conditions and processes that affect the growth of toxic cyanobacteria in rivers. River managers can use this information to maintain environmental conditions that prevent the occurrence of toxic algae thereby protecting public health and maintaining productive aquatic ecosystems.

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Project Amount: $84,000
Environmental Discipline: Aquatic Ecology

Spatial and Temporal Considerations in the Primary Mountaintop Removal and Valley Fill Mining Region of West Virginia

Bio

Eric Merriam received a B.S. in Biology from Marshall University (West Virginia) in 2007 and an M.S. in Wildlife and Fisheries Resources from West Virginia University in 2009. He is currently enrolled in a Ph.D. program in Forest Resource Science at West Virginia University. His research interests include ecological modeling and watershed restoration. His current research is on modeling aquatic ecosystem response to mountaintop removal and valley fill mining in the central Appalachian region.

Synopsis

Mountaintop removal and valley fill mining within the central Appalachians result in significant impacts on downstream ecosystems. Successful management of aquatic resources will require the ability to predict ecosystem response to future mining, particularly with respect to its cumulative impact with other land uses. This research aims to construct and validate empirical models for predicting current and future aquatic condition in an effort to facilitate management and regulatory decisions.

Keywords: land use, mountaintop mining, watershed models

Objective(s)/Research Question(s)

Successful management of aquatic resources within the mountaintop removal–valley fill (MTR-VF) mining region of central Appalachia will require the ability to predict ecosystem responses to current and future land use development across large spatial and temporal scales. The overall goal of this research is to develop a process to facilitate management and regulatory decisions in the face of current and future land use change within this dynamic region. Through a regional analysis of the primary MTR-VF province of West Virginia, the specific objectives of this research are to (1) compare the predictive success of spatial models constructed at different scales and (2) field test the ability of spatially derived models to predict changes in stream conditions over time.

Approach

In-stream data will consist of invertebrate, water chemistry and physical habitat samples collected from 160 sites during the summers of 2010 and 2011. Land cover and use data will consist of cumulative natural (e.g., coal geology) and anthropogenic (e.g., mining-related land cover, residential structures, NPDES permits) landscape characteristics for all 1:24,000 segment-level watersheds. A combination of multiple regression and boosted regression tree analyses will be used to construct models predicting aquatic condition from landscape attributes across multiple spatial scales (i.e., watershed and regional). Temporal uncertainty of the spatially derived models will be assessed through forecasting. A future landscape characterization will be constructed using 2013 NAIP aerial orthoimagery, and the spatially-derived models will predict future conditions. In-stream data collected from a network of sites during the summer of 2013 will be used to compare predicted to observed in-stream conditions.

Expected Results

The hypothesis for objective 1 (i.e., comparing predictive success of spatial models constructed at different scales) is that the proper scale for model construction is the watershed scale. More specifically, the inferred cause-effect relationships will vary with spatial scale and more accurately reflect true relationships at smaller spatial scales. Consequently, predictive performance will increase with decreasing spatial scale. The working hypothesis for objective 2 (i.e., testing the ability of spatial models to predict changes over time) is that spatial patterns relating landscape attributes to in-stream conditions will allow accurate predictions associated with temporal landscape change. Strong relationships should exist between observed and predicted in-stream conditions. However, watershed-scale models will offer the best temporal predictions owing to more accurate underlying cause-effect relationships.

Potential to Further Environmental/Human Health Protection

This project will result in an integrated process that can be used to inform management (e.g., restoration) and regulatory (e.g., mine permitting and mitigation) decisions within the MTR-VF region based on current and expected future conditions. Because the MTR-VF region represents the headwaters of the Mississippi River basin, which supports one of the highest levels of biodiversity within North America, it will be critical to protect and manage these resources now and in the future. Moreover, decreased human health within the study region has been associated with degraded aquatic condition, suggesting that preserving and managing ecosystem integrity will simultaneously benefit the health of individuals living in mining-affected areas.

Adelumola Adeoye Oladeinde

Re-Growth of Pathogens in Cow Fecal Extract

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Environmental Microbiology

Bio

Adelumola Oladeinde received a B.S. in Microbiology from the University of Lagos, Nigeria in 2008. The following year, he moved to the United States of America to further his career, which led to a Masters in Public Health with a concentration in Environmental Health Science. Since 2011 he has worked as a student services contractor at the U.S. Environmental Protection Agency's Office of Research and Development in Athens, Georgia. Currently, he is pursuing a Ph.D. in Environmental Health Science at the University of Georgia. His research focuses on the fate and transport of fecal pathogens in agricultural settings.

Synopsis

Agriculture still remains the primary source of fecal pathogens in surface waters. The vast majority of animals, such as cattle, harbor numerous types of pathogens. Although they may not cause any disease in the host, pathogens can be transmitted into the environment through direct fecal deposition to land or through overland runoff of fecal material deposited on soils, especially during rain events. The health risks that these pathogens pose to water and food resources are highly dependent on their fate and transport in agricultural settings. In order to assess these risks, understanding the factors that influence pathogen fate in agricultural settings is critical, especially for developing control and adaptation strategies to minimize their transfer. Most studies on the fate of pathogens focus on their die-off in the environment, even though there is clearly an initial re-growth of the pathogen before the start of decline. This research uses cow fecal extracts as a growth medium to investigate solely the re-growth potential of pathogens of public health interest in cow fecal extracts.

Keywords: cow fecal extract, E. coli, fecal indicator bacteria

Objective(s)/Research Question(s)

Cow fecal extract is rich in dissolved organic matter (DOM) and dissolved organic nitrogen (DON), which can be used as a nutrient source. In addition, the photodegradation of DOM results in the release of a variety of photoproducts that can stimulate the growth and activity of microorganisms in aquatic environments. This research uses cow fecal extract to understand the potential factors responsible for the re-growth of shiga-toxin producing *E. coli* 0157:H7, *E. coli* 026:H11 and fecal indicator bacteria (FIB). In addition, this research will explore the potential positive effects ultraviolent (UV) irradiation can play in aiding their re-growth in cow fecal extract.

Approach

To achieve this objective, cow manure samples will be made into slurries and diluted to concentrations representing both eutrophic and oligotrophic conditions and then filtered to eliminate all bacteria using 0.2-µm filters. For each condition, manure extracts will be irradiated using a solar simulator for 6–12 hours prior to inoculation with approximately 10^2 cells of each pathogen and incubated at room temperature. Samples will be taking for analysis every 6 hours for 72 hours. A growth rate will be determined and samples will be analyzed at each sampling point for the uptake of nutrients, including nitrates, phosphates, ammonium and dissolved organic carbon. In addition, RNA sequencing will be used to investigate gene expression for each pathogen under all conditions tested.

Expected Results

Sunlight has been shown to aid in the breakdown of dissolved organic matter into more labile compounds that can be easily used by microorganisms for growth. Based on this premise, it is reasonable to hypothesize that UV irradiation will result in a higher growth rate for pathogens inoculated into UV-irradiated manure extract than those inoculated into nonirradiated extracts. In addition, the rate of growth will be pathogen, UV dose and nutrient dependent. Furthermore, pathogens in irradiated extracts are expected to induce an entirely different set of transcription factors than nonirradiated extracts throughout different stages of growth.

Potential to Further Environmental/Human Health Protection

As the world's population continues to increase, so will the pressure to produce more food. This will result in an increase in the use of manure to facilitate crop yield, as well as an increased need for pasturelands for cattle grazing. Thus a potential threat to surface waters from runoff-producing rain events and direct fecal deposition is foreseeable. Understanding the fate of these pathogens in the environment after shedding through feces will be critical in developing control and adaptation strategies to minimize their transfer.

Gavin Saari

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Project Amount: $42,000
Environmental Discipline: Environmental Toxicology

Bio

After receiving a B.S. in Biology from the University of Wisconsin, (2010), Gavin N. Saari served as a Student Contractor Services Biologist at the U.S. Environmental Protection Agency Mid-Continent Ecology Division in Duluth, Minnesota. In 2012, he began an M.S. program in the Department of Environmental Science at Baylor University. Gavin's research interests include anthropogenic interactions with urban water resources, specifically, the interactive effects of stressors, such as depressed dissolved oxygen and pharmaceuticals, on fish.

Synopsis

Water resources in semi-arid regions are stressed by human population growth and drought. Such conditions influence contaminant dynamics in urban inland waters where flows can be dominated by or even dependent on wastewater discharges. In these urban watersheds, hypoxia and contaminants (e.g., pharmaceuticals) can affect fish physiology and thus may influence fish population sustainability. This study investigates the influences of hypoxia during chemical hazard assessments for freshwater fish.

Keywords: hypoxia, pharmaceuticals, wastewater treatment

Developing an Understanding of Multiple Stressor Influences on Fish Reproduction in Inland Waters: Interactive Effects of Hypoxia and Estrogen Agonists

Objective(s)/Research Question(s)

Inland surface waters in arid to semi-arid regions are effluent-dominated or dependent and often nutrient enriched, with the prevalence of endocrine-disrupting chemicals causing stress on water quality. This research will employ reproductive assays to identify thresholds of low dissolved oxygen (hypoxia) on endocrine function. In addition, the research will define the interactive effects of environmentally relevant ethinylestradiol (EE2) exposure on fish endocrine function and reproduction across gradients of dissolved oxygen. These results will be used to understand potential impairments to fish populations.

Approach

The research will entail 21-day reproductive assays with fathead minnows (*Pimephales promelas*) to identify thresholds of hypoxia, EE2 and the interactive effects of EE2 exposure across gradients of dissolved oxygen on endocrine function and reproduction. The study design considers critical aspects of reproduction and early development. This approach will enable the collection of mechanism-specific stressor response data for basic diagnosis and potential extrapolation across species. Results regarding the responses of endpoints will give valuable information about endocrine function and reproduction processes occurring in fathead minnows. Ultimately, this information will be interpreted under the adverse outcome pathway framework relevant to ecological risk assessment.

Expected Results

Continuous chronic exposure of hypoxia in aquatic systems impairs reproductive success and could potentially lead to long term effects on fish recruitment and population abundance. In addition to hypoxia stressing aquatic organisms in effluent-dominated inland waters, other stressors, such as EE2, also are prevalent and can cause reproductive impairment. The consequences of hypoxia and EE2 on fish reproduction have been well studied independently, but the interactions between the two are not well understood in terms of their potential impact on fish populations.

Potential to Further Environmental/Human Health Protection

Water quantity and the quality of wadeable streams and rivers in arid to semi-arid regions of the United States are decreasing because of water shortages as a result of drought and human consumption. Instream flows of surface waters in these regions are dominated by, and even dependent on, discharges from wastewater treatment plants, representing worst-case scenarios for instream exposures to multiple stressors. This research will determine the potential impairments of multiple environmentally relevant stressors, such as hypoxia and endocrine-disrupting chemicals, to fish reproduction. These results will elucidate the critical thresholds of interacting stressors relevant to maintaining aquatic populations. This type of study can be used in water resource management for sustainable approaches to environmental health.

Sheila Saia

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Project Period: 8/1/2015–8/1/2018
Project Amount: $84,000
Environmental Discipline: Environmental Engineering

Bio

Sheila Saia graduated from Binghamton University (New York) in 2007 with a Bachelor's of Science in Bioengineering. She taught English for a year in Japan and then worked as an AmeriCorps-sponsored volunteer coordinator at Buffalo Niagara Riverkeeper. She completed her Master's degree in Biological & Environmental Engineering at Cornell University and has since started her Ph.D. in the same department. The goal of Sheila's research is to improve water quality by gaining a better understanding of the linkages between microbes, hydrology and the transport of the phosphorus in the environment.

Synopsis

Phosphorus (P) is found naturally in small amounts but human P contributions often affect water quality negatively. Sheila's research focuses on quantifying the importance of polyphosphate-accumulating organisms (PAOs) that uptake and release P under changing hydrologic conditions. She will determine to what extent these bacteria contribute to P transport and what environmental factors control bacterially mediated uptake and release of P in soils and streams. The goal is to use this newly acquired knowledge to design effective management practices aimed at reducing nutrient pollution.

Keywords: management practices, microbiology, phosphorus

Linking Landscape Hydrology and Microbiology to Improve Our Understanding of Phosphorous Mobility Across the Landscape-Stream Continuum

Objective(s)/Research Question(s)

This research asks three main questions: (1) How does PAO abundance and diversity (i.e., quantity and identity) vary across spatial and temporal hydrologic gradients? (2) How do environmental controls (e.g., pH, temperature, etc.) affect phosphorus mobility? (3) How does PAO abundance and diversity correlate spatially and temporally with phosphorus mobility and various environmental controls?

Approach

To answer question 1, an area with a variety of soil moisture classes has been identified and a gridded distribution of soil samples has been collected. Each sample will be analyzed using a combination of microbial analysis techniques. Specifically, quantitative real-time polymerase chain reaction (qPCR) will be used to quantify the abundance of PAO genes. The qPCR results will be cross-checked using such microscopy techniques as fluorescence in situ hybridization (FISH). Monthly samples will be taken in the summer and early spring/autumn, a regimen that gives a better understanding of the seasonal and hydrological effects on PAO-mediated phosphorus mobility. Question 2 will be addressed by measuring environmental variables concurrently to those proposed above. Measurements will include in-situ readings of temperature, pH, soil water content and dissolved oxygen. Samples will be processed in the laboratory for levels of carbon, nitrogen, major ions, and various forms of phosphorus, using standard EPA methods. Finally question 3 will be approached with spatial interpolation and analysis techniques (e.g., universal kriging) to quantify PAO abundance as it varies with spatial/temporal changes in hydrologic gradients, phosphorus speciation and other environmental variables across the landscape-stream continuum.

Expected Results

PAOs are hypothesized to be ubiquitous in the environment and more numerous where soils are consistently wetting and drying. It is expected that wetting and drying cycles in soils lead to similar patterns in PAO-mediated phosphorus mobility as observed in wastewater treatment plants that use enhanced biological phosphorus removal (i.e. ,PO_4 is released by PAOs under anaerobic conditions and taken up by PAOs under aerobic conditions). It is likely that more frequent wetting-drying cycles will lead to greater magnitudes of PAO-mediated phosphorus availability. Additionally, colder temperatures are expected to decrease PAO-facilitated phosphorus transport because PAOs will not be as active and the presence of Fe and Al oxides may limit the availability of phosphorus to PAOs. Increasing nutrient (i.e. carbon, nitrogen, and phosphorus) availability will likely increase PAO-facilitated phosphorus transport, and alternative electron acceptors (i.e., nitrate and iron) may encourage the growth of organisms that compete with PAOs for carbon sources (e.g., denitrifiers and iron reducers).

Potential to Further Environmental/Human Health Protection

This research will contribute to science and society in several ways. First, spatial and temporal patterns of biotic- and abiotic-mediated phosphorus mobility can be used to better inform nutrient management, and thus, improve water quality in agricultural watersheds. Second, this information can be used to improve phosphorus transport models, management tools and other efforts to mechanistically predict phosphorus mobility in streams and landscapes. Because agriculture will continue to affect water quality as the demand for food expands alongside a growing population, this research can benefit society by helping to protect and improve water resources.

Matthew Seib

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Project Amount: $84,000
Environmental Discipline: Environmental Engineering

Bio

Matt Seib received a B.S. in civil engineering from the University of Wisconsin, Platteville, in 2008 and an M.S. in environmental engineering from Michigan Technological University in 2011, in conjunction with Peace Corps service in Mali (2009–2011), where he conducted research examining water quality between source and points-of-use in a rural village. Seib is currently pursuing a Ph.D. at Marquette University, conducting research on anaerobic wastewater treatment and anaerobic biotechnology.

Synopsis

Sewage management relies on activated sludge, which is unsustainable due to such factors as high land use, energy use and biosolids yield. This research will develop an anaerobic membrane bioreactor (AnMBR) for sewage treatment with sustainable benefits, including reduced energy use, land use and biosolids yield, renewable energy production and the ability to recover nutrients with downstream processes. The system will be designed to reduce energy requirements compared to other AnMBRs.

Keywords: anaerobic membrane, renewable energy, wastewater treatment

Anaerobic Fluidized Bed Membrane Bioreactor for Municipal Wastewater Treatment at Ambient Temperatures

Objective(s)/Research Question(s)

Anaerobic biotechnology coupled with membrane filtration offers several benefits, but is currently an unproven process. An AnMBR will be developed for more sustainable sewage treatment at ambient temperatures (as low as 10 °C) to evaluate the sustainable benefits of the system with a focus on standard effluent quality parameters (such as biochemical oxygen demand), energy demands, renewable energy production, and membrane performance behavior.

Approach

Bench-scale AnMBRs will be constructed and operated at low temperatures (10 to 22 °C) and will be fed a synthetic municipal primary effluent wastewater. The AnMBRs will employ external tubular membranes in conjunction with activated carbon to retain slow-growing anaerobic biomass, achieve high-quality effluent and reduce the membrane fouling rate. Monitoring parameters—including biochemical oxygen demand, renewable energy generation from methane production, energy requirements for pumping and membrane operation, and membrane cleaning interval—will be quantified and compared to data for conventional activated sludge wastewater treatment.

Expected Results

Bench-scale AnMBRs are expected to produce an effluent with a biochemical oxygen demand equal to that typical of conventional activated sludge processes. Additionally, the elimination of aeration and renewable energy production from methane will result in a significant reduction in required energy compared to activated sludge. Biosolids yields will be low and nutrients such as nitrogen and phosphorus will not be significantly removed, so they can be recovered using downstream technologies. Combined, these outcomes will result in a more sustainable wastewater treatment process than conventional activated sludge.

Potential to Further Environmental/Human Health Protection

An anaerobic membrane bioreactor system would safeguard against the harmful effects of raw wastewater entering the environment and would provide further additional benefits. These benefits include reduced energy consumption and carbon footprint, renewable energy production, as well as fertilizer production using downstream nutrient recovery, thus reducing the need for other energy-intensive fertilizer production methods.

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Project Amount: $84,000
Environmental Discipline: Environmental Engineering

Bio

Kyle Shimabuku received his B.S. in Civil Engineering from San Diego State University in 2008. In 2013 he received his M.S. from the University of Colorado at Boulder in Environmental Engineering. He started his Ph.D. in 2013 at the University of Washington in Environmental Engineering. His research interests surround water quality in natural and engineered systems. His current research focuses on the control of contaminants from nonpoint source pollution.

Synopsis

Nonpoint source pollution, such as urban and agricultural runoff, is the leading source of water quality impairment in the United States. Organic contaminants (OCs) are one of the main classes of pollutants found in runoff that pose a serious risk to human and environmental health. This research focuses on optimizing the efficiency of the sorbent biochar to enhance the ability of runoff treatment systems to remove organic contaminants from nonpoint source pollution.

Keywords: contaminants, nonpoint source pollution, retention basins

Biochar Sorbents for the Control of Organic Contaminants in Nonpoint Source Pollution: Relating Biochar Structure and Sorption Behavior

Objective(s)/Research Question(s)

Biochar sorbents have the potential to remove organic contaminants from nonpoint source pollution because they are inexpensive and can be applied over large areas. However, factors that determine OC removal efficiency from runoff with biochar are largely unknown. This research seeks to optimize biochar for use in nonpoint source pollution treatment systems (e.g., retention basins, bioswales) by relating production conditions to biochar structure and OC removal efficiency.

Approach

This study will use a range of biochar precursor materials, as well as production conditions, to generate a library of biochars that are diverse in physicochemical properties. Biochar adsorption, as well as desorption resistance, will be studied by spiking OCs in artificially buffered water, simulated runoff, and urban and agricultural runoff. The removal interactions between adsorption and biodegradation will be assessed using indigenous microbial populations in natural runoff. Experiments will be conducted in batch systems, laboratory columns and as a pilot study in biofilters.

Expected Results

It is hypothesized that the physicochemical properties can be predicted by the pyrolysis regime used, as well as by the feedstock material. Moreover, the properties of the OC are expected to influence sorption mechanisms. It is suspected that biochar surface functional groups will determine their ability to remove more polar versus nonpolar OCs. The physical properties of biochar are expected to influence OC adsorption capacity and the competitive impact from background adsorbates (e.g., metals, dissolved organic matter), as well as the ability of biochar to be regenerated by OC-degrading microorganisms. These results will ultimately identify optimal production conditions and feedstock characteristics to produce effective biochar media to remove organic contaminants in urban and agricultural runoff.

Potential to Further Environmental/Human Health Protection

This study will provide the scientific support necessary to validate the use of biochar in nonpoint source pollution treatment technologies to prevent harmful OCs from reaching aquatic ecosystems, recreational waters and drinking water sources. This also will increase water sustainability by facilitating runoff reuse that would circumvent the conveyance of water from distant regions.

SAFE & HEALTHY COMMUNITIES

We forget that the water cycle and the life cycle are one.

– Jacques Yves Cousteau

SAFE & HEALTHY COMMUNITIES

Ecosystem Services— Aquatic Systems Ecology

Raven Bier

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Project Amount: $84,000
Environmental Discipline: Ecology and Ecosystems

Bio

Raven Bier received a B.A. in Biology from Carleton College (Minnesota) in 2007. In 2010, she began working toward Ph.D. in Ecology at Duke University. She is interested in understanding how environmental contaminants can alter nutrient cycling by affecting the microbial communities that mediate those nutrient cycles. Currently, she is examining the response of microbial communities and nitrogen cycles to alkaline coal mine drainage.

Synopsis

Contamination of freshwater ecosystems is a growing concern in regions where humans extract geologic resources, such as coal. When exposed to rain, coal releases metals and sulfur into waterways. This research project will study the effect of contaminants from surface coal mining on bacteria and their role in nutrient modifications. It will examine how metals and sulfur change river bacteria communities and their ability to recycle nitrogen in water or export it to the atmosphere.

Keywords: alkaline mine drainage, metal contamination, mountaintop mining

Biological Controls on Chemical Pollution: How Aquatic Microbial Communities Regulate and Respond to Inputs from Land Use Change

Objective(s)/Research Question(s)

Weathering of exposed coal strata releases potential ecological stressors, including metals and sulfur into downstream waterways. This research asks how these stressors alter the fate of nitrogen by differentially affecting those microorganisms responsible for anaerobic nitrogen cycling processes. It further seeks to understand the extent to which microbial responses to these stressors can inform thermodynamic and geochemical predictions for the fate of inorganic nitrogen.

Approach

This work will take place in the streams of neighboring catchments in southern West Virginia. One catchment drains the largest surface coal mine in West Virginia: the Hobet Mine complex, and the other catchment is absent of surface coalmining. Water and sediment environmental variables will be collected, including substrates (C and N) and stressors (SO_4^{2-}, pH and metals) across a gradient of contaminants. In an observational approach, regression analysis will be used to investigate the extent to which contaminant concentrations and anaerobic nitrogen functional genes of sediment microbes in the field can help explain N_2O fluxes. In an experimental approach, $^{15}NO_2^-$ will be traced in sediment microcosms exposed to different combinations of stressors and will compare the fate of $^{15}NO_2^-$ along with the expression of anaerobic nitrogen cycling genes in contaminated and uncontaminated assays. The difference between observed and thermodynamically predicted N pool concentrations will be examined.

Expected Results

At low concentrations, contaminants may provide additional electron donors for denitrification processes, stimulating nitrogen export from aquatic ecosystems as N_2O and N_2. But at high concentrations they may serve as toxicants, reducing nitrogen export by the denitrifying community. Thus, the results are expected to show a nonlinear, concentration-dependent relationship between contaminants and N_2O fluxes. Incorporating contaminants and denitrification gene abundances into the regression analysis is expected to increase the explanatory power for denitrification in these aquatic ecosystems. Furthermore, it is anticipated that in laboratory assays with high contaminant loads, using biological information (such as the activity of sediment-denitrifying microorganisms) will improve thermodynamically based predictions for the fate of nitrite.

Potential to Further Environmental/Human Health Protection

Contamination of water resources is widespread, and microorganisms are employed to clean up these sites through bioremediation. By improving the understanding of the relative importance of contaminants in predicting microbially mediated processes, the results from this work could refine current approaches to nutrient management at contaminated sites. For example, at anoxic locations with elevated nitrate and high metal contaminant levels, contaminant-removal strategies may need to incorporate denitrification-management plans if reducing contaminants inhibits rather than stimulates denitrification.

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Project Amount: $84,000
Environmental Discipline: Zoology

Bio

John Burns received a B.S. in Biology from California Polytechnic State University, San Luis Obispo. After working as an Instructional Technician at the California Polytechnic Center for Coastal Marine Sciences, he completed his M.S. degree at the University of Hawaii at Hilo. John is currently a Ph.D. candidate in the Biology Department at the University of Hawaii, Manoa. His current research uses a multifaceted approach to investigate the ecology and biology of diseases affecting Hawaiian corals.

Synopsis

The objective of this project is to address local and emerging management needs for coral reefs on Hawaii Island. It will investigate coral diseases that are correlated with land-based sources of pollution and sedimentation on the Hamakua Coast. This productive agricultural region is eroded by high annual rainfall and exposes coastal reefs to terrigenous materials. This work will aid development of ecosystem-based management strategies to conserve these marine environments.

Keywords: coral reef, ecosystem function, land-based pollution

Investigating the Relationship Between Land-Based Sources of Pollution and Coral Reef Ecosystem Function

HI-2

Objective(s)/Research Question(s)

The health and architectural complexity of coral reefs profoundly influences the biodiversity and functionality of these complex ecosystems. Quantifying structural parameters can identify the effects of biological and environmental influences on the survival, growth and reproduction of scleractinian corals. This research project will evaluate the effects of land-based pollutants and sedimentation on coral health and disease, as well as on coral community structure.

Approach

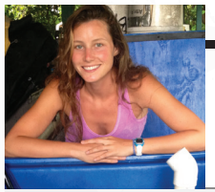
The Hamakua Coast on the northern slopes of Mauna Kea, Hawaii Island, is a highly productive agricultural region characterized by high annual rainfall, steep topography and soils derived from volcanic ash. The combination of high sediment and land-based pollutants, transported to coastal waters by runoff, is likely to physiologically compromise the coral communities inhabiting the Hamakua coastline. This area, therefore, represents an ideal site to investigate the effect of land-based pollutants and sedimentation on coral health dynamics. Epizootiological surveys will be conducted at several study sites along a gradient from delivery points of freshwater runoff. The epizootiological surveys will provide information pertaining to the presence and spread of all signs of reduced health and disease. Surveying along this gradient will elucidate the relationship between land-based pollution and coral disease severity. Structure-from-motion (SfM) photogrammetry techniques will be used to develop 3-D models of the coral reef habitat at each surveyed location. The SfM-derived models enable quantification of physical features, such as structural complexity, that provide habitat space and support ecosystem productivity. Creating 3-D models of each study site will facilitate analyses of the relationship between coral health and reef structure. Collating the findings from this dynamic research approach will ultimately provide the means to assess the effects of land-based pollutants and sedimentation on overall reef health and functionality.

Expected Results

The results of this research project will greatly improve understanding of the coastal ecosystems of Hawaii Island. This proposed research will complement other collaborative projects investigating coral ecosystems around the island and will help to determine environmental factors that drive coral health and ecosystem function. The findings will not only improve and characterize these sites, but also promote locally based management strategies aimed at preserving coral reef health and resilience. This work will produce the following specific scientific contributions by the end of the funding cycle: (1) epizootiological characterization of coral health and disease at each study site; (2) 3-D characterization of the physical characteristics of coral community structure at each study site; (3) identification of 3-D physical characteristics of coral community structure that exacerbate the effects and spread of coral disease; and (4) quantification of the effects of land-based pollution and sedimentation on coral reef health and structure. The proposed research will not only enhance the understanding of coral reef ecosystem function and produce meaningful results, but also serve as a platform for future studies to investigate the effects of land-based pollutants and sedimentation on coral health throughout the Hawaiian archipelago.

Potential to Further Environmental/Human Health Protection

The health and livelihood of humans depend heavily on goods and services derived from the world's oceans. Hawaiian communities surrounding coral reef ecosystems are especially reliant on seafood, tourism and recreation, coastal protection and cultural benefits. The results from this study will provide insight into the dynamics of coral reef health and function at a variety of sites that are affected by land-based sources of pollution. Ultimately, the proposed research will promote conservation action plans aimed at controlling land-based activities and pollutants that negatively affect coral health and ecosystem resilience.



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Project Amount: $84,000
Environmental Discipline: Marine Biology

Bio

Amanda Lockett Carter received a B.S. in Biology from the University of California, San Diego, in 2011. She then completed an M.S. in Biology at the University's Scripps Institution of Oceanography. She begins pursuing her doctorate in Marine Biology at Scripps in the Fall of 2014. Her research interests include mechanisms of biological invasions and disease on coral reefs. Her current research is focused on the synergistic effects of biotic and chemical pollutants on Pacific atolls.

Synopsis

Coral reefs are among the most diverse and productive ecosystems on the planet, yet they are under significant pressure from both natural and anthropogenic stressors. Biological invasions and phase shifts have been observed on some of the most relatively pristine coral reefs left in the world. This research focuses on determining the mechanisms of invasion by examining the synergistic effects of both biotic and chemical pollutants on the reefs. Furthermore, recovery of the benthic community will be studied in order to better inform management practices in the future.

Keywords: conservation, coral reef, invasive species

Mechanisms of Biological Invasions on Coral Reefs: Synergistic Effects of Biotic and Chemical Pollutants

Objective(s)/Research Question(s)

Palmyra Atoll and Kingman Reef have experienced biological invasions by a corallimorph, *Rhodactis howesii*, which appears to be associated with shipwrecks on the reef terraces. This research will address four integral questions: (1) What factors influence invasion of the corallimorph on Pacific reefs? (2) How does invasion affect community structure and function on the reefs? (3) Are these reefs resilient to reinvasion following experimental removal of the invader? (4) Is there evidence that the invasive corallimorph is actually a nonnative species?

Approach

Field-based experiments on Palmyra Atoll will determine how invasion of the corallimorph affects community structure, function and resilience on the reef. A series of plot-clearings along a gradient of corallimorph cover will measure rates of invasion, effects of invasion on coral cover and diversity and succession of the cleared plots over time. Population dynamics of the invader will be examined in the laboratory by extracting DNA from corallimorph tissue samples at sites around Palmyra Atoll and Kingman Reef. Isolation of the ITS1 region of the corallimorphs genome will determine whether or not the population is clonal, which would suggest that it stemmed from an invader brought over on the shipwreck.

Expected Results

Coral reefs are among the most diverse and productive ecosystems on the planet. Yet despite their natural resilience, they are under constant stress due to such global issues as ocean warming and acidification. As these global stressors alter the delicate balance on coral reefs, small-scale, local stressors have the potential to create large-scale disturbances. These changes may make coral reefs more susceptible to biological invasions, particularly when compounded with physical disturbance and chemical stressors. These results will provide valuable insight into the effect that the corallimorph has on ecosystem structure and function.

Potential to Further Environmental/Human Health Protection

Observational reports have documented the spread of *R. howesii* at numerous reefs worldwide, including smaller island communities that rely on subsistence fishing for their primary source of protein. Thus, this invader presents a threat to human health and well-being by altering the basic ecosystem functions of these reefs and, ultimately, the services they provide. This research contributes to increased protection of the environment by adding to the knowledge base regarding the vectors and mechanisms of biological invasions on coral reefs so that further invasions can be prevented.

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Project Amount: $84,000
Environmental Discipline: Entomology

Bio

Allison Gardner is a Ph.D. student in Entomology at the University of Illinois at Urbana-Champaign. She received a B.A. in History and Biology from Williams College (Massachusetts) in 2010 and an M.S. in Pathobiology at the University of Illinois in 2012. Her research and teaching interests are in vector-borne disease systems, community ecology and applied statistics. Her dissertation focuses on the effects of native and exotic and invasive plants on the abundance and distribution of larval and adult mosquitoes.

Synopsis

Due to a lack of vaccines for most mosquito-borne viruses, vector control is often the only viable option for reducing the risk of human exposure. Current mosquito control strategies rely on the use of synthetic insecticides, but environmental safety concerns have contributed to a need for sustainable alternatives for mosquito abatement. This research examines ecological drivers of habitat quality and attractiveness for mosquitoes and explores avenues to apply these findings for vector control.

Keywords: community ecology, integrated vector management, mosquitoes

Impact of Leaf Detritus Species on Mosquito Ecology in Artificial Container Habitats

Objective(s)/Research Question(s)

One of the most important predictors of human risk of exposure to mosquito-borne pathogens is the density of mosquito vectors. The abundance and distribution of container-breeding mosquitoes is determined in large part by terrestrial plant-based detritus, which supports the microbial flora on which larval mosquitoes feed. This research investigates ecological pathways by which leaf detritus of different plant species alter aquatic habitat quality and attractiveness for an important epidemic vector of West Nile virus, *Culex pipiens* (Diptera: Culicidae), and explores the potential to apply these findings to develop environmentally safe and sustainable mosquito control strategies.

Approach

Leaf detritus from different terrestrial plant species likely mediates aquatic habitat quality and attractiveness by two mechanisms: variation in nutritional quality and release of phytochemicals during decomposition. This study will test these alternate mechanisms by measuring the microbial composition of infusions of each of six common leaf species using quantitative PCR and the phytochemical content of the same species using gas chromatography. It also is likely that inputs of different leaf detritus species in closed aquatic habitats alters mosquito production in these environments, and combining inputs of attractive leaf species with conventional insecticides may result in a novel "attract-and-kill" mosquito control strategy. A field experiment will test these predictions in roadside stormwater catch basins, which are important aquatic habitats for *Cx. pipiens* in the urban ecosystem.

Expected Results

Two years of previous data indicate that the effect of leaf detritus on habitat selection and mosquito development is variable; in particular, an exotic and invasive plant (honeysuckle, *Lonicera maackii*) supports high oviposition and adult mosquito emergence rates, whereas a native species (blackberry, *Rubus allegheniensis*) is highly attractive but deleterious for the juvenile development of *Cx. pipiens*. It is expected that honeysuckle enables high mosquito production due to its nutritional quality, while blackberry leaves contain toxic phytochemicals (e.g., tannins). Provisioning storm water catch basins with either blackberry leaf detritus or honeysuckle combined with a conventional insecticide is expected to yield increased oviposition and equal emergence rates compared to the application of the insecticide alone, validating use of the attractive compounds contained in blackberry and honeysuckle leaves as supplements to insecticides for attract-and-kill mosquito control.

Potential to Further Environmental/Human Health Protection

Due to a lack of vaccines for most mosquito-borne viruses, vector control is the most effective and often the only viable option for reducing the risk of human exposure. Current mosquito control strategies rely heavily on the use of synthetic insecticides, but the evolution of insecticide resistance in vector species and environmental safety concerns have contributed to a need for sustainable alternatives for mosquito abatement. By examining ecological drivers of mosquito production, this study has the potential to discover a novel, inexpensive and effective vector-control method with minimal non-target effects and reduced potential to select for insecticide resistance.

Brandon Scott Gerig

The Interactive Effects of Watershed Condition and Contaminant Biotransport by Introduced Pacific Salmon on the Contaminant Load of Stream-Resident Fish in Great Lakes Basin Tributaries

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Project Amount: $84,000
Environmental Discipline: Aquatic Ecology and Ecosystems

Bio

Brandon Gerig received a B.S. from Lake Superior State University (Michigan) in 2009. He went on to receive an M.S. from the University of Florida, where he studied how native fish populations responded to experimental flow policies in the Colorado River in the Grand Canyon. After a year as a fisheries biologist with the Utah Division of Wildlife, Brandon began his Ph.D. at the University of Notre Dame, where he studies the effects of Pacific salmon contaminant transport to tributary food webs of the Great Lakes. Brandon's research interests bridge basic and applied aquatic ecology and include issues related to contaminant biotransport, ecosystem resource subsidies, introduced species, dam removal and river management.

Synopsis

Past research on Pacific salmon has recognized their role as ecosystem engineers and a resource subsidy. However, less research has been conducted to examine the potential for salmon to act as vectors for contaminant transport to tributary streams during spawning migrations. This research will quantify the transport of persistent organic contaminants and mercury by Pacific salmon to stream-resident fish across a large spatial extent in the Great Lakes Basin (GLB). It also will assess the pathways through which salmon materials (and contaminants) are transported through the food web. Last, it will use ecosystem models to assess how alternative management scenarios would influence stream community structure and stream-resident fish contaminant burden. This research will be useful to both basic and applied scientists interested in the effects of introduced species on stream structure and function and watershed management.

Keywords: contaminants, ecosystem assessment and modeling, Pacific salmon

Objective(s)/Research Question(s)

This study will evaluate the effects of watershed condition and contaminant biotransport by introduced Pacific salmon on the contaminant load of stream-resident fish in GLB tributaries. The objective is to establish an environmental framework to predict the influence of Pacific salmon spawners on the contaminant load of stream-resident fish (e.g., brook trout) in GLB tributaries. The Great Lakes fishery is especially sensitive to impacts on tributaries, because many fish species use those areas as spawning and rearing habitat and thus represent an indelible ecosystem linkage between the lakes and their tributaries. These fish can transfer effects from lakes to tributaries in ways that are contrary to the normal paradigm of downstream transport of organisms and material.

Approach

This research will combine field surveys, manipulative experiments and modeling to better understand the relationship between salmon spawners and contaminant levels in stream-resident fish, as well as the role of other factors (such as instream characteristics and watershed condition) in mitigating this relationship. A suite of predictive models will evaluate the influence of watershed and in-stream covariates on stream-resident contaminant levels. This project will also quantify the food web structure in streams affected by salmon runs, using stable isotope analyses to determine the mechanism by which contaminants are transported to fish. Third, analysis of stream food web structure in natural streams will be coupled with manipulative experiments at the Hunt Creek Fisheries Research Station. Using experimental stream reaches, salmon contaminant transfer to stream-resident fish will be directly assessed, while controlling for natural variation. Last, existing ecosystem and bioenergetics models will be used to predict how resident fish populations will respond to varying levels of contaminants, salmon spawner abundance and watershed management. Models will probe complex relationships in stream ecosystems to assess how contaminants are incorporated within the food web and ultimately affect fish.

Expected Results

The influence of salmon spawners on the contaminant load of stream-resident fish is expected to be most pronounced where (1) salmon-mediated transport of contaminants is highest and (2) background contaminant levels are minimal because of watershed and instream characteristics. Previous research suggests that introduced salmon spawners deliver contaminants to streams through their eggs and carcasses, as indicated by elevated contaminant loads in stream-resident fish from stream reaches supporting salmon runs.

Potential to Further Environmental/Human Health Protection

This research is critically important to assessing the effect of both non-native species (e.g., Pacific salmon) and contaminants (e.g., PCBs, mercury) on stream ecosystems in the GLB. It will assess the ecological benefits and costs of salmon management in the GLB, so that fisheries managers can pursue strategies that mitigate the costs associated with introducing non-native species that bioaccumulate contaminants. This research will also identify areas for salmon stocking where the risks of contaminant biotransport can be minimized. Additionally, it could assist with developing local consumption advisories for sport fish caught in watersheds with high contaminant loads. Local consumption advisories are especially important to underprivileged communities that rely on subsistence harvest of fishery resources to meet their dietary needs.

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Project Amount: $84,000
Environmental Discipline: Marine Sciences

Bio

Cassandra Glaspie received a B.S. in Zoology at Michigan State University in 2008. She is currently working toward her Ph.D. in Marine Science at the Virginia Institute of Marine Science, College of William and Mary. Her research involves predator-prey interactions between crabs, rays and a variety of Chesapeake Bay bivalves, as well as how these interactions are expected to change with global change, including habitat loss and ocean acidification.

Synopsis

In the Chesapeake Bay, seagrass has declined due to anthropogenic nutrient and sediment pollution. Video of predator-prey interactions in the laboratory will be used to examine the role of habitat (seagrass, oyster shell and shell hash) on interactions between the blue crab and two species of clams with different adaptations for dealing with predators. The results will be used to examine the effect of habitat loss on the persistence and distribution of clams and crabs in the Chesapeake Bay.

Keywords: habitat use and loss, nutrients, seagrass

The Role of Habitat in Bivalve Predator-Prey Interactions

Objective(s)/Research Question(s)

This project addresses the indirect effects of nutrient pollution on the Chesapeake Bay estuary, investigates a possible feedback loop that may lead to worsening effects of nutrient pollution and results in the creation of a model that can be parameterized and used to understand the effects of nutrient pollution in many systems worldwide. The specific objective of this study is to quantify the shift in functional response of blue crabs on bivalves due to a shift in habitat structural complexity.

Approach

Individuals of the soft-shell clam (*Mya arenaria*, thin-shelled deep infaunal) and hard clams (*Mercenaria mercenaria*, armored shallow infaunal) will be exposed to blue crab predation in a mesocosm experiment conducted at the Seawater Research Laboratory at the Virginia Institute of Marine Science. Mesocosms will be assigned one of four substrate treatments: sand, sand/seagrass, sand/oyster shell, and sand/shell hash. After 48 hours, the contents of all mesocosms will be collected, and the remaining bivalves (as well as any broken shells) will be counted. In addition, an infrared-sensitive video system will be used on two replicates from each treatment to estimate search time (amount of time spent foraging), encounter rat, and handling time (amount of time a blue crab spends handling and consuming a bivalve). Lotka-Volterra predator-prey models will be parameterized using the data from the mesocosm trials, and the resultant model will be used to examine the effect of habitat loss on the persistence and distribution of crabs and bivalves in the Chesapeake Bay.

Expected Results

Blue crabs have a type II hyperbolic functional response when feeding on armored clams and the attack rate is a function of habitat. Blue crabs have a type III sigmoidal functional response when feeding on thin-shelled burrowing bivalves and the attack rate is a function of habitat. Handling time will be significantly greater for armored species than for avoidance species and will not be influenced by the presence of complex habitat. Encounter rate will be significantly greater for armored species, and the presence of complex habitats will significantly decrease encounter rate for avoidance species. Burrowing bivalves will continue to persist under scenarios of habitat loss, but at much lower densities. Armored bivalves will not be affected by scenarios of habitat loss that are likely to occur in the Chesapeake Bay.

Potential to Further Environmental/Human Health Protection

This project will advance the current state of knowledge about important environmental issues, namely nutrient pollution and resultant seagrass habitat loss. Very few studies examine the mechanisms behind predator-prey interactions, and this study is particularly timely because it quantifies a shift in the functional response of benthic predators due to changes that are very likely to happen in nutrient-polluted systems. Understanding of the effects of changes in handling time and attack rate on predator-prey interactions is essential to predict what effects global change will have on marine communities and ecosystem services.

Daniel Joseph Gurdak

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Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Daniel J. Gurdak has broad interests in ecology, fisheries and conservation. He received his B.A. in Biology and Environmental Science from City University of New York Lehman College/Macaulay Honors. He then received an M.Sc. from the School of Geography and the Environment at the University of Oxford and a M.P.A. from the Maxwell School of Citizenship and Public Affairs at the University of Syracuse. He is currently a Ph.D. student at the SUNY College of Environmental Science and Forestry.

Synopsis

This research focuses on the taxonomy, growth, migration and conservation of Arapaima, a large fish that is part of an important fishery in the South American Amazon. The genus *Arapaima* is overfished and the floodplain habitat that it depends on is increasingly degraded by anthropogenic activities. This project contributes to existing knowledge about Arapaima in an effort to conserve this amazing animal and its globally important habitat in the Amazon.

Keywords: arapaima, conservation, floodplain

Unraveling Linkages Between River Floodplain Dynamics, Fish Populations and Habitat Structure in the Amazon

Objective(s)/Research Question(s)

Floodplain fisheries and the fish that depend on them are threatened worldwide. This work aims to improve fisheries management and the conservation of floodplain habitats in the Amazon by exploring various aspects of Arapaima ecology. The following null-hypotheses comprise the foundation of this research: (1) Arapaima growth and reproductive patterns are similar across the entire Amazon; (2) Arapaima are taxonomically similar across the entire Amazon; (3) Arapaima exhibit site fidelity; and (4) Arapaima habitat use is independent of floodplain habitat type.

Approach

Fieldwork will be conducted in select community zones near the city of Santarém (Pará State, Brazil) in the Lower Amazon, near the confluence of the Amazon and Tapajos Rivers. During the fishing season, fishermen will be accompanied to collect samples and data from Arapaima captured for market. The following will be collected for each fish: length, weight and sex, as well as scale samples (for growth studies), taxonomic data and a macroscopic accession of reproductive stage. After the fishing season, ultrasonic tags will be surgically implanted on 50 Arapaima. Their movements will be monitored during the low- and high-water seasons in two ways: passively, using an array of 20 receivers, and actively, using a portable receiver with hydrophone. All data and samples will be processed in the lab, and data will be synthesized to address each research hypothesis using appropriate statistical tools.

Expected Results

Growth and reproductive patterns are expected to differ from those in other parts of the Amazon and for different locations in the study area. In addition, initial data indicate that Arapaima from this region vary taxonomically. Arapaima are known to migrate laterally during high water, but specific movements, home range and habitat preferences will be elucidated by this research.

Potential to Further Environmental/Human Health Protection

This work integrates and depends on the participation of local communities (i.e., local land and habitat managers) and will engage local residents, fishermen and communities to promote effective conservation and management. This research also is closely integrated with the long-term efforts of a local nongovernmental organization and will help improve management of floodplain fisheries and ecosystems. Unfortunately, insufficient management of Arapaima has resulted in significant population decreases and even local extirpations of Arapaima in some areas. Successful community-based management of Arapaima has been associated with increased Arapaima populations and a boost in local and regional economies. However, without information about habitat use to include in management programs, these efforts cannot be sustainable. This work addresses this deficiency by providing a framework for the design of floodplain fisheries and habitat reserves with close involvement of community leaders. In addition, this project reflects the collaborative efforts and combined missions of multiple partner organizations in the United States and Brazil. This partnership will benefit both local and foreign partners, while contributing to science education in this region and worldwide. This work is pioneering telemetry research in the Amazon and will promote future collaborative research efforts and applications both in the Amazon and the United States.

Emily Marie Hall

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Project Officer: Gladys Cobbs
Project Period: 8/25/2014–8/25/2016
Project Amount: $84,000
Environmental Discipline: Zoology

Bio

Emily Hall received a B.S. in Environmental Biology/Zoology at Michigan State University in 2010. With an interest in conservation and ecology, she took an internship at the University of Minnesota, working on a wildlife conservation and biofuel production project in restored prairies. The subsequent year she began her Ph.D. at Washington State University. Her research focuses on maternal and environmental effects of roads on amphibian development and susceptibility to disease.

Synopsis

Paved roads cover about 1 percent of North America, and the area in which effects on the surrounding natural landscape are seen is estimated at 25 percent. De-icing salt application is increasing salinity in freshwater systems and likely increases osmoregulatory stress in animals dependent on these wetlands. This project will examine how conditions of roadside habitats influence larval development and disease susceptibility of an amphibian species and also will develop assays for population health monitoring.

Keywords: amphibians, environmental stressors, ranavirus

The Effects of Road Salt on Amphibian Disease Dynamics in the Northeastern United States

Objective(s)/Research Question(s)

This project aims to validate non-invasive techniques to measure hormone levels in the field for different life stages of amphibians and to use these assays to determine whether glucocorticoid levels can be a bioindicator of disease susceptibility. It also seeks to incorporate stress physiology and disease prevalence into a bioclimatic spatial model to map the susceptibility landscape of the wood frog-ranavirus system. It seeks to answer two specific questions: Can osmotic stress of road salt run-off during amphibian development affect immune function and susceptibility to disease? How do environmental variables relate to susceptibility and disease prevalence across the northeastern range of the wood frog?

Approach

Under a combination of laboratory and field experiments, animals will be reared in experimental road salt mesocosms and enclosures in roadside ponds. Various immunological and physiological assays will examine the hormonal, metabolic and cellular changes between these environmental conditions and maternal origins. Surveying populations using a non-invasive hormone assay and an environmental DNA assay for ranavirus will allow the incorporation of these indicators of disease susceptibility into an ecological niche model of the wood frog to map the "susceptibility landscape" to determine areas at risk for mortality events.

Expected Results

Roads can affect disease susceptibility of amphibians in two ways, by increasing transmission of diseases and by decreasing host resistance to infection. Roads increase human access to ponds, which could increase local introductions or spread of disease. Slower growth and development of wood frog larvae in roadside ponds indicate an energetic cost that could affect the immune system and ability to resist infection. Thus, populations in areas of high road density or heavy road-salt application will have an increased risk of disease-associated die offs. Results will provide non-invasive assays for monitoring amphibian population health and disease surveillance.

Potential to Further Environmental/Human Health Protection

Populations at high risk for a mortality event and in need of road-salt alternatives or reduction will be pinpointed using the interpolative spatial model. Also, in areas where there is low impact on wetlands, economic assessments can determine salt application levels that balance aquatic ecosystem services with automotive safety. Novel methods developed for environmental assessments of population health and disease risk can be validated for other species. Field survey data of salinity in surface waters can be used to further understand sources of salt in groundwater and drinking water for human health.

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Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Ecology

Classifying and Restoring Pacific Northwest Streams and Riparian Zones for Water Quality and Anadromous Fish Habitat

Bio

Nate is an applied ecologist working toward his Ph.D. in the Department of Watershed Sciences at Utah State University. His research is built on two components: process-based stream, riparian and wetland restoration and aquatic ecosystem monitoring and condition assessment. Nate received his B.A. in environmental studies and M.S. in ecosystem analysis from the University of Washington, Seattle, where he worked on the functional ecology of forests, wetlands and restored, novel ecosystems. Presently, Nate is investigating the effects of land-use, climate and local hydrogeomorphic variability on riparian plant communities in the Columbia and Missouri River Basins. In addition to his research, Nate designs, implements and monitors restoration schemes for incised and dewatered streams in the intermountain West.

Synopsis

Riparian vegetation is a keystone element of healthy streams as it responds to and shapes stream processes. Within small, wadeable streams, riparian vegetation is tied to upland and stream processes and serves as an indicator ecosystem health. This research proposes to identify how climate, disturbance and channel form shape riparian vegetation in wadeable streams of the American Pacific Northwest and to use these relationships to determine habitat quality and potential trajectories of change.

Keywords: Columbia River Basin, ecosystem assessment and modeling, stream habitat

Objective(s)/Research Question(s)

Wadeable streams comprise large proportions of watersheds' total stream area. These smaller, low-order streams harbor distinct habitats, biodiversity and hydrogeomorphic processes relative to larger rivers. Because relationships between riparian vegetation and environmental processes may be used to assess ecosystem integrity and future trajectories of change, their classification is a fundamental need for watershed managers. Accordingly, the overarching objective of this research is to effectively classify riparian vegetation communities and how they are likely to respond to multiple environmental processes that are sensitive to climate and land-use change.

Approach

This study will focus on wadeable streams of the Columbia and Missouri River Basins, two watersheds that provide crucial habitat for threatened and endangered salmonid species. Using existing riparian vegetation data collected by the USDA Forest Service, reaches will be clustered into community groups based on the compositional similarity of their riparian vegetation. Environmental attributes that filter vegetation from regional species pools down to those species that can occur at a given reach will be used to explain these patterns in riparian vegetation. These environmental filters originate at three major scales—the landscape, the watershed and stream buffer, and stream—and they will be grouped accordingly to partition the explanatory power of filters on vegetation composition. By correlating each riparian vegetation community to multiscale environmental filters, and the scales at which they originate, the realized niches of each community and component species can be identified. Those environmental filters that differ between communities also may be thresholds between vegetation transitions that can be modeled. By modeling vegetation under filters' predicted global change scenarios, future distributions of riparian vegetation communities can be projected.

Expected Results

Previous studies have predominantly looked at patterns in riparian plant diversity at either small spatial extents, or in large rivers. Because wadeable streams generally connect hill slopes to the fluvial environment, it is likely that distinct filters from some of the three scales will correspond to each riparian vegetation community. This is because it is likely that environmental processes will hierarchically shape riparian vegetation communities; that is, large-scale environmental filters will distinguish many communities' environmental tolerances before watershed and stream-scale filters differentiate riparian vegetation communities. Due to the large spatial extent of the study area, it is likely that climatic gradients shape riparian vegetation before other processes. Climate and watershed setting will likely feedback on the hydrologic processes that influence channel form, creating hydroclimatic gradients across which vegetation will assemble. It also is anticipated that watershed disturbances, such as grazing, will create tipping points between vegetation types that otherwise have similar bioclimatic and fluvial niches.

Potential to Further Environmental/Human Health Protection

As broad global change occurs from shifts in climate, land use and disturbance regimes, wadeable streams and their riparian zones will be exposed to numerous perturbations. By identifying the environmental drivers of riparian and aquatic resources within watersheds that support threatened and endangered fish and wildlife, agencies will be better prepared to manage streams and riparian areas for resilience to global change. The results of this research will help inform decision making at the broad spatial scales relevant to land managers within the upper Missouri and interior Columbia River basins, while also elucidating the mechanisms that drive riparian plant community assembly across landscapes.

Mallika Arudi Nocco

Potatoes for Trout: Managing Agricultural and Aquatic Ecosystem Services in the Wisconsin Central Sands

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Project Period: 9/2/2014–9/2/2016
Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Mallika Nocco received a B.A. in Comparative Literature/Philosophy from the University of Minnesota and worked in pharmaceutical sales for 5 years before attending graduate school. In 2012, she received an M.S. in Soil Science and began a Ph.D. in Environment and Resources at the University of Wisconsin. She is interested in the biophysical transformation of water, energy and carbon through the groundwater-soil-plant-atmosphere continuum. Her doctoral work focuses on how agricultural land use and climate affect aquatic ecosystem services in the Wisconsin Central Sands.

Synopsis

Agricultural groundwater irrigation in the glacial aquifers of Wisconsin, Minnesota and Michigan has expanded during the past 60 years. Because groundwater and surface water are one resource, regional water management must balance the needs of irrigated crops and aquatic ecosystems. This research uses biophysical models and field trials to characterize the water-energy cycle in response to scientific questions important to agricultural and aquatic stakeholders in the Wisconsin Central Sands.

Keywords: ecosystem services, irrigation, water-energy cycle

Objective(s)/Research Question(s)

The goal of this research is to determine how irrigated agriculture and climate affect surface water quantity and quality in response to scientific questions identified by stakeholders in the Wisconsin Central Sands. This work will produce coupled water-energy budgets under authentic agricultural management, which will be used to set parameters for and calibrate a regional agroecosystem-hydrological model. Model simulations will be driven with historical daily climate data to understand how cumulative changes in climate and land use have degraded surface waters over the past 60 years and to optimize future water management by contrasting low- and high-input scenarios.

Approach

This research uses a transdisciplinary approach encompassing environmental biophysics, plant physiology and hydrology. Field experiments will take place on Isherwood Farm, a sixth-generation, 1500-hectare farm with 100 hectares of woodland and 7 kilometers of coldwater trout habitat located in the heart of the Wisconsin Central Sands. Potential recharge, soil moisture/temperature and water table depth will be monitored year-round using replicated passive capillary lysimeters, frequency-domain reflectometry probes and wells in six irrigated rotations of maize, potatoes and peas. During the growing season, measurements of crop phenology, porometry and remotely sensed infrared canopy temperature also will be collected. Air temperature and relative humidity will be measured both locally on Isherwood Farm and regionally across an east-west transect to test an irrigation-induced cooling hypothesis. These data will be synthesized into models of evapotranspiration and groundwater recharge to further understand agricultural perturbations to the water-energy cycle across diverse temporal and spatial scales.

Expected Results

The Wisconsin Central Sands area has undergone both irrigation expansion and climate change over the past 60 years, which may have had either synergistic or antagonistic effects on the water-energy cycle. Surface waters in this region have been severely degraded over the past decade, with loss of both quantity and quality, leading to diminished aquatic ecosystem services. Hydrological models have estimated that groundwater pumping and irrigation may alter components of the water-energy budget on the same order of magnitude as climate change. It also has been demonstrated that intensive agricultural irrigation can modify regional climate patterns through evaporative cooling and increased cloud cover. Though it is well-established that groundwater pumping leads to aquifer depletion, this work will develop a more mechanistic model that links pumping, evapotranspiration, climate and aquatic interactions in shallow, glacial aquifers connected to surface waters, such as those found in Wisconsin, Minnesota and Michigan.

Potential to Further Environmental/Human Health Protection

Emergent philosophies of groundwater governance indicate that vertical integration, or a bottom-up social consensus, is critical to the success of any adaptive management plan. Central Sands farmers, conservationists and property owners have committed to understanding the land use processes that led to present aquatic conditions and implementing strategies to mitigate further damage to surface waters, while sustaining a viable agricultural economy. This project will engage key agricultural and aquatic stakeholders by integrating scientific results with local knowledge to identify remaining obstacles preventing adaptive management of surface waters.

Sarah Louise O'Neal

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Project Period: 9/24/2014–9/24/2016
Project Amount: $84,000
Environmental Discipline: Aquatic Ecology

Bio

Sarah O'Neal is a freshwater ecologist with 15 years of international experience working and conducting research in trout and salmon streams. She received a B.S. in Conservation Biology from the University of Washington in 1999 and an M.S. from the University of Montana's Flathead Lake Biological Station in 2008. Her professional and research interests relate to conservation of intact salmon habitat; her current project focuses on the toxicity of copper to sculpin as an indicator species in the proposed mining district of Bristol Bay, Alaska.

Synopsis

The project will determine the utility of slimy sculpin (*Cottus cognatus*) as bioindicators of the effects of copper sulfide mine development.

Keywords: bioindicator, mining, sculpin

Slimy Sculpin (*Cottus cognatus*) as a Bioindicator of Mining Impacts on Water Quality

Objective(s)/Research Question(s)

The overarching objective of this project is to evaluate the utility of sculpins as bioindicators for the purpose of measuring the effects of mining on aquatic ecosystems.

Approach

The project will focus on slimy sculpin in headwater streams potentially affected by proposed copper-sulfide mining, and it will evaluate (1) the site fidelity and home range of sculpins to determine if their condition is reflective of the environment in which they are found; (2) inter-annual population variability of sculpins within and outside the area of potential mine impact; and (3) acute, chronic and indirect effects of copper on sculpins in both field and laboratory environments.

Expected Results

The hypotheses are that sculpin movement is limited to short stream reaches, that sculpin comprise the highest densities of fish taxa in headwater streams potentially affected by mining activities and that sculpin are as sensitive—if not more so—than other fish species, making them an appropriate bioindicator taxa to detect acute, chronic and sub-lethal effects of mining.

Potential to Further Environmental/Human Health Protection

As bioindicators, detecting effects on sculpin from mining may prove to be a cost-effective tool to alert regulators that mine activities may be causing effects that could ultimately affect salmon and other fish if they are not changed.

Rachel Diane Wigginton

Predicting Return of Ecosystem Services Based on Impacts of Invasive Ecosystem Engineers

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Project Period: 9/1/2014–9/1/2016
Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Rachel Wigginton received her B.S. in Biology from Western Kentucky University in 2009. She then earned an M.S. in Biology from California State University, Long Beach. She is currently pursuing a Ph.D. in Ecology at the University of California, Davis. Her research interests include wetland ecology, invasions and food web ecology. She currently studies the effects of plant invasions in tidal marshes. Rachel is passionate about conservation and scientific communication.

Synopsis

Salt marshes provide numerous ecosystem services, such as carbon sequestration and food web support for fisheries. However, few salt marshes remain globally, and restoration is a priority. This work will examine restoration in marshes affected by an invasive plant. The research will compare recovery of salt marshes based on pre-invasion conditions and restoration approach. This study will inform future salt marsh restoration in the United States, which can conserve biodiversity and enhance ecosystem services.

Keywords: ecosystem services, salt marsh, restoration

Objective(s)/Research Question(s)

This research seeks to address three main objectives: (1) Determine how pre-restoration habitat modification by ecosystem engineers alters the success of salt marsh restoration and the recovery of ecosystem services; (2) explore the connection between restoration and ecological feedbacks, such as food web recovery and carbon sequestration, which provide a measure of restoration success; and (3) examine the effects of the restoration state (e.g., active replanting vs. passive restoration) on the success of restoration and ecosystem service recovery.

Approach

This approach will utilize the large-scale hybrid *Spartina* eradication effort currently being executed by California Coastal Conservancy's Invasive *Spartina* Project. Four categories of sites were chosen, representing four different restoration states: (1) invaded marsh: invasive hybrid *Spartina* present, no current restoration; (2) passive restoration: hybrid *Spartina* removed, no active revegetation; (3) active restoration: hybrid *Spartina* removed, revegetated with native *S. foliosa*; (4) uninvaded marsh: S. foliosa present, never displaced by hybrid *Spartina*. Sites will be sampled for both habitat alteration and ecological response data in order to fully assess the relationship between restoration state and site characteristics. Pre-eradication data are available from some sites and will be used to assess the degree of habitat alteration prior to eradication and compare it with current data following *Spartina* eradication (pre-eradication data were taken between 2000 and 2004). Ecological response data, including food web development and carbon sequestration, will serve as indicators of ecosystem recovery.

Expected Results

This research is expected to yield several valuable outcomes. First, it will explore the utility of active versus passive restoration on restoration success using food web development and carbon sequestration as success metrics. Second, the relative effect of the restoration state will be assessed and the effects of site-specific characteristics on outcomes will be better understood. Third, this project utilizes a large-scale manipulation already planned by the Invasive *Spartina* Project, giving timely feedback to the agency for current and future endeavors and gaining important information about restoration ecology, which can be applied in other marsh systems. This work also will provide direct tests of the predictions from ecological theory and from prior empirical studies of native and invasive species in salt marshes. The prediction is that restored and treated sites will achieve food webs equivalent to pre-invasion marshes as native plants replace invasive species, but without the negative consequences of the invaders. Carbon sequestration likely will be initially highest in sites restored with active restoration as compared to treated sites with only passive restoration. However, these initial differences are not likely to persist.

Potential to Further Environmental/Human Health Protection

After the damage caused by Hurricane Katrina and, more recently, Hurricane Sandy, coastal residents have a renewed appreciation for the services that coastal marshes provide. With better understanding of some of the fundamental characteristics, which increase the probability of restoration success, strategies can be developed for more rapid and more efficient restoration practices. In particular, this study will permit assessment of the more capital-intensive active restoration and to what degree this approach results in more successful restoration of the key ecosystem services that human communities need: carbon sequestration, flood abatement, coastline protection, erosion control and water filtration. These last four services directly apply to two of EPA's "Seven Priorities for EPA's Future." Restoration of salt marshes will directly affect the health and prosperity of countless coastal communities in the United States, helping to clean up communities. Second, EPA has been charged with protecting America's waters. This project addresses all of the major challenges pointed out by the seven priorities and helps develop an effective, innovative approach to returning ecosystem services.

SAFE & HEALTHY COMMUNITIES

When we show respect for other living things,
they respond with respect for us.
–Arapaho proverb

Ecosystem Services—Terrestrial Systems Animal Ecology

Nicholas Albert Mason

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Project Period: 8/1/2014–8/1/2016
Project Amount: $84,000
Environmental Discipline: Terrestrial Systems Ecology–includes animals

Analyzing Adaptation and Extirpation in Response to Climate Change and Agriculturization in the Horned Lark (*Eremophila alpestris*)

Bio

Nicholas Mason is an evolutionary biologist and an ecologist interested in leveraging scientific collections to help conserve biodiversity. He earned his B.A. in Biology at Vassar College (New York) and an M.Sc. in Environmental Biology at San Diego State University. He is a Ph.D. student at the Fuller Evolutionary Biology Laboratory at the Cornell Department of Ecology and Evolutionary Biology.

Synopsis

When faced with alterations to their habitat, species must adapt, migrate or go extinct. Understanding how populations persist through changes in abiotic conditions and modifications of their native habitat is a central, urgent imperative for sustaining biodiversity. This research project will explore how a tractable avian species, the horned lark, has responded to land use and agriculture in the southwestern United States. Combining ancient DNA sequencing of museum specimens, remote sensing technology and digital photography, the research will assess both phenotypic, environmental and genetic changes, toward a deeper understanding of how organisms adapt to dramatic changes caused by human land use.

Keywords: adaptation, climate change, land use

Objective(s)/Research Question(s)

When faced with alterations to their habitat, species must adapt, migrate, or go extinct. Understanding how populations persist through changes in abiotic conditions and modifications of their native habitat is a central, urgent imperative for sustaining biodiversity. This research studies how organisms (specifically, the horned lark, *Eremophila alpestris*) respond to land use (specifically, agriculture). The project examines how the horned lark has responded to a century of desert farming in the Imperial Valley of the southwestern United States. Within the Imperial Valley, the population of horned larks has become darker as the desert substrate has become irrigated and arable. This research seeks to determine the relative contributions of selection acting on existing genetic variation and the introgression of favorable alleles from other populations in the adaptive evolution of cryptic coloration.

Approach

This project will take an interdisciplinary approach to study how the horned lark has adapted to land use in the Imperial Valley. It will use novel high-throughput sequencing methods to analyze genetic variation among specimens collected before the All-American Canal was constructed in 1939. These "ancient DNA" samples will be compared to individuals form the extant population, samples that have been collected since 1990. Change in dorsal coloration will be assessed using a combination of digital photography and spectrophotometry. Finally, to evaluate whether the darkening of Horned Larks represents adaptive cryptic coloration, the coloration profiles of birds from both historic and current populations will be compared to reflectance profiles of the desert substrate before and after the agricultural era. This multifaceted approach will allow a comprehensive study of the evolutionary history and ecology of horned larks in the Imperial Valley.

Expected Results

If natural selection has acted on an already-existing genetic variation in the horned lark population in the Imperial Valley, historic and extant individuals will be from a single population. In contrast, if introgression of favorable genetic variants from populations outside of the Imperial Valley have contributed to the phenotypic change observed, then horned larks in the Imperial Valley will show signatures of admixture. In terms of phenotypic variation, if horned larks have gained darker plumage as an adaptation to a darker substrate in the Imperial Valley, then a correlation can be expected between the coloration profiles and substrate reflectance profiles between historic and extant populations.

Potential to Further Environmental/Human Health Protection

The project described here integrates ecology, evolutionary biology, conservation, genetics, remote sensing and digital photography to comprehensively study how a tractable avian species has adapted to agriculturization, aridification and increases in ambient temperature. The interdisciplinary nature of this research will promote novel collaborations among faculty and students from traditionally disparate disciplines including Civil Engineering, Bioinformatics, Ecology and Evolutionary Biology. Using the horned lark as a model system, the results from this research will inform management units as to how best to protect grassland and desert birds amidst increased agricultural land use. Agriculture will continue to play an important role in efforts to feed a growing world. Thus, understanding how organisms respond to agricultural practices is important from a conservation perspective and will help promote environmental health and conservation.

Laura Ann Schoenle

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Project Period: 8/25/2014–8/25/2016
Project Amount: $84,000
Environmental Discipline: Terrestrial Systems Ecology–includes animals

Bio

Laura Schoenle received a B.S. in Animal Science from Cornell University (New York) in 2006 and a Master's of Education from the University of Arizona in 2009. She taught high school environmental science and biology in Tucson, Arizona, for 3 years before entering a Ph.D. program in Biological Sciences at Virginia Tech in 2012. Her research interests include the physiology of stress, disease ecology and the impact of environmental change on wildlife populations. Laura is currently investigating how environmental stressors affect disease in red-winged blackbirds.

Synopsis

Mercury is a pervasive contaminant that causes a range of physiological effects in wildlife, including immunosuppression. When a contaminant compromises immune function, infections that previously were manageable instead present a substantial challenge. Avian malaria might be such an infection, as it often induces few overt symptoms but can reduce survival and reproductive success. This research is investigating how mercury exposure influences avian malaria infection intensity and the resulting effects on the behavior and physiology of the red-winged blackbird.

Keywords: malaria, mercury, red-winged blackbird

The Interaction Between Pollutants and Infectious Disease in a Model Organism

Objective(s)/Research Question(s)

Contaminants have the potential to alter physiology, behavior, disease and fitness in organisms. This research will use red-winged blackbirds (*Agelaius phoeniceus*) as a model to investigate (1) the influence of mercury exposure on avian malaria parasitemia, (2) the combined effects of these environmental stressors on fitness parameters and (3) aspects of physiology and behavior that might mediate changes in fitness.

Approach

The research employs both observational and experimental techniques to elucidate the relationship between mercury exposure and an infectious disease, avian malaria. Levels of mercury and avian malaria are being assessed in red-winged blackbirds breeding in both contaminated and pristine sites to identify if there is a relationship between mercury exposure and avian malaria parasitemia. Measuring parameters of physiological health, including hematocrit and red blood cell generation rates, will determine if mercury influences a bird's ability to tolerate the infection. To determine if mercury causes changes in physiology or the ability to resist or tolerate a malaria infection, a captive population of red-winged blackbirds will be exposed to varying levels of dietary mercury and changes in malaria parasitemia and physiological health will be evaluated.

Expected Results

If mercury suppresses immune function, red-winged blackbirds with greater exposure to mercury are expected to exhibit higher malaria parasitemia than those with lower mercury exposure. Individuals that are exposed to both mercury and avian malaria are expected to have reduced physiological health and reproductive success than those exposed to only one or neither of these stressors.

Potential to Further Environmental/Human Health Protection

In the struggle to manage the existing levels of environmental contamination and as growing human populations create more waste, it is imperative to understand the effects of contamination on ecosystems. Contaminants have the potential to enhance the effects of disease on wildlife population; thus, to accurately assess the effects of contaminants, it must be determined whether the effects of exposure to both a contaminant and a disease are synergistic or additive. This knowledge is essential to inform policy decisions regarding environmental contamination and cleanup.

SAFE & HEALTHY COMMUNITIES

A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people.

– Franklin D. Roosevelt

Ecosystem Services—Terrestrial Systems Soil and Plant Ecology

Michael Gerard Alonzo

Fusion of imaging spectroscopy and LiDAR for spatially explicit urban forest inventory

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Project Period: 9/28/2014–9/28/2016
Project Amount: $84,000
Environmental Discipline: Geography

Bio

Mike Alonzo got his start in the urban forestry sector with the Washington, D.C., nonprofit Casey Trees. While there he dug holes, planted trees and modeled the ecosystem services of the urban forest using field-inventory data. He parlayed this experience into a dissertation at the University of California, Santa Barbara, where he now maps urban forest structure and function using high-resolution remotely sensed imagery, both spatial and spectral. Mike has a B.A. in Geography from Middlebury College (Vermont) and an M.A. in Geography from the University of Denver (Colorado).

Synopsis

Urban trees are important in a city's effort to reduce air pollution, lower temperatures and control stormwater runoff. Mapping the species and structure of urban trees is necessary to understand the magnitude and spatial distribution of these ecosystem services.This research leverages high-resolution, remotely sensed imagery to delineate urban tree crowns, identify each crown's species and measure the crown's 3-D structure, including volume, leaf area and biomass.

Keywords: air pollution, urban climate, sensors

Objective(s)/Research Question(s)

Urban trees help reduce air pollution, lower temperatures and control stormwater runoff in cities. This study's goal is to map the species and structure of the urban forest in order to understand the magnitude and spatial distribution of these ecosystem services. This research leverages high-resolution, remotely sensed imagery to delineate urban tree crowns, identify each crown's species and measure the crown's 3-D structure, including volume, leaf area and biomass. The primary deliverable is a novel analytical toolkit for enhanced mapping of urban forest structure and function.

Approach

Three projects sequentially lead to fine-resolution maps of urban forest structure and function. First, the species of all canopy-dominant trees in an urban study are classified, using fused spectral and structural information extracted from hyperspectral imagery and LiDAR data, respectively. Second, key aspects of each tree's structure, including leaf area index, are estimated from the 3-D LiDAR point cloud. Finally, the maps of species and leaf area are used, along with existing models connecting structure to function, to generate spatially explicit estimates of air pollution mitigation, urban cooling and stormwater runoff reduction.

Expected Results

This study focuses on improving the methods employed to measure and analyze the urban ecosystem. Early results suggest that classification of tree species in a biodiverse setting is feasible with high-quality remote-sensing products. Estimation of such structural parameters as leaf area index also has been shown to produce acceptable values compared to field measurements. It is possible that citywide maps of ecosystem function generated with remote sensing methods will be more accurate than existing field methods due to the elimination of sampling error.

Potential to Further Environmental/Human Health Protection

Globally, three-quarters of all humans are projected to live in cities by 2050. Air and water pollution are at critical levels in dense, urban areas where millions of inhabitants suffer the attendant health and lifestyle consequences. A robust and well-planned urban forest can significantly mitigate health risks associated with pollution while bolstering overall city livability.

Jennifer Rae Eberwein

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Project Period: 9/22/2014–9/22/2016
Project Amount: $84,000
Environmental Discipline: Ecology

Bio

Jennifer Eberwein earned a B.S. in Environmental Science from the University of Texas, San Antonio in 2010. That fall, she began work toward her Ph.D. at the University of California, Riverside. Her research interests include microbial physiology, nutrient cycling and global change drivers. Her current research focuses on understanding soil feedbacks to the combined anthropogenic influences of climate change and nitrogen deposition.

Synopsis

Nitrogen inputs from air pollution exceed those from natural sources, and the consequences to soil processes are not well understood. Soil microorganisms regulate important feedbacks to global change drivers, such as climate change and air pollution, through production of the gases carbon dioxide and nitrogen oxides. This research investigates these soil feedbacks and explores the microbial physiology responsible with the intent of being better able to predict interactions between multiple global change drivers.

Keywords: carbon dioxide, nitrogen cycling and deposition, soil biome

The Influence of Nitrogen Deposition on Trace Gas Emissions of NO_x, N_2O and CO_2 in Arid and Semiarid Ecosystems

Objective(s)/Research Question(s)

This study will investigate soil feedbacks to nitrogen deposition through analysis of soil trace gas emissions of NO_x, N_2O and CO_2 along an anthropogenic nitrogen deposition gradient. Furthermore, this study will try to elucidate the mechanisms regulating that response through examination of microbial physiology and will contribute to further understanding of carbon and nitrogen interactions and soil trace gas emissions in arid environments.

Approach

NO_x, N_2O and CO_2 emissions are important contributors to air quality and terrestrial feedbacks to climate change. Knowledge gaps concerning interactions between the carbon and nitrogen cycles and changes in the ratio of carbon to nitrogen availability due to nitrogen deposition inhibit accurate predictions of the response of soil trace gas emissions to nitrogen deposition. This study will address that knowledge gap through a combination of laboratory incubations under controlled conditions and field observational data and manipulations of carbon and nitrogen availability. Furthermore, isotopic tracers and molecular techniques will be used to understand if changes in carbon and nitrogen alter soil emissions through changes in microbial physiology and/or shifts in microbial community composition.

Expected Results

Nitrogen addition has the potential to increase soil emissions of NO_x, N_2O and CO_2. The ratio of carbon to nitrogen availability is expected to be an important factor in regulating that response, due to associated changes in microbial physiology and/or community composition. This response is likely to be highly dependent on seasonal variations of soil moisture availability, plant activity and nitrogen deposition rates, with precipitation events following extended dry periods producing large pulses of microbial activity and corresponding emissions of NO_x, N_2O and CO_2.

Potential to Further Environmental/Human Health Protection

Thorough understanding of ecosystem responses to nitrogen deposition is necessary to inform modelers so that terrestrial feedbacks to nitrogen deposition and climate change drivers can be accurately predicted. The results from this project will enhance understanding of carbon and nitrogen budgets in arid ecosystems and provide insight into interactions between the carbon and nitrogen cycles. Additionally, NO_x represents important health implications and N_2O and CO_2 are major greenhouse gases. This research will provide valuable information to regulatory bodies so that ecosystem services provided by soils can be considered when emission standards are set.

Michael Harris

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Project Officer: Gladys Cobbs
Project Period: 9/22/2014–9/22/2016
Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Michael Harris received an M.S. in Civil and Environmental Engineering from the Georgia Institute of Technology in 2009, focusing on environmental fluid mechanics and water resource management. After graduating, he worked on various water- and sanitation-focused projects in Tanzania, Kenya and Bangladesh, progressing from research assistant to research manager. His research is on the environmental impact of this development field where health has been the main motivator.

Synopsis

Sanitation systems provide essential services for the protection of human health and ecosystem health, yet many developing countries lack adequate systems. This research proposes to investigate the environmental impact of various levels of development and associated sanitation infrastructure. Soil contamination and water quality indicators, such as fecal indicator bacteria concentration, will be studied to understand the implications for both human health and ecosystem health.

Keywords: ecosystem services, fecal indicator bacteria, sanitation

Drivers of Fecal Contamination in the Environment of Urban and Rural Areas of Tanzania and the Associated Impact on Ecological Health

Objective(s)/Research Question(s)

Human services (such as sanitation infrastructure) and ecosystem services (such as a soil's ability to absorb and process nutrients and pathogens) are integral to society's welfare. When the human services are not adequate, the development and population growth of a region will degrade the natural ecosystem services. The processes involved in this cycle of degradation are complex and involve many pathways within the natural and built environments. This research will attempt to understand drivers of microbial contamination of the environment in rural and urban areas of a rapidly developing region and how various sanitation infrastructure systems affect relevant ecosystem services.

Approach

Water quality indicators associated with sanitation systems, specifically fecal indicator bacteria, will be measured in both soil and water reservoirs for a prolonged sampling period across a region with various stages of development and population density. Sampling will occur at multiple frequencies and during both the wet and dry seasons to determine the natural variability due to weather and climate. Drivers of environmental change will be investigated with regard to the various reservoirs of sanitation-related contaminants by recording (1) observational characteristics of the sampling environment, such as animal and human presence, visible wetness and sun exposure, and (2) larger area characteristics, such as sanitation service type and coverage, impermeable surface coverage and population density.

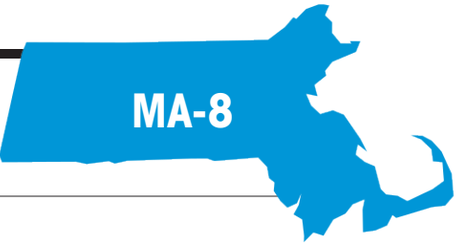
Expected Results

The relationship between soil contamination, water pollution and development is still unclear, yet the correlations are expected to be positive. Climate and weather have unclear influences, as fecal contamination of drinking water sources is correlated with increased rainfall in some regions and with the dry season in other places. Increased soil moisture should result in increased survival of pathogens and bacteria, while increased rainfall should result in increased runoff and associated washout of contaminants from the soil surface. Increased human activity, such as found in an urban area or rural market area, is expected to correlate with increased contamination and more frequent reloading of contaminants. The quality of sanitation infrastructure should have a direct influence on the concentrations of fecal-related contaminants, such that inadequate sanitation infrastructure and open defecation result in an increase in environmental contamination leading to potential degradation of ecosystem services and a decrease in human well-being.

Potential to Further Environmental/Human Health Protection

This research will demonstrate the various effects that sanitation infrastructure is having on public health and well-being, not only directly through exposure to contaminants but also through degrading ecosystem services of water and soil. Understanding trends in environmental contamination of fecal indicator bacteria and the underlying drivers will allow more focused interventions to be made for protecting environmental waters and public health. This knowledge, when applied to enhance ecosystem service valuations, will provide improved scientific and policy perspectives.

Margaret Hendrick



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Environmental Discipline: Environmental Monitoring

Bio

Margaret Hendrick received a B.A. in Biology from Reed College (Oregon) in 2008. She began a graduate program at the University of Montana in 2009, receiving her M.S. in Organismal Biology and Ecology in 2011. Later that year, Margaret started a Ph.D. program at Boston University in the Earth and Environment Department. Her research interests include global climate change, biogeochemical cycling, urban/rural ecology, ecosystem services and sustainable land management. Her current research characterizes the environmental impact of fugitive methane emissions from natural gas infrastructure.

Synopsis

Methane (CH_4) is a potent greenhouse gas and the main constituent of natural gas. As the United States develops its shale gas reserves, the environmental impact of fugitive CH_4 emissions from natural systems must be evaluated. Methane emissions affect soil and vegetation, which perform vital climate regulation services. This study assesses how CH_4 emissions across a gradient of natural gas production to distribution affect the strength of ecosystem services and how these effects influence climate change.

Keywords: ecosystem services, methane, natural gas

Impact of Fugitive Methane Emissions on Ecosystem Services Across a Gradient of Shale Gas Extraction to Natural Gas Distribution

Objective(s)/Research Question(s)

As the United States shifts away from oil and coal and develops its sizable shale gas reserves, the carbon (C) budgets associated with extracting, producing and distributing natural gas have come into sharp focus, especially as leaks from natural gas systems are the highest anthropogenic CH_4 emissions by source. Despite extensive research that characterizes the C sequestration and CH_4 oxidation services that soil biota and vegetation render, the effects of these services have not yet been evaluated locally or regionally with respect to the United States' natural gas industry. This research will characterize the effect of fugitive CH_4 emissions on the ecosystem services of C storage and CH_4 oxidation rendered by vegetation and soil across a gradient of shale gas extraction and natural gas distribution. By collecting and integrating ecological, biogeochemical and atmospheric data, this study aims to improve the quality of management and valuation of ecosystem services across the interdependent communities that produce and consume natural gas.

Approach

Soil, soil biota, vegetation and flux sampling will be performed in targeted communities in the Marcellus Shale Formation and within the greater metropolitan area of Boston, Massachusetts, where subterranean CH_4 emissions are known to be elevated. As Boston is one of the oldest cities in the United States, with an equally aged natural gas distribution infrastructure, it provides an ideal environment in which to investigate the effects of pervasive natural gas leaks on urban ecosystems. Field sampling will occur during the growing season when trees are fully leafed out and soil biota are most active. A smaller set of winter samples will be taken to gauge seasonal variation. To study the same field processes under controlled conditions, greenhouse experiments will be conducted to measure the response of soil, soil biota, vegetation and total CH_4 flux to treatments with known volumes of natural gas. By measuring microbial and vegetation processes, this research will quantify the impact of CH_4 on above- and belowground C storage and CH_4 oxidation. Flux chamber and landscape level CH_4 sampling will assess whole-ecosystem CH_4 flux across a rural to urban gradient of shale gas production and natural gas distribution, respectively.

Expected Results

Soils represent an extensive sink for atmospheric C, with soil biota oxidizing both atmospheric CH_4 and CH_4 that migrates up through the soil profile. Vegetation, especially trees, also represents a sizable sink for atmospheric C, and fugitive CH_4 emissions negatively affect tree health and survivorship. It is likely that CH_4 emissions from shale gas extraction and natural gas distribution will increase the proportion of methanotrophic bacteria in soil microbial communities and the potential for CH_4 oxidation. Conversely, it is likely that CH_4 emissions will decrease vegetation survivorship, growth rate, photosynthetic capacity and overall C storage potential. Total, relative CH_4 flux to the atmosphere from shale gas extraction and natural gas distribution is therefore expected to change relative to the capacity of soil and vegetation in urban and rural ecosystems to render these climate regulation services.

Potential to Further Environmental/Human Health Protection

As the global population has just surpassed 7 billion and current C emissions are the largest on record, more attention than ever must be paid to mitigating the impact of climate change. Characterizing the effects of fugitive CH_4 emissions in the United States is crucial because natural gas is central to this nation's current energy program, and leaks from natural gas systems are the highest anthropogenic CH_4 emissions by source. Data that fully characterize and quantify currently unvalued ecosystem services provided by soils and vegetation in response to sustained CH_4 enrichment are urgently needed to guide policy that better manages natural gas fuels, improves urban and rural ecosystem health and reduces potent greenhouse gas emissions.

Marissa Ruth Lee

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Environmental Discipline: Ecology

Bio

Marissa Lee received her B.A. in Biology from Swarthmore College in 2009. A year later, she began working toward a Ph.D. at Duke University in the University Program in Ecology. Her research interests involve the links between community composition and ecosystem functions. For her current research, she is studying how a highly invasive grass affects carbon and nitrogen cycling when it enters systems with different resident plant species and nutrient conditions.

Synopsis

Plant invasions have variable effects on such ecosystem services as carbon storage and nutrient retention in soils, which can make it difficult for land managers to allocate finite resources effectively. Using observational and experimental approaches, this project investigates the impact of one of the most invasive plant species in the eastern United States (Japanese stiltgrass) on carbon and nitrogen cycling and will develop a framework to understand how and why effects differ across forest stands.

Keywords: carbon cycling, nitrogen cycling and deposition, soil fertility

Predicting Variability in the Impact of Plant Invasion on C and N Cycling with a Conceptually Driven Framework

Objective(s)/Research Question(s)

Plant invasions can have detrimental consequences for critical ecosystem processes, such as carbon storage and nutrient retention. This project aims to understand factors that drive variability in the effect of one of the most widespread invasive plant species in the eastern United States, *Microstegium vimineum*, on carbon (C) and nitrogen (N) cycling. Specifically, it will investigate the relative importance of two hypotheses that describe variation in invader impact: first, that species have greater impact where they are most abundant (the mass ratio hypothesis); and second, that species have greater impact where they have the most different ecosystem function than the resident vegetation (the novel-traits hypothesis). In addition, experimental manipulations will determine the relative importance of litter and root-derived invader inputs on soil dynamics in forest plots varying in the dominant nutrient form (inorganic or organic) and, hence, the degree to which resident vegetation function most differently from the invader.

Approach

Observational studies and field manipulations will be used to study how *M. vimineum* affects coupled C and N cycling across a landscape that varies in *M. vimineum* abundance and varies in the degree to which *M. vimineum* nutrient-use characteristics differ most from the resident vegetation. C and N cycling will be characterized in paired invaded and uninvaded forest plots along a nutrient economy gradient. Plots will be chosen to maximize variation along the nutrient economy gradient based on the tree mycorrhizal status at each plot, because mycorrhizal status is a good indicator of the primary form of nutrients used by plants and microbes in that system. To determine the relative importance of litter and root-derived inputs from *M. vimineum* on soil C and N cycling across the nutrient economy gradient, a fully factorial experiment will cross root removal with three levels of ^{15}N-labeled *M. vimineum* litter addition (none, ambient density and double density) in invaded areas at three points along the nutrient economy gradient. Two forest stands with 0–20 percent, 40–60 percent, and 80–100 percent of the trees associated with arbuscular mycorrhizal fungi will be randomly selected for use in this study. *M. vimineum's* litter C and N contribution, root C contribution, and total C and N contribution under factorial treatments will be calculated by summing *M. vimineum*-derived C or N across all soil and microbial pools.

Expected Results

If the effects of *M. vimineum* are predicted by the mass ratio hypothesis, the magnitude of *M. vimineum's* effect will correlate with its abundance in invaded plots. Alternatively, if the impact of *M. vimineum* supports the novel-traits hypothesis, the magnitude of *M. vimineum's* effect will be greater in forest stands that occupy the organic end of the nutrient economy, where *M. vimineum* has traits that are dissimilar from the existing dominant nutrient economy. Results are expected to confirm the patterns in *M. vimineum's* effect magnitude found across *M. vimineum* biomass and nutrient economy gradients in the paired plots. It is further hypothesized that *M. vimineum* litter is more labile than resident litter in systems dominated by organic nutrient forms, thereby promoting litter decomposition; however, *M. vimineum* is likely to be more nutrient limited in these systems and thus may promote root exudation of labile C to stimulate rhizosphere N mineralization.

Potential to Further Environmental/Human Health Protection

Global climate, soil fertility, ecosystem productivity and ecosystem resilience are all tied to carbon cycling. This project will provide vital information for predicting where and under what conditions invasive species will have the greatest impact on C and N cycling, which will have significant implications for natural areas management and restoration. The focal species is listed by the U.S. Forest Service as one of only 26 Category 1 invasive plants—"highly invasive plants which invade natural habitats and replace native species"—in the Eastern Region of the United States. This research will provide data to generate better predictive models of where *M. vimineum* is likely to alter ecosystem functions, leading to more efficiently targeted control and restoration efforts and improved strategies for managing and restoring invaded habitats.

Gerald Franklin Schneider

UT-2

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Project Amount: $84,000
Environmental Discipline: Ecology

Keywords ozone, plant defense chemistry, plant physiology

Bio:

Jerry Schneider received a B.S. in Ecology, Behavior and Evolution from the University of California, San Diego, in 2009. He is currently a Ph.D. candidate in the Ecology, Evolution and Organismal Biology program at the University of Utah. Jerry's research interests include the influences of environmental stresses on plants' interactions with herbivores and pathogens. He is currently elucidating plasticity in leaf defense chemistry across gradients of solar radiation and ozone pollution.

Synopsis:

Ozone (O3) pollution affects plants by hindering photosynthesis and altering leaves' chemical defenses, which can in turn alter plant-herbivore interactions. Levels of anthropogenic O3 are increasing in tropical as well as temperate ecosystems. Tropical trees differ from their temperate counterparts in both chemistry and physiology, so they will likely respond differently to O3. This project will explore the effects of elevated O3 on the defense chemistry and herbivory rates of tropical tree species.

The Effects of Ozone Pollution on the Foliar Chemical Landscape of a Tropical Broadleaf Forest

Objective(s)/Research Question(s)

Do current levels of ozone pollution in an urban-influenced tropical forest cause qualitative and/or quantitative changes in the chemical defenses of the trees therein? If so, are certain plant species and certain types of chemicals more affected than others? Finally, are herbivory rates affected by these changes in defense chemistry?

Approach

This project will focus on the tropical forest at Barro Colorado Island, Panama, which shares an airshed with two large sources of ozone precursor emissions: the Panama Canal and Panama City. Ozone concentrations exhibit a marked decrease from the forest canopy and edges toward the forest interior, and the extremes of this gradient will be used as the spatial points of comparison for this study. Potted saplings of five tree species common in this forest will be placed at both extremes of the ozone gradient, with shade cloth used where applicable to standardize the light environment. The saplings will be left in place for two iterations of leaf production. During this time, ozone concentrations, stomatal aperture, emissions of volatile defense chemicals and herbivory levels will be monitored regularly. All leaves will then be harvested and their defense chemistry analyzed using liquid chromatography and mass spectrometry.

Expected Results

If current levels of ozone pollution at Barro Colorado Island are sufficient to induce changes in leaf chemical defenses, these changes will most likely come in the form of increased production of phenolic compounds and possibly terpenoid compounds. While many phenolic and terpenoid compounds function as anti-herbivore defenses, others appear to function in mitigating oxidative stress. An evaluation of chemical changes in the context of herbivory levels is necessary to determine which functional types of phenolics and terpenoids are regulated in response to ozone. These responses will likely be species specific, considering the high chemical diversity within tropical tree communities. For example, antioxidant phenolics and terpenoids may be upregulated while anti-herbivore compounds exhibit no change in concentration or are downregulated, resulting in increased herbivory rates. Alternatively, some species' anti-herbivore compounds also may function as antioxidants, and these will likely be upregulated, resulting in decreased herbivory rates. Finally, many tropical tree species exhibit delayed greening of expanding leaves and, thus, have minimal stomatal activity during the period when they are most vulnerable to herbivory and most heavily defended by anti-herbivore chemicals. These species will likely be much less affected by ozone than those species that initiate photosynthesis while leaves are still expanding.

Potential to Further Environmental/Human Health Protection

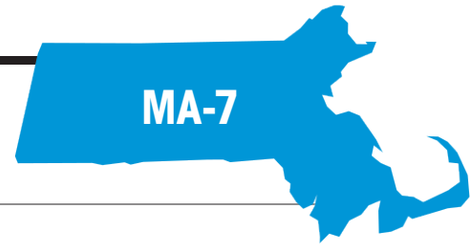
In tropical and temperate zones alike, trees are crucial elements of forest food webs, as well as of ecosystem services provided to society by forests. Because trees' interactions with pests are chemically mediated, changes in plant chemicals due to pollution could have extensive and long-term effects on ecosystems and ecosystem services. This study will explore the chemical responses of trees in a tropical forest to ground-level ozone, a globally increasing form of air pollution.

What we are doing to the forests of the world is but
a mirror reflection of what we are doing
to ourselves and to one another.
– Mahatma Gandhi

SAFE & HEALTHY COMMUNITIES

Built Environment & Land Use Protection

Todd Gerarden



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Project Amount: $84,000
Environmental Discipline: Environmental Policy

Bio

Todd Gerarden is a doctoral candidate in the Public Policy at Harvard's Kennedy School of Government. His research interests lie in environmental economics, public economics and industrial organization. Todd graduated from the University of Virginia in 2010 with a B.S. in Mechanical Engineering and was selected as a Truman Scholar. Before beginning doctoral studies, he worked at the White House Office of Science and Technology Policy and Resources for the Future.

Synopsis

Buildings account for roughly 40 percent of U.S. carbon dioxide emissions. Improving energy efficiency has the potential to save money, reduce pollution and generate tangible human health benefits. To motivate investment in efficiency, several U.S. cities have adopted policies that require building owners to report energy use for public disclosure. This research proposes to empirically assess the impact of energy use disclosure policies on market, energy use and environmental outcomes.

Keywords: benchmarking, built environment, energy efficiency

An Assessment of Energy Efficiency Information Provision: Financial, Energy and Environmental Impacts of City Benchmarking Mandates

Objective(s)/Research Question(s)

The purpose of this research is to quantify the impact of building energy use disclosure programs by studying three questions: What is the effect of energy use disclosure policies on the market valuation of energy efficiency? What is the effect of these policies on energy outcomes? What are the resulting environmental impacts and human health effects of these energy outcomes?

Approach

These research questions will be addressed through detailed econometric analysis. This analysis will harness new data to identify the effect of energy use disclosure policies using variation in the policies across buildings, neighborhoods and jurisdictions. This analysis also will incorporate existing research findings to translate energy use outcomes into environmental and human health effects.

Expected Results

This analysis will generate quantitative estimates of the impact of energy use disclosure policies on market, energy use and environmental outcomes. In doing so, it will provide evidence on the effectiveness of these policies in reducing local pollutants and greenhouse gas emissions associated with energy use.

Potential to Further Environmental/Human Health Protection

This project will provide quantitative evidence enabling policy makers to assess the effectiveness of energy use disclosure policies and respond more effectively to challenges posed by inefficient energy use. The methods used in this study may guide policy analysts in further examining specific programs. These results may inform the creation or modification of policies that provide concrete environmental and human health effects.

Gwynhwyfer Mhuireach

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Project Period: 9/29/2014–9/29/2016
Project Amount: $84,000
Environmental Discipline: Urban Planning

Bio

Gwynne Mhuireach received a B.S. in Biology from the University of Washington and an M.A. in Architecture from the University of Oregon. She is currently pursuing a Ph.D. in Landscape Architecture at the University of Oregon. Gwynne seeks to improve the urban built environment by combining analytical and synthetic problem-solving skills. Her current research focuses on relationships among microbial communities, green infrastructure, socioeconomic status and children's health.

Synopsis

Green infrastructure benefits human health, but urbanization may decrease vegetation cover, particularly in disadvantaged neighborhoods. Plants are major sources of microbes and reduced exposure to microbial diversity has been implicated in the increase of chronic diseases, such as allergies and asthma. This research will assess relationships among airborne microbial communities, green infrastructure, children's health and socioeconomic status to explore how urban design affects human well-being.

Keywords: children's health, microbiome, urban structure and planning

Relationships Among Airborne Microbial Communities, Urban Land Uses and Vegetation Cover: Implications for Urban Planning and Human Health

Objective(s)/Research Question(s)

Parks, street trees and other forms of green infrastructure have important health benefits, but urban densification can reduce vegetation cover and diversity, particularly in disadvantaged neighborhoods. Plants are major sources of microbes, and reduced exposure to microbial diversity has been implicated in the increase of such chronic diseases as allergies and asthma, suggesting that the demonstrated health benefits of urban green infrastructure may accrue partly through increased microbial diversity near vegetation. This study seeks to (1) quantify differences in airborne microbial communities within and across neighborhoods and whether observed differences are associated with neighborhood greenness; (2) investigate whether differences in vegetation or microbial communities are associated with reported student asthma or allergy; and (3) evaluate the degree to which vegetation patterns, airborne microbial community characteristics and health outcomes are associated with socioeconomic status.

Approach

An interdisciplinary approach will combine methods and techniques from microbial ecology, landscape architecture and epidemiology to investigate relationships among green infrastructure, airborne microbial communities, socioeconomic status and children's health in six elementary school neighborhoods in Eugene, Oregon. Spatial and temporal variation in airborne microbial communities within and among neighborhoods will be explored by sampling seasonally for four 1-week periods over 1 year. High-throughput sequencing of the 16S and ITS regions of the rRNA gene will be used to identify bacteria and fungi (respectively) in air samples, and geographic information systems and remote sensing will be used for vegetation and green space analysis. The resulting data will be analyzed against student health records of allergy and asthma from the six elementary schools using spatial and non-spatial statistical techniques (e.g. principal components analysis, land use regression, structural equation modeling).

Expected Results

This project will produce a quantitative model of the strength and direction of relationships among urban vegetation patterns, airborne microbial community composition, socioeconomic status and children's health. Specifically, it will investigate whether and how neighborhood vegetation—from public open spaces to street trees—influences airborne microbial communities, whether the relationship varies by socioeconomic status and how children's health is related to their access to green space and exposure to plant- and soil-associated microbes. The results are intended to provide foundational knowledge for how to better design and allocate urban green infrastructure to improve human health. Such understandings have the potential to reinvigorate historical connections between urban design and epidemiology by examining urban green space as health infrastructure using emerging tools from microbiology.

Potential to Further Environmental/Human Health Protection

The United States is at a critical nexus of urban planning. The country's population is expected to increase by more than 83 million people by 2050, most of whom will reside in urban areas. Understanding environmental influences on public health will help urban planners, designers and policy-makers target large-scale investments in public infrastructure projects. This project will further understanding of the multiple pathways through which urban green space may influence human well-being. Improved knowledge of the spatial and temporal dynamics of these relationships could enhance the design of healthier and more equitable cities of the future.

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Project Amount: $84,000
Environmental Discipline: Geography

Bio

Tammy is a Ph.D. Candidate in Virginia Tech's Geospatial and Environmental Analysis doctoral program; her dissertation research employs geospatial technologies to optimally site urban agriculture. She holds an M.S. in Geography from Virginia Tech and a B.S. in Interdisciplinary Studies from Virginia Commonwealth University. She maintains active engagement in K–12 STEM outreach and education and works closely with undergraduate students in her research and outreach activities. Her research interests include human-environment interactions, geospatial technologies and urban agriculture.

Synopsis

This research improves siting of urban agriculture, specifically, to create a model for evaluating an urban area's physical, economic and social environments. This model will identify locations providing the greatest potential for successful practice of urban agriculture to maximize benefits for local environments through ecosystem restoration to assist in sustaining current and future populations.

Keywords: food security, geospatial technologies, urban agriculture

Geospatial Analysis to Optimally Site Urban Agriculture

Objective(s)/Research Question(s)

This project poses several questions: (1) Can a geospatial model be developed that can analyze all environmental aspects of an urban environment and identify those locales that provide the optimal environmental benefits from urban agriculture? (2) Can a geospatial model be developed that identifies the correlations between food deserts, health issues, lack of green spaces and economic disparities in an urban area, so that urban agricultural green spaces can be sited to alleviate such issues? (3) Will the geospatial models developed in the first two objectives intersect to identify locales that provide optimal locations for urban agriculture to meet environmental, health, economic and social needs for the population?

Approach

This project comprises several phases: (1) investigation of spatial patterns of the urban terrain, hydrology and microclimates that create variability in crop-production potential and ability to alleviate environmental degradation; (2) investigation of the spatial dimensions of Roanoke's urban population to create a geospatial model that identifies the hierarchy of locations for urban agricultural production that best contribute economic, social and health benefits for low-income neighborhoods; and (3) investigation of spatial patterns defined by environmental, social, health and economic geospatial analyses from Objectives 1 and 2, above. The spatial covariation of these patterns will be analyzed to optimize locales for urban agriculture's contributions in providing specific ecosystem services and, thereby, alleviating environmental, social, health and economic issues prevalent in urban environments.

Expected Results

The outcome from the thematic overlay of each characteristic will be a hierarchy of urban parcels for the study site. This hierarchy will identify locations that best meet the goals of urban agriculture as a green space for providing food production. Some parcels will meet the needs of all themes; some will meet only the social themes; some, only the environmental; some will provide varying levels between the themes; and some locales will not provide any benefits. Developing a geospatial model that assimilates both the environmental and social spatial dimensions of urban agriculture will help identify locales that best contribute to generating ecosystems services and, thus, sustainability of urban environments.

Potential to Further Environmental/Human Health Protection

Through development of these three geospatial models, this research will develop analytical strategies, applicable within any urban area, to identify locations providing the best opportunities for successful agricultural production. Successful agricultural production will help alleviate environmental degradation and reduce food insecurity, along with related economic, social and health issues among at-risk urban populations. Ultimately, the project will identify the spatial dimensions of degraded areas in which urban agriculture will assist in restoring ecosystem services to guide various food production activities. The results can be generalized to other urban locations and help contribute to efficient use of urban land and space, improving all three pillars of worldwide sustainability—economic, environmental and social.

Look and listen for the welfare of the whole people and have always in view not only the present but also the coming generations, even those whose faces are yet beneath the surface of the ground —the unborn of the future Nation.

– *Constitution of the Iroquois Nations*

SAFE & HEALTHY COMMUNITIES

Tribes and American Indian/Alska Native/Pacific Islander Communitities

Scott Cardiff

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Project Amount: $84,000
Environmental Discipline: Environmental Sciences

Bio

Scott Cardiff is a Ph.D. candidate in Environment and Resources at the University of Wisconsin-Madison. He previously earned a B.S. in Natural Resources from Cornell University (New York) and an M.S. in Conservation Biology from Columbia University (New York). He is interested in the impact of large-scale mining and is studying cumulative land cover and water quality impact of such mining.

Synopsis

Large-scale metal mining can contaminate water and degrade areas of cultural and way-of-life importance. The risk of severe effects is likely to increase with increased mining, but few studies have assessed cumulative effects of mining. This research proposes to assess cumulative land cover and water-quality impacts of mining on Ojibwe treaty-ceded territories in states around Lake Superior. The work will improve understanding of the effects and assist evaluators of proposed new mining projects.

Keywords: cumulative impact, land cover, mining

An Assessment of Cumulative Land Cover and Water Quality Impacts of Mining on Ojibwe Treaty-Ceded Territories in Wisconsin, Michigan and Minnesota

Objective(s)/Research Question(s)

Large-scale metal mining has the potential to cause harmful environmental and social impact, including water contamination and degradation of areas of cultural importance. Assessing the cumulative impacts of past, present and potential future mining is important for understanding the risk of severe effects from multiple mines. This study will assess the cumulative effects of mining on land cover and water quality in Ojibwe treaty-ceded territories in Michigan, Minnesota and Wisconsin.

Approach

The research will analyze the spatial relationship of water quality and land cover with mining in the treaty-ceded territories of the Lake Superior Ojibwe in Michigan, Minnesota and Wisconsin. Existing water-quality data for constituents potentially related to mining will be used, supplemented with additional sampling as needed. Mining impact will be identified using comparisons with reference watershed sites and patterns of water quality downstream from mines. Remote sensing analysis of aerial photographs and satellite images will determine the current extent of mining and extent of pre-mining land cover classes. The relationship between mining land cover and water quality in individual watersheds also will be examined. These analyses will allow the measurement of the probable effects of past, present and potential future mining on the extent of mining land cover change and affected water quality across the Ojibwe territories.

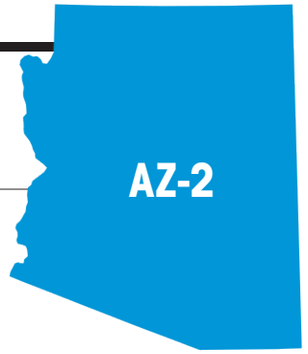
Expected Results

Based on studies of large-scale mining in other regions, mining extent will likely correlate with water quality changes within a watershed. Given the relatively abundant mines and mine discharge locations in Minnesota and Michigan, land-cover change and water-quality effects of mining are likely to be extensive in those portions of the Lake Superior Ojibwe territories.

Potential to Further Environmental/Human Health Protection

This research will improve understanding of the relationship between mining land cover and water quality and of the extent of the impact of mining on this region. The assessment of cumulative land cover and water quality effects of mining across the Ojibwe territories represents a key aspect of a potential broader study of cumulative impacts in those territories. It also will allow subsequent evaluation of possible influences of policy on the differences in the effects of mining between states and of the distribution of the effects of mining on particular communities and in sensitive areas. Finally, the assessment will provide information that is helpful to communities and decisionmakers who are evaluating proposals for new mining in the region.

Christopher Henry Guiterman



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Fire Regimes, Demography and Climatic Sensitivities of Navajo Forestlands: Insights From the Past to Inform Tribal Forest Management

Bio

Chris Guiterman holds a B.A. in geology from Bates College (Maine) and an M.S. in forestry from the University of Maine. He is currently a Ph.D. student at the University of Arizona, School of Natural Resources and the Environment, working in the Laboratory of Tree-Ring Research. Chris's research is aimed at understanding how people and climate affect forest dynamics over centuries and millennia, with the goal of enhancing forest management in the face of future climate change and increasing societal pressures.

Synopsis

Recent extreme fires and tree die-offs in the Southwest underscore the vulnerability of forests to climate change and land-use. Such events threaten the sustainability of Navajo Nation communities reliant on forests for ecosystem services. In collaboration with the Navajo Department of Forestry, this project will develop multi-centennial perspectives on changing fire regimes and forest sensitivity to climate in order to guide future management activities aimed at increasing forest resilience.

Keywords: climate change, ecosystem services, tribal communities

Objective(s)/Research Question(s)

This research takes place in the Chuska Mountains of the Navajo Nation, in partnership with the Navajo Forestry Department (NFD). The project was designed to address research needs identified by the NFD concerning the challenges that climate change poses to forest management and best pathways toward increasing forest resilience. To this end, the research strives (1) to quantify historical patterns of fire regimes and forest structure prior to extensive land use that led to an interruption of the fire regime in the early 1800s in order to assess the interplay between people, climate variability and fire and (2) to quantify long-term forest productivity and sensitivities of tree growth to climate variability across three major forest types in order to identify and triage areas where climate change might have the most profound effects on forest growth and survival.

Approach

Standard dendrochronological procedures will be implemented throughout the data collection and analysis portions of this research. Land-use histories will be derived from existing ethnographic and historical accounts of Navajo peoples, as well as from archaeological surveys within the study area. Reconstructing past spatiotemporal dynamics of fire events and tree recruitment will be accomplished by collecting fire-scarred trees and regeneration dates across a new network of combined fire history-demography sites in the Chuska Mountains. To quantify forest growth on a landscape-scale, work will be conducted alongside the Navajo Forestry Department to sample tree rings from their gridded network of Continuous Forest Inventory plots. Knowledge transfer will be done iteratively through face-to-face meetings and visits to the field, with the goal of assisting the foresters in designing science-based management practices in their next 10-year management plan, in which they will be addressing the vulnerabilities of their forests to climate change.

Expected Results

The dendrochronological analyses will generate multi-centennial perspectives on fire, age structure and tree growth-climate relationships. The fire history reconstruction will provide valuable data on the timing, frequency and scale of fires during a time period (pre-1850s) when Navajo people and widespread fires coexisted on the landscape, much in the same way as they would now if ecological processes were restored to Navajo forestlands. Identifying the primary climate drivers of forest growth across the Chuska Mountains will aid the NFD in preparing for future climate change by targeting their management strategies to those sites and forest types most sensitive to shifts in temperature and precipitation. These data sets also will be used to address several scientific knowledge gaps that concern the spatiotemporal dynamics of grazing-induced interruption of a surface fire regime, successional and ecological trajectories of forests that have been without fire for 70 to 100 years longer than elsewhere in the region, and refined estimates of forest-level sensitivities to climate from representatively sampled forest stands, as opposed to sites targeted specifically for drought sensitivity and climate reconstruction.

Potential to Further Environmental/Human Health Protection

The Chuska Mountains are a vital landscape to the Navajo Nation because they supply local communities with critical ecosystem services such as a clean and sustainable supply of drinking water, stable and fertile soils and traditional forest uses. The Navajo Forestry Department is responsible for maintaining forest health and resiliency across this landscape, as well as another five million acres of forests and woodlands. Due to a paucity of prior research, data necessary to address Navajo concerns regarding future environmental change are limited. Recognizing these challenges, the NFD have identified the research presented here as vital to their management practices, and it will therefore directly benefit and help to protect the environmental and human health of local communities of the Navajo Nation.

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