EPA
United States
Environmental Protection
Agency

STAR
FELLOWSHIP AWARDEES 2012
RESEARCH PORTFOLIO 2012

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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 2012 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 year's Portfolio is organized according to EPA's relevant research areas, including 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 impactful, with topics such 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 2012 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 2012 class of STAR Fellowship awardees.

EPA's National Center for Environmental Research

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

AIR, CLIMATE
& ENERGY

> All things share the same breath - the beast, the tree, the man… the air shares its spirit with all the life it supports.
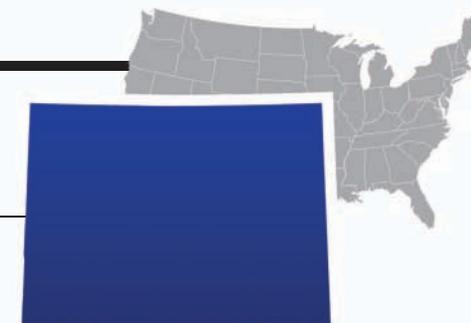>
> *– Chief Seattle*

AIR, CLIMATE & ENERGY

Clean Air

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EPA Project Officer: Ted Just
Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Environmental Engineering/Air Quality Monitoring

Keywords: indoor air quality, bioaerosols, particulate matter

Bio

Odessa Gomez received a B.S. degree in Chemical Engineering from Rensselaer Polytechnic Institute in 2007 and an M.S. degree in Chemical Engineering from the University of Colorado, Boulder (CU) in 2009. She continued at CU in the Environmental Engineering Ph.D. program where her research interests have included indoor air quality in communities of socioeconomic disadvantage. Her current research investigates the impact of combustion and biogenic indoor aerosols on respiratory health.

Synopsis

Poor indoor air quality has been identified as a major risk factor for acute and chronic respiratory diseases worldwide. Communities with socioeconomic disadvantages face substantially higher risk due to their proximity to industrialized areas, solid fuel use, water damage and residential overcrowding. In these communities, this research quantifies and characterizes indoor biological and combustion aerosols and their toxicological activity to quantify the potential for negative health impacts.

Characterizing Combustion and Biogenic Particulate Matter Present in the Indoor Environment

Objective(s)/Research Question(s)

Currently, there are no standards in place for black carbon (elemental carbon from combustion aerosols) or bioaerosols in the United States; further investigation into their sources, distribution and composite potential for negative health risks is needed. By examining the fundamental toxicological activity of these distinct indoor air pollutants, this research will provide a critical link between measured air pollutants and reported health outcomes identified by epidemiology studies. Concomitant with quantifying and characterizing indoor combustion and biological aerosols, this work will utilize mammalian cells to report rapidly the genotoxic and cytotoxic activity of combustion and biogenic particles recovered from indoor air.

Approach

Indoor and outdoor air sampling will be conducted in disadvantaged and developing communities situated near heavily industrialized areas or that use solid fuel (coal or biomass) as a means for heating and cooking. Particulate matter 10 and 2.5 microns and smaller (PM_{10} and $PM_{2.5}$) will be collected and analyzed for mass, organic and elemental carbon composition, as well as biopolymer content to establish the contribution of various sources, including biological and combustion, to the overall indoor aerosol load. Aerosols also will be analyzed for toxicological activity using a high-sensitivity, high-throughput single platform flow cytometry analysis, which simultaneously elucidates the potential of inflammation, cytotoxicity and genotoxicity as judged by biomarker induction and cell cycle analysis in human macrophages and lung cell lines.

Expected Results

This work will develop and apply methods to better characterize indoor air pollution using a robust perspective that considers primary biological content and toxicological activity that will contribute to faster and less invasive methods for monitoring indoor air quality and its potential impact on public health and the environment. In households using solid fuel (coal or biomass) for cooking and heating and/or those situated near industrialized or high transit areas, there is expected to be elevated levels of airborne particulate matter indoors, including elemental carbon and bioaerosols in combinations that induce significant toxicological responses. Households with water damage, pets or overcrowding should have higher biopolymer loads (proteins, carbohydrates and lipids), much of which will present toxicological signatures different than their combustion aerosol counterparts. Aerosol samples from households with elevated bioaerosol or combustion loads likely will exhibit a higher toxicological response than those with lesser loads. Additionally, thresholds will emerge where mixtures of combustion aerosols and biopolymers will present a synergistic toxicity beyond that of either component alone.

Potential to Further Environmental/Human Health Protection

Biological and combustion aspects of indoor air quality often are overlooked in the regulatory sector, yet have serious environmental and public health implications, particularly in those communities that disproportionately are affected. Broadening the range of particulate matter that is routinely monitored to include primary biopolymers and toxicological activity and aerosol interactions will strengthen the knowledge base for making environmentally and economically sound policy decisions while striving to protect the human and environmental health of communities. This work will engage a broad spectrum of community members in a citizen science campaign to increase public awareness and promote a better understanding of the dangers of indoor air pollution.

Christine M. Kendrick
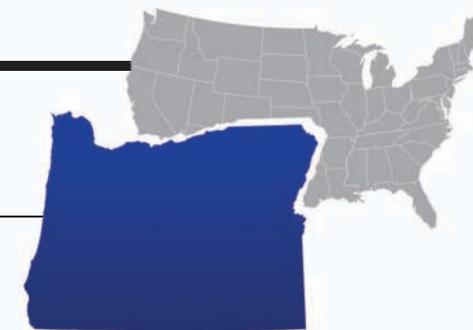
Keywords: air quality, transportation, human health

Bio

Christine Kendrick currently is pursuing her Ph.D. in Environmental Science at Portland State University specializing in air quality. She received a B.S. degree in Environmental Health Science from The University of Georgia. Her research interests include environmental and public health impacts of traffic-related air pollution in urban areas, investigation of personal exposures to transportation emissions as a function of travel mode and the built environment and evaluation of sustainable transportation systems in terms of mitigation to emissions.

Synopsis

Traffic-related emissions are a significant fraction of air pollutants in urban areas. Populations living or attending school in close proximity to roadways experience long-term exposures to increased pollution. Commuters encounter short-term exposures as drivers, cyclists or pedestrians. This research will monitor the change in air quality and traffic in response to altering traffic policy and use these data to develop models to assess impacts of traffic modifications on roadside air quality.

Integration of Air Quality Monitoring and Transportation Planning for Exposure Mitigation in Urban Roadway Environments

Objective(s)/Research Question(s)

Urban populations encounter short- and long-term exposures of increased vehicular emissions within roadway environments, but air quality effects in transportation planning traditionally are evaluated based on regional, airshed models that do not capture the impacts of these exposures. This research will integrate more refined measurements of traffic-related pollutants with traffic monitoring during the implementation of a large-scale traffic signal intervention on an urban corridor. Roadside monitoring data for air pollutants, traffic parameters and local meteorology will be used to develop models to assess impacts of traffic modifications on long-term localized and short-term corridor exposures at a project-level scale.

Approach

Air quality and traffic monitoring will occur on SE Powell Boulevard, a key regional commuter corridor, connecting highway US 26 to and through Portland, OR. The corridor's surrounding area is populated densely with residences, schools and businesses and carries a high compositional mix of traffic, including freight trucks, passenger cars and trucks, public transit buses, bicyclists and pedestrians. The corridor is switching from a set-timed traffic signal system to an adaptive traffic control system that will respond to traffic volume, queues at intersections and transit priority signals. This research will integrate continuous measurements, over multiple years, of air pollutants PM_{10}, $PM_{2.5}$, particle number concentrations (PNC), NO_2, CO and CO_2; traffic dynamics (speed, volume, classification), and meteorology (wind speed, wind direction, temperature, relative humidity) using permanent roadside stations. Separate field deployments of portable equipment also will be used to measure concentrations along the study corridor, along major roads intersecting the corridor, and dispersion into roadside parks, school lots and neighborhoods.

Expected Results

Data collected will be used to build models to investigate direct temporal relationships between acceleration, deceleration, queue lengths, fleet composition, meteorology and roadside air quality. Vehicle queues in the directions of heaviest traffic will be minimized once the traffic signal system is optimized. It is expected that maximum and average PM_{10}, PNCs and NO_2 concentrations will be reduced because of shorter queues at major intersections and less frequent acceleration and deceleration events. $PM_{2.5}$ concentrations may remain the same as fine PM background levels of urban areas can lead to a more homogeneous pattern for this pollutant. $PM_{2.5}$ hotspots may arise due to building geometry and meteorology. Monitoring results and emissions modeling will be combined with near-field dispersion modeling to incorporate the surrounding built environment and investigate such spatial patterns. This model development will be used to quantify and visualize traffic emissions spatially within built roadway environments as well as simulate and compare emissions from alternative traffic modifications.

Potential to Further Environmental/Human Health Protection

Transportation is an essential and daily component of lives across the globe. The adverse human health effects from long- and short-term exposures to increased roadway pollution pose a critical demand on transportation policy to reduce impacts of motor vehicle emissions. Integrated air quality and transportation planning on a project-level scale in addition to a regional scale can help target the high impacts of roadway environments and attain urban sustainable development goals like emissions mitigation more efficiently.

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Project Period: 8/27/2012 - 8/26/2015
Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: air pollutants, particles, health effects

Bio

Shahana Khurshid is a doctoral candidate at the University of Texas (UT), Austin, studying reactive oxygen species (ROS). She holds a B.S. degree in Environmental Engineering from the Massachusetts Institute of Technology and an M.S.E. degree in Biomedical Engineering from UT, Austin. She has been on the National Dean's List and has been initiated into three honor societies. She has published in highly ranked journals and has received several awards from the Air & Waste Management Association, American Association of University Women, and UT, Austin.

Synopsis

ROS are an important class of air pollutants generated from photochemical and ozone-initiated reactions in indoor and outdoor environments. ROS on particles smaller than 2.5 micrometers ($PM_{2.5}$) can reach deep into the lungs. This research proposes to understand the health effects of ROS and to determine the parameters that influence the outdoor and indoor concentrations of particulate ROS.

Particulate Reactive Oxygen Species: Prevalence and Health Effects

Objective(s)/Research Question(s)

The objectives of the proposed research are to: (1) delineate the indoor concentration of ROS in different types of buildings and compare it to the outdoor concentration of ROS; (2) determine the factors that influence indoor and outdoor concentrations of ROS; and (3) assess the health effects of ROS.

Approach

The study will characterize the concentration of particulate ROS in several types of buildings by collecting $PM_{2.5}$ from residences, institutional buildings and retail stores. A fluorogenic probe will be used to measure the concentration of ROS on the samples of $PM_{2.5}$. The indoor concentration of particulate ROS will be compared with the outdoor concentration of particulate ROS. A mechanistic approach will be used to assess the influence of specific building and other factors (including building age, total volatile organic compound concentration, distance from a major roadway, windows open or shut, indoor and outdoor concentrations of $PM_{2.5}$, outdoor ozone concentration, and indoor and outdoor temperature) on the concentration of ROS. Furthermore, the seasonal variation in the outdoor concentration of particulate ROS also will be assessed. The accuracy of all ROS measurements will be verified by conducting several experiments, including investigating the rate of decay of particulate ROS on sampled filters. In addition, the potential health effects of reactions that produce ROS will be assessed with an *in vitro* exposure model. Human lung epithelial cells will be exposed to ROS generated by a mixture of ozone and a model terpene, and the inflammatory proteins expressed by the lung cells in response to this exposure will be assessed. In this way, the research will delineate the concentration of particulate ROS in indoor and outdoor environments, determine the factors that influence the concentration of particulate ROS and assess the potential health effects of ROS.

Expected Results

This research will expand the understanding of the importance and potential health effects of ROS. It will provide insight into the indoor-to-outdoor ratio of particulate ROS and is one of the first studies to assess ROS in indoor environments, especially houses, where people spend the majority of their time. Sampling conducted to date in residential, institutional and retail buildings indicates that the indoor concentration of particulate ROS can be, on average, 80 percent greater than the outdoor concentration of particulate ROS. This can have important implications on the extent of exposure to particulate ROS. It is anticipated that the results from this study will help delineate the factors that influence indoor concentration of ROS; these results will be integrated to help determine the most effective strategy to limit exposure to ROS. Outdoor sampling conducted over several months already has shown that ROS is influenced partially by the ambient temperature. Furthermore, preliminary results from experiments already conducted at the National Institute for Occupational Safety and Health with an *in vitro* exposure model indicate that exposure to ozone-initiated reactions that produce ROS leads to greater inflammation in human lung epithelial cells than exposure to ozone alone. This research highlights the need to better understand the extent of exposure to this class of pollutants.

Potential to Further Environmental/Human Health Protection

Although there has been significant focus on the health effects of ozone, the relative health effects of products from ozone-initiated reactions have not received as much attention. This research will help determine the extent of exposure to products from ozone-initiated reactions as well as their potential health effects. Furthermore, the results from different components of this research will be integrated to elucidate the most effective strategy to limit exposure to ROS.
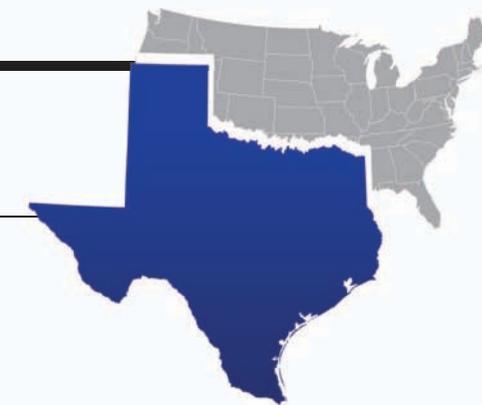
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Project Period: 8/23/2012 - 8/22/2015
Project Amount: $126,000
Environmental Discipline: Chemical Engineering

Keywords: catalyst deactivation, sulfation, microkinetic modeling

Bio

Hom Sharma received his B.Sc. degree in Chemistry from Tribhuvan University, Nepal, and a B.S. degree in Chemical Engineering from the University of New Hampshire. In 2010, he joined the University of Connecticut to pursue a Ph.D. in Chemical Engineering. His research interests are vehicle emission reduction, catalyst design and kinetic model development. He has experience working on microkinetic modeling for emissions oxidation chemistry and structure-activity relationships for soot oxidation.

Synopsis

Diesel Oxidation Catalysts (DOCs) are Pt-Pd based catalysts supported on alumina, used to oxidize the toxic emissions in the exhaust. They are susceptible to deactivation, however, because of the sulfur-containing compounds in the exhaust stream that originate from the sulfur in diesel. This research focuses on understanding the fundamental reaction mechanism of DOC sulfation, followed by computational catalyst design and experimental validation to identify robust, efficient and durable sulfur-resistant materials.

Computational and Experimental Investigation of Catalyst Deactivation to Design Sulfur-Resistant Emissions Oxidation Catalysts

Objective(s)/Research Question(s)

During diesel combustion in the engine, sulfur in the diesel is oxidized to sulfur oxides (SOx), which can block the active sites on the DOC (site poisoning) and also alter the chemical characteristics through sulfation. To identify sulfur-resistant catalyst materials for DOCs, one first needs to understand how SOx interacts with the catalyst, how metal and support of the catalyst get sulfated, how fast the sulfation chemistry is and which strategy should be used to screen promising materials.

Approach

In this research, quantum mechanical Density Functional Theory (DFT) will be utilized to estimate the kinetic parameters for bimetallic Pt-Pd catalyst, SOx chemistry, alumina support sulfation and PdO sulfation, consistent with the aforementioned technical challenges. This information will be incorporated into a kinetic model for emissions oxidation to predict the DOC deactivation over time. Finally, this study will explore the effect of catalyst doping on sulfation kinetics to identify promising sulfur resistant materials, followed by experimental validation.

Expected Results

Catalyst deactivation due to sulfur is a complex phenomenon that involves interactions of sulfur with metal catalysts, catalysts' support and DOC primary chemistry. This research will provide information of reaction kinetics for the underlying sulfation chemistry of DOC. Furthermore, it will help to overcome challenges of developing a novel catalyst screening tool and identify the improved sulfur resistant DOC materials.

Potential to Further Environmental/Human Health Protection

Engine emissions will continue to pose a serious threat to human health and the environment. Because the protection of human health and the environment from toxic emissions from engines depends on the robustness of after-treatment catalysts, a fundamental understanding of reaction kinetics and catalysts' deactivation chemistry is crucial to designing such materials. The proposed research findings will have applications beyond the DOC system, especially for emissions after-treatment components such as Selective Catalytic Reduction (SCR) and catalytic Diesel Particulate Filter (cDPF). Furthermore, engines and after-treatment system manufacturers will benefit from the research findings as they are required to meet the standards, whereas policy makers will be able to implement the appropriate regulations.
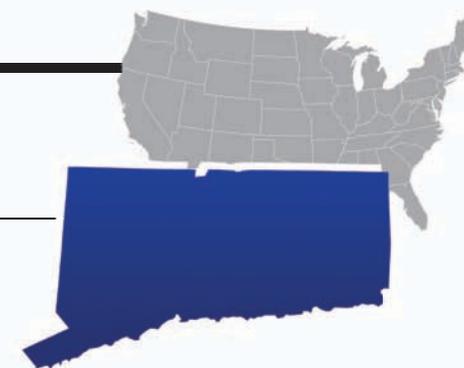
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EPA Project Officer: Ted Just
Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126000
Environmental Discipline: Chemical Engineering

Keywords: emissions control, diesel particulate filters (DPFs), air quality

Bio

Diep Vu received a B.S. degree in Chemistry and a B.A. degree in Economics from the University of California (UC), Santa Cruz, in 2008. That same year, she started a Master's program at California State University, Fullerton, in Civil Engineering with an emphasis in Environmental Engineering. She graduated in 2011, and currently is working on a Ph.D. in Chemical and Environmental Engineering at UC Riverside. Her research interests include characterization of secondary aerosol formation from advanced emission control technology sources and subsequent impact on the climate.

Synopsis

Emissions control system (ECS) technologies are used widely and globally to mitigate air pollution. Certain types of ECS technologies such as diesel particulate filters (DPFs), however, may generate new particles of different chemical and physical composition from the original emissions source during the filtering and regeneration process. The primary goal of this research is to characterize particle emissions downstream of ECS technologies and understand their role as precursors for secondary organic aerosol, air quality and climate.

Climate Impact of Advanced Emission Control Technologies

Objective(s)/Research Question(s)

ECS technologies are used widely and globally to mitigate air pollution. Certain types of ECS technologies such as DPFs, however, may generate new particles of different chemical and physical composition from the original emissions source during the filtering and regeneration process. Previous research has shown that, although DPFs can reduce mass emissions rates, they can enhance the formation of ultrafine semi-volatile particles during regeneration and pass through the filter. These particles potentially may act as precursors to secondary organic aerosol (SOA) and other photochemical pollutants. This research will measure and quantify the chemical activity and physical properties of these emissions.

Approach

Because the chemical composition and the physical properties of emissions downstream of ECS technologies are highly dependent on control technology types and fuels, the emissions will be characterized from different sources. Measurements for particle and vapor phase (e.g., size distribution and composition) will be collected and supported by instrumentation provided at the UC Riverside Center for Environmental Research and Technology. Instrumentation will include both online and offline measurements. In addition, fresh aerosol will be aged and evaluated in atmospheric processes chamber studies to assess downwind effects, such as atmospheric interactions and transformations, of the particles in the atmosphere to assess their potential at SOA precursors.

Expected Results

Emissions are expected to be highly dependent on the type of control technology and fuel. Recent research has been limited to few types of DPFs. This research will be extended to different types of technologies but with an emphasis on the chemical activity of these particles in the atmosphere. Through atmospheric aging, these particles can undergo various physical and chemical interactions that may cause changes in particle size and composition. This will provide insight on the impact of these technologies for air quality, the environment and climate.

Potential to Further Environmental/Human Health Protection

This proposed study allows for the opportunity to measure and quantify the chemical activity of these emissions in the atmosphere. It will provide a foundation to better assess the risks of exposure to human and environmental health, aid in the design of more effective emission control technologies, and allow for effective formation and/or revision of air quality regulations that protect the health of the population and environment.
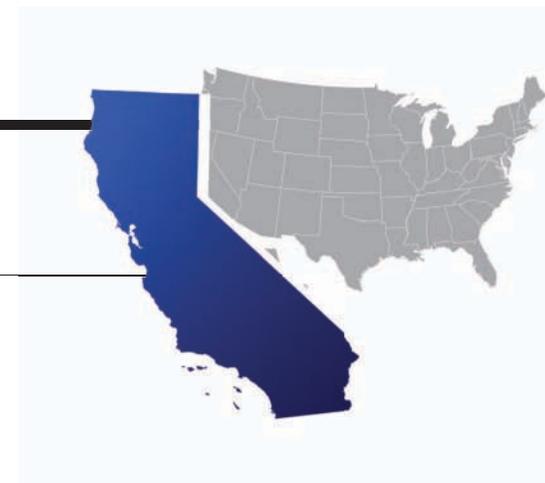
> It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.
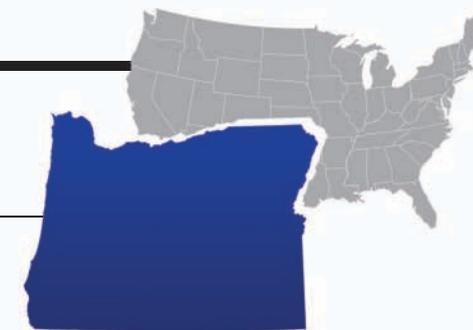>
> *—Charles Darwin*

Global Change

Allison Kate Barner

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EPA Project Officer: Ted Just
Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: climate change, species interactions, macroalgae

Bio

Allison Barner received her B.A. degree with honors in Biological Sciences (specialization in Ecology and Evolution) from the University of Chicago in 2009. In fall 2010, she started a Ph.D. program in Zoology at Oregon State University, where she currently works on the changing role of species interactions in intertidal algal communities under multiple climate change scenarios, using a combination of observational, experimental and quantitative approaches. Her research interests include species distribution modeling, spatial ecology, climate change and community regulation.

Synopsis

Species distributions are expected to shift as a result of climate change, but little is known about how climate change might affect interactions between species (e.g., competition). This research will investigate the role of climate stressors on intertidal marine algal species: how changes to the environment influence species interactions; how these changes may cause new ecological communities to form; and how to incorporate this knowledge into predictions about future species distributions.

Towards a Mechanistic Understanding of the Response of Rocky Shoreline Communities to Multiple Climate Change Scenarios

Objective(s)/Research Question(s)

Because predictions about future species distributions that are made under current climate conditions may not hold up as climate rapidly changes, accurate predictions of future ecosystem change require a mechanistic, experimental understanding of the species interactions (competition, facilitation) that structure communities. Current bioclimate prediction models do not account for species interactions, and to explore the consequences of ignoring interactions, this research will utilize a framework incorporating observational surveys, experimental manipulation and exploratory community-level modeling to investigate and predict intertidal community dynamics under climate change. The study asks: (1) What are the patterns of natural macroalgal community structure and function under different environmental gradients related to climate change along the California Current System? (2) What are the structural and functional responses of constructed communities to experimental climate change? (3) What are the predicted future trajectories for marine macroalgal communities under climate change?

Approach

This study will use existing variability in environmental conditions along the Oregon and California coasts as climate change proxies to test the effects of storm intensification and sea level rise on intertidal macroalgal communities through modifications to species interactions. The study will use large-scale, spatially explicit surveys of the macroalgal communities and environmental conditions to model current and future species distributions and ecosystem function (productivity). Transplant experiments across gradients relevant to climate change (storm intensification = wave exposure, sea level rise = tidal height) will be conducted to evaluate how climate change might affect macroalgal species interactions, and community structure and function. Finally, this study will test the predictive power of a series of bioclimate models that do and do not include species interactions using results from the observational and experimental work.

Expected Results

Although the need to incorporate species interactions into bioclimate models is recognized widely, there have been no experimental comparisons between predictions made by climate envelope models and species interaction models. This project will quantify these differences to understand the benefits and limitations to each modeling approach and identify sources of uncertainty in bioclimate models. It is expected that there will be large differences in the predicted future community structure and function among models, and that the model incorporating interactions under climate change will have the greatest ability to explain environment-structure-function associations. However, these predictions may not be relevant at large spatial scales, where oceanography and regional climate forcing is more important. This study will provide the unique ability to predict and compare changes to macroalgal coastal community structure and ecosystem function under different climate scenarios and models.

Potential to Further Environmental/Human Health Protection

Through *in situ* manipulations and modeling, the study will explore how individual species loss affects the functioning of this ecosystem, with crucial implications for ecosystem management. Resource managers and policy makers face a quandary, as traditional management tactics may not be valid when species distributions and interactions are altered. Thus, understanding the performance of models of species distributions under multiple climate change factors is critical to informing adaptive management and directing conservation effort. The results of this proposed research will have cross-system implications in management, as the theory and models developed here will be applicable in systems beyond the rocky intertidal, intended to engage in a more general discourse on community theory and its application to climate change.

Jillian Margaret Bible
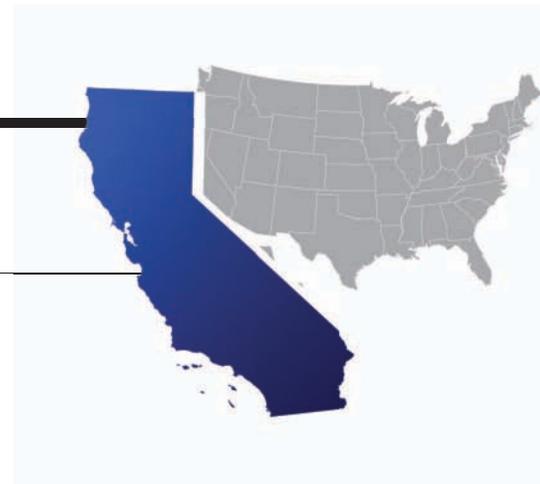
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EPA Project Officer: Ted Just
Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: climate change, local adaptation, native species

Bio

Jillian Bible received B.S. and M.S. degrees in Earth Systems from Stanford University. She then spent 3 years working at the California Academy of Sciences in San Francisco, CA, before starting a Ph.D. program in Ecology at the University of California, Davis, CA. Her broad research interests include human impacts on ecosystems and restoration ecology. Her current research examines whether populations of native Olympia oysters from different estuaries differ in their tolerance of climate change.

Synopsis

Successful conservation and restoration must consider how organisms will respond to climate change. This research investigates whether native Olympia oysters from three California estuaries have evolved different tolerances of factors expected to shift with climate change, including temperature, salinity and water chemistry. Results will inform oyster restoration by determining whether some populations are more vulnerable or more robust in the face of climate change.

Local Adaptation in Olympia Oysters in Northern California Estuaries: Designing Resilient Restoration Under Global Change

Objective(s)/Research Question(s)

The objective of this research is to determine whether different populations of Olympia oysters are adapted locally to their home estuaries and whether it results in different tolerances of stressors associated with climate change. Additionally, the results of this research will be applied to restoring Olympia oysters, an important foundation species.

Approach

This research will evaluate whether Olympia oyster populations from three northern California estuaries are adapted locally to their home estuary. To do this, my study will raise oysters from different populations for a full generation under common conditions in the laboratory to isolate persistent genetic differences from other confounding factors, such as effects of environmental history and phenotypic plasticity. Then, using second-generation, laboratory-reared oysters, this study will conduct reciprocal transplants in the field to assess local adaptation and perform laboratory experiments to analyze oyster survival and growth under conditions predicted to shift with climate change (e.g., temperature, salinity and carbonate chemistry).

Expected Results

This study is expected to find that oyster populations will survive and grow better in their home estuary than oysters from other estuaries. This would suggest that oysters are adapted locally to the conditions in their home estuaries. Because temperature, salinity and pH vary among the three studied estuaries, it also is expected that oysters from different estuaries will differ in their responses to these stressors. If oyster populations exhibit different responses to stressors, they likely will vary in their responses to climate change.

Potential to Further Environmental/Human Health Protection

This research will inform active oyster restoration by determining whether certain oyster populations are particularly vulnerable or particularly robust to global change. This knowledge will enable more informed management, assessing whether restoration will be better suited to some estuaries or some sites than others and whether certain sites should be prioritized for stock selection. It also will aid in prioritizing conservation of populations that contain stress-tolerant genotypes or ameliorating other stressors (e.g., pollution) for particularly vulnerable populations.

Mary Alice Cameron
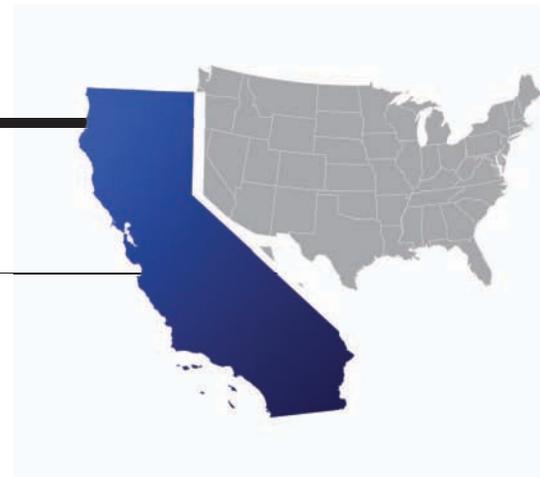
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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Atmospheric Sciences

Keywords: aircraft, air pollution, chemistry model

Bio

Mary Cameron received a B.S. degree in Mathematics from Arizona State University in 2009 and an M.S. degree in Computational and Mathematical Engineering from Stanford University in 2011. She began her Ph.D. studies the following year in Stanford's Atmosphere/Energy Program in the Department of Civil and Environmental Engineering. Her current research models the effects of aircraft emissions on air pollution and atmospheric composition.

Synopsis

Air travel is a rapidly growing industry, though its effects on air pollution and atmospheric composition still are uncertain. This research uses numerical techniques to model the transport and chemical evolution of individual aircraft plumes. This project will provide information on where ozone, nitrogen oxides, particulate matter and other harmful pollutants from aircraft exhaust are most damaging to human health and the environment, and how to minimize their effects.

Modeling Air Pollution From Aircraft Emissions in an Expanding Plume

Objective(s)/Research Question(s)

Because aircraft plumes change shape with time and meteorology, it is difficult to measure their effects on air pollution. The purpose of this research is to use computational modeling techniques to investigate how individual aircraft exhaust plumes change atmospheric chemistry and physics. Results from 3-D global simulations will be used to predict more accurately the transport and chemical evolution of exhaust plumes.

Approach

This research will couple atmospheric models with sub-grid plume emissions to treat individually the emissions from more than 30 million annual flights worldwide. This requires first determining an accurate, yet computationally inexpensive method for modeling single aircraft emissions as an expanding plume. With parallelization and a highly efficient chemistry solver, a more extensive chemical mechanism will be included to track thousands of reactions occurring in each plume. Next, 3-D global and regional simulations initialized with flight data will identify regions where aircraft emissions concentrate due to transport and meteorology.

Expected Results

It is expected that tracking emissions using sub-grid layered plumes will yield very different results than simulations where emissions are added uniformly to much larger atmospheric model grid scales. By tracking these plumes, it is possible to avoid the initial dilution that would otherwise occur when pairing an atmospheric model with emissions data. Especially near airports and busy flight paths, it is important that the emissions from multiple flights are distinct yet able to mix, more realistically changing pollution concentrations and chemical reactions at each time step. Results from this research are expected to show that refining the plume will significantly affect air pollution estimates near airports and heavy air-traffic areas, where humans can be most affected.

Potential to Further Environmental/Human Health Protection

The results from this research will be useful in seeing where and what types of emissions concentrate in different regions. For example, in the United States and Europe, where air traffic is particularly dense, it will be important to see where particulate matter and ozone levels are elevated due to aviation. These results particularly will be important to airport employees and neighborhoods near airports where air quality is a health concern, as well as areas further away from airports, where wind-blown emissions may pollute bodies of water, agricultural lands, forests or neighboring cities.

Melissa Lynn Chipman
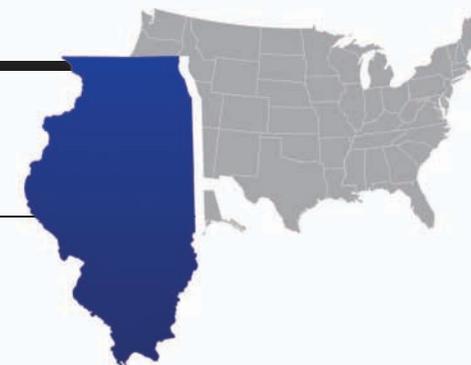
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: tundra, fire, paleoclimate

Bio

Melissa Chipman received a B.S. degree in Environmental Geosciences from Concord University in 2004 and an M.S. degree in Geology from the University of Illinois in 2007. After working as a research specialist for 3 years, she currently is pursuing a Ph.D. in the Program of Ecology, Evolution and Conservation Biology at the University of Illinois. Her research includes the use of paleoecological techniques to understand disturbance dynamics in tundra ecosystems.

Synopsis

Projected warming in the Arctic far exceeds that of modern times, and it is uncertain how tundra ecosystems will respond. Tundra fire regimes, characterized by small and/or rare fires at present, likely will change as new climate-vegetation structures emerge. The study will reconstruct climate, vegetation and fire frequency from Alaskan lake sediments. These records provide a natural experiment to test climate-vegetation-fire relationships across a broad range of scenarios.

Impacts of Climate Change on Tundra Fire Regimes: Using the Past as a Window to the Future

Objective(s)/Research Question(s)

In tundra ecosystems where burning is rare on the modern landscape, are recent fires unique in the context of the past several millennia? Were tundra fire regimes sensitive to abrupt, large-scale climate and associated vegetation change in the past, and what does this suggest for future climate scenarios? What are the climatic conditions that exacerbate tundra burning, and how do these differ for various vegetation types?

Approach

Paleoecological analyses of lake sediment cores will be used to reconstruct long-term climate-vegetation-fire dynamics. These analyses include macroscopic charcoal records to reconstruct fire frequency, pollen to infer vegetation change and a combination of midge assemblages and carbonate isotopes to reconstruct climate. Lakes from three tundra ecoregions in Alaska will be targeted for analyses, capturing a broad range of climate and vegetation scenarios. The long temporal span of the records (~5,000–14,000 years) allows for interpreting fire trends under novel past climate conditions, refining the understanding of climate thresholds that may alter fire regimes in the future.

Expected Results

In tundra regions that rarely burn today, recent fires likely are anomalous, related to unique climate conditions at present. When fires did occur in the past, a relationship to periods of distinct warm and/or dry conditions is expected. However, tundra burning also is vegetation limited, with forest-tundra more flammable than shrub-dominated tundra, which in turn should be more flammable than grass- and sedge-dominated tundra. Thus, these different vegetation types should have different climatic thresholds to increased burning.

Potential to Further Environmental/Human Health Protection

This research directly impacts Arctic residents who rely on the natural resources in the tundra for survival. For example, these data are important for conservation practices in Alaska, including the design and implementation of fire suppression strategies. Moreover, understanding the effects of ongoing climate change on tundra ecosystems will provide information on empirical climate-fire-vegetation relationships necessary to anticipate changes under future climate scenarios.

Elizabeth Derse Crook
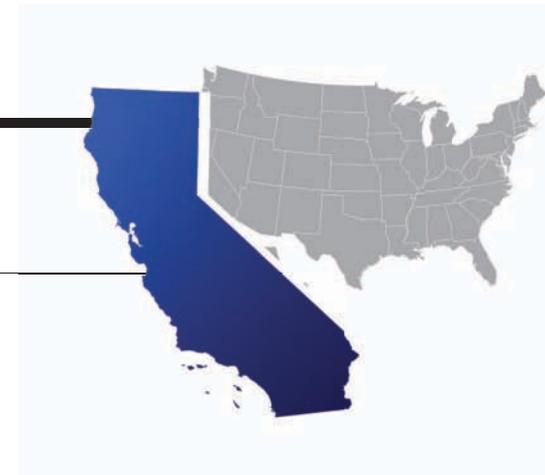
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Project Amount: $126,000
Environmental Discipline: Marine/Environmental Science

Keywords: ocean acidification, coral reefs, pH

Bio

Elizabeth Crook graduated from Stanford University in 2006 with a B.A. degree in Human Biology. She then joined the Teach For America program and taught 7th grade science in New York City, NY, while obtaining her M.Sc. in Education from Pace University. In 2008, she started her Ph.D. studies at the University of California, Santa Cruz, where she is interested in how coral reef ecosystems will be impacted by an increase in carbon dioxide to the oceans. Her current project monitors calcification rates and reef community development in the Caribbean.

Synopsis

The anthropogenic loading of carbon dioxide to the surface oceans, popularly referred to as ocean acidification, is expected to be one of the most important environmental concerns of our time. This research studies the impact of ocean acidification (decreasing pH) on coral calcification and reef community structure in hopes of better understanding how coral reef ecosystems may respond to the ocean acidification scenario.

The Impact of Ocean Acidification on the Calcification of Reef-Building Corals and Coral Reef Communities

Objective(s)/Research Question(s)

This research focuses on how decreasing pH may impact the calcification of coral reef ecosystems using a field site in the Caribbean that experiences natural acidification. The study will assess the impact of low pH water on organismal recruitment and subsequent individual and community development (succession). Additionally, this work aims to determine the calcification rates, lipid analysis and zooxanthellae counts of corals at the sites of low pH water to assess their relative growth rates and overall health when compared to corals at control sites.

Approach

To determine how ocean acidification will impact reef community development, experimental recruitment tiles have been deployed in the field (in both low pH and ambient zones) and will be retrieved after a period of approximately 14 months. These tiles then will be analyzed to determine differences in community structure and net calcification between the experimental and control tiles. To assess how ocean acidification will affect coral calcification, coral cores and coral tissue samples obtained from the low pH and control sites will be analyzed. The coral cores will be scanned by computed tomography, and the density, annual linear extension and calcification rates of the cores will be assessed. Additionally, tissue samples will be analyzed to address the overall health of polyps living in low pH seawater.

Expected Results

It is expected that coral calcification will decrease with decreasing pH, in addition to net community calcification rates. Specifically, the low pH water should negatively impact coral larvae recruitment and growth, as well as the settlement and growth of other calcifying organisms (such as crustose coralline algae and calcifying macroalgae). Moreover, it is likely that corals residing in the low pH seawater will have decreased density, linear extension and calcification rates.

Potential to Further Environmental/Human Health Protection

This research has the potential to aid in the understanding of how reef environments will be impacted by future increases in carbon dioxide. Combined, these projects should be adequate to assess the health of the reef in the proximity of the ojos, and to ascertain whether any ecosystem-wide or species-specific adaptations have been made with respect to low pH waters over time. The results will have implications for the long-term changes that could be expected in coral reef ecosystems in response to future ocean acidification and associated pH changes; therefore, they have the potential to impact a much broader framework of mitigation strategies and environmental decision making, public awareness and advanced sustainability of coral reefs in acidified oceans.

Samuel Butler Fey

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Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: invasive species, climate change, aquatic ecosystems

Bio

Sam Fey received his Bachelor's degree in Biology from Hamilton College in 2006. Following a post-baccalaureate fellowship at the National Institutes of Health, he entered the Dartmouth College Ecology and Evolutionary Biology Ph.D. program in the fall of 2008. He was an Integrative Graduate Education and Research Traineeship (IGERT) Fellow in Polar Environmental Change, and his research integrates physiological and community ecology to investigate how changes in temperature affect biological communities.

Synopsis

Global climate change likely will contribute to two specific threats to aquatic ecosystem services: the spread of non-native species and an increase in cyanobacterial blooms. Field and laboratory studies will be conducted, mathematical models created and long-term lake records analyzed to explore how increases in temperature may affect the success of non-native species as well as changes in the frequency and severity of cyanobacterial blooms in aquatic ecosystems.

The Effect of Temperature Increases on Lake Plankton Community Composition: Implications for the Spread of Invasive Species and Cyanobacterial Blooms

Objective(s)/Research Question(s)

This research program has two objectives: First, to understand how increases in climate change may affect the spread of the non-native crustacean *Daphnia lumholtzi*, and so enhance predictions of how increases in temperature generally may affect the spread of aquatic invasive species. Secondly, the study will investigate how increases in temperature, both directly and through altering lake stratification, may contribute to the occurrence of cyanobacterial blooms.

Approach

Field and laboratory studies will be conducted and mathematical models constructed to investigate the potential for climate change to increase the spread of the non-native aquatic crustacean *D. lumholtzi*, a species currently invading North America. *D. lumholtzi* is an informative species to study as it provides a general example of how tropical organisms, and difficult-to-consume organisms, may perform in a warmer world. The study also will analyze long-term lake records to assess the relationship between temperature and cyanobacterial blooms.

Expected Results

Although ecologists have much success in determining how the environment constrains where organisms can survive, predicting the ability of an organism to invade an existing biological community remains challenging, particularly in the face of climate warming. As the successful establishment of non-native species can threaten ecosystem services and cause substantial economic and social burdens, and the rate of non-native species introductions are increasing, the results of this research will lead to a more comprehensive understanding of factors that contribute to a successful biological invasion. Additionally, this work has benefits for lake management strategies seeking to minimize cyanobacterial blooms.

Potential to Further Environmental/Human Health Protection

This research will help translate the expected increases in temperature predicted as a consequence of climate change into clear biological outcomes. This research likely will yield better predictions of how temperature, both directly and through increasing lake stratification, may affect the ability of aquatic ecosystems to provide important services to humans in the future. As such, this research also will contribute to generating more effective lake management strategies in the face of a warming climate.
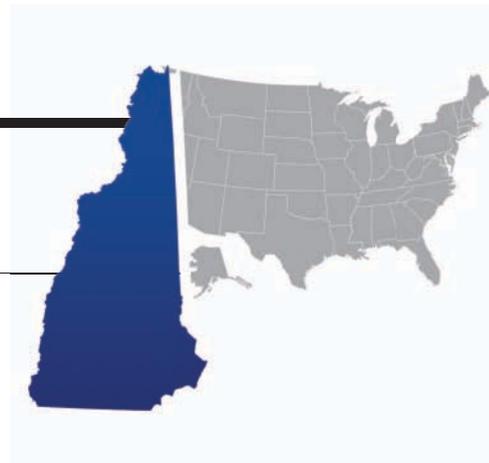
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Project Amount: $126,000
Environmental Discipline: Ecology and Ecosystems

Keywords: climate change, metapopulation, genetics

Bio

Heidi Golden received a B.S. degree in Ecology and Evolutionary Biology from the University of Connecticut and an M.S. degree in Wildlife and Fisheries Biology from the University of Massachusetts. Her prior work focused on anthropogenic impacts on trophic interactions in aqua systems. Currently, her research interests include population genetics and the movement patterns of Arctic fish with regard to climate change impacts.

Synopsis

Climate change in the Arctic affects aquatic systems by altering habitat quality and connectivity, disrupting gene flow between and movement within fish populations. This research uses population genetics, otolith microchemistry and mark/recapture methods to assess Arctic grayling population boundaries and critical migratory routes necessary for maintaining genetic diversity and identifying populations at risk to anthropogenic habitat alteration.

Will Climate Change Influence the Metapopulation Dynamics of the Arctic Grayling?

Objective(s)/Research Question(s)

Alterations in aquatic habitat connectivity on Alaska's North Slope due to climate change will likely increase habitat fragmentation and decrease habitat quality due to changes in hydrology, precipitation patterns and permafrost structure, thus influencing metapopulation configuration and population dynamics of freshwater migratory species, such as the Arctic grayling. This research will assess the connectivity between critical habitats within populations and gene flow between populations of Arctic grayling at three different timescales: Evolutionary (generations – centuries), Ecological (decadal) and Sampling (yearly), to determine metapopulation status and infer population persistence under different connectivity regimes.

Approach

Focusing on lakes and rivers on Alaska's North Slope near the Toolik Lake Long-Term Ecological Research Station, the study will collect caudal fin samples from 30 individuals per location to determine gene flow and population structure for Arctic grayling using 12 variable nuclear DNA (nDNA) microsatellite loci. Additionally, scale samples will be collected from individuals for population demographics and 10 otoliths per location to infer decadal movement patterns and critical ontogenetic habitat locations using correlations between otolith and habitat microchemistry. Further, the study will determine current adult and juvenile movement patterns, demographics and critical habitat locations by weighing and measuring individuals and using passive integrative transponder tags and remote sensing. Finally, the study will incorporate this information into a geospatial model with multiple layers for use in regional planning and management.
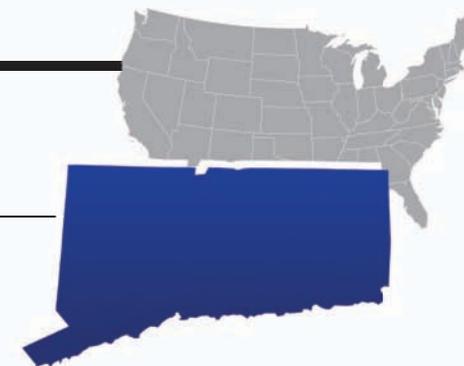
Expected Results

Based on preliminary results from genetic analyses, it is expected that populations within the study area will form genetically distinct clusters primarily based on watershed area and stream distance. Remote monitoring of tagged individuals suggests additional population structure within genetic clusters, likely related to population-specific ontogenetic habitat locations, such as spawning, rearing and overwintering habitats. It is expected that otolith microchemistry will not only corroborate tagging observations, but also will aid in locating critical habitat locations within populations. Incorporating information from genetic, otolith and tagging techniques into geospatial layers will enable delineation of population-specific management units for use in GIS modeling. These management units will define areas critical to both local population and metapopulation persistence by identifying locations of population susceptibility to landscape level changes in habitat quality and fragmentation.

Potential to Further Environmental/Human Health Protection

Climate change-related impacts coupled with increased human activity, including tourism, fishing, and road and oil-field development, could threaten the Arctic grayling due to this species' dependence on multiple, highly connected habitat types. Information from this study will strengthen understanding of habitat fragmentation impacts on both local and metapopulation persistence and provide a practical framework for regional planning and management of metapopulations.

Jessica Renee Henkel

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Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: global change, Gulf of Mexico, shorebirds

Bio

Jessica Renee Henkel received an M.S. degree in Biology from the University of New Orleans in 2009. In 2010, she joined the Ph.D. program in Ecology and Evolutionary Biology at Tulane University. She is interested in how environmental changes are impacting the coastal habitats of the U.S. Gulf of Mexico and the effects these changes are having on the bird populations that migrate through them. Her current research is using plasma metabolites and sea-level rise modeling to study the impact of global change on the stopover ecology of near-Arctic breeding shorebirds.

Synopsis

The coastlines of the northern Gulf of Mexico represent important stopover habitats for migratory shorebirds. As processes of global change accelerate, these habitats are expected to experience dramatic land loss. This research proposes to use plasma metabolites to study the migration ecology of shorebirds on the Gulf of Mexico. This information then will be applied to models of projected sea-level rise to develop predictions of the potential impacts of global change on these imperiled species.

Effects of Global Change on the Migration Ecology of Shorebirds on the Northern Gulf of Mexico

Objective(s)/Research Question(s)

This research will investigate the response of stopover refueling performance of migratory shorebirds to variation in habitat quality and evaluate variation in Northern Gulf of Mexico stopover habitat use between target species during spring migration. The potential changes to these stopover habitats due to projected sea-level rise then will be modeled to predict the potential consequences of these changes to the migration ecology of shorebirds.

Approach

For migrating shorebirds, one of the primary factors determining migration success is the efficiency of refueling rates at stopover sites. Therefore, fattening rates of birds on migration can be used as a proxy for habitat quality when comparing stopover sites. The study will investigate variation in stopover refueling performance across four habitat types in two declining species of shorebirds (Dunlin [*Calidris alpina*] and Semipalmated sandpipers [*Calidris pusilla*]) using plasma metabolites, which have been shown to be indicators of fattening rates in shorebirds. The study will then combine this information on the importance of Gulf coast habitats to shorebird migration with models of the impact of projected sea-level rise to these habitats using the Sea Level Affecting Marshes Model (SLAMM6) to evaluate the potential for population-level consequences for migratory shorebirds.

Expected Results

As shorebirds vary in their habitat use both between and within species, the importance of different northern Gulf stopover habitat types also will vary. Using the individual and environmental variables assessed in this study, the four coastal habitat types used by shorebirds on the northern Gulf of Mexico will be able to be characterized according to relative fueling rates in those habitats across species, within species and between species to rank their importance to shorebirds during migration. The result will be independent maps describing the comparative quality of each habitat type to shorebirds. The study will then link these quality characterizations to habitat descriptions used in the sea-level affecting marshes model, allowing for the projection of the change in the amount of high-quality habitat available for shorebirds under different sea-level rise scenarios. The results of this study will highlight the importance of the northern Gulf of Mexico for migrating shorebirds, provide baseline information for the conservation of threatened coastal habitats and bird species, and demonstrate the multiple ways in which global change can affect ecosystems and populations.

Potential to Further Environmental/Human Health Protection

Shorebirds are found along the shores of every coastline in the United States. The health of shorebird populations, therefore, can serve as indicators of the overall ecosystem health of habitats on which human populations rely. In addition, the shorebird species targeted in this study represent species that incorporate most of the Western Hemisphere in their migratory flight paths. Although analyses of land changes and weather stations can provide us with information on the impacts of global change at relatively local scales, shorebirds reflect this information on a global scale, providing potentially insightful information on the large-scale impacts of global change.

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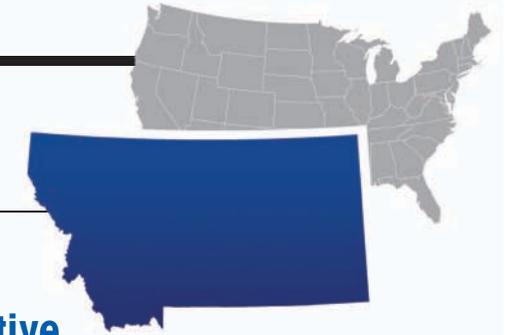
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Project Amount: $126,000
Environmental Discipline: Terrestrial Systems
   Ecology—includes animals

Keywords: biodiversity, climate change, forest distribution

Bio

Joseph LaManna received his M.S. degree in Wildlife Biology from Humboldt State University in 2010, and currently is pursuing his Ph.D. in Wildlife Biology at the University of Montana in Missoula, MT. His research interests include biodiversity-habitat relationships, the ecosystem consequences of climate change and avian reproduction and parental investment. He currently studies the impacts of climate change on forest distributions and bird diversity and reproductive success.

Synopsis

The loss of aspens and their productive, diverse ecosystems has been associated with climate change and is a great concern to scientists and managers. This research will assess the extent of the decline and involves an experimental removal of conifers from within aspen stands. The experiment will be to test climate's effect on animal diversity and reproductive success via changes in habitat as well as test the effectiveness of conifer removal at restoring aspen ecosystems.

A Region-Wide Shift From Aspens to Conifers Due to Climate Change May Imperil Biodiversity and Reproductive Success of Birds

Objective(s)/Research Question(s)

Climate change likely is influencing animal reproduction and diversity via its effects on habitat. This study will determine if a shift from aspen to conifers is associated with climate change at a region-wide scale and which habitat elements differ among these two habitats and lead to reproductive success and sustainable biodiversity. Using this information, the study will then project future region-wide shifts in the distributions of aspens, conifers and bird diversity that incorporate reproductive success.

Approach

Region-wide forest distributions will be generated from satellite and aerial photos, and state-transition models will test for an association with climate change. The study will examine bird reproductive success and the insect and vegetation communities in 11 mixed aspen-conifer sites in the Mt. Haggin Wildlife Management Area near Anaconda, MT, and in the White Sulphur Springs Ranger District of Lewis and Clark National Forest. These sites vary in their conifer composition, and the study will associate bird reproduction and diversity with insect and vegetation variables along this aspen-to-conifer gradient. In addition, conifers were removed from within and around three sites in the fall of 2010. This experimental design allows for spatial and temporal controls (i.e., Before-After-Control-Impact [BACI] design) and will experimentally validate the effect of conifers and climate change on aspen ecosystems and bird reproduction and diversity.

Expected Results

Already, data show that aspens are biodiversity hotspots for birds, and the study has observed a substantial increase in aspen regeneration following conifer removal. Aspens have declined severely during the past 60 years. Because they depend on deep snow, it is very likely that their decline is associated with climate change at the regional scale. It is expected that conifer encroachment into aspens is detrimental to bird reproduction and diversity due to a decrease in food and increase in nest predation. Nest predators in this system (e.g., squirrels, chipmunks, jays, ravens) are highly associated with conifers. In addition, aspens have higher primary productivity than conifers and likely produce higher insect food loads for birds.

Potential to Further Environmental/Human Health Protection

Managers are proposing a myriad of treatments to restore aspen ecosystems, but many do so with little empirical knowledge of the effectiveness or consequences of these treatments. The experimental removal of conifers from within and around aspens will be able to test the climate's effect on animal diversity and reproductive success via changes in habitat as well as test the effectiveness of conifer removal at restoring aspen ecosystems. These results could revolutionize the way scientists view habitat-biodiversity relationships and provide a valuable empirical assessment of a management technique to restore aspens. If climate change adversely affects biodiversity and reproductive success in aspens via accelerated conifer encroachment, land managers may choose to remove conifers from existing aspen stands to mitigate these ecosystem impacts.

Kirstin Lynn Neff
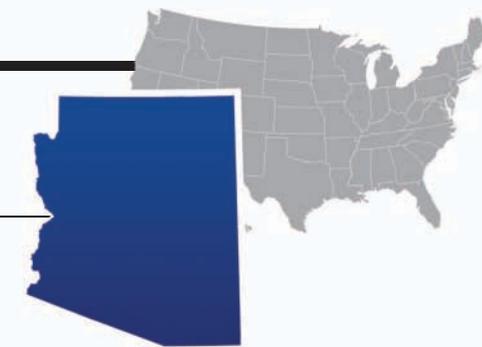
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Project Amount: $126,000
Environmental Discipline: Hydrology

Keywords: ground water recharge, climate change, riparian health

Bio

Kirstin Neff is a Ph.D. student in the Department of Hydrology and Water Resources at the University of Arizona. Her research interests include assessing the impacts of climate change, development and population growth on the water quantity and quality of aquifers, the application of spatial analysis tools to hydrological problems, and ground water-surface water interactions. In her Master's research, she modeled ground water in the Upper San Pedro River Basin in northern Mexico and southeastern Arizona. Her dissertation research will evaluate potential climate change impacts to ground water recharge in the Basin and Range Province of western North America. She also studies U.S. and international water policy and currently is researching water management issues in Central Asia. As an undergraduate at Wellesley College, she conducted research on U.S. immigration policy towards Mexico as well as the impacts of watershed development on the littoral community of Lake Baikal in Siberia. She grew up in Tucson, AZ, and attended public schools in the Amphitheater School District. She speaks Spanish and Russian.

Synopsis

Ground water is a critical freshwater resource in the Western United States, and the quantity and seasonality of ground water recharge will determine its future availability for human use and sustaining semi-arid riparian areas. This study will characterize recharge regimes from northern Mexico to Nevada by conducting new investigations and integrating existing data to predict the relative contributions of summer and winter precipitation to recharge throughout the region under predicted climate change.

Assessing Climate Change Impacts to the Quantity and Seasonality of Ground Water Recharge in the Basin and Range Province of the Western United States

Objective(s)/Research Question(s)

Ground water recharge replenishes aquifers, a primary source of freshwater for human consumption and riparian areas. It is critical to understand the current ground water recharge regimes in the Western United States and how those regimes might shift in the face of climate change, impacting the quantity and composition of riparian ground water. This research will address the following questions: How does the seasonality of ground water recharge vary in the Basin and Range Province? How is the quantity and seasonality of ground water recharge related to the size of riparian areas? How will the quantity and seasonality of ground water recharge change with climate change?

Approach

This research will characterize ground water recharge regimes in study basins throughout the Basin and Range Province, extending from northern Mexico to the U.S. states of Nevada and Utah. It is comprised of new field investigations using water chemistry analysis and computer modeling to partition incoming precipitation into recharge, runoff and evapotranspiration, as well as the amalgamation and analysis of existing data for the region. The result will be a survey of current conditions with an eye toward how they might change with climate change.

Expected Results

Watersheds in the Basin and Range Province are characterized by a bimodal precipitation regime of dry summers and wet winters. The current assumption is that the relative contributions to ground water recharge by summer and winter precipitation varies throughout the province, with winter precipitation dominating in the northern parts of the region and summer floods playing a more significant role in the south, where the North American Monsoon extends its influence. In the future, climatologists expect a shift northward of precipitation and temperature norms as surface temperatures increase across the region, and a survey of recharge regimes up and down the basin and range could provide a space-for-time substitution in predicting future hydrologic conditions throughout the region.

Potential to Further Environmental/Human Health Protection

Establishing a robust understanding of the current relationship between the seasonality and quantity of precipitation and ground water recharge processes will allow for predictions of how recharge regimes might change in the future, and thus how the quantity and quality of freshwater for human use and ecosystems also might change. This research will provide the foundation for better management of ground water resources, helping to plan for future human use and the conservation of delicate ground water-fed riparian ecosystems and the valuable ecosystem services they provide to the surrounding semi-arid communities, including public health and economic benefits.

AIR, CLIMATE & ENERGY

Green Energy/Natural Resources Production & Use

This is the moment when we must come together to save this planet. Let us resolve that we will not leave our children a world where the oceans rise and famine spreads and terrible storms devastate our lands.

– President Barack Obama

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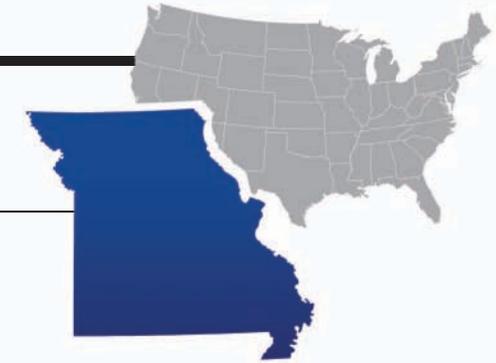
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Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: timber harvest, amphibians, genetic diversity

Bio

Grant Connette received a B.S. degree in Biology from Davidson College in 2008. In the fall of 2009, he began a Ph.D. program in Biology at the University of Missouri. His general research interests include various aspects of animal ecology, movement behavior and landscape-scale distribution modeling. His dissertation research integrates the behavior, population biology and landscape ecology of terrestrial salamanders in managed forest landscapes.

Synopsis

Due to high demand for timber products and growing interest in woody biomass as an alternative energy source, it is critical that forest management efforts balance the strong economic demand for timber with environmental sustainability. The goal of this study will be to relate the abundance and genetic diversity of terrestrial salamanders to timber stand age and patterns of stand rotation. Ultimately, this will provide tangible recommendations for preserving biodiversity at a landscape scale

Connecting the Dots: Local and Landscape-Scale Consequences of Timber Extraction

Objective(s)/Research Question(s)

The broad, study objective is to determine how natural resource extraction and the dynamics of local wildlife populations explain landscape-scale patterns of species abundance and genetic diversity. Specifically, the research goals will be to: (1) establish the relationship between terrestrial salamander abundance and timber stand age; (2) examine how patterns of stand rotation correlate with observed genetic diversity across a landscape; and (3) use this knowledge to predict the long-term effects of forest management decisions on the landscape-wide abundance and genetic diversity of species.

Approach

The research will focus on a historically managed landscape in the Nantahala Mountains of southwest North Carolina. By performing repeated counts of terrestrial salamanders from timber stands across a broad spectrum of age classes, the amount of time required for populations to recover following timber harvest will be estimated as well as the dependence of this recovery process on the immigration of animals from surrounding timber stands. DNA samples also will be collected from salamanders and genetic diversity quantified in the laboratory of each timber stand. The relationship between genetic diversity and stand age will then be used to estimate the timeframe for recovery of genetic diversity following timber harvesting. Computer modeling will then allow for the assessment of the potential effects of forest management strategies on animal populations and the development of recommendations for sustainable harvesting practices.

Expected Results

Because salamanders appear to experience large population declines following timber harvesting, it is expected to find greatly reduced salamander abundance in the youngest timber stands but a gradual recovery with increasing stand age. The recovery of genetic diversity following local population bottlenecks also may persist for many years after harvesting. If genetic diversity is recovered at a slower rate than species abundance, using model projections to optimize the size and placement of undisturbed habitat patches may ensure that pockets of high genetic diversity are available to prevent widespread "genetic erosion" across the landscape.

Potential to Further Environmental/Human Health Protection

Maintaining genetic diversity is critical for preserving the adaptive potential of species and environmental management that focuses solely on species abundance may overlook the problem of "genetic erosion." The maintenance of species abundance and genetic diversity is of particular interest when management focuses on plant or animal species of economic interest. Whether for preserving wildlife or maintaining sustainable fisheries and timber yields, it is critical that the timing and pattern of resource extraction provide the best possibility of long-term sustainability.

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Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: climate change, energy, forest

Bio

Mason Earles is a Ph.D. student in the University of California, Davis' Graduate Group in Ecology and Institute for Transportation Studies. His research examines the relationship between Earth's forests, energy production systems and climate change. He is interested in how natural and human-based forest disturbances affect the biogeochemical carbon cycle. His current research examines potential climatic impacts of wood removals for bioenergy from various U.S. forest types. He has an M.S. degree in Forest Resources from the University of Maine and an A.B. in Urban Studies from Washington University in St. Louis.

Synopsis

U.S. forests store a vast amount of terrestrial carbon. Wood removed from these forests can be refined and combusted as transport fuel. Combustion emits stored carbon as CO_2, which is re-absorbed primarily by plants and the ocean over time. This research examines potential climatic effects of wood-energy removals from U.S. diverse forest types using forest inventory data and tree growth modeling, along with industrial production data.
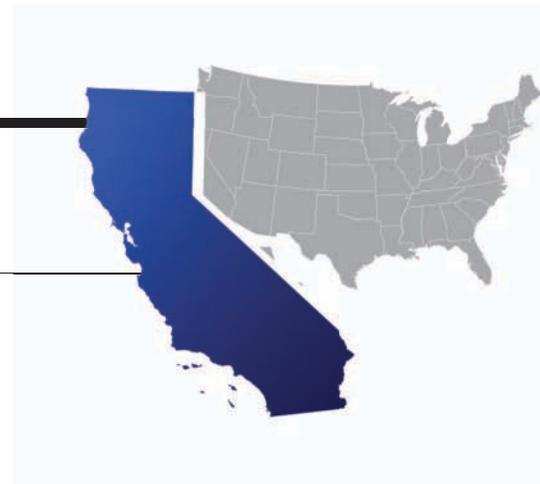
Spatio-Temporally Explicit Life Cycle Carbon Accounting for U.S. Wood-Based Transport Fuels

Objective(s)/Research Question(s)

This research aims to quantify potential climate forcing of transport fuels produced using wood removed from U.S. forests. The hypothesis is that potential climate forcing varies dramatically in the United States—depending on tree-, stand-, management- and disturbance-specific parameters. Under different time horizons, such variability could lead to an array of potential climate benefits and detriments associated with using wood for transport fuel production.

Approach

To accomplish these objectives, this research will: (1) spatio-temporally model forest growth, mortality, disturbances and harvest for transport fuels from more than 30,000 forested plots in the United States; (2) characterize life-cycle carbon exchanges between relevant biogeochemical and industrial stocks; and (3) evaluate wood-based fuels compared to other transport fuel options.

Expected Results

It is expected to obtain several useful outcomes from the proposed research: (1) spatio-temporally resolved climate forcing factors that can be applied to wood-based bioenergy pathways; (2) a wood-based transport fuel extension for Argonne National Laboratory's Greenhouse Gases, Regulated Emissions and Energy Use in Transportation model; (3) a set of maps displaying the net climate forcing impacts for the wood-based transport fuel system across the United States; and (4) policy recommendations regarding the locations and conditions in which wood-based fuels have the greatest radiative forcing reduction potential relative to other transportation fuel options.

Potential to Further Environmental/Human Health Protection

Today, society is challenged by a dependence on carbon-intensive fossil-based transport fuels and changing climate patterns with unknown future impacts on environmental and human health. Presently, wood-based transport fuels are expected to help meet aggressive greenhouse gas reduction targets. It is not clear, however, that this will be the case in the desired timeframe. This work will help to more precisely define when and where wood-based transport fuels may provide the greatest radiative forcing reduction potential.

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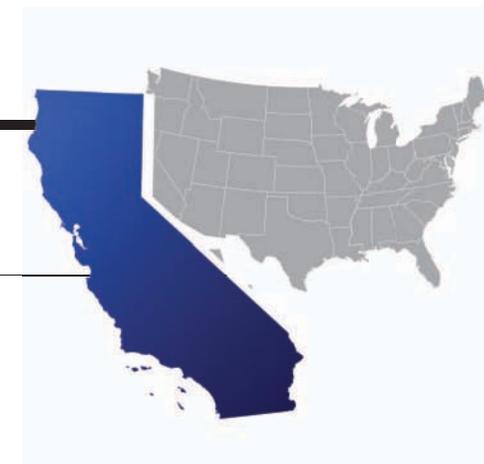
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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline:
    Bio-Environmental Engineering

Keywords: cellulosic ethanol, metabolic engineering, biofuel

Bio

Amanda Hildebrand received her B.S. degree in Chemical Engineering from the University of California (UC), Santa Barbara, in 2005. She spent the next 5 years in industry, first as a process development scientist at Clorox and later as a fermentation engineer at Genencor. Her time at Genencor shaped her interests in renewable energy and prompted her to pursue a Ph.D. in Biological Systems Engineering at UC, Davis. Her current research involves metabolic engineering and fermentation optimization for cellulosic ethanol production.

Synopsis

Cellulosic ethanol is a promising alternative energy source, offering significant potential to reduce dependence on foreign oil, lower greenhouse gas emissions and drive economic development. The main obstacle to commercialization is the absence of a low-cost processing technology. This research aims to develop a novel biochemical platform for fuels and chemical production that replaces the three most expensive steps in the conventional platform with a single biological step, bringing the industry one step closer to realizing an economically viable, sustainable technology.

A Novel Biochemical Platform for Fuels and Chemicals Production From Cellulosic Biomass: Metabolic Engineering and Fermentation Optimization for Improved Yield of Ethanol and Reactive Intermediates

Objective(s)/Research Question(s)

The proposed biochemical platform for cellulosic ethanol production consolidates the three most expensive steps in the conventional platform in a single, biological step. Cellulolytic microorganism(s) that can secrete all the enzymes needed to hydrolyze cellulose and hemicellulose despite the presence of lignin can be modified to convert most of the carbohydrate contained in the cellulosic biomass to sugar aldonates. In a second step, the sugar aldonates are utilized as the carbon source to produce ethanol and other products. Although the viability of this process has been demonstrated, substantial gains in sugar aldonate and ethanol yields are possible through metabolic and genetic engineering. Fermentation modeling and optimization will provide a means to further improve the overall yield of the process.

Approach

A metabolic engineering strategy will be employed to improve the yield of the sugar aldonate intermediates from cellulose, as well as the subsequent conversion of the sugar aldonates to ethanol. By knocking out certain genes in the cellulolytic organism, the carbon contained in cellulose will be diverted to the production of sugar aldonates. The study can ensure that the sugar aldonates are preserved as a carbon source for ethanol production rather than being consumed by the organism by knocking out genes involved in aldonate utilization. Additionally, genetic engineering can be employed to improve the activity of key enzyme(s) involved in converting cellulose to sugar aldonates. These processes can be modeled and optimized through a factorial design of experiment. Initial experiments will be conducted on the shake flask scale, followed by evaluation in a 1.3 liter bioreactor. Similarly, in the subsequent fermentation of these sugar aldonates to ethanol, genes for competing pathways can be inactivated to direct carbon flow toward ethanol production.

Expected Results

Preliminary experiments have demonstrated that sugar aldonates can be produced from cellulose by genetically engineering a cellulolytic organism, and that those aldonates can be converted to ethanol. By knocking out genes for competing pathways, it is expected that the yields for each of these steps will improve. By enhancing the activity of key enzymes involved, the conversion of cellulose to sugar aldonates can be improved further. Factorial designs will aid in understanding the key factors involved from a processing perspective, and a model will provide a tool for further optimization.

Potential to Further Environmental/Human Health Protection

Burning fossil fuels produces carbon dioxide, which is a major contributor of global climate change. With the supply of fossil fuels approaching depletion, the imbalance of power for the small collection of national suppliers of fossil fuels will become ever more disproportionate. The rising global demand for energy will only intensify these issues, creating an urgent need to develop alternative energy sources. The proposed biological platform seeks to advance the field of cellulosic ethanol by improving the overall processing costs through consolidation of the costliest process steps, bringing the industry one step closer to making renewable, economical and environmentally friendly energy a reality.

Brian James Krohn
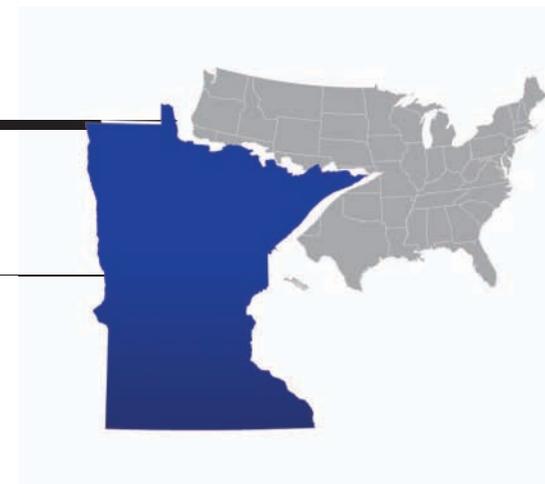
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Project Amount: $126,000
Environmental Discipline: Environmental Sciences

Keywords: biofuel, life-cycle assessment, land change

Bio

Brian Krohn is a Ph.D. candidate in Natural Resource Science and Management at the University of Minnesota. As an undergraduate in Chemistry at Augsburg College, he acquired a patent and was named a Goldwater Scholar for his research on biofuels. He then went on to obtain two M.S. degrees from the University of Oxford as a Rhodes Scholar. His current research focuses on analyzing the social, economic and environmental impacts of producing biofuels from perennial grasses.

Synopsis

The United States has a goal to produce 8 billion gallons of biofuel from native prairie grasses by 2022. Growing prairie grasses for bioenergy has the potential to increase biodiversity, improve water quality and reduce carbon emissions—but the large-scale impacts of this new bioindustry still are unknown. This research will forecast possible production scenarios, analyze the multifaceted impacts of this developing bioenergy industry and aid decision makers in facilitating its growth.

Pathways to Sustainable Bioenergy From Perennial Grasses

Objective(s)/Research Question(s)

The perennial grass industry is in its very early stages of development but likely will grow to have a sizable impact on the environment, primarily through changes in land use. This research will model potential development scenarios and analyze the subsequent environmental impacts. The overarching goal of this research is to present researchers, policy makers and industry leaders with a suite of development pathways to help them to maximize the industry's economic and environmental benefits.

Approach

To meet the research objectives, this study will develop a suite of potential land-use change scenarios to represent possible pathways for the development of perennial grass biomass for biofuels across the United States. Then a life-cycle assessment will be conducted of bioenergy from perennial grasses to accrue key agronomic and production data that will be necessary for the parameterization of the environmental impact models. Finally, with the scenario and life cycle data, each scenario will be analyzed across a number of environmental impact categories.

Expected Results

Developing a perennial grass bioenergy industry likely will have both positive and negative impacts on the environment. Furthermore, the way in which the industry develops (e.g., where and how the crops are grown) will change the scale and sign of the impacts. The results of this research will articulate the possible pathways to meet U.S. biofuel objectives while simultaneously highlighting the environmental tradeoffs that will occur in achieving the objectives.

Potential to Further Environmental/Human Health Protection

Perennial grass-based energy systems have the potential to greatly improve the environment and human health by providing green energy, reducing air and water emissions and improving biodiversity. This research provides large-scale analysis to ensure that policy makers and industry leaders have the tools to maximize the potential positive impacts and minimize the negative impacts of this developing bioenergy industry.

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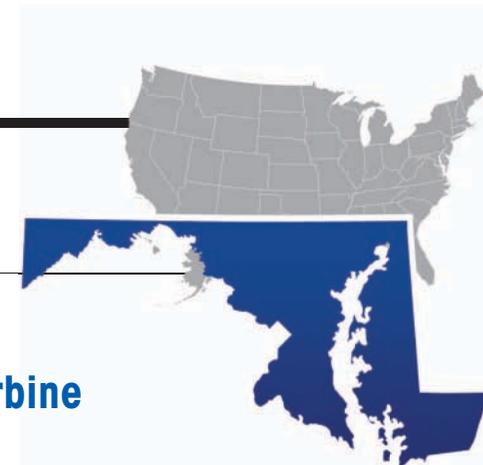
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Project Amount: $84,000
Environmental Discipline: Biological Sciences

Keywords: population genetics, stable hydrogen isotopes, wind energy

Bio

Cortney Pylant received a B.S. degree in Wildlife Biology from the University of Alaska-Fairbanks in 2009. In 2011, she began an M.Sc. program in Applied Ecology and Conservation Biology at Frostburg State University in partnership with the University of Maryland Center for Environmental Science's Appalachian Laboratory. Her research interests include wildlife ecology and conservation and the development of sustainable energy resources. Her current research integrates population genetics and stable hydrogen isotope analysis to determine the population structure and geographic origins of migratory tree bats killed at wind energy facilities in central Appalachia.

Synopsis

Mortality of migratory tree bats has been an unanticipated impact of wind energy development. To date, virtually nothing is known about the population genetics of affected species, nor is it clear from where these bats originate. The proposed research will use a combination of population genetics and stable hydrogen isotope analysis to address these unknowns and will help determine the cumulative biological impact of wind turbines on migratory hoary bats (*Lasiurus cinereus*) in central Appalachia.

Biological Impacts of Green Energy Development: Assessing Regional Sources of Bat Mortality at Wind Turbine Sites Using Stable Isotopes and Population Genetics

Objective(s)/Research Question(s)

Mortality of migratory tree bats has been an unanticipated impact of wind energy development. To date, virtually nothing is known about the population genetics of bat species impacted by wind turbine mortality, nor is it clear where these bats originate. The proposed research helps to address these unknowns for the hoary bat (*L. cinereus*), one of the most common fatalities at wind energy facilities in the eastern United States, by establishing baseline data on how large and diverse populations are; quantifying whether current rates of wind turbine mortality are associated with reductions in genetic diversity; and revealing whether bats are being killed locally or while on migration.

Approach

Fur and tissue samples will be collected from bats killed at wind energy facilities in central Appalachia during both spring and fall migration. Genetic analysis of tissue samples will be conducted to determine the effective population size and temporal stability of bat populations experiencing mortality. Stable hydrogen isotope analysis will be performed on fur samples to determine whether the bats killed are from local bat populations or those across a broad geographic extent. Combining datasets will allow increased confidence in the determination of population genetic structure and refinement of geographic assignment and will provide information crucial to determining the cumulative biological impact of wind turbines on migratory bats in central Appalachia.

Expected Results

The migratory patterns of hoary bats seem to suggest two general populations in North America. Based on genetic research of bats with similar life histories, it is expected that hoary bats will exhibit subpopulation structure rather than a single large breeding population. During the fall migration, some hoary bats appear to funnel southward along the east coast, potentially establishing the central Appalachians as an important migration corridor. In light of what is known regarding hoary bat migration, it is expected that the majority of hair samples from bats killed at wind energy facilities in the central Appalachians will exhibit stable hydrogen isotope values indicative of summering grounds primarily in the eastern regions of the United States and Canada. Because some degree of uncertainty is inherent in geographic assignment based on stable isotope values, evidence of subpopulation structure may be used to constrain assignments and refine models.

Potential to Further Environmental/Human Health Protection

As the primary predators of night-flying insects, bats are vitally important in controlling insect-related crop damage and preventing the spread of insect-borne plant and human pathogens. Predation of agricultural pests by bats in the United States alone prevents more than $3.7 billion of crop damage per year, thereby reducing pesticide application and its effects on public and environmental health. The information gained from this research will inform how best to design and site wind farms such that they promote ecological sustainability with minimal negative impacts on local natural resources.

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Project Amount: $126,000
Environmental Discipline: Chemical Engineering

Keywords: hydrothermal liquefaction, biofuel, renewable energy

Bio

Peter Valdez received his B.S. degree in Chemical Engineering from the New Mexico Institute of Mining and Technology. During his undergraduate career, he was recognized for his community involvement and academic achievements, receiving a Macey Scholarship and the prestigious Brown Award. He currently is pursuing a Ph.D. in the same field at the University of Michigan. His graduate research focuses on the investigation of hydrothermal liquefaction to convert algal biomass into liquid hydrocarbon fuels. His research interests include renewable energy topics and reaction engineering.

Synopsis

The hydrothermal liquefaction of microalgae is an emergent technology that converts wet algal biomass into an energy-dense biocrude. The scope of this project is to examine the processing parameters that will maximize the production of biocrude and to identify conditions that mitigate the formation of hazardous byproducts. This research will result in the creation of a model that will be used to predict and engineer the various products from hydrothermal liquefaction.

Reaction Engineering of Hydrothermal Liquefaction to Produce Microalgal Biocrude

Objective(s)/Research Question(s)

The goal of this research is to understand the reaction network and kinetics of the hydrothermal liquefaction of microalgae. A systematic study of liquefaction will help to identify reaction pathways and products that improve the quality and yield of the desirable biocrude, while elucidating how to control the formation of byproducts that could potentially harm the environment.

Approach

The processing conditions related to the liquefaction of microalgae will be studied, the products characterized and a global model using empirical data developed. The study will investigate how the composition of lipids, carbohydrates and proteins in the feedstock and processing conditions of liquefaction affect the yield and composition of all of the products, not just the biocrude. The study will characterize the products to understand how they change with respect to processing parameters, enabling the design of a model to predict the results. A systematic study of hydrothermal liquefaction will allow modeling of the outcome using reaction networks and global kinetic modeling. With an understanding of how to engineer microalgal biocrude, liquefaction reactors can be designed readily for regional and seasonal feedstock supplies, including other biomass feedstocks, to produce a valuable energy carrier.

Expected Results

This research will focus on understanding how to engineer the composition of microalgal biocrude by studying processing conditions that positively affect product results. There are several hypothesized benefits of this research. A systematic study of microalgae liquefaction will provide a fundamental knowledge of what to expect regarding product composition and yield. Ultimately, the model will not only predict the biocrude composition, but also the composition of all of the liquefaction products, including the gas phase, water-soluble products and the solid residues. Understanding the distribution of products will be useful for optimization of product and byproduct utilization, ideally reusing the byproducts to cultivate more biomass. An additional benefit will be to gain knowledge of how to prevent the formation of hazardous compounds during processing. The model derived from this research should define the optimum conditions for improved product characteristics, identifying the conditions for a high yield, high energy, low heteroatom, low viscosity biocrude. The ideal biocrude composition should be coupled with a mix of byproducts that are nontoxic and reusable for processing. Once a firm understanding is established about the capabilities of hydrothermal liquefaction, it will be easier to determine the next steps for the recovery and reuse of the liquefaction byproducts at a laboratory and industrial scale. With a complete model, it will be possible to extend the predictions to other biomass feedstocks. The ultimate result of this research should significantly contribute to the field of algae to liquid fuel conversions by providing key information for process designers and prepare the technology for widespread public use and development.

Potential to Further Environmental/Human Health Protection

As new biomass-conversion technologies are developed to help supplement the demand for renewable fuels, the environmental impact of the byproducts from such processes can be sometimes overlooked. For microalgal processing, it is especially important to know the fate of compounds that are known to cause damage to the environment, specifically phosphorus- and nitrogen-containing compounds that are needed for microalgal cultivation. High temperature reactions also can produce compounds that are not typically found in nature and can be harmful if released into the environment. This research will help to elucidate the fate of these and other potentially hazardous compounds during processing.

CHEMICAL
SAFETY FOR
SUSTAINABILITY

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

Organic buildings are the strength and lightness of the spiders' spinning, buildings qualified by light, bred by native character to environment, married to the ground.

– Frank Lloyd Wright

Andrea Jane Hanson

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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Biochemistry

Keywords: biodegradable plastics, dairy manure management, green engineering

Bio

Andrea Hanson earned a B.S. degree in Biochemistry and Molecular Biology from North Dakota State University in 2009. In the fall of 2010, she started a Ph.D. program in Microbiology, Molecular Biology and Biochemistry at the University of Idaho. Her research interests include microbial physiology/ecology and environmental biochemistry, integrated within the broader context of sustainable waste management practices. Her current research is investigating how bacterial consortia convert dairy manure to a biodegradable plastic of commercial interest.

Synopsis

Dairy cows in the United States generate more than 249 million wet tons of manure annually. Current manure management practices do not address fully all the associated human health and environmental concerns with improper manure disposal. Alternatively, natural bacterial consortia can be utilized to convert dairy manure to biodegradable plastics known as polyhydroxyalkanoates (PHAs). The research will investigate this resource conversion process on a molecular biological level to advance this green technology.

Investigating the Molecular Mechanisms Associated With Feast-Famine PHA Synthesis by Mixed Microbial Consortia

Objective(s)/Research Question(s)

More than 300 bacterial species synthesize PHAs as intracellular carbon and energy storage granules in response to starvation. The study conveniently can exploit this feast-famine PHA synthesis response to produce commercial quantities of PHAs while simultaneously treating dairy manure in an environmentally benign manner. To advance this technology, the study must first expand the fundamental knowledge of the metabolic steps involved with feast-famine PHA production by bacterial consortia. The primary objective of this research is to identify the key proteins responsible for feast-famine PHA synthesis in a bacterial consortium when using fermented dairy manure as a substrate. With this molecular information, the critical metabolisms associated with feast-famine PHA synthesis will be further defined and translated into engineering models that will help steer the large-scale production of this biodegradable plastic.

Approach

Mass spectrometry-based proteomic techniques will be utilized to determine the proteins responsible for the observed biochemical transformations occurring during feast-famine PHA synthesis. Because the bacterial consortium exhibits two distinct physiological states during feast-famine PHA synthesis, two-dimensional gel electrophoresis will be employed to separate proteins and visualize differences in protein abundance. Proteins of interest will be identified using nano-liquid chromatography coupled to tandem mass spectrometry. Through a statistical analysis of differential protein abundance, the critical metabolisms associated with feast-famine PHA synthesis will be characterized. This research also will investigate the proteins that are bound to the surface of PHA granules, as these proteins have been shown to play key roles in PHA synthesis. Finally, this research will begin to more carefully characterize how the global dynamic of a bacterial consortium changes during feast-famine
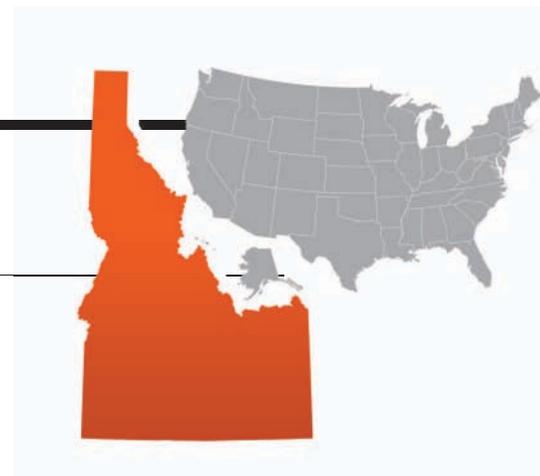
PHA synthesis by integrating the proteomic data with other molecular investigations.

Expected Results

Knowing the identity and relative expression of relevant proteins in a bacterial consortium performing feast-famine PHA synthesis will allow the reconstruction of the metabolic pathways that predominate the process. Detailed metabolic information will further aid in refining the stoichiometry of feast-famine PHA synthesis and thus metabolic flux analysis, thereby improving engineering models for large-scale production. Furthermore, information on metabolic intermediates can be leveraged to develop process monitoring techniques and aid model calibration. Lastly, understanding the expression of proteins relative to bulk solution parameters and consortium history could allow for the expansion of current engineering models from simple substrate/product-inhibition kinetics to more global forms of metabolic regulation.

Potential to Further Environmental/Human Health Protection

Advancing this technology would provide not only a sustainable strategy for the effective management of dairy manure, but also introduce more biodegradable alternatives to conventional petroleum-based plastics. Treating dairy manure in this manner would capture the nutrients from this resource to make valuable products while minimizing the human health and environmental hazards associated with inadequate manure disposal practices. Considering the abundance of organic-rich waste streams generated nationally, results from this research will help facilitate expanding and applying PHA production technologies at a larger scale. This, in return, would help decrease the amount of plastic waste accumulation in the environment, as well as lessen the dependence on fossil fuels for plastic manufacturing.

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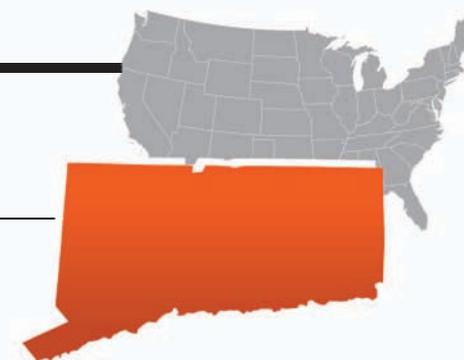
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Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: nanofiber, ground water contaminants, public water system

Bio

Amanda Lounsbury received a B.A. degree in Physics from Occidental College in 2009. She then studied integration of water, sanitation and hygiene (WASH) technology in Ghana as a Fulbright Fellow. In 2011, she received an M.S. from Stanford University and began a Ph.D. at Yale University, both in Environmental Engineering. Her research interests include green solutions to the water/energy nexus. Her current research uses photocatalytic TiO_2/Fe_2O_3 embedded in electrospun chitosan nanofibers for removal of heavy metals from ground water.

Synopsis

The aim of this project is to develop a multipurpose and adaptable green technology that is cost effective and maintains or improves the efficacy of current technologies for purifying ground water by small drinking water treatment plants. This work will focus on the removal of such metallic ground water contaminants as arsenic and chromium using photocatalytic functionalized electrospun chitosan nanofibers for the safe and reliable delivery of drinking water by small public water systems.

Semiconductor Photocatalytic Electrospun Nanofiber Mats as a Green Filter Media for Removal of Heavy Metals from Ground Water

Objective(s)/Research Question(s)

Many smaller U.S. public water systems (PWS) already are struggling to meet existing regulations and probably will not meet newer regulations without radical innovative changes in current technology. Best available treatment practices often are contaminant specific, energy, chemically and/or financially intensive, toxic and non-renewable, thereby imparting even greater challenges for these small-scale PWS. As an initial step towards the goal of a sustainable, adaptable, multipurpose and cost-effective drinking water treatment system, this project will focus on the development of a robust filter medium that simultaneously remediates arsenic and chromium, two priority heavy metals prevalent in ground water and of concern for human health and the environment. This work will focus on the removal of arsenic and chromium using non-toxic, photocatalytic nano-TiO_2 and nano-α-Fe_2O_3 functionalized electrospun chitosan nanofibers for the safe and reliable delivery of drinking water by small-scale PWS.

Approach

The first stage of the project will be the electrospinning and characterization of combined chitosan/semiconductor nanofiber mats. At first, the semiconductor will be embedded within the chitosan and then the semiconductor will be coated on top of the embedded nanofibers. The second stage of the project will assess the ability of neat and electrospun semiconductor photocatalytic nanomaterials to remove arsenic, chromium and a mixed solution of arsenic and chromium from synthetic ground water in the presence and absence of ultraviolet (UV) light. The third stage will determine the environmental impact and robustness of the more effective filter combination for removal of arsenic and chromium as compared to current small-scale water treatment systems.

Expected Results

TiO_2-chitosan and α-Fe_2O_3-chitosan nanofiber mats will be effectively electrospun and coated. The nanofiber mats will maintain successfully the photocatalytic and adsorption properties associated with the neat nanoparticles. All mechanisms will react and remove arsenic and chromium with a higher efficiency in the presence of UV light. Due to increased surface area, coated nanofibers will be better able to remove arsenic and chromium than non-coated fibrous mats. Oxidation/reduction of individual arsenic and chromium solutions will be pH-dependent because of the zero point charge of α-Fe_2O_3; however, arsenic may act to stabilize the electron/hole pair of α-Fe_2O_3, thereby increasing the oxidation/reduction of arsenic and chromium in a mixed solution. The use of the nanofibers in a small-scale system will have a lesser cost and environmental impact as compared to traditional small-scale treatment systems over the life of the system.

Potential to Further Environmental/Human Health Protection

A culturally based appropriate technology transfer of electrospun photocatalytic semiconductor nanofibers as one component of a green, sustainable and cost-effective multi-component system will allow small PWS to meet consistently more stringent water standards with lesser environmental impact and without having to replace costly technology. It also will provide people relying on small PWS with a source of clean water. A system of this sort will have a large impact on Native American reservations and peri-urban zones that are expanding at a rapid rate throughout the developing world.

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Civil Engineering

Keywords: biobased composite, life-cycle analysis, creep behavior

Bio

Sarah Miller received a Bachelor's degree in Civil Engineering with an emphasis on Structural Engineering from Washington University in Saint Louis and a Master's degree in Sustainable Design and Construction from Stanford University. Subsequently, she began a Ph.D. in Civil and Environmental Engineering at Stanford University researching biobased composite design, including environmental and mechanical property characterization and modeling.

Synopsis

Current construction practices result in significant landfill consumption. The use of natural fiber reinforced biopolymer composites that can be sustainably cultivated, as well as rapidly and completely biodegraded when discarded, as a replacement for slow degrading materials will alleviate burdens placed on the environment. This research focuses on using life-cycle assessment and numerical modeling to inform composite design for mechanically and environmentally favorable composites.

Mechanical and Environmental Characterization of Biobased Composites Through Experiments and Numerical Modeling

Objective(s)/Research Question(s)

Landfill consumption resulting from current construction practices could be reduced by replacing conventional materials with biobased composites that can be formed from naturally cultivated materials and are biodegradable. The objectives of this research include assessing manufacturing techniques and predicting service behavior of biobased composites. These assessments and predictions will be applied to life-cycle analysis to develop tools for engineering materials to have favorable mechanical properties and environmental impacts.

Approach

To develop tools for composite design, several tasks will be performed on biobased composites. Biobased composites will be characterized based on mechanical properties, determined through experimental testing, and characterized based on environmental impact properties, determined through life-cycle assessments. Service life predictions for material behavior will be based on deflection controlled scenarios, and creep testing will be conducted to assess long-term material performance. These service life predictions will be used to provide a use phase for life-cycle assessments, which when used in conjunction with other properties assessed, will provide a foundation for engineering materials with superior mechanical and environmental qualities.

Expected Results

This research will aid in validating the application of envisioned closed-loop biobased composites for construction applications through characterization and modeling of these materials. Different composite constituents can lead to a range of mechanical properties and environmental impacts for a composite. Due to the novel nature of the composites examined, mechanical, creep and life-cycle impact properties of the composites must be examined. With these properties assessed, numerical models to predict behavior and material design tools will be developed, which can be used to engineer composites for desired properties.

Potential to Further Environmental/Human Health Protection

The closed-loop nature of the biobased composites researched will mark a paradigm shift in construction materials from materials that have one service life application to materials that have synonymous feedstock and degradation products. The characterization of material durability and life-cycle impact that will be conducted will substantiate the application of envisioned closed-loop composites for construction. Techniques also will be developed to apply laboratory-scale experiments to the understanding of material durability and life-cycle impact to aid in the design of lower environmental impact materials. The results of which will contribute to advancing sustainability by quantitatively assessing the influence of material durability on life-cycle impact.

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Project Amount: $126,000
Environmental Discipline: Civil/Environmental Engineering

Keywords: biodegradable polymers, anaerobic degradation, greenhouse gases

Bio

Cecily Ryan received her B.S. degree in Materials Science and Engineering from the Massachusetts Institute of Technology and an M.S. degree in Applied Physics from the California Institute of Technology. Prior to starting a Ph.D. program in Civil and Environmental Engineering at Stanford University, she worked for the U.S. Department of Agriculture studying the impact of fire on greenhouse gas emissions and two startup companies developing sustainable concrete. Her current research focuses on the degradation of biodegradable composites and resultant biogas reuse for energy and as a material feedstock.

Synopsis

The construction industry has a significant environmental impact. This research furthers the development of biopolymer-based construction materials that can be recycled efficiently, reducing solid waste, greenhouse gas emissions and fossil fuel consumption. This project investigates how the manufacturing processing conditions, properties and use of these materials influences their degradation in an anaerobic environment (such as a landfill) into a reusable methane-rich biogas.

Closed-Loop Life Cycle Engineering of Biopolymer Composites: End-of-Life Degradation and Reuse

Objective(s)/Research Question(s)

The objective of this research is to further the development of biodegradable plastics and natural fiber composites by understanding and optimizing the relationship between processing, properties and end-of-life degradation. The key questions that will be addressed by this work include: How can anaerobic environments be optimized for rapid degradation of targeted polymers and composites? How does the crystallinity of the polymer component affect the degradability of the material? Will the composite and blend morphology create preferential pathways for microbial degradation?

Approach

To explore how the microbial environment affects the degradation process of biopolymer/natural fiber composites, anaerobic digesters will be operated on composite samples, optimizing the microbial community by natural selection to degrade the specific substrate. Two environments will be investigated: sludge adapted to the polymer substrate (simulated bioreactor for resource recovery) and anaerobic digester sludge (simulated landfill). For the second part of this study, how polymer crystallinity affects the overall properties of these composites will be understood, as well as how these properties affect microbial degradation of the polymer surfaces. To accomplish this, the study will undertake a series of experiments in thin biopolymer films, where diffraction and microscopy techniques will be used to characterize the morphology of the films during degradation. In the third part of this study, a novel application of X-ray micro-computed tomography (micro-CT) will be refined to observe how micro cracking and fiber/matrix interactions affect pathways for microbial ingress in composite samples and therefore impact the degradation process. Using this process, a time series of *in situ* three-dimensional images will be taken during the degradation of polymer and composite samples. Samples that have undergone simulated weathering via moisture absorption will be compared to un-weathered samples. The loss of material versus time as determined by micro-CT will be compared to biogas generation rate and methane/carbon dioxide composition.

Expected Results

The expected results of this research are a better understanding of how the fundamental properties of biopolymer-based composites affect its degradation in anaerobic environments. This research also will lead to a more optimized degradation environment for these materials, as indicated by an improved degradation rate and extent. This optimized anaerobic environment will be characterized, including the microbial community composition. Overall, this work will help lead to biocomposite materials that can be used in construction applications and then fully and completely degraded at the end of their useful life.

Potential to Further Environmental/Human Health Protection

There are significant global environmental and societal impacts of accumulating large volumes of waste, including the emissions from municipal solid waste and waste combustion facilities, which impact air quality and contribute to greenhouse gas emissions. By developing construction materials that rapidly and substantially degrade after use, these materials can be recycled rather than filling up space in a landfill. Anaerobic digestion of these materials leads to a useful methane-rich biogas that can be used in a gas-to-energy power plant or as a replacement for petrochemical feedstock used in materials manufacturing.

Jamila Saifee Yamani
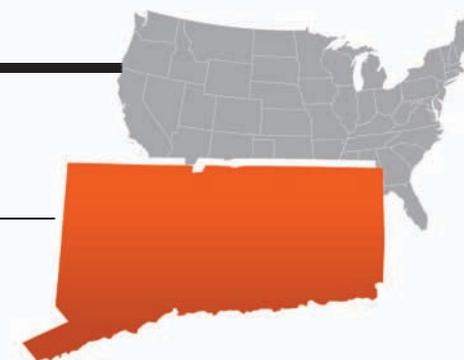
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: heavy metal contaminants, water, sustainable

Bio

Jamila Saifee Yamani received her B.S. degree in Chemical Engineering from the University of California, Los Angeles (UCLA) in 2008. She received her M.S. degree in Chemical Engineering from the Massachusetts Institute of Technology the following year. After spending a year pursuing other life goals, she began work towards her Ph.D. in the same field at Yale University. Her research interests include sustainable remediation of wastewater systems and infrastructure redesign.

Synopsis

Heavy metal contamination of waterways is of serious global concern. This study hopes to develop and investigate a novel and sustainable adsorbent for the removal of a variety of these heavy metal contaminants from water. The new adsorbent makes use of metal oxide nanopowders suspended in chitosan, an environmentally benign material that is a waste product of the shellfish industry. The novel sorbent allows for sustainable remediation of water without energy-intensive inputs.

A Novel Technology for the Treatment of Wastewater Using a Ubiquitous Chitosan Matrix With Varying Active Components

Objective(s)/Research Question(s)

Industrial manufacturing and mining processes produce wastewaters that are laden with a variety of heavy metal contaminants. As these metal solutions are released into the environment, there is a high potential for contamination of surface and ground water, which can serve as the primary drinking water source for many communities as well as the basis for ecological habitats. The proposed research intends to leverage a novel adsorbent design as a sustainable platform technology for the removal of multiple metal contaminants from aqueous systems.

Approach

The first stage of optimization of this chitosan-based metal remediation technology is the step-wise integration of active adsorbents (i.e., nanocrystalline metal oxides) into the chitosan matrix and assessment of the removal of co-existing heavy metal contaminants from aqueous solution. The evaluation of other ligand-metal complexes that are compatible with the current design will follow. Finally, relevant matrix/ligand characteristics, system design and operating parameters will be optimized for implementation.

Expected Results

The chitosan-based adsorbent, termed metal-oxide impregnated chitosan beads (MICB), of varying composition successfully will remediate aqueous solutions with a variety of metal contaminants with efficiencies comparable to those of neat nanopowder. The production process will make use of benign materials, and treatment of contaminated water will require minimal energy input. Rapid small-scale column tests using MICB will be instrumental in constructing a large-scale prototype for practical applications.

Potential to Further Environmental/Human Health Protection

The ultimate goal of this research is to implement a ubiquitous and sustainable heavy metal remediation technology to offset the risks posed by wastewater runoff from anthropogenic practices. Although many technologies for specific metal remediation already exist, there is no single technology that addresses a large variety of related contaminants. Wide-scale use of a simple, sustainable technology is key to successful remediation of these contaminated streams and recovery of the disturbed human communities and ecological habitats.
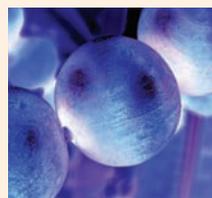
CHEMICAL SAFETY FOR SUSTAINABILITY

Nanotechnology

Ronald Douglas Kent

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Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: silver, nanoparticle, consumer products

Bio

Ronald Kent currently is a Ph.D. student at Virginia Tech majoring in Civil Engineering. He received a Bachelor's degree from Brigham Young University in 2009 and a Master's degree from Virginia Polytechnic Institute and State University in 2011, both in Civil Engineering. As an undergraduate researcher, he investigated the influence of nutrient cycling on algal growth and water quality in a drinking water reservoir in Utah. His current research probes the environmental transformations of silver nanoparticles.

Synopsis

Silver nanoparticles are incorporated into numerous consumer products because of their antibacterial properties. To understand the potential risks of silver nanoparticles to public health and the environment, it is necessary to know how rapidly they dissolve. This research examines how water properties, such as pH, and particle properties, such as size, influence silver nanoparticle dissolution rates. The results will facilitate predictions about the risks posed by silver nanoparticles.

Controlled Evaluation of Silver Nanoparticle Dissolution Using Atomic Force Microscopy

Objective(s)/Research Question(s)

The goal of this research is to acquire comprehensive kinetic data of silver nanoparticle (AgNP) dissolution that can be used in future assessments examining AgNP fate, transport and toxicity. The objective of this study is to quantify the effects of (1) surface coatings, (2) particle size and shape, (3) solution chemistry, and (4) reduced sulfur on the dissolution rates of un-aggregated AgNPs. An underlying hypothesis of this project is that aggregation hinders AgNP dissolution, so it is expected that the rate data obtained will represent the upper limit of AgNP dissolution for a specified condition.

Approach

Nanosphere lithography (NSL) will be used to fabricate uniform arrays of AgNPs on glass substrates. NSL is a versatile, inexpensive and high-throughput lithographic technique that enables creation of periodic nano- and micro-particle arrays and facilitates control over particle size, shape and interparticle spacing for a number of different materials and substrates. AgNPs produced by NSL are immobilized on the substrate to prevent aggregation. Following production, particle arrays will be functionalized with various surface coatings that commonly are used to stabilize AgNP suspensions, such as citrate and PVP. The prepared samples will be placed in solutions of varying pH, temperature, inorganic salt concentrations and organic matter concentrations. Particular emphasis will be given to inorganic and organic sulfides because of their high affinity for silver. Changes in particle height and morphology will be monitored over time by atomic force microscopy (AFM) to obtain a direct measure of AgNP dissolution rates in units of nm/d. Additional techniques, such as X-ray photoelectron spectroscopy and Raman spectroscopy, will be used to provide further information about the reactions occurring at the AgNP surfaces.

Expected Results

Preliminary experiments have demonstrated that the proposed method can successfully measure dissolution rates in units of nm/d with high precision, and a strong correlation has been shown between chloride concentration and AgNP dissolution rate. Future experimentation will yield important information regarding other influential variables. Regression models generated from the experimental data will provide a convenient method for calculating dissolution rates to predict the persistence of AgNPs in a specified environment. It is expected that the results will be applicable to a wide range of environments, from natural waters to biological fluids. The novel experimental approach overcomes many of the limitations of more traditional techniques and can potentially be extended to other nanomaterials as well; thus, this project may provide a pattern for future studies on the environmental fate of nanomaterials.

Potential to Further Environmental/Human Health Protection

This research will produce comprehensive information about AgNP dissolution that will be invaluable for rapidly assessing and managing the risks of AgNPs, which is paramount for protection of public health and the environment. Toxicity studies and exposure modeling will both benefit from this information since AgNP dissolution is linked intimately to both topics. Data collected from this project will assist in the sustainable application of AgNPs by revealing how size, shape or surface coating can either enhance or diminish particle inertness or persistence.

Jessica Renee Ray
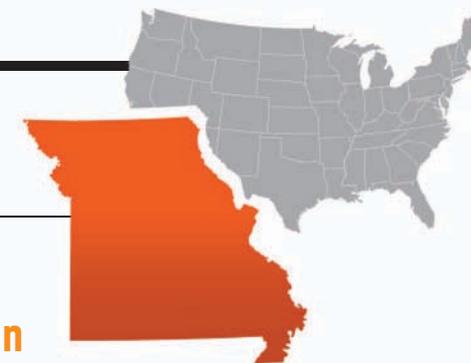
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Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: nanoparticles, wastewater, biofilms

Bio

Jessica Ray received a B.S. degree in Chemical Engineering from Washington University in St. Louis in 2009. She remained at this institution to begin the M.S. and Ph.D. program in Energy, Environmental and Chemical Engineering. Her research interests include environmental nanochemistry, particularly with respect to water treatment. Her current research is observing the nucleation of iron oxide nanoparticles in the presence of environmentally relevant substrates.

Synopsis

Nanoparticles can enter wastewater streams from industrial and natural sources; yet, the environmental and toxicological effects of nanoparticles and wastewater components still are poorly understood. This research will examine the interactions of engineered and naturally occurring nanoparticles, contaminants and natural organic matter with biofilm (a fixed layer of microbial cells often used for biological wastewater treatment) to help predict the fate of nanoparticles in wastewater systems.

Multidisciplinary Approach to Understanding the Fate and Transport of Natural and Engineered Nanoparticles in Wastewater Treatment Systems

Objective(s)/Research Question(s)

There have been reports of an increasing number of nanoparticles in wastewater streams from industrial, natural or engineered sources. Wastewater treatment plants often use biofilm, a naturally occurring microbial film, for removing organic materials in influent streams; however, it still is unclear how nanoparticles affect such biofilm properties as its microbial activity, and its physical and chemical structure. This research project will seek to gain a holistic understanding of the role of nanoparticle structure and stability on the fate and transport of contaminants in the presence of biofilm, by investigating interactions of model natural and engineered nanoparticles, contaminants and natural organic matter with biofilm. The results will help to predict and control adverse consequences of the rising number of nanoparticles in wastewater streams.

Approach

The first phase of this research will involve synthesizing and characterizing the nanoparticles. Hematite iron oxide and cerium oxide nanoparticles were chosen to model natural and engineered nanoparticles potentially found in wastewater streams. Bare and organic-coated nanoparticles will be used in the project, as often nanoparticles exist in nature accompanied by a surface coating for stabilization. The second phase will investigate the interactions of the nanoparticles with organic and inorganic contaminants in the presence of different substrates (including biofilm) using a diverse array of instrumentation for *in situ* analysis. The final phase involves creating a porous media channel to elucidate the transport of the nanoparticles in simulated wastewater streams and other aqueous systems.

Expected Results

A better understanding of the behavior of nanoparticles and contaminants in wastewater treatment systems will enable the design of more efficient and effective biofilm reactors that are more equipped to respond to the increasing number of nanoparticles in influent streams. The diverse and advanced nanoparticle methods used will help to determine whether nanoparticles and/or biofilm transformations during and after reaction will introduce more contaminants into effluent water, remove nanoparticles from the system, or result in an overall enhanced removal of contaminants. The results from this research project and research techniques can be used to design a reactive transport model that accurately accounts for nanoparticle-contaminant-biofilm interactions, including the degree of transverse and longitudinal mixing and aggregation. The proposed reaction system will be extremely advantageous in perceiving the physical and chemical evolution of environmental and engineered nanoparticles and biofilm in wastewater treatment systems.

Potential to Further Environmental/Human Health Protection

It is well documented that nanoparticles often exhibit different structures and reactivities compared with their bulk counterparts, which often includes a higher degree of toxicity. Nanoparticles are being generated at higher rates either as byproducts of industrial processes, as intentionally manufactured products for specific purposes, or as precipitates from natural aqueous processes. This has been shown to result in increased nanoparticle amounts in water and wastewater treatment systems. If biofilm is found to be ineffective in sequestering organic contaminants because of interactions with the increasing number of nanoparticles, the toxicity of the effluent stream could be significantly enhanced, posing a threat to human health and the environment. The findings from this research project will better inform the public about the degree of uptake and removal of nanoparticles and contaminants by wastewater treatment systems.

CHEMICAL SAFETY FOR SUSTAINABILITY

Pesticides & Toxic Substances

For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals, from the moment of conception until death.

—Rachel Carson

Kellie Anne Cotter

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Molecular and Cellular Biology

Keywords: endocrine disrupting chemicals, alternative splicing, adaptation

Bio

Kellie Cotter earned her B.S. degree in Molecular Biology from the State University of New York at Buffalo in 2008. The following year, she started a Ph.D. program in Molecular Biology, Cell Biology and Biochemistry at Boston University. Her research interests include endocrine disrupting chemicals and their effects at the molecular and genetic level. Her current research is on the effects of pollutant exposure on estrogen signaling in fish and the ability of some populations to adapt to these chemicals.

Synopsis

Endocrine disrupting chemicals present in many common pollutants exhibit detrimental effects on reproduction, development and other processes in many species, often at surprisingly low doses. Yet, how low-dose, chronic exposure across many generations affects populations remains to be determined. This research proposes to use a fish population that has adapted to high levels of pollutants to study the effects on estrogen signaling and the role of gene expression changes in adaptation.

Endocrine Disruption and Adaptation: An Innovative Mechanism Utilizing Alternative Splicing in Estrogen Signaling

Objective(s)/Research Question(s)

Endocrine disrupting chemicals present in many pollutants interfere with the normal hormonal signaling pathways regulating reproduction, development and other homeostatic processes. Their effects often occur at surprisingly low, non-toxic doses in human as well as wildlife populations. It remains poorly understood, however, how these low-dose exposures affect an organism across its entire lifetime, or how they affect populations across several lifetimes.

Approach

The study will utilize a population of killifish (*Fundulus heteroclitus*) from a highly polluted Superfund site that exhibits adaptive responses to pollutant exposure. Their resistance to the estrogenic nature of the polluted environment is of particular interest. The study first will identify and quantify alternatively spliced variants of the estrogen receptor in these fish in comparison to fish from a non-polluted environment. The study then will characterize these receptor variants to determine if they respond differently to estrogen. Lastly, the study will test these variants in the control fish to see if they are responsible for the estrogen resistance.

Expected Results

Previous studies in fish and other species have demonstrated a high level of variability in the splicing of estrogen receptors. Changes in the quantity of one or more variants within the available pool would allow a modulation in the response to estrogen. If a population upregulates the expression of a non-functional variant, the estrogen response pathway would be dampened, allowing the population to withstand higher-than-normal estrogen levels in the environment without significant effect. Replicating these splicing patterns in control fish will replicate this resistance seen in pollutant-exposed fish.

Potential to Further Environmental/Human Health Protection

This research would demonstrate a novel mechanism for action of endocrine disrupting chemicals, which likely will prove relevant to other hormone signaling pathways. Results from this study will aid in the development of new biomarkers for exposure, which will be helpful in the detection of new endocrine disrupting chemicals, and/or previously unidentified populations at risk.

Christopher Dennis Kassotis
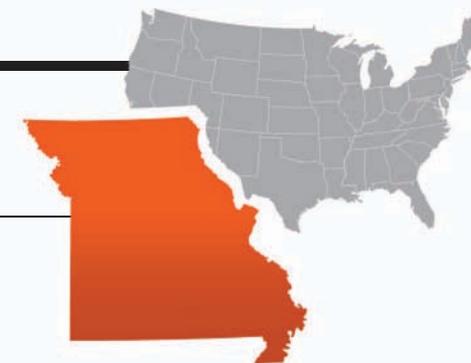
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Project Amount: $126,000
Environmental Discipline: Biological Sciences

Keywords: endocrine disrupting chemicals, hydraulic fracturing, water contamination

Bio

Christopher Kassotis received a B.S. degree in Biology from Keene State College in 2008. He then accepted a position as an Analytical Chemist in Princeton, NJ, at a contract research laboratory. Subsequently, he accepted a position in a Ph.D. program in Biological Sciences at the University of Missouri. His research interests include understanding the implications and mechanisms involved with mixtures of endocrine disrupting chemicals. His current research involves assessing the hormonal activity of natural water sources in a natural gas drilling-dense region.

Synopsis

There are endocrine disrupting chemicals present in fluids that are used in the process of hydraulic fracturing for natural gas, and these chemicals have been shown to contaminate natural sources of water within the United States. This research proposes to establish the link between hydraulic fracturing and the presence of elevated levels of hormonal activity in water, identify the specific chemicals that cause this hormonal activity and begin to identify potential health implications of these chemicals.

Contamination of Natural Water Sources in Natural Gas Drilling-Dense Regions

Objective(s)/Research Question(s)

Because hydraulic fracturing has been linked to local contamination of water supplies, this study seeks to develop a better understanding of this contamination and its potential impacts on the environment. This research aims to determine the relationship between various hormonal activities in natural sources of water with hydraulic fracturing processes and then to determine which chemicals specifically are causing this hormonal activity. Once established, this research aims to assess potential health implications to humans and wildlife from exposure to these chemicals based on in vivo experiments in the laboratory.

Approach

To further establish the link between hydraulic fracturing operations and contamination of natural water supplies, this study will sample water in drilling-dense and drilling-sparse regions and both before and after drilling has taken place within specific regions. To identify samples with hormonal activity, water samples will be subjected to solid phase extraction, and concentrated samples will be used in hormone response reporter gene assays. Samples with hormonal activity will be fractionated and specific chemicals identified. Lastly, to begin to answer the question of potential health implications of these chemicals entering natural sources of water, an animal study will be performed to look at specific health endpoints that may be seen in humans.

Expected Results

The specific interests are in understanding how environmentally relevant mixtures of endocrine disrupting chemicals impact human and environmental health. This project aims to look at the chemicals used in liberating natural gas that may be introducing multiple endocrine disruptors into natural sources of water. As there have been more than 1,000 reported cases of contamination related to hydraulic fracturing, it is clear that these chemicals are entering natural water sources and will expose humans and wildlife to complex mixtures of endocrine disruptors. This research should serve to identify those chemicals, replicate those mixtures in a controlled laboratory setting, and examine dose-related responses of the mixtures both *in vitro* and *in vivo* to assess the potential for impacts on human and environmental health. The results of this research will increase understanding of the potential hazards associated with hydraulic fracturing and provide a basis for regulatory agencies to develop science-based standards of safety and containment of waste from hydraulic fracturing processes.

Potential to Further Environmental/Human Health Protection

Establishing hormonal activity of samples to build a picture of environmental impact and potential threats to human health is crucial to supplement regulatory decision making and to further research that will examine the potential threats to human health related to exposure by specific chemicals that are identified. The key outcome to this is the establishment of a sustainable practice with minimal impact on human and environmental health. Although hydraulic fracturing processes already have a positive economic impact on regions throughout the country, the overarching goal for this research is to create a balance between this benefit and a safe-, health- and ecosystem-conscious approach to the issue.

Madisa B. Macon

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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Toxicology

Keywords: perfluorooctanoic acid (PFOA), mammary gland, development

Bio

Madisa Macon earned a B.S. degree in Chemistry from Xavier University of Louisiana in 2006, and an M.P.H. degree from Drexel University School of Public Health in 2008. Currently, she is pursuing a doctoral degree at the University of North Carolina, Chapel Hill, in the Curriculum in Toxicology, where she focuses on environmental health as it relates to mammary gland biology and developmental toxicology. Her dissertation research is focused on the effects of prenatal perfluorooctanoic acid (PFOA) exposure on the development of the mammary gland.

Synopsis

PFOA is a man-made chemical that is found everywhere in the environment, including human blood. This pollutant is linked to adverse health effects in humans and children, with children having higher PFOA exposures than adults. Laboratory studies have shown that prenatal PFOA exposure affects mammary gland growth during puberty, lactation and breast cancer risk. Using mouse-models, this research will determine how PFOA acts to affect normal mammary gland growth.

Mechanisms Underlying Low-Dose Perfluorooctanoic Acid Developmental Effects in Mouse Mammary Tissues

Objective(s)/Research Question(s)

PFOA is a synthetic surfactant that has been shown to delay mammary gland development of prenatally exposed mice resulting in persistent aberrations. Although PFOA toxicity in other tissues (e.g., liver) is mediated by the peroxisome proliferator activated receptor alpha (PPARα), the mode of action for PFOA-induced mammary gland delays has yet to be fully characterized. The overarching goal of this research project is to characterize the major molecular pathways involved in the persistent perturbation of mammary gland development following prenatal PFOA exposure, at dose levels that overlap with reported human exposures, so that the human relevance of these mechanisms can be determined.

Approach

Using mice as a model for humans, pregnant mice will be dosed with low levels of PFOA that are relevant to human exposures. The mammary glands of the female offspring will be examined during various ages spanning from neonatal time points to late adolescence. Activation of peroxisome proliferator activated-receptor alpha (PPARα) and its signaling pathways has been implicated to mediate the effects of PFOA in the liver, yet the role of PPARα in PFOA-induced mammary gland toxicity is unclear due to limited studies and conflicting results. Using 129S1/SvImJ PPARα wild-type (WT) and knock-out (KO) mice, time-pregnant mice will be orally dosed with 0, 0.01, 0.1, or 1.0 mg PFOA/kg B/day from gestation days 10-17. Mammary glands from the female offspring treated with PFOA will be compared to determine the role of PPARα in PFOA-induced mammary gland delays. In other experiments following the same dosing paradigms, time-pregnant CD-1 mice will be orally dosed with PFOA to characterize the changes in the mammary glands of the female offspring. Mammary glands of PFOA-treated animals will be compared to controls based on morphology, histology, protein and RNA. Data analyses will include mammary gland whole mount analysis, immunohistochemistry, serum PFOA and steroid hormone measurements, fluorescent activated cell sorting and microarray analysis.

Expected Results

Through the use of 129S1/SvImJ PPARα WT and KO mice, the role of PPARα activation in PFOA-induced mammary gland delays will be determined. Although the limited PPARα WT/KO studies with PFOA exposures have produced conflicting results, it is expected that PPARα activation does not play a major role in PFOA-induced mammary gland delays. Utilizing RNA microarray analysis from the CD-1 mice experiments, candidate signaling pathways will be identified and validated through various protein analyses.

Potential to Further Environmental/Human Health Protection

Although epidemiology studies have found positive associations between PFOA levels in human serum and adverse health effects, determination of a causal link relies on data produced from animal studies. Characterization of the major signaling pathways involved in PFOA-induced mammary gland delays at blood levels that overlap with known human exposures would further the understanding of PFOA toxicity and its heightened effects in children, and will help to determine the human relevance of this outcome. Therefore, data produced from this research project are expected to inform regulatory agencies at the state and federal levels in their risk assessment of PFOA so that intervention schemes can be developed.
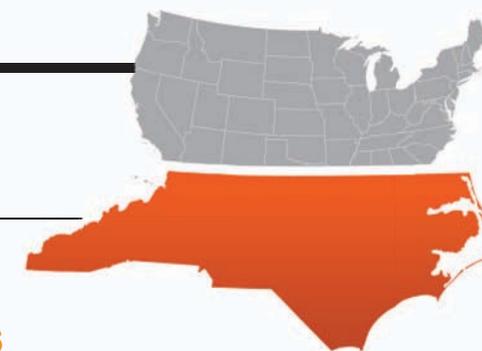
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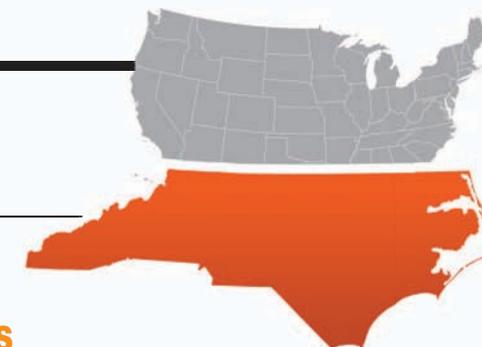
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Project Amount: $126,000
Environmental Discipline: Environmental Chemistry

Keywords: polybrominated diphenyl ethers (PBDEs), toxicology, endocrine disruption

Bio

Simon Roberts received a Bachelor's Degree in Environmental Health Sciences from East Tennessee State University in 2009. The next semester, he started graduate studies at Duke University in Environmental Chemistry and Toxicology. His current research focuses on the fate and effects of flame retardant chemicals used in commercial products. He enjoys rock climbing, cycling and running.

Synopsis

Flame-retardant chemicals are added to commercial products, such as furniture foam, to slow the propagation of fire. Although this may provide fire safety benefits, these chemicals have been shown to persist in the environment and may pose toxicological risks to humans. This research aims to investigate whether several flame retardants affect the developing brain by disrupting thyroid hormones in glial brain cells to facilitate risk assessments for the management of polybrominated diphenyl ethers (PBDEs) sources.

Metabolism of Brominated Flame Retardants in Human Astrocytes and Effects on Thyroid Hormone Homeostasis

Objective(s)/Research Question(s)

PBDEs are flame retardants used in consumer products, including furniture, electronics and textiles. Numerous studies have shown that PBDEs may affect human health via several mechanisms, including perturbed neurodevelopment and disruption of the thyroid hormone system. The central hypothesis of this proposed study is that PBDEs and/or their metabolites impair thyroid hormone metabolism in astrocytes contributing to impacts on neurodevelopment.

Approach

Cultured astrocyte cells will be used to assess the toxicity of PBDEs. First, the metabolism of PBDEs in astrocytes will be evaluated to determine whether hydroxylated PBDEs are formed at the blood-brain barrier. Second, thyroid hormone metabolism will be evaluated in cells exposed to PBDEs to determine whether PBDEs affect thyroid hormone levels at the blood-brain barrier. Finally, the expression of several genes will be evaluated in cultured astrocytes exposed to PBDEs to determine whether PBDEs affect thyroid hormone metabolism via interactions with various nuclear receptors in the cells.

Expected Results

In this proposed study, hydroxylated PBDEs and brominated phenols likely will be formed in astrocytes as a result of cytochrome p450-mediated metabolism. Previous studies have shown that polychlorinated biphenyls (PCBs) affect the regulation of thyroid hormones at the blood-brain barrier by increasing the activity of thyroid hormone deactivating enzymes (e.g., sulfotransferases) and by decreasing the activity of thyroid hormone activating enzymes (e.g., Type 2 deiodinase). It is likely that similar results will be observed with PBDEs because of their structural similarity to PCBs.

Potential to Further Environmental/Human Health Protection

The assessment of specific mechanisms of toxicity is vital for risk assessments to make informed decisions involving the management of PBDEs. Even though the commercial use of PBDEs has decreased, large reservoirs of these compounds exist in consumer products, and human exposure to PBDEs in indoor environments likely will continue for decades. Knowledge of toxic mechanisms with dose-response relationships will allow for better understanding of potential human health effects, particularly for children, who receive elevated exposures during critical windows of development. In addition, this knowledge will help facilitate the management of PBDEs in sources such as e-waste and commercial products containing PBDEs.

EMERGING
ENVIRONMENTAL
APPROACHES &
CHALLENGES

Innovations that are guided by smallholder farmers, adapted to local circumstances, and sustainable for the economy and environment will be necessary to ensure food security in the future.

– Bill Gates

Environmental Entrepreneurship

Peter Michael Alstone

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Project Amount: $126,000
Environmental Discipline: Environmental Science and
   Engineering

Keywords: telecommunication, micro-energy, greenhouse gases (GHG)

Bio

Peter Alstone earned a B.S. degree in Chemical Engineering at North Carolina State University in 2004 and an M.S. in Environmental Systems from Humboldt State University in 2009. After several years working on energy access in the developing world, he started a Ph.D. program in Energy and Resources at the University of California, Berkeley. His current interdisciplinary research aims to identify and understand new approaches to clean energy development that incorporate modern information technology.

Synopsis

Advances in battery, solar and light-emitting diode (LED) lighting technology have set the table for an off-grid micro-energy revolution. These devices can offer climate, economic justice and public health benefits for the 1.3 billion people who rely on dirty, expensive, unhealthy fuel-based lighting for their basic needs. This research investigates how widespread access to mobile phones and emerging access to mobile banking can be leveraged to overcome some of the key remaining barriers to micro-energy adoption.

Mobilizing Clean Energy: The Nexus of Micro-Energy and Mobile Phones Off the Grid in the Developing World

Objective(s)/Research Question(s)

Micro-energy devices—off-grid energy appliances that integrate solar, LED and battery technology—have the potential to offer significant climate, economic justice and public health benefits to the 1.3 billion people who live without electricity access. However, there are key barriers related to product quality assurance, financing, maintenance and institutional support. The objective of this work is to identify novel ways that mobile telecommunications and banking can be leveraged to transform the diverse, rapidly changing market for micro-energy devices and unlock their potential.

Approach

Drawing on multiple disciplines, spanning technology, economics, public policy and communications, this study will test and refine new ways to engage with buyers and end-users, with an overall goal of finding new "killer apps" that will enable rapid transformation of the micro-energy market. The approach is to engage with institutions and end users to understand the dynamics of the market for micro-energy, and then design and pilot test mobile communications and banking interventions with a forward-looking perspective.

Expected Results

This research will extend the knowledge base and toolset for researchers, manufacturers and institutions that need to engage with people in the developing world both before and after the sale of micro-energy systems in a market setting. If any of the particular ideas that are pilot tested—ranging from reducing transaction costs for micro financing to improving maintenance delivery—prove to be promising, it could have immediate impact. More broadly, this work will uncover new information about behavior, economics and institutional engagement in markets in the developing world.

Potential to Further Environmental/Human Health Protection

Micro-energy that is effective at eliminating fuel-based lighting can reduce greenhouse gas emissions, promote economic justice and improve public health. The current annual emissions burden for fuel-based lighting is up to 190 million tons of equivalent CO_2. People who use fuel-based lighting typically spend 5 percent of their income and get paltry service levels. The public health burden includes significant acute impacts from respiratory infections, not to mention significant fire hazards.

Joshua Perry Kearns
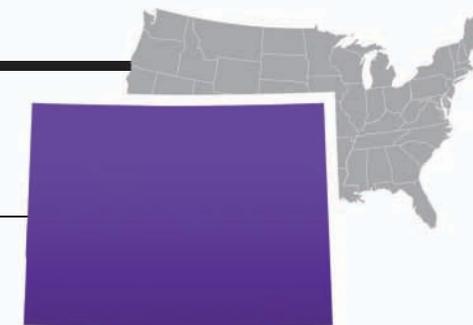
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Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: biochar, decentralized water treatment, developing communities

Bio

Joshua Kearns holds Bachelor degrees in Chemistry and Environmental Engineering from Clemson University and a Master's degree in Environmental Biogeochemistry from the University of California, Berkeley. He currently is a Ph.D. candidate in Environmental Engineering at the University of Colorado, Boulder. His research explores the applicability of locally produced charcoals and biochars as low-cost sorbents for drinking water treatment in developing communities.

Synopsis

Drinking water contamination by pesticides is a growing worldwide problem. Effective, affordable and scalable "green" technologies for pesticide removal are, however, lacking. Environmentally sustainable biomass char (biochar) adsorbent can be generated at the local level from agricultural and forestry residues using an innovative low emission, energy efficient gasification process. The study is investigating the applicability of biochar for pesticide removal in decentralized water treatment.

Evaluation of Traditional Charcoals and Gasifier Biochars as Sustainable Low-Cost Adsorbents for Water Treatment Serving Developing Communities

Objective(s)/Research Question(s)

It is hypothesized that locally generated gasifier biochars exhibit enhanced sorption properties compared with charcoals produced by traditional methods, and can be cost-effectively applied in decentralized water treatment for removal of synthetic organic contaminants (SOCs) such as pesticides.

Approach

The study first will generate a representative selection of chars using a traditional charcoal kiln, programmable laboratory pyrolyzer, and small and pilot-scale biomass gasifier systems. These chars then will be subjected to physico-chemical characterization and batch-mode SOC uptake assessment in the presence of background dissolved organic matter and competitive sorbates to identify sorbents with low, medium and high potential for application in water treatment. The study then will carry out laboratory bench-scale column tests to quantify the efficacy of selected representative chars for SOC removal under dynamic, field-relevant conditions. Finally, pilot column and field data will be collected and used to develop a scaling approach for predicting full-scale system performance.

Expected Results

This research will break new ground in elucidating connections between principal char manufacture variables and the development of enhanced sorption characteristics in the char product. These variables include feedstock identity (biomass precursor) and form (i.e., whole logs used for traditional charcoaling versus chipped or pelletized material used in gasifiers), peak temperature, duration of heating, and gas sweep rate during pyrolysis. The innovative work proposed here will extend beyond extant studies of equilibrium SOC uptake by chars under ideal laboratory conditions to demonstrate the roles of mass transport kinetics, fouling by background dissolved organic matter and competitive sorption under "real-world" conditions. Moreover, these results will provide novel baseline performance data scalable for engineered char adsorber units applicable in both water treatment and environmental remediation strategies (e.g., municipal stormwater and agricultural runoff passive treatment barriers, acid mine effluent attenuation), and in so doing provide scientific support for domestic and international entrepreneurship in the application of sustainable environmental technologies.

Potential to Further Environmental/Human Health Protection

This work realizes a triple-benefit for human health, environmental sustainability and local economies to: (1) offer economical and technologically accessible water treatment where currently none exist; (2) offset polluting and energy-inefficient charcoal production with a "green" technology; and (3) support village-level microenterprise in the manufacture of enhanced sorbents. This research thus exemplifies potentially "game-changing innovation" in sustainable engineering where benefits realized abroad also imply positive domestic environmental and economic outcomes.

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Project Period: 8/16/2012 - 8/15/2015
Project Amount: $126,000
Environmental Discipline: Environmental Microbiology

Keywords: water quality, household water, fecal contamination

Bio

Alice Wang is a Ph.D. candidate in Environmental Sciences and Engineering at the University of North Carolina Gillings School of Global Public Health. Her research focus is mainly on environmental microbiology and drinking water. Her career aspirations are to join the Epidemic Intelligence Service postgraduation and eventually serve her country as a U.S. Public Health Service environmental health officer. Her life aspirations are to run a marathon on all continents (excluding Antarctica), drive cross-country and visit all U.S. national parks, bicycle around the country of Taiwan and start a medium-sized organic farm. In her spare time, she enjoys playing piano and harmonica, running and hiking with her dog Stinkerpot, birdwatching, reading fiction, cooking and traveling.

Synopsis

A billion people lack access to safe drinking water, resulting in millions of deaths annually. The first step in improving the global drinking water situation is to monitor water quality. Because many countries lack active monitoring of drinking water quality, it often is unknown if sources are safe. Current monitoring methods require the use of specialized equipment, electricity and trained personnel. In low-resource settings, these luxuries often are unavailable. The Compartment Bag Test (CBT) is a novel water-quality field test that overcomes the obstacles of water-quality testing in low-resource settings. Characterizing and documenting the CBT performance in the laboratory and field settings can improve the test. With increased access to this novel water-quality field test, there can be increased water-quality monitoring, producing quality actionable data that will better inform practice and policy, and eventually catalyze the much needed action surrounding global drinking water issues.

Laboratory and Field Performance Evaluations of a Novel *Escherichia coli* Field Test

Objective(s)/Research Question(s)

The four EPA-approved methods for detecting *Escherichia coli* in water sources are expensive (i.e., more than $3/sample) and require extensive laboratory training along with non-portable or fragile equipment. Thus water-quality managers, public health and sanitation officials, and individuals living in low-resource settings often make decisions that affect the health of the public without reliable water-quality information that is not necessarily indicative of true health risks. Microbial water-quality testing in low-resource settings is one of the greatest challenges in implementing safe water programs in developing nations. The CBT is a novel water-quality field test that overcomes the current water-quality testing obstacles in low-resource settings. Additional laboratory experiments are needed to further characterize the performance of the test to detect *E. coli* bacteria in water, as well as to produce a version of the test that can be pilot tested in the field.

Approach

The water used with the CBT will be speciated to confirm that the CBT accurately is detecting *E. coli* with biochemical tests, as well as molecular methods such as polymerase chain reaction (PCR). Performance validations of the CBT also will include the incorporation of the CBT within U.S. Agency for International Development (USAID)-supported Demographic Health Surveys (DHS), previously in a Peruvian DHS in 2011, and in the planning process for a Liberian DHS in 2013. User feasibility and implication of knowledge of microbial water quality also will be assessed via semi-quantitative surveys in collaboration with United Nations (UN)-Habitat in Mwanza, Tanzania, in the summer of 2012.

Expected Results

Preliminary laboratory experiments demonstrate that via biochemical assays, the positive chambers in a CBT are truly *E. coli*. Future laboratory experiments speciating positive waters via molecular methods such as PCR and electrophoresis also likely will be true positives for *E. coli*.

Potential to Further Environmental/Human Health Protection

Improving the CBT for preparation to be a commercially viable product has significant implications. The CBT meets the criteria of being inexpensive, simple, robust and portable, such that the test can be used in even rural and rugged areas of a developing country. The simplicity of the test allows anyone with brief training to test their own water, thereby empowering people with knowing if their water is safe so that they can determine their own remedial actions. There are several applications of this technology, including water-quality management of water quality, food safety and disaster preparedness. Evaluation of the CBT in the field and documentation of observations will illuminate significantly the challenges of testing and possible solutions to problems facing the CBT test. Furthermore, the water-quality results from the inclusion of CBT in household surveys can depict better where we stand in our Millennium Development Goals on drinking water and provide quality actionable data for local interventions and national policy change.

Information Science
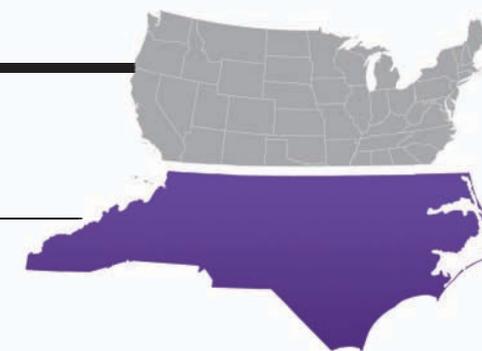
Part of the inhumanity of the computer is that, once it is competently programmed and working smoothly, it is completely honest.

– Isaac Asimov

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Project Amount: $126,000
Environmental Discipline: Geography

Keywords: forest disturbance, Chesapeake Bay, geographic information systems (GIS)

Bio

Lindsay Deel is a Ph.D. student in Geography at West Virginia University. Her research interests include forest ecology, remote sensing and geographic information systems (GIS). In addition to research, Lindsay is currently a news writer for the journal *Frontiers in Ecology and the Environment*. Her current work involves mapping forest conditions in the Chesapeake Bay Watershed (CBW) using remote sensing to enhance modeled estimates of nutrient and sediment export to the Bay.

Synopsis

Accurately estimating nutrient and sediment loads entering the Chesapeake Bay is recognized by the U.S. Environmental Protection Agency as a top priority in the journey towards mitigating excess nutrients and improving the health of the Bay. Forests comprise approximately 65 percent of the land cover within the CBW; however, nutrient and sediment export from forested watersheds varies widely depending on many factors, including disturbance history, past land use and other forest dynamics. Although past land use often is not well known and many forest dynamics, such as denitrification and nitrogen (N) fixation, are difficult to assess or unknown, forest disturbance can be monitored easily using remote sensing. This study uses National Aeronautics and Space Administration (NASA) satellite imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) to address the disconnect between modeled estimates of nutrient and sediment loads from forested watersheds within the CBW and the actual spatial condition and contribution of those forested lands. This project represents an ongoing collaboration with the Chesapeake Bay Program Office (CBPO) in Annapolis, MD, to ensure appropriate data and methods development that can be incorporated easily into the current model structure, with the objective being to support science-based policy and management decisions by the use of scientific knowledge, data and modeling.

Developing Satellite Imagery-Based Forest Disturbance Metrics to Improve Predictions of Nutrient and Sediment Loads to the Chesapeake Bay

Objective(s)/Research Question(s)

How do different disturbances differ spectrally across the landscape, and how can these differences be used to create discrete forest disturbance categories to be incorporated in the CBP Watershed Model?

Approach

The study uses NASA's MODIS imagery to create maps of disturbance in forests of the CBW. These maps will include information on the type and intensity of disturbance within forested areas. Using these data, the relationship between forest disturbance and streamwater nutrient and sediment export will be assessed.

Expected Results

It is expected that there will be a strong relationship between forest disturbance level and nutrient and sediment load on an annual basis at the river-segment scale. The newly created forest categories will add depth and detail to the Watershed Model and will refine the estimates of nitrogen, phosphorus and sulfur that are used to create total maximum daily loads for the entire Chesapeake Bay.

Potential to Further Environmental/Human Health Protection

These results will contribute to the overall goals of the Chesapeake Agreements (1987 and 2000) with regard to reducing nutrient pollution in the Bay by refining estimates of the origins and loads of nutrients from forested land-use types in the CBW. Therefore, the study has the potential to impact issues and policies surrounding water quality across an area that more than 16 million people call home. Policy changes that may result from a model refinement such as this are likely to have environmental and economic impacts reaching throughout the entire CBW. These include improved water quality affecting beneficial uses of many water bodies (such as provision of drinking water, fishing, swimming and ecosystem services related to aquatic habitats), and more directed regulatory actions designed to reduce nutrient and sediment additions from their sources.

EMERGING ENVIRONMENTAL APPROACHES & CHALLENGES

Social Sciences

> You must be the change you wish to see in the world.
> *—Mahatma Gandhi*

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Project Amount: $126,000
Environmental Discipline: Environmental Policy

Keywords: policy, water quality, forestry

Bio

Sarah Carvill received a B.A. degree in Environmental Studies from the University of California (UC), Santa Cruz in 2007. For the next 2 years, she studied local involvement in Superfund cleanup in rural Montana, earning an M.S. degree from the University of Montana in 2009. For her Ph.D., she returned to UC Santa Cruz, where she continues to examine the relationship between public policy, stakeholder interests and environmental outcomes in the resource industries of the U.S. West.

Synopsis

Water quality remains a serious problem in the United States, and forestry is one sector whose impacts on rivers and streams are under-regulated nationally. California has passed legislation to control more strongly polluted runoff from the timber industry. This study compares the resultant regional programs to determine what factors produce policies that are feasible for industry and protective of water resources. Results will inform the development of future logging-related water quality policy.

Producing Effective Water Quality Protections for Private Forests: A Comparative Study of Regional Pollution Control Programs in California

Objective(s)/Research Question(s)

Developing water pollution control programs that are responsive to public concerns, easily implemented by the regulated community and feasible for agencies to enforce are a significant challenge for state governments. In 1999, California instructed each of its regional water boards to write new regulations for several polluting industries that had previously operated under general waivers. This research will analyze the resulting "conditional waiver" programs for California's timber industry to identify: (1) which regions produced the most effective policies for controlling the water quality impacts of timber harvesting; and (2) how stakeholders involved themselves in the process and with what results.

Approach

California's effort to control timber-related discharges creates the conditions for a "natural experiment" in policy development and implementation. The regional boards designed and began enforcing their timber programs under a uniform legal framework and within the same time period, but the strategies of different stakeholders, their relative power and the features of the adopted policies vary among jurisdictions. This study will examine the timber programs from the water quality regions where most of California's logging takes place, combining within-case analysis and cross-case comparison to elucidate the effectiveness of each timber policy. Data will include agency memos, public comments, hearing transcripts, monitoring and enforcement data, press coverage and original interviews with a variety of informants.

Expected Results

Factors such as the difficulty of safely and reliably monitoring runoff from active harvest areas, the spatial extent of water quality regions and the number of hours required for participation in pre- and post-harvest inspections may pose feasibility challenges for regulatory agencies; these challenges, which have the potential to affect policy outcomes, may or may not be accounted for in policy outputs. Additionally, the structure of the timber industry and its economic importance vary regionally in California, and timberland ownership patterns differ across jurisdictions. These differences may have bearing on the willingness of industry interests to work together to secure favorable policy outputs and on the degree of organization of environmental advocates in the region.

Potential to Further Environmental/Human Health Protection

This research will yield useful information for state agencies charged with developing and refining water quality protections by providing detailed examples of more and less effective regulatory programs and uncovering key implementation challenges facing such programs. By linking variation in policy outputs to features of the political and economic contexts in which they were developed, this research will highlight the settings in which regulatory policy may be more or less likely to succeed, as well as the factors that encourage public involvement in the policy process.
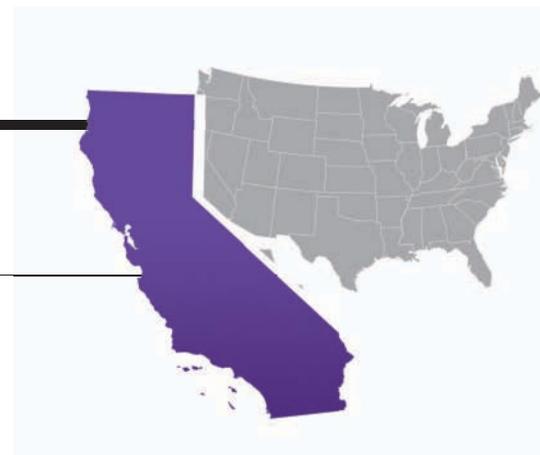
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Project Amount: $126,000
Environmental Discipline: Environmental Sciences

Keywords: drinking water, household water treatment, rural poverty

Bio

After graduating from the University of North Carolina, Chapel Hill in 2002, Alasdair Cohen lived abroad for more than 6 years, primarily in China and Italy, working, studying and conducting research on rural water resources and poverty assessment. He has an M.Sc. degree from Oxford University and now is a Ph.D. candidate at the University of California, Berkeley, studying Global Environmental Health with a research focus on water contamination, drinking water safety and household water treatment adoption. Geographically, he works in rural areas of Asia, China in particular.

Synopsis

Globally, hundreds of millions of rural people lack access to safe drinking water; in response, many boil their water. Although this household water treatment (HWT) method kills/inactivates pathogens, it costs time and money to collect or purchase fuel, and often causes respiratory ailments (via indoor air pollution) and environmental damage. Problematically, promoting alternative HWT rarely leads to sustained adoption. The study will investigate the potential for non-boiling HWT in rural China.

Improving Human and Environmental Health in Poor Rural Communities: Investigating the Potential for Sustainable Household Drinking Water Treatment in China

Objective(s)/Research Question(s)

The primary objective of this research is to understand if a drinking water treatment approach other than boiling could improve human and environmental health in rural China; and if so, under what conditions non-boiling HWT might be adopted. To accomplish this, the research will explore new methodologies for augmenting quantitative data with qualitative data to better inform the design of HWT promotion campaigns. Two primary research questions will guide the work: (1) Is a policy shift toward the promotion of non-boiling drinking water treatment in rural China warranted based on the potential benefits for human and environmental health? (2) If so, under what conditions are rural Chinese households likely to adopt non-boiling HWT?

Approach

These research questions will be addressed by collecting a wide range of quantitative and qualitative data at multiple scales in sparsely populated poor rural areas. This will include data on: water quality (microbial and chemical [as appropriate] for source water and drinking water); fuel usage (types [e.g., locally harvested biomass or coal], quantities used, and whether combusted indoors or outdoors); and the costs and time associated with collecting water and fuels. Socio-economic, demographic and poverty-related data at the household and village levels will be collected, in addition to information on existing behaviors and beliefs related to drinking water and HWT. These data will provide a clearer picture of the potential need for alternative HWT as well as a better understanding of the negative environmental externalities linked to existing HWT practices. With this accomplished, it will be possible then to analyze these data and identify relevant associations among households and villages/regions based on their HWT practices (e.g., boiling, not boiling) and other variables (e.g., livelihood characteristics). Additional qualitative data will then be collected, via focus groups and key-informant interviews, to better understand the "whys" behind these statistical associations.

Expected Results

This research will elucidate the most relevant behaviors and beliefs among groups and households with regard to HWT adoption. For the research community, the results of this study will add to the very limited knowledge and data on HWT in rural China. Furthermore, the findings will contribute to the broader research on HWT adoption and behavior change in rural areas, which is relevant especially to countries such as Mexico and Vietnam where many rural households also boil their water. The results also should demonstrate the potential environmental and health benefits of introducing non-boiling HWT in remote areas of rural China, which may in turn influence China's rural development policy. Lastly, others might replicate this particular methodology of combining qualitative and quantitative methods to better inform the design of HWT promotion interventions elsewhere.

Potential to Further Environmental/Human Health Protection

An estimated 600 million rural Chinese regularly boil their drinking water. This research may reveal both a need for, and a means of, providing a more sustainable and less-harmful option for rural drinking water treatment. By switching to non-boiling HWT, human health and well-being should benefit from safe water, less respiratory disease (from reduced indoor air pollution), and more available time. Moreover, the environmental degradation that results from the needs-based harvesting of local biomass (and/or burning coal) should be reduced as well. The aggregated benefits to human and environmental health could be significant.

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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Social Sciences

Keywords: unconventional natural gas development, risk communication, social representations

Bio

Darrick Evensen received his A.B. degree in Public Policy from Princeton University in 2006. After 1 year as an environmental educator, he began his M.S. degree in Natural Resources at Cornell University. He now is pursuing his Ph.D. at Cornell, investigating emergence of beliefs about unconventional natural gas and oil development, with the aim of using his findings to promote community sustainability. He has worked for five seasons as a backcountry wilderness guide and enjoys reading classical literature.

Synopsis

Although unconventional natural gas development presents a potentially lucrative opportunity to bolster the U.S. economy, support energy independence and revitalize depressed regions, it also threatens community sustainability. This study will examine the influence of individual- and community-level factors on sustainable development, describe how these factors emerge, and thereby facilitate subsequent identification and assessment of actions by which communities can promote sustainability.

Promoting Community Sustainability in Light of Natural Gas Development Through Increased Understanding of Communities

Objective(s)/Research Question(s)

The goal of this research is to generate knowledge about how communities develop beliefs, risk perceptions and representations of unconventional natural gas development, with the purpose of using this understanding to advance community sustainability (environmental, economic and social) in municipalities where development is occurring or is likely to occur. By better understanding how ideas and beliefs about natural gas development emerge, this research seeks to identify means for designing and tailoring communications that help communities to strive for the positive economic effects potentially connected with development, while minimizing adverse environmental, economic, social and governmental impacts.

Approach

This study will investigate a range of factors that have been theorized to contribute to community sustainability: (1) community and regional attributes accounting for structural characteristics that predispose communities to certain development patterns; (2) policy actions, as well as actions groups of local residents independent of local governance structures, that foster sustainability; and (3) the relative role of individual cognitions versus community representations in generating beliefs about sustainability. Comparative case studies across multiple communities exposed to unconventional natural gas development will be the primary means of data collection. The researcher will triangulate between qualitative interviewing (individual and focus group), observations of public ritual (e.g., public hearings, community group meetings), and quantitative questionnaires to evaluate how the aforementioned factors predict community sustainability in light of gas development in study communities. After the qualitative fieldwork, but before analyzing the survey data, a structural equation model will be created, designed to predict how the theorized factors lead to thoughts and actions supporting community sustainability.

Expected Results

This research program is designed to generate findings that provide specific guidance to extension educators, government officials, nongovernmental organizations, industry officials and even K-12 school teachers on how best to promote community sustainability in light of natural gas development, whether through policy, municipal ordinance, communication or education. The study seeks to identify, analyze and evaluate how community-level factors promote sustainability in real communities that are facing exacting decisions. This fits squarely within Objective 3.1 of EPA's FY2011-2015 Strategic Plan: "Promote sustainable and livable communities." Beyond the community level, this research will provide insight into how to use important regional and national energy resources wisely, while considering present and future environmental, social and economic needs. National security, the national economy, and the nation's environment (e.g., through a transition to cleaner energy sources) are all dependent in part on sustainable natural gas development.

Potential to Further Environmental/Human Health Protection

Unconventional natural gas development offers a range of positive economic benefits to the individuals who lease their land and to the communities in which development occurs. Concerns about damage to human health (mostly through contamination of drinking water supplies, but also due to air, light and noise pollution) and the environment (e.g., habitat fragmentation, stream and river pollution with highly saline wastewater, disposal of radioactive materials) also abound. Better understanding regarding how people develop beliefs about gas and oil development will help reveal ways to communicate with different populations and subpopulations about how most effectively to achieve the positive outcomes of development while limiting the negatives.
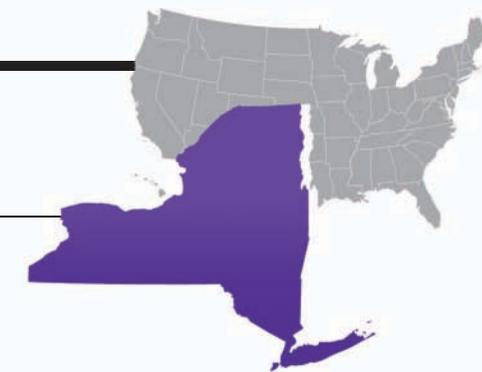
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Sociology

Keywords: environmental sociology, policy, Yellowstone National Park

Bio

Justin Farrell is a Ph.D. candidate in the Department of Sociology at the University of Notre Dame. His research focuses broadly on culture, environment, social movements, religion and morality. His dissertation is an analysis of the cultural dimensions of environmental policy conflict in the Greater Yellowstone Ecosystem (GYE).

Synopsis

This project examines intractable policy conflict as it plays out in the GYE, the crown-jewel of the American landscape, and a notorious hotbed of environmental controversy. Using this case, the present project enhances knowledge about the cultural dimensions of environmental protection, builds theoretical and methodological bridges between the natural and social sciences, and constructs a collaborative policy framework for overcoming persistent environmental conflict between different social groups.

Overcoming Policy Stalemate: The Cultural Dimensions of Environmental Conflict in the Greater Yellowstone Ecosystem

Objective(s)/Research Question(s)

This research will address the question, "How does cultural conflict impede environmental policy efforts?"

Approach

This project takes a multi-method approach, drawing on quantitative and qualitative methodology. The first stage of the research focuses on compiling and analyzing U.S. census data (1920-2010) to provide a longitudinal overview of important socioeconomic trends in the region. Second, the project will field a regional survey, conduct in-person interviews with policy stakeholders and conduct participant observation at policy events. Lastly, the project will link stage one and stage two findings to create a comprehensive picture of the social sources of intractable conflict in the GYE.

Expected Results

By charting the cultural dimensions of environmental conflict in the GYE, this project benefits society and the natural environment in several ways. First, an important part of building a collaborative framework involves restoring trust between private landowners and local (and national) environmental groups. The broken trust is rooted in misunderstandings and miscommunications that stem from different ways of culturally constructing environmental problems and their solutions. Renewal of trust between these notoriously conflicting groups will lead to improvements in wildlife policy—particularly with regard to preserving and expanding vital wildlife migration corridors. In addition to these practical results, this project will foster interdisciplinary collaboration between natural and social scientists, curtail litigation costs in the area and improve the local public's knowledge about the social factors involved in environmental decision making. Lastly, because of the historical and contemporary significance of Yellowstone National Park, the findings from this research will provide a model for scholars and practitioners in other contexts—both national and international—where similar environmental policy stalemates are taking place.

Potential to Further Environmental/Human Health Protection

The natural environment suffers greatly in cases of policy stalemate. This project will improve environmental protection by identifying the cultural causes of conflict that hinder environmental collaboration. After identifying these root causes, the project will create a plan to alleviate conflict between the individuals and institutions involved in protecting human and ecological health in the GYE.

Christine Danielle Miller Hesed
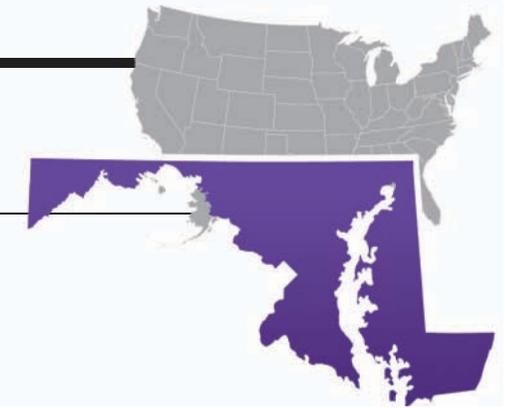
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Project Amount: $126,000
Environmental Discipline: Anthropology

Keywords: adaptation, climate change, environmental justice

Bio

Christine Miller Hesed received a B.A. degree in Biology from Goshen College in 2007 and an M.S. degree in Sustainable Development and Conservation Biology from the University of Maryland in 2010. Currently, she is pursuing a Ph.D. in Anthropology at the University of Maryland. Her research interests include adaptation to climate change and social-ecological systems. Her current research is investigating factors for resilience among rural communities on Maryland's Eastern Shore.

Synopsis

Sea-level rise threatens both wetland ecosystems and rural communities on the Eastern Shore of the Chesapeake Bay. Successful responses will require an understanding of what factors contribute to the capacity of social and ecological systems to persist and thrive in the face of environmental change. This study will integrate research on environmental justice, social-ecological systems and adaptation to identify and evaluate factors important for resilience to climate change impacts.

Social-Ecological Resilience and Adaptation on the Eastern Shore of the Chesapeake Bay

Objective(s)/Research Question(s)

Sea-level rise related to climate change threatens both wetland ecosystems and rural communities on the Eastern Shore of the Chesapeake Bay. Successful adaptation will require an understanding of what factors contribute to the resilience and adaptive capacity of the social-ecological system in the face of environmental change. Drawing on methods from cognitive environmental anthropology, this study will integrate research on environmental justice, social-ecological systems and adaptation to identify and evaluate factors important for resilience to climate change impacts in the present and future.

Approach

Four to six rural communities on Maryland's Eastern Shore will be selected that are susceptible to flooding related to sea-level rise. Ethnographic methods (including interviews, workshops and surveys) will be used to research how these communities have experienced and adapted to flooding in the past and how they anticipate coping with flooding related to sea-level rise in the future. In addition, regional scientists and policymakers will be interviewed and surveyed to analyze the degree to which these different stakeholder groups share knowledge and perspectives on vulnerability and possibilities for the successful adaptation of the social-ecological system. Throughout the research, the presence of key resilience factors will be assessed, which include living with uncertainty, nurturing diversity, combining different types of knowledge and creating opportunities for self-organization.

Expected Results

It is expected that this research will yield methods for operationalizing and assessing the presence of factors of resilience in social-ecological systems, as well as further understanding on the relationship between vulnerability, adaptation and resilience. In addition, it is anticipated that this research will result in transdisciplinary and transcultural learning between stakeholder groups and reveal areas in which under-represented communities (especially environmental justice communities) can engage in the policy-making process.

Potential to Further Environmental/Human Health Protection

Adaptation to sea-level rise from climate change potentially will involve trade-offs between wetland conservation and protecting rural communities from flooding. By using a holistic social-ecological system framework to study resilience and adaptive capacity on the Eastern Shore, this research will explore possibilities for adaptation that simultaneously can help to ensure that adequate ecological resources are available for future generations, and that people living today have equal access to clean, healthy environments.

Gary Thomas LaVanchy

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Geography

Keywords: water, tourism, Nicaragua

Bio

Gary LaVanchy received a B.A. degree in Geology and in Education from Wheaton College (IL) in 1998. During the following 10 years, he taught geology laboratories and worked in student development at his alma mater. In addition to mentoring students in cross-cultural environmental research, he has spent significant time in developing countries and conducted various research and development projects. He received an M.A. degree in Social Science (Geographical Studies) from the University of Chicago in 2010. His research and thesis addressed the human-environment interaction accompanying the urbanization of Dakar, Senegal. Currently, he is in a Ph.D. program in Geography at the University of Denver. His research interests include ground water modeling and human-environment interaction in Latin America. His current research assesses water supply and availability as well as water quality amid the growing challenges of tourism development in southwest Nicaragua.

Synopsis

Freshwater ecosystem services are indispensable to human well-being, but increasingly are vulnerable to growing demand, climate change and pollution. These stresses are particularly problematic for poorer populations who often lack access to adequate freshwater of safe quality. Timing, access and allocation have implications for both individual livelihoods and for community-wide development. This research proposes to assess water supply availability and water quality amid the growing challenges of tourism development and the predicted decrease in precipitation from global climate change in southwest Nicaragua.

Water Resource Implications From Tourism Development Along the Western Coast of Nicaragua

Objective(s)/Research Question(s)

The objectives of this research are to assess water supply availability and water quality amid the growing challenges of tourism development and to document land cover change associated with tourism development in the Playa Gigante area. It proposes to answer the question, can local ground water supplies sustain the demand for freshwater imposed by increased tourism development? The importance of this physical science question must necessarily be framed in a cultural and social manner because tourism plays a significant role in the Nicaraguan economy and has become a national agenda for generating revenue.

Approach

Qualitative methods will feature key informant interviews and interviews of well owners (n = 65). Quantitative and spatial data will be collected from geological field mapping, satellite imagery and hydrologic surveys (n = 60). Interviews of well owners will be tied to space using global positioning system (GPS) tagging and will allow for perceptions of change and access to be combined with measured change. Analysis of data will include interview coding, data exploration, mapping, variance tests and logistic regression. Support is obtained from personal prior experience in Playa Gigante and the sustained presence of the research advisor in this community and long-term relationships with a range of leaders and community actors.

Expected Results

This project contributes to debates over the socio-environmental influences of tourism development on local populations in Central America. In the case of Nicaragua, the potential for conflict over freshwater availability appertains to tourism development and predicted decrease in precipitation from global climate change. Information and conclusions generated from this study will help local populations and developers make plans for a future with less water. This study also has implications for biodiversity and watershed preservation since the research area represents a fragment of the original dry forests along the southern Pacific coast of Mesoamerica. Further fragmentation will translate to a loss of biodiversity and deterioration of watersheds, and thus water supply. Therefore, findings on land cover change in light of the drivers of tourism development will provide valuable input to those responsible for management and preservation schemes.

Potential to Further Environmental/Human Health Protection

The broader impacts of this research hold significance and relevance in that Americans are substantial stakeholders in tourism development in this area of Nicaragua. An examination of the linkages between North American foreign direct investment and environmental change will provide valuable information for U.S. funded development projects (e.g., U.S. Agency for International Development, Inter-American Development Bank and The World Bank, among others). A deeper understanding of the dynamics between development growth and associated effects on local populations and water resource usage holds merit for a range of actors.
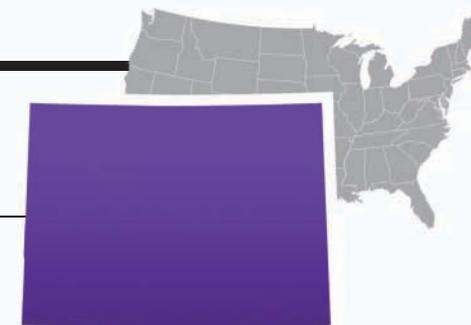
Jessica Jaslow Lewis

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EPA Project Officer: Jose Zambrana
Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Atmospheric Sciences

Keywords: improved cookstove, indoor air pollution, personal exposure

Bio

Jessica Jaslow Lewis is a Ph.D. student at Duke University's Nicholas School of the Environment. In 2009, she received an M.S. in Public Health from the University of North Carolina, Chapel Hill, Gillings School of Global Public Health. She previously has worked at the U.S. Environmental Protection Agency in Research Triangle Park, NC; Atlanta, GA; and Cincinnati, OH; as well as nonprofit and consulting organizations. Her research focuses on the interactions between behavior and global health, climate and air pollution. Her current research includes household cooking practices and environmental health impacts in rural India.

Synopsis

Solid fuel use in primitive cookstoves is the primary environmental cause of death, and also adversely affects local environment, climate and livelihoods. One potential solution is improved cookstoves that reduce harmful air pollutant emissions. These technologies, however, face barriers to adoption and correct use. This research aims to capture underlying differences between adopting and non-adopting households and measures true personal exposure to air pollution.

Impact of Behavior on a Burning Problem: Improved Cookstove Adoption and PM Exposure

Objective(s)/Research Question(s)

Households with high levels of indoor air pollution from traditional cookstoves often also are exposed to dangerous outdoor and occupational air pollution. Individual choices and behavior, such as education or the decision to adopt an improved cookstove (ICS), have the potential to confound exposure and attribution estimates, but these factors generally are omitted from exposure studies. To truly understand exposure, this research merges an exposure study (attribution of personal, indoor and outdoor exposure) with behavioral change and implementation science research (statistical analysis of variation between households that adopt or do not adopt ICS, as well as exposed and unexposed populations) to understand who adopts ICS and why.

Approach

This research will take place in India, where 90 percent of rural households burn biomass for cooking. By partnering with a behavioral research study of ICS interventions (including information campaigns and social marketing), this air study will merge empirical data on household decisions to adopt with indoor, outdoor and personal particulate matter (PM) measurements, thus providing the closest possible estimate of true PM exposure. This study will quantify stove usage and adoption using temperature loggers, and will take three 24-hour PM measurements (indoor, outdoor and personal) using portable nephelometers at two points in time (baseline and 1 year later) in the sample population. This study will compare the air pollution exposure of individuals (primary cooks) who are using improved stoves and clean fuels to observationally equivalent individuals who are using traditional chullahs and dirty fuels.

Expected Results

ICS has the potential to decrease indoor air pollution, but the fraction of pollution exposure that indoor sources provide is poorly understood. Decisions made by a household (e.g., whether to use the stove), the type of stove and fuel, and manner of using the stove moderate the potential benefits of an ICS. This study will generate onsite confirmation of how differences between adopting and non-adopting households can be used to specify and estimate a theoretical model of stove adoption.

Potential to Further Environmental/Human Health Protection

The broader impacts of this project include general lessons for indoor air pollution, personal exposure and ICS dissemination and uptake. The proposed research quantitatively will document which variables influence ICS adoption and pollution exposure and thereby allow careful estimation of households' true exposure to PM from biomass fuels in developing countries.
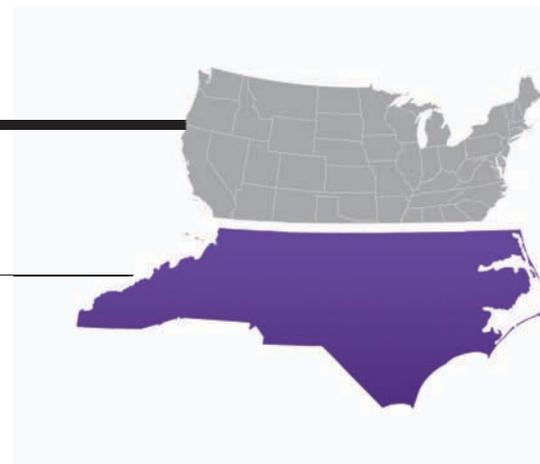
Christine Suzanne Moskell
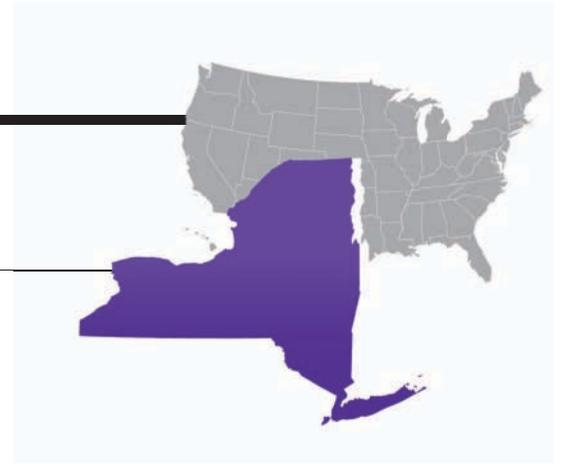
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Project Amount: $126000
Environmental Discipline: Social Sciences

Keywords: urban forestry, environmental governance, citizen participation

Bio

Christine Moskell received a B.A. degree in Environmental Studies from Hobart and William Smith Colleges in 2008. In 2012, she received an M.S. degree from the Department of Natural Resources at Cornell University and now is in the Ph.D. program. Her research interests include the human dimensions of urban green infrastructure management. Her current research examines citizen participation in urban tree planting initiatives and residents' attitudes toward urban trees and municipal tree planting activities.

Synopsis

Cities across the United States are planting millions of trees, and local governments are relying on residents to help maintain the trees. Residents are not always consulted, however, before the trees are planted and thus may view the plantings as unfair due to the financial cost of tree maintenance. This research examines the relationship between residents' perceptions of the procedural fairness of planting decisions and their attitudes toward, and intention to maintain, newly planted trees.

An Examination of Citizen Participation and Procedural Fairness in Large-Scale Urban Tree Planting Initiatives in the United States

Objective(s)/Research Question(s)

The goal of this research is to identify the different degrees and forms of citizen participation in the tree-planting decisions of large-scale tree planting initiatives. Using the social psychological theory of procedural fairness, this project will explore residents' perceptions of the aspects of the tree planting process that they view as fair and unfair. The project also will measure how the degree of citizen participation in decision making, and residents' perceptions of procedural fairness of tree planting processes, influence their attitudes toward trees, opinions toward municipal tree planting and urban forest management activities, and their willingness to steward newly planted trees.

Approach

This research will utilize a mixed-methods design. In phase 1, study sites (cities) will be selected that currently are implementing a large-scale tree planting initiative. Semi-structured interviews will be conducted with urban forest managers in each study site to identify the rationale for involving (or not involving) residents in the tree planting decision-making process, and the methods used to engage residents in tree planting activities. These results will be used to construct a typology that classifies the degrees (high, low) and forms of citizen participation in each city's tree planting initiative. Focus groups will be conducted with residents in neighborhoods where trees have been planted in each city to assess their perceptions of the fair and unfair elements of the tree planting process in their community. In phase 2, the typology and qualitative results from phase 1 will be used to develop a quantitative survey to be administered to residents in each city that have had trees planted in their neighborhood as part of the tree planting initiative. Survey questions will measure the dependent variables: (1) residents' attitudes toward trees; (2) opinions toward municipal tree planting and urban forest management; and (3) willingness to steward the newly planted trees. Data analysis for the survey will measure significant differences in the dependent variables, depending on the level of citizen participation in the tree planting process (determined via the typology) and perceptions of procedural fairness.

Expected Results

This project will result in a typology of the degrees and forms of citizen participation in large-scale urban tree planting initiatives. It also will identify specific aspects of urban tree planting processes that residents perceive as fair and unfair, which will provide additional insight into residents' attitudes toward urban trees and their opinions toward local governments' tree planting activities and urban forest management in their community. This research also will quantify the relationship between urban tree planting processes and residents' attitudes toward, and their intentions to maintain, trees that are planted as part of large-scale tree planting initiatives.

Potential to Further Environmental/Human Health Protection

This research will provide a better understanding of how the urban tree planting processes and urban environmental governance can be made more inclusive, transparent and fair so that residents are more likely to be receptive toward, and willing to steward, newly planted trees. Findings will enhance urban forest managers' capacity to design and implement tree planting processes that are more likely to result in improved attitudes toward urban trees and planting activities conducted by local governments. This research also will provide key insights into how trees can be planted in a manner that is most likely to foster increased citizen participation in stewardship, which may lead to a greater number of residents taking steps to care for young street trees, thereby helping to sustain the ecological and health services provided by urban forests.

Rachel Stehouwer Visscher
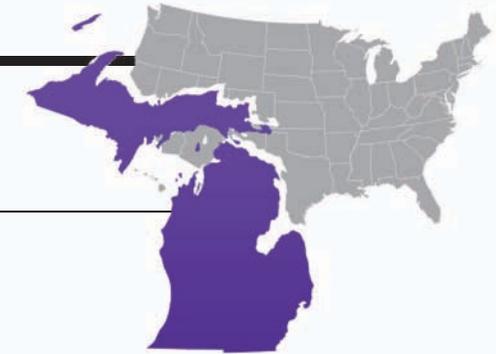
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Project Period: 9/1/2012 - 8/31/2014
Project Amount: $84,000
Environmental Discipline: Urban Planning

Keywords: ecosystem services, landscape ecology, yard design

Bio

Rachel Visscher completed her Bachelor's degree at Calvin College in 2010, where she studied Environmental Studies, Studio Art and German. After graduating, she began pursuing dual Master's degrees at the University of Michigan in Landscape Architecture (MLA) and Urban Planning (MUP) with a concentration in Environmental Planning. She is researching socio-environmental approaches to enhancing ecosystem services in residential landscapes.

Synopsis

This research examines homeowner yard behavior and preferences to develop culturally acceptable and environmentally beneficial designs, management strategies and policies for large-lot residential development. Ecosystem services (e.g., carbon storage and water quality improvements) could be further incorporated into large-lot residential areas, particularly if designed to be acceptable to homeowners. Backyards may be more culturally acceptable areas for incorporating innovative designs.

Exurban Backyards: Hotspots for Ecosystem Services?

Objective(s)/Research Question(s)

This research will investigate whether the backyard, as a more private space than the front yard, is a potential place to incorporate innovative, environmentally beneficial management practices into large yards. Homeowner reported behaviors and preferences will be measured in exurban residential landscapes, allowing the development of recommendations for design, management and policy.

Approach

In addition to building on previous research in landscape ecology, environmental planning and related fields, the study will use data collected since 2005 from three related surveys to further understand homeowner preferences and behaviors. In 2005 and 2011, Web surveys asked Michigan homeowners about their yard management behaviors and preferences. The surveys used images to determine the types of yard designs people liked and disliked. In 2009, in-depth interviews provided more specific insight into these questions. This study will use statistical analysis to examine homeowner preferences over time, as well as compare front and backyard preferences. This analysis will provide an understanding of how people perceive their yards and what kinds of innovations would be acceptable to them.

Expected Results

The broad goal of this research is to identify ecosystem services provided by exurban residential landscapes and make inferences about practices that may mitigate negative environmental impacts of sprawl. Because of the more private nature of backyards, it is hypothesized that homeowners are more willing to use innovative yard designs and management techniques in their backyards. This research will provide specific recommendations for developing these techniques. Combining these findings with previous landscape ecology and environmental planning research will lead to actionable results for design, management and policy.

Potential to Further Environmental/Human Health Protection

Finding methods of enhancing ecosystem services in backyards could have positive implications for human health and the environment. Ecosystem services such as climate change mitigation, carbon storage, water quality improvements, pollutant reduction, wildlife habitat and nutrient cycling could all be incorporated into residential landscapes. This could reduce significantly the negative impacts of sprawl.

Joy Huan Wang

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Project Period: 8/20/2012 - 8/19/2015
Project Amount: $126,000
Environmental Discipline: Environmental Policy

Keywords: energy consumption, smart grid, smart meters

Bio

Joy Wang earned B.S. and M.S. degrees in Biosystems Engineering from Michigan State University. She currently is a doctoral candidate in the School of Public Policy at the Georgia Institute of Technology focusing on Energy and Environmental Policy. Her research interests include energy consumption behavior, energy efficiency within buildings and renewable energy.

Synopsis

Significant funds have been dedicated to grid modernization and smart grid. Despite decades of energy research, how information, like real-time pricing and use, can be provided to consumers to most impact energy decisions is still not well understood. Smart meters, which provide such information, are vital to smart grids. To determine what social factors affect energy behavior and demand, this project examines how information, like that from smart meters, impacts residential energy consumption.

Real-Time Energy Information and Consumer Behavior: A Meta-Analysis and Forecast

Objective(s)/Research Question(s)

What determines study-to-study variation in energy savings from projects and programs providing energy information feedback? What are the effect-sizes for program variables (such as duration, region, information type, information method and so forth) across multiple previous studies? How will nationally implemented smart metering in the residential sector affect U.S. energy demand? What are the associated costs and benefits?

Approach

First, a meta-analysis will be conducted regarding the current program results and implementation methods of various smart metering initiatives throughout the nation. Published literature on information effects on energy behavior also will be included. Next, the outputs of the meta-analysis will be used within the National Energy Modeling System (NEMS) to estimate the energy impacts of national smart metering.

Expected Results

The meta-analysis of literature and program results will shed light on potential causes of study-to-study variation in information feedback programs and trials. Outputs from the meta-analysis, such as price elasticity, will be used in NEMS to estimate the impact of a national smart metering program. The potential energy saved will be estimated, as will other benefits and costs.

Potential to Further Environmental/Human Health Protection

The residential sector consumes almost one-quarter of total U.S. energy and emits almost one-third of national carbon emissions. Improved understanding of how smart meters affect energy behavior may help realize greater energy efficiency within households, saving significant energy while also avoiding carbon emissions.
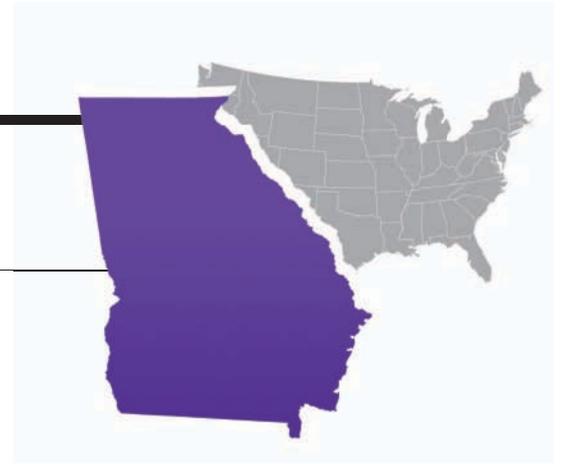
HUMAN
HEALTH RISK
ASSESSMENT

Public Health

We won't have a society if we destroy the environment.
– Margaret Mead

Samuel Carter Byrne

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

Keywords: exposure assessment, asthma, propylene glycol ether

Bio

Sam Byrne received a B.A. degree in Human Ecology and Environmental Health from Hampshire College in 2008. Following graduation, he worked for Alaska Community Action on Toxics, an environmental health and advocacy organization based in Anchorage, AK. In 2011, he entered the University at Albany's M.S. program in Environmental Health Sciences. His current research focuses on exposure assessment and the links between perinatal exposures to household chemicals and chronic diseases such as asthma.

Synopsis

Propylene glycol and glycol ethers (PGEs) are ubiquitous, water-based solvents and product intermediates, present in paints, adhesives and personal care products. PGEs recently have been associated with asthma and allergic disease. There is some evidence that PGEs might play a role in the association between indoor dampness and adverse health outcomes. This exposure assessment will determine the sources and correlates of PGEs in the home environment.

Assessing Exposure to Propylene Glycol and Glycol Ethers in Relation to Asthma and Allergic Disease: Independent Risk Factor or Correlate of Known Triggers?

Objective(s)/Research Question(s)

Exposure to PGEs in the home environment is associated significantly with clinically diagnosed asthma and multiple allergic diseases in a cohort of Swedish children. Furthermore, PGE concentrations in indoor air significantly predicted elevated dampness, or excess humidity, in the home. Home dampness is a well-known risk factor for asthma and allergic diseases; however, specific causal mechanisms of its action remain unknown. Dampness is associated positively with multiple indoor risk factors for asthma and allergic diseases, including biogenic allergens, as well as lifestyle-related, man-made chemicals. This makes examination of risks posed by a single or multiple compounds difficult. This study will examine the indoor temporal variability in the concentration of PGEs and routes of human exposure to PGEs, as well as their correlation with other man-made and biogenic risk factors.

Approach

This study will determine the sources and the correlates of indoor PGEs in a pilot cohort of 80 pregnant women from the Albany metropolitan area. An in-depth exposure assessment of PGEs will be conducted in this cohort through repeated personal and indoor air monitoring during their entire gestational period. In addition, this investigation will examine whether other indoor environmental risk factors are correlated with PGE concentrations. Potential sources of PGE exposure will be characterized by an inspection of participants' homes, as well as interviews about behavior and lifestyle factors, such as frequency of cleaning, or history of home remodeling. Personal and home indoor exposure levels will be quantified using validated active and passive air monitoring, ranging from a 48-hour to a 30-day period during each trimester.

Expected Results

This study will determine the potential human exposure, the sources and the life-course of PGEs and other indoor air pollutants through a combination of repeated and direct personal and indoor monitoring. Specifically, this study is expected to identify major sources of PGEs, possibly including recently painted surfaces and new synthetic surface coatings, as well as frequent use of water-based cleaning products. Additionally, dampness and low air exchange rates in homes might contribute to the life-course of PGEs in indoor air, thereby modifying the human exposure potential. This comprehensive exposure assessment of PGEs in the home environment is expected to elucidate the sources and correlates of PGEs in the home.

Potential to Further Environmental/Human Health Protection

Reducing or eliminating hazardous chemical exposures is an important facet of sustainable chemical use. For this to occur, relevant exposure pathways first must be recognized through laboratory and epidemiologic research. This study seeks to characterize the home indoor factors that contribute to PGE exposure. The results will lay the groundwork for further studies on the early-life risks from exposure to PGEs and dampness on asthma and multiple-allergic disease development.
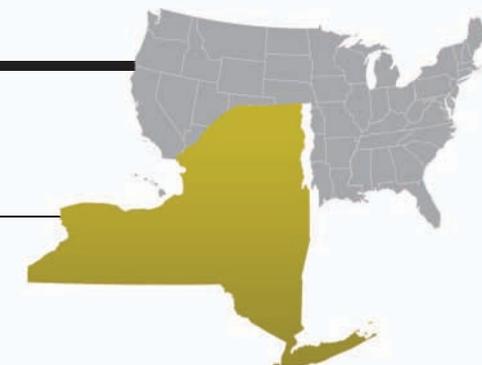
HUMAN HEALTH RISK ASSESSMENT

Risk Assessment & Risk Management

Lara J. Cushing

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Project Amount: $126,000
Environmental Discipline: Risk Assessment

Keywords: climate change, environmental justice, cumulative risk assessment

Bio

Lara Cushing is a Ph.D. student in the Energy and Resources Group at the University of California, Berkeley, and has worked on issues of environmental justice since 2006. Her dissertation work will combine geographic information systems and principles of community-based participatory research to look at the impacts of climate change among low-income communities in the United States. She holds a B.S. degree in Molecular Environmental Biology and Master's degrees in Energy and Resources and Epidemiology.

Synopsis

Climate change threatens human health around the world, but not everyone will be equally affected. There is good reason to believe that, within the United States, low-income communities of color will be hit hardest. Focusing on the state of Texas and employing a community-based participatory research framework, this work seeks to better understand and map vulnerability to the cumulative health impacts of climate change and thereby evaluate the implications of climate change for environmental justice.

An Environmental Justice Analysis of the Health Impacts of Climate Change

Objective(s)/Research Question(s)

Global climate change threatens human health around the world, but its impacts will not affect everyone equally. There is good reason to believe that, within the United States, health impacts associated with climate change will vary by race, ethnicity and class, both because low-income communities of color are more likely to be exposed to environmental hazards and because they are more vulnerable to the impacts of those hazards. Studies of past heat waves have found that African Americans are at greater risk of heat-related deaths, with social isolation and access to air-conditioning being important mediators. This dissertation research seeks to analyze the distribution of potential climate change health impacts in relation to race, ethnicity and class. Focusing on the state of Texas, this work will investigate the following research questions: (1) How can one best measure vulnerability to the health impacts of climate change? In particular, what do community-based participatory methods add to the scientific characterization of vulnerability? How do the results of "top-down," indicator-based assessments compare to "bottom-up," qualitative methods? (2) How are the health impacts of climate change likely to be distributed in space and in regards to race and class?

Approach

This work will apply a community-based participatory research approach and a cumulative impact framework at two geographic scales: the state and neighborhood levels. First, existing secondary data will be used to develop indices of vulnerability that combine information on exposure to climate change-related hazards, sensitivity to those hazards (including both biological and social factors), and adaptive capacity. These indices will enable a relative ranking of communities across the state of Texas in terms of their vulnerability to health impacts associated with climate change. Vulnerability indices for the multiple hazards associated with climate change—such as heat waves, sea level rise and wildfires—will be combined into a summary measure of cumulative impact, and compared to race/ethnicity and income data from the U.S. Census. Multivariate

analyses will be used to determine whether there are statistically significant racial or ethnic disparities in vulnerability. This research also will engage community members from two communities that already are disproportionately affected by environmental degradation with the goal of better understanding local drivers of vulnerability and resilience to climate change. Through processes of participatory mapping, focus group discussions and thematic context analysis, community perceptions and knowledge regarding climate change vulnerability will be compared to the "top-down" assessment described above and used to improve it. This component of the research also seeks to identify actionable local or regional projects and programs to enhance adaptive capacity.

Expected Results

This research will result in a state-wide mapping of communities vulnerable to climate change and an analysis of the potential for racial or ethnic disparities in the impacts of climate change within the United States. It will help to understand the environmental justice implications of climate change as well as whether and how climate change can be expected to deepen racial/ethnic health disparities in Texas.

Potential to Further Environmental/Human Health Protection

In its 2009 review of risk assessment methods, the National Research Council called for the consideration of "nonchemical stressors, vulnerability and background risk factors" and emphasized the "need for simplified risk assessment tools [to] allow communities and stakeholders to conduct assessments and thus increase stakeholder participation." This project contributes an innovative approach for one such methodology of collaborative cumulative impact assessment in regards to climate change. The results also can be used to help target climate adaptation programs and projects towards the communities that are likely to be affected the most.

Anne Louise Thebo

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Project Period: 8/16/2012 - 8/15/2015
Project Amount: $126,000
Environmental Discipline: Civil/
 Environmental Engineering

Keywords: wastewater irrigation, wastewater treatment, spatial models

Bio

Anne Thebo is a Ph.D. student in Environmental Engineering at the University of California, Berkeley. Her doctoral research focuses on understanding the drivers and health risks associated with the *de facto* reuse of wastewater in irrigated peri-urban agriculture. During the past 7 years, her work has included research on water management in India, irrigation water quality and health in Ghana, stormwater management in New England, and drinking water quality in Senegal. She earned an M.S. degree in Environmental Engineering from Stanford University and B.S. degrees in Civil Engineering and Environmental Science from Ohio State University.

Synopsis

At present, 90 percent of the world's wastewater receives no treatment before it is discharged to the environment. Paradoxically, these same flows concurrently pose health risks and provide a reliable, nutrient-rich water source for peri-urban farmers. This research will quantify the global extent of *de facto* reuse of untreated wastewater in agriculture while further elucidating the drivers, health risks and food security impacts of this practice using systems level, geospatial models.

Global Assessment of Wastewater Irrigation: Understanding Health Risks and Contributions to Food Security Using an Environmental Systems Approach

Objective(s)/Research Question(s)

Rapid urbanization without concomitant improvements in wastewater treatment infrastructure in developing countries has led to the widespread contamination of surface water sources, which downstream farmers rely on for irrigation. At present, 90 percent of the world's wastewater receives no treatment before it is discharged to the environment. Paradoxically, these same flows concurrently pose health risks and provide a reliable, nutrient rich water source for peri-urban farmers. The overarching objectives of this research include: (1) quantifying the global extent of *de facto* reuse of untreated wastewater for irrigation; (2) understanding how the drivers and health risks associated with this practice vary spatially; and (3) characterizing the role of wastewater irrigation in global food security and integrated water resources management strategies.

Approach

Wastewater irrigation inherently is a local practice with global implications. A multitude of case studies document irrigation with untreated wastewater in 158 cities, but the majority of case studies is limited to four countries: Mexico, India, Pakistan and Vietnam. Several recently released spatial datasets provide a unique opportunity to estimate quantitatively the extent of wastewater irrigation with dramatically lower computational complexity, increased accuracy and in less time than was previously possible. Through the development of spatial models within an environmental systems framework, the four major phases and key activities of this research include: (1) mapping and characterization—quantifying the global extent of wastewater irrigation followed by extensive validation; (2) defining typologies of wastewater irrigation—understanding how the drivers and use of untreated wastewater in agriculture varies across contexts; (3) health risk assessment—differentiating spatial variation in health risks between typologies of wastewater irrigation; and (4) contributions of wastewater irrigation to food security and water management—understanding the role of wastewater irrigation in peri-urban food production.

Expected Results

This research will quantify the extent of *de facto* reuse of untreated wastewater at the global scale. Through the integration of multiple existing spatial data sources, this project will produce rigorous analyses assessing the relationship between wastewater irrigation, health, fecal contamination in surface water sources, water resources allocation and urban food security. The inherent flexibility in the spatial models being developed for this project allows for the inclusion of additional modules and higher resolution datasets, as they become available. Examples of additional analyses that could be built onto this existing framework in the future include an assessment of the water quality impacts of different sanitation interventions, nutrient production and reuse potential, changes in wastewater irrigation over time and the role of wastewater in mitigating the impacts of water scarcity.

Potential to Further Environmental/Human Health Protection

Conspicuously absent from the Joint Monitoring Program's definition of improved sanitation facilities is the provision for treatment of accumulated human waste from "improved" sanitation facilities. Such an approach to sanitation planning disregards the implications of sanitation infrastructure choice on downstream communities, especially farmers reliant on surface water sources for irrigation. By quantifying the extent of irrigation with untreated wastewater at the global scale, this research not only draws attention to the need for integrated wastewater and water resources management but also provides planners and policy makers with rigorous, concrete data on the drivers and health risks of this practice at scale. This research fills these key knowledge gaps through its systems-level analysis of the extent, drivers and risks of wastewater irrigation across heterogeneous water resources, agricultural, economic, infrastructural and ecological contexts.

Julia Rachel Varshavsky

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Project Period: 8/16/2012 - 8/15/2015
Project Amount: $126,000
Environmental Discipline: Public Health Sciences

Keywords: phthalates, reproductive health, risk communication

Bio

Julia Varshavsky is a Ph.D. student in Environmental Health Sciences at the University of California (UC) Berkeley School of Public Health, where she also received her M.P.H. Prior to entering graduate school, she was the reproductive health coordinator for a diverse partnership that fosters scientific and public dialogue on environmental health. Her past research includes assisting in microarray development to improve metal detection in water. She received a B.S. degree in Molecular Environmental Biology from UC Berkeley in 2004.

Synopsis

Phthalates are hormonally active chemicals used in a wide range of products. They have been measured in humans and linked to developmental health problems in animals. These findings are concerning for women of reproductive age or who are pregnant, especially for those burdened by other social or environmental factors. This research will evaluate phthalate mixtures in sensitive populations to characterize exposure and risk and identify potential sources and communication best practices.

Cumulative Exposure, Risk Assessment and Communication of Phthalates in Vulnerable Populations

Objective(s)/Research Question(s)

This project will implement a cumulative phthalates risk assessment methodology set forth by the National Academy of Sciences (NAS) in 2008. It will address whether in two populations of disadvantaged women there are sentinel metabolites that characterize phthalate exposure; whether a dose addition, component-based model for cumulative risk assessment can be used to predict additive risk in these groups; and what the major exposure sources and risk communication best practices are in these populations.

Approach

As part of larger ongoing efforts to assess exposure and risk, this research will enlist two under-represented communities: low-income California (CA) pregnant women and Vietnamese immigrant nail salon workers. The study will compare multiple urinary phthalate metabolite exposure levels in these groups to nationally representative population averages. Based on measures of frequency and potency, the study will construct a cumulative exposure metric and will then employ a component-based approach to cumulative risk assessment using a dose addition model to estimate additive mixture effects. The study also will explore potential exposure sources by correlating phthalate levels with culturally and linguistically appropriate questionnaires. Lastly, the study will report results to consenting participants in at least one of these populations. Interviews will be recorded for use in later qualitative analysis.

Expected Results

By exploring the utility of the NAS method in predicting risk in vulnerable populations, this project will answer the question of whether certain metabolites characterize phthalate exposure in two sensitive groups. Nail salon workers likely will have higher levels due to their membership in a uniquely exposed occupational group. This research will result in the first-ever measurement of cumulative phthalate exposure in a CA population and also will reveal whether the NAS method can be used to evaluate cumulative risk. Phthalate levels likely will correlate with questionnaire data, providing insights into exposure sources and potential intervention strategies. A risk communication analysis will further identify best practices for responsible results communication in these vulnerable populations, helping to build trust and continued participation in the research process.

Potential to Further Environmental/Human Health Protection

This research will advance scientific thinking around mixtures, cumulative risk assessment, exposure sources and risk communication in susceptible populations. It will inform efforts to characterize and address social disparities in chemical exposures and contribute to initiatives to manage phthalates and other compounds, ensure chemical safety, engage disadvantaged populations and promote sustainable and healthy communities.

SAFE & HEALTHY COMMUNITIES

> Your background and environment is with you for life.
> No question about that.
>
> — *Sean Connery*

SAFE & HEALTHY COMMUNITIES

Built Environment & Land Use Protection

Peter Anton Christensen
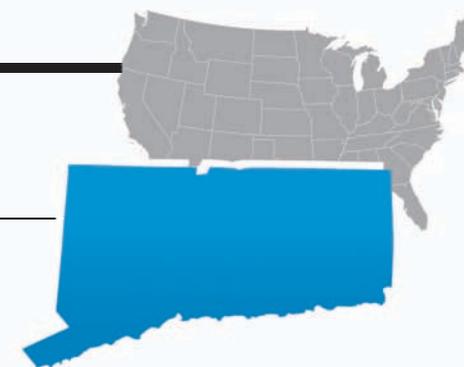
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Forestry and Environmental Studies

Keywords: urbanization, remote sensing, econometrics

Bio

Peter Christensen received a B.A. degree from the University of California (UC), Davis, in 2004 and an M.E.S. degree from Yale University in 2009. His research interests include environmental economics and policy, development economics and climate change mitigation and adaptation in the context of rapid urbanization. Peter has worked as a consultant for the World Bank and currently is a chapter scientist for the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. His dissertation research focuses on the drivers and impacts of urban growth in rapidly developing countries.

Synopsis

The world's urban population is expected to exceed 6 billion by 2050. Empirical work suggests that urban form is a critical determinant of greenhouse gas (GHG) emissions in the transportation and residential buildings sectors. However, the drivers and impacts of urban spatial structure have not been well identified, particularly in rapidly urbanizing regions. This research measures the density of urban areas in a national sample from China, examining the drivers and implications of current growth patterns.

Up or Out: Measuring and Modeling the Growth of China's Built Environment

Objective(s)/Research Question(s)

Are China's cities growing up or out? Designed to investigate the drivers and impacts of urban form in the context of rapid urbanization, this project will: (1) integrate satellite remote sensing and census observations to develop a spatially explicit, national model of urban growth in China; and (2) examine the economic drivers of urban spatial structure across urban China with an emphasis on identifying the impacts of land market constraints and regulatory policies. Given proper identification of the mechanisms driving urban spatial structure, this research seeks ultimately to project future trends in urban development and evaluate the relationship between urban form and emissions in China's residential building and transportation sectors.

Approach

This project applies an economic framework to test current hypotheses about China's urban growth trends. Utilizing a variety of econometric methods to identify the drivers of urban spatial structure, this project will derive empirical estimates using both a long time series of urban growth patterns for the period 1950-2000 and a higher resolution (1×1 km^2) model of urban density across China for the period 1990-2005. Physical measurements of urban growth and geophysical features are obtained from the Landsat TM and MODIS satellite sensors and combined with economic and social data from national statistical yearbooks.

Expected Results

Enormous population and income increases in China's urban centers are expected drive the built environment both upward and outward. However, the density of urban development is expected to vary considerably across regions, particularly in the context of heterogeneous land markets. To the extent that land conservation policy and land market controls constrain the conversion of urban land in rapidly expanding metropolitan regions, these policies may lead the development of less compact and more dispersed urban centers.

Potential to Further Environmental/Human Health Protection

Although there is broad interest in facilitating smart urban growth, a more comprehensive set of empirical results identifying the drivers and impacts of urban spatial structure is necessary for evaluating and negotiating trade-offs at the intersection of urban development and environmental policy. This project will contribute to regional modeling efforts and sustainable urban growth policy, focusing on outcomes in the most rapidly urbanizing nation on Earth. The multidisciplinary research framework employed in this project allows for the consistent analysis of urban form across a large sample of cities, providing generalizable insights into the pathways to a low carbon future in urbanizing regions.

Melissa Jeanne Haber

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Project Period: 9/1/2012 - 8/31/2014
Project Amount: $84,000
Environmental Discipline: Environmental Microbiology

Keywords: microbially induced calcite precipitation, Sporosarcina pasteurii, *ureolysis*

Bio

Melissa Haber received a B.S. degree in Biology from Lafayette College in 2012. In the upcoming year, she will begin an M.S./Ph.D. program in Soil Science at the University of Wisconsin, Madison. Her research interests include environmental microbiology and the influence of soil fortification processes on natural microbial communities and soil chemistry. In future work, she will study the effect of ureolysis on nutrient cycling and bacterial flora.

Synopsis

Currently, the need for rapid infrastructural development is limited directly by the dearth of competent soils. One promising solution to fortifying competent soils is known as microbially induced calcite precipitation (MICP). The study will use next generation sequencing and ion chromatography to determine the effects of MICP on natural bacterial flora and soil chemistry. This research promises to determine if MICP is an environmentally friendly solution to soil fortification.

Bio-Remediated Soil Techniques: Sustainable Solutions to Environmental Problems

Objective(s)/Research Question(s)

Currently, the need for rapid infrastructural development is limited directly by the dearth of competent soils. This, along with the problem of soil degradation, necessitates a cost-effective and environmentally friendly method to fortify soils. Induced by ureolytic bacteria, MICP is a potential solution for solving this problem; however, the introduction of non-native microbial species could be harmful to the balance of native microbial populations, as well as soil chemistry. This project seeks to use next generation sequencing and ion chromatography to understand if the process of ureolysis disrupts the natural bacterial flora and alters natural nutrient cycling processes.

Approach

To investigate the effect of MICP treatment on microbial diversity, the study will prepare individual soil microcosms containing the ureolytic bacterium *Sporosarcina pasteurii* using established protocols. MICP will be induced, and soil samples from treated microcosms, as well as those from untreated control microcosms, will be analyzed for changes in bacterial diversity and nutrient content. To measure bacterial diversity, the study will determine the 16s rRNA profile of each sample, using next generation sequencing to determine the abundance of individual bacterial genera. Representative analytes of the three major nutrient cycles (nitrogen, phosphorous and carbon) will be measured by ion chromatography using established protocols.

Expected Results

The effect of ureolysis increases the surrounding pH of the environment due to the production of ammonia and bicarbonate. The result of this alkaline environment may change the relative abundance of members in the population, for example, by favoring the growth of alkalinophiles over acidophiles. Furthermore, the impact of the buildup of ammonia on the natural flora and resulting change in the natural environment is unknown. This approach will allow the more global determination of the types of changes that are expected to occur after MICP treatment.

Potential to Further Environmental/Human Health Protection

The MICP treatment may help fortify degraded soils in areas prone to liquefaction. It is important to understand the environmental effects of this treatment as a buildup of ammonia in the soil followed by subsequent runoff into ground water/lake systems that may cause these waterways to become eutrophic across time. The results of this research will help determine if MICP is an environmentally friendly solution to soil fortification.

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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Urban Planning

Keywords: brownfields, urban manufacturing, sustainable development

Bio

Nathanael (Nate) Hoelzel is a City and Regional Planning Ph.D. student (class of 2014) at the Georgia Institute of Technology. His research examines local governance and brownfield redevelopment for sustainable manufacturing and economic development in inner-city neighborhoods. He managed Cleveland, OH's industrial-commercial land bank and brownfield redevelopment programs. He earned a B.S. degree in Environmental, Safety and Occupational Health Management from the University of Findlay in 2002, and a Master's degree in Community Planning from the University of Cincinnati in 2004.

Synopsis

This research will explain why and how U.S. cities and their planners are supporting certain types of manufacturing in inner-city neighborhoods affected by brownfields. The research examines evolving structures and functions of policy networks involving local stakeholders concerned with brownfields, economic development, smart growth, environmental justice and manufacturing that result in alternative neighborhood revitalization strategies encouraging sustainable industrial development.

Overcoming Brownfield Barriers to Urban Manufacturing: Comparative Study of Policy Networks and Changing Local Economic Development Strategies in Four U.S. Cities

Objective(s)/Research Question(s)

The purpose is to explain why and how four U.S. cities and their planners are supporting certain types of urban manufacturing in inner-city neighborhoods impacted by brownfields. Specifically, the changing relationships will be examined between local planning stakeholders that result in alternative economic development strategies encouraging new industrial development in neighborhoods distressed by industrial decline.

Approach

This study will be a mixed-methods research project designed with a comparative case study approach. Specific objectives include: (1) providing a critical literature review to identify local economic development and brownfield redevelopment issues affecting urban manufacturing; (2) framing urban manufacturing issues in the national manufacturing policy debate; (3) creating a typology of sustainable manufacturing suitable for inner-city neighborhoods and identifying characteristics of productive industrial areas required to support desirable types of urban manufacturing; (4) completing a comparative study between neighborhood contexts, social (policy) networks, and economic development planning strategies emphasizing manufacturing in brownfields-impacted neighborhoods in Atlanta, GA; Milwaukee, WI; Philadelphia, PA; and San Francisco, CA; (5) synthesizing common themes and divergent issues from the case studies; and (6) recommending policy and research directions for advancing urban manufacturing in smart growth, brownfield redevelopment, environmental justice, sustainable local economic development and national manufacturing strategies.

Expected Results

This study suggests that growing optimism in the U.S. manufacturing's recovery, coupled with evolving structures and functions of social (policy) networks involving diverse groups of local stakeholders concerned with brownfields, economic development, smart growth, environmental justice and manufacturing are influencing inner-city neighborhood revitalization decisions.

Potential to Further Environmental/Human Health Protection

This project builds on prior research documenting that smart growth policies tend to overlook manufacturing's contribution to sustainable local economic development, and reinforce non-industrial reuse of brownfields and converting remaining industrial areas to uses other than manufacturing. The presence of brownfields and their impacts in inner-city neighborhoods remain a widespread phenomenon, and a number of cities are reconsidering their smart growth and brownfield redevelopment strategies. These cities are seeking to revitalize neighborhoods while simultaneously encouraging manufacturing and strengthening remaining productive industrial areas in these neighborhoods. This research will examine these issues and answer related policy questions: What is happening and why? Who is involved in changing brownfield redevelopment and neighborhood revitalization strategies? What is working, and what is not? Are there lessons and concepts for advancing sustainable local economic development planning? How can answers to these questions inform the national manufacturing policy debate?

Nikki Johnson Springer
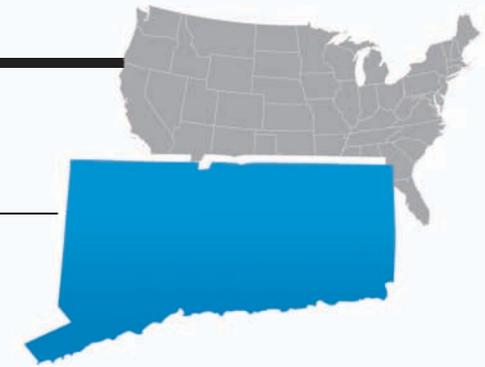
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Project Period: 8/29/2012 - 8/28/2015
Project Amount: $126,000
Environmental Discipline: Forestry and Environmental Studies

Keywords: life-cycle analysis, environmental footprint, landscape management

Bio

As the former manager of landscape and irrigation services for every Walmart and Sam's Club location in the United States, Nikki Springer is well-familiar with the management and environmental impacts of large landscape portfolios and their relationship to corporate sustainability endeavors. Currently pursuing a Ph.D. in Environmental Management at Yale's School of Forestry and Environmental Studies, she received her B.S. degree in Architecture from the Massachusetts Institute of Technology in 2004 as well as a Master's of Urban Planning and a Master's of Landscape Architecture, both from Harvard's Graduate School of Design, in 2008.

Synopsis

The Sustainable Sites Initiative (SITES), building off of the format and methodology of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program, soon will provide guidelines and benchmarks for the design, construction and management of landscapes and open space. This research will test the impact of these guidelines by applying life-cycle assessment, carbon/water footprint methodology and cost-benefit analysis to the program's pilot projects, ultimately seeking to incorporate these metrics into national, state and local codes for the development of more sustainable landscapes in the United States.

Performance Metrics for Landscape Design: Assessing the Sustainable Sites Initiative

Objective(s)/Research Question(s)

The goal of this research is to complement the SITES pilot program with performance-based, quantitative proof that the SITES Guidelines and Benchmarks produce landscapes with a reduced environmental impact. Specifically, it will address the following two hypotheses: (1) Pilot projects that score higher in the SITES certification system will have smaller carbon and water footprints than those that score lower; and (2) The distribution of credit points in the SITES program is correlated positively with the relative impact produced by each aspect of the project.

Approach

The research will combine a variety of environmental impact assessment methodologies with cost-benefit analysis to assess the performance of landscapes designed under the SITES program guidelines. The carbon footprint assessment will measure both direct (scope 1) and indirect (scope 2) emissions using the World Resources Institute/World Business Council for Sustainable Development Carbon Footprint Standard. Carbon sequestration will be measured non-destructively by calculating the biomass of trees and vegetation utilizing both design documents and aerial photography to determine land cover. Water footprint calculations will be based on the ISO Standard 14046 and local rainfall data from the National Oceanic and Atmospheric Administration Climate Data Directory. Water consumption will address not only the empirical amount for each project but also its relative impact on local resources given its location, elevation and drought risk. Both carbon and water footprints will be calculated and aggregated for a 50-year project life cycle. EPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) will be utilized as the basis for calculating the impact assessments and will be run using the SimaPro 7 software platform.

Expected Results

The research is expected to confirm the efficacy of the SITES program by verifying that projects ranked higher in program have a smaller carbon and water footprint than those that score lower. It is further expected to confirm the appropriate allocation of credits within the scoring system by illustrating that the life-cycle impacts associated with each credit point are equivalent, indicating that equal project scores, regardless of distribution, correlate with an equal environmental benefit. If the research reveals that either of these hypotheses is not correct, the data will help to inform a revision of the SITES program.

Potential to Further Environmental/Human Health Protection

Though LEED was launched as a voluntary certification, it increasingly will be transformed into a regulatory mechanism as many local jurisdictions and even the federal government now require LEED certification for new buildings (Cater, F. 2010. NPR Story ID 129727547). Given that the SITES program is intended to be incorporated into LEED, it is likely that it also will be written into local regulations in many locations. Thus, confidence in the SITES program's ability to create landscapes that conserve natural resources and ensure that usage remains in check for the life span of the project is crucial to the future of shared landscapes. Coupled with the potential of portfolio-wide certification by large developers, the potential impact of this research is on a scale of national importance.

> If I were to name the three most precious resources of life, I should say books, friends, and nature; and the greatest of these, at least the most constant and always at hand, is nature.
> — *John Burroughs*

SAFE & HEALTHY COMMUNITIES

Ecosystem Services

Jeffrey W. Ackley

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Project Amount: $126,000
Environmental Discipline: Biology

Keywords: lizards, urban ecology, heat island effect

Bio

Jeffrey Ackley studies urban reptile ecology as part of his doctoral degree. His goal is to identify characteristics of urban ecosystems that support biodiversity and determine why others are detrimental. Observing animals as they adapt to continued development and other anthropogenic changes will allow the management of existing urban areas to be more sustainable and to design greener cities in the future. He also is a rescue diver and loves underwater photography. In his spare time, he writes articles about his adventures for nature magazines. He graduated from Eckerd College in St. Petersburg, FL, with a B.S. degree in Biology and a double minor in East Asian Studies and Japanese. He served as a teaching assistant for Ecology and Herpetology classes and was the vice president and co-founder of the Ale Connoisseurs Club. During the summers, he has participated in two National Science Foundation research programs: Experimental Field Biology at Sam Houston State University, TX; and Natural History of a West Indian Herpetofauna at Avila University in Kansas City, MO.

Synopsis

In Phoenix, AZ, a heterogeneous urban heat island (UHI) averages +3°C and locally can exceed +10°C at night. Ecological consequences of the UHI remain almost completely uninvestigated. This study will examine how lizards are impacted by the urban thermal landscape and evaluate a proposal to use ecosystem services for UHI mitigation. This will help to better predict the consequences of climate change for the future distribution and abundance of ectotherms.
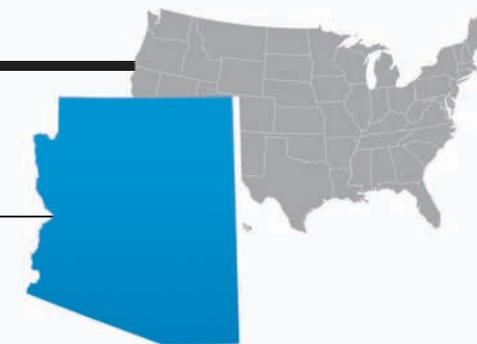
Off the Sand and Onto the Asphalt: Does the Urban Heat Island Influence Desert Lizards?

Objective(s)/Research Question(s)

What is the relative significance of the UHI and urban land use/cover for the continued viability of lizard communities? Can landscaping choices mitigate ecological costs due to warmer climates at small scales?

Approach

Visual lizard diversity surveys across varied land use and cover types in Phoenix, AZ, and the surrounding desert will be used, as well as small-scale thermal mapping of urban micro-habitats.

Expected Results

Lower lizard diversity and potential activity likely will be found at hotter sites in summer, with higher potential lizard activity at hotter sites in winter.

Potential to Further Environmental/Human Health Protection

This study will integrate ecology, physiology, behavior and climatology to better understand the impacts of urbanization and climate change on the activity of ectotherms. Perhaps most importantly, it will suggest whether plans to use ecosystem services to mitigate the UHI will be effective. Working alongside undergraduates, local citizens and state wildlife organizations will enable the dissemination of management implications resulting from the study to relevant government institutions and policy makers (e.g., Phoenix Tree and Shade Master Plan).

Eric Walter Bohnenblust

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Project Amount: $126,000
Environmental Discipline: Entomology

Keywords: plant growth regulator herbicide, transgenic crops, pollinators

Bio

Eric Bohnenblust received a B.S. degree in Biology from Gettysburg College in 2006 and an M.S. degree in Entomology from The Pennsylvania State University in 2009. Following his Master's degree, he enrolled in the Entomology Ph.D. program at The Pennsylvania State University. His research interests focus on the management of arthropods in agricultural ecosystems. His current research looks at the effects of sub-lethal herbicide doses to plants and their associated insect communities.

Synopsis

Weeds resistant to herbicides quickly are becoming a major problem for modern agriculture, and in response to this resistance problem, the agricultural industry is developing new crops resistant to multiple herbicides, providing farmers the ability to apply several different herbicides to kill weeds. However, some of these herbicides often cause non-targeted damage to nearby plants. This research focuses on how these herbicides affect non-targeted insects associated with these damaged plants.

Assessing the Influence of Plant Growth Regulator Herbicide Vapor Drift on Arthropod Communities in Field Crop Agro-Ecosystems

Objective(s)/Research Question(s)

Herbicide resistant weeds are a major problem facing the future of modern agriculture. This research will look at the effects of applying the plant growth regulator herbicide, dicamba, directly to several different insects. Also, plants will be sprayed with various herbicide doses and insects will be allowed to feed on them to understand how insect behavior, insect growth, plant chemistry and plant nutrition change when plants are sub-lethally dosed with herbicides.

Approach

The study will use a series of laboratory, greenhouse and field studies to look at the effects of sub-lethal doses of the plant growth regulator herbicide, dicamba, on insects directly and indirectly. Studies focusing on indirect effects will be performed in the greenhouse and field where insects will feed on plants that have been dosed with different rates of dicamba. The study will look at insect growth with caterpillars, population growth with aphids and behavior of pollinating insects. Studies focusing on direct effects will be performed in the laboratory and the greenhouse where insects will be topically dosed with one of six dosage rates, and toxicity will be assessed based on mortality. The study also will look at chemical compounds that plants use for defense against insects to see if a plant's ability to defend itself against insect herbivores changes after herbicide damage has occurred.

Expected Results

Sub-lethal herbicide damage is likely to have negative consequences for plant health. This in turn could lead to positive or negative effects on insects. Plants that are not healthy may not provide the best floral resources for pollinators, potentially further stressing honeybees. Unhealthy plants also may have a lower nutritional quality, stunting the growth of caterpillars. Additionally, plant defenses are likely to be impaired, potentially exacerbating pest problems as aphid populations may be higher on herbicide stressed plants, and the impaired defenses also may reduce the ability of the plant to recruit natural enemies that control pests.

Potential to Further Environmental/Human Health Protection

This research will provide a risk assessment for plant growth regulator herbicides that likely are to be applied increasingly more often in the near future. It will inform regulators, farmers and industry about some of the potential risks associated with use of these plant growth regulator herbicides and influence future plant growth regulator use patterns.

Anika R. Bratt

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Aquatic Ecology

Keywords: urban ecology, water quality, stable isotopes

Bio

Anika Bratt received a B.A. degree in Biology from St. Catherine University in St. Paul, MN, in 2010. The following year, she started a Ph.D. program in Ecology, Evolution and Behavior at the University of Minnesota. Her research interests include aquatic biogeochemistry, urban ecology and freshwater nitrogen cycling. Her current research seeks to use established and novel isotope analyses to understand diffuse sources of nitrogen (N) and phosphorus (P) in urban landscapes.

Synopsis

N and P are the most ubiquitous water pollutants across aquatic habitats. Urban contributions of these nutrients can be large, yet very little is known of urban sources because they vary greatly, even at small spatial scales. This research proposes to use stable isotope natural abundance techniques to understand sources of nitrogen and phosphorus in the urban environment and connect these sources to landscape characteristics such as tree species cover, management and soil characteristics.

Using Stable Isotopes to Identify Sources of Organic and Inorganic Phosphorous and Nitrogen in the Twin Cities Watershed

Objective(s)/Research Question(s)

N and P are the most ubiquitous water pollutants across aquatic habitats. Urban contributions of these nutrients can be large, yet very little is known of urban sources because they are more diverse than any other system due to high densities of a variety of human activities. Stable isotope analyses often are applied to natural and agricultural systems. This research seeks to examine how they can be used in urban systems toward detailed and mechanistic understanding of N and P sources in human dominated areas. To address this broad question, the focus of the scope of this work will be as follows: (1) What are the sources of N and P in urban ecosystems? (2) What role does seasonal variation play, especially snowmelt, in these sources? (3) How do landscape features (e.g., tree species cover, management and soil characteristics) influence sources and transformations of N and P?

Approach

The study will address these questions using the Twin Cities metropolitan area watershed as a model site. Methods include collaboration with a local watershed management agency to collect both bi-monthly baseflow and event (immediately following precipitation) water samples in five urban watersheds in 2013 and 2014. Sources of dissolved inorganic and organic N in water samples using stable isotope analysis of $d^{15}N$ will be determined. Recent studies have demonstrated that ^{18}OP (bound to P) can be an accurate and precise tracer of dissolved inorganic P in freshwater and estuarine ecosystems. These methods will be employed to elucidate urban sources of inorganic and organic P. The study will augment sampling regimes (i.e., long-term vs. intensive event sampling) in certain watersheds to investigate questions of seasonality and connections to landscape features.

Expected Results

It is expected that human activity and terrestrial input (i.e., leaf litter, throughfall) will be the dominant sources of N and P, but that sources will vary greatly at small spatial scales. Preliminary work suggests that tree species cover, soil characteristics and snowmelt dynamics may play a large role in driving differences in sources and loads of N and P in baseflow and event runoff.

Potential to Further Environmental/Human Health Protection

N and P availability often limits primary production and, in excess, can fuel large algal blooms and subsequent decomposition and depletion of dissolved O_2. Hypoxia and anoxia commonly are consequences of eutrophication in human-impacted aquatic ecosystems, and such impairment of freshwater and estuarine ecosystems has drastic implications for aquatic ecosystem health (i.e., gross disruptions of ecosystem processes and foodweb interactions). This reduced water quality ultimately can affect human wellbeing. Management and reduction of both N and P in these systems is necessary for ecosystem, and thereby human health.

Bridget R. Deemer

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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Aquatic Ecology and Ecosystems

Keywords: denitrification, sedimentation, nitrogen saturation

Bio

Bridget Deemer received her undergraduate degree in Environmental Studies from Vassar College in 2004. After several internships with natural resource agencies, including the National Park Service and the U.S. Fish and Wildlife Service, she returned to academia, working as a biological technician for the Wildlife Ecology and Conservation Laboratory at the University of Florida. In 2007, she joined the Global Change and Watershed Biogeochemistry Laboratory group at Washington State University, Vancouver, to study nitrogen transformations in a nearby reservoir. During this time, she worked with a sixth grade science teacher to incorporate inquiry-based projects into class curriculum under a National Science Foundation (NSF) GK-12 fellowship. She completed her M.E.S. degree in 2010 and continues to work with the same laboratory group in pursuit of her Ph.D. She currently is a Fellow in the NSF Integrative Graduate Education and Research Traineeship (IGERT) program called "Nitrogen Systems: Policy-Oriented Integrated Research and Education," where she is engaging in interdisciplinary approaches to understanding how reservoir management affects downstream water quality and greenhouse gas production. More broadly, she is interested in how human activities are affecting the way that energy and nutrients cycle through ecosystems.

Synopsis

This research will examine the pathways by which reservoirs process biologically available nitrogen (N). High concentrations of N in aquatic systems can negatively affect both ecosystem and human health. N sedimentation, microbial N removal and nitrous oxide production will be measured in five reservoirs that experience varying degrees of background N loading. This work is expected to increase the understanding of how background N pollution affects the ecosystem services provided by reservoirs.
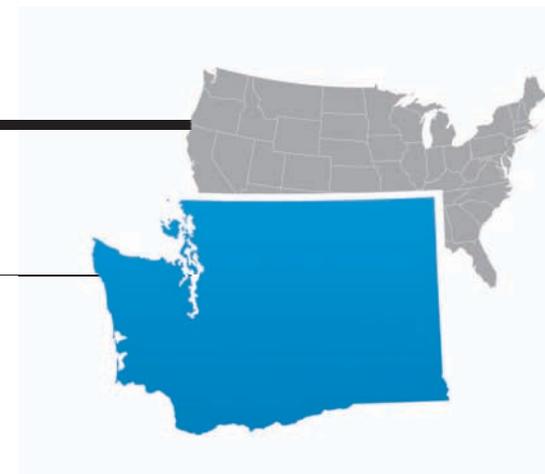
Nitrogen-Related Ecosystem Services Along a Nitrogen Saturation Gradient in the Klamath Hydroelectric Project Reservoirs

Objective(s)/Research Question(s)

The goal of this study is to quantify summertime denitrification, N sedimentation and nitrous oxide production in the Klamath Hydroelectric Project Reservoirs. Specifically, this research will examine how background N concentrations affect the proportion of N that is removed permanently via denitrification versus the proportion of N buried within more temporary storage pools in the sediment. The study also will examine how background N concentrations affect denitrification efficiency, or the proportion of N converted to dinitrogen versus nitrous oxide.

Approach

This study will focus on five reservoirs within the Klamath River basin that experience a range of background N concentrations. Denitrification rates and nitrous oxide production rates will be estimated in each reservoir by quantifying the accumulation of dinitrogen and nitrous oxide within the hypolimnion over the course of the summer. Potential denitrification as a function of depth also will be quantified in each system using the acetylene block technique. N sedimentation rates will be quantified by deploying a series of in situ sedimentation traps in each reservoir and analyzing sediments for total N content. Background nitrogen concentrations (total nitrogen, dissolved organic nitrogen, nitrate and ammonium) also will be measured several times throughout the summer by sampling along a vertical profile at the deepest part of each reservoir.

Expected Results

Denitrification rates are not expected to scale linearly with system N-status, supporting the notion that Klamath reservoirs are N-saturated. Elevated N concentrations are expected to result in lower rates of denitrification relative to N sedimentation and higher rates of nitrous oxide production relative to dinitrogen production. Overall, it is expected that elevated background N concentrations reduce the ecosystem services provided by reservoir ecosystems.

Potential to Further Environmental/Human Health Protection

Anthropogenically fixed excess nitrogen is associated with a number of serious aquatic and atmospheric pollution issues, including an increase in the frequency and severity of harmful algal blooms, the proliferation of coastal hypoxic zones, the contamination of drinking water wells, and increased fluxes of nitrous oxide to the atmosphere. This study will describe how anthropogenic N loading affects N removal processes in reservoirs. This will represent a significant contribution to the understanding of the controls on N-related ecosystem services.

Rachel Lianna Douglass
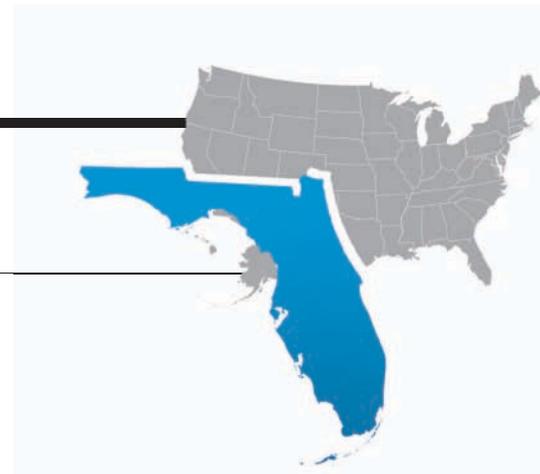
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: ecological stoichiometry, competitive ability, species composition

Bio

Rachel Douglass received a B.S. degree from North Carolina State University in 2006. She then earned an M.E.M. degree in Environmental Economics and Policy from Duke University's Nicholas School of the Environment and Earth Sciences. In 2009, she began a Ph.D. program in Interdisciplinary Ecology at the University of Florida. Her current research investigates the relationship between primary producers and ecosystem metabolism using ecological stoichiometry.

Synopsis

Springs are experiencing accelerated degradation, namely in the form of vegetation shifts from submerged vascular plants to filamentous algae. This research proposes to use ecological stoichiometry, the balance of C-carbon:N-nitrogen:P-phosphorus within ecosystems, and nutrient sensing technology to assess the competitive interactions between vascular plants and algae under various nutrient regimes as well as the effects on ecosystem functioning due to changes in species composition.

From Nutrients to Metabolism: Linking Numeric Nutrient Criteria to Ecosystem Composition and Function Using Ecological Stoichiometry

Objective(s)/Research Question(s)

The U.S. Environmental Protection Agency recently proposed numeric nutrient criteria for spring ecosystems; however, prior research indicates nutrient concentrations alone may not adequately predict vegetation shifts for spring ecosystems. As such, this study seeks to answer how variation in the bottom-up forcing of changing resource C:N:P ratios and flow interact with top-down effects of grazing to regulate the competitive ability of vascular and algal species in springs. In addition, the study will evaluate how differing compositions of algal and vascular species affect ecosystem metabolism, a measure of ecosystem function, by deploying a suite of three real-time nutrient sensors across a gradient of species composition.

Approach

By utilizing an *in situ* experimental approach during spring runs, the competitive ability of vascular versus algal species under two different resource C:N:P regimes found in spring ecosystems will be examined. By comparing the two resource regimes under both high and low flow as well as in the presence and absence of grazers, the study will evaluate the relative influence of bottom-up forces versus top-down grazing effects. In the field, percent cover and biomass of each species will be measured. Next, the study will use real-time nutrient sensing technology combined with vegetation sampling in springs with varying amounts of algal and vascular taxa to determine how variation in primary producer composition affects ecosystem metabolism and the associated stoichiometry. Using the sensor data, ecosystem metabolism will be calculated as well as the C:N:P of the ecosystem, which will be compared to the stoichiometry of the dominant taxa.

Expected Results

Results of these experiments will inform resource managers of the impacts of raising ecosystem C:N ratios on species composition under various flow regimes as well as the extent to which the N:P interacts with the C:N ratio to affect individual species' competitive ability, and hence, primary producer species composition. This research also is expected to document the extent to which the bottom-up forces of flow and nutrient ratios are influenced by top-down pressure of grazing. Finally, this project will evaluate the effects of differing species composition on ecosystem metabolism.

Potential to Further Environmental/Human Health Protection

Projected population increases and associated land use change are predicted to only exacerbate existing nutrient inputs to these ecosystems. This research provides crucial information to improve environmental decision making by enabling managers to better predict potential effects of nutrient-driven eutrophication on ecosystem composition and function through the use of nutrient ratios under varying flow regimes and grazing intensities. This information can be utilized to formulate effective long-term plans to sustain and restore these economically and ecologically important spring ecosystems.

Katherine Phillips Ingram
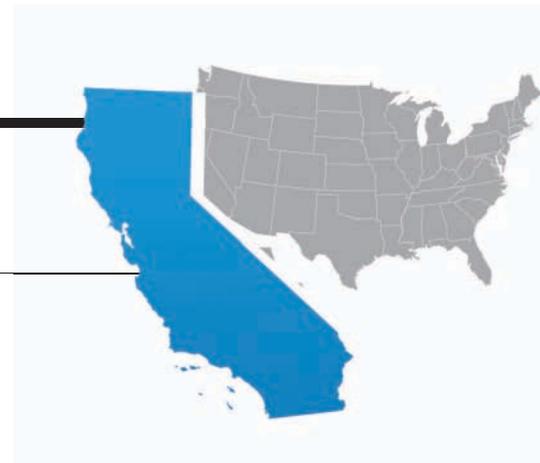
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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: ecosystem services, pesticides, agricultural decision making

Bio

Katherine Ingram began her career in science at Furman University, where she received a B.Sc. degree in Biology in 2003. In 2007, she received an M.Sc. degree in Biology from the University of Nevada, Reno. She is a current Ph.D. student in the Ecology Graduate Group at the University of California, Davis, where she continues to focus on the evolutionary ecology of bats. At present, her research seeks to understand the role of bats as providers of a key ecosystem service (pest control) in agroecology.

Synopsis

Agricultural pesticides contribute to environmental pollution and pose health risks to society. Practices that increase the abundance of natural insect predators such as bats can reduce pesticide use, increase agricultural biodiversity and save farmers money. This study will assess the pest control service provided by bats in the California Central Valley, build an economic model of this service and determine how farmers make decisions with respect to ecosystem services.

Incorporating Bats in Agroecosystem Management and Crop Protection Decisions

Objective(s)/Research Question(s)

The widespread use of pesticides for pest control has led to the unfortunate side effect that pesticides are now major elements of environmental pollution in some agricultural regions. Biological pest control increasingly is recognized as a viable and cost-effective alternative to pesticide use. This research project will investigate the economic, social and environmental potential of bats as natural pest-control agents in California's Central Valley and will serve as a model for future efforts to incorporate ecosystem services into the agricultural industry.

Approach

Before the economic value of an ecological service is assessed, the service itself must first be characterized. This proposed study will characterize the assemblage of bat species that forage in or around walnut groves in central California and assess their diets using DNA barcoding techniques. The quantity of insect pests being consumed per bat will be estimated and used to create an economic model of the cost savings of bat-aided crop pest depletion. Using these biological and economic data, this research will address agricultural decision making; specifically, those factors (social, economic, behavioral) that influence the willingness of farmers to adopt techniques that encourage bat residency on farms will be determined.

Expected Results

By characterizing the diet of bats in agroecosystems, this research likely will document that bats are important consumers of pest species.

Additionally, this investigation will document which pest species are consumed and the relative contribution of these species to bat diets. Information on bat diets and pest species consumption will demonstrate economic savings associated with facilitating bat foraging in orchards; one key objective of this study is to quantify these savings and work with farmers to incorporate bats as part of a broader integrated pest management (IPM) approach. By assessing the social and behavioral factors that contribute to the implementation of this relatively novel agricultural practice in the Central Valley, this research will develop educational tools to help farmers assess the costs and benefits of "bat IPM", and to demonstrate simple and cost-effective means of incorporating bats into their agricultural management.

Potential to Further Environmental/Human Health Protection

In closed basins such as California's Central Valley, agricultural pesticide has the potential to negatively impact non-agricultural regions such as wild lands and riparian areas, and has grave health implications for both crop handlers and consumers of agricultural products. This project will provide basic economic information to the regional agricultural community, thereby allowing farmers to make their own cost-benefit analysis of the value of incorporating bats into their agricultural management. Additionally, the economic implications of this study will provide policy makers with a tool to create safer, more sustainable agricultural infrastructure.

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Aquatic Ecology & Ecosystems

Keywords: climate change, freshwater, ecosystem services

Bio

KathiJo Jankowski received a B.S. degree in Environmental Science and Anthropology from the University of Notre Dame in 2003 and an M.S. degree in Biology in 2007 from Loyola University, Chicago. She currently is enrolled in a Ph.D. program at the University of Washington School of Aquatic and Fishery Sciences. Her research interests focus on understanding how carbon and nutrient cycling in stream and river ecosystems will respond to increasing temperatures associated with climate change.

Synopsis

Rivers process and transport carbon on land, to the ocean and the atmosphere, yet little is understood about how those processes will respond to climate change. Most assessments of how ecosystems store carbon do not actually include their aquatic components. The goals of this research are to evaluate how landscape context influences the sensitivity of river carbon cycles to climate warming and to create tools that incorporate aquatic ecosystems into estimates of carbon storage and flux.

Metabolic Responses of Aquatic Ecosystems to Climate Warming

Objective(s)/Research Question(s)

The capacity for landscapes to sequester carbon and how landscape features regulate sequestration remain poorly understood under current and future climate conditions. The growing appreciation for the importance of aquatic ecosystems in understanding the capacity of watersheds to sequester carbon, and in fact the global carbon cycle, reinforces the need for improved understanding of their response to global change. Therefore, this research will evaluate how watershed context, by regulating both the physical template of aquatic ecosystems (e.g., temperature, light, hydrology) and the quality and amount of carbon delivered to them from the terrestrial landscape, influences the sensitivity of aquatic carbon cycling and metabolism to climate change.

Approach

This research will quantify the landscape-scale variation in temperature sensitivity of stream metabolism and resulting CO_2 flux from streams in the Wood River system of southwestern Alaska, a region showing the fastest warming trends globally. Field surveys of O_2 and CO_2 dynamics and small-scale incubations will be used to reformulate an existing ecosystem metabolic model to include temperature dependence of stream metabolism, that is, respiration (CO_2 source) and primary productivity (CO_2 sink). These results then will be linked to existing geographic information system (GIS) data on watershed characteristics that control the delivery of carbon, nutrients, water and light to streams to create functional relationships between the temperature sensitivity of stream metabolism and readily available watershed-scale data on watershed slope, watershed area, vegetation cover and so forth. This approach allows for an evaluation of temperature dependence of stream metabolism at an ecosystem scale and the projection of watershed responses to ongoing climate change.

Expected Results

There is increasing evidence that stream metabolic processes that increase CO_2 flux to the atmosphere will be highly sensitive to rising temperatures, changing precipitation patterns and shifts in carbon loading from watersheds. In addition, preliminary data suggest that the thermal scaling of organic matter processing in these Alaskan watersheds correspond with watershed geomorphic features. This research aims to develop functional relationships between watershed-scale data and stream metabolism to include aquatic ecosystems in assessments of watershed carbon storage. This research also will incorporate state-of-the-art statistical approaches that enable formal uncertainty analysis of aquatic ecosystem metabolism estimates that are critical for the evaluation of ecosystem responses to environmental change at scales relevant to management and policy making.

Potential to Further Environmental/Human Health Protection

Climate change threatens human health and economies by altering the services provided by intact ecosystems such as food production, clean water and carbon storage. Freshwater ecosystems not only provide valuable food and water but also play a large role in the carbon balance of watersheds. Therefore, understanding how climate change will affect the carbon cycle in aquatic ecosystems will improve the ability to predict how watersheds and the carbon sequestration services they provide will respond to climate change.
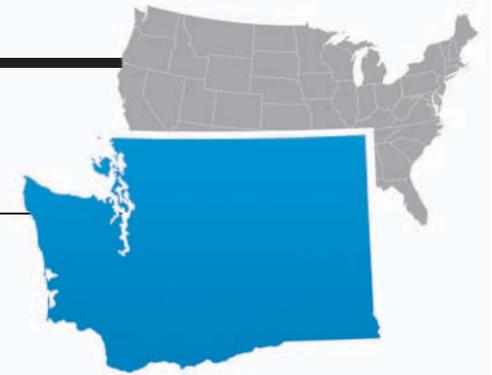
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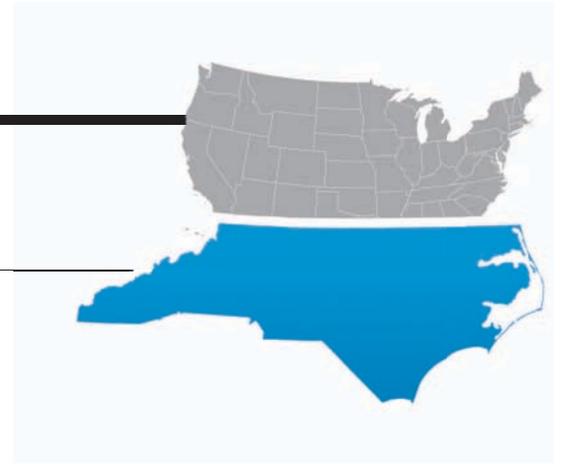
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Project Amount: $126,000
Environmental Discipline: Entomology

Keywords: urbanization, urban heat island, ecosystem services

Bio

Emily Meineke graduated from the University of North Carolina at Chapel Hill in 2008 with a B.S. degree in Environmental Science. She went to Southeast Asia as a Francis L. Phillips scholar directly following graduation. For the following 2 years, she worked several seasonal jobs as a technician for ecology projects and an AmeriCorps trail worker. She is now a Ph.D. student at North Carolina State University, where she studies how herbivorous insects respond to urban warming.

Synopsis

Eighty percent of the U.S. population lives in cities, where high temperatures and pollution pose significant human health risks. Urban trees combat these risks and improve living conditions by reducing urban temperatures and sequestering pollutants. Unfortunately, urban trees are threatened by arthropod pests, which are more abundant and damaging in urban areas. This study will address how urban heat and herbivores interact to affect the future of urban trees and the services that they provide.

Urban Forest Protection: Investigating How Local Warming Causes Outbreaks of a Common Pest Insect

Objective(s)/Research Question(s)

Arthropod tree pests typically are more abundant and damaging in urban than in rural areas. The hypothesis is that heat is an important factor driving pest outbreaks on urban trees. This study will investigate how urban heat affects scale insect fitness and interactions with natural enemies as mechanisms of scale insect outbreaks. Ultimately, the study will determine how the effects of heat and scale insects interact to affect urban tree health and ecosystem services.

Approach

The research will identify study trees in the hottest and coolest parts of Raleigh, NC. On each tree, tree health will be measured (via photosynthesis and growth), scale insect abundance, natural enemy abundance/diversity and site-level temperature to understand how temperature and scale insect abundance interact to affect tree health. The study will use DNA sequences from these samples, along with thermal chamber experiments, to investigate scale insect adaptation to urban heat and natural enemy efficacy.

Expected Results

It is expected that trees in warmer areas will have greater scale abundance and a concomitant reduction in health and ecosystem services relative to trees at cooler sites. Also, it is expected that natural enemy activity and scale development coincide in cold areas but scale develop earlier and faster in hot areas, causing a phenological mismatch between scale in hot areas and their enemies. Based on current literature, it is expected that scale insect populations have evolved to tolerate urban heat.

Potential to Further Environmental/Human Health Protection

Urban trees provide myriad health and environmental services, and their protection will be a key concern for environmental managers and policy makers in the future. Several cities across the world have experienced extreme heat events that have killed tens of thousands of people, and trees remain one of few key ways to reduce urban temperatures. Additionally, urban trees in the United States currently sequester 700 million tons of carbon, an invaluable service that combats the effects of global climate warming.

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Project Amount: $84,000
Environmental Discipline: Ecology

Keywords: persistent organic pollutants, seabirds, stable isotopes

Bio

Christopher Millow received a B.S. degree in Wildlife Ecology from the University of Delaware in 2006. After 4 years of working in Seattle-based environmental non-profits, he returned to graduate school at San Diego State University where he currently is pursuing an M.S. in Ecology. His research interests include applied conservation ecology, anthropogenic impacts to wildlife, and ecotoxicology. His thesis focuses on identifying and quantifying targeted and nontargeted chemical compounds in a coastal seabird, the Black Skimmer (*Rynchops niger*), and the potential effects they have on reproductive output.

Synopsis

Persistent organic pollutants (POPs) are known to cause reproductive and physiological impairments in wildlife. Nontargeted (emerging/unregulated) compounds also have been recognized as probable causes of impairments and have been identified in marine fauna. Black Skimmers are long-lived seabirds that nest in San Diego Bay, exhibit poor reproductive output and accumulate contaminants in high amounts. Analyzing nontargeted compounds with POPs comprehensively will assess total toxin burdens.

Black Skimmers (*Rynchops niger*) in an Urban Landscape: Contaminant and Diet Influences on Reproductive Output in San Diego Bay

Objective(s)/Research Question(s)

The goal of this research is to investigate contaminant exposure in Black Skimmers and explore associations with diet and reproductive output. Specifically, the research aims to: (1) quantify nontargeted and targeted contaminants present in egg homogenate and blood plasma; (2) evaluate relationships between contaminant loads and egg viability; and (3) determine if a relationship exists between adult diet and egg contaminants.

Approach

To address objectives (1) and (2), egg and plasma will be liquid-liquid extracted, spiked with reference standards and cleaned of lipids by gel permeation chromatography (GPC) and Solid Phase Extraction (SPE). Nitrogen-evaporated extracts will be analyzed by a novel comprehensive two-dimensional gas chromatography with time-of-flight mass spectrometry (GCÃ—GC/TOF-MS). Acquired mass spectra of contaminants will be library-referenced, visually examined and quantified against standard curves. To address objective (3), carbon and nitrogen stable isotope values of eggshell membranes (indicative of adult diet at time of egg formation) will be compared with contaminants found within egg homogenate.

Expected Results

The project addresses an applied ecological question through interdisciplinary and innovative analytical methods. By combining stable isotope and contaminant analyses, this project will provide a comprehensive perspective of how contaminants and diet vary within an organism believed to exhibit high levels of environmental contaminants. Limited studies connect bioaccumulative contaminant impacts with the productivity of an organism. Using a novel analytical approach, the study will evaluate relationships between targeted and nontargeted compounds and reproductive output. Results from this research will provide a comprehensive inventory of both known and previously unknown chemical compounds in southern California's coastal waters, using the Black Skimmer as an upper-level environmental sentinel.

Potential to Further Environmental/Human Health Protection

Emerging from this research will be a comprehensive inventory of both known and previously unknown chemical compounds in southern California's coastal waters, subsequently aiding in the assessment of environmental exposure to a wide range of contaminants. From a human health perspective, chemicals detected in marine species inform of contamination risks to the high density human populations along southern California's urbanized and industrialized coastline. From here, contaminant sources can be traced and existing and/or new regulatory policies can be strengthened. This research also will provide a novel methodological framework for analyzing contaminants in seabird tissues.
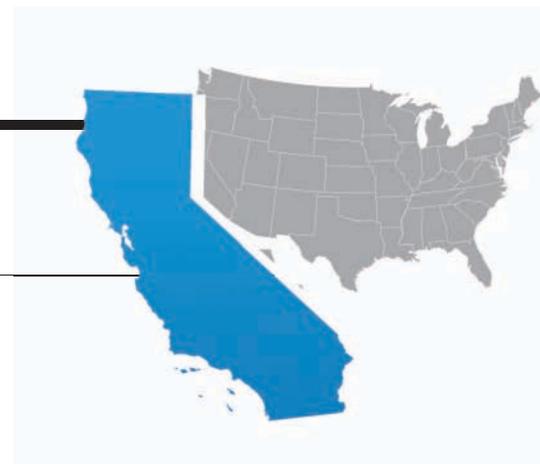
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Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: ecosystem services, secondary forests, land use

Bio

Chelsea Nagy received a Bachelor's degree in Environmental Science from Miami University and a Master's degree in Forestry from Auburn University. She now is a Ph.D. student in a joint program with Brown University and the Marine Biological Laboratory. Broadly, she is interested in the ecological and biogeochemical consequences of land use change in the tropics. Her research will focus on the ecosystem services provided by secondary forests in the Atlantic Forest region of Brazil.

Synopsis

Secondary forests on abandoned agricultural lands are becoming more prominent throughout the tropics, yet the derived societal benefits of these forests are unknown. Land use history affects will be studied of the carbon (C) storage and productivity of secondary forests in Brazil's Atlantic Forest. The potential of these forests to store C, which will be important increasingly in a carbon dioxide-rich future, may depend on the former management regime and associated nutrient losses.

Ecosystem Services of Secondary Forests in the Mata Atlântica of Brazil

Objective(s)/Research Question(s)

The potential for C storage in secondary forests is limited by productivity of regrowing vegetation and in turn, productivity often is limited by one or more nutrients. Additionally, high species richness may enhance complementary resource use among species (niche complementarity) and thus increase productivity and biomass. This research will focus on how land use history affects the service of C storage and C storage potential as it is influenced by nutrient limitation and species richness effects on productivity.

Approach

This research will combine ecological and biogeochemical analyses of soils and vegetation to compare primary and secondary forests with different land use histories. The Atlantic Forest, or Mata Atlântica, of Brazil is a model for the future of tropical secondary forests and the ecosystems they provide. The project will be conducted in the state of Sao Paulo in a network of forest preserves created in the 1970s that contains secondary forests regenerated from abandoned pastures and eucalyptus plantations.

Expected Results

Land use history can be an important driver of many ecosystem services. Carbon storage and species richness of primary forests likely will exceed that of secondary forests. Productivity of secondary forests may be limited by nitrogen and/or phosphorus because of nutrient removal in management practices such as fires and harvests. Productivity is expected to increase with increasing diversity due to complementary resource use among species.

Potential to Further Environmental/Human Health Protection

The interactions among these ecosystem services will provide insight into the overall ability of secondary forests to act as a sink for CO_2. This work will provide information as to how different land covers might be compensated under reduced emissions from a deforestation and degradation (REDD) framework, which in turn may be a direct benefit to local communities. Incorporating small-scale landowners in this framework, by providing incentives to restore forests and thus enhance the ecosystem services they provide, has the potential to improve the livelihoods of poorer communities in the region.
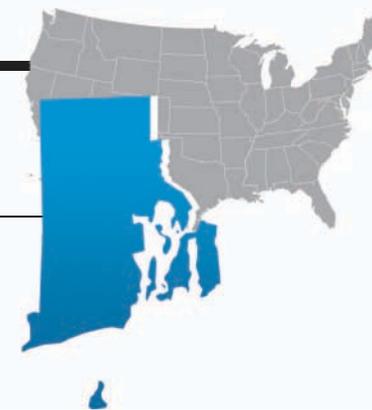
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Project Amount: $84,000
Environmental Discipline: Ecology

Keywords: water quality, ecosystem services, nutrient recycling

Bio

Christen Steele received a B.S. degree from Ohio University. After receiving her degree, she gained research experience at Jones Ecological Research Center and MacArthur Agroecology Research Center (MAERC). She is enrolled in the Conservation Biology Master's program at the University of Central Florida. Her interests include beneficial arthropods and the influence of biodiversity on ecosystem function in human-dominated systems. Currently, she is investigating the impact of land management and non-native species on the ecosystem services provided by dung beetles.

Synopsis

Although small in size, dung beetles provide an enormous number of ecosystem services. They improve water quality by recycling soil nutrients and decreasing surface water runoff. They also benefit livestock and human health by decreasing pests and parasites within dung. Unfortunately, their populations are threatened by land conversion, non-native species and insecticide use. This research will investigate how land management and the non-native red imported fire ant influence dung beetle diversity and abundance as well as the ecosystem services they provide.

Pasture Management, the Red Imported Fire Ant (*Solenopsis invicta*), and Dung Beetle Mediated Ecosystem Services

Objective(s)/Research Question(s)

Grazing animals in Florida deposit more than 20 million metric tons of dung per year, making dung a significant non-point source of pollution. Degradation of this dung occurs naturally, primarily due to *Coleopterans* (beetles) in the families *Scarabaeidae* and *Geotrupidae* (hereafter dung beetles). Dung that is not degraded may be leached into water bodies and provides an incubation site for the pests and parasites of both humans and livestock. Thus, the optimization of the ecosystem services provided by dung beetles is a priority for not only the protection of terrestrial and aquatic biota, but also the cattle industry. This project will utilize semi-natural and intensively managed pastures to determine how management driven differences in habitat alter dung beetle assemblages. This study also will evaluate experimentally how pasture type and the presence or absence of the non-native red imported fire ant influence the ecosystem services of dung degradation and parasite suppression.

Approach

This research will be conducted at MAERC (part of Archbold Biological Station), a 4,170-ha commercial cattle ranch in central Florida. Dung baited pitfall traps will be used to determine the diversity, abundance and biomass of beetles within semi-native and intensively managed pastures. The influence of pasture type and fire ants on ecosystem services will be assessed using 20 treatment grids (10 in each pasture type). Each grid will consist of two 30 Ã—30 m plots; one as a fire ant exclusion and the other as a fire ant inclusion. Experimental dung pats placed within the treatment grid also will exclude or include dung beetles using a dome-shaped wire frame wrapped in mesh. Parasite abundance will be sampled by collecting vegetation surrounding the pat and extracting infective larvae using a modification of the methods of Whitehead and Hemming (1965 *Ann Appl Biol* 55: 25-38). Dung pats will be collected from the field after 40 days and oven dried to determine the rate of dung degradation.

Expected Results

It is expected to find greater diversity of dung beetle species and functional groups in the semi-natural pastures on MAERC, as it is suspected that intensive management practices such as high fertilizer use and frequent mechanical disturbance will result in localized extinction of large-bodied species. Preliminary sampling results conducted in spring of 2011, revealed a trend of increased species richness within semi-natural pastures. Higher beetle diversity is expected to increase dung degradation but may not increase parasite suppression. During preliminary sampling, fire ants foraged in high quantities within more than 70 percent of pats. Large numbers of fire ants within a pat are likely to increase pat aeration and desiccation. Although this will not improve dung degradation, it may lead to increased parasite mortality.

Potential to Further Environmental/Human Health Protection

A multitude of controlled experiments have shown that biodiversity has a significant influence over ecosystem function and services. These studies make clear that the preservation of diverse natural areas and semi-natural areas is paramount to the delivery of the ecosystem services on which humans rely. Agricultural systems, like natural systems, can sustain biodiversity and provide valuable ecosystem services, but this may depend on the methods used to manage these systems. Because this project will focus on the relationship between biodiversity and function within a working landscape, it provides the opportunity to examine the influence of diversity as it interacts directly with livestock and human health. This project will inform ranch managers on the importance of regulating natural systems on their ranches and may lead to modification of management practices to maintain beneficial ecosystem services.

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Aquatic Ecology

Keywords: benthic macroinvertebrate, ecosystem function, mountaintop removal mining

Bio

After earning a B.S. degree in Chemistry from Texas A&M University, Kristofer Voss taught high school chemistry and environmental science between 2001 and 2009. Upon completing a Master's degree in Environmental Engineering, he enrolled in the doctoral program at Duke University's Nicholas School of the Environment to examine how landscape-scale disturbance gradients shape aquatic ecosystems. His current research investigates the linkage between structural and functional responses to land-cover change by studying aquatic macroinvertebrate communities in Appalachian river networks.

Synopsis

Mountaintop removal mining for coal is the largest form of land-cover change in Central Appalachia. Mining degrades water quality and threatens sensitive aquatic organisms by increasing the ionic strength and metal content in receiving waters. This research examines how ecosystem processes and properties change when sensitive organisms are lost in river networks affected by mining. Making this linkage explicit will enhance the understanding of biological integrity in streams and rivers.

Linking Community Structure and Ecosystem Function in Aquatic Ecosystems Degraded by Mountaintop Mining

Objective(s)/Research Question(s)

Freshwater macroinvertebrates respond so consistently to land-cover disturbance gradients that environmental managers regularly use them to assess the ecological status of lakes and rivers. Although the predictable loss of sensitive aquatic macroinvertebrates can indicate environmental degradation, far fewer efforts have linked the losses of individual taxa and the traits they possess to the functional consequences these losses impose on ecosystem properties and processes. To make this link requires increased attention to the functional traits and trophic position of individual taxa that change in abundance along disturbance gradients. By fulfilling this goal, the mechanisms can be described behind community-level responses to disturbance, determine whether taxa are unique or redundant community members and quantify the relevance of trait loss to the flow of energy and nutrients through the community.

Approach

To accomplish the research objectives, an approach that combines statistical analyses of compiled benthic macroinvertebrate data from Central Appalachia with field and experimental studies in a focus watershed will be used. First, compiled datasets will be analyzed using Bayesian hierarchical models to assess how the ecological trait composition of the macroinvertebrate community changes along a gradient of mining activity. Secondly, the functional consequences of trait shifts will be determined using an in-depth field study that compares macroinvertebrate secondary production in streams affected and unaffected by mountaintop removal mining. Finally, a synoptic study of chemically stranded headwaters will be employed to assess whether downstream chemical pollution can shape the aquatic communities in headwaters.

Expected Results

The Clean Water Act and its subsequent amendments recognize the importance of protecting biological integrity, a concept synonymous with preserving structure and function within lotic ecosystems. This research will improve current taxonomically based risk assessment models, identify the specific effects of mountaintop mining on macroinvertebrate trait composition, follow those effects up the food chain by linking macroinvertebrate community shifts to higher trophic levels, and evaluate the effects of chemical isolation—a hitherto underexplored consequence of mountaintop removal mining and other land use changes—on aquatic communities.

Potential to Further Environmental/Human Health Protection

This research will fill an important gap in the understanding of the relationship between the structure of the ubiquitously monitored macroinvertebrate assemblage and important functions that this assemblage supports. Such basic research is necessary to quantify the relationship between biodiversity loss and stream ecosystem function within the broader context of ecosystem service cascades on which humans rely.
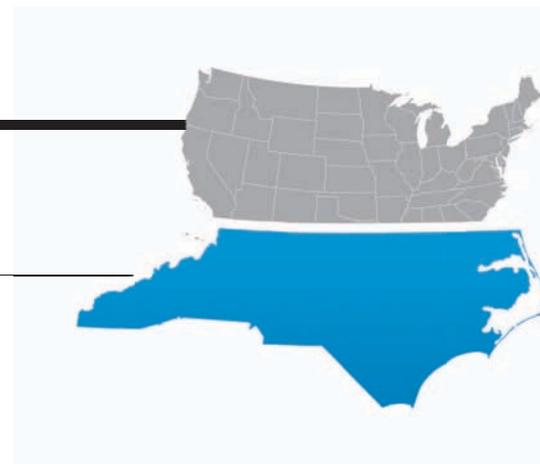
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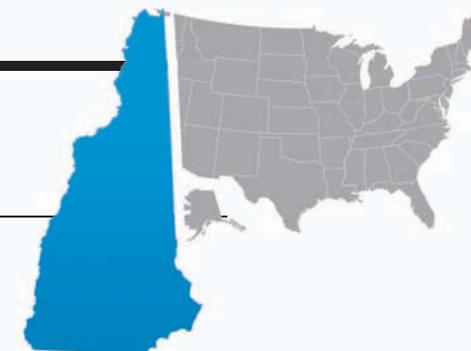
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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Ecology

Keywords: olfactory imprinting, amino acids, ecosystem services

Bio

Marcus Welker received his B.S. degree from the University of Alaska, Anchorage, in Natural Sciences in 2009. The following year, he received his M.S. degree from King's College London, University of London in Aquatic Resource Management. He currently is working on his Ph.D. at Dartmouth College in the Ecology and Evolutionary Biology program as a National Science Foundation Integrative Graduate Education and Research Traineeship Fellow. His project seeks to improve the Atlantic salmon restoration program in Lake Champlain and unlock the mysteries of salmon migrations.

Synopsis

This research aims to improve the restoration of Lake Champlain Atlantic salmon by increasing river-runs and self-sustaining populations. Additionally, the study experimentally will identify the stream odors responsible for Atlantic salmon imprinting and homing. Atlantic salmon provide many important ecosystem services. This study will focus on identifying problems, finding solutions and developing new strategies for restoring threatened, endangered and extinct populations of salmon.

Restoration of Atlantic Salmon and Their Ecosystem Services to Lake Champlain by Restoring Their River Imprinting

Objective(s)/Research Question(s)

The research goal is to improve the understanding of salmon imprinting, homing and hatchery practices to promote environmentally, socially and economically beneficial salmon restoration. This research project will test two hypotheses: (1) amino acid profiles (concentrations and compositions) are different in the lake, rivers and hatcheries across key locations and times; and (2) juvenile Atlantic salmon imprint to the amino acid profile they experience during their parr-smolt transition (PST) and show preference as adults to that specific profile.

Approach

To explore differences in the amino acid composition and concentrations of river, lake and hatchery waters, the study will sample during two key periods, juvenile imprinting and adult homing, and in locations relevant to each of these important processes. The water samples will be analyzed using HPLC in collaboration with Dr. Hiroshi Ueda's laboratory at Hokkaido University in Japan. To test if Atlantic salmon use amino acids as cues to finding their home streams, juveniles undergoing the PST will be exposed to a cocktail of five amino acids, reared to adulthood, and then their behavioral preference for the amino acid cocktail will be tested in a two-choice Y-maze.

Expected Results

It is expected that each river and hatchery will have a distinct amino acid profile. Also, it is predicted that amino acid concentrations will be highest in the hatcheries, lowest in the lake and at intermediate levels in the rivers. If the hatcheries have a different amino acid profile than the rivers, juvenile Atlantic salmon undergoing the PST in the hatchery may be inappropriately imprinting to the hatchery waters instead of to the release-river. Fish reared in captivity and imprinted to the amino acid cocktail during the PST are predicted to show a preference for the amino acid cocktail as adults. Additionally, it is anticipated that fish exposed for just 2 weeks to the amino acid cocktail will respond similarly to those exposed for 10 weeks. These results will inform Lake Champlain aquatic ecosystem managers regarding if and how they can modify hatchery rearing waters and the timing of river outplanting to correctly imprint Atlantic salmon.

Potential to Further Environmental/Human Health Protection

Restoring river-runs of Atlantic salmon would provide all four classes of ecosystem services to the watershed (supporting, provisioning, regulating and cultural), simultaneously strengthening the environmental, social and economic pillars of sustainability.

Tribes & American Indian, Alaska Native, Pacific Islander Communities

When all the trees have been cut down,
when all the animals have been hunted,
when all the waters are polluted,
when all the air is unsafe to breathe,
only then will you discover you cannot eat money.

– Cree Prophecy
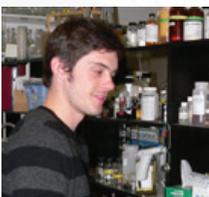
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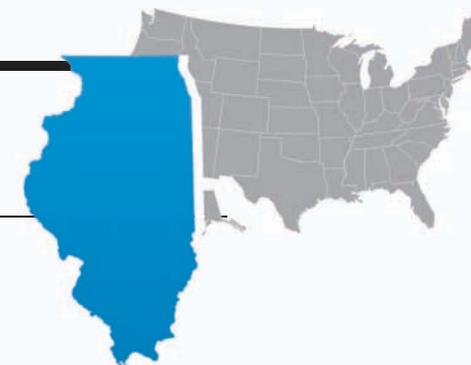
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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Environmental Microbiology

Keywords: metagenomics, microbial ecology, bioinformatics

Bio

Sean Gibbons received Bachelor degrees in Cellular and Molecular Biology, Microbiology (with a minor in Chemistry) and French Language and Literature from The University of Montana (UM) in 2008. He then worked as the laboratory manager for the UM Environmental Microbiology Laboratory. In 2009, he received a Fulbright scholarship to study renewable energy and microbial genetics at Uppsala University in Sweden. He graduated with an M.S. degree in Microbiology from Uppsala University in 2010. Upon returning to the United States, he started working at a private ecosystem restoration company in Montana. In 2010, he took an adjunct faculty position at Chief Dull Knife College where he taught molecular biology and laboratory techniques to tribal students. In 2011, he was accepted into the biophysical sciences Ph.D. program at the University of Chicago, where he studies computational metagenomics, microbial ecology and biogeochemistry.

Synopsis

Large-scale sequencing projects on benthic freshwater sediments are rare; as such, there is a significant gap in the knowledge of global ecosystem diversity. Although functional dynamics still are poorly understood, microbial community structure, as determined using 16S rRNA analysis has shown shifts in microbial community structure in stream sediments in response to chemical gradients and seasonal changes. Shotgun and amplicon sequencing will be used to characterize freshwater sediment metagenomes. These data will be combined with environmental metadata to characterize the dynamics of benthic microbial communities in response to physiochemical gradients. The proposed research aims to explore whether the taxonomic responses are mirrored in the functional capability of the microbial community.

Metagenomics of Tongue River Sediments: Working With Tribal Students to Assess the Impacts of Climate, Season and Resource Extraction on Freshwater Microbial Community Structure and Gene Content

Objective(s)/Research Question(s)

These data will enable several hypotheses to be tested. First, "microbial community structure and gene content will shift significantly between fall and spring samples at all sites, with seasonal dynamics having a stronger impact on community diversity and function than any other factor." Second, "microbial community dynamics in taxonomy represent changes in the relative abundance of community members, rather than fluctuations in community membership." Thirdly, "community structure will change with proximity to coal bed methane activity and to the Decker Coal Mine, with an increase in genes associated with hydrocarbon metabolism and osmotic stress."

Approach

The study will take sediment samples from six sites along the Tongue River over the course of 2 years (fall and spring samplings). Sample collection, metadata documentation and genomic DNA extractions will be conducted with the help of students at Chief Dull Knife College. Polymerase chain reaction (PCR) and Illumina® Hi-Seq runs will be performed at Argonne National Laboratory. Amplicon and metagenomic data will be processed through the QIIME and MG-RAST workflows, respectively. Multivariate statistical techniques will be used to determine community similarity (principal component analysis and non-metric multidimensional scaling) and to find significant correlations between sequence data and contextual metadata (Resource Description and Access and canonical correspondence analysis). The data will be used to train ecosystem models (microbial assemblage prediction and predictive relative metabolic turnover), which in turn will be used to predict the phylogenetic and functional diversity of the Tongue River across space and time. These models will enable the estimation of carbon and nitrogen cycling in the system, and how these ecosystem services are impacted by human activities (e.g., coal mining and coal-bed methane development) along the Tongue River.

Expected Results

It is expected to find a strong relationship between season and microbial community structure. Also, it is expected to find an increased prevalence of genes associated with hydrocarbon metabolism and osmotic stress near the Decker Coal Mine and around coal-bed methane extraction sites. The hypothesis is that environmental stressors, like high salt levels or hydrocarbon contamination, will impair key ecosystem services. Based on prior research, it is predicted that microbial communities will harbor a persistent seed bank of low-abundance organisms and that changes in community structure will be due to changes in relative abundance of taxa, rather than presence/absence of particular organisms.

Potential to Further Environmental/Human Health Protection

The results from this study will help elucidate the relationship between environmental conditions and freshwater microbial community structure and function. This information will help the U.S. Environmental Protection Agency to better manage and protect freshwater resources. In addition, tribal authorities can make use of the models to better understand the impacts of human development on their riparian ecosystems. This will lead to better management decisions. Also, several tribal college students are expected to be trained in cutting-edge molecular biology and bioinformatic techniques. These students will be better equipped to pursue a 4-year degree program and then to successful careers in environmental science.

Tai Elizabeth Johnson
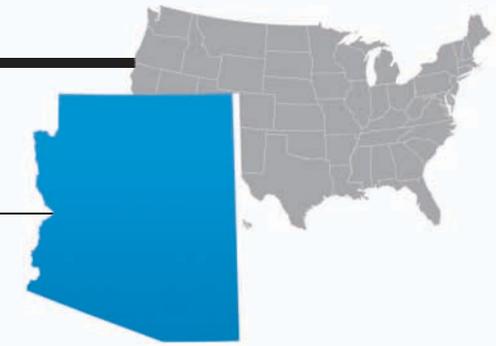
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Environmental History

Keywords: fossil fuel, water, Native American

Bio

Tai Johnson received a B.A. degree in History from West Virginia University in 2003, and an M.A. degree in History from Northern Arizona University in 2007. Currently, she is pursuing a Ph.D. in Environmental History at the University of Arizona. Her dissertation research examines the effects of coal and ground water mining on traditional agricultural practices on the Hopi Indian Reservation in northern Arizona.

Synopsis

Beginning in 1970, mining operations on the Hopi Indian Reservation in northern Arizona withdrew vast quantities of ground water for the processing and transportation of coal. Hopi farmers and gardeners depend on these water resources for the continuation of traditional subsistence practices. This project merges environmental research with local ecological knowledge, exploring how fossil fuel development and coal slurry pipeline technology have affected local food systems and natural resources on the Hopi Indian Reservation.

Assessing the Impacts of Coal Mining on Hopi Land, Water and Farming Practices Through Merging Local Knowledge With Environmental Research

Objective(s)/Research Question(s)

This research explores how fossil fuel development affected local food systems and natural resources on the Hopi Indian Reservation. Employing a multidisciplinary approach that examines scientific data in conjunction with Hopi environmental knowledge, this project examines the local effects of coal and ground water mining on Hopi land use, water resources and agricultural biodiversity since 1970.

Approach

The study will combine community-based participatory methodology with archival research to assess environmental change over time. First, tribal, state, and federal records, and scientific studies of coal and ground water mining on the Hopi Indian Reservation will be examined. Then, interviews will be conducted with Hopi farmers, gardeners and natural resource specialists regarding changes in water resources, land use and agricultural biodiversity since 1970. This qualitative data will be compared and contrasted with the quantitative and historical data obtained through archival research to identify gaps and correlations between the lived experiences, field observations and local knowledge of Hopis and the technical information presented in scientific studies of mining activities.

Expected Results

This study hypothesizes that coal and ground water mining on the Hopi Indian Reservation adversely affected local food systems through the depletion of ground water, limiting the ability of farmers and gardeners to produce traditional crops dependent on these water resources. The analysis of formal scientific studies in conjunction with local ecological knowledge acquired through interviews will provide a more comprehensive understanding of the environmental, social and cultural implications of mining activities on the Hopi Indian Reservation.

Potential to Further Environmental/Human Health Protection

This research demonstrates the importance of incorporating local ecological knowledge in environmental research. On a local level, the project will produce a usable archive of information on changes in water resources, crop diversity and agricultural practices since 1970 that can be utilized by the Hopi Tribe in the further development of water and food security initiatives. On national and global levels, this research has the potential to protect human and environmental health through the creation of a methodological model that utilizes local ecological knowledge, environmental history and formal scientific research to understand and address the environmental implications of fossil fuel development on local populations, food systems and water resources.

Ellen P. Preece

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Project Period: 8/20/2012 - 8/19/2015
Project Amount: $126,000
Environmental Discipline: Environmental and Water
    Science

Keywords: fish, cyanobacteria, toxin

Bio

Ellen Preece received a B.S. degree in Environmental Economics from the University of New Hampshire in 2002. After working 5 years for the U.S. Forest Service, she started graduate school at Washington State University. In 2010, she received an M.S. degree in Natural Resource Sciences and currently is pursuing her Ph.D. Her research focuses on limnology and climate change. Presently, she is researching accumulation of cyanobacterial toxins in trout to determine if eating contaminated fish is a human health risk.

Synopsis

Climate change and pollution of freshwater is increasing the prevalence of toxic cyanobacteria. It is understood that fish can accumulate cyanotoxins, but the significance of this pathway to humans is unclear. For people in tribal communities reliant on fish consumption, toxin accumulation is a health concern. This research will measure the cyanotoxin microcystin in trout harvested from tribal lakes and determine if cooking fish increases the potential for toxin transfer up the food web.

Cyanobacteria and Fish: A Toxic Health Threat to Tribal Communities?

Objective(s)/Research Question(s)

The prevalence of toxic cyanobacteria is increasing in freshwater worldwide, thus humans reliant on fish for their diet, such as Native Americans, may face adverse health effects from eating contaminated fish. This research will determine if members of the Confederated Tribes of the Colville Reservation are exposed to the cyanotoxin microcystin by consuming fish harvested from reservation lakes. This research also will determine if cooking fish makes microcystin more biologically available, and therefore more likely to move through the food web.

Approach

This study will concentrate on collecting fish from four lakes on the Confederated Tribes of the Colville Reservation in northern Washington State known to have cyanobacteria blooms. Fish will be analyzed raw, seared, boiled and baked. Fish also will be tested for the cyanotoxin microcystin using two immunoassay (ELISA) tests and liquid chromatography (HPLC) coupled with a mass spectrometer.

Expected Results

It is expected that the cyanotoxin microcystin will be found in trout collected from lakes with cyanobacteria blooms. The results from this study will be used in conjunction with a fish consumption survey recently conducted by the Colville Confederated tribes and the U.S. Environmental Protection Agency. Positive microcystin concentrations measured throughout the summer then can be transformed into a dietary exposure assessment using information collected in the consumption survey. These exposure profiles will be used to form risk assessments to identify the degree of risk being posed to tribal members.

Potential to Further Environmental/Human Health Protection

With the dependency on fish as an inexpensive protein source for both tribal and other communities worldwide, a better understanding of the potential for trophic transfer of cyanotoxins is necessary. Determining the levels of the most common cyanotoxin, microcystin, in fish tissue will help communities reliant on consuming fish from polluted lakes determine dietary exposure assessments for fish and other aquatic biota. Identifying risks associated with consumption of microcystin will help communities determine mitigation practices for improving water quality and decreasing the occurrence of cyanobacteria.
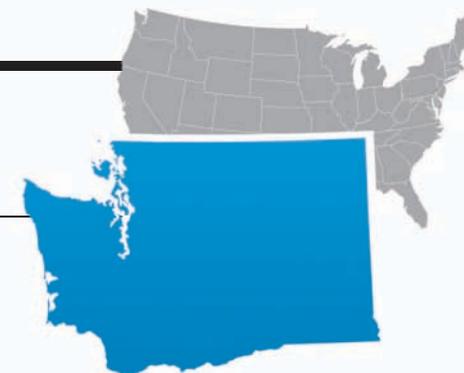
Lani M. Tsinnajinnie
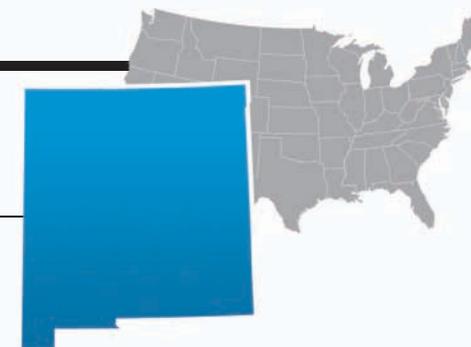
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Project Period: 8/21/2012 - 8/20/2015
Project Amount: $126,000
Environmental Discipline: Hydrology

Keywords: climate change, mountain hydrology, water resources

Bio

Lani Tsinnajinnie received a B.S. degree in Environmental Science and a B.A. degree in Native American Studies from the University of New Mexico in 2007. She also received a Master of Water Resources degree from the University of New Mexico in the spring of 2011. The following fall, she started a Ph.D. program in Hydrology at the New Mexico Institute of Mining and Technology. Her current research is investigating the hydrologic responses of mountainous watersheds to climate change in the Navajo Nation.

Synopsis

Snow-dominated mountainous watersheds play an essential role in the water resources of the Southwest. A hydrologic study featuring the development of a hydrologic model will be used to increase the understanding of the ground water and surface water systems in the Chuska Mountains, located in the central part of the Navajo Nation. This study will help Navajo communities surrounding the Chuska Mountains plan for the potential impacts of climate change and other environmental impacts.

Sustainability of Mountain Sources of Water for the Navajo Nation Under the Impact of Climate Change

Objective(s)/Research Question(s)

Through data collected by the Navajo Nation Department of Water Resources (NNDWR) and through additional field data collected, the study intends to develop a coupled ground water/surface water hydrologic model that will synthesize data and improve the understanding of the hydrologic and environmental systems of the Chuska Mountains. The study will use the model to increase the understanding of how surface water and ground water in the Chuska Mountains interact, the role the Chuska Mountains play in recharging aquifers and generating streamflow, and how the surface water and ground water in the Chuska Mountains will respond to climate change and other environmental changes, such as land use/land cover.

Approach

The hydrologic model will be developed by using and coupling modeling programs such as the Precipitation Runoff Modeling System (PRMS) and MODFLOW. Climatic and hydrological data will be requested from the Navajo Nation and other agencies. Field observations, data collection and development of the model will provide a better overall understanding of the hydrologic systems in the Chuska Mountains. After the model is calibrated and tested, different climate and environmental scenarios, such as snowpack variability and land use/land cover changes, will be run by the model to estimate the impacts of climate change and other environmental changes to water resources of the Chuska Mountains.

Expected Results

This model may assist Navajo communities to implement strategies that prepare the communities for impacts of climate change. Other tribes may be encouraged to develop similar hydrologic models to help understand the hydrologic responses of climate change in their area and how it may affect their communities. The information provided by these models could be coupled with local and traditional knowledge of tribal members in comprehending the impacts of climate change in their communities. Further understanding of the potential impacts of climate change created by this model will help the Navajo Nation look towards advancing the sustainability of the environment and communities. If tribal leaders and community members act proactively in preparing for climate change and become sustainable, they may no longer be seen as the most vulnerable populations to the changing climate.

Potential to Further Environmental/Human Health Protection

Some benefits of this study include helping ranchers and farmers determine when and where there may be water shortages. For those communities that depend on ground water recharged from the Chuska Mountains, the model also will help inform how climate change would affect their sources of drinking water. Additionally, the hydrologic model will help identify how any water contaminants in the Chuska Mountains may be distributed.

SAFE &
SUSTAINABLE
WATER RESOURCES

Water is the driving force of all nature.
– Leonardo da Vinci

Drinking Water

Timothy Michael Byrne
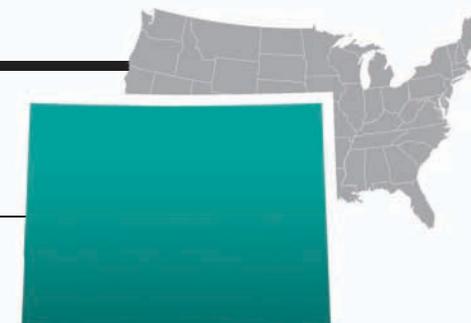
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Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: activated carbon, natural organic matter, drinking water treatment

Bio

Tim Byrne graduated with a B.S. degree in Engineering Science with a minor in Environmental Engineering in 2010 from The Pennsylvania State University. He then continued to pursue an M.S. degree in Environmental Engineering in the following fall and completed the degree in 2012. His research has focused on application of tailored, activated carbon materials for drinking water applications. In 2012, he will begin a Ph.D. in Environmental Engineering at the University of Colorado, Boulder, focusing on activated carbon adsorption for treatment of environmental drinking water contaminants, including disinfection byproduct precursors from wildfire impacted watersheds.

Synopsis

Emerging sources of environmental contamination threaten the safety of the world's drinking water supply. As the world population continues to rise and problems of freshwater scarcity increase, sustainable and cost-effective treatment methods must be developed to maintain purveyance of safe drinking water from freshwater supplies that are subject to emerging threats. One of these threats is the change in water quality, especially the character of dissolved organic matter, caused by environmental events such as wildfires. The altered water quality affects the ability of impacted water utilities to meet treatment goals and regulations. The proposed research aims to understand the impacts of wildfires on water quality, especially disinfection byproduct precursor formation, and to evaluate the ability of activated carbon for mitigation of the associated impacts of these events.

Tailored Activated Carbons for Sustainable Removal of Environmental Contaminants

Objective(s)/Research Question(s)

What impact do extreme environmental events such as wildfires, hurricanes and floods have on the water quality of impacted watersheds and what challenges do they present to drinking water treatment? This research aims to better understand the water quality changes, especially changes in natural organic matter that result when wildfires occur in a watershed. In addition, the treatability of these waters will be explored with conventional water treatment techniques and tailored activated carbons.

Approach

This research will study the impact of wildfire on the source water quality of impacted Colorado watersheds by characterizing the natural organic matter along with other common water parameters (i.e., pH, alkalinity and turbidity) for samples taken at different locations within these watersheds. Removal of natural organic matter will be evaluated for activated carbons produced from various lignocellulosic materials and will be related to surface chemistry and porosity data from the activated carbons. This removal will be compared with other conventional water treatment techniques.

Expected Results

The natural organic matter of wild-fire impacted watersheds is altered due to the combustion and pyrolysis of lignocellulosic and other organic materials that occur during the fire. These processes can alter greatly the composition and structure of the dissolved organic matter (DOM), which transports into the surface water. The DOM profiles are unique from that of a healthy, un-impacted watershed and are expected to produce different disinfection byproducts upon disinfection. The character of the DOM will be monitored throughout a watershed and at different points in a full-scale drinking water treatment plant, which can help to explain the mechanisms involved in DOM creation, transformation and removal. In addition, different types of activated carbon will be tested, and removal will be related to different characteristics of the activated carbon properties.

Potential to Further Environmental/Human Health Protection

Because humans depend on safe drinking water sources to maintain their well-being, an understanding of the effects of environmental events on drinking water sources is essential to protecting this precious resource. In addition, the development of economically and environmentally sustainable treatment options will help water utilities ensure a safe drinking water supply despite emerging environmental contaminants.

Kerri Leah Hickenbottom
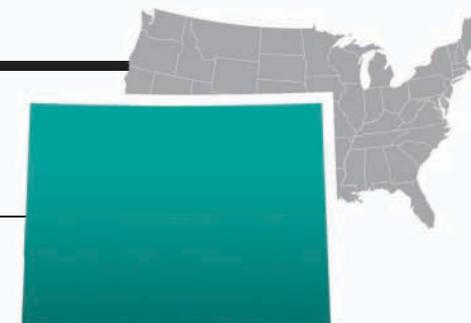
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Civil/
    Environmental Engineering

Keywords: membrane processes, water reuse, resource recovery

Bio

Kerri Hickenbottom became involved in membrane research as an undergraduate at the University of Nevada, Reno (UNR), where she graduated in 2010 with her B.S. degree in Civil Engineering. She continued her research as a Master's student at the Colorado School of Mines, where currently she is pursuing a Ph.D. in Environmental Science and Engineering. Her research interests are in advanced wastewater treatment processes for water and wastewater reuse, sustainable design, and systems for natural resource and energy recovery. Her research focuses on applying hybrid membrane processes for decentralized brine management and mineral production.

Synopsis

To alleviate global water stress, water resource management requires a paradigm shift from waste to reuse. Decentralized wastewater treatment systems will have to operate at high water recovery and thus will need to efficiently and economically desalinate brines. Waste-to-reuse systems using commercial and novel membrane technologies could be essential in managing brines, by maximizing water recovery and enabling mineral and nutrient production while utilizing local renewable energy sources.

Waste-to-Resource: Novel Membrane Systems for Safe and Sustainable Brine Management

Objective(s)/Research Question(s)

Advanced membrane separation processes such as membrane distillation (MD) and electrodialysis (ED) will be used to facilitate recovery of unconventional impaired water resources and enable tailored water reuse, in which water of different types can be reused beneficially for different applications. ED and MD have the potential to operate at or above saturation concentrations, but the mechanisms of heat and mass transport and membrane fouling and scaling (and their reversibility) must be further explored. To address the limitations of ED and MD, this project will elucidate scaling and fouling mechanisms and optimize system performance of these processes and their hybrids.

Approach

A systems-based approach will be used to evaluate how ED/ED reversal (EDR) and MD are integrated in decentralized water treatment systems, and will address how the economics and environmental implications of decentralized water treatment systems affect the broader public. The performance of ED/EDR and MD will be optimized in terms of water flux, solute rejection, energy consumption and recovery, and long-term operation through a methodical bench- and laboratory-scale investigation with increasing source water complexities and varying operating conditions. Hybrid and individual processes will be evaluated to treat site-specific source waters for beneficial uses. Once these processes are optimized, pilot-scale systems will be deployed at test-bed facilities to evaluate the economics and performance of these processes on a larger scale. Novel flux restoration techniques will be implemented to mitigate membrane scaling and sustain high water fluxes.

Expected Results

Decentralized waste-to-reuse systems will be optimized to maximize resource and energy recovery and minimize chemicals and energy use. This research will enhance fundamental knowledge on simultaneous heat and mass transport through membranes, lower process costs, and further address the range of treatment of hybrid and individual membrane processes. Results from the life cycle and cost assessment as well as the design program will have an impact on promoting the use of technologies in new applications.

Potential to Further Environmental/Human Health Protection

This research can aid in transforming how water and other natural resources are managed effectively. Discharge of high salinity waters, which can lead to ecosystem damage, surface and ground water contamination and land consumption, will be mitigated with the proposed systems. Optimization of these processes ultimately will aid in recovering valuable mineral resources for beneficial use and in supplying a low-cost, safe and sustainable water source that broadly is accessible to developed and advancing countries.

Devin L. Shaffer

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Project Period: 8/29/2012 - 8/28/2015
Project Amount: $126,000
Environmental Discipline: Environmental Engineering

Keywords: desalination, membrane fouling, surface modification

Bio

Devin Shaffer is a Ph.D. student at Yale University. His research interest is improving the performance and sustainability of membrane desalination processes for seawater, brackish water and wastewater treatment. He is a graduate of Oklahoma State University and the Massachusetts Institute of Technology. After a career as a consulting engineer, he was inspired to pursue a Ph.D. to contribute to technological innovations that create new, high-quality, more sustainable water supplies.

Synopsis

Desalination technology can help solve water quality and water supply challenges by treating abundant seawater and brackish water sources to a high quality for a variety of uses. Membrane fouling and scaling limit the use of membrane desalination by reducing its performance and increasing its energy requirements. This research aims to modify the surface of desalination membranes to reduce the attachment of fouling bacteria and minimize the surface crystallization of scaling minerals.

Improving the Quality, Availability and Sustainability of Drinking Water Supplies Through Antifouling and Antiscaling Desalination Membranes

Objective(s)/Research Question(s)

The objective of this research is to advance membrane desalination technology by reducing the fouling and scaling propensity of thin-film composite desalination membranes through surface modification. Modifying the membrane surface layer to increase the hydrophilicity and decrease the roughness will impart biofouling and scaling resistance by reducing both the attachment of bacteria and the surface crystallization of inorganic precipitates.

Approach

Coating and grafting techniques will be employed to attach poly(vinyl alcohol) and poly(ethylene glycol) polymers to the surface of thin-film composite desalination membranes. These polymers render the membrane surface layer smoother and more hydrophilic. The fouling and scaling resistance of the grafting and coating techniques using different polymers and membranes will be assessed through bench-scale experiments. Biofouling and scaling feed water conditions will be simulated, such as those that might exist for seawater desalination or desalination of brines from brackish water treatment plants. The effects of surface modification on the transport and structural properties of the membranes will be characterized using a laboratory-scale membrane filtration unit.

Expected Results

Surface modification with the selected polymers is expected to reduce the fouling and scaling propensity of desalination membranes by strongly binding water at the membrane surface. Foulants will interact with this bound water layer and not with the membrane surface itself. Reductions in the irreversible attachment of bacteria, an important step in biofilm formation, and the surface crystallization of inorganic precipitates are expected. Some tradeoffs between improved fouling and scaling resistance of the modified membranes and reduced membrane water permeability and salt rejection are anticipated. This work will contribute to an understanding of how the surface modification techniques and conditions affect membrane transport properties.

Potential to Further Environmental/Human Health Protection

Fouling and scaling resistant membranes will improve the sustainability and reduce the costs of desalination by improving membrane performance, reducing cleaning frequency and intensity, and extending membrane life. Lowering these barriers to implementing membrane desalination technology can help alleviate water quality and water supply problems for communities in diverse geographic areas. Implementing desalination also reduces stress on existing freshwater supplies so that they may be preserved for ecosystem benefits.

SAFE & SUSTAINABLE WATER RESOURCES
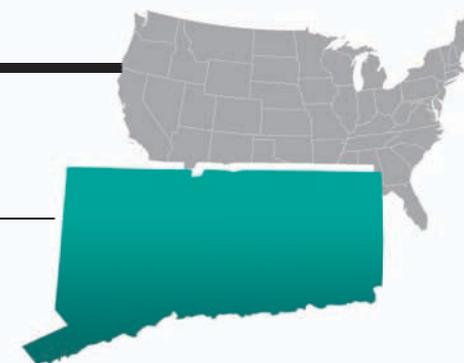
The activist is not the man who says the river is dirty.
The activist is the man who cleans up the river.

–Ross Perot

■ Water Quality

Jessica A. Bryant

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Marine Sciences

Keywords: marine microbial ecology, plastic pollution

Bio

Jessica Bryant received a B.S. degree from the University of California, Santa Cruz in 2005. Afterwards, she worked on a variety of research projects, including quantifying carbon stocks in tropical forests and investigating bio-diversity in the Rocky Mountains. She entered the Civil and Environmental Engineering Ph.D. program at the Massachusetts Institute of Technology in 2012. Her research interests include microbial diversity, microbial processes, genomics and environmental protection.

Synopsis

Plastic debris is a common pollutant and major threat to marine ecosystems, but little is known about the fate of plastic when it enters an ocean. Microorganisms (bacteria, archaea and microeukaryotes) likely play a key role because they are metabolically diverse and colonize plastic debris rapidly. This research explores the microbes inhabiting plastic debris to uncover if and how they are degrading plastics in the ocean and if plastic is impacting the types of microbes in marine ecosystems.

Interactions Between Plastic Debris, Persistent Organic Pollutants and Microorganisms in Ocean Surface Waters

Objective(s)/Research Question(s)

Microorganisms are likely important players in the lifecycle of plastic debris that reaches marine environments. The aim of this research is to uncover what types of microorganisms are colonizing plastics in marine surface waters and whether they differ from free-living and natural particle-associated strains typically identified in the ocean. This research also will investigate how plastic-associated microbes obtain nutrients and energy and if and how plastic-associated microorganisms are degrading plastic or persistent organic pollutants commonly bound to plastic particles.

Approach

Field surveys will be used to observe naturally forming plastic-associated microorganisms and controlled incubation experiments to observe the chemical processes mediated by these microbes. Community genomic and transcriptomic sequencing techniques will be used to characterize microbial communities. Community genome sequencing (metagenomics) uncovers the identity of microbes and provides a "parts list" of the genes these microbes can utilize to survive. Community RNA sequencing (metatranscriptomics) uncovers which microbes are active within a community and what genes they are expressing and therefore likely using.

Expected Results

The chemical structure of plastics greatly differs from natural marine particulate matter and therefore plastics likely are creating new and unique niches for microorganisms in the ocean. It is hypothesized that the microbes found on plastic particles will be taxonomically and functionally distinct from free-living and natural particle-associated marine strains. Microorganisms have been observed degrading types of plastics in several environments, so it is likely that this will be similarly observed. It is predicted that the degradation process will vary, depending on nutrient concentrations in the water.

Potential to Further Environmental/Human Health Protection

This work will deepen the understanding of the microorganisms that colonize plastics in marine systems. This may help material scientists engineer more ecofriendly plastics that can be readily biodegraded in the marine environment. This work will increase the understanding of the lifecycle of plastic debris when it enters the ocean. This information is fundamental to developing better informed plastic pollution management and policy decisions.
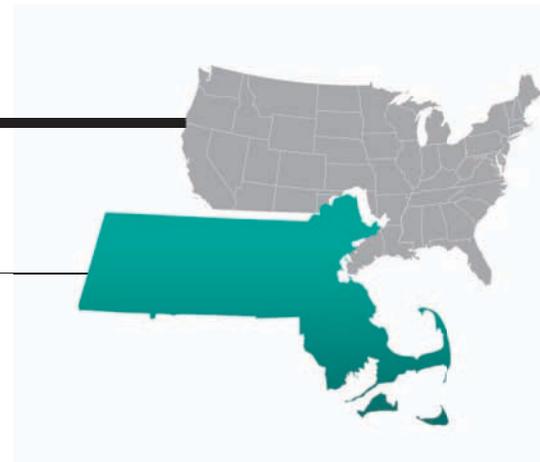
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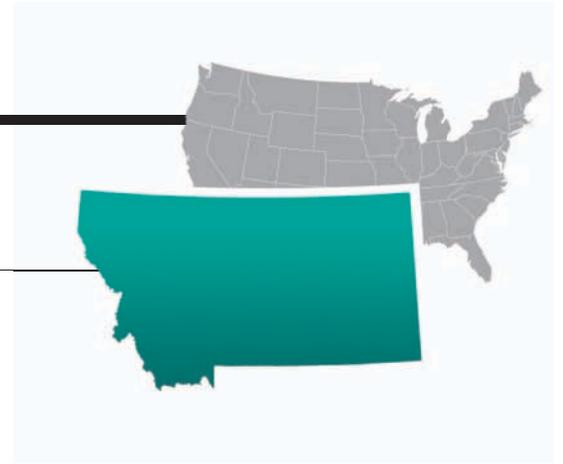
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $126,000
Environmental Discipline: Environmental
   and Water Science

Keywords: ecogeomorphology, ecosystem services, non-point source pollution

Bio

Sharon Bywater-Reyes received a B.S. degree in Geology from Southern Oregon University in 2007 and an M.S. degree in Geology from the University of Wyoming in 2009. In 2011, she entered the Ph.D. program in Geosciences at the University of Montana. Her research focuses on thresholds and feedbacks between pioneer riparian plants and fluvial geomorphic processes.

Synopsis

Riparian areas buffer the negative effects of floods, climate change and pollution. In the American Southwest, river regulation and invasion of salt cedar have resulted in a reduction of native cottonwood forests. To maintain the ecosystem services associated with these forests, the feedbacks between pioneer woody trees and fluvial processes must be understood. This research will investigate the conditions under which cottonwood seedlings survive in the riverine environment.

Applying Ecogeomorphology to Restoration and Management of Native Riparian Ecosystems

Objective(s)/Research Question(s)

This research aims to: (1) characterize vegetation-hydrogeomorphic interactions at a variety of scales; and (2) explore management scenarios that would encourage the recruitment of native species via a calibrated hydraulic model that incorporates the effect of vegetation and sediment routing.

Approach

The study will use the Bill Williams River, AZ, as the field site for this research. Topographic change resulting from a flood release from Alamo Dam will be measured with traditional surveying techniques as well as cutting-edge, ground-based LiDAR technology. This will allow for scaling of point densities, depending upon the spatial scale being measured. Scour and deposition will be quantified and related to vegetation characteristics to understand how vegetation affects sediment transport and erosional processes. Recruitment of pioneer vegetation will be monitored and the interactions with sediment transport measured.

Expected Results

It is expected to find differential sediment transport patterns between species (native cottonwood vs. invasive salt cedar) and size classes of woody trees, and at various spatial scales. Salt cedar is expected to trap greater volumes of sediment compared to cottonwood and may prevent it from scouring. Thresholds are expected to be found above which an increase in size of plants does not have a significant effect on sediment transport processes. Additionally, different processes are expected to be significant at different spatial scales.

Potential to Further Environmental/Human Health Protection

This research will provide scientists and managers with important knowledge concerning the effects of woody riparian tree species on sediment routing, having implications for controlling nonpoint source sediment pollution. Additionally, this research will inform restoration efforts of native riparian areas by revealing the conditions under which native riparian plants can recruit and persist, preserving the important ecosystem services that riparian areas provide.

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Oceanography

Keywords: virus, phytoplankton, harmful algal bloom

Bio

Michael Carlson received his B.A. degree in Biology and History from Pomona College in 2008. He began pursuing his Ph.D. in Oceanography at the University of Washington the following year and uses genomic approaches to understand the ecology of marine viruses. His research focuses on viruses that infect eukaryotic phytoplankton, specifically the toxigenic diatom *Pseudo-nitzschia*.

Synopsis

Pseudo-nitzschia is a diatom capable of producing the neurotoxin, domoic acid (DA). Biomagnification of DA during blooms leads to marine fauna mortality, threatens human health and causes economic repercussions for shellfisheries. DA production is variable by species and environment, making prediction of toxic blooms difficult. This research will use genomic methods to explore how viruses, the most abundant predators in the ocean, influence *Pseudo-nitzschia* communities in the Pacific Northwest.

Genome Enabled Ecology of *Pseudo-Nitzschia* Infecting Viruses and Their Impact on *Pseudo-Nitzschia* Communities

Objective(s)/Research Question(s)

To understand how viruses influence *Pseudo-nitzschia* community dynamics, a model host-virus system will be established with an isolated and characterized *Pseudo-nitzschia*-infecting virus. Using genome-enabled methods, the biogeography of *Pseudo-nitzschia* infecting viruses and their impact on *Pseudo-nitzschia* assemblages in the Pacific Northwest will be assessed.

Approach

A virus that infects the highly toxigenic *Pseudo-nitzschia* multiseries will be isolated and characterized. The study will sequence its genome and compare it to previously sequenced diatom virus genomes, the publically available *P.* multiseries genome, and viral metagenomes. Based on the diversity of *Pseudo-nitzschia* virus-like genes observed in the metagenomic data and the other diatom virus genomes, quantitative polymerase chain reaction assays will be designed to specifically target *Pseudo-nitzschia* infecting viruses, which will be used to quantify their abundance in the environment. The Pacific Northwest Region will be the focus of field research not only because of its robust oceanographic monitoring, but also because of the numerous economic, cultural and social interests invested in this region. The study will establish three sampling schemes to understand how viruses and their co-occurring hosts change in space, seasonally and over the course of individual blooms. The study also will use a DNA fingerprinting technique to quantitatively characterize the *Pseudo-nitzschi*a community diversity. The molecular data of both *Pseudo-nitzschia* and their viruses will be used to understand how viral mortality influences the diversity and abundance of *Pseudo-nitzschia* over seasonal cycles, contributes to bloom formation and demise, and drives regional differences between *Pseudo-nitzschia* communities.

Expected Results

With short infection cycles and large burst sizes (viruses per cell), the infection dynamics of diatom viruses appear to be optimized for rapidly growing diatom populations. On the timescale of bloom events, total *Pseudo-nitzschia* virus abundance should increase rapidly over the course of the bloom, while *Pseudo-nitzschia* abundance conversely should decline once a critical concentration of viruses is reached in the water column. If viruses are the cause of decline of a toxic bloom, by the nature of lysis, which releases cell contents into the water column, cellular domoic acid would be converted to dissolved DA and not be transferred up the food web. Additionally, this decline of *Pseudo-nitzschia* should lead to a shift in the overall phytoplankton community to either other diatom genera or other phytoplankton groups. Over the course of the season, *Pseudo-nitzschia* virus abundance should be correlated with diatom abundance and therefore be highest in the spring and summer. However, changes in the species composition of *Pseudo-nitzschia* communities, which generally shift from low toxin producers in the spring to high toxin producers in the fall, should be reflected in changes in viral diversity as well. Finally, both viral selection and environmental conditions lead to the various distinct *Pseudo-nitzschia* communities found in the Pacific Northwest.

Potential to Further Environmental/Human Health Protection

Understanding *Pseudo-nitzschia* viruses has several implications for the field dynamics of the diatoms it infects, such as limiting the duration and mediating the impact of toxic *Pseudo-nitzschia* bloom events. Ultimately, understanding how *Pseudo-nitzschia* communities are changing in space and time is critical to the development of models that seek to forecast potentially toxic events and can aid in the protection of commercial interests and public health.

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Oceanography

Keywords: carbon export, estuaries, ecosystem metabolism

Bio

Jamie Collins received a B.A. degree in Political Science from Yale College in 2004. After serving for 5 years in the U.S. Coast Guard, in 2011 he earned a Master's degree in Environmental Science from the Yale School of Forestry and Environmental Studies. He currently is pursuing a Ph.D. in Chemical Oceanography in the Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program. His research interests include the role of microbial respiration in marine ecosystems, mechanisms of cell-cell signaling in marine microorganisms and oceanographic instrument development. His present research centers on degradation pathways of polar lipids produced by marine phytoplankton.

Synopsis

Millions of Americans benefit from critical ecosystem services provided by estuaries. Among these services is a carbon processing capacity that transforms anthropogenic organic matter as it is exported to the ocean. This capacity can be impaired by stressors such as eutrophication and global temperature change. The study will use intact polar lipids, a class of unique structural compounds that comprise 10 to 20 percent of cells in marine plankton, as real-time indicators of environmental stress in coastal ecosystems.

Characterizing the Transformation and Metabolism of Anthropogenic Organic Matter in Estuaries Using Intact Polar Lipids: A Biomarker Approach to Ecosystem Health Assessment

Objective(s)/Research Question(s)

This research will use intact polar lipid biomarkers to characterize the combined, synergistic effects of multiple environmental stressors on the processing of anthropogenic organic matter in two Massachusetts estuaries. By characterizing and quantifying the various polar lipids produced by species in the two ecosystems across a broad range of nutrient loading conditions and temperatures, the study will demonstrate the efficacy of these unique compounds as diagnostic indicators of ecosystem function.

Approach

Work will be conducted in two estuaries in coastal New England, each of which is subjected to different anthropogenic stressors. Using observations from in situ instruments and samples collected for laboratory analysis, the effects of environmental conditions on the biosynthesis and respiration of intact polar lipids by bacteria and algae will be assessed, the two groups that constitute marine plankton. Polar lipid analysis will be performed using novel techniques in high-performance liquid chromatography/mass spectrometry. Compound-specific stable and radio-isotope analysis will be used to identify the fate and origin of the organic matter that comprises each group of molecules. The daughter compounds produced through degradation and respiration of the intact polar lipids then will be identified and analyzed for their potential role in cell-cell communication under environmental stress.

Expected Results

Because polar lipids are critical structural components of all planktonic cells, it is expected that anthropogenic stressors will be found to alter substantively the relative proportions and types of polar lipids produced by various species in the two ecosystems. In addition, it is expected that changes in polar lipid concentrations will be predictive in each estuary of the rate of community metabolism, a key determinant of water quality and ecosystem health.

Potential to Further Environmental/Human Health Protection

This research will yield a new, highly sensitive metric for assessing the health of coastal marine ecosystems. In addition, it is hoped that several compounds of potential biomedical interest will be isolated and identified that are produced through the degradation of polar lipids.
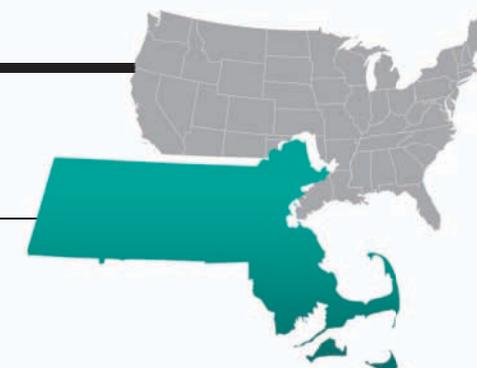
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Project Amount: $126,000
Environmental Discipline: Environmental Chemistry

Keywords: dissolved organic carbon (DOC), acid mine drainage (AMD), toxic heavy metals

Bio

Kato Dee received B.S. (1997) and M.S. (2001) degrees in Geology from the University of Kansas. He then was employed in the environmental consulting industry for 5.5 years as a hydrogeochemist and as a Project Manager, and later as a faculty member in the Natural Resource Management program at Colorado Mountain College. He started his Ph.D. program in Geochemistry at the Colorado School of Mines in 2009. His current research focuses on the dissolved organic carbon (DOC) characteristics in acid mine drainage (AMD) impacted surface water and implications on copper toxicity.

Synopsis

AMD continues to be a significant source of toxic heavy metals in the Rocky Mountain Region. Water that has been affected by AMD includes characteristics of lowered pH, increased concentration of heavy metals, and a stressed or non-existent aquatic ecosystem. This research will examine the characteristics of DOC in impacted surface water as related to source, fractionation processes and reduction of the toxicity of copper in aquatic organisms.

Dissolved Organic Carbon Characteristics in Metal-Rich Waters and the Implications for Copper Aquatic Toxicity

Objective(s)/Research Question(s)

This research will test two main hypotheses. First, fractionation of DOC occurs when it is partially removed from stream water by adsorption to precipitated hydrous iron (HFO) and hydrous aluminum oxides (HAO). Secondly, the remaining DOC will have poorer metal binding properties than the fraction that sorbs to the HFO and HAO. An alternative hypothesis also will be examined, namely that variations in DOC characteristics will arise from differences in source (i.e., wetlands, streams, etc.), and this will be more significant than fractionation in defining DOC metal binding properties. The consequence of these processes is that the protective effects of DOC with respect to aquatic metal toxicity will be reduced.

Approach

The sample collection and analysis methods will focus on aqueous and sediment media associated with AMD impacted aquatic systems that will test the hypothesis. Sites are selected for this research based on their watershed environment and if they are known to have been impacted by AMD. Samples collected at each site will include analysis for metals, water quality parameters (i.e., pH, conductance, etc.), major anions (i.e., sulfate [SO_4], chlorine [Cl], etc.), alkalinity and dissolved oxygen. Sediment from each site will be leached with a mild acid to release adsorbed metals and DOC. These results will provide a thorough chemical profile at each site and the impact of AMD. The fulvic acid component of DOC in each sample will be isolated for later use for ultraviolet-visible spectroscopy (UV/VIS) and fluorescence, toxicological and fractionation characterization.

Expected Results

This research will aim to quantify the effects of fractionation between DOC, HFO, HAO, free copper and the behavior of resultant free DOC in the water column on the toxicological effects of copper. Fractionation between DOC, free metals and iron (Fe) and aluminum (Al) hydroxides will be examined further in this research, particularly in AMD impacted aquatic systems that have variable Fe, Al and DOC chemistry. This variable chemistry likely will demonstrate differences in DOC fractionation with the free metal and HFO/HAO components. It is anticipated that the fraction of DOC remaining in the water will have lesser binding capacity than the fraction that has undergone adsorption or complexation with other ligands. The "depleted" DOC fraction will be characterized by specific UV absorbance and excitation-emission matrix (EEM) analyses. Moreover, the resultant DOC-Copper (Cu) species is especially important for aquatic toxicology applications. A better understanding of the DOC fractionation characteristics as related to bioavailability of free metal ions will provide significant acute and chronic LC50 data to more accurately represent metal-laden AMD impacted waters.

Potential to Further Environmental/Human Health Protection

Results from this project potentially will have significant regulatory impacts that will provide a continuum to improving water quality for human health and aquatic ecosystems. This project likely may provide some better insight to the effectiveness of DOC-rich effluent from treatment systems in mitigating the toxicological effects of heavy metals. As a result, this technology may aid efforts to improve the health of numerous fisheries impacted by AMD originating from abandoned mines and thus potentially lead to improved recreational opportunities and tourism. Regulatory decisions based on utilizing the Biotic Ligand Model for water quality certification standards likely will be enhanced by this research.
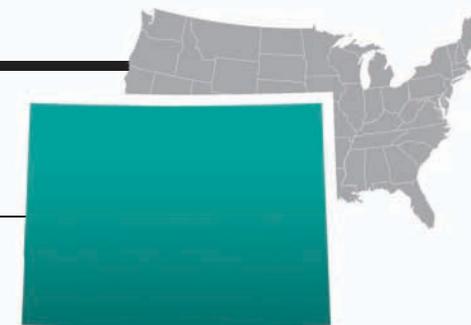
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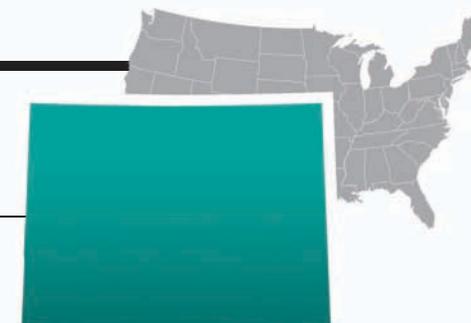
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Project Period: 8/1/2012 - 7/31/2015
Project Amount: $84,000
Environmental Discipline: Environmental Engineering

Keywords: hydraulic fracturing fluids, ground water contamination, contaminant transport modeling

Bio

Jessica Dehart received a B.A. degree in English with a Minor in Hydrology from the University of Colorado in 2012. In the fall of 2012, she will start the M.S. program in Environmental Engineering at the University of Colorado. Her research interests include contaminant fate and transport in natural waters and groundwater hydrology. Her current research is predictive modeling of the environmental behavior of hydraulic fracturing fluid chemical additives.

Synopsis

As the practice of hydraulic fracturing rapidly expands, there is increasing concern about the potential environmental impacts such as the effects on groundwater quality. This research proposes to apply experimentally derived rates of primary removal mechanisms to a ground water model to predict the environmental behavior of organic hydraulic fracturing fluid compounds. The model will identify persistent compounds with a high likelihood for transport, including potential organic tracers.

Experimental Analysis of the Environmental Behavior of Hydraulic Fracturing Fluid Compounds Prioritized by Potential of Environmental or Health Risk

Objective(s)/Research Question(s)

As the practice of hydraulic fracturing rapidly expands, there is increasing concern about potential environmental impacts, including effects on ground water quality. Challenges to understanding potential impacts include limited data on the environmental behavior of fracturing fluid additives as well as insufficient analytical methods to detect evidence of transport. This research experimentally will derive the degradation kinetics and subsurface transport mechanisms of prioritized categories of organic contaminants, and subsequently build a predictive model of the environmental behavior of fracturing fluid organic additives introduced to shallow ground water drinking resources.

Approach

Organic compounds will be selected for experimental study of degradation and transport out of two possible categories: potential environmental risk and potential fracturing fluid tracers. Column tests will be used to inject pulses of known masses of the selected organic compounds in addition to a conservative tracer into an aquifer material. To compare the relative importance of sorption to degradation as primary removal mechanisms, batch reactors will be used to experimentally derive degradation rates under anaerobic conditions. The experimentally derived physiochemical data then will be applied to a ground water model to test the fate and transport of the compounds under varying subsurface conditions.

Expected Results

Given the large number of chemical additives used in hydraulic fracturing fluids, it is not practical to conduct a comprehensive analysis in cases where contamination is suspected. The fate and transport model can identify compounds with high likelihood for transport and persistence out of the hundreds possible, given the hydrogeologic conditions for a particular site. Additionally, the model may be applied to identify non-conservative organic compounds as tracers for evidence of fracturing fluid migration. The use of organic compounds as tracers could increase confidence in assessment of the environmental impact of hydraulic fracturing, particularly in cases where baseline water quality data are not available. This is due to the fact that many of these compounds would be unlikely to appear in water samples due to the natural background geochemistry or alternative anthropogenic sources.

Potential to Further Environmental/Human Health Protection

Water and energy are two basic needs of society. There is a great amount of potential to further develop natural gas as a domestic energy source; however, the risk to human and environmental health is not fully understood. Improved knowledge about the environmental behavior of fracturing fluid compounds, as well as more reliable analytical methods such as the use of organic tracers, may allow for better management by environmental regulators regarding potential contamination of ground water resources.

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Project Period: 9/1/2012 - 8/31/2015
Project Amount: $126,000
Environmental Discipline: Environmental and Water Science

Keywords: mercury, eutrophication, bioaccumulation

Bio

Kenly Hiller received a B.A. degree in Biology (Ecology track) from Connecticut College in 2011. The following year, she started a Ph.D. program in Environmental Biology at the University of Massachusetts at Boston, MA. Her research interests include the biogeochemical cycling of nitrogen in estuaries and the ways in which microbial communities can influence this cycle. Her current research will discover whether an experimental method to reduce nitrogen loading to coastal systems actually is worsening toxic mercury concentrations.

Synopsis

This project will determine if NITREX barriers are increasing mercury concentrations in Waquoit Bay. The barrier consists of woodchips buried under a beach that intercept the ground water flowing into the bay and that remove the nitrate that fuels eutrophication. It is effective at stopping nuisance algae growth, but it also harbors sulfate-reducing bacteria. They can methylate mercury that also is present in ground water and make it more toxic. If the results show increased methylmercury concentrations, the town of Falmouth, MA, will have to curtail its plans to install a larger test barrier.

Effects of a Permeable Reactive Barrier on Denitrifying Bacteria Communities and Methylmercury Concentrations in Waquoit Bay, MA

Objective(s)/Research Question(s)

A new approach to mitigating nutrient loading called a permeable reactive barrier has been installed at Waquoit Bay, MA. This barrier intercepts ground water and provides a carbon source for an increased population of denitrifying bacteria. These bacteria scrub ground water of the excess nitrate that fuels eutrophication. However, the barriers also support increased populations of sulfate-reducing bacteria, which have the ability to methylate the large amounts of mercury coming in through the ground water. Only geochemical studies have been conducted on the barrier so far, so this study aims to characterize the denitrifying bacteria in the barrier to determine how populations differ from a control beach. It also aims to measure the amount of toxic methylmercury entering the bay as a result of the barrier.

Approach

To determine if denitrifying bacteria in the barrier are distinct from denitrifying bacteria from control sites, the study will build clone libraries from ground water at both sites to look at the genetic diversity and phylogeny of the bacteria. To determine mercury concentrations, the study will measure mercury levels in the ground water throughout three seasons (summer, fall and spring because microbial activity is probably very low during the winter). Finally, the study will measure mercury concentrations in benthic infauna once a year (at the end of summer after the period of highest microbial activity) to see whether toxic methylmercury is being bioaccumulated in the food web. If this is the case, the study also will characterize the genetic variability of sulfate-reducing bacteria.

Expected Results

It is expected that microbial denitrifying bacterial communities in the barrier will be distinct from those at control sites due to the high amount of degradable carbon and the unique redox conditions present within the barrier. It also is expected that toxic methylmercury concentrations will be elevated downgradient from the barrier relative to control sites because of the presence of sulfate-reducing bacteria (indicated by the production of hydrogen sulfide). If they are methylating even one-tenth of the mercury coming in from ground water, it might be enough to accumulate in fish tissue.

Potential to Further Environmental/Human Health Protection

Methylmercury is the most toxic form of mercury in terms of bioaccumulation. Very small concentrations in the water column are enough to biomagnify to fish tissue, so if the barriers are contributing a significant amount of methylmercury, the Town of Falmouth cannot continue with its plan to install a 300-meter long test barrier despite its efficiency at mitigating eutrophication.
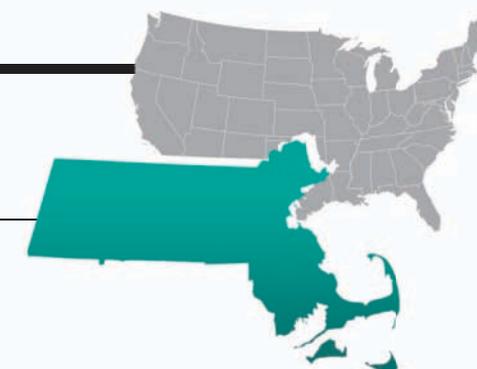
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Project Period: 8/16/2012 - 8/15/2015
Project Amount: $126,000
Environmental Discipline:
    Bio-Environmental Engineering

Keywords: wetland restoration, denitrification, DRAINMOD

Bio

Tiffany Messer received a B.S. degree in Biosystems and Agricultural Engineering from the University of Kentucky in 2008. She completed an M.S. degree and started a Ph.D. program in Biological and Agricultural Engineering at North Carolina State University in 2010. Her research interests include wetland and stream hydrologic, ecological and biogeochemical processes. Her current research will determine optimum hydraulic and nutrient loads for restored wetlands utilizing laboratory, field and modeling efforts.

Synopsis

Agriculture production is vital to the economy in coastal regions, but its successes have placed environmental pressures on shellfishing waters and wetland ecosystems. Strategic wetland restorations on farmlands could improve water quality and wetland ecosystems without overloading surrounding environments. This research will quantify optimum hydraulic and nutrient loads for a proposed wetland restoration utilizing laboratory-based research, coupled with field observations and modeling.

Predicting Impacts of Rerouting Drainage Water From the Pamlico Sound to Restored Wetlands—A Critical Component to Galvanize Stakeholder Cooperation

Objective(s)/Research Question(s)

Wetland restoration project partners need to know with certainty that drainage water moving from the restoration site will not impose negative hydrologic and water quality impacts downstream. Previous studies in the Albemarle-Pamlico peninsula in North Carolina have reported wetlands receiving agricultural drainage water to store water while reducing nutrients, sediment and fecal bacteria. However, controlled experiments have been difficult to complete, and wetland effectiveness is variable depending on such factors as soil type, loading rate and wetland to watershed ratio, which has made stakeholders hesitant to enroll land for wetland restoration projects. This research will determine with confidence the maximum hydraulic and nitrogen loads that can be diverted from the Pamlico Sound without negatively impacting downstream areas through the combination of field and wetland mesocosm observations coupled with modeling efforts. Additionally, socio-economic attitudes of project partners will be documented as this project progresses to determine how to build stronger bonds between stakeholders.

Approach

Six large wetland mesocosms containing two excavated wetland soils from future wetland sites in eastern North Carolina have been constructed in a greenhouse. Twenty-four batch studies will be conducted over a 2-year period in the mecososms with nitrogen pollutant loads typical of agricultural drainage water. Hourly nitrogen (N), carbon and dissolved oxygen concentrations and yearly biomass and soil samples will be monitored. Differences in nitrogen removals will be determined using a mass balance approach. Hydrologic monitoring and modeling efforts at the restoration site will be completed using water table elevation data loggers and water quality grab samples. Water table data, along with soil, crop and climatic data, will be used to calibrate the hydrologic model DRAINMOD to predict the volume of drainage water that can be pumped from the agricultural fields into the planned wetland restoration areas. The model will be validated by comparing predicted water levels to those measured in the wetland. Predicted N concentrations, from the model, will be compared to measured N concentrations at the inlet and outlet of the wetland mesocosms.

Expected Results

Denitrification, a microbially mediated transformation of nitrate to nitrogen gas that escapes from the wetland to the atmosphere, has been identified as the primary pathway for nitrogen removal in wetlands. Requirements for denitrification, which include anoxic conditions, carbon sources, suitable temperature and suitable pH conditions, are found in wetlands in the southeastern United States during most of the year. Therefore, nitrogen is expected to assimilate at a high level through physical and biogeochemical transformations while drainage water flows through the restored wetlands and will be significantly affected by carbon availability, nitrogen loading and water table fluctuations. Additionally, the completion of this project could lead to changes in local perceptions of conservation groups by the agricultural community, which may further lead to partnerships on larger projects that will have huge impacts on both coastal and economic conditions in eastern North Carolina and other coastal communities.

Potential to Further Environmental/Human Health Protection

The restoration project in this study has the potential to become the largest project of its type in North Carolina, and significantly improve water quality in the prime shellfish waters of the Pamlico Sound. This research project will be instrumental in galvanizing stakeholders with differing attitudes on wetland restoration success, and maximize the project's impact. Lost oyster beds and wetland hydrology could be recovered due to improvements in water quality and hydrology from this and future projects. Improvements in the ecology of the sound and adjacent forest, reduced fire risks and pumping costs, and a boost in the region's economy could be additional impacts. Findings will advance the scientific understanding of innovative ways to manage coastal resources, and will be utilized in outreach activities, such as extension workshops and community events, to solidify critical partnerships. This project could become a national model for how large-scale environmental projects can avoid sacrificing agricultural production while resulting in win-win projects for landowners, local citizens and the environment.
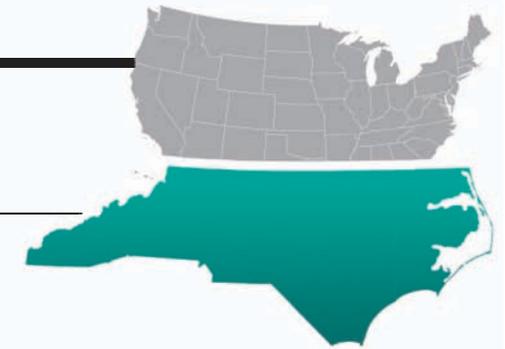
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Project Period: 8/20/2012 - 8/19/2015
Project Amount: $126,000
Environmental Discipline: Marine Sciences

Keywords: invasive plants, water quality, nonpoint source pollution

Bio

Molly Miller earned her B.S. (2006) and M.S. (2010) degrees from the University of South Alabama. With interests in aquatic plant physiological ecology and invasive biology, her current research will investigate species-specific differences in plant responses to nutrient availability and interplay between nitrogen and carbon metabolism as a means to better understand impacts of nutrient pollution and rising CO_2 levels on fragile, highly impacted coastal ecosystems.

Synopsis

Poor water quality is a major problem affecting both ecosystem structure and function, and human health. Anthropogenically generated nitrate is the most common form of chemical contaminant associated with poor water quality. This research will address the degree to which native and invasive, non-native aquatic plants metabolize this contaminant and how the combined effect of global climate change might affect aquatic plant capacity to scrub the waters of contaminating nitrogen compounds.

Anthropogenic Nutrient Input and Its Influence on Plant Competitive Outcomes: Implications for Habitat Degradation and Community Shifts

Objective(s)/Research Question(s)

The objectives of this study are to: (1) determine what, if any, positive influences non-native aquatic plants have on the ecosystems they invade; (2) integrate nitrogen and carbon metabolism, and identify molecular markers that respond to nutrient availability as a means of understanding the underlying mechanisms of resource competition between native and non-native plants; and (3) determine what influence the changing atmospheric CO_2 concentration will have on nitrogen acquisition and assimilation in key aquatic plant species.

Approach

An integrated approach toward addressing the impact of Non-Point Source (NPS) nutrient pollution on native and non-native aquatic plant performance and competitive ability with a specific emphasis on nitrogen will be taken. Traditional biochemical (enzyme activity) and physiological (Chl-a fluorescence and oxygen evolution) as well as quantitative assays of gene expression (qPCR) and changes in global protein abundance (differential proteomic analysis) will be conducted to investigate the plant response to nutrient availability. Coupled with biochemical and physiological data, these techniques will provide biologically based mechanistic data, allowing for the integration of relevant sub-organismal processes into organismal performance and infer fitness in the field.

Expected Results

By taking a multifactorial approach, the study will document complex aquatic plant responses to NPS nutrient contamination, providing fundamental insight into the broader impacts of environmental degradation, its impacts on plant function, and implications for ecosystem services (e.g., nutrient remediation). Finally, armed with a better understanding of how plants physiologically respond to resource fluctuations, simple models will be developed to guide future field project design, allowing appropriate testing of inferences about the ability of plants to remediate nutrient pollution, interspecific plant interactions and resource competition, and the roles these processes play in determining ecosystem health in nature.

Potential to Further Environmental/Human Health Protection

Poor water quality and its obvious impacts on ecosystem structure and function constitute a major environmental and potential human health problem. Although declines and/or compositional shifts in aquatic vegetation have been linked to increases in water column nutrient concentrations, it is unclear how such changes affect the overall capacity of aquatic plant communities to remove toxic compounds (the most common form of which is nitrate) from near-shore waters. Moreover, as global climate changes and atmospheric CO_2 levels rise, taxonomic differences in plant physiological responses will necessarily influence nutrient uptake and assimilatory processes, resource competition and overall ecosystem health.

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Project Period: 8/29/2012 - 8/28/2015
Project Amount: $126,000
Environmental Discipline: Marine Sciences

Keywords: hypoxia, otolith chemistry, trophic ecology

Bio

John Mohan received a B.S. degree in Biology from Pennsylvania State University in 2006 and an M.S degree in Biology from East Carolina University in 2009. His research focuses on fisheries ecology, including migration and habitat use of juvenile and adult fish, by utilizing the chronological and geochemical properties of fish earstones (otoliths) that form part of the hearing organ in fish. As a second-year, Marine Science Ph.D. student at the University of Texas Marine Science Institute, he is investigating the potential of fish otoliths to serve as natural records of hypoxia exposure with experimental and field-based approaches.

Synopsis

Hypoxic (low oxygen) episodes are increasing in frequency and severity in coastal ecosystems due to human activities. Fish exposed to hypoxia have exhibited negative sub-lethal effects, including reduced growth and impaired reproduction, yet little is known about natural exposure levels that elicit harmful biological and ecological responses. This project will investigate the chemistry of fish otoliths, carbonate earstones that deposit permanent daily growth bands, as natural long-term records of hypoxic exposure to understand better the effects on fish populations.

Assessing the Effects of Hypoxia on Fish Population Ecology Using Elements and Isotopes

Objective(s)/Research Question(s)

The objectives of this research are to use fish otolith (earstone) chemistry as a natural chronological indicator of hypoxia exposure, and investigate links between exposure history, fish performance and trophic dynamics in the seasonally hypoxic northern Gulf of Mexico. Specific research questions include: Does the redox-sensitive element manganese (Mn) get released from the sediment during hypoxic conditions and become incorporated into fish otoliths, offering a proxy of exposure? Does hypoxic exposure alter fish growth rates, conditions and trophic interactions?

Approach

For preliminary studies, Atlantic croakers were exposed for 4 weeks to constant hypoxia that mimicked field values. Hypoxic stress altered growth rates but not otolith chemistry, suggesting that endogenous physiological mechanisms exert minor influence on otolith composition. Atlantic croakers were collected from the northern Gulf of Mexico at both hypoxic and normoxic sites, in October 2010. Otolith Mn concentrations were orders of magnitude (up to 100x) different between sites, suggesting strong environmental exogenous influence on otolith chemistry, perhaps related to redox release of Mn from the sediments. This study will use two controlled experiments to (1) examine relationships between dissolved oxygen (DO) level and food type, on somatic growth, otolith growth and tissue carbon and nitrogen stable isotopes; and (2) investigate relationships of ambient water Mn to otolith Mn and the effects of food ration and growth on elemental uptake using a spiking study. For the first experiment, treatments include hypoxic (DO = 1.7 mg/L) or normoxic (DO > 5 mg/L) water and benthic (clam based) or pelagic (fish-based) diet. Prior to the experiment, otoliths will be chemically marked and fish individually tagged to track individual somatic and otolith growth throughout the 8-week study. At 2-week intervals, length

and weight measurements and scale samples will be collected to determine growth and characterize the isotope signatures and estimate the incorporation rates of $d^{13}C$ and $d^{15}N$ retained in the scales. The spiking experiment will involve three dissolved Mn treatments of low, medium, or high and low or high food ration for 6 weeks. Otoliths will be chemically marked prior to spiking, and water samples will be collected weekly to monitor dissolved Mn. This will allow precise temporal matching of otolith Mn to water Mn and comparisons to growth rate. Validating and calibrating these relationships in the laboratory is essential to interpret patterns observed in wild croakers collected in the northern Gulf of Mexico.

Expected Results

Linking hypoxic exposure to trophic dynamics of Atlantic croaker, an abundant fish and integral component in Gulf of Mexico food webs, will provide information on ecosystem structure and functioning in response to seasonal hypoxia. Additionally, validating a natural permanent chronological recorder of hypoxia in fish will allow new hypotheses to be tested regarding historic hypoxic episodes by examining archived otoliths of other species and in other ecosystems across the world.

Potential to Further Environmental/Human Health Protection

Hypoxia is one of many stressors that threaten the sustainability of valuable ecosystem services provided by estuarine and coastal regions across the United States and world. Understanding the sub-lethal population-wide effects of hypoxia, such as reduced individual fitness and altered trophic structure of ecologically and economically important fish species, is necessary to improve objectives of environmental policy and enhance resource protection measures.
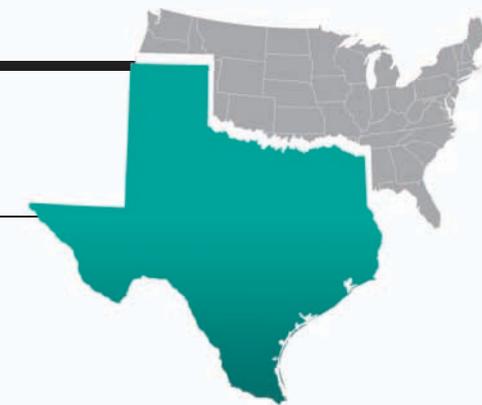
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Project Amount: $126,000
Environmental Discipline: Environmental and Water Science

Keywords: wastewater treatment, waste stabilization ponds, constructed wetlands

Bio

Simon Mostafa received his Bachelor's and Master's degrees in Environmental Engineering from the University of Central Florida. He joined the University of Colorado, Boulder, to pursue a doctorate degree in Environmental Engineering within the Engineering for Developing Communities track. His interests include the development and improvement of methods for water and wastewater treatment that are appropriate for traditionally under-served communities in both developed and developing regions.

Synopsis

Non-conventional wastewater treatment (NC-WWT) systems (e.g., treatment ponds and wetlands) are attractive given their low energy, chemical and maintenance requirements. This study will explore the role of sunlight-driven photochemical processes on the inactivation of pathogens in NC-WWT. The results are expected to mitigate the impacts of wastewater streams on communities and the ecosystem that do not have access to conventional treatment methods through the improvement of decentralized WWT systems.

The Role of Photochemical Processes for Pathogen Inactivation in Non-Conventional Wastewater Treatment Systems

Objective(s)/Research Question(s)

Several studies have been dedicated to learning more about the impact of photochemical processes on pathogens present in NC-WWT systems. This research attempts to provide a better understanding of the impact of natural and effluent organic matter (NOM, EfOM) in the formation of reactive oxygen species (ROS), such as singlet oxygen, and their potential impacts on pathogen concentrations via indirect photolysis processes.

Approach

Water samples from various sources will be collected and analyzed with respect to their organic matter content (using size exclusion chromatography [SEC] and fluorescence techniques) and the steady-state concentrations of ROS (particularly singlet oxygen) generated under sunlight conditions. Known concentrations of microbes will be introduced and their inactivation measured after exposure to conditions that enable photolysis to take place (i.e., irradiation under a solar simulator or natural sunlight) to establish the relationship between ROS dose (steady-state concentration time, CT) and pathogen indicator inactivation rates. Analysis of the organic matter, ROS concentrations and microbe concentrations within working systems can be conducted, and the correlations established in the previous project components can be measured against parameters found in units working under real-world conditions.

Expected Results

This research will lead to a better understanding of sunlight-mediated photochemical processes within NC-WWT systems, their relation to the NOM/EfOM found within such systems and their role in pathogen inactivation. Such results should lead to better estimations on systems performance based on the OM present and inform future designs that take advantage of such oft-ignored indirect photolysis processes.

Potential to Further Environmental/Human Health Protection

Because of the high microbial concentrations present in raw sewage, the removal of pathogens is one of the primary objectives in WWT. Without it, soil, crops and water sources (both ground water and surface water bodies) may become contaminated when coming into contact with untreated water streams, leading to detrimental health and environmental impacts. Thus, it becomes clear that the development, optimization and introduction of decentralized NC-WWT systems that do not rely on high energy, chemical and labor inputs and that are sound socially and environmentally would be highly beneficial to those communities that do not have access to conventional treatment technologies common in more developed regions.
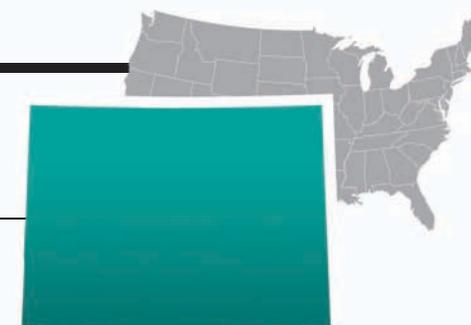
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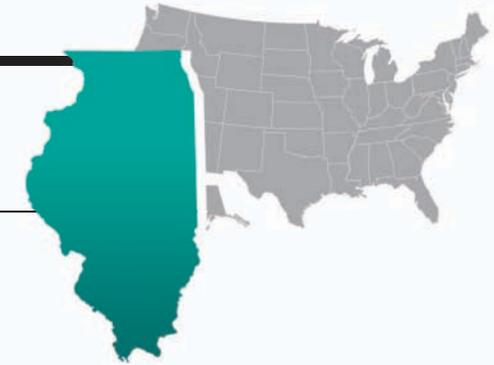
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Keywords: non-trophic interactions, microbial ecology, nitrogen cycle

Bio

Orissa Moulton received a B.A. degree in Biology from Wheaton College (Norton, MA) in 2007. In 2010, she completed an M.S. degree in Zoology at Oregon State University where she studied seagrass community ecology. Since 2010, she has been pursuing a Ph.D. in Ecology and Evolution at the University of Chicago. Her current studies focus on intertidal marine community ecology, especially ecology pertaining to the nitrogen cycle. Her current research takes place in northwest Washington and focuses on interactions between seaweeds and microbes in terms of ammonium, a shared resource.

Synopsis

Marine animal-excreted nitrogen (N) is an important resource for both seaweeds and nitrogen-metabolizing microbes, resulting in both competitive and facilitative interactions between these groups. Harvest of marine fauna could alter these interactions. This project will use a suite of tools to study the range of possible interactions in terms of the shared nutrient resource. Results will be used to make predictions for the future of coastal productivity in the face of faunal decline.

Non-Trophic Role of Animals in Mediation of Algal-Microbial Interactions Via the Nitrogen Cycle

Objective(s)/Research Question(s)

This study will address two questions: (1) Is the relationship between nitrogen-utilizing microbes and seaweeds competitive (negative) or facilitative (positive) in terms of ammonium use, and how is the net interaction among microbes and macroalgae mediated by the supply of nitrogen? (2) How do rocky intertidal microbial communities vary at the landscape scale and across a gradient of faunal nitrogen input, specifically in terms of high animal biomass marine preserve/corresponding control comparisons?

Approach

This work will be conducted in NW Washington state, with mesocosm experiments at the University of Washington Friday Harbor Laboratories and field work in the San Juan Islands and along the Strait of Juan de Fuca. The study will use mesocosm manipulations, stable isotopes (natural abundance in tissues samples and enrichment in small-scale tracer experiments), and microbial metagenomics to test the net effect of microbial metabolism and N transformation on primary producers, particularly seaweeds, to determine how the net interaction among microbes and seaweeds is mediated by the supply of nitrogen. The study will investigate the effect of high animal biomass marine preserves on algal productivity and microbial metabolism via microbial settlement surveys, environmental monitoring, stable isotopes and microbial metagenomics. These comparative methods will quantify how microbes contribute to rocky shore productivity via interactions with ammonium-excreting animals and the microbial potential to retain nitrogen in coastal waters in marine preserves versus corresponding control sites.

Expected Results

Animals play a quantitative role as nitrogen recyclers in shallow marine systems, so seaweed and microbe communities dependent on ammonium excretion are linked intimately to animal community abundance. Ammonium constitutes a shared resource for seaweeds and microbes, so microbial nitrification could pose a competitive (negative) force on seaweeds via rapid removal of ammonium from the water column. By utilizing ammonium, though, nitrifying microbes could facilitate (positively affect) seaweed productivity by retaining nitrogen onshore as nitrate and nitrite in high-energy areas where nitrogen advection is expected. Both interaction signs are likely to occur under different environmental contexts. In regions where marine animal density has decreased as a result of overharvest, onshore seaweed-microbe interactions likely will be modified due to a reduction in available ammonium.

Potential to Further Environmental/Human Health Protection

Improved knowledge of natural nitrogen-cycling and development of a predictable nitrogen budget for primary producers will allow for better protection of the temperate coastlines, where fisheries are most developed. Understanding the responses of microbes and seaweeds globally to changing environmental factors (e.g., temperature, pH, N-availability) will improve the ability to predict specific responses of rocky intertidal microbes, including community composition and function shifts. Ideally, marine reserves are sited based on criteria that maintain biodiversity and ecosystem functioning at large scales; this work will evaluate the effectiveness of restricted-use marine reserves for ecosystem-scale nitrogen cycling and disentangle linkages between ecosystem function and environmental context.

Emily Rose

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Environmental Discipline: Biology

Keywords: endocrine disrupting compounds, synthetic estrogen (EE2), population genetics

Bio

Emily Rose received a B.S. degree in Marine Science Biology from the University of Tampa in 2007, where she studied the effects of human disturbances on syngnathid fishes, including pipefish and seahorses, with Dr. Mason Jones. She is a Ph.D. candidate in the Jones laboratory in the Biology Department at Texas A&M University. Her research interests include the effects of endocrine disrupting compounds (EDCs) and climate change on the recruitment, population genomics and mating systems of syngnathid fishes.

Synopsis

This study aims to determine the effects of EDCs on marine fishes in coastal environments by using the gulf pipefish as an indicator species. This project will address possible effects of EDCs on pipefish recruitment, including offspring viability, juvenile sex determination and early development in laboratory pipefish populations, as well as on phenotypes, gene expression levels and the genetic structure of pipefish populations in the Gulf of Mexico region.

The Effects of Endocrine Disrupting Compounds on Gulf Pipefish

Objective(s)/Research Question(s)

The main goals of this research are to: (1) determine the effect of endocrine disruptors on pipefish recruitment by testing how synthetic estrogen (EE2) exposure affects brood viability, juvenile sex determination and/or early development in gulf pipefish; and (2) understand the impacts EDCs have on natural populations of gulf pipefish in the Gulf of Mexico region using population genetics, gene expression biomarkers and evolutionary genomics.

Approach

The first aim of the proposed research will be conducted in the laboratory to determine the effects of EDCs on pipefish recruitment. This study will determine the effects of EDCs on the parental pipefish by pairing non-exposed males with exposed females and non-exposed females with exposed males. Data will be collected on offspring viability using egg size, embryonic survivorship and size of juveniles at birth, as well as sex determination and early development of juveniles to determine the effects of exposure to EDCs. The second aim will ascertain whether or not EDCs are affecting natural populations of pipefish using field populations from across the Gulf of Mexico region, including Texas, Alabama and Florida. In addition, the second aim will investigate the impacts of endocrine disruptors on morphological and reproductive traits as well as quantify gene expression levels using real-time quantitative-PCR, focusing on candidate genes in exposed populations. Lastly, the second aim also will focus on the genetic structure of these populations using restriction-site associated DNA (RAD) markers and next-generation sequencing.
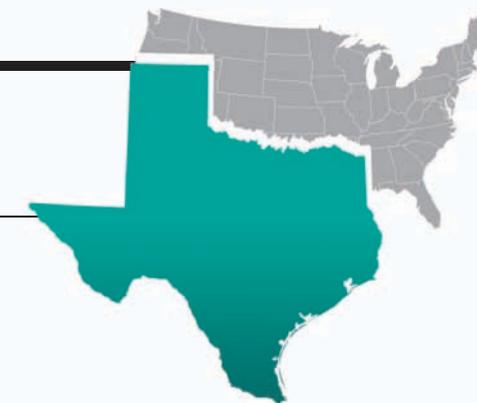
Expected Results

Pipefish exposed to endocrine disruptors, such as EE2, are expected to have lower reproductive success, resulting in a decrease in recruitment in exposed populations. Egg viability also is expected to be lowest in the paired mating of an exposed male and female, compared to non-exposed individuals. Exposed juvenile pipefish are expected to show signs of feminization in male fish in addition to possible skewed sex ratios in exposed populations. Pipefish are expected to respond physiologically to endocrine disruptor contamination, resulting in changes in expression patterns across several genes. As a result of this study, several molecular markers will be developed as indicators of endocrine disruptor contamination. There also is the possibility of endocrine disruptor contamination causing changes in the genetic structure of exposed pipefish populations, as well as the pipefish's genome, which will be detected using next-generation sequencing data.

Potential to Further Environmental/Human Health Protection

The proposed research represents a key step toward understanding the long-term effects of EDCs on the reproductive health of coastal fish populations in the Gulf of Mexico region. As a result of this study, molecular markers will be developed to assess impacts of pollutants and use population genomics to survey population structure over time to determine how long-term exposure to these contaminants affects natural populations. A better understanding of these impacts will provide the information necessary to achieve future goals, such as developing solutions to environmental contamination, and ultimately improve the water quality and well-being of the aquatic life within these ecosystems.

Robert Daniel Sabo

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Project Period: 8/29/2012 - 8/28/2015
Project Amount: $126,000
Environmental Discipline: Environmental

Keywords: nitrate, forested watersheds, atmospheric deposition

Bio

Robert Sabo received his B.S. degree from Mount Saint Mary's University in 2011. He then began his graduate career at the Appalachian Laboratory with the University of Maryland, College Park. His general interests include isotope biogeochemistry and watershed ecology. Currently, he is pursuing research that looks to establish the source contributions of stream water nitrate from forested systems by using dual isotopic analysis of nitrate and employing traditional water quality monitoring techniques.

Synopsis

Temperate forests may play a key role in restoring the Chesapeake Bay. Recent observations of declining nitrate export from predominantly forested watersheds have raised questions into the sources/fluxes of nitrogen (N) within this ecosystem. This research will utilize dual isotopic analysis of nitrate and a region-wide soil monitoring network to establish source contributions of nitrate to streams; in turn, communities will possess the needed knowledge to meet their nutrient reduction goals.

Forest Nitrogen Retention in the Chesapeake Bay Watershed: A Role in Water Quality Restoration?

Objective(s)/Research Question(s)

What are the main sources of nitrate in streams from forested watersheds? Can a previously declared N-saturated forest respond rapidly to declining N-inputs from wet deposition? Has N-scarcity become more predominant in forests even in the face of chronic atmospheric deposition? How do soil processes, specifically nitrification and mineralization rates, respond to declining wet deposition?

Approach

There are two main components to this study: an intensive watershed study and a regional observational network of N-dynamics within forests. The watershed study will measure N processing efficiency based on dual isotopic analysis of ^{18}O and ^{15}N of nitrate in surface water discharge. The research will be conducted in a reported N-saturated watershed to assess declining atmospheric N deposition and possible climate change. Weekly to bi-weekly grab samples will be obtained along with a storm characterization by an ISCO auto-sampler. Along with the dual isotopic analysis, samples will be subjected to traditional water quality analyses (nitrate, ammonium, ANC, closed pH and so forth). The regional observation network will conduct monthly stream water quality monitoring programs, along with the deployment of buried bags to assess nitrification and mineralization rates in forested catchments throughout the Chesapeake Bay Watershed. This regional network will be coordinated through the Ecological Research as Education Network (EREN). N-scarcity also will be assessed through isotopic analysis of ^{15}N in tree rings; EREN schools and the Appalachian Laboratory will collect cores and assess if N-availability of forests have decreased over time.

Expected Results

This research also will explore how the shifting N deposition patterns affect maturing Central Appalachian forests in the context of N saturation hypothesis and the progressive N limitation hypothesis. It is expected to find a large atmospheric nitrate component in streamwater from forested catchments. The proportion of atmospheric nitrate should decline as wet deposition of anthropogenic nitrate decreases. A previously N-saturated catchment, TNEF, will demonstrate a rapid response in N-export to declining N deposition. The absolute magnitude of nitrification and mineralization should decrease due to declining N-availability and should correspond with a nitrate deposition gradient. Overall, N-scarcity should become more predominant as forests recover and redevelop even in the face of decades of chronic deposition of nitrate. Increased NPP and CO_2 enhancement is not suspected to play as large of a role in the declining nitrate export trends observed in forested catchments in the Chesapeake Bay Watershed.

Potential to Further Environmental/Human Health Protection

EPA's and the Chesapeake Bay Program's responsibilities in this initiative must be rooted in empirical data from a multifaceted study that provides information from small, intensive watershed studies to broad geospatial and temporal-scaled studies that adequately assess forest responses to climate change and shifting meteorological inputs. This study aims to assess the unexpected and indirect benefits of clean air legislation. Atmospheric N accounts for 25 to 80 percent of the N load entering the Bay today. Forests have decreased their nitrate exports during the past decade, coinciding with the Clean Air Act Amendments of 1990. This decline not only makes forested streams less likely to suffer from acidification episodes but also allows them to provide higher quality water further downstream. This may aid EPA and Mid-Atlantic States greatly in restoring the eutrophic Chesapeake Bay. Ultimately, local municipalities must incorporate proper accounting of N-export from their forests to make cost-effective decisions that support public health and environmental integrity. Nutrient reductions are key for the Bay, which currently suffers from periodic harmful algal blooms and deadzones. These phenomena endanger residents and visitors to the Bay's shores and expose seafood consumers to unacceptable risks. In conclusion, proper understanding of N-dynamics within forests will allow proper predictions of forests' response to shifting meteorological inputs of N and climate change.

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