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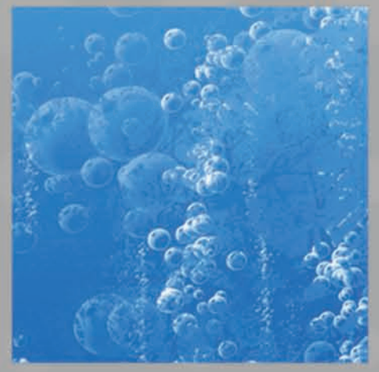




STAR Fellowship *Awardees* Research Portfolio

2010

National Center for Environmental Research
Science To Achieve Results (STAR) Research Program

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Letter from the Director

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF RESEARCH AND DEVELOPMENT

November 23, 2010

Dear Research Partners:

As Director of the EPA's National Center for Environmental Research (NCER), I am pleased to welcome the 2010 class of STAR Fellowship awardees into the community of researchers supported by the EPA.

The awardees profiled in this compilation were carefully selected for one of the most coveted, competitive, and distinctive fellowship awards supported by a federal agency. Their pre-eminent selection is part of the EPA's aim to bolster the environmental generation of today, to help bridge diverse communities, and to boost excellent research and development that advances both the protection of human health and the environment.

For this competition, our staff re-structured its competitive categories in order to highlight the topics of applied environmental research and thus emphasize the type of innovation that is needed in order to address the environmental challenges facing us today and tomorrow.

This Fellowship Awardees' Portfolio is organized according to the topical areas which include Global Change, Clean Air, Drinking Water, Water Quality, Human Health, Ecosystem Services, Pesticides and Toxic Substances, Land Protection, Science & Technology for Sustainability, and Emerging Environmental Approaches—Informatics.

Please join my staff and me as we pique your interest with this diverse Portfolio of cutting-edge research.

Sincerely,

William H. Sanders, III, Dr.P.H.
Director
National Center for Environmental Research

Global Change

Global Change Fellows

Henry David Adams

EPA Grant Number: FP917178
Institution: University of Arizona (AZ)
EPA Project Officer: Ted Just
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
E-mail:

BIO:

Henry Adams received his Bachelor's degree in Biology and Environmental Studies from Alfred University in 1999 and his Master's degree in Forestry from Northern Arizona University in 2003. Henry then worked as a research tech nician at the Institute of Arctic and Antarctic Research at the University of Colorado, Boulder. Henry enrolled in the Ecology and Evolutionary Biology Ph.D. program in 2007. His research interests lie in ecological responses to global change with a specific focus on understanding and predict ing tree drought mortality in a warmer world.

SYNOPSIS:

With the current trends in global change, droughts will be more frequent, which could disrupt the carbon storage function of forest ecosystems, leading to accelerated global warming. Therefore, understanding how trees die from drought in a warmer world is critical for predicting whether forests will continue to sequester a portion of carbon dioxde released by human activities. This project calls for experi mentally killing trees with rought to measure the tempera ture sensitivity and physiology of tree death from drought.

G

Temperature sensitivity and physiological mechanism of drought-induced tree mortality: improving assessments of global change impacts

OBJECTIVE(S)/RESEARCH QUESTION(S)

To improve predictions of ecosystem vulnerability to global change, I will continue my dissertation research examining the temperature sensitivity and physiological mechanism of drought-induced tree mortality in pinyon pine (Pinus edulis) using a combination of experimental approaches to simulate drought under ambient and warmer (4 °C) drought conditions. Specifically this grant supports analyses of tree mobile carbohydrates to test two hypotheses for the physiological mechanism of tree drought mortality: 1) that trees die from drought when respiratory demands deplete mobile carbohydrate resources, and 2) that trees die from drought when failure of mobile carbohydrate translocation to sink tissues occurs.

APPROACH

This project takes advantage of three pinyon pine drought mortality experiments that explore the temperature sensitivity of drought mortality: one already completed with transplanted trees in a glasshouse; an ongoing experiment with transplanted trees under realistic field conditions; and a planned growth chamber experiment with tree seedlings. Testing hypotheses for the physiological mechanism of drought will be accomplished by analyzing a time series of tissue collected during drought through mortality for concentration of mobile carbohydrates, including sugars and starches. These analyses will include leaf (pine needle) tissue collected from the glasshouse and field experiments as well as whole-plant, leaf, root, and stem mobile carbohydrates from seedlings in the growth chamber experiment, which will include samples from trees grown under four temperature regimes.

EXPECTED RESULTS

I expect that leaf mobile carbohydrate concentrations from the glasshouse and field experiments will decline as the trees approach death, reflecting previously observed trends in respiration during the glasshouse drought experiment and supporting hypothesis 1 as the mechanism of drought-induced tree mortality for pinyon. I also expect that mobile carbohydrate concentrations from the growth chamber experiment in foliar, stem, and root tissue will decline similarly through drought-induced mortality, analogous to trends expected for the glasshouse and field experiments both for carbon resources and gas exchange. However, if mobile carbohydrates do not decline through drought mortality in some tissues, this will provide evidence in support of carbohydrate translocation failure (hypothesis 2 above).

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Shifts in biosphere-atmosphere feedbacks remain a critical gap in our understanding of global change impacts. One challenge is to predict plant responses to extreme climate events, such as droughts, in a warmer world. Estimates of future carbon budgets assume continued uptake of atmospheric CO2 by the biosphere. Therefore, quantifying the vulnerability of terrestrial biosphere carbon sinks is critical for current global change science. A key to predicting the ability of forests to continue sequestering atmospheric CO2 is an understanding of how trees die, specifically the temperature sensitivity and physiological mechanism of drought-induced tree mortality. Tree mortality has the potential to influence regional water budgets, affecting regional water quality and availability, yet research that addresses these issues is notably lacking.

Keywords: *tree drought mortality, global change, mobile carbohydrates, biosphere-atmosphere feedbacks*

Meghan Lynn Avolio

EPA Grant Number: FP917240
Institution: Yale University (CT)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Meghan Avolio graduated from Barnard College in 2002 with a Bachelor of Arts degree in Environmental Biology. In 2006 she received a Master's Degree from Fordham Univer sity studying ectomycorrhizal fungal communities, during which she spent a year in Germany on a Fulbright Grant. She is currently a Ph.D. candidate at Yale University in the Department of Ecology and Evolutionary Biology studying how global climate change affects the genetic diversity of a dominant species in tallgrass prairies.

SYNOPSIS:

Global change is expected to result in larger rainfall events that occur less frequently. Understanding their effects on ecosystem biodiversity is essential for determining how cli mate change will alter the conversion of atmospheric carbon into biomass. Studying the most abundant tallgrass species and focusing on genetic diversity, this research explores how climate induced alterations of plant populations will affect biomass production and is predictive of ecosystem function in future climates.

G

Mechanisms Driving Climate Change-induced Diversifying Selection in a Dominant Tallgrass Species

OBJECTIVE(S)/RESEARCH QUESTION(S)

Climate change is predicted to alter global hydrological cycles, including changes in variability of precipitation regimes, which will affect biodiversity, both intra- and inter-specific. My research to date has shown that a decade of altered precipitation patterns increased the genetic diversity of *Andopogon gerardii*, a dominant C4 grass species. The goal of this research is to mechanistically explain the observed pattern of selection and determine whether these changes in genetic diversity scale up to affect ecosystem productivity.

APPROACH

This research combines both field and greenhouse studies. The first stage of this research was conducted in the field, utilizing an ongoing experiment, the Rainfall Manipulation Plots (RaMPs) at the Konza Prairie Biological Research Station. The RaMPs experiment creates more variable precipitation events in intact tallgrass prairie communities. The field-based research investigated the effect of more variable precipitation patterns on the genetic diversity of a dominant species. The second stage will be conducted in a greenhouse addressing which mechanism is driving the observed patterns in the field, the reduction of soil moisture, an increase in soil moisture variability or their combination. In both the field and greenhouse phenotypic measurements were and will be made on specific genotypes to understand whether there are differences between genotypes in their ability to persist in more variable precipitation regimes.

EXPECTED RESULTS

Global climate change is predicted to result in rapid evolution of traits as species respond to new climatic conditions. This research has the unique ability to identify traits that have been selected for in a decade long climate change experiment. The results from the on-going field studies and greenhouse experiment will allow for a comprehensive synthesis of differences between genotypes across a range of biological levels of organization. This research will result in a mechanistic explanation of the patterns of selection that have been observed in the field after a decade of experiencing altered precipitation patterns.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Results from this research can be extrapolated to predict how global change may affect similar terrestrial ecosystems, and by focusing on the ubiquitous and dominant species *A. gerardii*, this research also has the potential to be useful in the field of biofuels. Insight into future trait selection in *A. gerardii* will help inform decisions about potential biofuel crops.

Keywords: *global climate change, variability, precipitation, genetic diversity, genotypes, Andropogon gerardii, dominant species, C4 grass, tallgrass prairie*

Rosemary Tolbert Bush

EPA Grant Number: FP917179
Institution: Northwestern University (IL)
EPA Project Officer: Ted Just
Project Period: 9/21/2010 – 9/20/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
E-mail:

BIO:

Rosemary Bush received her undergraduate degree from the University of Colorado, Boulder, with honors in 2006 in Environmental Biology. She completed a Master's degree in Plant Biology and Conservation, a joint program with North western University and the Chicago Botanic Garden. She is presently working towards her Ph.D. in Earth and Planetary Science at Northwestern University. She studies the im pact of ancient climate change on plant communities using modern and fossilized plant molecules.

SYNOPSIS:

Analysis of ecosystem responses to global warming in the geologic past will help us predict the ecological effects of modern climate change. My research compares plant groups (e.g. evergreen and deciduous) using 1) biomarkers (alkanes) in modern and fossil plants to track past changes in plant communities and 2) carbon isotopes in leaf amino acids to study nitrogen use. The combined molecular tools aid interpretation of the climate change impact on plants, ecosystems, and nutrient cycles.

G

Novel Molecular Methods for Probing Ancient Climate Impacts on Plant Communities and Ecosystem Functioning: Implications for the Future

OBJECTIVE(S)/RESEARCH QUESTION(S)

The goal of my research is to elucidate the functional dynamics of plant communities and ecosystems in response to climate change in the geologic past. To accomplish this, I intend to investigate how preserved biomolecules in plant fossils and sediments can distinguish between angiosperms, gymnosperms, and deciduous and evergreen plants. I also intend to investigate the seasonal dynamics of leaf nitrogen use in deciduous and evergreen plants in order to probe differences in nitrogen allocation between the two groups.

APPROACH

Using leaves collected across a growing season from modern plants, I will analyze the stable carbon isotope ratios of carboxyl carbons in leaf amino acids in order to investigate potential differences in biosynthetic discrimination and nitrogen allocation between deciduous and evergreen species. Additionally, my research involves carbon isotope analysis of leaf wax hydrocarbons (alkanes) in order to investigate a second biomolecular distinction between deciduous and evergreen species, one which can be preserved in ancient soils and sediments and serve as a proxy for plant community composition changes during past climate change. First, the molecular composition of modern plants must be characterized for interpreting the fossil molecular record. I will then test fossils from the Late Cretaceous and the Paleocene-Eocene boundary, both of which are periods of Earth's history marked by warm global climates. Thus, I will apply novel studies of modern plants to follow changes in the biomolecular signals of plant groups through past greenhouse climate conditions.

EXPECTED RESULTS

In examining amino acids, I anticipate an isotopic distinction between deciduous and evergreen plant species that is not confounded by the taxonomy of angiosperms and gymnosperms. The variance in carbon isotope ratios is caused by shifting biosynthetic pathways and metabolic carbon sources in the leaves, and is related to nitrogen use because the vast majority of plant nitrogen is found in protein amino acids. I expect also to confirm a molecular and isotopic distinction between similar groups (deciduous and evergreen, angiosperm and gymnosperm) through analysis of leaf wax alkanes in modern plants. I anticipate that by constraining the controls, whether taxonomic or functional, on carbon isotope fractionation in leaf wax alkanes, we can greatly clarify the interpretation of alkanes as ancient plant and ecosystem biomarkers. In this way, we can track changes in the composition of ancient ecosystems during warm periods in Earth's history.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Plant biomolecules serve as both the mediators of a plant's response to its environment and as records of past plant-environment interactions, and once the biochemical relationships between plant physiology and modern environment are characterized, we can use those relationships to analyze fossilized plant biomarkers from ancient ecosystems. Using biomarker-based knowledge of plant community dynamics under past warm climate regimes, we can predict the responses of modern plant communities to a future warming climate. In this way, we can use molecular tools to further our understanding of ancient ecosystems in order to better predict ecosystem changes under a no-analogue future climate state.

Keywords: *climate change, terrestrial ecology, paleoecology, plant functional types, carbon isotope ratios, n-alkanes, amino acids, PETM, Cretaceous*

Anthony M. DeAngelis

EPA Grant Number: FP917182
Institution: Rutgers University (NJ)
EPA Project Officer: Ted Just
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
E-mail:

BIO:

Anthony DeAngelis received an undergraduate degree in Meteorology from Rutgers University in 2008. In the following year, he began the Ph.D. program in Atmospheric Science at Rutgers University. His research interests include regional and large scale climate variability and change. He has been involved in a project dealing with the effects of irrigation on regional precipitation and is currently investigating the effects of greenhouse gases on global and regional extreme precipitation.

SYNOPSIS:

Global increases in the frequency and intensity of heavy precipitation have been linked with warmer temperatures and increased greenhouse gases. Such climate changes could have devastating impacts on human life, property, and ecosystems. This project will quantify the global and regional responses of extreme precipitation to increased greenhouse gases using current generation coupled climate models. The physical mechanisms associated with extreme precipitation changes will also be investigated.

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Towards an Improved Understanding of Simulated and Observed Changes in Extreme Precipitation

OBJECTIVE(S)/RESEARCH QUESTION(S)

The purpose of this research is to develop a better scientific understanding of changes in extreme precipitation that have been observed over the 20th century and are likely to continue in response to increased greenhouse gases. The changes in extreme precipitation will be quantified and the mechanisms for such changes will be investigated. In particular, a major goal of the project is to elucidate the mechanisms for changes in regional extreme precipitation, which do not appear to be constrained by atmospheric moisture availability.

APPROACH

The changes in extreme precipitation will be investigated with output from coupled atmosphere-ocean climate models from the Coupled Model Intercomparison Project Phase III (CMIP3). The model simulated daily precipitation and mechanisms for extreme precipitation will be evaluated by comparing 20th century simulations with gridded observations over the United States. Future changes in extreme precipitation in response to increased greenhouse gases will be assessed with the A1B emissions scenario simulations, in which atmospheric carbon dioxide concentrations increase to 720 parts per million by 2100. Quantifying changes in extreme precipitation will involve the use of a variety of statistical methods, where a large goal of the quantification will be to see if regional and global changes in extreme precipitation are constrained by atmospheric moisture. To understand the mechanisms responsible for extreme precipitation events, composites of the circulation and thermodynamic structure of simulated and observed weather systems that produce extreme precipitation will be developed and analyzed.

EXPECTED RESULTS

The evaluation of climate model precipitation is expected to reveal biases in simulated mean and extreme precipitation which may be a result of coarse model resolution or inefficiencies in the precipitation generating mechanisms in models. The analysis of future extreme precipitation under the A1B emissions scenario is expected to show robust patterns of heavy precipitation change among the climate models. In particular, most regions are expected to show increased intensity of extreme precipitation events, while only very dry regions are expected to show decreases. This would result in a globally averaged increase in extreme precipitation intensity. Such expectations are consistent with existing studies on extreme precipitation change and preliminary results on this project. In terms of precipitation change mechanisms, globally averaged extreme precipitation is expected to increase according to atmospheric moisture following the Clausius-Clapeyron relationship. Regionally, the mechanisms for extreme precipitation change are likely to be more complicated, and include process such as changes in atmospheric circulation, atmospheric stability, El Niño, and land-atmosphere moisture fluxes. In summary, this project will provide a great amount of information about the way the climate system works and responds to anthropogenic activity, as well as highlight the good and bad aspects of climate model simulated precipitation.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Increases in intense precipitation is likely to be one of the most devastating consequences of anthropogenic climate change. Quantifying the changes in extreme precipitation events is therefore vital to the public and policy makers as we face potentially serious consequences of global warming in current and future generations. Additionally, enhanced understanding of the mechanisms of extreme precipitation change can help improve our understanding of the climate system and lead to the development of better climate models.

Keywords: *climate change, global, regional, greenhouse gases, global warming, extremes, precipitation, climate models, physical mechanisms*

Ethan Robert Deyle

EPA Grant Number: FP917244
Institution: University of California, San Diego (CA)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
E-mail: edeyle@ucsd.edu

BIO:

Ethan Deyle received his undergraduate degree in Phys ics from Swarthmore College in 2008. The following year he completed Part III of the Mathematics Tripos (a one year graduate program in pure and applied mathematics) at the University of Cambridge, UK. In the fall of 2009 he began a Ph.D. at the Scripps Institution of Oceanography, University of California San Diego. As an undergraduate, he pursued research in physics and materials science with applications to renewable energy technology. While at Cam bridge, he pursued his interest in nonlinear systems. Now at Scripps he is working to develop nonlinear mathematical tools to address the impacts of climate change on fisheries and marine ecosystems.

SYNOPSIS:

Anthropogenic climate change has the potential to put fur ther stress on fish populations exploited for fishing. Conse quently, effective fishing policy for the future will need to account for the biological consequences of changing envi ronments. The goal of this project is to develop predictive tools that integrate climate, biological, and human behavior variables which can be used in future fishery management.

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Developing Nonlinear Methods for Understanding and Predicting Climate Impacts on Fisheries

OBJECTIVE(S)/RESEARCH QUESTION(S)

Maximum sustainable yield puts species in close proximity to a tipping point and thus likely exposes species to the risk of being pushed to collapse by variations in the climate. At the same time, climate change is predicted to increase variability across a wide range of climate variables—including frequency of storms, ocean surface temperatures, and wind speeds—which means that as climate change intensifies, the risk of collapse to fished species also will increase. The goal of this project is to develop tools to predict the combined effects of fishing and climate on population dynamics and to integrate these tools in adaptive management schemes that can better protect fishing resources in the face of anthropogenic climate change.

APPROACH

This project will expand on the nonlinear forecasting techniques of simplex forecasting and state space reconstruction, which have shown great promise in improving forecasting in fisheries and other marine biological systems. Together, these techniques make forecasts out of patterns in previous observations of the variable of interest. The methods can be adapted to include information from physical variables as well (e.g., sea surface temperature). The techniques will be further augmented by tracking standard deviations, variance spectra, and auto-correlation of time series for signs of critical behavior. The first phase will test the power of these techniques for predicting collapse using time series kept by the Food and Agriculture Organization of the United Nations and a range of applicable physical time series. The second phase will simulate adaptive regulation to investigate if the climate forecasts can be utilized to reduce collapse risk.

EXPECTED RESULTS

By developing the ability to make forecasts of fishery dynamics that account for the effects of physical variables, this research will enable scenario exploration under various climate predictions to further understanding of climate effects on fished populations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Anthropogenic climate change and fishing behavior affect fish populations at two different time scales- climate change on the scale of decades and fishing patterns on the scale of years. Now, policy aims to minimize the risk of causing collapses and extinction. Though climate change mitigating policy is hopefully in the works, the effects of human activity up until the present have already locked in some amount of climate change over the next few decades, and these changes will impact marine populations. These techniques will facilitate management that can adjust fishing behavior to compensate for climate change and effectively manage these resources.

Keywords: *climate change, fisheries management, resource management, marine ecosystems, overfishing*

Nicholas A. Fisichelli

EPA Grant Number: FP917183
Institution: University of Minnesota (MN)
EPA Project Officer: Ted Just
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
E-mail: fisic001@umn.edu

BIO:

Nicholas Fisichelli earned his undergraduate degree in Resource Ecology and Management from the University of Michigan in 1997. He has worked in various natural re source positions, most notably for the National Park Service in vegetation management and wildland fire. In 2007 he began work towards a Ph.D. in Natural Resources Science and Management at the University of Minnesota. His re search interests include forest dynamics, tree regeneration, competition, succession, and tree range limits.

SYNOPSIS:

Climate change is forecast to cause major shifts in tree spe cies distributions. In the Great Lakes region, forests domi nated by boreal spruce and fir may transition to temperate maple and oak. My research examines initial signs of forest change in the seedling and sapling layers and quantifies the effects of climate on the performance and competitive interactions of temperate and boreal species. These find ings will enable land managers to prepare for the rate and direction of forest change.

G

Assessing the Impacts of Climate Change on Forest Regeneration in the Upper Great Lakes Region

OBJECTIVE(S)/RESEARCH QUESTION(S)

The upper Great Lakes region contains a wide forest transition zone where temperate and boreal tree species reach their northern and southern range limits, respectively. Local factors such as resource availability, competition, and browsing by deer affect tree regeneration trends and may facilitate or impede tree species responses to climate change. The objective of this research is to understand how a warming climate in conjunction with varying levels of local factors are influencing the performance of temperate and boreal tree species in the seedling and sapling layers of transition zone forests.

APPROACH

Because trees are long-lived, initial evidence of forest response to climate change should be found in the younger understory regeneration layers. I will compare the performance of temperate and boreal regeneration through field studies of relative abundance patterns, growth rates, and survival. The common tree species in this study are balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), sugar maple (*Acer saccharum*), red maple (*Acer ruburm*), red oak (*Quercus rubra*), and American basswood (*Tilia americana*). Field sites span a 2.5 °C temperature gradient across northern Minnesota, Wisconsin, and Michigan. I will examine how species abundances change with size class from the low seedlings up to the overstory tree layer. Using radial and height growth rates, I will assess how the competitive abilities of each species changes with temperature, browse pressure, and other factors. Finally, I will follow the survival of marked seedlings over several growing seasons to compare survival rates.

EXPECTED RESULTS

I expect to find individualistic species level responses to interacting ecosystem drivers. In general, temperate species should show a greater positive response to temperature through enhanced growth rates, higher survival, and greater understory abundance levels than boreal species, supporting predictions of temperate species northern expansion. However, because temperate broadleaf saplings are also preferred browse species, areas with heavy browse pressure may favor unpalatable boreal spruce and fir. Overstories dominated by boreal conifers create low light and nutrient poor conditions that will also limit temperate species response to temperature. These findings will indicate whether species specific responses to climate are inhibited or promoted by other factors such as browse pressure and resource availability.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Understanding forest responses to climate warming is necessary to ensure the economic and ecological health of the region and this research will create empirical knowledge needed to inform land management and policy decisions aimed at mitigating climate change impacts.

Keywords: *forest dynamics, ecotone, climate change, interspecific competition, tree regeneration, herbivory, range shift*

Meridith McGee Fry

EPA Grant Number: FP917184
Institution: University of North Carolina, Chapel Hill (NC)
EPA Project Officer: Ted Just
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Meridith Fry received her B.S. in Civil & Environmental Engineering and B.S. in Engineering & Public Policy from Carnegie Mellon University in 2006. She then earned her M.S. in Civil & Environmental Engineering from Stanford University in 2007. Meridith worked for 2 years as an envi ronmental engineer for Geosyntec Consultants in Maryland. In 2009, Meridith returned to school to pursue her Ph.D. in Environmental Sciences & Engineering at the University of North Carolina at Chapel Hill. She is researching the effects of ozone precursor emissions on climate forcing and air quality.

SYNOPSIS:

Ozone, a tropospheric air pollutant and greenhouse gas, im pacts both air quality and global climate. Although ozone is not emitted directly, short-lived ozone precursors influence ozone concentrations in the atmosphere. Regional reduc tions in ozone precursors can benefit climate and air quality in many world regions. This study assesses the effects of ozone precursor emissions on the radiative forcing of cli mate and air quality as a function of emission location from various source regions.

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The Influence of Short-Lived Ozone Precursor Emissions on Radiative Climate Forcing and Air Quality

OBJECTIVE(S)/RESEARCH QUESTION(S)

Regional reductions in ozone precursor emissions influence both global climate and air quality through changes in tropospheric ozone and methane concentrations. This research will assess the effects of changes in ozone precursor emissions on the net radiative forcing of climate and air quality as a function of emission location from various world regions. This research also aims to inform coordinated planning to improve air quality and reduce climate forcing.

APPROACH

The initial phase will evaluate how reductions in emissions of short-lived ozone precursors, NOx, CO, and NMVOCs from four world regions (North America, Europe, East Asia, and South Asia), influence the net radiative forcing of climate. This study will utilize the Hemi-spheric Transport of Air Pollution (HTAP) multimodel intercomparison study results and the Geophysical Fluid Dynamics Laboratory radiative transfer model to estimate the net radiative forcing as a function of the location of changes in ozone precursor emissions. Follow-on studies will be conducted using a global chemical transport model, MOZART-4, to evaluate potential climate mitigation strategies. By simulating ozone precursor emission reductions from many world regions, this study will determine the consequences on climate forcing, ozone and methane con-centrations in the upper troposphere, long-range transport of ozone and its precursors, and human mortality.

EXPECTED RESULTS

This research will quantify the consequences of short-lived ozone pre-cursor emission reductions on global climate, air quality, and human health. The radiative forcing study of the HTAP simulations will show the relative contribution of each world region to the net radiative forc-ing due to regional changes in ozone precursor emissions. The results from the follow-on studies will indicate how climate and air quality can be improved through reductions in specific ozone precursors. This work will support the advancement of future policies that address air pollution and climate change concurrently. In addition, this research may motivate the inclusion of ozone precursors in future international climate change agreements.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Findings from this study have the potential to contribute to the develop-ment of future national and international air quality and climate policies that limit global change and protect human health and the environment. Before short-lived ozone precursors are included in future climate mitiga-tion strategies, the relative influence of their emissions on climate forcing, air quality, and human health as a function of emission location needs to be better understood. This study aims to identify the opportunities and obstacles to include ozone precursor emission reductions in future agree-ments to slow global climate change and improve air quality concurrently.

Keywords: *ozone, radiative forcing, climate change, air quality, long-range transport, climate mitigation, methane, carbon monoxide, atmospheric chemistry*

Richard Daniel Griffin

EPA Grant Number: FP917185
Institution: University of Arizona (AZ)
EPA Project Officer: Ted Just
Project Period: 8/15/2010 – 8/14/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Dan Griffin holds a B.S. in Earth Science and a M.A. in Geography, both from the University of Arkansas, where he worked for 7 years at the Tree-Ring Lab on projects in the U.S. and Mexico. He now works at the University of Arizona in the Laboratory of Tree-Ring Research and is a Ph.D. can didate in Geography. A student of drought, climate change, and water resource issues, his graduate research has fo cused around reconstructing hydroclimatic variability from tree rings in California and the Southwest.

SYNOPSIS:

Summer monsoon climate variability, which impacts soci ety and the environment in the Southwest, is inadequately defined by instrumental data. With the first network of monsoon-sensitive tree-ring records for AZ and NM, this project reconstructs spatiotemporal variability of summer drought for the past 500 years and explores its long-term relationship to winter climate and ocean-atmosphere circu lation. Tuned to stakeholder needs, the study aims to inform climate modeling and resource management.

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Tree-Ring Reconstructions of North American Monsoon Variability in the Southwestern U.S.

OBJECTIVE(S)/RESEARCH QUESTION(S)

The objectives of my research are to develop the first systematic network of monsoon-sensitive tree-ring records for Arizona and New Mexico and to reconstruct monsoon variability across the region for the last 500 years. My research questions include: (1) How exactly do trees respond physiologically to monsoon rainfall, and how can tree-ring chronologies be best tailored to maximize monsoon-moisture sensitivity? (2) Over the past 500 years, how has the monsoon varied across space in the southwestern U.S., and what is the long-term relationship between the monsoon, winter climate variability, and large-scale ocean-atmosphere dynamics? (3) How can monsoon-sensitive tree-ring data be applied within the stakeholder-oriented context of resource management?

APPROACH

The tree-growth response to summer rainfall will be observed and documented with a cambial phenology monitoring campaign, implemented at the weekly timescale for three growing seasons. The network of monsoon-sensitive latewood chronologies will be developed using the standard methods of dendrochronology. Twenty-five existing tree-ring collections will be updated through the current growing season, and for the first time, earlywood- and latewood-width, which respectively correspond to winter and summer hydroclimatic variability, will be measured independently on the archived collections. Summer and winter precipitation reconstructions will be developed for the study area using the new network of chronologies and gridded climate data. The long term history of monsoon variability and its relationship to ocean-atmosphere circulation will be characterized with spatiotemporal analyses. To determine how these data can be best tailored to the water resources management framework, collaborative relationships will be cultivated with stakeholders from the region.

EXPECTED RESULTS

The forthcoming results will contribute to the broader body of knowledge in several fields, including modern climatology, paleoclimatology, dendrochronology, and water resource management. The study will provide 400 to 500 years of perspective on the natural spatiotemporal range of summer monsoon drought variability over the U.S. border region and will describe the time-evolving phase relationship between drought and wetness during the winter and summer seasons. The high-resolution reconstructions will provide a benchmark for other paleoclimate studies in the region and will also be used for assessing regional climate models' ability to reproduce the full range of natural monsoon variability. The methods established for extracting monsoon-rainfall signal from the tree-ring data should also be useful in other regions with seasonally independent precipitation regimes. Finally, iterative collaborations will be developed with regional water managers to apply the monsoon reconstructions within their planning frameworks.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The arid environment of the U.S. Southwest has long supported ecosystems adapted to a bimodal precipitation regime characterized by a high degree of natural variability. Humans have also thrived in this region for thousands of years, but in recent decades we have placed unreasonable demands on the natural environment, particularly with respect to water resource development. Increasing population growth and new agriculture and energy demands on water are resulting in a greater vulnerability to droughts, which are anticipated to increase in frequency and magnitude in the future. The results of this study will provide improved information about the range of monsoon drought variability possible under natural forcing conditions, variability that will most likely be superimposed over projected changes in future climate. Water management, now critical to sustaining both human and environmental health, urgently requires the adoption of sustainable use practices. Tailored to the needs of water management stakeholders from the region, the data produced by this research will aid in efforts that are currently underway to robustly plan for the range of plausible future climate change scenarios.

Keywords: *climate variability, climate change, paleoclimate, water resources, drought, monsoon, tree rings, southwest, Arizona, New Mexico, border region*

Julie Ann Hart

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EPA Project Officer: Brandon Jones
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Project Amount: $111,000.00
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BIO:

Julie Hart graduated from the University of Vermont in 2001 with a Bachelor of Science in Environmental Science. Since that time she has worked on field projects, worked as a conservation intern at the Cornell Laboratory of Ornithol ogy and National Audubon Society, and spent 3 years as a conservation biologist with the Vermont Center for Ecostud ies, where she coordinated a long-term bird monitoring program in the Northeast. She is currently a Ph.D. student at the University of Wyoming, conducting research focused on conservation of the endemic South Hills Crossbill in southern Idaho.

SYNOPSIS:

Recent declines of South Hills Crossbill (*Loxia sinesciurus*) appear to be associated with recent and unprecedented high temperatures during summer, which apparently cause lodgepole pine cones to open and prematurely shed their seeds. Crossbills rely upon seeds in old, weathering closed cones, so premature cone opening reduces the crossbill food supply. This project will predict future seed and cross bill abundance in a warming climate and inform a conserva tion plan for this species.

G

Towards a Mechanistic Understanding of Climate Change Impacts on a Specialized Terrestrial System

OBJECTIVE(S)/RESEARCH QUESTION(S)

This project focuses on the South Hills Crossbill, restricted to two small mountain ranges in southern Idaho (100 km^2), where it is an obligate seed predator of Rocky Mountain lodgepole pine (*Pinus contorta latifolia*). Both species are predicted to go extinct by the end of the century. Recent evidence shows a large decline in crossbill annual survival and population size that appears related to warmer temperatures. The most plausible hypothesis for the observed declines is that warmer temperatures have increased cone opening and seed shedding, which reduces seed availability for crossbills (they rely on seeds in closed cones that have accumulated and weathered over many years) and thereby decreases the carrying capacity for crossbills.

APPROACH

This project will determine the effect of increasing temperature on seed availability in closed cones of lodgepole pine, correlate seed availability with crossbill abundance, and then use a spatially explicit model to predict landscape-scale changes in crossbill abundance under different climate change scenarios. In addition, it will determine variability in heat-tolerance of cones and combine this with knowledge of localized temperatures across the landscape to provide guidance for a lodgepole reforestation plan.

EXPECTED RESULTS

This research aims to provide a mechanistic understanding of phenological disruption in two vulnerable species, the South Hills Crossbill and a morphologically distinct population of lodgepole pine. This understanding will be used to predict future seed and crossbill abundance in a warming climate. These predictions will indicate vulnerability of the crossbill population and, combined with the results of this project, can be used to develop a conservation plan for the South Hills Crossbill. Without a clear conservation strategy for these species, both are likely to go extinct by the end of the century. One management tool resulting from this study will be the creation of a suitability map for planting lodgepole pine that, for example, recommends cooler sites with lower rates of cone opening for reforestation. The U.S. Forest Service is the sole landowner of the two mountain ranges in the South Hills and has the authority and experience to implement a landscape-scale reforestation effort, making habitat restoration and species conservation realistic outcomes of this project.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

In addition to species-specific management implications for the South Hills Crossbill, the mechanistic understanding gained in this study will influence mitigation strategies for a host of other species. Other seed-eating species (birds and small mammals) will benefit from an understanding of how climate change is disrupting the phenology of a widespread pine. This project aims to synthesize a mechanistic understanding of a three-way (climate-lodgepole-crossbill) relationship to project climate change impacts at a landscape scale, thereby developing a modeling approach that can be applied to other sensitive species, especially other taxa of Red Crossbills that appear to be declining.

Keywords: *climate change, habitat use, lodgepole pine, Loxia sinesciurus, population ecology, resource abundance, South Hills Crossbill*

Jessica Leigh Hite

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BIO:

Jessica Hite received her undergraduate degree in Botany from the University of Tennessee in 2007. In August of 2007, she began her Master's research with Dr. James R. Vonesh at Virginia Commonwealth University. After complet ing her Master's, she was a Fulbright Scholar working with Amphibian Conservation in Panama. She will begin her Ph.D. in the Evolution, Ecology, and Behavior Department with Dr. Spencer Hall at Indiana University in August 2010. Her research will focus on how the interaction between cli mate change, predators, and emerging amphibian diseases will affect amphibian biodiversity and aquatic ecosystem health and function.

SYNOPSIS:

This research will examine how climate change alters spe cies interactions and aquatic ecosystem health and function via changes in rainfall periodicity and intensity. I will use a combination of observational, experimental, and modeling approaches. The overall goal is to synthesize the individual parts to gain insight on the impact climate change, terres trial predators, and abiotic conditions have on tadpoles and how these factors influence the aquatic food web.

G

Changing Rainfall Patterns in the Neotropics, Predation, and Amphibian Declines: Implications for Aquatic Ecosystem Processes

OBJECTIVE(S)/RESEARCH QUESTION(S)

This research will examine how climate change alters species interactions and aquatic ecosystem health and function via changes in rainfall periodicity and intensity.

APPROACH

The first part of my fieldwork will be conducted in ponds located along a precipitation gradient throughout Panama. I will focus on treefrog species with arboreal eggs and aquatic larvae. Species that lay their eggs out of water may be particularly vulnerable to variation in rainfall patterns associated with global climate change. To better understand the mechanisms that determine survival and phenotype of treefrog eggs in the presence of different predators and under various climatic conditions, I will develop a simulation model using data collected from my fieldwork that incorporates differences in clutch hydrology and predation rates. This model will aid in conservation efforts by graphically demonstrating how climate change may affect ecosystem function via effects on individual species interactions. The combination of observational, experimental, and theoretical studies will strengthen our ability to more rigorously investigate the direct and indirect effects of global climate change on species interactions and how these changes may influence aquatic ecosystem processes.

EXPECTED RESULTS

The overall goal is to synthesize the individual parts to gain insight on the impact climate change, terrestrial predators and abiotic conditions have on tadpoles and how these factors influence the aquatic food web. This project will allow more rigorous statistical analysis of the links between climate change, population declines, and natural population fluctuations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

These results will provide valuable information on the effects of climate change on species loss and related ecosystems and contributes to our understanding of research on the consequences of ecological diversity.

Keywords: *climate change, ecosystem function, aquatic food webs, amphibians, biodiversity, direct and indirect effects, neotropics, conservation*

Sara Ann Kaiser

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BIO:

Sara Kaiser earned her Bachelor's degree in Zoology from Iowa State University in 2001 and an interdisciplinary Mas ter's degree in Ecology, Evolutionary Biology and Behavior at Michigan State University in 2004. After 4 years of work ing as an avian ecologist for a nonprofit wildlife organization on the California Channel Islands, in 2008 she began her Ph.D. program. For her doctoral work at Cornell University, Sara is researching the impact of anthropogenic climate change on avian life-history decisions and the hormonal mechanisms that influence variation in avian reproductive and survival strategies. She studies a breeding popula tion of Black-throated Blue Warblers at the Hubbard Brook Experimental Forest in the White Mountains of New Hamp shire in collaboration with researchers at the Smithsonian Migratory Bird Center.

SYNOPSIS:

Global climate change may negatively impact populations of migratory birds. As temperatures shift, migrating birds experience adjustments in the timing of leaf-out and peak food resources. These cues may be used to time breeding events with environmental conditions. To assess the po tential for species response to climate change, this project examines how temperature and food signal the hormones modulating the breeding behaviors of birds that influence their survival and reproductive success.

G

Adaptive Significance of Plasticity in Hormone-mediated Avian Reproductive Behaviors in a Changing Climate

OBJECTIVE(S)/RESEARCH QUESTION(S)

Climate change in north temperate latitudes is causing temporal shifts in the environmental cues organisms use to time breeding events with environmental conditions (e.g., food resources), and this likely will have drastic consequences for the population demographics of migratory birds. Currently, there is little known about whether and how species will be able to respond to these changes. We know that seasonal changes in circulating hormone levels can modulate avian reproductive behaviors that directly influence fitness, but surprisingly little is known about the environmental cues that signal these underlying endocrine mechanisms. To assess the potential for species response to climate change, it is necessary to know the mechanism by which environmental cues such as food and temperature affect endocrine systems and also the extent to which plasticity in the regulated reproductive behaviors is adaptive.

APPROACH

I propose to examine the linkage between testosterone and corticosterone and individual adjustments in mating and parental effort by males in response to experimentally manipulated food availability along an environmental gradient. I will simultaneously measure several factors during supplemental feeding that contribute to territory quality and may influence mating and parental effort to isolate the effects of food. I will thus be able to assess the degree of plasticity in male hormonal and behavioral responses to resource conditions and their fitness consequences. The study I propose will integrate genetic and hormone analyses, population demographics of a migratory songbird that has been monitored for 40 years at a site where anthropogenic climate change has had detectable effects, and experimental manipulation of food on individual territories.

EXPECTED RESULTS

My large-scale experiment is a novel approach that will lead to important insights about the effects of food on mating and parental effort and the adaptive significance of reproductive trade-offs in a changing environment.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

As human populations and their demand for resources grow, there is an increasing need to monitor the response of indicator species in natural ecosystems to changes in the environment that are causing resource depletion and reducing the ecosystem services provided by species. Understanding the relationship between species and ecosystem stability is essential to the management of natural resources.

Keywords: *climate change, birds, hormones, reproductive behaviors, environmental gradient*

Ashley D. Keiser

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BIO:

Ashley Keiser graduated *summa cum laude* from the Uni versity of New Hampshire in 2004 earning a B.S. in En vironmental Science. After graduating, she completed an internship at the Smithsonian Environmental Research Center in Edgewater, MD. For the next two and a half years, Ashley worked as an ecologist for the environmental con sulting firm, Blasland, Bouck & Lee (ARCADIS). She is cur rently enrolled in the Ph.D. program at the Yale School of Forestry and Environmental Studies. Her research examines the impacts of climate change on above- and belowground processes in temperate forests.

SYNOPSIS:

Under predictive climate change models, species' ranges are expected to move poleward in latitude and upward in elevation. Understanding the implications of this move ment for biogeochemical cycles is necessary to accurately predict global change impacts on forested ecosystems. This research examines how soil microbial community function, examined as carbon and nitrogen fluxes from decomposing leaf litters, will respond as dominant, overstory tree species shift due to changing climate conditions.

G

Merging Above- and Belowground Processes: Non-Random Tree Species Change and Microbial Community Function

OBJECTIVE(S)/RESEARCH QUESTION(S)

Under predictive climate change models, species' ranges are expected to move poleward in latitude and upward in elevation with warming. There remains significant uncertainty surrounding the response of below-ground carbon and nitrogen cycling and storage to climate changes and related species shifts. The IPCC recognizes the importance of linking biogeochemical cycles to changes in climate, yet belowground carbon cycling has largely been treated as a black-box. My research exam-ines how soil microbial community function, examined as carbon and nitrogen fluxes from decomposing leaf litters, will respond as dominant, overstory tree species shift their ranges due to changing climate condi-tions. The results will yield an improved understanding of the impacts of non-random tree species change on soil microbial communities and, consequently, the biogeochemistry of forested landscapes.

APPROACH

I plan to investigate litter decomposition patterns and carbon and nitro-gen dynamics on four tree species across an elevation gradient: *Liri-odendron tulipifera* (tulip poplar), *Acer rubrum* (red maple), *Betula alleghaniensis* (yellow birch), and *Picea rubens* (red spruce). The four species have been chosen to represent a range in litter chemistry, their dominance at each study site, and their susceptibility to migrate under predicted climate change models. Leaf litter will be collected beneath mature trees during fall senescence. A reciprocal-transplant field experi-ment with single- and mixed-species litter bags, combined with a com-plementary, common garden, laboratory microcosm study, will be used to address this question. At each field collection event, soils and litter will undergo multiple analyses ranging from estimates of soil microbial biomass carbon and nitrogen to litter nutrient analysis. These analyses will permit estimation of net carbon and nitrogen dynamics over time.

EXPECTED RESULTS

This research will advance our understanding of how microbial com-munity function, exhibited through carbon and nitrogen dynamics, will change as dominant, overstory tree species shift due to changing climate conditions. As a species moves up an elevational gradient, previously dominant species may remain dominant or lose abundance. Resulting leaf litter inputs may impact litter decomposition rates, and ecosystem-level biogeochemical cycles. Understanding the implications of non-random species change for biogeochemical cycles will be necessary to accurately predict global change impacts on forested ecosystems. This is critical in creating realistic carbon and nitrogen budgets at local, region-al, and global scales.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Changes in aboveground biodiversity are likely to impact essential eco-system processes, such as nutrient cycling, in such a way that future ter-restrial and aquatic community structure and function are altered. The southern Appalachian region, my study site, is considered the "water tower" of the Southeast. Changes to nutrient loads upstream could have a sizeable impact on human populations in the region through dimin-ished drinking water quality. This research proposal is an important step in informing land managers of the potential biogeochemical impacts related to non-random tree species change.

Keywords: *carbon, nitrogen, non-random species change, decomposition, temperate forest, global climate change*

Stephanie Nicole Kivlin

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BIO:

Stephanie Kivlin received her undergraduate degree in Microbiology and Ecology from the University of Texas in 2007. At the University of Texas, she studied the effects of plant diversity on belowground microbial communities in the lab of Dr. Christine Hawkes. After two years as a labo ratory technician in the Hawkes lab, she began her Ph.D. program in Ecology and Evolutionary Biology with Dr. Kath leen Treseder at the University of California, Irvine. She is currently researching how dispersal limitation affects soil fungal communities.

SYNOPSIS:

As global change begins to affect many ecosystems, organ isms may need to shift their ranges to maintain ecosystem functioning. Range shifts in plants and animals are com mon. However, little is known of how microbes can disperse to new areas. This fellow's research focuses on determining the capability of soil fungi to disperse via the atmosphere. Knowledge from this project will also inform us of how hu man and plant pathogen transmission will occur in future climates.

G

How Well Can Fungi Migrate Under a Changing Climate

OBJECTIVE(S)/RESEARCH QUESTION(S)

It is well known that species ranges are shifting under a changing climate. While the capability of macroorganisms to shift their ranges has been well characterized, the dispersal ability of microorganisms is largely unknown. Characterizing microbial persistence, via range shifts in altered climates, is crucial as these organisms affect primary productivity and decomposition, and cause numerous human and plant diseases. This research project will investigate how soil fungi disperse among and within ecosystems. The results will be the first step in developing a mechanistic model to determine the effects of global change on pathogen spread and environmental microbial distributions.

APPROACH

Fungal community composition in the soil will be characterized from over 50 locations in Southern California at eight time points. In addition, fungi in the air will collected from five towers bi-monthly. The wind patterns of Southern California are well known, which will allow us to correlate soil and air fungal composition. This data then will be used to create a model of fungal dispersal capabilities in the region.

EXPECTED RESULTS

Fungal composition of air samples is expected to vary by season and location. Changes in soil fungal community composition are expected to be the largest contributor to alterations in air fungal community composition. Furthermore, we expect that some fungal species will be able to disperse very long ranges, while other species will exhibit restricted distributions. These variations in dispersal capabilities will be utilized to create a model of how fungal species, including human and plant pathogens, will shift their ranges under global change.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

We currently do not understand how pathogens and environmental microbes will respond to global climate change. This research is the first step to determine how microbial distributions will shift in future climates. The results from this study will inform public health officials of potential alterations in pathogen loads. Additionally, ecologists will be informed of possible changes in environmental microbial distributions that will impact ecosystem-level nutrient cycling.

Keywords: *climate change, fungi, microbes, atmosphere, dispersal, range shifts, pathogens, nutrient cycling*

Penny Flick Langhammer

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EPA Project Officer: Ted Just
Project Period: 8/19/2010 – 8/18/2013
Project Amount: $111,000.00
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BIO:

Penny Langhammer is interested in the drivers of species extinction and the application of science to biodiversity conservation. Upon receiving a Master's of Environmental Management degree from Duke University, she worked at Conservation International for 9 years. There, she directed conservation planning and priority-setting initiatives, mainly in Asia and the Pacific. Her Ph.D. research addresses the impacts of infectious disease and climate change on spe cies persistence at global and local scales.

SYNOPSIS:

Chytridiomycosis, an emerging infectious disease of am phibians, has caused the decline or extinction of 100+ amphibian species. Studies in Puerto Rico indicate climate change may elevate the risk of disease-induced extinction for some species. This project assesses the climate change vulnerability of Caribbean frogs and investigates disease transmission and mortality under normal and drought condi tions. Data collected on Puerto Rican frogs will be used to model population-level disease impacts.

G

Impacts of Climate Change and Emerging Infectious Disease on Amphibians

OBJECTIVE(S)/RESEARCH QUESTION(S)

Climate change and infectious disease are two causes implicated in the global loss of biodiversity. Amphibians may be particularly sensitive to both threats, individually and in concert. Chytridiomycosis, an emerging infectious disease of amphibians, has led to the recent decline or extinction of over 100 amphibian species globally. Climate change is also expected to harm many species, through habitat loss and/or physiological stress that affects reproduction. Furthermore, there is evidence from Puerto Rico that these factors may interact to negatively influence species persistence. This research project aims to evaluate how vulnerable frogs are to climate change across the Caribbean, how key disease parameters differ under normal and drought conditions, and whether frog populations currently persisting with endemic chytridiomycosis may face disease-induced extinction if the climate changes. The Caribbean is expected to face increasing periods of drought over the next 50 years.

APPROACH

This research project involves a synthesis of existing data on Caribbean frog species, namely a set of biological and exposure risk factors, to determine species' vulnerability to climate change. Subsequently, three lab experiments will be conducted in Puerto Rico to (a) better understand why frogs are more likely to die from chytirdiomycosis under drought conditions, (b) quantify the rates of disease transmission and disease-induced mortality in drought and normal conditions, and (c) assess whether frogs can become infected indirectly through contaminated soil or vegetation. These lab data, along with historical field data, will be used to parameterize a mathematical model of chytridiomycosis that can be used to better understand disease dynamics and evaluate the likelihood of species extinction from disease.

EXPECTED RESULTS

This project will combine laboratory research, field studies, and mathematical modeling to better understand the impacts of global climate change and emerging infectious disease on amphibian biodiversity. Specifically, the lab experiments will clarify why frogs are more likely to die from chytridiomycosis under drought conditions, which has been observed previously. In addition, the experiments will quantify the rate of disease transmission under normal and drought conditions, a key parameter driving disease dynamics, and will possibly show that indirect transmission of the disease occurs. This work is novel for terrestrial frogs that develop directly from eggs to juvenile frogs, bypassing an aquatic larval stage, which occur throughout Latin America and the Caribbean. The mathematical modeling will help clarify the conditions that can lead to population extinction from, or persistence with, chytridiomycosis. Overall, this research will inform the development of specific strategies that facilitate adaptation by Caribbean frogs to global climate change and disease emergence.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Amphibians play significant roles in ecosystems as both predators and prey, and they provide many direct benefits to human societies as food, pets, research animals, cultural symbols, and producers of medicinal compounds. Although habitat loss remains the most significant threat to amphibians (and biodiversity) worldwide, many species have declined, some to extinction, from the emerging infectious disease chytridiomycosis. Climate change is likely to interact with this disease to increase the risk of extinction for some species. Understanding this interaction is the first step towards developing policies that adequately respond to threats above and beyond habitat loss.

Keywords: *climate change, infectious disease, chytridiomycosis, amphibian, Caribbean, Puerto Rico, mathematical modeling*

Gregory Owen Lehn

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EPA Project Officer: Ted Just
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BIO:

Gregory Lehn received a Bachelor's of Science in Biochem istry from Saint Louis University in 2009. The following year, he started a Ph.D. program in Earth and Planetary Sciences at Northwestern University. His research interests include aqueous geochemistry and the sources/sinks of the global carbon cycle. His current research is tracking the rates of permafrost thaw and carbon cycling using isotope geochemistry of Arctic streams.

SYNOPSIS:

Permafrost contains vast quantities of frozen organic carbon that will likely transform into greenhouse gasses upon thawing. Current and future Arctic warming could create a positive feedback to global warming, as a warmer climate will release more carbon, which in turn will favor more warming. This research proposes to use calcium isotopes to understand, monitor, and predict the rate and extent of permafrost thawing and associated organic carbon release.

G

Tracking Arctic Climate Change With Calcium Isotopes

OBJECTIVE(S)/RESEARCH QUESTION(S)

Permafrost contains vast quantities of frozen organic carbon that will likely transform to greenhouse gasses (e.g., CO_2 and CH_4) upon thawing, which will contribute to global climate change over the next 100 years. Rivers and permafrost appear to have distinct calcium (Ca) isotope compositions due to seasonal differences in chemical weathering and hydrologic processes. This research will employ calcium isotope composition (d44Ca) of Arctic Alaskan river changes as a function of permafrost thaw depth due to seasonal differences in chemical weathering and hydrologic processes, which can be used to understand, monitor, and predict the rate and extent of permafrost thawing.

APPROACH

I will concentrate on six rivers draining the North Slope of Alaska near the Toolik Lake Long-Term Ecological Research Station. By comparing data between rivers draining bedrock versus those that drain both bedrock and permafrost, I will isolate soil zone processes. I will collect water samples from early spring through late fall following established protocols and collect soil cores from each watershed. In the laboratory, I will measure cation and anion concentrations, Ca isotope concentrations, and dissolved organic carbon (DOC) concentrations. Data synthesis will include major ion mass-balances, carbonate equilibria calculations, isotope mixing equations, hydrograph separations, and reactive transport modeling to determine permafrost thaw mechanisms.

EXPECTED RESULTS

Rivers and permafrost appear to have distinct Ca isotope compositions due to seasonal differences in chemical weathering and hydrologic processes. When permafrost melts during the summer, the isotope composition of rivers approaches that of permafrost. In the late fall (mid-September in the Alaskan Arctic), the melt depth reaches its maximum extent before the freezing front moves downward from the surface at the onset of winter. In a warmer world, the extent and duration of melting will likely increase, which implies that the "isotopic fingerprint" of permafrost in rivers will be more evident for a longer period of time. Combined with concentration of DOC, the Ca isotope composition of rivers can track the quantity of carbon reintroduced into the carbon cycle as the active layer deepens.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

With the dependence of humanity on the environment, climate change threatens human health and economies through alteration of water and food sources, ecosystems, agriculture, and weather patterns. Since the permafrost could contribute a significant amount of carbon to the global cycle, a better understanding is necessary to predict its effects on global climate change. This information is crucial to current and future policy makers in their attempt to mitigate the effects of climate change.

Keywords: *Arctic, climate change, calcium isotopes, permafrost, thaw, Alaska, river geochemistry, tundra*

Ryan A. Long

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BIO:

Ryan Long received his undergraduate degree in Wildlife Bi ology from the University of Alaska Fairbanks in 2004, and his Master's degree in Wildlife Resources from the Universi ty of Idaho in 2007. He began work on a Ph.D. in Biological Sciences with a minor in Biology Education at Idaho State University in 2007. Ryan's research focuses on behavioral and physiological interactions between large mammals and their environment, and he is currently studying potential ef fects of climate change on elk.

SYNOPSIS:

Large herbivores play important roles in the ecosystems they inhabit, and are capable of transporting both nutri ents and contaminants great distances across landscapes. Consequently, understanding how these animals respond to climatic variability can provide insights into the potential effects of climate change on whole ecosystems. This proj ect evaluates the causes and consequences of behavioral responses to climatic variability observed in North American elk occupying two different ecosystems.

G

Linking Climatic Variability to Behavior and Fitness in Herbivores: A Bioenergetic Approach

OBJECTIVE(S)/RESEARCH QUESTION(S)

Effects of climate change on ecosystem structure and function are driven largely by environmental temperature, and because they often act as keystone species, large herbivores are likely to play an important role in responses of ecosystems to climate change. Nevertheless, little is known about how large herbivores respond behaviorally to spatiotemporal variability in the thermal environment, and how those responses influence individual fitness. The primary objectives of this research project are to: 1) evaluate direct and indirect influences of the thermal environment on behavior of North American elk occupying forested versus sagebrush steppe ecosystems; and 2) determine how differences in foraging and movement strategies relate to variability in fitness among elk.

APPROACH

This research will utilize a biophysical model that combines detailed data on microclimate, topography, habitat, physiology, and morphology to produce spatiotemporally explicit estimates of metabolic expenditures by individual herbivores as they navigate a landscape. Model predictions will be combined with high-frequency location data from GPS collars and data on important fitness correlates such as birth mass of young and body condition at the onset of winter to evaluate relationships among the thermal environment, behavior, energy balance, and fitness of large herbivores. In addition, by evaluating these relationships for elk occupying a montane forest ecosystem versus an arid sagebrush-steppe ecosystem where temperatures and radiant heat loads are substantially higher, this analysis will provide important clues about how predicted increases in global temperatures are likely to influence large herbivores and the ecosystems they inhabit.

EXPECTED RESULTS

Quantifying both direct and indirect effects of climate and associated weather patterns on animal behavior and physiology is necessary for understanding ecosystem responses to climate change and projecting future ecological trends. This research will provide a strong mechanistic foundation for understanding herbivore-mediated effects of climate change on ecosystems. For example, understanding the role of the thermal environment relative to other environmental factors (i.e., forage, risk of predation, topography, and human development) in influencing patterns of movement, behavior, and fitness of elk in an arid desert ecosystem will facilitate predictions of how increased temperatures resulting from climate change are likely to affect elk-ecosystem interactions in more classically occupied montane forests throughout the intermountain west. In addition, data collected for individual herbivores during this study will aid in explaining previously observed responses of herbivores to climate at the population level, which is of broad scientific value as a result of the important functional roles played by large herbivores in the ecosystems they occupy.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Large herbivores such as elk are extremely vagile, and are capable of transporting both nutrients and environmental contaminants great distances across landscapes. In addition, these animals often act as keystone species in the ecosystems they inhabit. This project will shed light on how individual herbivores respond to climatic variability, which will be critical for minimizing future negative effects of climate change on ecosystems occupied by large herbivores.

Keywords: *behavior, biophysical model, climate change, ecosystem, elk, energy balance, large herbivores, movement, thermal environment*

Renee Michelle Marchin

EPA Grant Number: FP917194
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EPA Project Officer: Ted Just
Project Period: 8/16/2010 – 8/15/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Renee Marchin received her undergraduate degree in Envi ronmental Science from Texas Christian University in 2003 and her Master's degree in Botany from the University of Kansas in 2006 for research on the variation in physiologi cal traits among populations of white ash trees. The fol lowing summer, she worked on aspen restoration projects for the Bureau of Land Management in California. After working as a research technician for 3 years, she began the Ph.D. program in Plant Biology at North Carolina State Uni versity. She is currently researching the effects of climate change on the growth and survival of temperate forest tree species.

SYNOPSIS:

Afforestation and tree plantations have been promoted as greenhouse gas mitigation options in the Kyoto Protocol. Forests store more carbon, but also require more water, and it is important that carbon sequestration strategies consider all environmental consequences, especially in regions where water resources are limited. This project analyzes the trade-off between carbon uptake and water loss in trees, empha sizing species differences in water use efficiency under variable climates.

G

Assessing the Hydrological Costs of Carbon Sequestration in Managed Forests and Biofuel Plantations

OBJECTIVE(S)/RESEARCH QUESTION(S)

Afforestation and tree plantations have been promoted as greenhouse gas mitigation options in the Kyoto Protocol. Growth of trees, however, is inseparably connected to water loss by stomatal control of gas exchange, and thus productivity is dependent upon water availability. It is important that carbon sequestration strategies consider all environmental consequences, especially in regions where water resources are expected to be stressed by population growth and climate change. This research project will quantify tree species differences in carbon uptake and water loss in forests and biofuel plantations of the southeastern United States in order to better match land management decisions with the ecohydrology of local sites.

APPROACH

This project will compare the stomatal regulation of tree species with different growth strategies (e.g., yellow poplar, sycamore, red maple, hickory, white oak) under experimentally manipulated levels of temperature, soil moisture, and atmospheric vapor pressure deficit. To explore differences among land uses, trees will be measured in three different sites: natural forest ecosystems, managed forests, and biofuel tree plantations. Water use efficiency (WUE) is the ratio of carbon dioxide uptake to water consumption in an individual tree and will provide a direct measure for species comparisons of the tradeoff between carbon and water. Other physiological measurements, including seasonal changes in transpiration and photosynthesis, will be used to assess the impact of climate variability on plant growth and survival.

EXPECTED RESULTS

Forest tree species responses to climate change are complex and currently unpredictable. Climate changes that physiologically stress trees will decrease overall forest growth and increase susceptibility to pests and disease. This research will address the effects of changing climatic conditions on tree growth and survival. The results of this project can be used to inform selection of tree species for forests and biofuel plantations, allowing maximization of carbon sequestration for a given water budget and minimizing climate change-induced death of trees.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This project will provide information on how land management practices will affect local ecosystems. By comparing quantitative estimates of water use among tree species to predicted water availability in the Southeast, it will be possible to determine which species to plant in forests and biofuel plantations. For example, while species such as oaks and hickories have a reputation for high drought tolerance, it has been shown that severe drought can cause more dieback in these species than in co-occurring species. Through intensive measurement of trees under varying climatic conditions, such as experimentally increased temperature and imposed drought, these results can be used to model how future climate variability will affect growth and carbon sequestration in forests.

Keywords: *climate change, carbon sequestration, tree physiology, land management, water use efficiency, species traits*

Sarah Butler Myhre

EPA Grant Number: FP917196
Institution: Sarah Lawrence College (NY)
EPA Project Officer: Ted Just
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Sarah Myhre received her undergraduate degree in marine biology from Western Washington University (WWU). While a student at WWU, Sarah attended classes and conducted research on the tropical reef ecology of the Caribbean Sea. Upon graduating, she spent 2 years working for NO AA's Coral Reef Ecosystem Division (CRED) in Honolulu, HI as a coral reef ecologist and scientific diver. While working for CRED, she studied and dove in some of the most remote and pristine reef ecosystems in the world. Sarah is currently a Ph.D. student at the University of Cali fornia, Davis, where she studies climate change, marine ecosystems, and oceanography. At the beginning of her graduate work, Sarah was a fellow with the National Science Foundation's Integrative Graduate Edu cation and Research Traineeship program, where she focused on how social, economic, and political institutions interface with the problems of a rapidly changing climate. Sarah is broadly interested in how marine ecosystems respond to climate forcing and what the implications are for conservation and policy.

SYNOPSIS:

The distribution of dissolved oxygen in the ocean fundamentally de fines the composition and ecology of benthic and pelagic ecosystems. In the context of modern climate change, the expansion of low oxygen waters along the continental margin of North American is an immediate conservation and management concern. In order to understand modern ecological change we must delve into historical analogues where ocean systems underwent changes in parallel to what is currently happening. This project will focus on the Eastern Pacific Oxygen Minimum Zone (OMZ) through the most recent and significant climate transition in the modern climate system: the shift from the cold glacial period into today's modern, warm climate, which occurred from ~12-15,000 years ago (ka). The proposed research will utilize geochemical, ecological and sedimentary records to reconstruct the movement of low oxygen waters through rapid warming events. These data will broaden the existing scientific basis for interpreting both past and present ecological and oceanographic change along the Eastern Pacific OMZ, and provide a baseline from which to predict future OMZ conditions.

G

Constraining the Movement of the Eastern Pacific Oxygen Minimum Zone Through Rapid Climate Transitions

OBJECTIVE(S)/RESEARCH QUESTION(S)

In the context of modern climate change, the expansion of low oxygen waters along the continental margin of North America is an immediate conservation and management concern. This research will examine the history of the Eastern Pacific Oxygen Minimum Zone. The goal of the research is to fluidly couple climate science with deep-sea ecology and natural history in order to reconstruct how global-scale climate change determines ecosystem-scale structure and function.

APPROACH

This project will focus on the Eastern Pacific Oxygen Minimum Zone (OMZ) through the most recent and significant climate transition in the modern climate system: the shift from the cold glacial period into today's modern, warm climate, which occurred from ~12 to 15,000 years ago (ka). Three recently acquired sediment cores from Santa Barbara Basin will be used to describe oceanographic and ecological changes in the Oxygen Minimum Zone in the past 20,000 years. This investigation will be established upon a suite of data, including radiocarbon dat- ing, geochemical temperature proxies, and faunal record constructions (including protistan and invertebrate communities). This work will allow for core-to-core comparisons with a unified chronology and provide a foundation upon which to map ecological changes through rapid warm- ing events. It will also provide the first reconstruction of benthic com- munity responses to shifting oxygen concentrations that are driven by global-scale warming.

EXPECTED RESULTS

The goal of this research is to understand the movement and ecology of the eastern Pacific Oxygen Minimum Zone (OMZ) during time periods of rapid global warming. Fundamental gaps exist in our current knowl- edge of how OMZs persist through time, what drives their contraction and expansion in the water column, how they are related to surface pro- ductivity regimes, and what role they play in shaping coastal biological communities. Because of this research vacuum, there are broad scientific implications for the research that I propose to conduct. Constraining the rate and magnitude of vertical expansion of the Eastern Pacific OMZ during the last 20,000 years will both describe the processes by which the modern eastern Pacific OMZ developed and provide an analyti- cal basis on which to predict how the Eastern Pacific OMZ expansion will occur in the immediate future. Through this, I hope to broaden the existing scientific basis of the linkages between rapid global warming, changing oxygen concentrations, and benthic ecology.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research is highly applicable to informing how conservation and management policy are established, because the future of both maritime economies and marine ecosystems in a changing ocean is dependent on the integration of climate and environmental science. Understanding the movement of Oxygen Minimum Zones is relevant to both marine man- agement and coastal fishing economies. Because oxygen concentrations strongly organize marine communities, spatially explicit commercial fisheries policy and industrial development must incorporate low-oxygen zones as natural barriers to marine life. This investigation will provide policy makers and conservationists with the tools to make policy and management decisions, specifically in regards to activities within the Exclusive Economic Zone adjacent to the Pacific coast.

Keywords: *climate change, oxygen, rapid warming events, benthic ecology, California Margin Oxygen Minimum Zone*

Clinton Alexander Oakley

EPA Grant Number: FP917197
Institution: University of Georgia (GA)
EPA Project Officer: Ted Just
Project Period: 8/16/2010 – 8/15/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Clinton Oakley earned his undergraduate degree in Biology from Washington and Lee University in 2006. After working as a technician at Duke University and a research assistant at Brown University, he began his doctoral studies at the University of Georgia in 2007. His research is based on applying physiological processes to ecological questions. His current research investigates the unique photosynthesis and carbon fixation of corals and their response to climate change.

SYNOPSIS:

Coral reefs are under threat from many stressors, including climate change and thermally induced coral bleaching. The algal symbionts of corals are genetically very diverse, but how this diversity relates to tolerance to future climate conditions of higher temperatures is unknown. This project will determine the thermal tolerances of diverse symbiont types and provide insight into their unique means of photosynthesis to better inform coral management and predict reef response to climate change.

G

Carbon Fixation of the Diverse Coral Symbiont Symbiodinium in a High-CO2 Ocean

OBJECTIVE(S)/RESEARCH QUESTION(S)

The focus of these studies is the reaction of the carbon fixation mechanisms of the coral/algal symbiosis to predicted future climate scenarios, particularly to what degree the Calvin cycle of *Symbiodinium*, the algal symbiont of corals, is impaired by elevated temperatures. How the large genetic diversity of *Symbiodinium* relates to variation in their physiological function will also be investigated, including Form II Rubisco CO_2/O_2 specificity and carbon compensation points. The amount of carbon supplied, or possibly limited, by the coral host under thermally stressful scenarios is also of interest.

APPROACH

A series of studies utilizing novel methodologies will identify key differential responses of photosynthesis of many types of *Symbiodinium* to environmental conditions consistent with predicted future climate scenarios. Measuring the absolute respiration and photosynthetic rates of O_2 and CO_2 production/fixation of *Symbiodinium* types in real time, both in culture and in coral fragments, across a range of temperatures will elucidate the contributions of the alga and the animal to carbon fixation. The CO_2/O_2 specificity of Form II Rubisco, unique among eukaryotes to *Symbiodinium*, will be determined *in vivo* under normal and thermally stressful conditions in multiple genetic types, as these parameters greatly influence the productivity of corals.

EXPECTED RESULTS

Genetic diversity of *Symbiodinium* is likely to be reflected in differential physiological responses to environmental factors relevant to predicted future climate scenarios, but broad cladal identity is unlikely to determine physiological specialization. These physiological differences are expected to correlate with geographic location and habitat (depth, light regime, average summer maximum temperature) of the host(s). The Calvin cycle of *Symbiodinium* is expected to be susceptible to thermal impairment at temperatures that correlate to bleaching thresholds reported from the source organisms at the geographic point of collection, which can be used as a point of comparison. Form II Rubisco CO_2 specificity will likely have a negative relationship with temperature. Carbon limitation of photosynthesis due to high temperatures may promote a positive feedback loop by increasing photodamage.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The proposed research will significantly contribute to our basic understanding of coral reef biology and bleaching susceptibility; provide greater knowledge of the *Symbiodinium* host and ecosystem specialization; and identify coral species most at risk of climate-driven decline to aid potential reef management strategies.

Keywords: *coral reefs, coral, global climate change, algae, algal physiology, photosynthesis, CO_2, Calvin cycle, ocean acidification, Rubisco, Symbiodinium*

Jessica Dawn Pratt

EPA Grant Number: FP9172411
Institution: Abilene Christian University (TX)
EPA Project Officer: Brandon Jones
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Jessica Pratt received a B.S. in Biology from Grand Valley State University in 2003. She then completed an M.S. in Zoology at North Carolina State University, where she studied the conservation value of shaded-coffee plantations for native avifauna. After working as a lecturer for 3 years at the University of California, Irvine (UCI), she returned to graduate school to pursue a Ph.D. in Ecology and Evolutionary Biology at UCI. Her research focuses on integrating the study of community ecology and species interactions into restoration and land management planning in light of climate change.

SYNOPSIS:

The way in which a plant species responds to environmental change has implications for the community of organisms that interact with that species. This project aims to assess geographic variation in plant traits and plant-herbivore interactions in *Artemisia californica*. Understanding how plant trait variation affects higher trophic levels will inform land management decisions in light of climate change and help predict community-wide impacts of conservation strategies, such as assisted migration.

G

Clinal Variation in Artemisia californica Traits and Implications for Herbivore Communities, Invasion Resistance, and Plant Adaptation in a Changing Climate

OBJECTIVE(S)/RESEARCH QUESTION(S)

The way in which a keystone plant species responds to environmental change has important implications for its associated biotic community. If there is geographic variation in plant responses to environmental change, then conservation and management decisions to mitigate climate impacts will need to occur on a local or population-level scale. I aim to understand how higher trophic levels respond to variation in plant traits of *Artemisia californica* along a four-fold precipitation gradient across 700 km of the species range.

APPROACH

I will use a series of common garden experiments and manipulative field studies to examine geographic variation in plant traits and plant-herbivore interactions of *Artemisia californica*, a keystone plant species in California's endangered coastal sage scrub habitat. Cuttings of *A. californica* collected from populations across the range of the species are being grown in a common garden experiment where I have manipulated precipitation. I will measure morphological, physiological, and chemical traits of plants from across the species range in order to understand how these plants respond not only to changes in precipitation, but also nitrogen deposition and herbivore pressure. In addition, I will monitor arthropod communities on plants in the common garden environment to examine community-level consequences of plant response to environmental change.

EXPECTED RESULTS

In a common garden setting, I have documented clinal variation in plant growth rate and resistance to herbivores. Plants can allocate available resources to growth, defense, and reproduction. Ecological theory predicts that tradeoffs occur between investment in growth and defense and that these tradeoffs are more evident in a resource poor environment. I predict that geographic variation in the strength of these tradeoffs will affect plant-herbivore interactions and result in different emergent communities that associate with *A. californica* across its range. In addition, management approaches, such as assisted migration of *A. californica*, may be necessary to mitigate the impacts of climate change on coastal sage scrub communities if *A. californica* populations are locally adapted to current climate conditions.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Understanding geographic variation in plant traits and plant-herbivore interactions will allow us to better understand how a plant species as a whole will respond to environmental change, and how the response of the plant will affect higher trophic levels. If adaptation to climate is detected across the species range, then my results will inform adaptive management programs, such as assisted migration. Data from this study will provide land managers with important information about how adaptive genetic variation can ensure the long-term success of restoration projects as well as an indication of what is required to maintain evolutionary potential in natural and restored populations.

Keywords: *climate adaptation, community genetics, plant-herbivore interactions, assisted migration, assisted colonization, restoration, coastal sage scrub, Artemisia californica*

Janet Sullivan Prevey

EPA Grant Number: FP917198
Institution: University of Colorado, Boulder (CO)
EPA Project Officer: Ted Just
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Janet Prevey received her undergraduate degree in Biol ogy at The Colorado College in 2004. For the next three summers, she worked as a seasonal biological technician conducting rare plant surveys on the San Isabel National Forest, CO. She went on to obtain her M.S. in Botany from Idaho State University in 2008. In the summer of 2009, she worked as a vascular botanist in Denali National Park, AK. Currently, she is a Ph.D. candidate in Ecology and Evo lutionary Biology at the University of Colorado at Boulder.

SYNOPSIS:

Global climate change will cause shifts in the distribution of plant species. Climate-induced shifts in the composition of plant communities may alter vital ecosystem services. I will conduct a manipulative experiment to examine how changes in growing season length and precipitation patterns will affect the abundance of historically dominant (native) and recently arrived (non-native) plant species, and how the resulting plant community will influence ecosystem func tion and services.

G

Effects of Climate Change on Vegetation and Ecosystem Services in the Colorado Front Range

OBJECTIVE(S)/RESEARCH QUESTION(S)

Global climate change will cause shifts in the distributions of plant species. Current native vegetation communities provide important ecosystem services such as erosion control, soil conservation, carbon sequestration, nutrient cycling, and maintenance of water quality. Climate-induced shifts in the species compositions of these communities may alter their ecosystem services. A very relevant, and largely unaddressed, research question is: how will climate change interact with biotic change (non-native species) to alter ecosystem structure, function, and services? If shifts in vegetation simply involve replacement of species with similar functional roles, impacts on ecosystem services will be modest. However, if climate change creates new temporal niches and novel climates, then it will be the outcome of climate-vegetation interactions that determines shifts in ecological services.

APPROACH

I will establish a manipulative study in the foothills region of the Colorado Front Range, USA, to examine how changes in growing season length and precipitation patterns are affecting the abundance of historically dominant and non-native plant species. Additionally, I will look at how the composition of these plant communities affects available resources to detect resource-mediated interactions between native and non-native species. This approach will allow for a more informed look at both species-specific and ecosystem-level changes that may occur under different climate scenarios.

EXPECTED RESULTS

If climate change leads to an extended growing season and somewhat wetter winters in the Front Range of Colorado, then a new time period of resource availability will be created. Non-native vegetation whose native lands possessed climates similar to the "new conditions" may be better able to utilize these resources than native species. One possibility is that the species occupying the new temporal niche will not compete with traditionally dominant species growing later in spring. Alternatively, early spring growth and resource use by non-native winter annuals will suppress historically dominant late-spring and summer species. Regardless, aboveground net primary productivity may increase as the expanded growing season allows for more effective use of precipitation by plants.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Research addressing the effects of climate change on plant community composition and associated changes in ecosystem function will contribute vital information for ecosystem managers in the future. It will be important to predict how plant communities will change under different climatic scenarios to inform decisions concerning the intensity and timing of livestock grazing, and the potential negative impacts of non-native species on native ecosystems. Additionally, knowledge of which native and desirable plant species will thrive in future climate scenarios will be necessary for successful restoration projects.

Keywords: *climate change, precipitation, ecosystem services, plant community, non-native species*

Hollie M. Putnam

EPA Grant Number: FP917199
Institution: University of Hawaii, Manoa (HI)
EPA Project Officer: Ted Just
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Hollie Putnam received her undergraduate degree with dual majors in Aquatic Biology and Broad Field Science from the University of Wisconsin, Superior in 2004. After a year as a contract researcher at the U.S. EPA, Hollie went on to com plete a M.S. in Biology at California State University North ridge, where she examined the effects of thermal variability on coral physiology. In 2008, Hollie began a Ph.D. program in Zoology at the University of Hawaii, Manoa. Her current research is focused on the resilience and acclimatization potential of reef-building corals to global change stressors.

SYNOPSIS:

Changing global climate is predicted to have dire conse quences for coral reef ecosystems. Specifically, increases in temperature and ocean acidification are damaging coral health through bleaching and decreased growth of the coral skeleton. In an effort to protect valuable reef ecosystems, this research will examine the response of corals to global change stressors, thereby providing essential data with which to more fully understand and predict the persistence of coral reefs into the future.

G

Resilience and Acclimatization Potential of Reef Corals Under Predicted Global Climate Change Stressors

OBJECTIVE(S)/RESEARCH QUESTION(S)

Anthropogenic impacts on coral reefs have already resulted in a de-cline in coral health and abundance across coastal oceans, and coral reefs are predicted to undergo severe ecosystem loss and potentially even extinction under the impacts of future global climate change (GCC) stressors. My research seeks to understand potential mecha-nisms, outcomes, and consequences of coral acclimatization potential in the face of GCC stressors, both across coral generations and with respect to reproductive mode.

APPROACH

Reproductively viable reef building corals (*Pocillipora damicornis* and *Montipora capitata*) will be experimentally exposed to the GCC stress-ors of temperature and ocean acidification and the biological impacts of the exposures evaluated. Specifically, corals will be exposed to three different temperatures and CO_2 levels simulating current and future en-vironmental parameters, and will subsequently be assessed for reproduc-tive output, calcification, protein turnover, and changes in gene expres-sion. Additionally, the offspring of the exposed corals will be challenged again with these stressors to determine the potential for acclimatization across generations.

EXPECTED RESULTS

The expected outcomes of this research include 1) a greater knowledge of key processes in coral biology such as metabolism, reproduction, and biomineralization; 2) a molecular and physiological toolkit for reef man-agers to detect the early warning signs and phenotypic manifestations of decline in fitness parameters; and 3) data on the effects of coral response and acclimatization potential to GCC for use in predictive models of coral reef population viability in the future. Overall, this research will contribute to our understanding of the sensitivity and resilience of coral reefs to anthropogenic impacts occurring at the global scale.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

My research will assist our understanding of the resilience of coral populations in the future, thereby identifying reef areas or coral types that should be targeted for protection. In addition, this research will aid in our quantification of detrimental levels of GCC stressors, informing policy makers on global anthropogenic-induced stress tolerance limits in reef-building corals (e.g., detrimental levels of seawater temperature and CO_2 concentrations).

Keywords: *coral, climate change, ocean acidification, acclimatization, resilience, temperature, bleaching, CO_2, Pocillopora damicornis, Montipora capitata*

Rachel Cope Putnam

EPA Grant Number: FP917234
Institution: University of Minnesota (MN)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Rachel Putnam earned her undergraduate degree from Carleton College in 2001. After 5 years of teaching science to elementary and middle school students, she began the Ph.D. program in Ecology at the University of Minnesota. From 2007 to 2009, she combined her graduate studies and teaching experience as a National Science Foundation GK-12 Fellow. Her research focuses on species distribution and climate change; her current project examines the direct and indirect effects of climate on tree range limits.

SYNOPSIS:

Rapid changes in global climate are likely to have multiple effects on forest ecosystems. Plant ranges are already shift ing, which in turn alters plant communities and competitive interactions between species. This study will examine how climate and biotic factors shape the current range limit of sugar maple, identify population differences in response to climate and competition, and clarify our understanding of how novel climate conditions may affect biotic interactions and forest ecosystems.

G

From Arkansas to Ontario: Understanding Climate and Climate Change Impacts on Sugar Maple Range Limits

OBJECTIVE(S)/RESEARCH QUESTION(S)

Forest ecosystems will be affected by global climate change in multiple ways, from changes in community composition to shifts in species distribution. The long-term goal for this research is to determine the relative importance of climate and biotic interactions on plant ranges to better understand how climate change will affect range limits of temperate tree species and forest community dynamics. The current objective for this project is to determine how climate interacts with competitive and facilitative dynamics to define the range limits of sugar maple.

APPROACH

Sugar maple seeds and seedlings were planted in the forest understory at ten locations along a latitude and climate gradient extending across and beyond this species' range. To identify population-specific responses to climate and neighbors, seeds and seedlings from populations in Minnesota, Iowa, and Missouri were planted at each site. To determine how biotic interactions affect growth and survival across the climate gradient, competition was reduced in half of the plots by clipping nearby vegetation, whereas vegetation in remaining plots was left intact. Neighbor removal treatments will be repeated during each growing season of the study. Where present, sugar maple seedlings naturally growing at each site will receive identical treatments as a control for the effects of transplanting. Annual seedling growth, survival, and population-specific phenology will be recorded at all sites.

EXPECTED RESULTS

Climate is an important factor limiting plant ranges, especially at northern range margins. Therefore, sugar maple growth and survival are expected to be poor beyond the northern edge of its range. At the northern range margin, the presence of neighbors is expected to mitigate the limiting effects of climate through facilitation. At the southern range margin, neighbors are expected to exacerbate the effects of climate through competitive interactions, and sugar maple experiencing reduced competition is expected to have high growth and survival. It is hypothesized that sugar maple is less competitive relative to other woody species in the southern part of its range due to a significantly lower growth rate than southern competitors and an optimum temperature for photosynthesis that matches the climate less well than competitors'. At any given site, it is expected that the sugar maple population closest to its native region will be best adapted to local climate and competition and therefore have the highest growth and survival.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Plant ranges are already shifting in response to climate change, which in turn alters plant communities and interactions between species. Determining which factors are foremost in constraining plant ranges is therefore critical to maintaining the diversity and overall health of forest ecosystems. Forest ecosystems are important for carbon storage and nutrient cycling, as well as local and regional economies; understanding how climate and competition interact to affect tree growth is crucial to predicting how forests may respond to novel climate conditions.

Keywords: *climate change, range limits, sugar maple, competition, facilitation, biotic interactions*

Costanza Rampini

EPA Grant Number: FP917242
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EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Costanza Rampini received her undergraduate degree in En vironmental Studies from the University of California, Santa Barbara in 2007. Soon after, she moved to New Orleans and began working as a case manager for the New Orleans Women's Shelter. She was concurrently employed as a grant writer at the Backbeat Foundation. After 2 years of working in New Orleans, she began her Ph.D. program in Environ mental Studies at the University of California, Santa Cruz. Her research focuses on the intersection of transnational collaboration and environmental issues. She is currently examining the prospect of Sino-Indian collaboration in ad dressing the impacts of climate change in the Himalayas.

SYNOPSIS:

This research examines the prospect of scientific and politi cal collaboration between China and India as the two coun tries face the challenges of climate change impacts in the boundary region of the Himalayas. It uses interviews and par ticipant observation to examine the capacity of the region's institutions and the role of Sino Indian collaborations in ad dressing the crisis. This research will provide insight into the dynamics of transnational environmental governance.

G

Climate Change in the Himalayas: The Prospect of Sino-Indian Collaboration

OBJECTIVE(S)/RESEARCH QUESTION(S)

The IPCC Fourth Assessment Report has concluded that the Himalayan glaciers are receding faster than in any other part of the world as a result of anthropogenic climate change. The accelerated melting of the Hima-layan glaciers will have ripple effects on the entire Asian continent as Himalayan glacial runoff is at the center of Asia's water supply, includ-ing that of India and China. Given the long-term implications of climate change in the region, it will be important to understand how the coun-tries that depend on the Himalayan glaciers, and especially China and India, will align authority, responsibility, and expertise to collaborate in the resolving of this high-stakes crisis.

APPROACH

This project mobilizes the disciplines of Science and Technology Stud-ies (STS) and interdisciplinary research on Vulnerability and Resilience to understand and document the opportunities, successes, and failures of Sino-Indian scientific and political collaboration in the Himalayan region. The first stage of research will use semi-structured interviews and participant observation to identify the key players and institutions involved in climate change research in the region, and examine how China and India are monitoring, detecting, and analyzing the impacts of climate change in the Himalayas. By examining the points of contention and consensus between Chinese and Indian key players and institutions, this analysis will contribute to an understanding of the potential for Sino-Indian collaborations over climate change impacts in the region.

EXPECTED RESULTS

Through an evaluation of the prospect of Sino-Indian collaboration over the impacts of climate change in the Himalayas, this research will provide important insight into the limits and benefits of cross-border collaborations between dissimilar actors in dealing with transnational environmental crises. An analysis of Sino-Indian scientific and political collaborations in the region and an understanding of the implications of such collaboration for knowledge production and political decision-mak-ing will help predict the climate change adaptation strategies of other neighboring countries in the Greater Himalayan region and the overall future of the uniquely diverse region and its people.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Understanding whether Sino-Indian scientific and political collabora-tions, as they are taking place in the Himalayas, display the prerequisite qualities to play a crucial role in resolving a water crisis in the region is imperative considering the relative importance of the Himalayan glaciers for the global community. A social study of the prospect for Sino-Indian collaboration with respect to climate change in the Himala-yas will contribute to assessing the capacity for response of the region. In particular, by identifying barriers and limitations to cross-border collaboration, this research will emphasize the potential for bridging knowledge gaps, building institutions, increasing research capacity, and facilitating the transboundary flow of information and cooperation.

Keywords: *climate change, water, Himalayas, glaciers, transnational governance, collaboration, science policy, risk, uncertainty, scientific expertise, vulnerability, resilience, science and technology*

Colleen Elizabeth Reid

EPA Grant Number: FP917200
Institution: University of California, Berkeley (CA)
EPA Project Officer: Ted Just
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Global Change
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BIO:

Colleen Reid is a Ph.D. student in Environmental Health Sciences at the University of California, Berkeley's School of Public Health. Prior to her doctoral studies, Colleen was an Environmental Health Fellow at the U.S. EPA, where she did research on the health impacts of climate change. Colleen holds an M.P.H. degree from the University of California, Berkeley and an Sc.B. degree in Environmental Studies from Brown University. Between her undergraduate and graduate studies, Colleen was a secondary math and science teacher.

SYNOPSIS:

Climate change is projected to increase the frequency and severity of wildfires in many parts of the world and to in crease the concentration of aeroallergens. My research will employ spatial epidemiological methods to produce better estimates of the health effects of these "natural" air pol lutants, focusing on case studies in California. The findings from my research can be used to inform regulatory deci sions regarding mitigation of and public health adaptation to climate change.

G

The Public Health Impacts of Wildfire Smoke and Aeroallergens Altered by Changing Climate: A Spatial Epidemiological Approach

OBJECTIVE(S)/RESEARCH QUESTION(S)

My research focuses on two related topics within the field of climate change and health that have not been well studied: the health effects of exposure to wildfire smoke and to aeroallergens. Human alterations to the climate and to the landscape contribute to the frequency and severity of both exposures, and there are documented respiratory health effects of both, with significant burdens for the growing asthmatic population. Better understanding of the health effects of natural pollutants and their interactions with urban air pollution can influence policies that can have significant benefits for human health.

APPROACH

The overall goal of my research is to use spatial epidemiological methods to produce better estimates of the health effects of wildfire smoke and aeroallergen exposures. Ground-level measurements of air pollution and meteorology, along with remotely sensed satellite data, will be combined to assess exposure to the 2008 northern California wildfires on fine spatial and temporal scales, which will then be analyzed to estimate the impacts of these extensive fires on respiratory outcomes. For the aeroallergens project, I will pilot a methodology to spatially and temporally model aeroallergen exposure in order to assess the interactions between aeroallergens and urban air pollutants on asthma among children in an ongoing cohort study in Fresno, CA, an area with high air pollution and pesticide exposures.

EXPECTED RESULTS

These analyses will yield more refined estimates of dose-response relationships of health outcomes from these two natural air pollutants as well as identification of vulnerable populations. Both of these studies use more spatially refined exposure assessment compared to previous studies, as most studies of wildfires have used coarsely defined spatial exposure assessment and no studies to my knowledge have spatially modeled aeroallergen exposure. Improved spatial exposure will lead to more accurate dose-response estimates, which are essential for use in cost-benefit analyses that are used to make decisions on climate change mitigation. Better understanding of the health impacts of wildfire smoke and aeroallergens can also enable decisions to be made for public health adaptation to climate change.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The findings from my research will have two principal purposes: to inform current debates and regulatory decisions regarding mitigation and public health protection and to provide a scientific basis for understanding how climate change will generate new or exacerbate current health impacts. Additionally, my research will help further understand which populations are most vulnerable to wildfire smoke and aeroallergens. With better understanding of where the most vulnerable populations are, local public health agencies can target limited funds toward efforts to lessen the adverse health impacts on these populations.

Keywords: *climate change, aeroallergens, wildfires, air pollution, environmental epidemiology, remote sensing, geographic information systems, exposure assessment, public health*

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BIO:

Jeff Salacup received his B.S. in Earth Systems and M.S. in Geology from the University of Massachusetts at Amherst in 2006 and 2008, respectively. During this time, he was awarded a Summer Student Fellowship at the Research Center for Ocean Margins at the University of Bremen, Germany. In 2008, he began his PhD in Geology at Brown University in Providence, RI. His current research focuses on the high resolution reconstruction of environmental and ecological change in coastal settings using bulk sediment, organic geochemical, and environmental isotopic approaches.

SYNOPSIS:

Anthropogenic climate change and cultural eutrophication can lead to changes in primary and secondary productivity in impacted coastal and estuarine ecosystems. Specifically, interactions between increasing sea-surface temperatures and nutrient loads may conspire to increase the likelihood of summer hypoxia with deleterious effects for local ecosys tems. This study aims to investigate such modern ecosys tem change within the context of the past using sediments recovered from Narragansett Bay, RI.

G

A New Approach to Assessing the Anthropogenic Impact on an Urbanized Estuary: Sediment Record of Pre-historical and Historical Environmental Change in Narragansett Bay, RI, USA

OBJECTIVE(S)/RESEARCH QUESTION(S)

Anthropogenic climate change and cultural eutrophication can lead to changes in primary and secondary productivity in impacted coastal and estuarine ecosystems such as Narragansett Bay, RI. Specifically, interactions between increasing sea-surface temperatures and nutrient loads may conspire to increase the likelihood of summer hypoxia with deleterious effects for local ecosystems and economies. Given projections for continued global warming and changes in local wastewater treatment, a better understanding of spatial and temporal responses of this system to past disturbances is critical to future management decisions. This study aims to investigate such modern ecosystem change within the context of the past using sediment archives recovered from Narragansett Bay, RI.

APPROACH

This research will employ sediment cores in the reconstruction of approximately five well-dated multi-proxy records. Environmental and ecological conditions will be reconstructed employing a suite of paleoceanographic proxies to include organic carbon, nitrogen, alkenones concentration and unsaturation ratios, hopanoid and steroid biomarker abundances, and d15N and d13C in organic matter. In well-dated cores, this suite of measurements will provide insight into the complex and dynamic behavior of Narragansett Bay productivity, eutrophication, water quality, and habitability in response to environmental perturbation.

EXPECTED RESULTS

This proposal directly addresses issues critical to the science of global change, particularly climate variability and change in the United States and its impacts on the quality of water, ecosystems, human health, and socio-economic systems. The productivity and environmental records produced in this study will shed light on how different parts of the Bay respond to environmental and anthropogenic forcings beyond that available from the relatively short instrumental record. The results of this study will allow the integration of our relatively limited understanding of Narragansett Bay into the past millennium, providing policy and management officials with a strong foundation on which to base future resource decisions. The health of Narragansett Bay directly and intimately impacts the health of the neighboring human, and non-human, communities.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

A spatially and temporally expanded understanding of the behavior of Narragansett Bay in the face of past environmental change will allow for the scientifically informed management of Bay resources in the future. The dependence of the local human and non-human communities on the Bay's existence as a productive fishery, haven for biological diversity, and source of recreation hinges directly on the environmental health of the Bay and will benefit directly from this work.

Keywords: *climate change, eutrophication, estuaries, biomarkers*

Matthew Scott Schuler

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BIO:

Matt Schuler graduated with a degree in Wildlife Manage ment from the University of Wisconsin Stevens Point in 2007. Following graduation, he began his Master's research at Indiana State University, testing models of thermoregula tion in ectotherms. In 2009, Matt started at Washington Uni versity in the Department of Biology. His research integrates management, theory, physiology, and community ecology. He hopes to use recent models to describe optimally structured habitats that maintain diversity of rare plants and arthropods, while buffering negative effects of climate change.

SYNOPSIS:

My research will focus on management and restoration efforts that change structural and thermal heterogeneity in forest ecosystems. By combining theory and management, I hope to quantify levels of structural and thermal het erogeneity that minimize the effects of climate change in forest ecosystems. Highly structured forests are expected to better maintain rare plant and arthropod diversity, com pared to single stage structured forests, even after extreme climatic events.

G

Using Structural and Thermal Heterogeneity To Minimize or Reverse the Impacts of Climate Change in Terrestrial Systems

OBJECTIVE(S)/RESEARCH QUESTION(S)

Current forest management techniques have reduced structural heterogeneity at broad ecological scales, likely having a major impact on species diversity and ecosystem function. I will use stage-structured Species Area Distributions and Species Biomass Distributions to quantify differences in structural heterogeneity in forest plots across a latitudinal gradient. Two types of forest stands will be compared: mixed-stage structure (heterogeneous), and single-stage structure (homogenous). By quantifying differences at each site, I hope to show that structural heterogeneity buffers extreme variation in climate, allowing for the maintenance of rare plant and arthropod populations.

APPROACH

Using methods described by O'Dwyer et al. (2009), I will measure demographics, Species Area Distributions, and Species Biomass Distributions in 1-hectare forest plots, allowing me to quantify structural heterogeneity across a latitudinal gradient. Within each plot, I will quantify plant and arthropod diversity prior to any treatments. The distribution of temperatures in the environment has been shown to be important for thermoregulation by ectothermic species; therefore, I will use iButton data-loggers to record differences in thermal heterogeneity within each plot. Following these measurements, I will modify the timing and quantity of rain events to mimic potential effects of climate change. Control plots will receive no treatment, but natural rainfall amounts will be measured within each plot to compare to treatment plots. The treatments will last for at least 3 years. During and immediately following the treatments, I will measure changes in plant and arthropod diversity, as well as any changes in structural heterogeneity. These experiments will test the importance of vertical structure in forest plots, and how structure and climate interact to change species abundances and distributions.

EXPECTED RESULTS

When assessing the effects of stochastic climate variation, I expect to find that highly structured plots maintain biodiversity of plants and arthropods better than homogenous forest plots. The thermal heterogeneity in structured plots will allow ectothermic species to thermoregulate effectively, and maximize performance and reproduction. A high diversity of ectothermic animals will positively influence plant populations through plant-pollinator interactions, and potentially increase seed dispersal. Recent models also predict that predators are more able to control herbivorous insect populations in habitats with high thermal heterogeneity; reduced herbivory will increase plant fitness.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Forests have been heavily harvested worldwide. Broad scale clear-cuts have diminished natural structure once found in forest habitats, likely diminishing any beneficial buffering against climatic stochasticity. Habitat management plans need to be implemented that make it logical for land owners to re-establish natural heterogeneity once found in forest ecosystems. By re-establishing forest structure, using the management tools I propose, scientists and land managers can take an interactive and cooperative role in minimizing the effects of climate change. This proposal combines multiple disciplinary backgrounds, and therefore applies to those studying ecology, wildlife, physiology, and habitat management. Beyond the scope of science, promoting habitats that maintain biodiversity, even in the light of increased climatic stochasticity, offers interesting implications for farmers, conservationists, and the general public.

Keywords: *biodiversity, structure, heterogeneity, forest, rainfall, temperature, climate change, latitudinal gradient*

Katharine Lisa Stuble

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BIO:

Katie Stuble received her undergraduate degree in Biology from St. Mary's College of Maryland in 2004. In 2008, she completed a Masters degree in Ecology at the University of Georgia, where she conducted research on the ecological im pacts of the red imported fire ant on the threatened longleaf pine ecosystem. She is now a Ph.D. student at the University of Tennessee, researching the ecological impacts of climatic warming. She is specifically interested in the mechanisms by which ant communities may be restructured with warming and how these changes may alter ecosystem function.

SYNOPSIS:

Global warming has the potential to alter species distribu tions. However, the importance of biotic interactions in driv ing these changes is unclear, as are the consequences of these shifts for ecosystem processes. I will experimentally increase air temperature to examine the impact of warming on ant community composition and the ecosystem functions ants mediate. I will also examine shifts in foraging behavior and competitive interactions as potential drivers of change in community composition.

G

Disruption of Ant Communities by Climatic Warming

OBJECTIVE(S)/RESEARCH QUESTION(S)

Climatic warming has the potential to dramatically alter species distributions and ecosystem function across the globe. This research will examine the impact of climatic warming on ant community composition and the ecosystem functions they mediate. It will also examine shifts in foraging behavior and competitive interactions as potential drivers of changes in community composition.

APPROACH

This study will use open-top chambers that will manipulate temperature at Duke Forest in North Carolina and Harvard Forest in Massachusetts. I will monitor ant species abundances and community composition within these chambers. Competitive interactions between ant species under the different temperature treatments will be examined using food baits. On these baits I will note the species that first discovers the bait, interactions between individuals of different species, and the species that ultimately dominates the bait. Additionally, 24-hour baiting experiments will be used to examine the hours per day spent foraging by each species. To examine the influence of warming on seed dispersal, I will conduct a series of seed dispersal trials whereby caches of seeds are made available to ants within the warmed chambers to determine any potential influence of climatic warming on seed dispersal rates.

EXPECTED RESULTS

This research will examine the impact of experimental warming on animal communities and will yield information on shifts in species-specific abundances and community composition as a result of climatic warming. Specifically, examination of shifts in foraging behavior and competitive abilities will enhance our understanding of factors influencing changes in community composition. This is especially noteworthy as these potentially important behavioral factors are almost always ignored in models of projected shifts in species ranges resulting from climate change. Thus, in addition to enhancing our understanding of the effects of climate change on species composition, the data generated through this research will inform future predictive models by enhancing our understanding of the importance of interspecies interactions and altered behavior. Additionally, this study will examine the potential for climatic warming to have indirect effects on community composition. Specifically, it will examine the potential for climatic warming to restructure the plant community, as mediated through changes in the ant-plant seed dispersal mutualism.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Ultimately, results generated through this research will help to improve predictions of the ecological impacts of climatic warming as well as increase our knowledge of the potential indirect effects of climatic warming. This will enhance our knowledge of the various impacts climatic change is likely to have on the composition and function of terrestrial ecosystems. Such knowledge is crucial in order to inform both the public and policy makers as to the impacts of global climate change and to assist with the development and prioritization of policies dealing with climate change.

Keywords: *climate change, warming, ants, interspecies interactions, seed dispersal*

Robert Frank Swarthout

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BIO:

Robert Swarthout obtained his undergraduate degree in Chemistry and Biology from the State University of New York, Cortland in 2003. He then earned a Master's degree in Environmental Studies at the College of Charleston in 2006, where he conducted research in analytical environ mental chemistry. His Master's thesis focused on develop ing methods for analyzing organic pollutants in blood and the threat posed by these pollutants to Kemp's ridley sea turtles. In 2008 he began a Ph.D. program at the University of New Hampshire, where his research focuses on under standing climate-atmosphere feedback mechanisms.

SYNOPSIS:

Climate change has been shown to affect plant emissions of biogenic volatile organic compounds (BVOCs). BVOCs, in turn, influence climate by affecting hydroxyl radical avail ability and greenhouse gas (GHG) lifetimes, and by alter ing tropospheric ozone chemistry. Using measurements of BVOC emissions from plants exposed to predicted future climate conditions, this study will quantify and model the impact of future BVOC production on the oxidative capacity of the atmosphere and ozone chemistry.

G

Effects of Elevated Carbon Dioxide and Temperature on BVOC Emissions: Implications for Hydroxyl Radical Reactivity and Ozone Chemistry

OBJECTIVE(S)/RESEARCH QUESTION(S)

Climate change has been demonstrated to alter emissions of biogenic volatile organic compounds (BVOCs) from plants. BVOCs, in turn, have an impact on climate through three primary feedback mechanisms: 1) reaction with hydroxyl radical, the primary atmospheric oxidant responsible for the removal of many pollutants and greenhouse gases (GHGs); 2) affecting rates of tropospheric ozone production and destruction; and 3) contributing to the formation of aerosols. This study will quantify the effects of plant BVOC emissions on atmospheric hydroxyl radical availability and ozone production under current and future climate conditions using a combination of measurements and modeling.

APPROACH

This study will employ a combination of laboratory and field measurements as well as modeling to address two fundamental scientific questions: 1) how will individual BVOC emissions and the total hydroxyl radical reactivity of BVOC emissions change as a result of climate change; and 2) how will changes in BVOC emissions affect future ozone production? In the laboratory, plant species will be exposed to a matrix of climate conditions. Exposing plants to current and predicted future levels of carbon dioxide and temperature in the presence or absence of light and ozone will elucidate the effects of each variable separately and any synergistic effects on BVOC emissions. Emissions of BVOCs from these plants will be monitored by several gas chromatographic techniques, proton transfer reaction mass spectrometry, and an integrative method of measuring total hydroxyl radical reactivity that will account for difficult-to-measure BVOCs. These laboratory measurements, in combination with field measurements of individual BVOCs and total hydroxyl radical reactivity made at Thompson Farm, a forested site in New Hampshire, will be used to develop quantitative relationships between climate variables and BVOC emissions. These data will ultimately be used to model future ozone chemistry and lifetimes of important GHGs in order to predict the effect that future BVOC emissions will have on radiative forcing.

EXPECTED RESULTS

Using an integrative approach of measurements and modeling, this study will determine the sensitivity of individual BVOCs to changes in climate and will directly measure the hydroxyl radical reactivity of BVOC emissions from plants exposed to elevated carbon dioxide and temperature. These measurements will quantify two of the climate feedback cycles associated with BVOC emissions (the effect on hydroxyl radical availability and the effect on ozone chemistry), and will provide a more solid empirical foundation for future climate modeling studies. Greater quantitative knowledge of future BVOC emissions will also facilitate modeling studies of secondary organic aerosol formation and the associated effects on radiative forcing. Most importantly, data generated by this work will lead to more informed climate policy decisions.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Data generated by this study will lead to more accurate predictions of the oxidative capacity of the atmosphere and GHG lifetimes in a changing climate. These data will also aid in predicting the contribution that BVOCs will make to future ozone levels, which could have important human health implications.

Keywords: *climate change, biogenic volatile organic compounds, plant emissions, ozone, greenhouse gases, air pollution, atmospheric chemistry*

Rory S. Telemeco

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BIO:

Rory Telemeco received his B.S. degree in Biology from the University of Central Oklahoma (UCO) in 2006. The follow ing year, he was a Fulbright scholar and studied the impacts of thermal variation on the reproductive life history of an Australian lizard. Upon his return to the United States, Rory used these data to complete his M.S. degree in Biology (UCO, 2009). He then immediately began a Ph.D. program in Ecology and Evolutionary Biology at Iowa State University. His Ph.D. research focuses on predicting the likely effects of impending climate change on reptile populations.

SYNOPSIS:

Numerous aspects of reptile biology are impacted by tem perature. Because of this, reptiles are at high risk of climate change-induced decline. However, little is known about the specific effects of thermal variation, much less climate change, on many reptile species. This project will help bridge these knowledge gaps by combining field and labo ratory experimental techniques with molecular techniques and bioclimatic modeling using alligator lizards (genus *Elgaria*) as a model system.

G

Predicting the Biotic Effects of Climate Change: An Integrative Approach Using an Ectothermic Vertebrate Model

OBJECTIVE(S)/RESEARCH QUESTION(S)

Because numerous aspects of reptilian biology, from embryonic development to behavior, are strongly impacted by the thermal environment, reptiles are thought to be at high risk of climate change-induced decline. Even so, virtually nothing is known about the effects of thermal variation, much less climate change, on the natural history and development of many reptile species. This research project will help bridge these knowledge gaps using alligator lizards (genus *Elgaria*, family Anguidae) as a model system.

APPROACH

To determine the probable effects of climate change on alligator lizards and their relatives, this research will combine field and laboratory experimental techniques with cutting-edge molecular phylogeographic techniques and bioclimatic modeling. The first stage of research will involve experimental incubation studies designed to describe the effects of thermal variation during embryonic development on offspring phenotype and fitness. Next, field and laboratory experiments will be utilized to examine whether or not female lizards can effectively buffer their progeny from climatic variation by altering the microclimate of their nests (nest depth, shade cover, moisture, etc). This information will then be used to build bioclimatic envelope models capable of predicting the likely effects of climate change on alligator lizards and their relatives. For this model to be effectively applied, it will be important to identify taxonomic groups of conservation concern, particularly cryptic species that may not be immediately obvious. Therefore, molecular phylogeographic techniques will be utilized to identify any cryptic species within the southern alligator lizard (*Elgaria multicarinata*) species group. Finally, the bioclimatic envelope model will be applied to threatened alligator lizard species and any identified cryptic species such that management recommendations may be made.

EXPECTED RESULTS

Results from the experimental portions of this study will detail the effects of varied thermal conditions on the reproductive life-histories of alligator lizards and the capacity of alligator lizards to adaptively and/or plastically adjust their phenotypes in response to climate change. For example, this research will determine whether or not increasing temperatures in the nest will skew the sex ratios of offspring, what temperatures are too high for successful embryogenesis, the effects of climatic variation on natural nests in the field, and the ability of females to adjust their behavior or physiology to counter these deleterious effects. The molecular portion of the study will result in the reconstruction of a phylogeny for *Elgaria multicarinata* that will resolve the validity of each *E. multicarinata* subspecies. There are three possible fates for the currently recognized subspecies: 1) they might be supported; 2) they might not be supported, in which case it will be recommended that the subspecies designation be removed; or 3) they might be strongly supported as individual clades, in which case it will be recommended that they be elevated to species status and considered as discrete taxonomic units for conservation purposes. Finally, the modeling portion of the study will incorporate the experimental and molecular data from the previous portions, and current climate change predictions, into a model that predicts the effects of future climate change on high-risk groups of alligator lizards. With this model, it will be possible to make informed management recommendations for these and other lizards.

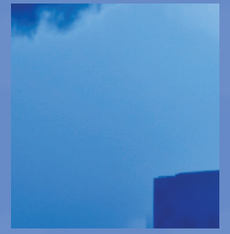
POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This study will provide information vital to the effective management of alligator lizards and their relatives as global climates change. Furthermore, with minor modification the bioclimatic envelope model that results from this study should be applicable to other, diverse reptile species (particularly squamates, snakes, and lizards), thereby allowing predictions to be made about how these populations will likely respond to impending climate change.

Keywords: *alligator lizard, Elgaria, Anguidae, squamate, climate change, global warming, life history, temperature-dependent sex determination, bioclimatic envelope*

Clean Air










Clean Air Fellows

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BIO:

Ellison Carter graduated from Indiana University in 2004 with degrees in Biology and Spanish. The following year, she was a resident naturalist in the rain forest of Costa Rica, conducting ecological research and leading environ mental education programs. After a brief working stint back in the US, she returned to school and recently finished an M.S.E. in Civil Engineering at the University of Texas (UT) at Austin. She is working toward a Ph.D. in Environmental Engineering, pursuing research in environmental chemistry and pollution control. Her current work is focused on the surface properties of air filter media that promote gas-phase removal of recalcitrant, polar contaminants common to indoor environments.

SYNOPSIS:

This work addresses a need to provide people with clean, indoor air by reducing their exposure to harmful aldehydes. The project consists of three main tasks: 1) physical and chemical characterization of activated carbon adsorbents, 2) adsorption equilibrium and desorption studies, and 3) mathematical modeling of the sorption processes observed. The outcome of this work will be a predictive tool for as sessing the performance of adsorption-based media for gas-phase treatment of indoor air.

C

Removal of Aldehydes from Indoor Air: Elucidating Adsorption Mechanisms, Modeling Competitive Adsorption, and Predicting Removal in Gas-phase Air Cleaners

OBJECTIVE(S)/RESEARCH QUESTION(S)

Poor indoor air quality in the workplace, public buildings, and residential dwellings has the potential to adversely impact human health. Polar, volatile organic compounds are common contributors to indoor air pollution, and formaldehyde and other aldehydes are among the most studied indoor environmental pollutants as a consequence of their ubiquity indoors and established human health significance. Adsorption-based treatment strategies offer an attractive alternative to both energy-intensive ventilation and impractical source removal. The focus of this research is to develop, through experimentally-based research, a mechanistic understanding of the sorption interactions between polar, gas-phase organic pollutants and the surfaces of adsorbent media used in air treatment systems. This work will strengthen efforts to protect public health in indoor environments by reducing environmental exposure to harmful indoor air pollutants.

APPROACH

This research project consists of three main tasks: 1) physical and chemical characterization of both commercial and synthesized activated carbon adsorbents using a variety of surface analytical techniques, 2) adsorption equilibrium and desorption studies in differential batch reactors and columns, and 3) mathematical modeling of the sorption processes observed.

EXPECTED RESULTS

This research project will identify specific chemical and physical characteristics of activated carbon surfaces that promote the removal of gas-phase, polar organic pollutants. It is expected that basic and acidic functional groups will influence aldehyde adsorption through distinct sorption mechanisms, depending on indoor environmental conditions, such as relative humidity and temperature. By precisely describing molecular-level sorption interactions over a range of environmental conditions, the outcome of this work will be the development of a predictive tool for assessing the performance of adsorption-based media for gas-phase treatment of indoor air.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This work should serve as a model approach for evaluation and/or design of indoor surfaces and their potential for pollutant removal. Gas-phase sorption processes greatly influence the mobility and distribution of many indoor contaminants, but these processes are not yet well characterized for indoor environments. In response to the need for sustainable, healthy building materials, these studies will underscore the value of concurrent physical/chemical surface characterization and adsorption/desorption studies by contributing to knowledge of gas-solid sorption mechanisms. On a larger scale, this work should further the development of materials that live up to the principles of green engineering and ultimately minimize human exposure to indoor pollutants.

Keywords: *formaldehyde, aldehydes, polar organic compounds, adsorption, desorption, sorptive interactions, environmental organic chemistry, surface chemistry, indoor air, activated carbon, treatment strategies*

Jessica Grace Charrier

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BIO:

Jessie Charrier received a Bachelor of Science in Chemistry from the University of California, San Diego in 2006. Ms. Charrier was introduced to the field of Atmospheric Chem istry while performing two years of undergraduate research with Dr. Kim Prather. After graduation, Ms. Charrier worked at Sonoma Technology, Inc., in Petaluma, CA as an Air Quality Data Analyst. In 2008, she began her Ph.D. in Environmental Chemistry with an emphasis on Atmospheric Chemistry at the University of California, Davis. Her current research examines adverse oxidant production from particu late matter.

SYNOPSIS:

Inhalation of particulate matter can cause adverse health effects and mortality in humans. One mechanism of toxic ity is production of oxidants in the lungs, which can lead to inflammation and disease. My project will investigate the detailed chemistry of oxidant production from particulate matter and its components. The results of this research will provide insight in the chemical components, sources, and atmospheric processes that cause particles to be most harmful to human health.

C

Elucidating the Role of Transition Metals, Organic Species, and Atmospheric Processing in Oxidant Production from Laboratory and Ambient Particulate Matter

OBJECTIVE(S)/RESEARCH QUESTION(S)

Inhalation of ambient particulate pollution is known to cause morbidity and mortality in humans. One likely mechanism of toxicity is the production of oxidants in the lungs by the particles, which has been shown to cause inflammation and disease. The objective of my research is to elucidate the chemical species, sources, and atmospheric processes that affect oxidant production in the lungs from ambient particulate matter (PM).

APPROACH

My research will quantify production of two oxidants, hydroxyl radical and hydrogen peroxide, from laboratory and ambient particulate matter PM in cell-free surrogate lung fluid. The research will consist of four stages: 1) quantifying oxidant production from laboratory particles containing individual and mixed transition metals, 2) evaluating oxidant production from PM collected directly from various sources (e.g., diesel from dynamometer studies), 3) understanding the effect of atmospheric aging and secondary organic aerosol on oxidant production from both particle types in 1 and 2 by artificially aging the particle in the laboratory, and 4) applying this knowledge to ambient $PM_{2.5}$ collected at sites with different source impacts.

EXPECTED RESULTS

Previous work in my lab shows strong evidence that oxidant production is related to the transition metal content of ambient PM, especially iron and copper, and is dependent on the presence of ascorbate (or some other electron donor). I expected oxidant production from particles to primarily depend on the availability of soluble transition metals. Artificial aging of particles with ozone and light has been show to oxidize the surface of the particles, which may affect metal solubility and oxidant production. The addition of organics may affect oxidant production through multiple mechanisms: organics act as metal ligands, which can increase or decrease the reactivity of the metals; organics may act as electron donors increasing oxidant production from metals; or organics may be redox active and produce oxidants themselves. The organic content of the particles may strongly affect oxidant production in some cases.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The results of my research will provide insight in the chemical components, sources, and atmospheric processes that cause PM to produce high concentrations of oxidants, providing the necessary information to enact effective policy for protection of human health. Along with an understanding of the detailed chemistry, the method I will use allows for quantitative determination of hydroxyl radical and hydrogen peroxide, which provides dose estimates necessary to better understand health effects.

Keywords: *oxidative stress, reactive oxygen species, hydroxyl radical, hydrogen peroxide, health, particulate matter, air pollution*

Lea Hildebrandt

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BIO:

Lea Hildebrandt received her Bachelor of Science in Chemi cal Engineering (Environmental) from the California Insti tute of Technology in 2006. She then began the Ph.D. pro gram at Carnegie Mellon University in Chemical Engineering (Fall 2006) and in Engineering and Public Policy (Spring 2007). Her research in air quality focuses on an improved understanding of atmospheric organic aerosol (AO), which can lead to improved atmospheric models and better in formed policy decisions.

SYNOPSIS:

Fine atmospheric particles adversely affect human health, and they have a highly uncertain effect on climate. OA glob ally comprises 20 90% of the fine particle mass, but a full understanding of its formation, evolution and characteristics remains elusive. The goal of this project is to improve air quality by better understanding OA, facilitating the articula tion of policy actions that lead to a reduction in OA and its adverse effects on human health and the environment.

C

Anthropogenic Secondary Organic Particulate Matter: From Measurements to Models to Mitigation

OBJECTIVE(S)/RESEARCH QUESTION(S)

Submicron atmospheric particles are of interest because they adversely affect human health and regional visibility, and they have a highly uncertain effect on climate. Organic aerosol (OA) globally comprises 20-90% of the submicron particle mass, but a full understanding of its formation, evolution, and characteristics remains elusive. The goal of this research project is to better understand the processes governing the properties and concentrations of OA, facilitating the articulation of policy actions that lead to a reduction in atmospheric OA and its adverse effects.

APPROACH

The main part of this project focuses on investigating OA through a series of laboratory experiments and ambient measurements. In particular, we measure the potential of individual gaseous precursors to form OA in laboratory experiments. We also explore the changes in OA ("aging") in laboratory experiments by further oxidizing the OA after its initial formation. We observe the effects of OA aging in the atmosphere by measuring ambient OA at a remote location that is not influenced by fresh pollution. Finally, we investigate the interactions of different types of OA in the laboratory by forming them during the same experiment. We use isotopic labeling and a high-resolution aerosol mass spectrometer to distinguish between the different OA types.

EXPECTED RESULTS

The experiments and ambient measurements will provide insights into the formation, transformation, and interactions of organic aerosol (OA). Based on these new insights, we will develop improved model parameterizations and include them in the three-dimensional chemical transport model PMCAMx. We will then test the model against observations from ambient measurements. Finally, we will use the improved model to evaluate different emission control options for reducing OA concentrations and then make recommendations for regulatory efforts aimed at mitigating OA concentrations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This project will enable the development of more effective policy actions aimed at reducing organic aerosol and total fine particle concentrations in the atmosphere. This will lead to decreased adverse effects from fine particles on human health and the environment.

Keywords: *air quality, organic aerosol, aerosol mass spectrometer, laboratory experiments, ambient measurements, chemical transport model, policy*

Gabriel A. Isaacman

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Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Gabriel Isaacman was raised by wild scientists in Bowie, MD, before going to Wesleyan University, where he received a B.A. in Chemistry and Earth and Environmental Science in 2007. He moved to the Bay Area to pursue his dream of having many part-time jobs. Following a year at a science museum and teaching gardening to children, he decided to use his science background in a field that affects everyone. His research focuses on air pollution sources. Hopefully his work will assist mitigation efforts.

SYNOPSIS:

Specific compounds in atmospheric particulate matter ("smog") can be used to understand its sources and forma tion. This project will study the variability over the course of the day of such "marker compounds" using a custom instrument that has a better time resolution than typical techniques. The applicant proposes to expand current capa bilities of this instrument to include the detection of com pounds found in more aged air, which make up a significant fraction of all particulate matter.

C

Characterization of Highly Oxygenated Organic Compounds and Organosulfates in Atmospheric Particulate Matter

OBJECTIVE(S)/RESEARCH QUESTION(S)

This project aims to expand the ability to characterize both highly oxygenated and sulfur-containing atmospheric oxidation products of prevalent volatile organic compounds. It also will attempt to quantify the extent to which interaction between anthropogenic and biogenic emissions to the atmosphere leads to formation of secondary aerosol in regions like the southeastern United States, where emissions from both sources are high.

APPROACH

The composition of organic atmospheric aerosol has been characterized to date primarily through the use of filter collection and analysis. However, this approach does not provide an understanding of diurnal variability of individual compounds, which can be used to understand sources and formation processes. Therefore, this project will seek to improve a recently designed custom instrument, the Thermal Desorption Aerosol Gas Chromatograph (TAG). The range of compounds detectable by TAG will be expanded to include markers of oxidized and aged air through the use of "derivatization," where a chemical reaction will be employed to change the structure of analyzed air in such a way to allow detection. The exact reaction is not yet known and will require significant experimentation. Following development of these methods, the instrument will be deployed to the field to understand the sources of particulate matter in polluted and/or non-polluted areas.

EXPECTED RESULTS

Highly oxygenated compounds are known to be a significant fraction of atmospheric aerosol but cannot be easily characterized with high time resolution using current methods. This work will address this issue, providing better knowledge about the diurnal variability of these compounds. Such knowledge can and will be used for source apportionment as well as studies into the products of known precursor gas-phase compounds. This work will better constrain the causes of some air pollution, specifically small particulate matter ($PM_{2.5}$), one of EPA's six "criteria pollutants."

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Atmospheric aerosol affects human health and climate, and these effects vary based on the composition of the aerosol. This research seeks to understand the composition of aerosol, thus understanding its effects. Furthermore, by having high time resolution in these measurements, the sources and formation processes can be better understood, assisting in future mitigation efforts.

Keywords: *air pollution, aerosol, particulate matter, $PM_{2.5}$, criteria pollutants, derivatization, volatile organic compounds*

Allison Paige St. Vincent

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BIO:

Allison St. Vincent was born and raised in Bristol, Rhode Island. She graduated from Mt. Hope High School in 2005 and then went on to the Massachusetts Institute of Technol ogy, where she earned an undergraduate degree in Environ mental Engineering in 2009. The following fall, she began the Ph.D. program in Environmental and Water Resources Engineering at Tufts University in Medford, Massachusetts. Her research focuses on measuring and modeling highway-generated air pollution.

SYNOPSIS:

Living near highways is associated with elevated risk of adverse health effects due to exposure to traffic-related air pollution. Concentrations of ultrafine particles (1-100 nm; UFP), which penetrate the lungs more effectively than larger particles, may be as much as 25 times higher near highways than in other urban areas. This project couples mobile air pollution monitoring with local-scale modeling to understand the concentrations and dispersion of UFP in near-highway urban neighborhoods.

C

Developing Time-Resolved Models for Predicting Atmospheric Concentrations of Highway-Generated Nanoparticles in Urban Neighborhoods

OBJECTIVE(S)/RESEARCH QUESTION(S)

The concentration of nanoparticles (1-100 nm, also referred to as ultra-fine particles or UFP) can be elevated 25-fold or more near highways compared to urban background sites. This smallest range of particles may disproportionately increase health risk by their ability to penetrate into the lungs, yet accurately estimating human exposures to nanoparticles has proved to be difficult due to lack of temporally (hourly) and spatially (< 1 km^2) resolved estimates of nanoparticle concentrations. The objective of this research is to develop a method to accurately predict the concentrations and distribution of highway-generated nanoparticles in near-highway urban neighborhoods.

APPROACH

A mobile laboratory housing a suite of rapid-response instruments will monitor particle number concentration (7-225 nm), CO, and other pollutants in three Boston-area neighborhoods. Monitoring will be done at different times (i.e., morning, evening) and on both weekdays and weekends in all four seasons so as to capture temporal as well as spatial variations in pollutant levels. Models (e.g., CALINE4, QUIC) will be developed and calibrated against measurements to predict the concentrations for times and places that are not directly measured. The model will involve the effects of traffic conditions and meteorology (e.g., wind speed, wind direction, temperature) on the dispersion of nanoparticles. Calibration will include an analysis of the sensitivity of vehicular emission rates of nanoparticles to environmental conditions.

EXPECTED RESULTS

This research is one of many steps towards new nanoparticle regulations that will be protective of human health. Intensive spatial and temporal monitoring of highway-generated air pollution will provide valuable insight into the potential exposures of people who live near highways in urban neighborhoods. A modeling approach for the near-highway environment will be developed to include wind speed and direction, boundary layer height, time of day, weekdays and weekends, and seasonal changes as well as the chemistry and physics of the near-highway zone. In addition, it will explore methods of generalizing vehicular nanoparticle source strength. Modeling on the same time scale as changes in particle concentrations (~1 hr) will increase applicability of this study to other near-highway urban residential neighborhoods, especially those where monitoring is impractical. The model will facilitate accurate predictions of long-term human exposure to traffic-generated nanoparticles.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This work could serve to inform policy makers who may be considering the merits of new regulations for nanoparticles as well as citizen advocates who are working to protect public health. Collaborators in Boston (Tufts Medical School, Harvard School of Public Health) will use the model to quantify exposure to traffic pollutants at individual homes, allowing for the correlation of health endpoints with exposure. The model could also be used by other research groups who are actively investigating health effects of near-highway air pollution exposure in other locations (e.g., Los Angeles, North Carolina, Toronto, Helsinki, Stockholm, the Netherlands).

Keywords: *highway-generated air pollution, nanoparticles, ultrafine particles, urban-scale meteorology, CALINE4, QUIC*

Drinking Water










Drinking Water Fellows

Sara Elizabeth Beck

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EPA Project Officer: Brandon Jones
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Bio:

Sara Beck received her undergraduate degrees in aerospace engineering and studio art from the University of Colorado at Boulder. For six years, she worked as a flight controller on the Space Shuttle and International Space Station programs at Mission Control Centers in Houston, TX, Moscow, Russia, and Tsukuba, Japan. During that time, she pursued her pas sion for engineering in developing communities by serving as founding president of the Central Houston Professional Partners chapter of Engineers Without Borders USA and working on projects for El Salvador, Bolivia, Nicaragua, and Uganda. After receiving a M.S. in Environmental Engineering from Georgia Tech, Sara left NASA in order to work on water treatment technologies for developing communities. She is working on her Ph.D. in Environmental Engineering at the University of Colorado, Boulder, studying appropriate water treatment technologies. Her research focuses on water reuse, ultrafiltration membranes, and UV disinfection.

Synopsis:

The research will evaluate small-scale, low-cost, high tech nology systems for treating greywater and contaminated surface water for agricultural and potable water uses. The project will characterize the source water quality necessary for these treatment processes to be effective. Determining the efficiency of these systems in the lab and examining their sustainability in the field could lead to their use by development or emergency relief organizations and facilities in industrialized countries.

D

Pilot Scale Water Reuse System

OBJECTIVE(S)/RESEARCH QUESTION(S)

Rapid population growth will continue to stress already scarce water resources and contaminate surface water and groundwater supplies. As a result, engineers are evaluating water supply and treatment methods that can augment traditional supplies, including water reuse. Since the majority of the population growth will take place in areas that lack adequate water supply and sanitation systems, this research project will develop and evaluate water supply and treatment technologies that are appropriate for developing communities.

APPROACH

Although water reuse is frequently practiced in developing communities, it is not well evaluated. The research will evaluate pilot scale systems that use low-cost, high technology solutions (such as UV light and ultrafiltration) for reusing greywater and treating traditional surface water and runoff sources with the end goal of generating agricultural and potable water. The project will characterize the source water quality necessary for effective reuse treatment processes, determining maximum levels of turbidity, organic loading, pathogens, and microbial contaminants in the source water. After verifying treated source water quality in the laboratory, the systems will be tested in the field and evaluated for their sustainability in developing communities.

EXPECTED RESULTS

The efficiency of the treatment technologies is expected to vary with the source water quality. By testing the technologies with various source waters, the research will quantify the limits of the technology: testing the flow rate variations with influent water quality, evaluating the tendencies of the technologies to foul, characterizing the foulants, and exploring appropriate cleaning methods. Understanding the fundamentals of the fouling tendencies will lead to ways to minimize fouling and optimize the treatment processes. Quantifying the technological efficiency of these systems in the laboratory first and then examining their sustainability in the field will lead to their potential use by development and emergency relief organizations as well as facilities in industrialized countries. Implementing appropriate, low-cost, low-energy technologies in developing communities can potentially shift paradigms for sustainable technology implementation in the developed world as well.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

By 2025, an estimated 1.7 billion people will not have access to enough water to satisfy their basic human needs. This research project seeks to evaluate potential appropriate technology solutions that can address water scarcity and contamination problems worldwide.

Keywords: *water reuse, source water quality, water quality parameters, developing communities, appropriate technology, sustainable technology*

Laura Craig

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Bio:

Laura Craig received a B.S. in Hydrology from the Univer sity of California, Davis in 2002, and subsequently worked at Lawrence Livermore National Laboratory. In 2004 she enrolled at the University of Wisconsin-Madison, and earned M.S. degrees in Geology and Water Resources Management. Laura then spent a year as a Fulbright Fellow-Mexico study ing water quality. In 2009, she began a Ph.D. program in Hydrogeology at the University of Nevada, Reno. Her cur rent focus is safe drinking water in rural Ghana.

Synopsis:

Excess fluoride in drinking water is a serious health prob lem. Poor and rural areas, such as the study sites in north ern Ghana, are particularly vulnerable as they often lack access to treated water. Developing successful locally-managed drinking water systems under these conditions is needed, but also require direct community involvement. Thus, the focus of this study is to work extensively with the affected communities to develop a simple de-fluoridation system and management plan.

D

Developing a Systems and Community-Based Approach for Controlling Excess Fluoride in Drinking Water in Northern Ghana

OBJECTIVE(S)/RESEARCH QUESTION(S)

Excess fluoride in drinking water is a serious global health problem, causing dental fluorisis in children and skeletal fluorosis that affects all ages. Poor and rural areas are particularly vulnerable as they often lack access to necessary water treatment methods. The focus of this research is to develop and implement a simple de-fluoridation system and management plan in close collaboration with affected communities in northern Ghana.

APPROACH

This research includes both laboratory and field components. The laboratory component is dedicated to treatment methods, and will initially focus on batch and column experiments to determine fluoride adsorption behavior of materials indigenous to northern Ghana and to experiment with filter column designs. The field component is dedicated to collecting well data, developing appropriate field designs, and surveying the community regarding health risks and proposed de-fluoridation systems. The well data include measuring fluoride concentrations and seasonal changes. The development of field designs involves testing and subsequent modification of filters depending upon fluoride removal capacity in the field, ease of use and maintenance of selected filter systems, and community responses to the designs. Community surveys will be conducted to (1) determine how much water is consumed daily (including setting up physical measurements in some households), (2) gauge the level of awareness regarding dangers of consuming excess fluoride, (3) estimate what percentage of the population suffers from fluorosis, and (4) determine which filter systems (i.e., in home or at hand-pump) will be most appropriate.

EXPECTED RESULTS

This interdisciplinary research project will provide experience including engineering design, hydrogeologic and geochemical analysis, socio-economic evaluation of a small-scale drinking water system, and information for development of a long-term health management plan at the community level. The project scope includes collection of key data on seasonal variation in groundwater levels and correlated changes in fluoride concentrations, daily water consumption, estimates of milligrams of fluoride consumed per day, dietary information, prevalence of fluorosis, and the most feasible filter designs and filter material. Through this project, we will develop a holistic approach for providing safe drinking water at the small-scale to low-income communities with a high risk of exposure to excess fluoride. A variation of this method may be replicable in other communities with similar drinking water issues.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The described project will contribute toward raising awareness of the dangers of excess fluoride intake and creation of a program for development and maintenance of de-fluoridation filters. Success with this effort in Ghana may extend to other regions facing safe drinking water and health management issues.

Keywords: *drinking water quality, fluorosis, fluoride, water resource management, health management*

Christine Susan Fagnant

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EPA Project Officer: Brandon Jones
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Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Drinking Water
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Bio:

Christine Fagnant received her undergraduate degree in Civil Engineering from Gonzaga University in 2008. The following year, she worked as a case manager in a women's homeless shelter through the Jesuit Volunteer Corps. She began the Ph.D. program at the University of Washington in 2009. Her research focuses on photochemical and chemi cal redox processes, with a specific focus on applications for drinking water and sanitation for developing communi ties. When not working in the lab, she loves to backpack, garden, and play guitar.

Synopsis:

This project will examine the use of natural chemical reac tions to develop simple, inexpensive, and low-energy water disinfection systems. The research will focus on the uti lization of metals (e.g., iron or aluminum) and/or various organic photocatalysts to produce chemical disinfectants in the dark and under the influence of direct solar irradiation. These processes are ultimately intended for application in point-of-use drinking water treatment and/or sanitation in developing communities.

D

Optimization of Natural Photochemistry for Cost-Effective, Energy-Efficient Human Pathogen Inactivation in Compromised Water Sources

OBJECTIVE(S)/RESEARCH QUESTION(S)

This research project will aim to optimize natural processes to develop simple, sustainable, and inexpensive water disinfection processes that could be used in both the developed and developing worlds.

APPROACH

Bench-scale experiments will examine the ability of redox systems catalyzed by transition metals (such as iron or aluminum) and/or organic photosensitizers to produce water disinfectants such as hydrogen perox ide or chlorine with minimal or no electrical input. Both sunlight-medi ated and dark reactions will be investigated. Furthermore, this research will examine the effects of coupling such chemical disinfectants with solar disinfection of water for enhanced pathogen inactivation. After bench-scale models are developed, scaling of these processes for point-of-use water treatment will be investigated. Materials utilized in these experiments will be selected on the basis of their ready availability and affordability in diverse geographical regions.

EXPECTED RESULTS

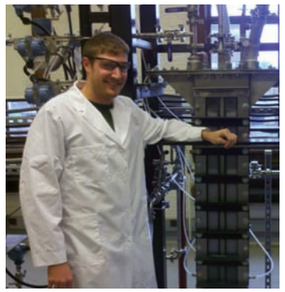
This research is expected to yield inexpensive, simple, and sustainable means of generating chemical disinfectants. These processes will be op timized to produce disinfectants at concentrations appropriate for water treatment applications. The processes developed during this work will be simple to operate and appropriate for use in developing communities. The findings obtained from this work will also provide important fun damental insights into chemical and photochemical processes relevant to various other applications in environmental chemistry and engineer ing (e.g., iron and aluminum corrosion, transition metal photochemistry, photosensitized chlorine production in marine waters).

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research will facilitate the development of simple, point-of-use water disinfection systems, thus contributing to improvement of the health and safety of people in developing communities through reduc tion of gastrointestinal and other waterborne diseases. These benefits could be amplified through use of disinfectants for improved sanitation. Furthermore, this research will contribute to the development of more sustainable methods for chemical disinfectant generation in general water treatment practice, potentially resulting in significant reductions of harmful greenhouse gas emissions.

Keywords: *water treatment, disinfection, sanitation, iron, aluminum, chlorine, hydrogen peroxide, photochemistry, SODIS, compromised waters, appropriate technology, developing communities*

David M. Follansbee



EPA Grant Number: FP917095
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Bio:

David Follansbee received his Bachelor's of Science degree in Chemical Engineering from Rensselaer Polytechnic Institute (RPI) in 2006. The following year he worked on a joint project with RPI and the New York State Department of Health to con struct and characterize a small scale circulating fluidized bed system. During this time, he was enrolled in the Masters program at RPI, but became so interested and involved in the design of this water system that he decided to enter the Ph.D. program and use this project as the starting point for his dissertation. David's research currently focuses on understanding the use of photo catalytic technologies as they apply to the treatment of organi cally contaminated water and overcoming the limitations that previous photocatalytic systems have encountered. He also uses optimization-based methods to develop water treatment networks that can be adapted and applied to drinking and recreational water systems.

Synopsis:

Increasing demands for potable drinking water, along with in creasingly stringent water quality standards, provide an impetus to develop novel, high-throughput material processing. One such technology is the use of photoactive material to decompose or ganic material. This project will focus on improving the efficiency of photocatalytic technologies, analyze the desired optimal particle properties, and identify key design characteristics for a continuous photocatalytic water treatment system.

D

Optimal Design, Development, and Characterization of Photocatalytic Composite Particles and Technology for Advanced Oxidation Process Applications

OBJECTIVE(S)/RESEARCH QUESTION(S)

Increasing demands for potable drinking water, increasingly stringent water quality standards, and the seemingly perpetual discovery of new biological and chemical contaminants all provide an impetus to develop novel, high-throughput material processing (e.g., purification and disinfection) technologies. Several studies have shown that when excited, photoactive materials (such as titanium dioxide) generate oxidizing chemical species that can destroy organic compounds (mineralization) and pathogens in aqueous media. The use of this technology has received considerable attention as a viable treatment strategy for water contaminated with organic compounds, specifically pharmaceuticals. This technology is very attractive due to its low-cost operation and ability to oxidize a wide variety of organic compounds; however much effort is needed to fundamentally understand the optimal particle properties and how to optimally design a system that will be able to efficiently treat a high-throughput of contaminated water. To this end, the focus of this research will include three specific aims: (1) to improve quantum efficiencies of photocatalytic technologies by fundamentally understanding the kinetics of photo-active materials; (2) to maximize adsorptive mass transfer rates of species to the catalyst surface under various flow conditions and develop associated Langmuir isotherms; and (3) to identify key design characteristics that facilitate the transport of composite particles within a continuous system.

APPROACH

The approach of this research entails three aspects that directly correspond to the specific aims (i) determine reaction rate and reactivation rate, (ii) determine mass transfer rates and isotherms for composite particles, and (iii) test mechanical durability of recirculating particles. Each one of these deals with some characteristic or aspect of design of the composite particle; however, each property can be studied independently from the others. The reactivation rate can be determined on a bench scale by activating a light source for a given length of time and then removing the light source and introducing a dye. This experiment gives insight into the rate at which the photons are absorbed by the photocatalyst and the possible mechanism associated with this process. The desire is to understand if the absorption of the photons is rate limiting and needs to be accounted for in the reaction rate. The reaction rate can be determined through similar experiments by measuring the conversion rate of a chemical process (e.g., oxidation of nitrite to nitrate) through the photon chamber while using the reactivation unit to reactivate the catalyst and comparing this to the amount of energy spent on reactivation. The mass transfer of contaminant to the surface of the catalyst can be determined by sampling the rich phase as a function of annular bed height and testing its concentration. This will be done for various influent flow rates and concentrations to provide information for the mass transfer rate and saturation of the adsorbent respectively. This equilibrium data will be used to formulate isotherms in order to characterize the particles. The mechanical durability of the particles can be tested by running the system in fluidization, hydraulic transport, and re-circulating modes. This will provide information for the force at which these particles are coming into contact with the walls and neighboring particles. The frictional and inertial effects will also be studied by the pressure drop exerted by particles of various sizes and densities within the riser section compared to the energy spent to transport them.

EXPECTED RESULTS

These results will provide insight into the surface reaction kinetics and mechanism of a photocatalytic process based on light intensity, residence time, and loading of adsorbent. It will allow for the understanding of how the effective surface area of a particle can increase its adsorptive potential without hindering its photo-oxidative potential and what the pore size constraints (i.e., mesoporous or nanoporous) allow for effective adsorption and regeneration. They also will provide an understanding of the ease of transportation and operating costs associated with this system. This information will be used to construct a model-based framework that when accurate will be able to determine optimal particle properties by identifying the loading of a given adsorbent for a particular photocatalyst, the appropriate substrate to use that facilitates transportation and mechanical durability, and the optimal operating conditions for this catalyst testing system.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The impact that the proposed research will have on human society is the fundamental advancement of a low-cost technology that has the ability to completely oxidize chemical and biological contaminants in aqueous media. Photocatalytic technology takes advantage of the energy emitted from light and produces no disinfection byproducts such as those identified in drinking water (trihalomethanes, haloacetic acids, bromate, and chlorite). To date, all advanced oxidation processes (including photocatalysis) have only been performed on primarily bench scale applications. This is partially due to the bottlenecks associated with the fundamental understanding of this technology. The advancement lies with the ability to independently study the mass transfer limitations of contaminant to the surface of the particle and the efficient use of photons (quantum efficiency) that is posed by photocatalysis. With the proposed research, the intent is to move past these bottlenecks and provide a means to allow photocatalytic technologies to progress beyond the bench scale to industrial applications. This proposed research also will provide an apparatus that can be utilized to test the effectiveness of composite photocatalytic particles as well as be applied to the treatment of contaminated water prior to discharge or within drinking water plants. Although this research focuses on remediating pollution after it has been introduced, it is important to try to stop pollution at its source. This is done by developing an outreach program called "Pollution Prevention Day" at local elementary schools and addressing these issues to children. The purpose of this event would be to actively teach children of various age levels about the importance of clean drinking water, the water cycle, water sources, pollution prevention, and traditional treatment techniques. Many of these lesson plans and activities are outlined on the EPA Web Site. This outreach program will help children to take an active role for reducing pollution at its source in their own lives and make them aware that this is a growing concern.

Keywords: *photocatalysis, fluidization, adsorption, water treatment*

Rebekah Oulton

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EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
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Bio:

Rebekah Oulton is a student at the University of California, Riverside, Department of Chemical and Environmental En gineering. She holds a Master's degree in Engineering and is licensed in California in both Mechanical and Civil En gineering. Her professional experience includes water and wastewater treatment plant process improvements, utility system analyses, oil field remediation, stormwater pollution control, and environmental permitting and compliance. Her current research focuses on wastewater treatment process improvements targeting removal of emerging contaminants.

Synopsis:

Pharmaceuticals and related compounds (PhACs) have been found in surface and drinking water systems throughout the United States. The main entry route for PhACs into these wa ter systems is wastewater treatment plant (WWTP) effluent. Current research suggests that the impact of WWTP discharg es on human and ecosystem health may be far greater than is now understood. This project explores the use of carbon nanotubes (CNTs) as catalysts for advanced oxidation to im prove removal of PhACs during wastewater treatment.

D

Application of Carbon Nanotubes in Catalytic Ozonation for Sustainable Water Reuse

OBJECTIVE(S)/RESEARCH QUESTION(S)

This project explores the efficacy of using CNTs as catalysts for advanced oxidation processes (AOPs), targeting the removal of pharmaceuticals and pharmaceutically active compounds (PhACs) during wastewater treatment. Catalytic ozonation research using activated carbon (AC) to enhance hydroxyl radical production via ozone decomposition suggests that AC high in surface area and exhibiting basic surface functionalities is most effective. Due to the higher surface area and unique material and surface properties of CNTs relative to AC, it is expected that CNT-catalyzed ozonation will show improved removal of PhACs across a broad range of structurally diverse organic micropollutants and will achieve a higher degree of mineralization, compared with traditional AOPs.

APPROACH

This study includes two phases: synthesis and characterization of functionalized CNTs; and, reactivity and performance assessment of synthesized materials. Phase One involves development and characterization of a collection of CNTs with distinct surface chemistries. Specific tasks include both covalent and non-covalent surface functionalization of CNTs. All tasks will use commercially available single-walled (SW), double-walled (DW), and/or multi-walled (MW) CNTs. Phase Two will use materials synthesized in Phase One to determine their efficacy in hydroxyl radical generation during ozonation. These data, coupled with the characterization data compiled in Phase One, will yield a greater understanding of the CNT-surface properties affecting catalytic ozonation. A second goal of Phase Two is to determine how variations in water chemistry and composition influence the operational performance of these catalysts during treatment applications. This phase looks first at CNT performance in model water systems; the most promising catalysts will then undergo further performance testing in variable water quality systems.

EXPECTED RESULTS

Preliminary results suggest that CNTs enhance ozone decomposition and that the rate of this reaction is tunable through CNT functionalization. Using chemical probe compounds, enhanced hydroxyl radical production has been observed at CNTs loading as low as 5 mg/L, compared with 500 mg/L of AC required to achieve a noticeable increase in ozone decomposition. Further, preliminary results show that greater hydroxyl radical production in the CNT-catalyzed system results in greater PhAC removal than with either ozone or CNTs alone. These results support the hypothesis that CNT-catalyzed ozonation offers promise for use in advanced water and wastewater treatment for increased removal of emerging organic micropollutants, including PhACs.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

A key outcome of this research is development of new technologies to promote sustainable water reuse. As more and more communities search for ways to make better use of their resources to meet drinking water needs, effective treatment of wastewater will become increasingly important. CNTs can be a valuable tool in reducing PhACs from wastewater effluent; it is foreseeable that CNT-catalyzed ozonation technologies may simultaneously disinfect the wastewater, break down PhACs and other micropollutants, and minimize or sequester ozonation byproducts, thereby offering promise for improved protection of human health and the environment.

Keywords: *catalytic ozonation, advanced oxidation, carbon nanotubes, wastewater treatment, water treatment, water reuse, pharmaceuticals, pharmaceutically active compounds*

Jason Wayne Stuckey

EPA Grant Number: FP917111
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Project Amount: $111,000.00
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Bio:

Jason Stuckey received his Bachelor's degree in Soil Sci ence with a minor in Philosophy from California Polytechnic State University, San Luis Obispo, in 2005. He went on to earn a Master's degree in Soil Chemistry at Pennsylvania State University, where he tested a strategy for remediat ing copper-contaminated soils in Chile. He began the Ph.D. program in Environmental Earth System Science at Stan ford University in 2008. His research interests include the processes governing the fate and movement of trace ele ments in soils and sediments. Currently, he is researching the biogeochemical and physical controls of arsenic cycling in deltaic systems.

Synopsis:

Through a combination of field and laboratory techniques, this research seeks to quantify the factors controlling the release of arsenic from sediment to groundwater, namely the reactivity of organic carbon and iron oxides, as well as physical processes. The resulting parameterization will serve as the experimental basis for modeling dissolved arsenic concentrations in space and time, thereby informing drinking water well construction in areas of arsenic risk.

D

Discovering the Nexus Between, and Quantifying the Rates of, the Physical and Biogeochemical Mechanisms Governing Arsenic Release From Soil and Sediment to Pore-Water Under Anaerobic Conditions

OBJECTIVE(S)/RESEARCH QUESTION(S)

Millions of people around the world drink arsenic-contaminated groundwater. The protection of groundwater as a drinking water source requires that we develop the ability to identify areas of active arsenic release to pore-water, to identify areas without the capacity to release appreciable arsenic, and to predict how this spatial distribution will change temporally. This research project will quantify the biogeochemi-cal and physical controls of arsenic transport rate in soils and sediments, supporting the accurate projection of site-specific groundwater arsenic concentrations in space and time.

APPROACH

The three key aspects dictating microbial-driven release of arsenic from soil/sediment solids to pore-water under anaerobic conditions are the (i) reactivity and (ii) quantity of organic carbon and arsenic-bearing iron oxides, and (iii) the diffusion of arsenic and dissolved organic carbon between mobile and less mobile flow regimes. The first stage of research will be the development of batch assays for determining site-specific organic matter and arsenic reactivity representative of *in situ* conditions. Column studies using undisturbed sediment cores will discern whether physical (diffusion) or biogeochemical processes control arsenic trans-port. Quantifying the controls of arsenic transport rate will provide the necessary input parameters for modeling dissolved arsenic concentra-tions along a flow path.

EXPECTED RESULTS

This research will reveal what controls the rate of arsenic transport in soils and sediments. In a system with high water flow (both advection and diffusion) velocities, the availability of reactive catabolic substrate (either organic carbon or iron oxide) will govern the rate of arsenic release into advecting pore-water. Alternatively, a slow diffusion rate will limit the transfer of arsenic from micro-aggregates to pore-water, even in instances where microorganisms have plenty of reactive organic carbon and arsenic-bearing iron oxides at their disposal. The assays developed here to quantify the reactivity of arsenic and susceptibility of organic matter to oxidation coupled to arsenic(V)/iron(III) reduction will provide accurate parameters for identifying areas of active (and inactive) arsenic transfer from sediment to pore-water. Combined with hydraulic and physical transport data, the parameterization will form the experimental basis for a reactive transport modeling of arsenic in soils and sediments. Field calibration will facilitate transfer of this model parameterization method to aquifer systems worldwide.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Hundreds of millions of people rely on groundwater for drinking that is or has the potential to be contaminated with arsenic. The experimental approach developed here will allow scientists to accurately predict arsenic transport rates and residence times, and provide policy makers with an improved framework for making sound land and water management deci-sions, especially regarding drinking water well construction in rural areas.

Keywords: *arsenic, groundwater, water quality, soil, sediment*

Water Quality

- Hydrogeology and Surface Water

- Coastal and Estuarine Processes










Water Quality Fellows

HYDROGEOLOGY AND SURFACE WATER

COASTAL AND ESTUARINE PROCESSES

Hydrogeology and Surface Water

Gwendolyn B. Arnold

EPA Grant Number: FP917088
Institution: Indiana University, Bloomington (IN)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Gwendoyln (Gwen) Arnold graduated from the University of Michigan in 2003 with highest honors in political science and a minor in global environmental change. She spent three years working at the nonprofit Environmental Law Institute in Washington, D.C., editing a national wetlands policy journal and a book on post-Hurricane Katrina wet land restoration, as well as co-authoring a report on wetland compensatory mitigation. In 2006, she began pursuing a Ph.D. in Public Policy at Indiana University, studying po litical theory and methods and environmental policy. She spent the summers of 2008, 2009, and 2010 as a National Network for Environmental Management Studies fellow at the U.S. Environmental Protection Agency's Region 3 office, working on wetland functional assessment. Her research interests include U.S. wetland policy and integrating sound science into policymaking.

SYNOPSIS:

The fellow investigates why many tools for assessing wet land functions and values exist, yet state wetland manag ers use such tools infrequently. Only roughly four percent of wetlands nationwide are assessed, leaving policymakers without enough data to improve wetland quality. They will survey and interview wetland managers in five states in the Mid-Atlantic region to identify systematically factors that encourage or prevent states from adopting and implement ing scientifically sound wetland assessment tools.

Saving Wetlands from the Ground Up: Understanding the Needs of State Decision-makers To Improve Rapid Wetland Assessment

OBJECTIVE(S)/RESEARCH QUESTION(S)

What factors lead state environmental bureaucrats charged with wetland regulation to adopt and successfully implement over time rapid wetland assessment tools?

APPROACH

I will survey current and former state wetland regulators in Pennsylvania, Delaware, Maryland, Virginia, and West Virginia concerning their experiences with and perceptions concerning rapid wetland assessment tools used in those states since 1980. Following this broad survey, I will do in-depth interviews with a subset of respondents, as well as with state, regional, and national wetland policy experts and scientists. I also will perform content analysis of the rapid wetland assessment tools to understand how the structure and content of such tools affect their usefulness.

EXPECTED RESULTS

My findings and analysis will help scientists and policymakers learn how to modify rapid wetland assessment tools so that state wetland managers find them more tractable. My research will help states modify their approaches to wetland monitoring and assessment so that they are able to pursue long-term wetland evaluation. States then will be able to gather over-time data that will help policymakers—who sorely lack data on wetland condition—better protect and improve wetland water quality.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Only about 4 percent of the nation's wetlands are assessed, leaving policymakers without the data necessary to quantify pollution in these resources or protect them adequately. My research seeks to discover the factors that encourage states to adopt and implement the rapid wetland assessment tools critical to gathering such data. When policymakers understand these facilitative factors, they can foster them. Fostering these factors should then lead to increased use of wetland assessment tools by states, increased wetland data availability, and ultimately more scientifically grounded and comprehensive protection of U.S. wetlands.

Keywords: *wetland assessment, environmental monitoring, environmental assessment, wetland policy, bureaucrats, state environmental policy, policy learning*

Joseph S. Shapiro

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BIO:

Joseph Shapiro received a B.A. from Stanford University, with distinction in Economics and interdisciplinary honors in the Ethics in Society program. He has worked as a Ju nior Professional Associate for the World Bank and received Master's degrees from Oxford and the London School of Economics as a Marshall Scholar. A Ph.D. student in the Economics Department at MIT, his research focuses on environmental and energy economics.

SYNOPSIS:

This research investigates several questions about water pollution. First, what are long-term trends in U.S. water quality? Second, what share of the trends is due to the Clean Water Act? Third, to what extent do Americans value clean surface waters? Finally, what is the potential of new regulatory mechanisms to decrease both ambient water pol lution and abatement costs?

W Hydrogeology and Surface Water

Assessing and Managing Surface Water Pollution. This Research Investigates Effects of the Clean Water Act and Potential of Water Quality Trading to Decrease Surface Water Pollution

OBJECTIVE(S)/RESEARCH QUESTION(S)

This research investigates several questions about water pollution. First, what are the long-term trends in U.S. water quality? Second, what share of the trends is due to the Clean Water Act? Third, to what extent do Americans value clean surface waters? Finally, what is the potential of new regulatory mechanisms to decrease both ambient water pollution and abatement costs?

APPROACH

This analysis is compiling data on water quality, regulatory enforcement, and federal funding instituted under the Clean Water Act. It introduces new methods in environmental statistics to analyze how the Clean Water Act affects water quality. The analysis exploits idiosyncrasies in the location and timing of federal activities. The analysis also constructs a simulation to measure how redesigning water pollution regulations would affect water quality, abatement costs, and social welfare.

EXPECTED RESULTS

This analysis will provide evidence on how the Clean Water Act affected surface water quality. It will also investigate how Americans value clean surface waters and thereby clarify the benefits of the Clean Water Act. Finally, it will investigate the potential benefits of new regulatory mechanisms for water pollution emissions.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Although the United States has invested tremendous levels of resources to improve surface water quality, roughly 40 percent of surface waters still violate standards for designated uses. This research will provide new evidence on the extent to which the Clean Water Act has improved water quality, on the potential benefits from improving water quality, and on potential improvements in water quality that could result from using new regulatory mechanisms.

Keywords: *Clean Water Act, water quality, pollution regulations*

Caroline Breen Turner

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EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Water Quality: Hydrogeology and Surface Water
E-mail:

BIO:

Caroline Turner graduated from Oberlin College in 2004 with a degree in Biology. After spending a year as a tutor with AmeriCorps, she joined the Department of Ecology and Evolutionary Biology at Cornell University, where she conducted her Master's thesis research on the effects of invasive zebra mussels on nitrogen and phosphorus cycling. Caroline worked as a laboratory manager at the University of Notre Dame for a year before starting a Ph.D. at Michigan State University in 2009. She is currently studying how ecology and evolution interact in shaping the use of novel resources by bacteria.

SYNOPSIS:

Humans produce many pollutants that are rare or absent in nature. Remarkably, bacteria have evolved that can degrade many of these contaminants. However, we lack understand ing of the evolutionary and ecological factors that drive this process. This research will study bacteria that have evolved to consume a new compound. By measuring rates of con sumption as the bacteria evolve under various conditions, this research will allow improved utilization of microbes for bioremediation of pollutants.

W Hydrogeology and Surface Water

Ecology and Evolution of Bacterial Remediation of Water Pollution: Changing Microbes in a Changing World

OBJECTIVE(S)/RESEARCH QUESTION(S)

The goal of my research is to study how evolutionary and ecological interactions affect the ability of bacteria to degrade novel compounds. What selection pressures shape the rates at which bacteria are able to consume new substances? How do ecological interactions such as competition and predation affect the ability of bacteria to effectively remove novel compounds from the environment?

APPROACH

This research will use as a model system a strain of *Escherichia coli* bacteria that evolved the ability to consume citrate, a compound that *E. coli* normally cannot metabolize aerobically. This trait evolved as part of a long-term evolution experiment in the laboratory and is an ideal system in which to study the evolution of a new metabolism because the availability of frozen populations throughout the experiment will allow measurement of changes in citrate metabolism over more than 10,000 generations of evolution. The second portion of the project will focus on further evolution experiments with citrate consumers in the presence and absence of competitors and phage (bacterial viruses) to determine how these factors can shape the evolution of resource use.

EXPECTED RESULTS

Later generations of citrate-consuming *E. coli* are expected to evolve increased rates of citrate consumption and to draw citrate concentrations down to lower levels as compared to earlier generations of citrate consumers. It is also predicted that in the presence of competitors for other carbon sources, the citrate consumers will evolve a greater degree of specialization on citrate than in the absence of such competitors. Evolution in the presence of phage may decrease rates of citrate consumption due to decreased population sizes and/or trade-offs between viral resistance and citrate consumption rates.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Bioremediation by microbes is an important mechanism for the removal of harmful and toxic compounds from surface and groundwater. However, we understand little about the basic evolutionary and ecological factors that drive this process. A better understanding of these phenomena will allow scientists to improve prediction of degradation rates of pollutants and to better utilize the evolutionary potential of microbes for bioremediation of novel contaminants.

Keywords: *water pollution, bioremediation, experimental evolution, ecology, E. coli*

Corinne I. Wong

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EPA Project Officer: Brandon Jones
Project Period: 8/25/2010 – 8/24/2013
Project Amount: $111,000.00
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BIO:

Corinne Wong received her undergraduate degree in Geo logical Sciences and Environmental Studies from the Uni versity of the Pacific in Stockton, CA. She then served as a U.S. Peace Corps Volunteer in The Gambia, West Africa, in the agro-forestry division. She received a Masters degree from The University of Texas at Austin (UT), for which she investigated the effectiveness of brush clearing at increas ing recharge in central Texas. She has continued at UT, working toward a Ph.D. Her research is focused on surface water impacts on groundwater quality.

SYNOPSIS:

In karst systems, groundwater is especially vulnerable to contamination via surface water. The nature of surface and groundwater interaction is dependent on antecedent mois ture conditions, and I work to understand the dynamics of surface and groundwater mixing under varying rainfall conditions in the Barton Springs segment of the Edwards aquifer in central Texas.

W Hydrogeology and Surface Water

Investigating Surface Water Quality Impacts on Groundwater Quality Under Varying Flow Conditions in the Barton Springs Segment of the Edwards Aquifer, Central Texas

OBJECTIVE(S)/RESEARCH QUESTION(S)

It is critical to understand the processes that control groundwater quality, especially in arid regions with a high dependence on groundwater that are managing increasing rates of urban development and aridity associated with climate change. Karst terrains add complexity as solutional features (i.e., caves and sink holes) allow rapid infiltration and subsurface transport of water through the system. This research investigates the hydrological and geochemical dynamics affecting groundwater quality in the Barton Springs segment of the Edwards aquifer (a karst aquifer) in central Texas by investigating the question of how surface water quality impacts groundwater quality under varying rainfall conditions.

APPROACH

Surface and groundwater quality will be monitored during base flow and storm conditions for 18 months. Surface water quality will be characterized and correlated to groundwater quality under varying rainfall conditions to quantify: i) the proportion of surface water consisting of groundwater discharge, and ii) impacts of surface water quality on groundwater. Geochemical modeling will be conducted to identify the controls on groundwater quality and understand how these controls vary temporally and in response to climatic variation.

EXPECTED RESULTS

The expected results from this research include: i) the quantification of the proportion of surface water comprising spring discharge under varying flow conditions; ii) the characterization of surface watersheds under varying antecedent moisture conditions, and evaluation of how these characterizations reflect the degree of watershed urbanization; iii) identifying the controls on groundwater quality under varying antecedent moisture conditions. Groundwater quality is likely more vulnerable to surface water quality during dry antecedent moisture conditions when aquifer levels are insufficient to effectively buffer (i.e., dilute) surface water compositions.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Demonstrating the impact of surface water quality on groundwater quality will be useful to water resource managers and law and policy makers as they make decisions regarding the protection of surface water quality in the contributing and recharge zones of the Barton Springs segment of the Edwards aquifer. More specifically, this research will lend insight about the consequences of discharging treated wastewater into surface streams that recharge the Edwards aquifer.

Keywords: *groundwater, water quality, nutrients, water management, karst, aquifer, Texas, Edwards aquifer, surface water, Barton Springs*

Coastal and Estuarine Processes

Amalia Marie Aruda

EPA Grant Number: FP917089
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EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Water Quality: Coastal and Estuarine Processes
E-mail:

BIO:

Amalia Aruda's research experience began on an oyster farm and transitioned to the lab bench as she became active in molecular biology at her alma mater Georgetown Univer sity and the Woods Hole Oceanographic Institution. Amalia received her B.S. in Biology and a minor in Environmental Science from Georgetown in 2009. In the summer of 2009, Amalia began the Ph.D. Joint Program in Biological Ocean ography at MIT/WHOI. Her current research focuses on whether estuarine copepods regulate their microbial com munities and how stressors such as endocrine disrupting pollutants may affect these copepod-microbial interactions.

SYNOPSIS:

Estuaries can be major sinks for terrestrial and waterborne contaminants thereby exposing organisms such as copepods to high levels of pollutants. Copepods are abundant crus taceans that enhance survival of the bacteria *Vibrionaceae*, which include human and animal pathogens. This project examines how *Vibrio* attachment affects copepods, whether copepods can control what microbes attach to them, and how exposure to endocrine disrupting pollutants may alter the copepod response to *Vibrio* attachment.

W Coastal and Estuarine Processes

The Impacts of Endocrine Disrupting Pollutants on Copepod-Vibrio Interactions in Estuarine Environments

OBJECTIVE(S)/RESEARCH QUESTION(S)

Estuaries are highly dynamic and productive ecosystems that often are exposed to high levels of endocrine disrupting pollutants and other contaminants. Copepods are a major food source in estuarine ecosystems and are beneficial hosts for the abundant bacteria *Vibrionaceae*, which include human and animal pathogens. This project will investigate how microbial associations affect copepod physiology, whether copepods regulate these microbial associations, and subsequently how exposure to endocrine disruptors may affect copepod-*Vibrio* interactions.

APPROACH

The first set of laboratory experiments will examine how an estuarine copepod, *Apocyclops spartinus*, responds to colonization by different classes of *Vibrio sp.* (e.g. facultatively symbiotic, commensal) by comparing copepod physiology and gene expression between treatments. These copepod responses to *Vibrio* attachment will then be explored in the context of stressors such as endocrine disrupting compounds (EDCs). Copepods and *Vibrio* strains will be separately exposed to two ecologically relevant EDCs (methoprene, Bisphenol A [BPA]) and their growth and development will be monitored to determine the effects of EDCs when the species are isolated from one another. Copepods colonized by the different classes of *Vibrio* then will be exposed to EDCs and copepod gene expression and physiology will be compared to those treatments without exposure to EDCs. These treatments will assess how EDCs may alter the copepod-*Vibrio* association.

EXPECTED RESULTS

Differential gene expression, potentially in immune response (e.g., production of antimicrobial peptides) and/or the endocrine system (e.g., shedding of associated microbes by molting) in copepods exposed to different "types" of *Vibrio* strains would suggest that *A. spartinus* can distinguish between beneficial and commensal associations with *Vibrio* and is perhaps regulating its microbial associations. Copepod host responses to microbial associations could be an important influence on *Vibrio* ecology that has, to our knowledge, not yet been explored. Exposure to endocrine disrupting pollutants (as are often present in contaminated estuaries) may disturb copepod-*Vibrio* interactions. Our approach will reveal if changes in host-microbe interactions are driven primarily by EDC effects on individual members of the association and if the impacts of EDCs are further compounded (either antagonistically or synergistically) when the organisms interact. Differences in gene expression patterns in copepods colonized by *Vibrio sp.* under normal conditions versus EDC exposed conditions could further indicate that copepod regulation of colonization by various *Vibrio* "types" may be context dependent. Alteration of interactions between copepods and microbes due to stresses may impact both *Vibrio* ecology and copepod populations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The results of this study will influence the understanding of how environmental stressors such as widespread endocrine disrupting pollutants (methoprene, BPA) can affect the copepod host response to *Vibrio sp.* and alter the nature of copepod-*Vibrio* interactions. The broader impacts of this study will help model how degraded water quality in estuaries due to endocrine disrupting pollutants can modulate copepod-*Vibrio* interactions to affect the life history of copepods and the survival of *Vibrionaceae*, which include human and animal pathogens. Through potentially changing the dynamic of the copepod-*Vibrio* interaction, EDCs may expose copepods to novel stress through making copepod hosts less able to regulate their normal balance with microbial flora.

Keywords: *Vibrio, Apocyclops spartinus, host response, gene expression, endocrine disruptors, bisphenol A, methoprene, microbial interactions, estuary*

Joanna Carey

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EPA Project Officer: Brandon Jones
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Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Joanna Carey received her B.S. in Environmental Policy and Planning from Viriginia Tech in 2005 and her M.S. in Environmental Science from Yale University in 2007. At Yale, she focused on salt marsh processes, specifically decomposition rates in Long Island Sound marshes. After finishing her Master's degree she worked for the Massachu setts Department of Fish and Game performing river resto ration monitoring and streamflow analysis. During the fall of 2009, Joanna started a Ph.D. program at Boston University where she will study silica along the land-ocean continuum, with a focus on river and wetland processes. Joanna hopes her research will aid in improved applied restoration and management techniques.

SYNOPSIS:

Excess nitrogen and phosphorus in relation to silica can lead to a silica starved system, stimulating a shift in phy toplankton species composition from diatom to non-diatom species and altering tropic interactions. This research will quantify the impact of historic and current land use change on silica export from the terrestrial to the aquatic ecosystem and determine the relationship between current watershed land use and estuarine phytoplankton species composition and abundance.

Evaluating Anthropogenic Impacts Along the Land-Ocean Continuum Using Silica

OBJECTIVE(S)/RESEARCH QUESTION(S)

Anthropogenic activities have greatly altered the global fluxes of nitrogen (N) and phosphorus (P) to coastal receiving waters. While N and P have appropriately received much research attention, another important nutrient, silica (Si), has largely gone unexamined and thus, Si cycling at the land-sea interface remains poorly understood. The purpose of this research is to examine how land use change alters the export of Si to New England estuaries.

APPROACH

This funding will quantify and characterize the type (dissolved vs. particulate) of Si, as well as N and P, exported via rivers from several New England watersheds with contrasting land use characteristics. In order to directly link watershed characteristics and downstream ecosystem response, concurrent phytoplankton composition and abundance measurements will be made in the receiving estuary (Plum Island Sound, MA). In addition, river sediment cores and historical land use data will help establish how the relationship between land use and watershed Si flux has changed in the recent past.

EXPECTED RESULTS

This research will determine how land use change alters the export of Si via rivers, with attention to behavior of Si in relation to N and P and the impacts of such nutrient ratios on phytoplankton species composition in the receiving estuary. The resulting relationships between land use, river nutrient stoichiometry and phytoplankton species will provide new and critical insights into silica cycling at the terrestrial-aquatic interface.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Excess Nitrogen and Phosphorus can lead to Si-starvation in coastal waters, causing a shift in phytoplankton species composition from diatom to non-diatom species. The non-diatom species can be harmful algae blooms, such as red tides, which can alter higher trophic levels and, in some cases, are dangerous to human health. This research will provide important information for the management of coastal ecosystems.

Keywords: *silica, eutrophication, land use, non-point source pollution, phytoplankton, diatoms, watershed, New England, Plum Island Sound, nutrient ratios, nitrogen, phosphorus*

Troy Derek Hill

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EPA Project Officer: Brandon Jones
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Project Amount: $111,000.00
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BIO:

Troy Hill graduated from Clark University in 2006 with a B.A. in Environmental Science and Policy. He subsequently studied salt marsh carbon dynamics at Yale University, where he received a Master of Environmental Science degree. After a year as a research assistant with the Ma rine Biological Laboratory, Troy returned to Yale's Forestry School to begin his doctoral work. His current research blends restoration ecology, salt marsh biogeochemistry, and ecosystem ecology.

SYNOPSIS:

Salt marshes serve as long-term repositories of toxic trace metals, a critical function in urbanized estuaries such as Long Island Sound. Salt marsh drowning, and the potential for drowning marshes to erode and export pollutants, merits serious concern. In hopes of understanding marsh loss and its implications for trace metal storage, this project com bines sediment profile analyses with aerial photography and high-resolution monitoring of pollutant fluxes in marshes along the Connecticut coast.

Salt Marsh Drowning in Long Island Sound: Causes and Biogeochemical Consequences

OBJECTIVE(S)/RESEARCH QUESTION(S)

Healthy marshes accumulate pollutants in their sediments, including heavy metals brought in with the tides or deposited atmospherically. In Long Island Sound, some marshes are gradually converting to unvegetated mud flats, a poorly understood process that may compromise their role as sediment and pollutant sinks. If drowning marshes erode and begin exporting the metals stored in their sediment profiles, they could be unrecognized and potentially important non-point sources of pollution, a circumstance with serious implications for environmental and human health.

APPROACH

One explanatory mechanism for marsh drowning is sediment deprivation; marshes may not be receiving adequate sediment loads. This study will investigate the sediment deprivation hypothesis by constructing long- and short-term sediment budgets for drowning and healthy marshes using a combination of dated sediment cores, sediment traps, and sediment supply measurements. In addition to understanding causes, this research evaluates the consequences of marsh loss by coupling volumetric changes in marsh sediments with pollutant depth profiles to estimate historic trends in metal storage over the last 35 years. Metal concentrations in sediments and in tidal waters also will be measured to discern the current direction and magnitude of metal flux between marshes and the estuary. By studying long- and short-term trends in metal fluxes and accumulation, my research will detail the role of healthy marshes in pollutant sequestration.

EXPECTED RESULTS

The project will focus on marshes in western Long Island Sound, an area exposed to intensive anthropogenic stress and elevated ambient metal levels. The accumulation of metals in salt marsh sediments in the western basin has been understudied, despite the high local population densities and the prevalence of marsh drowning in western Long Island Sound. This research provides information about the causes and consequences of marsh decline, information that is critical for salt marsh conservation efforts. This work also will use a novel approach to conduct detailed metal inventories for marshes in Long Island Sound and advance our understanding of the capacity of healthy marshes to sequester metals—a valuable contribution to the community of researchers interested in monitoring material fluxes and budgets in intertidal ecosystems.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research will contribute important information to the management and policy communities by establishing inventories of pollutants stored in marsh sediments and by studying the potential for deteriorating marshes to become non-point sources of metal pollution. The public health, conservation, and scientific communities all will benefit from a finely-detailed assessment of the role healthy marshes play in retaining metals, and the functional losses associated with marsh drowning. Understanding the fate of sediment-derived pollutants helps guide monitoring and mitigation programs aimed at reducing public exposure to metal pollution.

Keywords: *salt marsh, mass balance, trace metal, sediment budget, Long Island Sound*

Daniel Redd Obenour

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EPA Project Officer: Brandon Jones
Project Period: 9/1/10 - 8/31/13
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Water Quality: Coastal and Estuarine Processes
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BIO:

Daniel Obenour received an undergraduate degree in Civil Engineering from the University of Akron (2002), and a Master's degree in Environmental and Water Resources Engineering from the University of Texas, Austin (2004). After completing his Master's degree, Dan worked as an en vironmental consultant, specializing in the field of surface water quality modeling. He is now enrolled at the University of Michigan, where he is pursuing a Ph.D. studying hypoxia formation in the Gulf of Mexico.

SYNOPSIS:

Many coastal ecosystems are subject to an environmental condition known as hypoxia, which is defined by oxygen levels too low for the support of aquatic life. A particularly severe example of this problem is the hypoxic zone in the northern Gulf of Mexico. This project will focus on the de velopment of an innovative geostatistical model for assess ing Gulf hypoxia. The model will be used to better under stand the causes of hypoxia, and to estimate the size of the hypoxic zone throughout time.

W Coastal and Estuarine Processes

A Geostatistical Model of Hypoxia Formation in the Northern Gulf of Mexico

OBJECTIVE(S)/RESEARCH QUESTION(S)

Hypoxia is an environmental problem common to many coastal waters, and that is particularly severe in the northern Gulf of Mexico. The purpose of this project is to enhance our understanding of Gulf hypoxia formation through the development of a geostatistical model capable of integrating data from a variety of relevant sources. The model will be used to estimate the extent and severity of hypoxia through time, and to evaluate factors related to its formation.

APPROACH

This research will focus on development of a geostatistical model that will incorporate dissolved oxygen measurements along with a wide array of auxiliary information, such as bathymetry, remote sensing, hydrodynamics, wind stress, and river loading data. In general, the geostatistical model will take the form of an advanced system of kriging equations that accounts for spatial correlations and relationships among the auxiliary information and dissolved oxygen. Another component of this work will be development of a simple biophysical model, focused primarily on the temporal dynamics of hypoxia, and which will be linked with the geostatistical model to enhance its predictive capabilities.

EXPECTED RESULTS

This project will improve our understanding of hypoxia formation in several ways. First, the geostatistical model will allow for estimation of the hypoxic extent (with confidence intervals) at regular time intervals throughout the year. Second, this research will determine which factors (and associated auxiliary data sources) are highly correlated with hypoxia formation and which are not. The time scales on which these factors influence hypoxia will also be evaluated, and the potential for the model to predict future hypoxia will be explored. The model will also be used to evaluate hypothetical scenarios, such as changes in the nutrient load from the Mississippi River. Finally, although this project will focus on hypoxia in the northern Gulf of Mexico, the tools and methodologies developed by this research should be applicable to the study of other environmental phenomena as well.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The results of this research project will be useful in the management and protection of the Gulf coast ecosystem and its associated fisheries. First, the project will improve our knowledge of how the extent and intensity of hypoxia vary throughout the year, so that aquatic scientists can make better assessments of how hypoxia is limiting available habitat. Second, the project will enhance our knowledge of the primary factors causing hypoxia, potentially allowing for more effective pollution mitigation strategies.

Keywords: *water quality modeling, hypoxia, geostatistics, kriging, eutrophication, Gulf of Mexico*

Charles A. Schutte

EPA Grant Number: FP917108
Institution: University of Georgia (GA)
EPA Project Officer: Brandon Jones
Project Period: 8/16/2010 – 8/15/2013
Project Amount: $111,000.00
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BIO:

Charles Schutte graduated from the University of North Carolina at Chapel Hill in 2007 with B.S. degrees in En vironmental Science and Biology. He spent the following year studying riverine sediment transport processes in the Department of Marine Sciences at UNC-CH. Charles began the marine sciences Ph.D. program at the University of Georgia in 2008. His research focuses on quantifying rates and pathways of nitrogen cycling in shallow, coastal aqui fers in order to better understand the role of groundwater in coastal nitrogen budgets.

SYNOPSIS:

Groundwater may act as a critical source of nitrogen to coastal environments where it can lead to decreased water quality through eutrophication and hypoxia. Microorgan isms living within coastal aquifers can efficiently alter the amount and type of nitrogen-containing chemicals found in groundwater. This project aims to better understand the role of groundwater in coastal nitrogen budgets by quantify ing how microorganisms respond to changes in their envi ronment caused by tides and how this interaction affects rates of nitrogen processing within aquifers.

Mechanisms Driving Variability in Groundwater-derived Materials Flux to Coastal Waters

OBJECTIVE(S)/RESEARCH QUESTION(S)

Nitrogen loading is an important cause of water quality degradation in coastal estuaries and bays, but the amount of nitrogen coming from many sources is not well known. The goal of this project is to better understand the role of groundwater discharge in the nitrogen budget of coastal water bodies and the influence of within-aquifer processes on the nitrogen content of that discharge. The overarching hypothesis for this project is that the response of aquifer microbial nitrogen cycling to tidal forcing acts as an important mechanism driving temporal variability in groundwater-derived nitrogen flux to coastal waters.

APPROACH

This project consists of experiments carried out at multiple sites in coastal Georgia during spring and neap tides in order to determine the influence of tidal forcing on aquifer nitrogen cycling. Nitrogen transformation rates will be calculated *in situ* by adding nitrogen to groundwater within the aquifer and measuring how the concentration of nitrogen changes through time. At the same time, sediment samples will be collected in order to extract microbial mRNA and determine the abundance of active nitrogen cycling genes as a proxy of aquifer microbial activity. Finally, groundwater-derived nitrogen fluxes will be quantified at each time point using radium as a conservative tracer of groundwater movement.

EXPECTED RESULTS

The data generated through this project will allow exploration of the relationship between tidal forcing, aquifer microbial activity, nitrogen transformation rates, and groundwater-derived nitrogen flux. This project will document the role of groundwater as a dynamic and important source of nitrogen to coastal water bodies. It will also generate fundamentally new information about how hydrological (e.g., tides) and biological (e.g., microbial nitrogen cycling) processes alter groundwater composition and drive variability in groundwater-derived nitrogen fluxes to coastal waters, and thus influence coastal water quality.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This project will provide a refined understanding of aquifer processes and groundwater flux that will assist policy makers and resource managers in assessing and managing coastal water quality and resources. It will serve to better inform regulations regarding septic tanks and buffer zones and design and implementation of water quality standards such as total maximum daily loads. The mechanistic understanding of a critical pollutant source generated by this research will aid in the creation of such policies by providing a framework for the prediction of the source response to perturbations such as increased coastal development, sea level rise, and climate change.

Keywords: *nitrogen, coast, water quality, aquifer, groundwater, microbial processes, biogeochemistry*

Human Health

- Public Health Sciences

- Risk Assessment and Decision Making










Human Health Fellows

PUBLIC HEALTH SCIENCES

RISK ASSESSMENT AND DECISION MAKING

Public Health Sciences

Brie Michelle Hawley

EPA Grant Number: FP917247
Institution: Colorado State University (CO)
EPA Project Officer: Georgette Boddie
Project Period: 8/24/2010 – 8/23/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Human Health: Public Health Sciences
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BIO:

Brie Hawley received her B.S. in Animal Science with minors in Bio chemistry and English from the University of Delaware in 2007. She entered the graduate program in Environmental and Radiological Health Sciences at Colorado State University (CSU) the same year. At Colo rado State University, she pursued studies in occupational and envi ronmental health. She is particularly interested in lung toxicology. The perpetual moment-to-moment need to breathe means that the lungs are perpetually exposed to environmental gases and particulate matter, making them particularly vulnerable to environmental pollution. Her research pursuits revolve around elucidating the mechanisms by which air pollutants from combustion sources cause disease in the lungs. An interest in lung toxicology and global health was honed during her Master's project, in which she investigated the inflammatory effects of emissions from a traditional cook stove and two improved cook stoves in global distribution. The project was part of a larger clean cook stove research and development program with CSU's Engines and Energy Laboratory and the non-profit group, Envirofit International. She plans to continue collaborations with CSU's Engines and Energy Conversion Laboratory during her doctoral research, in which she will investigate the inflammatory effects of diesel exhaust (DE). This research is fueled by the hope that a greater understanding of the means by which air pollutants cause disease will help to identify what it is in the mixture of the air around us that is most toxic, allowing for targeted and more informed regulation and control.

SYNOPSIS:

In a country that relies heavily on diesel fuel combustion, exposure to DE is widespread. DE is a large contributor to soot and fine particles in the air and inhalational exposure is associated with cardiopulmonary compromise. Tighter emissions regulations and increased biodiesel use are changing the physicochemical nature of DE. This project will com pare the health effects of DE from an engine run with Tier 4 vs. Tier 2 control technologies and petro vs. biodiesel fuels.

Investigating the Inflammatory Effects of Traditional Petrodiesel and Alternative Biodiesel Exhaust Using an Improved *In Vitro* Exposure System

OBJECTIVE(S)/RESEARCH QUESTION(S)

Humans have been rapidly altering the air around us ever since the discovery of fire. Today, there is widespread combustion of fossil fuels to meet our transportation, energy, and industrial needs. In a country that relies heavily upon the combustion of diesel fuel for construction, agricultural, and transportation needs, exposure to diesel exhaust (DE) is widespread. DE is a large contributor to soot and fine particles in the air and inhalational exposures have been implicated in increasing one's risk for chronic lung inflammation and fibrosis, allergic immune responses in the lungs, asthma, lung cancer, and cardiovascular events. However, much of this understanding stems from population, animal, or limited *in vitro* studies. There exists a need for an improved understanding of what occurs at the cellular level following diesel exposure. Further, the nature of diesel exhaust is changing as environmental and public health concerns dictate stricter EPA regulation of emissions from diesel engines. Environmental and energy concerns have called for the use of alternative fuels like biodiesel, which also changes the physical and chemical nature of diesel exhaust. Given the changing dynamics of the particulate matter (PM) found in DE, there exists a need to more fully understand the human health implications of switching to more efficient and "cleaner" (Tier 4) diesel engines, and engines that run on alternative fuels like soy-based or algae-based diesel. This project seeks to utilize an improved lung cell culture and exposure system to (1) compare the health effects of diesel exhaust from a Tier 4 engine vs. a Tier 2 engine and (2) compare the health effects of DE from engines run on traditional petrodiesel vs. alternative biodiesel fuels.

APPROACH

An improved aerosol *in vitro* exposure system will be used to compare the inflammatory effects of exhaust from an off road diesel engine meeting Tier 2 emissions guidelines and a diesel engine meeting Tier 4 emissions guidelines. The inflammatory effects will be assessed by measuring the mRNA transcript profiles for interleukin-8, heme oxygenase-1, cyclooxygenase-2, heat-shock protein 70, and the release of lactate dehydrogenase from cultured normal human bronchial epithelial cells at 1 and 24 hours post-exposure.

EXPECTED RESULTS

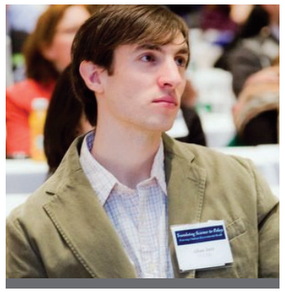
This project will investigate if emissions from engines meeting the EPA Tier 4 guidelines are truly less damaging to the human lung cell than their predecessors (a Tier 2 engine) by investigating changes in the expression of selected genes associated with inflammation, and oxidative stress. Cell death by necrosis and apoptosis will also be assessed. The same cellular endpoints will be utilized to assess differences in the health impacts from exposures to traditional petrodiesel exhaust vs. exhaust from soy-based and algae-based diesel fuel. Three hypotheses regarding the inflammatory potential of diesel exhaust will be tested: (1) An increase in diesel exhaust particle number (and not necessarily mass) increases cellular inflammation, oxidative stress, and necrosis; (2) The redox potential of the diesel particulate matter produced is associated with cellular stress and inflammatory response; and (3) Biodiesel emissions contain less sulfur, NOx, and PAHS than petrodiesel emissions, and therefore there is less of a marked response in cells exposed to biodiesel emissions than in cells exposed to petrodiesel emissions.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

As emissions standards become stricter, attempts to understand the health impacts of DE are complicated by the changing nature of DE. The EPA has sought to improve air quality and public welfare by reducing the allowable mass of PM produced by diesel engines. However, the question remains as to whether reducing the mass output from diesel engines will lessen the burden upon human health. It is not clearly understood if mass is a good determinant in the dose-response to diesel exhaust exposure, as it may not be the mass of diesel particles, but rather the number concentration, or surface area, or composition of the particles that produces toxicological effects. Previous studies have shown that particle surface area is a better dose metric than particle mass or number. By reducing the allowable mass of PM output from diesel engines, the particle mode may be shifted to the ultrafine and nano range ($dp < 0.1$ μm) of particle sizes. This shift would greatly increase the particle surface area to mass ratio. Further, the small size of nanoparticles has also been speculated to increase their uptake into cells. This investigation seeks to identify the physical characteristics of the PM in DE that make DE most inflammatory to human lung cells. The results from this investigation may be used to rethink DE PM standards (perhaps shifting from a standard based on PM mass to one based on PM size and surface area) such that the PM standards more fully protect human health. The same research methodology will be used to investigate the human health implications of using bio-based diesel fuel versus traditional petrodiesel fuel. The global dependence upon the combustion of fossil fuels to meet energy demands has created a need to look to alternative fuels as the petroleum supply remains fixed while global energy demands increase. From an environmental and public health perspective, bio-based diesel fuel has an appeal as it is naturally lower in sulfur, NOx, and PAHs emissions.

Keywords: *air pollution effects, air, in vitro toxicology, diesel exhaust, petrodiesel, biodiesel, particulate matter, inflammatory biomarkers*

Allan Carpenter Just



EPA Grant Number: FP917120
Institution: Columbia University (NY)
EPA Project Officer: Georgette Boddie
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Human Health: Public Health Sciences
E-mail:

BIO:

Allan Just received his undergraduate degree in Environ mental Science from Brown University in 2005. For the following two years, he worked in exposure science as a research assistant at the Silent Spring Institute. In 2007, he entered Columbia University's Ph.D. program in Environ mental Health Science working with the Columbia Center for Children's Environmental Health. His current research examines the links between exposure to endocrine-disrupt ing compounds and inner-city asthma in children.

SYNOPSIS:

Phthalates are common additives in plastics with nearly ubiquitous exposure to many different phthalates among the general population, including pregnant women and chil dren. This epidemiologic research will apply novel statisti cal methods to measure the association between simultane ous exposure to mixtures of phthalates in early life with the development of asthma and allergy in a cohort of inner-city school aged children followed since pregnancy.

Exposure to Phthalate Mixtures and Inner-City Pediatric Asthma

OBJECTIVE(S)/RESEARCH QUESTION(S)

Phthalates are used as additives in plastic with widespread exposure and potential associations with allergy and asthma in children. Although the general population is continually exposed to a complex mixture of toxicants, epidemiologic studies quantifying the risks posed by these chemicals are often focused on one chemical at a time. This research project seeks to identify whether mixtures of phthalates contribute to the development of asthma or allergy or effect lung function and inflamma tion in school aged children.

APPROACH

The research will focus on an analysis of data from 400 inner-city chil dren collected as part of an ongoing prospective birth cohort. Exposure measures will utilize repeated measures of phthalate urinary metabolites starting in the prenatal period and at an early school age as well as an indoor air sample collection coordinated at the same early school age. Measures of allergy and asthma will include a physician's evaluation, concentration of specific immunoglobulin E (IgE) in blood samples, and measures of pediatric lung function and inflammation. Epidemiologic modeling approaches will be expanded to consider multiple correlated phthalate exposures by utilizing hierarchical Bayesian regression to stabilize variance estimates.

EXPECTED RESULTS

With prospectively collected data on exposure to phthalates, we believe this research will be able to more carefully examine the potential of early life exposure to phthalates to contribute to the already high burden of allergy and asthma in an inner city cohort than has been previously possible. Because of the strength of the outcome measures, this research also may be able to point to components of pediatric asthma and allergy affected by these common exposures for additional study. The applica tion of hierarchical modeling may lead to better methods for character izing effects of multiple exposures in epidemiologic studies that improve upon previous conventions of considering each exposure separately.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research may help elucidate how common exposures to a set of environmental pollutants, the phthalates, contribute to rising burdens of pediatric allergy and asthma. In addition, methodologies explored in these analyses may be broadly applicable to other epidemiologic models where exposures to many correlated environmental pollutants exist.

Keywords: *asthma, children's environmental health, phthalates, DEHP, endocrine disrupting compounds, Bayesian analysis, hierarchical model*

Erin O'Brien Semmens

EPA Grant Number: FP917124
Institution: University of Washington (WA)
EPA Project Officer: Georgette Boddie
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
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BIO:

Erin Semmens received an A.B. in Biology and Political Sci ence from Duke University in 2002. After a year of service in the Jesuit Volunteer Corps, she worked as a research specialist in the Center for Structural and Functional Neu roscience at the University of Montana. Erin entered the Environmental Health program at the University of Washing ton in 2005 and earned her M.P.H. in 2007. Her doctoral research focuses on traffic-related air pollution exposure impacts on the brain in older adults.

SYNOPSIS:

Links between air pollution and cardiovascular disease (CVD) have been the focus of intense research. Although CVD and Alzheimer's disease (AD) share similar risk fac tors, and environmental exposures likely play a role in AD, potential links between air pollution and AD remain largely unexplored. This project evaluates the relationship between traffic-related air pollution exposure and cognitive decline, dementia, and MRI-detected brain abnormalities in a large population of older adults.

Effects of Traffic-Related Air Pollution on Cognitive Function, Dementia Risk, and MRI Brain Findings in the Cardiovascular Health Study

OBJECTIVE(S)/RESEARCH QUESTION(S)

Long-term exposure to air pollution, particularly traffic-related air pollution, is associated with cardiovascular (CV) morbidity and mortality; however, less is known about the impact of these exposures on neurodegenerative disorders. Evidence indicates that systemic inflammation, a response to which the brain is particularly vulnerable, may mediate CV effects, suggesting that neurodegenerative disorders may also be subject to this environmental injury. The proposed research will investigate associations between air pollution exposure and cognitive decline, risk of dementia, and MRI-detected brain abnormalities in the Cardiovascular Health Study (CHS), a large, National Heart, Lung and Blood Institute–funded longitudinal study of coronary heart disease and stroke in older adults.

APPROACH

This study will include men and women aged 65 years and older, living in four communities in the United States, who were recruited into the CHS between 1989 and 1993 and who participated in annual clinical exams through 1999. Air pollution exposure will be estimated by calculating proximity of residences to major roadways using a geographic information system. In addition, the study will utilize already-collected monthly individual estimates of exposure to NO_2, CO, O_3, SO_2, and PM10. Outcomes will include cognitive performance, prevalent and incident dementia (both AD and vascular dementia), presence of MRI-detected brain abnormalities including brain infarcts and white matter disease, and changes in these measures over time. This project takes advantage of the unique population-based phenotypic resource of repeated brain MRIs and cognitive assessments in CHS to examine the effects of air pollution on the brain.

EXPECTED RESULTS

This project will characterize more broadly the health effects of air pollution exposure. Although consistent links between air pollution and cardiovascular disease have been observed, the potential contribution of air pollution exposure to neurodegeneration is a novel research direction. This research is one of the first large studies with extensive information on potentially confounding factors, such as socioeconomic status, to investigate the effects of air pollution on cognitive performance, risk of dementia, and subclinical brain abnormalities, which carry elevated risk of cognitive decline and stroke. This project has the opportunity to bring together new collaborations of data sources and expertise for a complex and resource-efficient study.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This project will provide novel and important information on the relationship between air pollution and the brain. Findings will provide a broader understanding of the health risks associated with air pollution exposure to guide policy decisions and future efforts to improve public health.

Keywords: *air pollution, traffic, neurodegeneration, cognition, Cardiovascular Health Study*

Risk Assessment and Decision Making

Kyle James Bibby

EPA Grant Number: FP917115
Institution: Yale University (CT)
EPA Project Officer: Georgette Boddie
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Human Health: Risk Assessment and Decision Making
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BIO:

Kyle Bibby received his undergraduate degree in Civil Engineering from the University of Notre Dame in 2008 and is currently pursuing a Ph.D. in Environmental Engi neering from Yale University. Motivated to study pertinent environmental issues by his great love of the outdoors, in college he investigated nutrient removal in wastewater treatment. His current research focuses on using DNA sequencing technology to study viral pathogens in stabi lized sewage sludge.

SYNOPSIS:

Biosolids are stabilized sewage sludges that are applied to agricultural lands to take advantage of their high nutri ent content. Due to their source, biosolids have the po tential to contain pathogens, and the risks posed to the public by their land application are poorly understood. This research will sequence the viral DNA in a biosolids sample, for the first time identifying the full diversity of viruses present in biosolids, and apply this measure to existing risk assessments.

Risk Assessment of Viral Pathogens in Land Applied Biosolids Using 454 Pyrosequencing

OBJECTIVE(S)/RESEARCH QUESTION(S)

To gain a better understanding of the viral content and diversity in biosolids, I propose the following three objectives: Objective 1. Perform massively parallel next-generation sequencing on viral DNA and cDNA from the influent and effluent of a mesophilic anaerobic digester. Objective 2. Develop approaches to increase the certainty of virus identification from sequence information. Objective 3. Use sequencing data to develop pathogen concentrations in biosolids and produce an aerosol risk analysis for individual and total virus content.

APPROACH

This research will utilize next-generation DNA sequencing to describe the viral metagenome of biosolids from a mesophilic anaerobic digester. Virus-sized particles will be isolated from the biosolids, nucleic acids extracted and sequenced. These sequences will be identified, and the updated viral concentrations applied to existing risk assessments. This work will develop the tools necessary to properly produce and classify these sequences as well as to apply this sequence information to risk assessments.

EXPECTED RESULTS

There are two primary expected results from this research. The first is the development of next-generation DNA sequencing-enabled tools and methodologies for risk assessment. The study of biosolids provides an excellent platform for the development of improved, next-generation sequencing-enabled risk assessment methods. In order for these methods to be properly applied, bioinformatics methods must be further developed to ensure the identity of pathogenic sequences. The completion of an *in silico* study will resolve remaining questions about the importance of BLAST search algorithm, selection of database, and read length. The development of the idea of "gene certainty" will be an important advancement in assuring the identity of sequences as pathogens. The second expected result of this research is an updated viral risk assessment of biosolids land application. A primary barrier to risk-based regulation of pathogens in biosolids has been the lack of reliable pathogen concentrations. Through the incorporation of infectious virus concentrations and qPCR measurements, virome data may be made quantitative. By including all highly enriched viruses in the sample and updating existing exposure and risk assessments, the risk estimates generated will be the most comprehensive to date. Using multiple aerosol transport models for risk assessment will facilitate a consensus view on the risk posed by biosolids land application. These results will promote the movement towards risk-based regulation of biosolids land application practices. Ensuring public safety during land application will encourage sustainable reuse of nutrient rich biosolids and the further development of renewable energy anaerobic digestion technologies. These methods may then be applied in the future to a myriad of quantitative microbial risk assessment cases.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This work will serve to encourage the sustainable practice of biosolids land application while ensuring the protection of public health. In addition, the use of next-generation DNA sequencing-enabled risk assessment tools will facilitate the move from indicator organism-based risk assessments to risk assessments based on the complete diversity of pathogens present.

Keywords: *biosolids, sewage sludge, anaerobic digestion, compost, DNA sequencing, bioinformatics, pathogen, risk assessment*

Joseph Paul Campanale

EPA Grant Number: FP917116
Institution: University of California, San Diego (CA)
EPA Project Officer: Georgette Boddie
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Human Health: Risk Assessment and Decision Making
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BIO:

Joseph Campanale received a Bachelor's degrees in Biology and Microbiology from California Polytechnic (Cal Poly) State University, San Luis Obispo. After graduating, he worked for 2 years as a microbiologist at Den Mat Corp., formulat ing commercial and clinical oral care products. In 2009, he completed his Master's degree in Developmental Biology at Cal Poly, San Luis Obispo. There, he measured the affects of ultraviolet radiation on the developmental physiology of sea urchin embryos. Currently he is a doctoral student at Scripps Institution of Oceanography and his present research inter ests focus on the interactions between environmental stress and development, including chemical defense.

SYNOPSIS:

Embryonic cells have evolved mechanisms for protection against chemicals, including membrane transporters that efflux toxins. Anthropogenic compounds in the environment present new challenges for defenses and can adversely influence the health of adults or subsequent generations. Descriptions of chemical defenses in embryonic cells of the sea urchin can provide information about the role of efflux transporters in chemical protection and inform predictions of stage-specific risks to health.

H Risk Assessment and Decision Making

Windows of Vulnerability in Embryo Development: Loss of Multidrug Efflux in Sea Urchin Pluripotent Cells

OBJECTIVE(S)/RESEARCH QUESTION(S)

The large number of chemicals in the environment could represent a significant emerging risk to the health of most embryos. Recent research by the Environmental Working Group indicate 287 environmental chemicals, including pesticides, herbicides, heavy metals, DDT and dioxins could be detected in human umbilical cord blood (http://ewg.org/). These results show that human embryos are exposed to many chemicals *in utero*, as are embryos of most other species that develop in direct contact with the external environment. However, little is known about how embryos eliminate and/or detoxify chemicals or about specific windows of chemical vulnerability during development. Although embryos have potent defenses against environmental stress, many chemicals can act in stage, species and cell-type specific ways to induce teratology. The overall goal of this research project is to characterize the developmental changes in activity of these cellular defenses and their consequences for the vulnerability of multi-potent cells in embryos.

APPROACH

Preliminary results indicate that multi-potent stem cells, the small micromeres, in the early sea urchin embryo experience a dramatic decrease in a key chemical defense, ATP-binding cassette (ABC) efflux transport, during development. To understand the causes and consequences for the loss of protective efflux activity from critical cell types, embryos from the purple sea urchin, *Strongylocentrotus purpuratus,* will be exposed to fluorescent substrates of these transporters and then imaged by confocal microscopy. In order to understand the regulation of defensive strategies, this research will quantitatively describe the amount and types of efflux transporter activity for a variety of cell types and the developmental timeline for these events. Second, assessments of whether the loss of ABC-transporter activity sensitizes the small micromeres to known environmental contaminants will indicate the relative vulnerability of these cells to environmental chemicals. Finally, this research will examine whether loss of ABC-transporter activity is part of a conserved developmental signaling pathway that drives cellular migration by sensitizing different cells to different developmental chemicals in the embryo.

EXPECTED RESULTS

Qualitative and quantitative estimates of ABC-efflux in critical cell types, including multi-potent stem cells, in embryos will provide important information regarding the relative sensitivity of these cells to environmental chemicals. The results of exposure experiments will accurately describe the timing and magnitude of any reduction in ABC-transporter activity for cells destined to become different tissue types. Experiments using ABC-transporter inhibitors will provide a correlation of reduced ABC-efflux and the vulnerability of critical cells to toxicants. Critical evaluations of the loss of cellular defenses, including in chemical efflux, will uncover information about windows of susceptibility for specific cells during embryogenesis and may provide links between defense against the environment and the developmental program in embryos.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Describing losses in the key chemical defenses provided by ABC-transporter mediated efflux of chemicals from cells in sea urchin embryos will provide information about the role of efflux transporters in protection in general and insights into developmental processes that underlie windows of chemical sensitivity in early embryos. This basic information would inform predictions of stage-specific risks to health and also expand our understanding of cellular regulation of key chemical defenses during the execution of the developmental program.

Keywords: *sea urchin embryo, ABC-efflux, Strongylocentrotus purpuratus, small micromeres, chemical defense, stem cells, multi-potent, confocal microscopy, pollution, toxicants, environmental chemicals*

Mary Caroline Chan

EPA Grant Number: FP917117
Institution: University of Louisville (KY)
EPA Project Officer: Georgette Boddie
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Human Health: Risk Assessment and Decision Making
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BIO:

In her undergraduate work, Caroline Chan focused on aquatic ecology, receiving a B.S. in Biology from the Univer sity of Notre Dame in 1984. With an interest in understand ing how science informs policy, she earned an M.P.H. in 2007 from the University of Louisville. Subsequently, she entered the Ph.D. program in Public Health, Environmen tal Health Sciences. Her research goal is to create tools for decision makers to gain insight into the impact of potential regulations on complex environmental systems.

SYNOPSIS:

Low levels of mercury exposure through fish consumption can cause nervous system deficits in the developing fetus. A major source of contamination of fish comes from emis sions into the atmosphere, with subsequent deposition and transport of mercury into waterways. As a tool for decision makers to gain insight into this system, a model will be de veloped that tracks mercury from emission sources through environmental compartments and the food web to the expo sure of susceptible populations.

Building a Dynamic Model Linking Mercury Emission Regulations to Risk to Susceptible Populations

OBJECTIVE(S)/RESEARCH QUESTION(S)

To predict the results of regulatory decisions requires a broad range of knowledge that incorporates the interactions of physical, chemical, and biological systems with human exposures. When many systems interact, complex problems result and proposed solutions often lead to unexpected results. Dynamic models can be used to address such complex problems by breaking down the systems into their component parts and evaluating the relationships between these parts. This project will explore the reduction in human risk that can be achieved by simulating the environmental and human health impacts from various regulatory decision scenarios at the local level that link mercury emissions to human exposure from the consumption of contaminated fish.

APPROACH

A systems thinking approach will be used to model mercury dynamics downwind from emission sources. A dynamic model will be developed in three stages: human disposition, bioaccumulation through the food web, and environmental compartments. The human disposition sector will predict common biomarkers of methylmercury exposure from fish consumption for select populations. Calibration and validation will be from literature sources. Subsequently, biomagnification of mercury through the food web will forecast predatory fish tissue concentrations at chosen sites by calibrating and validating with site-specific data collected for regulatory purposes. Finally, the characterization of mercury from emission source, to deposition and movement through terrestrial and aquatic compartments will be simulated for these sites. The sub-models will be connected, linking local emissions to human exposure. Upon completion, the model can be used to determine if proposed regulatory scenarios are adequate in bringing fish tissue mercury levels into compliance with water quality standards, and more importantly, in reducing risk to susceptible populations.

EXPECTED RESULTS

The fully developed model will be used to evaluate various policy choices that may result in reduction in risk to specified populations. The distribution of maternal and fetal blood mercury levels will be compared to the level that the U.S. Environmental Protection Agency has determined to be protective of health. Regulators can decide if a proposed regulation is satisfactory by assessing the magnitude of decrease in the population at risk. Of particular importance is the time frame to reach the desired reduction in risk. Because certain environmental compartments act as sinks for mercury, particularly soil and sediment, a biphasic decline may occur after emission reduction policies are implemented as the mercury stored in soil and sediments may continue to release stored mercury before reaching steady state with the new loading scenario. A longer time to reach desired levels may suggest the need for larger reductions in emissions in order to reach reduction goals in a reasonable amount of time.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Efforts to regulate mercury emissions by the U.S. government have been unsuccessful as a consensus on legislation to address this problem has not been found. The stalemate at the federal level has led some states to consider implementing their own regulations to reduce mercury emissions. To do so, states must demonstrate that local reductions in emissions would result in reduced levels of mercury in local waterways with a subsequent reduction in risk to susceptible populations. The finished model will be a tool for states to project the impact of local regulations on local populations.

Keywords: *mercury exposure, fish consumption, susceptible populations, policy assessment*

Grace Hwai-Yen Chang

EPA Grant Number: FP917118
Institution: University of Massachusetts, Amherst (MA)
EPA Project Officer: Georgette Boddie
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Human Health: Risk Assessment and Decision Making
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BIO:

A graduate of Amherst College, Grace Chang received her Ph.D. in French literature from Yale in 1999. She taught francophone literature and cinema at San Diego State and the University of New Hampshire before joining the Ph.D. program in economics at the University of Massachusetts, Amherst in 2006. Her research focuses broadly on the po litical economy of environmental problems, with particular interests in environmental justice, industrial air toxics, and climate change.

SYNOPSIS:

Exposure to industrial toxic air pollution poses serious health risks in the United States. Environmental justice re search has shown that low-income communities of color ex perience a greater share of the total human health risk from exposure, compared to their population share. This project is a statistical investigation of the relationship between the income and race/ethnicity of residents and their exposure to toxic air pollution, examining how it varies across geograph ic regions and industrial sectors.

Distribution of Airborne Industrial Toxic Pollution in the United States: Dynamic Spatial Analysis of Environmental Inequality

OBJECTIVE(S)/RESEARCH QUESTION(S)

This project investigates the social, temporal, and geographic structure of exposure to industrial toxic air releases in the United States, focusing on the potential health risks affecting low-income communities and people of color. It examines how the relationship between population characteristics (income and race/ethnicity) and pollution exposure varies across time, geographic region, and industrial sector. The study will provide an empirical test of the effects of social, political, and economic features of a region—income inequality, voter participation, and residential segregation—on the relationship between income/race/ethnicity and toxic exposure, and similarly for industrial sector characteristics such as energy intensity and firm concentration.

APPROACH

The project will apply descriptive and multivariate methods, using socioeconomic data on neighborhoods from the 1990 and 2000 Censuses of Population and Housing and a unique, new dataset from the Risk-Screening Environmental Indicators (RSEI) project of the U.S. Environmental Protection Agency that provides highly detailed geographic data on exposure to industrial toxic air releases. These data cover the entire United States and are available annually from 1988 through 2006. The correlations between demographics and exposure will be mapped before investigating how these vary across time, region, and industrial sector.

EXPECTED RESULTS

Environmental justice researchers have offered many explanations for why pollution burdens may fall disproportionately on low-income and minority communities, an important subset of which focuses on imbalances in resources, representation, and political clout. Housing discrimination is an additional barrier that racial and ethnic minorities may face; even when they might have incomes comparable to whites who have the financial means to move into environmentally cleaner neighborhoods, they may be constrained by housing discrimination, thus forcing them to remain in their currently polluted neighborhoods. It is expected that regions with high degrees of economic and political inequality have steeper gradients between socioeconomic attributes and pollution exposure (positive for race/ethnicity and negative for income). Further, regions with high degrees of racial/ethnic segregation would be expected to have steeper gradients between race/ethnicity and exposure to pollution. With respect to industrial sector characteristics, it is possible that high-visibility industries like electric power may face greater pressure to locate facilities away from politically influential constituencies. Conversely, firms in industries with high concentration ratios may be more sensitive to potential damage to their image from environmental inequities because they may attract more public scrutiny. The net effects will be determined empirically, but it is expected that industries with high degrees of energy intensity have steeper gradients between socioeconomic attributes and pollution exposure (positive for race/ethnicity and negative for income), while industries with higher concentration ratios have shallower gradients.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The project will make a contribution to scientific knowledge and social progress in several important ways. First, the research will help improve our understanding of the dynamics of neighborhood environmental inequality, with broader impacts in the fields of environmental justice, community health, and public policy. Second, the findings will be of direct relevance to shareholders and other stakeholders in corporate environmental performance. Third, in addition to seeking publication in scholarly journals, the results will be disseminated in the form of public presentations and popular publications that should be of interest to scholars and activists alike.

Keywords: *environmental justice, environmental inequality, industrial air toxics, corporate environmental performance, RSEI, race, income*

Alissa Annie Cordner

EPA Grant Number: FP917119
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EPA Project Officer: Georgette Boddie
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Human Health: Risk Assessment and Decision Making
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BIO:

Alissa Cordner grew up in Oregon, and received her under graduate degree in Sociology and French from Bowdoin College in 2004. She spent time teaching, working for an environmental organization, and leading youth wilderness programs before deciding to return to graduate school. She is currently pursuing her Ph.D. in Sociology at Brown Uni versity. Her research interests include environmental sociol ogy, science and technology studies, and urban sociology. Her current research focuses on the social implications of chemicals use and policy.

SYNOPSIS:

Flame retardant chemicals are widely used in consumer products, and may harm human health and the environ ment. This project identifies how these chemicals are studied and regulated, how they have entered into public discussion and activist campaigns, and how stakeholders respond to the risks and hazards of flame retardants. It serves as a case study for how people characterize the dan gers of ubiquitous chemicals, and how this understanding of risk informs their personal and professional actions.

The Social Implications of Flame Retardant Chemicals: A Case Study in Risk and Hazard Perception

OBJECTIVE(S)/RESEARCH QUESTION(S)

This project investigates the social implications of flame retardant chemicals that are used in consumer products and may harm human health and the environment. Some flame retardants have been widely researched, and have become important in advocacy and policy circles as an example of the ubiquity and dangers of chemicals used in consumer products. This makes them an ideal case study for how different actors characterize the dangers of ubiquitous chemicals, and how they interpret the risks and hazards of routine chemical exposure. This project identifies how these chemicals are studied and regulated, how they have entered into public discussion and activist campaigns, and how stakeholders respond to the risks and hazards of chemicals.

APPROACH

This research includes a literature review, content analysis, and in-depth interviews. I will conduct a detailed literature review tracking the growth of scholarship and awareness of flame retardant chemicals. I will also examine published and publicly available documents related to flame retardants for how the chemical dangers are described in terms of risks and hazards. The main portion of the project consists of approximately 60 in-depth, semi-structured interviews with individuals whose work impacts the public's relationship to and understanding of chemicals. I will interview scientists, policy makers, activists, industry representatives, participants in biomonitoring studies, and fire fighters and other occupationally-exposed individuals.

EXPECTED RESULTS

This study is expected to fill an important gap in the literature by focusing on how individuals characterize exposure in terms of risk and hazard, and how this understanding can lead to concrete changes in their personal and professional lives. I expect that people differ greatly in how they think about chemical exposures, and this project will document how different stakeholders translate assessed, technological risk into perceived social risk. I also expect that people transform these different perceptions of risk into concrete personal and professional actions. Finally, I anticipate that flame retardants can serve as a case study for how people respond to other emerging contaminants and environmental health threats through scientific, regulatory, and industrial action. Policy decisions on issues like chemical exposure are socially driven, and so studies of the social implications of environmental problems are necessary for a complete understanding of environmental problems and solutions.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The ubiquity of chemicals in our environment is an area of growing public and regulatory concern, and yet there is pervasive uncertainty about the risks and hazards of chemicals in the perceptions of scientists, policymakers, activists, and the general public. This research will identify how people with varying personal and professional connections to chemicals make sense of chemical exposure. The understanding of risk and hazard furthered by this project may contribute to the Environmental Protection Agency's ability to incorporate social and economic factors and public values into the risk management process by identifying how policy is influenced by social actors, and by improving the potential for productive inter-agency and inter-group communication. This research will also produce outreach materials for a broad spectrum of audiences, including environmental health researchers and activists, regulators and policy makers, occupationally exposed individuals, and the chemical and manufacturing industries.

Keywords: *Flame retardant chemicals, emerging contaminants, risk and hazard, risk assessment, biomonitoring, chemicals policy*

Jonathan McKinney

EPA Grant Number: FP917121
Institution: Missouri University of Science and Technology (MO)
EPA Project Officer: Georgette Boddie
Project Period: 8/23/2010 – 8/21/2012
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Jon McKinney received his undergraduate degree in Envi ronmental Engineering from the Missouri University of Sci ence and Technology (S&T) in May 2010, under the support of an EPA GRO Fellowship. Currently he is pursuing a M.S. in Chemical Engineering at S&T. Jon's research focuses on quantifying historical occupant exposure to volatile organic compounds (VOCs) in buildings. He is currently developing inverse analysis methods that will allow for quantification of the exposures via forensic analysis of building materials.

SYNOPSIS:

Health scientists believe that VOCs in indoor air lead to many adverse health effects, which occur long after occu pant exposure. Studies regarding historical exposures and their health effects are often uncertain due to limitations in air sampling methods. This project's goal is to quantify his torical occupant exposure by sampling chemical concentra tions in building materials, such as walls, then using mass transport models to back-calculate historical exposures.

H Risk Assessment and Decision Making

Quantifying Historical Human Exposure to Indoor Air Pollutants Through Building Material Forensics Combined with Inverse Diffusion Modeling

OBJECTIVE(S)/RESEARCH QUESTION(S)

Health scientists believe that VOCs in indoor air may lead to a variety of adverse health effects, which occur long after the occupant was actually exposed to the chemical. Current air sampling methods only allow for quantification of air quality at the present time, and not the past, which leads to uncertain conclusions from studies regarding which VOC exposures lead to adverse health effects. This project's goal is to generate sampling and data analysis methods for health scientists to use in the field that significantly improve their understanding of historical occupant exposure. The goal may be achieved by forensically analyzing VOCs that have transported into building materials via diffusion, such as toluene in walls or foam cushions, and then using inverse diffusion analysis to determine what historical exposure may have led to the present samples of the building material.

APPROACH

We will use a three-phase approach to meet research objectives. Sampling methods for chemical concentrations in building materials using Solid Phase Micro-Extraction (SPME), methods for forward diffusion analysis, and a system to simulate and allow sampling of diffusion through building materials in the laboratory were previously generated during undergraduate research. First, we will create inverse diffusion analysis methods, and use the existing laboratory system to verify both the existing forward analysis and new inverse analysis methods. Second, we will perform parameter sensitivity analyses using the laboratory system, and modify the diffusion models and analysis methods to match realistic field situations, rather than laboratory conditions. Last, we will field-test all sampling and analysis methods that were developed.

EXPECTED RESULTS

The expected result of this research is to provide health scientists with a new toolbox that allows them to better understand historical occupant exposure to VOCs in indoor environments. As a result, the health scientists may be able to draw more concise conclusions about which VOC exposures lead to which health problems. We expect limitations to how sampling and analysis methods can be used in the field based on uncertainties such as temperature/humidity fluctuations and unknown historical gas phase chemistry in buildings. Uncertainty propagation is inherent in inverse diffusion analysis. The further back in time we try to "see," our "snapshot of the past" will get fuzzier in the background, but stay clear in the foreground. The most critical results of this research are clear guidelines to health scientists about what is feasible, and not feasible, with this new toolbox in the field.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

If scientists are able to use our methods to show certain VOCs are harmful, then there will be a direct positive impact on human health and society. Knowledge of which VOCs at which doses are harmful would develop, opening a regulatory path to better protect human health and society in the future, including regulation of chemicals released by consumer products that are typically used indoors, such as air fresheners and cleaning solvents. Our methods also have other applications, such as predicting future exposure rates in new homes that were previously contaminated.

Keywords: *indoor air quality, indoor environment, diffusion, mass transport, inverse analysis, volatile organic compounds, VOCs, human exposure, human health, SPME*

Shannon Renee Murphy

EPA Grant Number: FP917122
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EPA Project Officer: Georgette Boddie
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Shannon Murphy received her undergraduate degree in Animal Science at the University of California, Davis (UC Davis) in 2002. She then pursued her research interests at Pacific BioLabs in the areas of biocompatibility, systemic toxicity, and agrichemistry for 5 years. As Assistant Manager of Toxicology Services, Shannon worked directly with clients on projects intensely regulated by agencies such as the Environmental Protection Agency. She began her doctoral program in Pharmacology and Toxicology at UC Davis in 2007 and currently focuses on the interactions of environ mental air pollution and respiratory health at the Center for Health and the Environment.

SYNOPSIS:

Ozone is a major component of air pollution that worsens childhood asthma. Exposure to unhealthful levels of ozone poses a health concern for children, a group more vulner able than adults to poor air quality as their lungs are not yet fully developed. This project examines the role of serotonin, a key nerve chemical, in air pollution-driven asthma exac erbation in children. Ultimately, this work may identify new targets for disease treatment.

H Risk Assessment and Decision Making

Serotonin Expression in the Airway Epithelium of Postnatal Rhesus Monkeys: Effect of Ozone or House Dust Mite Antigen (HDMA) Exposure

OBJECTIVE(S)/RESEARCH QUESTION(S)

Evidence supports that air pollutants such as ozone exacerbate asthma symptoms and children represent a particularly sensitive population. This research project will use an animal model of childhood asthma to define how effects of ozone exposure during postnatal lung development change serotonin/receptor expression, potentially enhancing airway hyperresponsiveness.

APPROACH

This research takes advantage of an established rhesus monkey model of postnatal airway development and allergic airway disease to further examine how exposure to house dust mite antigen (HDMA) and ozone during early postnatal development leads to altered afferent (sensory) and efferent nerve-tissue interactions that may contribute to deficiencies in pulmonary function and increased airway reactivity. This project focuses on changes in receptors and ligands normally associated with neural function and will be executed in three parts. First, we will define the normal development pattern of serotonin and serotonin receptor distribution by airway level and increasing age of the postnatal Rhesus monkey model through immunohistochemically based morphometric approaches. Second, we will compare serotonin and serotonin receptor patterns in the epithelium and interstitium of normal versus exposed animals, defining serotonin sequestration among four key lung cell types. Finally, we will examine postnatal airway exposure history to evaluate responses to neurokinin receptor-mediated acute oxidant stress. Ultimately, these specific aims seek to define the presence of serotonin and its potential modulatory activities in neural and immunological interactions within the lung.

EXPECTED RESULTS

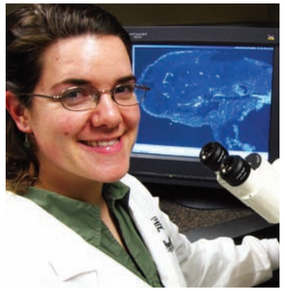
This project seeks to examine the overall question of how episodic exposure to allergens or oxidative pollutants during the critical window of postnatal development results in serotonin/receptor expression changes that may participate in the development of hyperresponsive airways. We hypothesize that the abundance of serotonin in normal lung will decrease with postnatal age and that its expression in airway epithelium will be associated with specific airway regions. Exposure to inhaled pollutants may increase the abundance of serotonin with postnatal age and can also change the cell type and airway level distribution profile. We hypothesize that exposure to inhaled pollutants alters the response to oxidative stress, making airways more vulnerable to injury. We postulate that developmental deviations are exacerbated when immune functions are altered due to antigenic exposure and, when combined with oxidative stress from the air pollutant ozone, result in development of a sensitive phenotype.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research further investigates why a key subpopulation is more sensitive to a known environmental pollutant and ultimately facilitates pulmonary health risk assessment for children living in polluted areas. Additionally, this work more clearly defines the adverse developmental consequences of exposure to air pollution during childhood that may present greater, and potentially irreversible, health problems throughout the life of the individual.

Keywords: *asthma, lung, serotonin, airway disease, ozone, oxidant air pollutants, bronchoconstriction, health risk assessment, airway hyperresponsiveness, NAAQS*

Katerine Schletz Saili



EPA Grant Number: FP917123
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EPA Project Officer: Georgette Boddie
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Project Amount: $111,000.00
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BIO:

Katerine Saili earned her B.A. in Biology from Carroll Col lege (Helena, MT) in 1998. She joined the Peace Corps in 1999 and taught high school science in Samoa for 2 years. She then worked for several years in the field of wildlife biology. In 2006, she joined the Department of Environ mental and Molecular Toxicology at Oregon State University, where she is currently pursuing a Ph.D. in Toxicology. Her thesis research utilizes the zebrafish model to study the developmental effects of bisphenol A (BPA) exposure.

SYNOPSIS:

Bisphenol A (BPA) leaches from polycarbonate plastic and resin linings of food cans. Ingestion of contaminated food or water is a major source of human exposure. Prenatal and infant BPA exposure may impact brain development and contribute to childhood behavioral disorders. Although BPA is a suspected endocrine disruptor, the underlying cause of BPA's effects on the developing brain remains unclear. This project investigates how relevant BPA exposure levels im pact brain development and behavior.

Developmental Neurobehavioral Toxicity of Bisphenol A: Defining the Role of ERRgamma

OBJECTIVE(S)/RESEARCH QUESTION(S)

BPA is a contaminant that leaches into food or drinks stored in poly-carbonate plastic or resin-lined cans. Exposure to BPA either directly through the placenta or via ingestion of contaminated breast milk, food, or water during critical periods of brain development has been proposed to result in childhood behavioral disorders. Although BPA is a suspected endocrine disruptor, the extent to which this contaminant impacts classic estrogen signaling remains unclear. This project will investigate the role of estrogen-related receptor gamma (ERR3), a receptor that binds BPA with high affinity, in mediating the neurobehavioral effects of low-dose BPA exposure.

APPROACH

Zebrafish express a form of ERR3 in the brain that is 95 percent identical to the human ortholog. Thus, the molecular events measured in embry-onic zebrafish following developmental BPA exposure are expected to be relevant to humans. To determine the behavioral effects of low-dose BPA exposure, embryonic zebrafish will be exposed to BPA during neuro-genesis, a 2-day period of central nervous system (CNS) development that is analogous to the first trimester. Following exposure, performance on behavior tests, including a test of locomotor activity in response to a startle stimulus, will be measured in both larval (5 days post fertilization; dpf) and adult (60 dpf) zebrafish. To determine the extent to which ERR3 mediates the neurobehavioral effects of BPA exposure, antisense oligo-nucleotide morpholinos will be used to repress ERR3 expression during the BPA exposure period, followed by the same behavior assessments. In addition to investigating the role of ERR3, biomarkers of BPA exposure will be identified by isolating neuron-specific RNA from 1 dpf transgenic zebrafish embryos, followed by global microarray analyses. By capital-izing on the strengths of the embryonic zebrafish model, this project will, for the first time, examine the role of ERR3 at both the molecular and be-havioral levels and generate data that will help explain how BPA interacts with and perturbs vertebrate CNS development.

EXPECTED RESULTS

Preliminary experiments identified a hyperactive behavioral pheno-type in 6-day-old and mature zebrafish that were transiently exposed to environmentally relevant BPA concentrations during CNS development. These behavioral effects are expected to be directly dependent upon ERR3 signaling. BPA binds to ERR3 with 100 – 10,000 times greater affinity than it binds classical estrogen receptors. ERR3 is also highly expressed in the brain and placenta, supporting the likelihood that it has a significant role in mediating the behavioral effects of low-concentra-tion BPA exposure during early brain development. Accordingly, it is expected that repression of ERR3 expression during BPA exposure will remove the principal BPA target, and therefore will rescue the behavioral phenotypes (e.g., hyperactivity) associated with BPA exposure. Further-more, it is expected that a set of genes expressed downstream of ERR3 activation will be identified as biomarkers of BPA exposure by the mi-croarray analyses. These studies will identify, for the first time, a set of neuron-specific ERR3 responsive genes that are misexpressed following exposure to environmentally relevant BPA concentrations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

A decision to redefine BPA regulatory standards to protect our youngest demographic would have significant economic and public health impli-cations and therefore requires identification of a plausible mechanism of action acting at environmentally relevant concentrations. This study will generate critical information regarding BPA-mediated neurotoxicity, in addition to identifying low-dose BPA exposure biomarkers that can be used as risk management tools.

Keywords: *bisphenol A, BPA, endocrine disruption, estrogen, estrogen related receptor gamma, ERR3, behavior, behavior disorder, hyperactivity, fetus, infant, children, polycarbonate, plastic, resin linings, zebrafish, microarray, genes, gene environment interactions, neurobehavioral development, development, brain, central nervous system, CNS, placenta, breast milk*

Ecosystem Services

- *Aquatic Systems Ecology*
- *Terrestrial Systems Soil and Plant Ecology*
- *Terrestrial Systems Animal Ecology*










Ecosystem Services Fellows



AQUATIC SYSTEMS ECOLOGY

TERRESTRIAL SYSTEMS SOIL AND PLANT ECOLOGY

TERRESTRIAL SYSTEMS ANIMAL ECOLOGY

Aquatic Systems Ecology

Jacob Edward Allgeier

EPA Grant Number: FP917087
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EPA Project Officer: Brandon Jones
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Jacob Allgeier received his B.S. in Biology from Centre College in 2001. After graduation, he conducted aquatic ecology research in Tanzania and Venezuela. He then spent two years conducting research in the Bahamas conducting ecological restoration of local wetlands. He began a Ph.D. program in Ecology at the Odum School of Ecology, Univer sity of Georgia in 2006. His current research interests focus on the implications of anthropogenic change to the coastal marine environment, specifically overfishing and nutrient loading, for nutrient cycling in the coastal realm.

SYNOPSIS:

Overfishing and nutrient pollution affect the supply of growth-limiting nutrients for algae and seagrasses, the base of most marine ecosystems. Human inputs increase the supply of nutrients, while overfishing can reduce nutrient supply because fish provide inputs of nutrients via excre tion. We test the hypothesis that human-derived nutrients can supplant fish-derived nutrients by simulating both of these scenarios independently and simultaneously using artificial patch reef habitats.

Shifting Baselines? The Ecological Implications of Simultaneous Eutrophication and Overfishing

OBJECTIVE(S)/RESEARCH QUESTION(S)

Overfishing and human-derived nutrient pollution affect the supply of growth-limiting nutrients (nitrogen and phosphorus) for algae and sea-grasses, the base of most marine ecosystems. Human inputs increase the supply of nutrients, which are largely sewage-derived, while overfishing has been shown to reduce nutrient supply because fish provide substan-tial inputs of nutrients via excretion. These contrasting inputs present the paradox that human-derived nutrients may supplant fish-derived nutrients. However, human-derived nutrients are higher in phosphorus relative to fish-derived nutrients, shifting the baseline at which nutrients are supplied and potentially altering the diversity and growth rates of algae and seagrass species.

APPROACH

Overfishing and nutrient enrichment will be simulated independently and simultaneously on experimental patch-reef ecosystems in the Baha-mas by manipulating the community structure of fishes on the reef, and through the use of commercial fertilizing compounds, respectively. The implications for changes in diversity, growth, and nutrient limitation of algae and seagrass species will be measured through the use of benthic surveys, examination of seagrass nutrient content, and nutrient limita-tion assays for benthic algae.

EXPECTED RESULTS

We predict that changes in nutrient supply rates will alter the seagrass community by favoring species that are typically less dominant but have a greater affinity for these baseline nutrient conditions. We also predict substantial shifts in benthic algae nutrient limitation, whereby nutrient limitation will decrease with increased perturbation (i.e., simultaneous overfishing and nutrient enrichment).

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Subtropical and tropical marine ecosystems have evolved to function under extremely low nutrient conditions, making them particularly sus-ceptible to even minor alterations in nutrient dynamics. The enormous services provided by these ecosystems appear to critically hinge on the amount and relative supply of nitrogen and phosphorus, yet understand-ing of the effects of simultaneous overfishing and eutrophication for these services is lacking, particularly in the Caribbean. Increased under-standing of nutrient effects is critical to the management and conserva-tion of marine ecosystems globally.

Keywords: *coastal ecosystems, enrichment, interaction, nitrogen, nutrient, phosphorus, patch reefs*

Kimberly Sarah Brewitt

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EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Kim Brewitt received her undergraduate degree in English and physics from Dartmouth College in 2002. For five years following college, she worked as an environmental educator, teaching in North Carolina, Washington, and Yo semite, California. In 2007, she pursued summer research on coral mortality with the Central Caribbean Marine Institute. After working as a lab assistant for NOAA Fisher ies, she began a Ph.D. program in Ecology and Evolution ary Biology at UC Santa Cruz. Her research focuses on the effects of elevated water temperatures on salmon popula tions in northern California.

SYNOPSIS:

Recent increases in river water temperatures caused by climate change and altered land-use practices threaten the health of salmon populations world-wide. This fellow's re search will focus on quantifying how fluctuations in temper ature and prey availability drive variations in the amount of usable freshwater salmonid habitat during periods of high summer water temperatures, and on developing a bioener getics model that can be used to inform future fisheries and water management decisions.

The Importance of Thermal Refugia as Critical Habitat for Threatened Juvenile Salmonids

OBJECTIVE(S)/RESEARCH QUESTION(S)

Water temperatures have critical impacts on fish physiology, distribution, and behavior. Elevated river water temperatures, caused by changes in land and water use, decrease the amount of usable freshwater habitat available to declining salmon populations along the Pacific coast of the United States. At the limits of their thermal tolerance, salmonids may behaviorally thermoregulate by moving to localized patches of colder water, or thermal refugia. As water temperatures continue to rise, it will be important to understand the implications for salmonid growth and survival. This research project will focus on defining the mechanisms driving salmonid use of thermal refugia on the Klamath River in northern California and on developing a bioenergetics model that can be used to inform future fisheries and water management decisions.

APPROACH

The first stage of research will entail collecting field data to map the thermal environment surrounding coolwater refugia, to radio tag juvenile salmonids for spatiotemporal distribution data, and to collect water samples to quantify daily prey availability. Correlating these data will allow me to determine how spatiotemporal temperature dynamics and food availability drive salmonid behavior. A thorough understanding of thermal refugia use by salmonids will be essential for the preservation of salmon populations in coming decades as climate change may lead to substantial changes in water temperatures and river flow regimes, further decreasing available freshwater habitat.

EXPECTED RESULTS

This research will provide a better understanding of the specific mechanisms driving salmonid use of thermal refugia. The results of the field research will be integrated into a bioenergetics model, which will quantify the amount of thermally prohibitive versus usable habitat for different food and temperature scenarios. This will allow fisheries and land managers to gain a better understanding of the conditions under which thermal refugia become critical habitat, and the importance of variations in temperature and prey availability in influencing the superiority of a given habitat. Many tributaries on the West Coast have heavily logged watersheds, which can significantly impact water quality and temperature. Determining the relative importance of thermal refugia to salmonid survival will therefore help inform logging and other land-use practices in the region. These findings will be important for decisions concerning designations of critical habitat in rivers with high summer water temperatures, as the model will be applicable to similar systems.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research will examine how elevated river water temperatures influence the growth and survival of juvenile salmonid populations. It will use field data on temperature dynamics, spatiotemporal fish distribution, and prey availability data to construct a bioenergetics model to examine the patchy nature of usable habitat for salmonids in rivers with high summer water temperatures. With an understanding of the importance of coolwater tributary inputs, this research will be an important tool for fisheries and land managers in determining watershed land-use practices.

Keywords: *climate change, critical habitat, salmonid, steelhead, water temperature, refugia, thermoregulate*

Christine L. Dolph

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Institution: University of Minnesota, Twin Cities (MN)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Christine Dolph received her undergraduate degree in Biol ogy from Grinnell College in 2002. Upon graduating, she served as a Student Conservation Association Intern in California and Alabama, and was subsequently hired as a biological technician by the U.S. Fish and Wildlife Service in Alaska. After working in Alaska for three field seasons, she entered a Master's program in Water Resources Science at the University of Minnesota in 2006. Currently a Ph.D. student in the same program, her research focuses on the effect of human land use on stream ecosystem services.

SYNOPSIS:

Recently, attempts to restore degraded stream systems have become widespread, with over a billion dollars a year spent on stream restoration projects in the United States alone. At the same time, the ecological effects of stream restora tion are rarely studied in a systematic manner. My research aims to evaluate the response of both ecosystem function and invertebrate community composition to recent restora tion activities conducted within agricultural streams of the Minnesota River basin.

E Aquatic Systems Ecology

Linking Ecosystem Processes to Macroinvertebrate Community Structure in Restored Stream Systems of the Minnesota River Basin

OBJECTIVE(S)/RESEARCH QUESTION(S)

Throughout much of the globe, human activities have resulted in drastic and pervasive alterations to many of the defining characteristics of stream systems. Recently, attempts to restore or rehabilitate degraded streams have become widespread, with well over a billion dollars a year spent on stream restoration projects in the United States alone. Despite this investment of financial re-sources – and the purported motivation of many restoration projects to im-prove ecosystem health – ecological changes following the implementation of restoration activities are rarely evaluated in a systematic fashion. In this study, I will evaluate the response of stream community structure and function to stream restoration attempts conducted in three different agricultural streams. I will seek to (1) provide estimates of the level of ecological services provided by restored streams in agroecosystems, (2) provide managers with informa-tion about the most appropriate water quality monitoring tools to gauge stream recovery, and (3) provide information about environmental variables that may determine the success of stream restoration efforts.

APPROACH

Stream community structure and function will be evaluated within both restored and untreated (i.e., control) reaches of three different warmwater streams, all of which flow through predominantly agricultural landscapes and are located within or near the Minnesota River basin in southwestern Minne-sota. Specifically, I will quantify rates of two important ecosystem processes in each of these study reaches: (1) secondary production of macroinvertebrates (i.e., the amount of macroinvertebrate biomass that is produced over time), and (2) leaf litter decomposition (the amount of coarse organic material that decays or is lost over time). Both processes critically affect energy flow in lotic sys-tems, and are indicative of a stream's potential to provide a number of ecologi-cal services including nutrient cycling, protection of biodiversity, and fisheries production. I will also compare patterns in these processes to patterns in mac-roinvertebrate community structure, and identify environmental parameters that are associated with either structural or functional measures. Differences in secondary production, leaf litter decomposition, macroinvertebrate community structure, and in-stream and riparian habitat will be compared among restored and control reaches.

EXPECTED RESULTS

Restoration activities implemented to the study streams may have a number of effects on macroinvertebrate community structure and ecosystem function. Re-vegetation of the riparian zone with deciduous trees and shrubs may in-crease allochthonous inputs (i.e., leaf litter) to the stream, and thereby provide an energy source for detritivore (i.e., shredder) populations. Since shredders are believed to regulate leaf decomposition, an increase in shredder produc-tion in the restored reaches could increase rates of leaf litter breakdown. On the other hand, the addition of large wood and boulders may decrease current velocity in the restored channel at high flows, resulting in lower rates of leaf breakdown due to physical fragmentation. The addition of large boulders and wood to the stream channel also may affect macroinvertebrate diversity and production by (1) directly increasing the amount of stable substrate for macro-invertebrates to colonize, (2) indirectly affecting habitat availability by caus-ing changes in stream channel geomorphology (i.e., changes in the number of pools, substrate complexity), and (3) increasing retention of allochthonous organic matter such as leaf packs and debris dams, thereby prolonging the availability of an important energy source to detritivores.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Based on the results of this project, I expect to develop several recommenda-tions for managers that pertain to how stream restoration projects are imple-mented and monitored, including (1) whether stream restoration activities at the reach scale can be expected to impact the structure or function of highly disturbed agricultural streams of the Minnesota River basin, (2) whether sec-ondary production and/or litter decomposition could be used as tools to aid in restoration effectiveness monitoring, (3) which, if any, structural attributes of macroinvertebrate communities can be used to gauge the functional integrity of streams and therefore represent good candidate metrics for restoration as-sessment, and (4) which, if any, individual macroinvertebrate taxa are strongly associated with patterns in ecosystem processes and therefore represent impor-tant endpoints for conservation efforts.

Keywords: *indicators, aquatic, insects, sustainability, biology, ecology, large woody debris, entomology, agriculture, farming, Clean Water Act, impaired waters, watersheds, soil, turbidity, eutrophication, degradation, stream health, pollution, TMDL, primary production, energy flow, trophic, RIVPACS, IBI, diversity, biodiversity, erosion*

Julia E. Earl

EPA Grant Number: FP917093
Institution: University of Missouri, Columbia (MO)
EPA Project Officer: Brandon Jones
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Julia Earl received her undergraduate degree in Environ mental Studies from Emory University in 2003. Afterwards, she worked as a wildlife technician. In 2007, she complet ed a Master's in Water Science at Murray State University, where she studied the effects of nitrate and phosphate on tadpoles. Julia has been working on her doctorate at the University of Missouri as a Life Sciences Fellow for the past three years. Her research focuses on the effects of human land use on pond-forest linkages.

SYNOPSIS:

Leaf litter, a spatial subsidy, is a resource linking forests and ponds. Leaves provide food for pond organisms but also contain chemicals, like tannins, that can be harmful. I will examine effects of leaf litter on pond amphibians by manipulating leaf input into artificial ponds and examin ing tadpole survival and diet. I will also measure tannins in pond water varying in tree species and study the effects of tannins on tadpoles, helping us understand how forestry af fects pond communities.

E Aquatic Systems Ecology

The Effects of Spatial Subsidies on Amphibians

OBJECTIVE(S)/RESEARCH QUESTION(S)

Spatial subsidies are resources that move from one habitat to another, providing linkages among ecosystems. I plan to determine how spatial subsidies affect the vital rates of species with ontogenetic habitat shifts, which are themselves spatial subsidies. I will assess the impacts of the presence and quality (nutrients and plant secondary compounds) of spatial subsidies (forest leaf litter input to ponds) when compared to within system inputs (aquatic grasses) on amphibian larvae.

APPROACH

This study will examine the effects of the presence and quality of spatial subsidies on the vital rates of species amphibian larvae. To investigate the effects of the presence of spatial subsidies, I will compare tadpole vital rates and diet (using stable isotopes) in pond mesocosms with spatial subsidy input (deciduous leaf litter) to mesocosms containing within system input (aquatic grass) and no input along a light gradient. Because frogs move away from ponds into forest after metamorphosis (another spatial subsidy), this study is a beginning step to understanding spatial subsidy feedback loops between forest and ponds. Although spatial subsidies are essentially nutrient and energy vectors from one ecosystem to another, the subsidy's effects depend on the degree to which the subsidy's nutrients are labile, along with the concentrations of other active compounds, such as tannins. To investigate the effects of the quality (primarily tannin concentration) of spatial subsidies on tadpole vital rates, a mesocosm study and a laboratory study have already been performed to compare the community and chemical effects of litter input from different species of trees on tadpoles. To adjust the laboratory study to be more realistic, I plan to conduct an observational study on the tannin concentrations in closed canopy ponds that vary in the species of surrounding trees. Realistic concentrations will then be used in a laboratory experiment.

EXPECTED RESULTS

Theory on spatial subsidies predicts that additional input will support ecosystems with low productivity. Preliminary results show this to be true for leaf litter input and overall macroinvertebrate biomass in ponds, but amphibians appear to have lower survival and growth likely due to high tannin concentrations, lower dissolved oxygen from microbial decomposition, and lower food quality. I hypothesize that tadpoles from clearcut tanks eat and assimilate material from algae, and tadpoles from forest tanks will have isotopic signatures reflecting the detritus available, which has lower food quality than algae. For spatial subsidy quality, I predict leaf litter input with higher tannin concentrations will negatively affect tadpole performance, resulting in differing tadpole performance with litter input from different tree species.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Many land use changes, such as forestry practices addressed in this study, may impact the flow and type of spatial subsidy input into ponds. In aquatic systems, spatial subsidies may impact water quality by altering dissolved oxygen levels and transporting secondary plant compounds into water. Information on forestry practices on amphibians and water quality and the indirect and direct causes of those effects will help determine best management practices and help landowners and public managers make educated decisions about their property.

Keywords: *amphibians, pond communities, spatial subsidies, plant secondary compounds, stable isotopes*

Harmony A. Hancock

EPA Grant Number: FP917097
Institution: Nova Southeastern University (FL)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2012
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Harmony Hancock earned her Bachelor's degree in Biology from the College of Saint Elizabeth (CSE) in 2003. After an internship at Biscayne National Park, she returned to CSE to earn her secondary teaching certificate and taught high school science for four years. In 2008, she began a joint Master's degree program in Marine Biology and Coast al Zone Management at Nova Southeastern University's Oceanographic Center. She is currently developing a bio-optical model for coral health.

SYNOPSIS:

Coral health is a bioindicator of climate change. The most accepted proxy for coral health is coral pigmentation. Cur rent methods to quantify pigments are either visible (and therefore highly subjective) or invasive. Bio-optical model ing is a promising alternative. This study applies a variety of mathematical treatments to determine the relationship between coral spectra and pigment concentrations. A bio-optical model is being developed, whereby coral spectra predict pigments to represent coral health.

Developing a Non-Invasive Technique to Quantify Coral Health

OBJECTIVE(S)/RESEARCH QUESTION(S)

In the face of global climate change, there has been a great deal of research into coral organisms/population response to stress, including bleaching, disease, turbidity, pollution, and acidification. Despite the importance of understanding coral status (health and/or stress), there are surprisingly no generally accepted quantitative measures of coral health. All methods to determine coral status use coral pigmentation as an indicator. Ascertaining pigment concentrations is possible through a variety of approaches. Current methods to determine coral status rely on either subjective visual assessment or highly invasive assays. There is need for a more appropriate method to quantify coral pigments to interpret status. Coral photosynthetic pigment concentrations vary in response to stress, thus optical measurements offer a means for rapid, non-invasive determination of coral status. The terrestrial plant pigment literature is replete with optical indices designed to assess plant status. These, as well as novel indices, are investigated to determine the relationship between coral photosynthetic pigment concentrations and spectral reflectance signatures. The development of a model to predict coral pigment concentration will allow for the relative status of a coral to be quantified, without the use of invasive or subjective methodology.

APPROACH

The first stage of research will utilize known coral photosynthetic pigment concentrations derived by high performance liquid chromatography and corresponding optical spectra to determine the mathematical relationship between them. By analyzing spectral data using mathematical applications employed by terrestrial pigment researchers, a bio-optical model or spectral index will be developed to describe coral status in terms of photosynthetic pigment concentrations. Several pigment ratios and spectral indices used to remotely sense terrestrial photosynthetic pigments will be examined, including but not limited to partial least squares, stepwise and multiple linear regression, photochemical reflectance index, normalized difference vegetation index, and ratio vegetation index. The outcome of each mathematical treatment will be compared statistically to determine which accurately predicts pigment concentrations, and therefore, coral status. This bio-optical model will provide a non-invasive, quantitative method for assessing coral health necessary for consistent sampling and applicable to a wide range of reef areas.

EXPECTED RESULTS

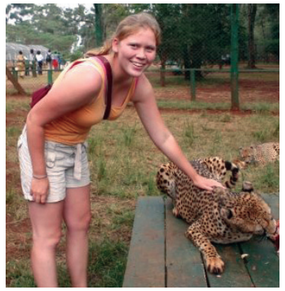
The use of high performance liquid chromatography to determine coral pigment concentrations and corresponding optical spectra provide a paired data set to determine the relationship between them. With knowledge of the statistical relationship between pigments and spectra, as well as the best predictive spectral index for modeling of pigments, this project will provide both a method to quantify photosynthetic pigments and an alternative to invasive sampling techniques. A novel, more appropriate index for corals will also be developed based on pigment ratios and spectral indices from the terrestrial literature, as well as coral spectral features of interest. These findings will be important in providing the scientific basis for future remote sensing of reef health.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The focus of this project is to improve knowledge necessary to protect and restore the services coral reef ecosystems provide, by developing a method and subsequent optical model to repeatedly, non-invasively monitor corals. With an optical model, maps indicating status of entire tracts of reefs can be constructed (e.g., chlorophyll or NDVI maps). It is the Environmental Protection Agency's mission to develop the underlying science to quantify ecosystem services and investigate the science involved in the protection and restoration of ecosystems. By quantifying the status of economically and aesthetically valuable coral reef ecosystems, this mission will be accomplished.

Keywords: *bio-optical modeling, high performance liquid chromatography, coral health, spectral index, aquatic ecosystem health*

Christa Ann Kelleher



EPA Grant Number: FP917099
Institution: University of Pennsylvania (PA)
EPA Project Officer: Brandon Jones
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $111,000.00
RFA: TAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Christa Kelleher obtained her undergraduate degree in May 2008 from Lafayette College in Civil and Environmental Engineering. She began her graduate work after acceptance to a Master's program in Civil Engineering with a Water Re sources Concentration at the Pennsylvania State University, and finished in December 2009. Research for her Master's degree focused on the characterization of stream tempera tures across Pennsylvania. She is currently pursuing a Ph.D. within the same department. Her research interests center on the interactions between climate, ecosystems, and hy drology. Her current research focuses on understanding the effects that climate change will have on ecosystem services in headwaters.

SYNOPSIS:

The purpose of my project is to understand how ecosystem services within headwater streams will be affected by cli mate and land use change across the United States. Head waters represent the small and largely ungauged streams within the river network, but account for a large fraction of the total stream length across the country. I plan to exam ine headwaters in very different parts of the United States to see how changes to ecosystem services will vary with climate and geography.

E Aquatic Systems Ecology

Evaluating the Evolution of Habitat for Fish Species in Headwaters Across the United States

OBJECTIVE(S)/RESEARCH QUESTION(S)

Headwater streams are the smallest streams within the river network. They account for a large cumulative amount of stream length across the United States, but are often not gauged, meaning that little is known about their current characteristics. Headwater streams, which represent critical habitat for a wide range of species, are assumed to be highly sensitive to both climate and land use change. The purpose of this pro-posal is to understand both historical and future changes to headwater streams, and to predict how this will affect aquatic ecosystems within this habitat.

APPROACH

I plan to begin my analysis by examining data from eight experimental headwater catchments with long-term records of climate and hydrology measurements that are located throughout the United States. An empiri-cal approach will help to determine how headwater streams in different parts of the United States have already responded to climate and land use change. The second part of the analysis will model these changes using a coupled hydrologic-water temperature model. The model will be used to determine how ecosystem services have historically been affect-ed by change and to project changes for climate and land use scenarios into the future. I plan to regionalize the model output to different head-water streams based on a conceptual approach that captures the controls for change. Based on the regionalization and a database of fish species requirements, I plan to map out how habitat, in terms of streamflow and water temperature, will change under climate and land use scenarios for a range of fish species across the United States.

EXPECTED RESULTS

The proposed research will provide a predictive model of how ecosystem services within headwater streams will be affected by both climate and land use change. I hypothesize that headwaters will see greater impacts to streamflow and ecology than any other part of the stream network. Because the research will investigate headwaters in a range of different settings, we also will show how impacts to ecosystem services will vary across the United States. The results of this project may identify controls that mediate the impacts of environmental change within headwaters, which can be used by planners and policy makers to protect these areas of unique habitat.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

There is currently a lack of understanding as to how headwater streams and the ecosystems they support will respond to climate and land use change across the United States. This project will make recommenda-tions as to how these areas will be impacted that will help to encourage protection of these areas. In addition, the project hopes to identify con-trols that mediate the effects of change, which can be used to determine strategies to soften the impact of change within these watersheds.

Keywords: *hydrology, climate change, ecosystem services, aquatic ecosystems*

Kimberly A. Lellis-Dibble

EPA Grant Number: FP917100
Institution: University of Rhode Island (RI)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Kim Lellis-Dibble received her undergraduate degree in En vironmental Studies from Gettysburg College in 2002. She continued her education at the University of Rhode Island (URI) and earned a M.A. in Marine Affairs, after which she worked for NOAA on federal ocean policy issues for 3 years. Kim returned to URI as a Ph.D. student in the National Science Foundation (NSF) IGERT program, which enhanced her leadership and multidisciplinary problem-solving skills. Her research focuses on the environmental impact of non-native plant invaders. She is currently quantifying the effect of the *Phragmites australis* invasion on salt marsh food webs and fauna.

SYNOPSIS:

This research quantifies the effect of a non-native plant invader on wetland ecosystems by examining alterations in food web dynamics and the condition, growth rate, and overall health of fauna residing in invaded habitats. Data will be generated using a variety of field and laboratory-based methods. The knowledge gained from this research can be applied beyond wetlands to more fully understand how invasive species affect native habitats and their associ ated plant and animal communities.

E Aquatic Systems Ecology

Quantifying the Effects of Plant Invasions on Aquatic Food Webs, Fish Condition, and Aquatic Ecosystem Function in the Northeast

OBJECTIVE(S)/RESEARCH QUESTION(S)

Invasive species are persistent biological pollutants that outcompete native species, alter community composition, and disrupt the flow of energy and materials through terrestrial and aquatic ecosystems. Numerous studies have documented a decline in habitat value for birds, mammals, and nekton (fish and swimming crustaceans) as invasive plants expand through ecosystems. However, few studies have focused on the effects of invasive plants on food webs and animal condition in the invaded ranges. The expansion of an invasive generalist plant (*Phragmites australis australis*) into disturbed wetland habitats, and the subsequent attempts to eradicate this weedy invader, provide an excellent model that I will use to quantify the impact of a nuisance species on overall ecosystem function.

APPROACH

Specifically, my research will: 1) determine whether resources released by *Phragmites* are being incorporated into aquatic food webs; 2) quantify fish energy reserves, growth rate, and overall body condition in invaded, restoring, and reference marshes; and 3) investigate links between the dominant energy source and fish condition in invaded and restoring systems relative to reference marshes. I will analyze food web structure and dominant energy source via carbon, nitrogen, and sulfur stable isotopes in macrophyte, macroalgae, benthic microalgae, suspended particulate, and *Fundulus heteroclitus* (mummichog) samples. Lipids will be extracted from *Fundulus* to determine total energy reserves and will be compared with a morphometric index (Fulton's K) to determine overall fish health. Sagittal otoliths will be removed from *Fundulus* to reveal recent growth rate and age structure of fish populations in each marsh system.

EXPECTED RESULTS

This study will be the first study to directly compare and quantify fish condition in invaded and restoring marshes as compared to reference habitat. Results will extend beyond salt marsh systems to provide significant insights on how invasive plants affect habitats and their associated food webs, and whether restoration activities are in fact accomplishing their ecological goals. Since the invasion front of *Phragmites* continues to advance in the United States to the south and west, managers can use this information to make plant management decisions and prioritize habitat restoration projects before introduced *Phragmites* takes over other biologically diverse wetland ecosystems.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research directly supports the Environmental Protection Agency's mission to protect human health and the environment. Invasive species are arguably among the most persistent and widespread biological pollutants the Earth faces today. They pose a significant threat to ecosystems, biological security, and human well-being. They foul navigable waters and have significant economic costs. This research will provide critical information to better understand the full consequences of biological invasions, will help managers to prioritize restoration and control efforts, and will assist with the development of appropriate tools to control the spread of invasive species in order to better serve society.

Keywords: *invasive species, fish, plant, Phragmites australis, Fundulus heteroclitus, wetland, energy reserves, growth rate, stable isotopes, otolith, lipid, food web*

Mariah Pine Mayfield

EPA Grant Number: FP917101
Institution: Montana State University, Bozeman (MT)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2012
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Mariah Mayfield received her undergraduate degree in Biol ogy from Willamette University, Salem, Oregon, in 2007. After spending several years working on trout and salmon restoration projects across the country, she eventually settled at Montana State University and began work on her graduate degree in the field of Fish and Wildlife Manage ment. Mariah's research focuses on the potential for trout restoration in a river system severely impacted by human use, most notably the effects from mining.

SYNOPSIS:

Mining waste deposition in the Upper Clark Fork River, Montana, decimated fish populations in the early 1900s. Due to remediation, fish have returned, although in num bers less than expected. Radio tagged trout will be moni tored to identify critical habitat areas, such as spawning and refuge habitats. Movement patterns will also be ana lyzed to assess how fish are reacting to the environmental factors unique to the Upper Clark Fork River Basin (heavy metal pulses and poor water quality).

E Aquatic Systems Ecology

Fisheries Restoration Potential of the Clark Fork Superfund Site: Habitat Use, Movement, and Health of Trout in Relation to Environmental Factors

OBJECTIVE(S)/RESEARCH QUESTION(S)

Fish populations in the Upper Clark Fork River Superfund Site were decimated over large portions of the river in the 1900s due to the deposition of hazardous mining waste. Improvements in wastewater treatment and mine waste remediation have resulted in a rebound of trout populations, although in numbers well below expected carrying capacity. The objective of this study is to identify critical habitat areas, such as spawning sites, refuge areas, and over-wintering habitat, in order to set priorities for trout restoration. Movement patterns will also be analyzed to assess how fish are reacting to the environmental factors unique to the Upper Clark Fork River Basin (combination of heavy metal pulses during storm events and warm summer temperatures).

APPROACH

Two hundred trout have been surgically implanted with radio transmitters throughout the Upper Clark Fork River, from Warm Springs to the confluence with the Blackfoot River, a distance of 120 river miles. Transmitters were spatially distributed evenly throughout the study area and species were selected based on relative abundance found in the river. The primary species tagged was brown trout *Salmo trutta*, although westslope cutthroat trout *Oncorhynchus clarki lewisi*, rainbow trout *O. mykiss*, suspected cutthroat/rainbow trout hybrids, and bull trout *Salvelinus confluentus* were also tagged in reaches where they were present. Radio tagged fish are re-located at least once a week during spring, summer, and fall (more during periods of spawning) and at least twice per month during the winter. Water quality data, such as temperature, dissolved oxygen, conductivity, and turbidity, are also collected throughout the study area in order to determine what environmental factors are contributing to fish movement and habitat use.

EXPECTED RESULTS

Habitat use by radio tagged trout will be analyzed, and critical habitat areas will be determined as restoration priorities. Using the movement and water quality data, the effects of poor water quality on trout behavior will give us a better idea of how mining waste deposition affects trout movement and overall health. Based on previous laboratory studies, it is expected that trout avoidance of increased heavy metal contamination will be observed throughout the study period.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This study offers the opportunity to help guide remediation efforts in the Upper Clark Fork River, in order to restore trout populations to expected carrying capacity levels. Results from this study may also be able to help restoration plans in other mine impacted basins. In addition to increasing trout populations, this project will help bring economic development to rural Montana communities, in the form of tourism and fishing industries.

Keywords: *trout movement, radio telemetry, heavy metals, water quality, habitat use, mine waste*

John Anthony Mischler

EPA Grant Number: FP917102
Institution: University of Colorado, Boulder (CO)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

John Mischler received his undergraduate degree in both Geology and Physics at Augustana College in Rock Island, IL. After working as an environmental consultant for Delta Environmental Consulting and a TA for the Nyanza project, he received his M.S. in Geosciences at The Pennsylvania State University. John is currently a Ph.D. candidate at the University of Colorado, studying the interactions between environmental factors (nutrients, etc.) and human disease (schistosomiasis, cercarial dermatitis, etc.).

SYNOPSIS:

My research project seeks to determine the effects of water quality on emerging and emergent infectious diseases. In particular, I will be studying the effects of pesticides (such as atrazine) and eutrophication (caused by nitrogen and phosphorus loading via fertilizers, sewage, etc.) on fresh water ecosystems. I will concentrate on disease caused by trematode parasites, which have a complicated life cycle. Trematode parasites require an aquatic snail as first inter mediate host.

E Aquatic Systems Ecology

Effects of Nutrient and Pesticide Loading on Aquatic Ecosystems as Pertaining to the Emergence and Transmission of Human Disease: The Case of "Swimmers' Itch"

OBJECTIVE(S)/RESEARCH QUESTION(S)

I propose a novel and integrative approach to understanding and mitigating one major aspect of disease risk: the poorly understood, but potentially important, links between nutrient-driven eutrophication and pesticide loading, and an increased risk of several vector-borne diseases. Do increases in (1) nutrients and (2) endocrine disrupting pesticides (such as atrazine) supplied to aquatic ecosystems lead to an increase in the risk of humans contracting cercarial dermatitis?

APPROACH

I will use a combined field (pond study) and experimental (mesocosm study) approach to explore both the severity and underlying mechanisms of this issue.

EXPECTED RESULTS

It is expected that nutrient additions (nitrogen and phosphorus in the form of fertilizers, sewage effluent, etc.) boost both food quantity and food quality for aquatic snails (the intermediate hosts for cercarial dermatitis). As a result, these grazers will be more competent hosts and produce more parasite cercariae over a longer period of time than snails in non-eutrophic conditions. Endocrine disrupting pesticides are expected to inhibit the immune response of snails to parasite penetration, thus making infection more widespread in the snail population. Both increased nutrients and pesticide application should work synergistically to increase infection in the snail population, thus increasing the risk of infection for the human population.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Enhanced understanding of these interactions will enable more accurate forecasting and management in areas where cercarial dermatitis is emerging.

Keywords: *nutrients, pesticide, disease, nitrogen, phosphorus*

Brooke Elizabeth Penaluna

EPA Grant Number: FP917104
Institution: Oregon State University (OR)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
E-mail:

BIO:

Brooke Penaluna received her undergraduate degree in En vironmental Studies from University of St. Thomas in 2000. The following year, she worked for the Oregon Department of Fish and Wildlife before she began her Master's degree in Environmental Science at Western Washington University. In 2004, she was a Fulbright Fellow to Chile studying the effects of invasive trout and salmon on native fishes. After two more years working with researchers in Chile, she be gan her Ph.D. degree in Fisheries Science at Oregon State University. Her research focuses on examining the effects of contemporary forest harvest on coastal cutthroat trout using a combination of approaches including manipulative experi ments and a simulated model.

SYNOPSIS:

My goal is to understand the potential impacts of contem porary forest practices on water quality, water quantity, and in-stream habitat; and how these conditions influence coastal cutthroat trout individuals and emerge as population dynamics. I will use manipulative experiments, an individu al-based simulation model, and field observations. Accord ingly, my work will have real on-the-ground implications by influencing major natural resource sectors in the Pacific Northwest: forests and fish.

E Aquatic Systems Ecology

Coastal Cutthroat Trout Responses to Forest Harvest: Examining Roles of Physical and Biotic Processes Using an Individual-Based Model and Manipulative Experiments

OBJECTIVE(S)/RESEARCH QUESTION(S)

My overall research goal is to understand the potential impacts of contemporary forest practices on water quality, water quantity, and in-stream habitat; and how these conditions influence coastal cutthroat trout individuals and emerge as population dynamics. My first research objective is to examine relationships of coastal cutthroat trout to physical and biotic processes in streams under a wide range of conditions using a detailed individual-based simulation model parameterized for coastal cutthroat trout and data from intensively monitored streams in the Trask Watershed Study, a major study of forest practices involving private, state, and federal lands. My second research objective is to evaluate individual- and population-level responses in coastal cutthroat trout to varying levels of a specific physical factor: in-stream cover using manipulative experiments.

APPROACH

I propose to employ a combination of modeling, experiments, and observations to understand the impacts of contemporary forest practices on coastal cutthroat trout in the context of a new generation of watershed studies currently underway in western Oregon (www.watershedsresearch.org). To achieve Objective 1, I will simulate different forest harvest practices using an individual based model (inSTREAM version 4.2, http://www.humboldt.edu/~ecomodel/instream.htm) which is computer based and so allows for multifaceted combinations of treatments in a prospective perspective that cannot be achieved using any other approach. Since the model performs projections of events in the future based on past data, I will also be considering climate changes since they simultaneously will be occurring. To run the model, I will input existing data from the Trask study watershed located in the northern Oregon Coast Range, which is part of a larger watershed-intensive case study that incorporates pre-harvest and post-harvest observations. To complete my second objective, I am currently conducting large-scale experiments in a semi-natural outdoor setting at the Oregon Hatchery Research Center (OHRC; http://www.dfw.state.or.us/OHRC/) in Alsea, OR. I am examining varying levels of physical habitat structure in the form of in-stream cover on short-term trout responses because it has been suggested that in-stream cover may play a more critical role in the response of fish to forest harvest than previously recognized.

EXPECTED RESULTS

IBMs coupled together with manipulative experiments prevent confounding factors and in conjunction with field observations may be able to most correctly respond to questions relating to forest harvest on fish. Through this combination of approaches I will be able to address specific hypotheses and predictions about forest harvest impacts on fish by determining specific physical and biotic factors that control fish in streams.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

My work will have real on-the-ground implications by influencing forests and fish in the Pacific Northwest through providing a better understanding of the effectiveness of contemporary forest harvest practices and individual and population responses of fish. I also hope to determine the importance of in-stream cover to coastal cutthroat trout, and thereby help managers with habitat management decisions and the implementation of more effective restoration projects, aimed at maintaining coastal cutthroat trout populations. This is especially important as fisheries managers have implemented restoration projects placing large wood and boulders in streams to increase habitat complexity and additional cover for fish.

Keywords: *population level, individual level, demographic responses, density*

Kathryn Richards-Hrdlicka

EPA Grant Number: FP917107
Institution: Yale University (CT)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Kathryn Richards-Hrdlicka received her Bachelor of Science, magna cum laude, in Biology from Arizona State University in 2004. As an undergraduate, she completed two independent research projects: one in which she investigated local declines of a native leopard frog (*Rana yavapaiensis*) and another where she comprehensively evaluated two marking techniques for metamorphosed tiger salamanders (*Ambystoma tigrinum*): passive integrative transmitters and fluorescent elastomer injectable dye. Post graduation she worked as a research assistant for Dr. James P. Collins, Arizona State University. She left Arizona in 2006, having co-authored three peer-reviewed papers, and began her Ph.D. program in the School of Forestry and Environmental Studies at Yale University. Her dissertation research focuses on understanding the global origin of a devastating infectious disease to amphibians and how it has changed over time in New England. Over the years, Kathryn has enjoyed being a Teaching Fellow for introductory biology courses, men toring undergraduates, and fostering relationships with private citizens through public outreach. In her spare time, Kathryn enjoys camping, hiking, mountain biking, and visiting her home state, New Hampshire, with both her husband and her dog.

SYNOPSIS:

A new fungal pathogen, *Batrachochytrium dendrobatidis* (Bd), is partly responsible for the global decline of amphibian populations. I analyze the genetic variation of Bd on a global scale to address its geographic origins. I also apply similar techniques to describe how Bd has evolved in New England (NE), by comparing the genetic variation of contemporary to museum preserved Bd DNA from within amphibian tissues. Results from my research will identify where Bd came from and how it evolves.

The Evolutionary History of Batrachochytrium dendrobatidis

OBJECTIVE(S)/RESEARCH QUESTION(S)

Chytridiomycosis, an epidermal infection caused by the emerging infectious fungal pathogen *Batrachochytrium dendrobatidis* (Bd), is a major driver implicated in the worldwide decline of amphibian populations. I use next generation sequencing technology to identify new genetic markers in Bd and apply them in a series of population genetic analyses, some of which intend to uncover Bd's global origin(s). I also apply similar techniques to describe how Bd has evolved through time in a focused region of the world, New England, by comparing genetic variation from contemporary and museum-preserved Bd DNA from within host (amphibian) tissues.

APPROACH

My dissertation research will be addressed in three Aims. For Aim #1 I will develop new molecular markers by sequencing 21 new Bd isolates on the next generation sequencing platform, Illumina. The genomes will be aligned and mined for new molecular markers (single nucleotide polymorphisms [SNPs] and microsatellites). The end result of Aim #1 will be a table listing all markers and which hierarchical level of variation they address: worldwide, among regions, or within populations. In Aim #2 I will assess the genetic variation among isolates of Bd and identify its geographic origin. In addition, I intend to estimate the following population parameters: levels of variation in each population, demographic inferences (i.e., whether the genetic diversity indicates a stable, shrinking, or growing population), patterns and levels of genetic differentiation between samples, and the level of genetic intermixing between samples from different locations. The sampling and analytical procedures described in Aim #2 will allow me to understand patterns and levels of gene flow at different time scales, from events that occurred many generations ago to genetic exchange that occurred only one or a few generations ago. For Aim #3 I will describe Bd's genotypic differences between contemporary and decades-old infections. Across New England, I will compare the genetic variation between contemporary sites and animals from similar locations yet preserved in museum collections. We know little about Bd prevalence in New England; reportedly, it is endemic. But most importantly, New England has been suggested as the origin of its worldwide spread. These analyses in Aim #3 may determine if the variation in genes implicated with virulence or evolution of virulence deviate from neutral expectation for the same population samples. Addressing genotypic differences between epidemic and endemic sites will help Bd researchers and conservation managers understand the genetic basis for observed phenotypes, namely virulence.

EXPECTED RESULTS

There are two major scientific contributions within this research proposal. The most obvious is to finally understand from where Bd originated and how it subsequently spread throughout the world. If conservation measures are to protect amphibians from future declines, it is important to understand how Bd moves between and within amphibian communities. The second major achievement this research aims to accomplish is applying cutting-edge next generation sequencing techniques to a large set of individuals, or pathogenic isolates in this case. While next generation sequencing is becoming more popular and the sought after technology, rare is it that multiple, entire genomes of a non-model organism are being sequenced. Plus, the results are directly applicable to two of today's most pressing environmental issues, as determined by the National Research Council: biodiversity conservation and infectious diseases within the environment.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Amphibian populations are declining worldwide, taking ecosystems they help to regulate with them. In light of their decline, we are beginning to understand the crucial role amphibians play in regulating primary productivity, organic matter processes, insect and riparian predator abundances and diversity, and energy transport between aquatic, riparian, and terrestrial ecosystems. We understand that to preserve aquatic, riparian, and terrestrial ecosystems, amphibian populations must be protected. One measure that can help equip our conservation efforts is to understand the population genetics of Bd, a major driver in the amphibian decline crisis. Implementing population genetics in conservation programs is a well-founded practice. Population genetics can uncover how the invading pathogen adapts and evolves in newly introduced regions and the resulting geographic patterns of how the pathogen colonizes and spreads between regions. Uncovering any evolutionary response by the pathogen holds great promise in preventing the decay of aquatic ecosystems by stabilizing amphibian populations.

Keywords: *Batrachochytrium dendrobatidis, amphibian, emerging infectious disease, pathogen, fungus, chytrid, extinction, next generation sequencing, population genetics, invasive species, quantitative PCR, ancient DNA, SNPs, microsatellites*

Daniel J. Stanaway

EPA Grant Number: FP917110
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EPA Project Officer: Brandon Jones
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Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Daniel Stanaway received his undergraduate degree in En vironmental Studies and Applications from Michigan State University in 2004. After completing a year of service ad dressing issues related to chronic poverty in the Americorps VISTA program, he worked as a Watershed Coordinator in southwest Michigan managing a Clean Water Act watershed project. From here, he began the M.S. program in Hydro logical Sciences at Boise State University. Approaching this degree through the Department of Biology, he is investigat ing lotic ecosystem response to heavy metal contamination.

SYNOPSIS:

Mining activity has contaminated numerous waterways with heavy metals. Vibrant microbial communities have evolved to thrive in these toxic environments. However, the presence of the pollutants appears to continually inhibit ecosystem services. We are employing a novel metabolically reactive hydrologic tracer that directly links ecosystem processes to flow hydraulics to interrogate how chronic contamination af fects ecosystem function through quantifying *in situ* micro bial community metabolism.

E Aquatic Systems Ecology

Quantification of River Metabolism Along a Heavy Metal Contamination Gradient Through the Development and Application of a Smart Tracer System

OBJECTIVE(S)/RESEARCH QUESTION(S)

Contrary to current models of ecosystem response to chronic metal induced stress, microbial communities of the Clark Fork River in western Montana, the largest Superfund site in the United States, have high species diversity with repressed functional characteristics. Our study attempts to quantify the magnitude of metal contamination-induced limits on *in situ* heterotrophic microbial activity in metal tolerant communities via the application of a novel metabolically reactive hydrologic tracer.

APPROACH

We hypothesize that chronic metal contamination produces a measureable metabolic cost to tolerant communities. To test this hypothesis, hyporheic sediments, supporting intact microbial communities, will be collected from sites along the Clark Fork River contamination gradient and pristine reference sites. Rates of microbial heterotrophic metabolism will be assessed in the presence and absence of an acute metal exposure to determine the metabolic cost of communities evolved for metal tolerance. Further, this approach allows us to assess metabolic costs in absolute and relative terms within and among communities evolved under different selective pressures (e.g, levels of metal contamination). We hypothesize that both community types will be negatively affected by the acute exposure, thereby indicating that even in tolerant communities, exposure to persistent pollutants exacts an energetic toll on community metabolism. To interrogate these communities, flow-through columns replicating hyporheic conditions will be packed with contaminated or clean sediment from six site pairs (contaminated vs. pristine). From each field site, three replicate columns will be treated with cadmium (Cd) (metal stressor), resazurin (metabolically reactive hydrologic tracer), and chloride (conservative hydrologic tracer); another set of three control columns will be treated with chloride and resazurin only. Of the metal cocktail that exists in the Clark Fork River, cadmium was selected as the experimental treatment because of its high toxicity and inability to abiotically reduce resazurin. Dissolved oxygen (DO) measurements will also be taken at the upstream and downstream end of the columns through non-intrusive fluorescence quenching to support the findings of the smart tracer. The Raz-Rru reactive advection dispersion equation (ADE), a modified version of the standard ADE equation, is used to determine the reaction rate of the biological reduction of resazurin to resorufin within a given hydrological setting. A Markov chain Monte Carlo approach will be developed to optimize line fitting to data for populating the ADE. The outcome of this approach will be a direct measure of the influence of metal stress on heterotrophic metabolism by microbial communities inhabiting the hyporheic zone of the chronically contaminated Clark Fork River.

EXPECTED RESULTS

The reduction rate of resazurin to resorufin provides direct quantification of the rate of microbial community respiration in the context of the overarching hydrological parameters such as velocity, dispersivity, and retardation. In aerobic heterotrophic microbial communities, the overall metabolic rate is a functional variable indicative of ecosystem health. In the absence of acute metal exposure, it is expected that the metabolic rate of communities from contaminated sites will be reduced relative to the corresponding pristine site, with the greatest inhibition observed in communities from the most heavily contaminated sites. Additionally, it is expected that in the presence of an acute metal exposure, resazurin reduction rate will be reduced in all communities relative to rates observed in the absence of an acute metal stress. The magnitude of inhibition of the metabolic rate reflects the continued metabolic cost of exposure to persistent metal pollutants even after long periods of selection for tolerant organisms. More specifically, communities from pristine and low contamination sites are expected to be more dramatically affected by the acute Cd exposure than communities associated with sediments from sites with higher *in situ* contamination levels. Secondarily, our study strives to further develop the Raz Rru Smart Tracer system as a viable tool for directly linking ecosystem processes with hydraulic parameters. It is expected that a strong correlation will exist between the reduction of resazurin to resorufin and dissolved oxygen consumption, thus corroborating the use of this system as a eco-hydrological tool.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The findings of this study will be important in supporting a new perspective of ecosystem response to chronic stress. Quantification of in-stream microbial function has a breadth of potential ecological and environmental regulatory applications. Development of an index relating changes in microbial respiration to metabolic function will allow for the determination of the consequences of anthropogenic contamination in terms of ecosystem services, such as hyporheic biogeochemical cycling, productivity, and nutrient retention. This relationship is of global importance in the context of carbon cycling, nutrient availability, and ecosystem integrity in systems impacted by the presence of persistent pollutants or other chronic stressors such as global climate change. This index, with appropriate tools, has the potential to advance the science governing environmental regulation and monitoring. Hyporheic biofilms can be more sensitive indicators of environmental stress than the ichthyological and macro-invertebrate based protocols currently employed because they form the base of aquatic food webs and have a high degree of exposure. Changes in hyporheic microbial assemblages have been detected at concentrations nearly an order of magnitude less than that at which responses in benthic macro-invertebrates can be measured. Therefore, a mechanism such as the Raz Rru Smart Tracer system that directly interrogates the *in situ* metabolic status of the microbial community has potential to improve water quality monitoring techniques and implementation of higher resolution environmental regulations based on impacts to quantifiable ecosystem services.

Keywords: *microbial ecology, chronic ecosystem stress, mining, Clark Fork River, Raz Rru Smart Tracer, metal contamination, ecosystem services, environmental regulation and monitoring, hyporheic zone, heterotrophic ecosystem metabolism*

Brittany Elizabeth West

EPA Grant Number: FP917113
Institution: University of Maryland, College Park (MD)
EPA Project Officer: Brandon Jones
Project Period: 8/30/2010 – 8/29/2012
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Aquatic Systems Ecology
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BIO:

Brittany West graduated from the University of Richmond with a B.S. in Biology in 2008. During the following year she worked as an environmental educator for the Chesa peake Bay Foundation and the U.S. Fish and Wildlife Service. In the fall of 2009, excited by all things aquatic, she decided to pursue graduate school at the University of Maryland in the Marine, Estuarine, and Environmental Studies program. To inform SAV restoration efforts, she is currently researching the link between genetic identity and phenotypic growth responses in submersed aquatic vegeta tion in the Chesapeake Bay.

SYNOPSIS:

Efforts to restore submersed aquatic vegetation (SAV) have been marginally successful, and threats of climate change present more challenges. This research analyzes the re lationships between genetic diversity and plant growth responses of Vallisneria americana (wild celery) collected along the Atlantic Coast. The results will provide insight into conservation/restoration efforts regarding the potential of individuals from different regions to tolerate or adapt to novel environmental conditions.

E Aquatic Systems Ecology

Using Genetic Diversity of Vallisneria americana Across a Latitudinal Gradient To Inform Submersed Aquatic Vegetation Restoration Strategies

OBJECTIVE(S)/RESEARCH QUESTION(S)

Submersed aquatic vegetation (SAV) is an important component of aquatic ecosystems that has experienced large-scale losses over relatively short time periods. In addition to the intensifying threats SAV encounters as human population size increases, the effects of global climate change are not well understood, but anticipated to dramatically alter SAV abundance and distribution. To contribute to the understanding of these potential effects I will describe the structure of genetic diversity in the SAV species *Vallisneria americana* (wild celery) at local, regional, and macrogeographic scales across a broad latitudinal gradient along the western Atlantic coast. I also will investigate the phenotypic responses of different genotypes from across that gradient to environmental stressors. The research results will provide information on how current stressors have affected diversity within and connectivity among *V. americana* occurrences and will provide insight into potential for adaptation to future conditions anticipated under climate change.

APPROACH

I will use developed microsatellite markers to compare the population genetic diversity and structure of *V. americana* among sites within regions and among regions spanning the latitudinal gradient along the western edge of the Atlantic Ocean. Samples of *V. americana* will be collected along the latitudinal gradient from Florida to Maine for this analysis. Collected samples will then be propagated at the University of Maryland under common conditions, and additional environmental stress experiments will be performed in controlled growth chamber or greenhouse environments. Two sets of growth experiments will specifically focus on the effects of temperature and light availability, environmental factors that are expected to vary over a latitudinal gradient and under altered climate conditions, on the growth and survival of *V. americana* collected from these different regions. The data from this research will quantify the genetic diversity in *V. americana* along the Atlantic coast of the United States, identify areas of high genetic diversity or areas with large discrepancies in regional allele composition along a latitudinal gradient, as well as quantify the vegetative growth differences among individuals within sites, among sites within regions, and among regions across the latitudinal gradient that arise from environmental stresses.

EXPECTED RESULTS

This research aims to describe the structure of *V. americana* genetic diversity at local, regional, and macrogeographic scales across a latitudinal gradient and to link genetic variation with phenotypic variation to understand potential for persistence in the presence of environmental stressors. The local and regional genetic structuring in *V. americana* may vary across a latitudinal gradient, and different genotypes of *V. americana* may exhibit varying phenotypic responses to environmental stressors. It is important to understand these dynamics because a species' capacity to adapt to a changing environment (i.e., its evolutionary potential) is determined by the amount of genetic variance on which natural selection can act. A thorough understanding of how SAV genetic diversity is structured at multiple spatial scales across the latitudinal gradient, and how the breadth of environmental tolerance varies among individuals, sites, and regions will provide insight into the degree of phenotypic variation available and the potential for adaptation under anticipated future conditions. These data will provide a scientifically sound basis for choosing among management options aimed at slowing and reversing declines in submersed aquatic vegetation.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The results of this research will enhance the protection and restoration of valuable SAV habitat by applying molecular genetic techniques to augment current conservation and restoration practices and to shape future restoration initiatives. Characterizing the genetic structuring of *V. americana* across a latitudinal gradient will allow managers to identify populations that show signs of isolation or inbreeding, and to prioritize preservation of areas with high genetic diversity or unique allelic composition. The data linking genetic variation with phenotypic response also will inform current restoration efforts by enhancing the selection of suitable restoration stock. Moreover, this project can inform future restoration initiatives by providing information necessary to anticipate future conditions in *V. americana* beds along the Atlantic coast. With the continued threats of climate change, new restoration strategies like managed relocation (MR) are rapidly being developed to address biodiversity management and restoration when both persistence and recolonization are not possible. Data from this research could evaluate the necessity of drastic actions like MR by assessing the tolerance of *V. americana* individuals across a broad latitudinal gradient to current and projected future conditions.

Keywords: *Vallisneria americana, SAV restoration, genetic structure, phenotypic plasticity, latitudinal gradient, climate change, managed relocation*

Terrestrial Systems Soil and Plant Ecology

Tanya E. A. Cheeke

EPA Grant Number: FP917125
Institution: Portland State University (OR)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Terrestrial Systems Soil and Plant Ecology
E-mail:

BIO:

Tanya Cheeke received her undergraduate degree in Sus tainable Agriculture/Environmental Science from The Ever green State College in 1999. As an undergraduate she con ducted on-farm sustainable agriculture research and later worked as a soil microbiologist in a soil ecology lab. After serving as lab manager for 2 years, she began a Ph.D. pro gram at Portland State University where she is investigating the non-target effects of transgenic corn on symbiotic fungi in the soil ecosystem. Her research interests include soil ecology, agroecology, and biotech risk assessment.

SYNOPSIS:

Currently, 80% of the corn grown in the US is genetically modified yet the ecological effects of this technology on soil organisms have not been thoroughly evaluated. Healthy plant microbe interactions can stimulate plant growth and help protect plants from drought and disease. This research examines whether symbiotic plant fungal relationships are reduced in transgenic Bt *(Bacillus thuringiensis)* corn and as sesses the effects of Bt crops on the abundance and diversity of arbuscular mycorrhizal fungi in the soil ecosystem.

Evaluating the Effects of Genetically Modified Plants on Symbiotic Fungi in the Soil Ecosystem

OBJECTIVE(S)/RESEARCH QUESTION(S)

Genetically modified corn has been grown commercially since 1996 and now constitutes 80% of all corn grown in the United States, yet the ecological effects of this technology in the soil ecosystem have not been thoroughly evaluated. My dissertation research aims to develop an understanding of the mechanisms that both enable and limit arbuscular mycorrhizal fungal (AMF) colonization in transgenic plants with the overall goal of determining whether Bt crop cultivation has an inhibitory effect on AMF abundance and diversity in the soil ecosystem. Some of my primary objectives are to: 1) identify key mechanisms for AMF establishment in the Bt model system by examining fundamental differences in root permeability, root exudates, and Bt toxin accumulation in the root zone among multiple Bt and non-Bt maize isolines and 2) to determine the impact of Bt maize on the abundance and diversity of AMF in the roots and rhizosphere under field conditions.

APPROACH

Microscopic, morphological, and molecular sequencing methods will be used to investigate the effects of transgenic Bt plants on the colonization ability, abundance, and diversity of symbiotic arbuscular mycorrhizal fungi using laboratory, greenhouse, and field studies. Greenhouse and laboratory experiments will be used to investigate possible correlations between the level of AMF colonization in each root system to potential differences in root permeability, root exudate profiles, and/or Bt toxin accumulation in the rhizosphere. Field trials will be performed using Bt isolines engineered to express single or stacked combinations of Cry1Ab, Cry34/35Ab1, Cry3Bb1, and Cry1F Bt proteins (along with the non-transgenic parental controls) to determine the effects of transgenic Bt maize cultivation on symbiotic fungi in the soil ecosystem over multiple growing seasons.

EXPECTED RESULTS

Results from these experiments will provide a comprehensive assessment of the impact of Bt plants on symbiotic soil fungi across a broad range of environmental and ecological conditions and will investigate possible mechanisms that may influence AMF colonization in Bt maize. The effects of AMF colonization levels on plant growth will be tested by entering AMF census data for each plant as a covariate in the repeated measures and univariate models. Depending on the extent to which Bt toxin levels and other compounds in the root exudate profiles vary independently among modified isolines, we will be able to assess statistical associations between the concentration of individual compounds and AMF colonization using multiple regression techniques. The identification of groups of compounds that are associated with lower fungal colonization will lead to the development of new hypotheses and experiments aimed at identifying causal mechanisms of reduced mycorrhizal associations in Bt-modified plants. Upon completion, this research will contribute to the development of future biotech risk assessment protocols to minimize the non-target effects of Bt crops on symbiotic fungi and will expand the area of knowledge surrounding these crops.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

My research will evaluate both the benefits and potential impacts of agricultural biotechnology on the soil environment with the goal of finding an acceptable balance between the use of genetically engineered crops and the preservation of a healthy soil ecosystem.

Keywords: *mycorrhizae, biotech, corn, maize, Bt, soil, arbuscular mycorrhizal fungi, transgenic*

Laura Camille Jones

EPA Grant Number: FP917135
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Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

A native of the Golden State, Ms. Jones, who goes by her middle name, Camille, ventured east in 2004 to Bryn Mawr College in the Philadelphia suburbs. Four years later and many dollars smarter, she received a B.A. with honors in Geology. After graduation, she worked in geochemistry at the U.S. Geological Survey in Menlo Park, CA. In 2009, Camille joined Dr. Sparks' environmental soil chemistry group at the University of Delaware. Camille is now studying microbial and mineral redox processes in soils. She plans to enroll in a Ph.D. program following the completion of her Master of Science degree.

SYNOPSIS:

Millions of people are currently exposed to arsenic, a toxic metalloid, via contaminated food and drinking water. Com plex chemical, bioloigical, and hydrological processes in soils mobilize arsenic from natural (i.e. rock) and anthro pogenic (i.e. pesticide) sources to contaminate water. This study investigates coupled biological and abiotic pathways of a chemical reaction that transforms arsenic to a less mobile and less toxic form in soils. The results of this study will be used to understand how arsenic moves around in soils and for prediction and remediation of the worldwide human health hazards caused by arsenic.

Coupling of Biotic and Abiotic Arsenite Oxidation in Soil

OBJECTIVE(S)/RESEARCH QUESTION(S)

Arsenic (As) is a redox-active metalloid whose toxicity, bioavailability, and environmental mobility depend on oxidation state. This project investigates the kinetics and mechanisms of arsenic oxidation, which is a transformation to the less toxic and less mobile form of arsenic, by natural biotic and abiotic oxidants found in soils.

APPROACH

Arsenite [As(III)], the more toxic and mobile form of inorganic As, can be oxidized to arsenate [As(V)] by both minerals and bacteria in soils. It has been noted in previous studies that, in isolation, manganese (Mn) oxide minerals can oxidize As(III) and sorb As(V). Numerous isolates of heterotrophic soil bacteria, including the bacteria used here (*Alcaligenes faecalis* and *Pseudomonas fluorescens*) have also been shown to oxidize As(III) in a detoxification mechanism. Despite having some experimental evidence for activity of these soil oxidants in isolation, not much is known about the coupling of biotic and abiotic oxidants in soils. This study investigates the rates and coupling of As(III) oxidation by model heterotrophic bacteria, *A. faecalis* and *P. fluorescens*, and a Mn oxide mineral, δ-MnO_2 using batch experiments.

EXPECTED RESULTS

This project is expected to produce rate and kinetic information about As(III) oxidation in a model system with a mixture of mineral and microbial oxidants. Comparing the apparent kinetics of As(III) oxidation in mixed microbe-mineral batch experiments with isolated batch experiments, with the bacteria or the mineral alone, will give evidence for the mechanisms and reactivity of these pathways. In soils, minerals and microbes coexist and yet little is known about the rate and mechanisms surrounding this reaction in an experimental system with both types of oxidants. These results will contribute to understanding coupled microbe-mineral processes involved in the fate and transport of As.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Recent instances of human exposure to toxic levels of arsenic in drinking water have motivated investigation into the biogeochemical processes governing As mobility in soil. The rate information produced in this study can be used to model coupled biotic and abiotic arsenic redox processes and predict potential human health and environmental hazards posed by arsenic.

Keywords: *arsenic, arsenite, microbe-mineral, soil chemistry, redox, water quality*

Kathleen Egan Lawlor

EPA Grant Number: FP917140
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EPA Project Officer: Gladys Cobbs-Green
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Project Amount: $111,000.00
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Research Category: Ecosystem Services: Terrestrial Systems Soil and Plant Ecology
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BIO:

Kathleen Lawlor is a Public Policy Ph.D. student at UNC-Chapel Hill. She has worked in conservation and develop ment for 10 years with a variety of organizations: Duke University's Nicholas Institute on forest and climate policy research; the World Bank Group, investigating communities' claims of social and environmental harm; the U.S. Forest Service on African forestry issues; and with farmers in Cam eroon as a Peace Corps Volunteer. She holds a M.E.M. from Duke and a B.A. from William & Mary.

SYNOPSIS:

Programs for reducing emissions from deforestation and degradation in developing countries (REDD) aim to keep forests intact by valuing forests for the global service of carbon storage, yet the permanence of emissions reductions may hinge on the provision of local benefits. This research seeks to quantify the impacts of REDD on rural populations' welfare and identify the conditions that lead to more even distribution of welfare gains and carbon storage across af fected populations and landscapes.

Evaluating the Impacts of Reduced Deforestation Programs on Carbon Storage and Human Welfare in Tropical Forests

OBJECTIVE(S)/RESEARCH QUESTION(S)

Tropical forests provide ecosystem services to society globally, by storing huge quantities of carbon and regulating the climate, and locally, by providing clean water, flood control, food, fuel, and medicine for adjacent populations. Emerging programs for reducing emissions from deforestation and degradation in developing countries (REDD) aim to keep forests intact by valuing forests for the globally-enjoyed service of carbon storage, yet the realization and permanence of reductions in forest emissions may hinge on the provision of local benefits. This research project seeks to both (1) quantify the impact of REDD on rural populations' welfare and (2) identify which characteristics of REDD interventions (e.g., extent of local participation) result in a more even distribution of welfare gains across affected populations (less inequality) and a more even distribution of carbon storage (less leakage) across landscapes.

APPROACH

This research will combine quantitative impact evaluation techniques with qualitative methods to identify welfare impacts attributable to the REDD project and the conditions leading to these impacts. Assessing the impact of conservation interventions on welfare requires more than simple before-after comparisons or comparisons between households living near and far from the conservation area. Rather, assessing the impact due to the intervention requires comparing the change between pre- and post-intervention conditions with a counterfactual scenario (i.e., what would the change have been in the absence of the intervention?), which cannot be observed. Impact evaluation techniques overcome these challenges by using applied econometric techniques to construct a counterfactual scenario and control for confounding variables that might complicate identification of attribution and impact. This research intends to analyze household-level data collected at both control and intervention sites, both before and after project implementation. Assessment of well-being will consider cash income (from agriculture, carbon payments, etc.), the value of assets owned or used (land, non-timber forest products, and other ecosystem services), and other indicators of well-being, such as household incidence of illness and access to key services (health care, education, clean water). Carbon storage impacts will be assessed through analysis of project documents. Variation in REDD projects' institutional conditions and implementation characteristics will be harnessed and combined with analysis of qualitative data to identify the causal mechanism(s) responsible for changes in the distribution of welfare and forest emissions across communities and landscapes.

EXPECTED RESULTS

Despite decades of efforts to reduce deforestation, we know very little about the specific causal mechanisms leading to improved outcomes for both forests and people in conservation. This is due to both a general lack of rigorous impact evaluation in the conservation field and a lack of data on changes in welfare at the household level. By using impact evaluation techniques to quantify the impact of REDD on forests and welfare, while also examining variations in institutional conditions and implementation characteristics of REDD projects, it is expected that this research will be able to identify both the distribution of welfare and carbon gains across affected populations and landscapes and the conditions that lead to less inequality and less leakage.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

REDD programs have great potential to protect ecosystem services for both global and local populations, yet because REDD will be implemented in complex social-ecological systems where land conversion contributes to local livelihoods and property rights and governance systems are weak, risks of negative impacts on the rural poor may be high. Understanding the locally-borne costs and benefits of REDD through impact evaluation will be the first step towards improving outcomes for people and forests. By examining the impacts and the conditions that lead to these impacts, it is hoped that this research can produce lessons for improving the design of conservation interventions.

Keywords: *tropical deforestation, REDD, impact evaluation, forests, socio-economic impacts*

Leanne M. Martin

EPA Grant Number: FP917227
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EPA Project Officer: Brandon Jones
Project Period: 8/1/2010 - 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Terrestrial Systems Soil and Plant Ecology
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BIO:

Leanne Martin received her B.S. in Biology from Mount Mercy College, Iowa in 2002. She studied tallgrass prairie restoration success at Iowa State University, and graduated with an M.S. in Ecology and Evolutionary Biology in 2005. After spending the next 4 years managing tallgrass prai rie preserves at the University of Nebraska at Omaha, she returned to Iowa State University to begin a Ph.D. program studying influences of native and exotic grasslands on eco system services.

SYNOPSIS:

Grasslands provide multiple ecosystem services essential for human health. However, they are represented by a variety of plant species compositions, and it is not well known how ecosystem services may vary among them. This research aims to understand how relative abundances of exotic and native species in grasslands affect multiple ecosystem service tradeoffs between plant species diversity, carbon storage, productivity, and bee pollinator abundances at a landscape scale.

Quantifying a Fundamental Gap in Ecosystem Service Tradeoffs: Differences Among Native- and Exotic-Dominated Landscapes

OBJECTIVE(S)/RESEARCH QUESTION(S)

Landscapes exhibit tradeoffs in the amount and extent of ecosystem services provided, and this may be particularly true in grasslands, which are represented by a variety of native- and exotic-dominated species compositions. However, exotic species impacts are typically quantified by looking at only one or a few exotic species invasions into native environments, and ecosystem services of persistent exotic communities, which occur commonly, have not been compared to native communities in working landscapes. This research aims to understand how relative abundances of exotic and native species in grasslands influence multiple ecosystem service tradeoffs between plant species and/or functional group diversity, carbon storage, productivity, and bee pollinator abundances at a landscape scale.

APPROACH

Sampling will take place over 2 years in a latitudinal gradient spanning the tallgrass prairie region of the Great Plains, which is one of the most endangered ecosystems in the world and contains both native- and exotic-dominated grasslands in urban and rural systems. A minimum of 40 grassland sites will be selected and paired according to whether they are dominated by native or exotic species. The proportion of native species, plant species diversity, bee pollinator abundances, and aboveground productivity will be measured at each site to quantify ecosystem service tradeoffs among native- and exotic-dominated grasslands. A meta-analysis will be conducted on soil carbon levels in unplowed (native) and previously plowed (exotic) grasslands to consider carbon storage in the ecosystem service tradeoff framework.

EXPECTED RESULTS

Ecosystem service tradeoffs are predicted to differ between exotic- and native-dominated grasslands, and these results could impact landscape-scale management recommendations. Exotic grasslands are predicted to contain lower species and/or functional group diversity, bee pollinator abundances, and soil carbon levels, and higher productivity (ANPP) compared to native grasslands. Conversely, pollinator abundances may be higher in some exotic communities if pollinator generalists are attracted to exotics. Furthermore, exotic/native grasslands (measured as the proportion of natives) may directly affect species/functional group diversity, productivity and pollinators. Alternatively, the proportion of natives could affect productivity and pollinators via the indirect effects of species and/or functional group diversity.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Quantifying ecosystem service tradeoffs and direct and indirect effects of exotic and native grasslands on multiple ecosystem services will improve our ability to manage grasslands for these services, and ultimately human and environmental health.

Keywords: *exotic species, novel communities, species diversity, ecosystem service, pollinators, carbon storage, productivity*

David Michael Minor

EPA Grant Number: FP917142
Institution: Michigan State University (MI)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2012
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Terrestrial Systems Soil and Plant Ecology
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BIO:

David Minor received undergraduate degrees in Zoology and Forestry from Michigan State University (MSU) in 2009. During his undergraduate program, he worked as a labora tory and field assistant in a forest ecology laboratory. In 2009, he began a Master's program at MSU in Plant Biol ogy. His research focuses on factors affecting seed produc tion in trees, and how these effects vary by species.

SYNOPSIS:

Seed production is the fundamental process that deter mines the tree species present in a forest. Factors that may affect the chance of an individual producing seed include the size of the individual, crowding from neighboring trees, and the soil resources available, which are altered through nitrogen deposition. By measuring seed production in indi vidual trees, this project will investigate the influence each of these factors has on seed production, and how nitrogen deposition may affect future production.

Seed Production Across a Soil Nitrogen Availability Gradient as a Model of N-Deposition

OBJECTIVE(S)/RESEARCH QUESTION(S)

Many factors may affect seed production in trees, including the size of an individual, interactions with neighboring trees, and the soil resources available. Because nitrogen deposition can alter the availability of this and other nutrients in the soil, it is important to understand how this chang- ing chemical environment may alter fecundity of species differently, and subsequently alter the species composition of forest communities. This research will investigate the influence of tree size, local crowding, and nutrient availability on seed production in northern hardwood tree species.

APPROACH

Seed production will be visually estimated in 11 northern hardwood spe- cies across a natural fertility gradient in northwest lower Michigan over the course of 3 years. Individual-based models will then be calibrated to test the influences of tree size, neighborhood crowding, and soil re- source availability on seed production. In addition, the effect of specific nutrients, including nitrogen, will be assessed through measuring seed production in fertilized trees of four species.

EXPECTED RESULTS

I expect that tree size will be the best predictor of seed production, but that additional variability will be explained by soil nutrient availability and neighborhood crowding. Because nitrogen is typically a limiting nutrient in temperate forests, I expect that it will have a greater positive effect on seed production than other nutrients, both along the natural gradient and in the fertilization experiment. Other nutrients, such as cal- cium, phosphorus, and potassium, may also affect seed production, and their effect may vary by species. Finally, I expect that size and proximity of neighbors will have a negative relationship with seed production.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Anthropogenic additions of nutrients, such as nitrogen deposition, may cause species-specific seed production responses. Because species dif- ferences in reproductive response may result in a change in the species composition of a community, understanding the response to changing soil nutrients is the first step to safeguarding future forests against diver- sity loss for the wide range of ecosystem services that they provide.

Keywords: *seed production, soil nutrients, neighborhood crowding, nitrogen deposition*

Terrestrial Systems Animal Ecology

Jeremy Catalin Andersen

EPA Grant Number: FP917248
Institution: University of California, Berkeley (CA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/18/2010 – 8/17/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Terrestrial Systems Animal Ecology
E-mail:

BIO:

Jeremy received his undergraduate degree in Biology in 2006 and his Masters degree in Organismic and Evolution ary Biology in 2009 from the University of Massachusetts Amherst. After completion of his Masters degree, Mr. An dersen began the Ph.D. program in Environmental Science Policy and Management at the University of California, Berkeley. His research focuses on the effects of hybridiza tion on the sustainability of biological control services.

SYNOPSIS:

To protect U.S. agriculture from arthropod pests, pesticides continue to be used extensively. Pesticides, however, have been linked to pest resistance, pollution, loss of biodiversity, and are becoming politically unpopular. Biological control can be a sustainable approach for reducing damage by crop pests, but to ensure their safety and viability we need to re examine previous successes to determine how evolution can influence the sustainability of biological control services.

E Terrestrial Systems Animal Ecology

Revisiting the Success of Natural Enemies To Provide Sustainable Ecosystem Services and Reduce Pollution

OBJECTIVE(S)/RESEARCH QUESTION(S)

The United States has more than 300 million acres of agro-ecosystems, which are highly dependent upon regulating ecosystem services such as pollination and biological control. These agro-ecosystems are also major contributors to nonpoint source pollution from pesticides. Biological control can be a sustainable approach to pest management through the reduction of pesticide use. For this approach to be truly sustainable, it is necessary to study what factors may influence the evolution of biological control agents after their introduction. In this project, I propose to investigate how intraspecific hybridization among different strains of imported insect parasitoids and variation in the susceptibility of aphid clones to parasitism can influence the sustainability of biological control services in the management of invasive crop pests. My research will lead to improved understanding of the management of ecosystem services, and to a reduction in pesticide usage and consequently to a reduction in nonpoint source pollution from agricultural ecosystems.

APPROACH

The first stage of research will include sampling of the biological control agent *Trioxys pallidus*, a parasitoid wasp introduced to control aphids in walnut and hazelnut orchards. Separate strains of *T. pallidus* were introduced for each crop, and both systems have been textbook examples of successful biological control. Now, 40 years after the initial introductions, both systems are starting to fail. Using molecular DNA techniques, individuals will be genotyped to examine whether or not hybridization has occurred between the two strains of *T. pallidus* introduced into the western United States. After the rates of hybridization are determined in the orchards, samples will be brought back to the lab where crossing experiments and behavioral assays will be performed to determine the specific effects of hybridization on the efficiency of biological control in this system and the potential for the pest species to develop resistance either through novel secondary symbionts or behaviors.

EXPECTED RESULTS

This data will then be used to identify the population structure of *T. pallidus* in California and Oregon, and the incidence of hybridization in orchards. We expect that hybridization has occurred between the two strains, and that gene flow is occurring between the two parasitoid strains. This result could have widespread implications for existing biological control programs, due to the fact that multiple introductions/strains have often been introduced into other systems as well. It is likely that the co-adapted gene complexes between the parasitoids and their aphid hosts will be disrupted due to the introgression of novel genetic material, reducing the success of larval development, and thus limiting the effectiveness of *T. pallidus* as a control agent. It is likely as well that the pests have been able to adapt to the natural enemies introduced to control them. The potential for horizontal transfer also makes the acquisition of novel defensive symbionts an attractive explanation for the rise in walnut and filbert aphid populations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Biological control has the potential to be a sustainable pest control option. Immediately following the release of *T. pallidus* in walnut and hazelnut orchards, the use of pesticides to control aphids was completely eliminated, protecting the environment from nonpoint source pollution pesticide runoff into waterways, and reducing costs to farmers. This work will directly be involved in the re-establishment of that control. In addition, to establish the long-term effectiveness of biological control programs in general, we need to examine the evolutionary potential of control agents in their new habitats. By studying the effects of hybridization in biological settings we can make informed management decisions about the release of natural enemies and reduce the pollution and negative health effects associated with the use of pesticides.

Keywords: *biological control, hybridization, evolution, pesticides, pollution, insect pests, agriculture, IPM, sustainable, agro-ecosystems, parasitoid, natural enemies*

Jennifer Dawn Palladini

EPA Grant Number: FP917147
Institution: University of Montana, Missoula (MT)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Terrestrial Systems Animal Ecology
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BIO:

Jennifer Palladini received her undergraduate degree in Bi ology from the College of Charleston in 1999. After 3 years of working as a science educator, she returned to school and earned her M.A. in Biology at Humboldt State Universi ty (2004), investigating links between clearcut logging, ant communities, and seed dispersal. Currently, she is enrolled in a doctoral program at the University of Montana, where her research focuses on how plant invasion and herbicide use influence native bees.

SYNOPSIS:

Herbicides are increasingly used in natural areas to sup press invasive plants, which commonly results in a decrease in the abundance of native flowering plants. Pollinators are likely particularly susceptible to the loss of native flowering plants, though this link has not been explored. The goal of my work is to determine how herbicides affect abundance and diversity of native bees, and to explore whether changes in bee abundance have consequences for the pollination of native plants.

E Terrestrial Systems Animal Ecology

Does Intensive Herbicide Use in Natural Areas Indirectly Drive Declines in Pollinator Abundance?

OBJECTIVE(S)/RESEARCH QUESTION(S)

Herbicides are increasingly used in natural areas to suppress invasive plants, yet the consequences of herbicide use in the communities in which they are applied are largely unknown. Although herbicides can have direct non-target effects on plants, they may also have strong indirect effects on other trophic levels, particularly pollinators. Native bee populations have suffered extreme declines in recent years, and though the cause of these declines remains unclear, exposure to chemicals and habitat alteration are two likely drivers. Because many plant species require an animal pollinator for sexual reproduction, reductions in the abundance of pollinators could greatly disrupt the viability of plant populations. This work will examine the influence of herbicides on (1) species richness and abundance of native bees, (2) nest establishment and offspring production for native bees, and (3) pollinator visitation and seed production for native plants.

APPROACH

My research takes place at 10 low-elevation and 10 mid-elevation intermountain prairie sites in western Montana. Of the 20 study areas, 10 (5 low-elevation and 5 mid-elevation) have a history of intense broadleaf herbicide use, including aerial application and/or broadcast spraying with Milestone® (aminopyralid) or Tordon® (picloram). Herbicides have been used in these areas to suppress three invasive forbs: spotted knapweed, leafy spurge, and Dalmatian toadflax. Vegetation and bee communities will be surveyed at each site. To explore differences in bee reproductive rates, I will place a wooden nesting block in each site and monitor nesting by *Osmia lignaria* (Megachilidae), a native solitary bee. Finally, pollination of native plants will be examined by observing visits by pollinators to arrays of potted *Clarkia pulchella* (Onagraceae) placed at each site.

EXPECTED RESULTS

I predict that vegetation communities in areas with a history of herbicide use will have greater grass cover and lower forb cover. Reductions in forb cover that accompany herbicide use will result in lower bee diversity and abundance, as well as reduced nest establishment and offspring production. Finally, I predict that visitation by pollinators to *C. pulchella* will be reduced in areas with a history of herbicide use.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

My research will assess the importance of a proposed mechanism of pollinator declines, chemical usage. Herbicides are widely employed to suppress invasive plants, and nontarget effects are of great concern to land managers. However, data on the indirect effects of herbicides on other trophic levels are lacking even though indirect effects, while more difficult to detect, can be as strong or stronger than direct effects. Declines in pollinator populations in natural areas due to herbicide use will have broad implications for land management. By elucidating mechanisms of native pollinator declines, my work will aid conservation biologists in the maintenance of native pollinator populations in both natural and agricultural settings. Finally, my work has relevance for farmers of insect-pollinated crops. As honeybees continue to decline, biologists predict that services by native pollinators could help ameliorate these losses. If herbicides negatively affect native bees, farmers may benefit from limiting the use of herbicides in uncultivated areas.

Keywords: *herbicide, Osmia lignaria, plant invasion, pollinator, solitary bee*

Pamela G. Thompson

EPA Grant Number: FP917245
Institution: University of California, Los Angeles (CA)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Ecosystem Services: Terrestrial Systems Animal Ecology
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BIO:

Pamela Thompson received her B.S. degree in Ecology and Evolutionary Biology from Tulane University in 2005. After graduation, she pursued several research assistant positions on projects involving plants and animals in Guatemala, Panama, and the Sonoran Desert. In Fall 2006 she was a Policy Intern at The Wildlife Society and the following year, she began the Ph.D. program in Ecology and Evolutionary Biology at the University of California, Los Angeles. She hopes to use her training to work in science policy, and shape future conservation priorities in tropical regions.

SYNOPSIS:

Tropical dry forests are highly threatened due to human conversion of the landscape. These seasonal forests are also home to many endemic species and critical ecosystem pro cesses. I am investigating how forest fragmentation in these areas may affect species interactions, specifically pollina tion of tropical trees by bats. I will compare continuous and fragmented forest sites, and examine nectar-bat abundance and diversity, as well as genetic patterns of pollen move ment in a bat-pollinated tree.

The Effects of Landscape Structure on Pollination and Gene Flow in a Tropical Tree Species

OBJECTIVE(S)/RESEARCH QUESTION(S)

People living in tropical forests are often dependent on ecosystem services provided by the forest, such as animal pollination of plants. These services can be disrupted by forest fragmentation. My research will examine the impact of landscape structure on pollination by comparing pollen-mediated gene flow in a bat-pollinated tree species, and pollinator abundance and diversity, between fragmented forest sites and continuous forest sites in Mexico.

APPROACH

I am using a landscape genetics and ecological approach to answer my questions about the impacts of forest fragmentation on bat-pollination. The first step is to locate and map the focal tree species (*Crescentia alata*), and collect leaf samples and seeds from these trees. By extracting DNA and genotyping the individual trees and their offspring (seeds) using neutral genetic markers, the spatial connectedness via pollen flow between the trees can be deduced, and patterns of pollen movement between trees in different sites (fragmented or not) can be compared. Additional work will focus on the pollinator abundance and diversity in the different sites, which will be accomplished through temporary capture of bats near flowering trees in the different sites, using mist-nets.

EXPECTED RESULTS

It is unclear whether nectar-feeding bats are directly impacted by forest fragmentation, or whether they can cope with these changes to the environment due to their ability to fly long distances. The degree of this impact may be different for different species of nectar-feeding bats. By comparing species and abundances of nectar-feeding bats in fragmented versus continuous forest sites, it is possible to see if there are any direct impacts to the bat pollinator community. By comparing pollen movement between sites, we can see an indirect genetic signature of the bat movement, and how this movement is impacted by changes to the landscape structure. We can also tell how connected different sites are, and the scale at which bats are moving pollen across the landscape.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research will contribute to a larger understanding of the responses of an important tropical plant-animal interaction to the surrounding landscape structure, and how landscape features affect genetic connectivity among tropical trees. Knowledge of how bat pollinators use landscapes is essential for the design of successful conservation programs to preserve tropical ecosystem services. Moreover, by demonstrating the ecosystem service that bats perform by pollinating culturally important plants, this research can motivate decision-makers to protect threatened bat species such as *Musonycteris harrisoni* and *Leptonycteris yerbabuenae*. In addition, this project focuses on tropical dry forests which, although critically threatened due to a long history of human use and susceptibility to fire, are understudied compared to tropical rain forests. Only approximately 19 percent of Mexico's original tropical dry forest remains today, and deforestation continues at a rate of 1.4 percent per year. An analysis of the ecosystem services provided by tropical dry forests in the Jalisco region of Mexico stated pollination by native bee pollinators and bats was one of the most essential services. Plants in the tropical dry forests are also more dependent on bats as pollinators than plants in the wet tropical forests, making this research highly valuable to the preservation of this critically threatened ecosystem.

Keywords: *nectar-feeding bats, ecosystem services, landscape genetics, pollen-mediated gene flow, tropical dry forest*

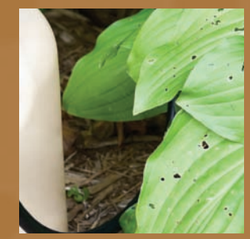
Pesticides and Toxic Substances












Pesticides and Toxic Substances Fellows

David James Civitello

EPA Grant Number: FP917126
Institution: Indiana University, Bloomington (IN)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

David Civitello received a B.A. in Biology from Colby Col lege in 2006. He then began a Ph.D. program in Ecology, Evolution, and Behavior at Indiana University. He is broadly interested in the importance of environmental factors on disease. He has studied heartworm in gray fox and the effects of an exotic grass invasion on ticks that transmit hu man disease. He is currently researching the joint effects of chemical contamination and infectious disease on a fresh water invertebrate.

SYNOPSIS:

Ecologists have become increasingly concerned that chemi cal pollution and disease outbreaks seem to be increas ing in natural ecosystems. Are these linked? Do pollutants increase disease? If so, do pollutants and infectious disease jointly threaten the persistence of host populations? This research aims to use experiments and theoretical models to identify general processes that underlie the combined effects of copper contamination and fungal disease on an aquatic invertebrate.

P

The Effects of Toxins on Epidemic Disease in the Freshwater Grazer, Daphnia dentifera

OBJECTIVE(S)/RESEARCH QUESTION(S)

Ecologists, natural area managers, and conservationists alike have become increasingly concerned that chemical contamination and disease outbreaks seem to be increasing in natural ecosystems. Are these linked? Could pollutants increase disease? If so, do pollutants and infectious disease jointly threaten the persistence of host populations?

APPROACH

I will study the effects of copper, a heavy metal, on the interaction between a freshwater invertebrate, *Daphnia dentifera*, and its fungal parasite, *Metschnikowia bicuspidata*. First, I will use short term experiments to determine how copper affects disease related traits. Next, I will utilize disease ecology models to predict how these trait changes will affect the size and severity of disease outbreaks. Finally, I will utilize long-term experiments to test these predictions. I will also construct a physiological model to investigate how copper affects these important individual-level disease traits and how other contaminants might affect epidemics and host population persistence.

EXPECTED RESULTS

This research will characterize the effects that a common pollutant has on key disease related traits. These diverse effects will be integrated into disease ecology models to provide predictions for the size and severity of epidemics across different contamination scenarios. Testing these predictions will challenge these models and identify key processes that alter epidemics in contaminated habitats. Additionally, this research will determine if host genetic variation or variation in the supply rate or identity of the contaminant further modifies the effects of contamination on disease. Ultimately, this research can reveal key factors and processes that determine whether contamination exacerbates or alleviates disease in natural populations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This interdisciplinary research tackles a challenging environmental problem by creating a predictive, general framework that combines techniques and theory from toxicology, energetics, community ecology and evolutionary biology. Armed with this integrative theory, we will better understand how and when pollutants and disease jointly threaten host persistence in natural communities.

Keywords: *copper, fungal disease, epidemic, disease outbreak, disease ecology, freshwater, invertebrate, population persistence, contamination, pollution*

Sandrine Georgette Clairardin

EPA Grant Number: FP917127
Institution: Illinois State University (IL)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2012
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

Sandrine Clairardin received her undergraduate degree in 2009 from Illinois State University (ISU) in Biological Sci ences Teacher Education to earn her high school teaching certificate. During this time she was involved in undergradu ate research and she completed a yearlong student teaching internship working with high school biology students. She is now pursuing her M.S. in Biological Sciences at ISU before she begins her career as a high school science teacher. Her research focuses on mechanisms underlying how man made chemicals alter the functioning of the endocrine system.

SYNOPSIS:

Many man-made chemicals are released into the environ ment everyday. Some of these chemicals, called endocrine disrupting compounds (EDCs), can affect the functioning of an organism's endocrine system and have been shown to have a wide range of negative effects; however, little is un derstood about how these chemicals produce their effects. This project will test the effects of Bisphenol-A (BPA), an EDC commonly found in plastics, on steroid regulation dur ing development as a possible mechanism.

P

Investigating the Mechanism of Action and Estrogenic Effects of Bisphenol-A, an Endocrine Disruptor, in the Red-eared Slider Turtle (Trachemys scripta) Model System

OBJECTIVE(S)/RESEARCH QUESTION(S)

The overall objective of this project is to understand the mechanism(s) through which Bisphenol-A (BPA) exerts its estrogenic effects with the goal of applying this information to studies of other endocrine disrupting compounds (EDCs). The proposed series of projects outlined in this proposal will test the hypothesis that BPA exerts its estrogenic effects by inhibiting the natural metabolism of estradiol (E2, an estrogen) during development, leading to an increase in available estradiol. This will be done by addressing three main questions: (1) How does BPA affect steroid levels (specifically E2 metabolism)? (2) How does an organism metabolize BPA? (3) How does BPA affect gene expression related to E2 and BPA metabolism?

APPROACH

The questions will be addressed using the red-eared slider turtle *Trachemys scripta* as a model system. This system was chosen because a great deal is already known about steroid levels throughout development and the sex of individuals can be experimentally controlled due to their temperature-dependent sex determination (an important characteristic when studying feminizing effects). *T. scripta* eggs and hatchlings will be treated with BPA in order to gather data concerning levels of steroids (focusing on E2), BPA, and their metabolites, the enzymes responsible for metabolizing E2 and BPA (sulfotransferases, SULT and glucuronyltransferases, UGT for the purposes of this study), and the expression of genes relating to the metabolizing enzymes. This approach combines both *in vitro* and *in vivo* studies that will identify which component is ultimately responsible for producing estrogenic effects in the living organism.

EXPECTED RESULTS

These data will show how BPA affects E2 metabolism during a point in development known for steroid sensitivity in this species. In BPA-treated eggs, it is expected that E2 levels will increase in the embryo resulting from the inhibition of SULT activity rather than decreased SULT gene expression. This would indicate that BPA, and other EDCs, may elicit estrogenic effects by increasing available estrogen through SULT inhibition.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

While substantial advances have been made in determining the impacts of EDCs, most research has focused on understanding the endpoint effects—largely feminizing/estrogenic—of these chemicals in various organisms. Few studies, however, have been done to unravel the mechanisms of action for these compounds. By understanding the mechanisms by which these compounds exert their effects, instead of simply describing the endpoint effects, chemical companies can utilize these ideas during product development, manufacturers can choose safer chemicals for production, and governmental agencies can set more responsible standards and safety guidelines.

Keywords: *Bisphenol-A, endocrine disruptors, steroid metabolism, sulfotransferase, estradiol, estrogenic effects*

Tami Lynn Clark

EPA Grant Number: FP917128
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EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

Tami Clark received her undergraduate degree in Biochem istry at the University of Wisconsin, Madison in 2007. After graduation, she worked as a research assistant in the En vironmental Chemistry and Toxicological Laboratory at the University of California at Berkeley under the direction of John Casida. This experience introduced Tami to the ex citing area of pesticide toxicology. As a graduate student, she now continues her research in Dr. Casida's laboratory at Berkeley focusing on the mechanisms of neonicotinoid insecticide metabolite toxicity.

SYNOPSIS:

Neonicotinoids account for more than 20 percent of the worldwide insecticide market. From the seven commercial neonicotinoids, over 100 metabolites have been identi fied in plants and mammals, many of which have not been evaluated for toxicity. This project examines the multiple targets of neonicotinoid metabolites and their potential mechanisms of toxicity. The findings will be important in determining the safest and most effective use of neonicoti noids as their use in agriculture expands.

P

Multiple Targets of Neonicotinoid Insecticide Metabolites

OBJECTIVE(S)/RESEARCH QUESTION(S)

Neonicotinoids are the newest major class of insecticides. They have been shown to generate a large number and great variety of metabolites in mammals and plants. This project will investigate the toxicological mechanisms and targets of neonicotinoid insecticide metabolites.

APPROACH

This research will involve several methods to investigate the potential of neonicotinoid metabolites to inhibit essential mammalian enzymes based on previous research and/or unique chemical features. In addition, the biochemical impact of these effects will be assessed. First, this project will analyze the ability of nitroguanidine neonicotinoid metabolites to inhibit nitric oxide synthase (NOS) and determine how altered levels of nitric oxide may potentiate hepatotoxic and hepatocarcinogenic effects of other metabolites. Next, nitrosoguanidine and aminoguanidine metabolites of a specific neonicotinoid, imidacloprid, will be examined as potential tissue aldehyde- and ketone-depleting agents and as irreversible inhibitors of the xenobiotic-metabolizing enzyme, aldehyde oxidase (AOX). Third, the production of glucuronide- or glucoside-sequestered neonicotinoid metabolites will be analyzed in mammals and plants, respectively. Finally, neonicotinoid phase I and phase II metabolites will be evaluated for their ability to chelate and inhibit metallo-oxidase enzymes.

EXPECTED RESULTS

The ability of neonicotinoid metabolites to alter the function of key regulatory mammalian enzymes will clarify their role in the secondary mechanisms of neonicotinoid toxicity. NOS inhibition may potentiate the hepatotoxic and hepatocarcinogenic effects of other neonicotinoid metabolites. AOX inhibition may prevent further metabolism of imidacloprid and other neonicotinoids since AOX is implicated as a key enzyme in neonicotinoid metabolism. Glucuronide- or glucoside-sequestered metabolites may serve as masked nicotinic acetylcholine receptor agonists and metallo-oxidase inhibition would greatly alter important biochemical functions in mammalian systems.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The world relies on pesticides to generate the amount of food necessary to sustain expanding populations. Evaluating the mechanisms of toxicity of neonicotinoid insecticide metabolites will facilitate safe and effective use of these chemicals. Results from this project may ultimately lead to the creation of safer, less toxic insecticides and implementation of new regulations for future pest control.

Keywords: *neonicotinoids, insecticide, metabolites, imidacloprid, nitric oxide synthase, aldehyde oxidase, metallo-oxidase*

Cynthia Leigh Curl

EPA Grant Number: FP917129
Institution: University of Washington (WA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

Cynthia Curl earned a B.A. in Chemistry from Swarthmore College in 1998 and an M.S. in Environmental Health from the University of Washington in 2000. She worked at the University of Washington as a researcher until 2003, where she studied pesticide exposure to children and farmworkers. She then worked for a non-profit group and spent 2 years in environmental consulting before returning to academia. Cynthia is primarily interested agriculture and health, and her current research focus is dietary pesticide exposure.

SYNOPSIS:

Americans spend more than $20 billion each year on organ ic foods (grown without most pesticides). Although low-level pesticide exposure had been associated with neurobehav ioral changes in farmworkers and in children living in farm ing communities, little is known about the health impacts of dietary exposure to pesticides in the general population. This project examines the relationship between dietary pesticide exposure and neurobehavioral outcomes in over 5,000 people from six U.S. cities.

P

Dietary Exposure to Organophosphorus Pesticides and Neurobehavioral Effects in a Large Multi-City Cohort

OBJECTIVE(S)/RESEARCH QUESTION(S)

Organophosphorus (OP) pesticide exposure in the general U.S. population is believed to be dominated by the dietary pathway. Although research suggests that long-term low-level exposure to OP pesticides may be associated with neurobehavioral changes in occupationally exposed groups or in children living in agricultural communities, no research to date has examined the health impacts of dietary exposure to OP pesticides within the general population. This research project will examine the relationship between chronic dietary exposures to OP pesticides and neurobehavioral outcomes in a multi-city, multi-ethnic cohort of approximately 5,500 non-occupationally exposed participants.

APPROACH

This project will build on the existing Multi-Ethnic Study of Atherosclerosis (MESA), an NHLBI-funded cardiovascular cohort study that includes participants recruited from 6 US cities. MESA began in 1999, and all participants completed a comprehensive baseline clinic exam that included, among many other components, a food frequency questionnaire (FFQ) and urine sample collection. Subsequent clinic exams have occurred approximately every two years, and in 2010-2011, participants will return for their fifth exam. Exam 5 will include a comprehensive suite of neurocognitive tests, urine sample collection, and a repeated FFQ, to which this research project adds questions about organic food consumption. This research project will then utilize the FFQ data from both Exams 1 and 5 to conduct an assessment of chronic dietary exposure to OP pesticides based on the foods reported, typical pesticide residue levels from the USDA's Pesticide Data Program, and processing factors for the method of food preparation from the EPA's OP Cumulative Risk Assessment of 2006. Urinary biomarkers of OP pesticides will be used to assess the reasonableness of these estimates. The association between dietary OP pesticide exposure and a specific set of neurobehavioral outcomes (including measures of attention, concentration, complex visual-motor processing and executive function, and short-term memory) will be examined.

EXPECTED RESULTS

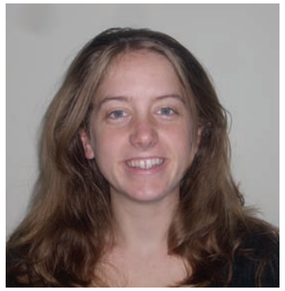
This project will be the first large-scale epidemiologic investigation of the health impacts of dietary exposures to OP pesticides. This large cohort is extremely well characterized, with available information on demographics and socioeconomics, employment history, residential history, health status, medication use, and other variables, each of which can be considered in the analysis. The dietary exposure assessment component of this study will incorporate data covering a ten-year period, and will be evaluated in comparison with the results of repeated urinary biomarker analyses. Finally, the neurobehavioral outcomes that are already being measured in MESA are consistent with those found to be relevant in previous occupational research. This project provides a unique opportunity to leverage existing data on dietary patterns and neurobehavioral outcomes, and to add to these data information on organic food consumption practices and urinary biomarker analyses.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The results of this project will help inform policy regarding the safety of current agricultural practices with respect to OP pesticides, and to inform the public about the degree to which reducing dietary exposures to pesticides can impact their health.

Keywords: *organophosphorus pesticides, organic, dietary exposure, neurobehavioral changes, urinary metabolites*

Kayleigh Dunnett



EPA Grant Number: FP917130
Institution: University of Illinois, Urbana-Champaign (IL)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
E-mail:

BIO:

Kayleigh Dunnett received her undergraduate degree in Civil Engineering at Florida State University (FSU). During her last 18 months at FSU, she worked as a co-op student in petroleum cleanup at the Florida Department of Envi ronmental Protection. She received a Master of Science in Environmental Engineering at the University of Illinois, Urbana-Champaign (UIUC) in 2009. Her M.S. studies used biologically activated carbon to remove *tert*-butyl alcohol, a gasoline derivative. She is currently a UIUC doctoral stu dent; her research focuses on biotransformation of contami nants sorbed to activated carbon.

SYNOPSIS:

Explosives are a common groundwater contaminant at mili tary facilities. Activated carbon is the most utilized treat ment method; however, this produces explosive hazardous waste that is expensive to handle and dispose. This study aims to transform explosives on spent activated carbon, making the treated carbon nonhazardous and recyclable. Carbon will be treated using a combination of bacterial cul tures and chemical additives. The project would enhance, not replace, current cleanup systems.

P

Biological Regeneration of RDX-Contaminated Granular Activated Carbon (GAC) using Extracellular Electron Shuttling Compounds

OBJECTIVE(S)/RESEARCH QUESTION(S)

Activated carbon is commonly used to remove high explosives such as RDX from groundwater, but the safe handling of spent carbon granules is both hazardous and costly. Therefore, this work aims to develop a biological-chemical model system for adsorbed RDX transformation to granular activated carbon (GAC) using known electron-shuttle reducing microorganisms. Studies will utilize different cellular cultures to deter mine the rate and extent to which adsorbed RDX can be reduced using hydroquinone electron shuttles and will identify key intermediates in the degradation pathway.

APPROACH

Chemically reduced hydroquinones will be added to solutions contain ing RDX sorbed to GAC granules, and both GAC granules and aqueous solution will be analyzed for RDX and transformation products in order to determine whether hydroquinones can donate electrons to sorbed RDX as a one-way reaction. Next, GAC/RDX/quinone solutions will be inoculated with quinone-respiring *Geobacter metallireducens* to deter mine whether quinones could be reduced using cellular cultures, thus producing a continuous flow of electrons to RDX. Studies will progress to flow-through column experiments that mimic an ex-situ remedial system, and alternate cultures will be tested.

EXPECTED RESULTS

Preliminary data suggest that chemically reduced hydroquinones can successfully transform RDX sorbed to activated carbon, although kinetics and extent of degradation are unknown. However, this reac tion occurs in less than 48 hours, suggesting that sorbed RDX can be treated in a timely manner. Published studies have already proven that *G. metallireducens* can reduce quinones in aqueous solution; therefore, it is believed that the combination of cells and hydroquinones will produce a system where RDX is continuously reduced and GAC granules can be utilized indefinitely. It is believed that this cellular-chemical system can be retrofitted to existing GAC units that are already treating RDX.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The safe transport and landfilling of RDX-spent GAC requires a consid erable amount of labor and cost; potentially explosive hazardous waste must be handled carefully and deliberately, and appropriate landfills are often far from clean-up sites. The proposed treatment strategy would reduce the risk of explosion and would eliminate the need for GAC land filling as carbon granules will be continuously recycled.

Keywords: *RDX, granular activated carbon, hydroquinones, electron shuttles, bioregeneration*

John F. Egan

EPA Grant Number: FP917131
Institution: Pennsylvania State University (PA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

J. Franklin Egan completed a B.S. in Biology from Cornell University in 2004. Over the subsequent three years, he traveled widely while working as a technician on various ecological research projects for Cornell, the USGS, and Brown University. In 2007 he began his Ph.D. in the ecol ogy graduate program at Penn State University, working in a research group focusing on the ecology and management of weedy plants. His research interests include herbicide ecotoxicology and the assessment and management of plant diversity in agroecosystems.

SYNOPSIS:

To combat a crisis with glyphosate resistant weeds, the biotechnology industry is developing crops that can toler ate other herbicide ingredients, including the plant growth regulator herbicides (PGR) dicamba and 2,4-D. A potential problem is that PGR herbicides can be volatile and often move away from targeted fields as droplets and vapors. My research will quantify vapor drift of PGR herbicides and explore potential risks to farmers growing susceptible crops and to natural habitats.

P

Assessing the Impacts of PGR-Based Weed Management Systems to Plant and Insect Diversity in Agricultural Landscapes

OBJECTIVE(S)/RESEARCH QUESTION(S)

The impending commercialization of cotton and soybean genetically modified for resistance to plant growth regulator herbicides (PGR) including dicamba and 2,4-D will allow these compounds to be used much more widely in the future. Because these herbicides are volatile and prone to drifting off of crop fields, there is the potential for non-target damage to susceptible crops and natural vegetation. Focusing on dicamba, my research objectives are to quantify dicamba vapor drift at field and landscape scales and to measure the effects of low doses of this herbicide on susceptible crops and natural plant and insect communities in agroecosystems.

APPROACH

Dicamba vapor drift will be empirically measured at field scales by applying the herbicide to test plots and measuring emitted vapor concentrations at increasing distances using potted soybeans as a bioassay system. These results will be translated to landscape scales using GIS simulations that combine this data with previously-used air dispersion models. A comprehensive literature based meta-analysis will assess the effects of drift-level doses of dicamba on soybean, cotton, and other important susceptible crops species. Effects on natural plant and associated insect communities will be assessed using experiments on field edge and hedge row habitats treated with low doses of dicamba.

EXPECTED RESULTS

My research will provide data to ensure that PGR-resistant crops are commercialized with a robust understanding of any potential risks to environmental quality. Data on the dynamics of dicamba vapor drift will help develop strategies to minimize or avoid vapor drift while using this herbicide effectively. A comprehensive analysis of crop susceptibility will help farmers understand drift risks to neighboring fields and to gauge economic costs from herbicide drift incidences. Analysis of effects on natural vegetation will produce understanding of the sensitivity of these habitats to herbicide drift and the potential effects on associated ecosystem services including pollination.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

PGR resistance biotechnology is being developed as a solution to a growing worldwide crisis with glyphosate resistant weed species. Complementing the transgenic technologies advanced by the biotechnology industries, farmers and researchers have for decades been developing sustainable, integrated weed management (IWM) approaches. While herbicides are an effective and important component of IWM systems, due to their unique volatility and toxicological properties, widespread use of PGR herbicides may pose unique risks to agroecosystems. At this critical juncture, my research will encourage a reinvestment in IWM science and provide data to ensure that PGR-resistant technologies are implemented within a robust understanding of any potential risks to environmental quality.

Keywords: *herbicide resistance, glyphosate, dicamba, agroecosystem, pollination*

Richard Arlin Erickson

EPA Grant Number: FP917132
Institution: Texas Tech University (TX)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

Richard Erickson grew up in rural Wisconsin and became interested in applied ecology after restoring a native prairie for his Eagle Scout Leadership Service Project. He earned his undergraduate degree in Wildlife Ecology from the University of Wisconsin-Stevens Point in 2007 and an M.S. from Texas Tech in 2009. He is currently pursuing a doc torate in Environmental Toxicology, with a minor in Math ematics, at Texas Tech, where he studying how mixtures of toxicants affect ecological communities.

SYNOPSIS:

Toxic chemicals occur ubiquitously within the environment and are one of many stressors that impact natural systems. However, our understanding of the impacts of these chemi cals is based on single-species toxicity testing where each chemical is studied individually without consideration of other chemicals or ecological stressors. This project uses current ecological theory as a context for developing ap proaches to quantify the impact of toxicant mixtures in an ecologically meaningful way.

P

Quantifying the Impacts of Chemical Mixtures on Ecological Communities

OBJECTIVE(S)/RESEARCH QUESTION(S)

This study will test the overarching hypothesis that mixtures of toxicants impact ecological community structure by altering relationships among species. This hypothesis will be tested by using and comparing two frameworks for quantifying the effects of toxic chemicals and chemical mixtures in the environment: (1) a “pesticide-as-predator” framework, and (2) a community “resistance and resilience” framework.

APPROACH

A field investigation of the impacts of the variety of pesticides on invertebrate community structure in multiple ephemeral lakes of the Southern High Plains will be conducted. In addition, a series of laboratory experiments will provide resolution of the direct and indirect effects of toxicant mixtures. The ecological frameworks will be investigated by integrating the field and laboratory studies through hierarchical modeling.

EXPECTED RESULTS

In general, the field of environmental toxicology has developed with surprisingly little interaction with the field of ecology. Nevertheless, a variety of theoretical frameworks within ecology have been developed to understand how ecological communities are structured. I expect that these frameworks will offer insight into the ways toxicants alter interspecific relationships, and, ultimately, the structure of ecological communities. This would represent a significant conceptual advance for the field of environmental toxicology.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Adequate environmental protection depends on the ability to understand and quantify the potential impacts of anthropogenic factors (in particular, chemicals) in an ecologically relevant manner. Current understanding of the ecological relevance of toxicity data, however, is severely lacking. This project will bridge this gap in knowledge.

Keywords: *ecological toxicology, ecotoxicology, community ecology, aquatic toxicology, pesticide, chemical mixtures*

Thomas Ross Garner

EPA Grant Number: FP917133
Institution: Clemson University (SC)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/18/2010 – 8/17/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

A native of Mullins, South Carolina, Ross Garner received his Bachelor's degree in Biology from The Citadel, The Military Col lege of South Carolina, as a Palmetto Fellow and Citadel Scholar in 2006, and his Master's degree from The Citadel Graduate College in 2008. There, his research involvement ranged from photoreceptor development in transgenic *Xenopus laevis* to the photoinduced toxicity of polycyclic aromatic hydrocarbons in *Palaemonetes pugio* larvae, and included contaminant surveys of estuaries and stormwater ponds in coastal South Carolina. Between degrees he worked as a counselor for the Governor's School of South Carolina at The College of Charleston, which he previously attended in 2001. He has studied the Spanish lan guage and Latin American culture in Peru, as well as rainforest and coral reef ecology in Belize. An avid sportsman and conserva tionist, Ross serves on the National Board of Directors for Wild life Action, Inc., an organization he has been involved with for over 20 years. Currently, Ross is a second year doctoral student at the Clemson University Institute of Environmental Toxicology. His research examines the role that nanoparticle characteristics, both physical and chemical, have on bioaccumulation by cells and organisms.

SYNOPSIS:

The nano-tech revolution has occurred in the absence of detailed knowledge concerning the interactions of nanoparticles with the environment. This lack of knowledge has prevented quantita tive assessments of the risks nanoparticles pose to humans and ecosystems. This research will characterize the influence that physical and chemical properties of nanoparticles have biological interactions. Results of this project will help predict the uptake of particles in various organisms in the environment.

P

Influence of Nanoparticle Characteristics on Membrane Transfer

OBJECTIVE(S)/RESEARCH QUESTION(S)

The explosion of products and applications using nanomaterials has occurred in the absence of detailed knowledge of the interactions of nanoparticles with biological membranes. This lack of knowledge has impeded the development of biomedical applications of nanomaterials and prevented quantitative assessments of the risk of nanoparticles to humans and ecosystems. Many biomedical applications of nanoparticles rely on their ability to cross membranes; for a nanoparticle to be potentially harmful, it typically must cross a membrane. In spite of this information, little deliberate research has been performed to quantitatively characterize the influence of nanoparticle characteristics on membrane transport. The goal of this research is to characterize the influence of particle core chemistry, size, shape and surface chemistry on the movement of nanoparticles across biological membranes.

APPROACH

This research will test the specific hypothesis that nanoparticle transfer across biological membranes is a function of particle physical and chemical properties. To test this hypothesis, this project will quantify the movement of nanoparticles of across cell membranes: out of the gut tract and into the body of *Daphnia magna* and across the gut tract of mice. Nanoparticles to be tested in this research vary in core chemistry, shape, size, and surface chemistry. Specifically, carbon dots and gold spheres (4 nm, 18 nm, and 50 nm), gold cubes (50 nm and 75 nm) and gold rods (20 nm × 100 nm and 20 nm × 400 nm) with cationic, anionic, and nonionic surface modifications will be tested. While both gold and carbon particles can be visualized using transmission electron microscopy, gold particles can also be visualized using dark field microscopy, and the autofluorescence of carbon dots makes them amenable to confocal fluorescent microscopy. Bioaccumulation of gold nanoparticles will be further substantiated and quantified by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). Use of these complete factorial designs will facilitate the use of Analysis of Variance to analyze the data and quantify primary effects as well as secondary and tertiary factor interactions.

EXPECTED RESULTS

We expect to find that most nanoparticles are poorly bioavailable and do not pass through membranes. However, some nanoparticles, particularly those that are smaller or mimic the charge and size characteristics of ions, prostaglandins, or hormones will be bioavailable as they will pass through either channels or ATP-dependent transporters. We predict that most, if not all, of the nanoparticles that are bioavailable will have similar characteristics. Specifically, we predict that spheres and cubes will show greater bioavailability than rods. Furthermore, we predict that particles that are bioavailable in *D. magna* will also be bioavailable in mice. We theorize that these particles will pass through the basolateral membranes of the small intestine, travel through the columnar epithelial cells of the small intestine, and exit the apical membranes into the blood. Demonstration of this effect of specific types of nanoparticles is important, as this work would show both basolateral and apical transport in an *in vivo* system.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The potential societal benefits of nanotechnology can only be realized if we adequately understand the interactions of these materials with biological systems. Current research has focused on cellular uptake of nanoparticles, as well as uptake in whole organisms. However, a lack of research quantitatively characterizing the influence of nanoparticle characteristics on their transport within these two systems exists. This research will help bridge the gaps in current research, while also providing a rapid, high volume bioassay that will facilitate future *in vitro* screenings of varying nanoparticles in the absence of *in vivo* testing. Results of this research will lay the foundation to develop quantitative structure-activity relationships (QSARs) that can be used to predict nanoparticle absorption in a variety of biological systems. In addition, these same relationships will reduce the uncertainties currently clouding quantitative human and ecological risk assessment.

Keywords: *nanoparticles, particle characterization, particle uptake, bioaccumulation, gold, carbon dots, cell culture, in vitro screening*

David Richmond Griffith

EPA Grant Number: FP917134
Institution: Massachusetts Institute of Technology (MA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
E-mail:

BIO:

David Griffith received a B.A. in Chemistry from Bowdoin College in 2000. Since then, he has taught high school sci ence at The Taft School and studied fisheries policy at the Property and Environment Research Center. In 2007, David completed his M.E.Sc. degree at the Yale School of Forestry and Environmental Studies. Currently David is a doctoral candidate at the MIT/WHOI Joint Program in Oceanography. His work focuses on the fate of sewage-derived contami nants in the coastal ocean.

SYNOPSIS:

Every day 35 billion gallons of treated waste water is re leased into U.S. rivers and oceans. These waste streams contain a variety of natural and synthetic estrogens that can threaten aquatic ecosystems and human health at extremely low (ppt) concentration, yet very little is known about the chemical behavior and form of estrogens in receiving coast al waters. This project will address this concern by charac terizing the quantity, speciation, and fate of estrogens in Massachusetts Bay.

P

The Fate of Natural and Synthetic Steroidal Estrogens in the Coastal Ocean

OBJECTIVE(S)/RESEARCH QUESTION(S)

Steroidal estrogens are potent endocrine disrupting chemicals (EDCs) that are routinely discharged to coastal seas via human and industrial wastewaters. Yet we remain largely uninformed about the sources, concentrations, fates, and effects of estrogens in marine ecosystems. We know even less about estrogen conjugates and chlorinated estrogens formed during wastewater disinfection. We hypothesize that past observations have greatly underestimated the environmental dosing with estrogens because conjugated and chlorinated derivatives were not assessed. This research project will quantify a broad suite of estrogens and their conjugated and chlorinated derivatives in wastewater and the receiving waters of Massachusetts Bay. The project also will investigate whether synthetic estrogens have carbon isotope signatures that may allow us to trace their fate in complex environments.

APPROACH

We will begin by determining the identities and concentrations of estrogens and their conjugated and chlorinated derivatives in Deer Island wastewater treatment plant effluent and at several locations in Massachusetts Bay. Estrogens will be concentrated from large volume water samples by solid phase extraction and quantified using a liquid chromatography coupled to a tandem mass spectrometer. These measurements will be used to construct the first quantitative budget of estrogens in Massachusetts Bay in order to identify important sources, sinks, and transformations, and assess the role of conjugated estrogens in the overall budget. In addition, preparative liquid chromatography-mass spectrometry will allow us to isolate individual estrogens from wastewater extracts for subsequent carbon isotopic analysis.

EXPECTED RESULTS

This study would be the first of its kind to measure the full suite of estrogens in coastal waters. Characterizing the chemical and isotopic signatures of estrogens represents an important first step towards developing a comprehensive understanding of the fate and hazard of estrogenic compounds in coastal ecosystems. The results will facilitate the development of quantitative tools, ranging from a simple mass balance box model to a 3-D numerical transport and fate model for steroidal estrogens in Massachusetts Bay. These models can then help us understand how different estrogen species (free vs. conjugated vs. chlorinated) respond to transport and transformation processes controlling their environmental distributions.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Improving our understanding of the speciation and chemical behavior of synthetic chemicals and endocrine disruptors in coastal waters will have far-reaching benefits to coastal ecosystems and human health. With more information about dominant estrogen species and their transformations, coastal managers and engineers can develop realistic chemical transport models and, together with policy makers, begin to evaluate the effectiveness of mitigation strategies that include source controls, treatment technologies, and redesigning pharmaceutical estrogens. This approach should be broadly applied as a way to anticipate and avoid similar problems in the future.

Keywords: *steroidal estrogens, conjugated estrogens, chlorinated estrogens, carbon isotopes, coastal ecosystem health, endocrine disrupting chemicals, mass balance model, Massachusetts Bay*

Volha S. Keen

EPA Grant Number: FP917136
Institution: University of Colorado, Boulder (CO)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/31/2010 – 8/30/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

Olya Keen received her Bachelor of Science in Civil Engi neering and Master of Science in Environmental Engineer ing degrees from the University of South Florida in Decem ber 2008. She started her Ph.D. program in Environmental Engineering at the University of Colorado at Boulder in January 2009. Her main research interest is the advanced treatment of water for the removal of emerging contami nants. Olya's current research focuses on the removal of antibacterial activity of antibiotics found in wastewater ef fluent to prevent the spread of bacterial resistance.

SYNOPSIS:

Human antibiotics are often found in waterways as a result of the improper disposal of drugs. The presence of antibiot ics in the environment is undesirable because it can lead to the development of antibiotic resistant strains of human pathogens and upset the ecological balance of the natural environment. Most human pharmaceuticals enter water sources through wastewater treatment plant effluent. This project will focus on advanced wastewater treatment tech nologies that can degrade antibiotics.

P

Oxidation of Antibiotics in Wastewater: Identifying Products and Impacts on Antibacterial Activity

OBJECTIVE(S)/RESEARCH QUESTION(S)

The increasing use of pharmaceuticals in our society has resulted in the scientific community recognizing these drugs as an emerging environmental contaminant. Among them, antibiotics are of special importance because they are used in large quantities and have been routinely detected in many waterways. Antibiotics have been implicated as one of the causes for the rise of pathogen resistance to antibacterial compounds. Wastewater treatment plant effluents are a major conveyor of human antibiotics into the environment. The project's goal is to evaluate the application of ultraviolet-based advanced oxidation as an advanced wastewater treatment method for its efficiency in degrading antibiotics such that they are inactive in the environment, helping to prevent microorganisms from developing widespread resistance to existing drugs.

APPROACH

Lab grade water and wastewater will be spiked with representatives of four major groups of human antibiotics. The samples will be subjected to bench scale advanced oxidation treatment similar to the full scale treatment used at drinking water and water reuse treatment plants in the United States. The treated samples will be evaluated using state of the art liquid chromatography/mass spectrometry methods to identify the loss of parent compound and generation of degradation products. The samples also will be subjected to bacterial inhibition assays to assess their antibacterial activity in parallel.

EXPECTED RESULTS

It is hypothesized that advanced oxidation can be applied effectively and in an economically responsible manner for the removal of the antibacterial activity of antibiotics. Ultimately, this study will develop a set of recommendations for the application of advanced oxidation processes to wastewater treatment. Effective removal of antibacterial activity of antibiotics entering the environment can prevent the rise of widespread antibiotic resistance of human pathogens, which is a growing problem world-wide.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This study intends to develop process application guidelines that will aid in the design of advanced wastewater treatment systems for removal of antibacterial activity of antibiotics. If regulation of specific antibiotics contaminating our waterways is enacted in the future, this study will provide information on the use of advanced oxidation processes to destroy antibiotic activity. Removal of the activity of the antibiotics entering the environment is essential for preventing resistance among human pathogens to the currently available classes of antibacterial drugs.

Keywords: *advanced oxidation, antibiotics, pharmaceuticals, antibacterial resistance, wastewater treatment*

James P. Killarney

EPA Grant Number: FP917137
Institution: University of Maine (ME)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
E-mail:

BIO:

James Killarney received his undergraduate degree in Biol ogy from the University of Maine in 1998. After graduat ing, he worked for the biotechnology firm Biogen Idec in Cambridge, MA for 8 years as a quality assurance specialist responsible for evaluating clinical development data. He re ceived his Master's in Public Health from Boston University in 2005 with a focus in environmental health. He returned to the University Maine in 2007 and is working towards a Ph.D. in chemistry. His research focuses on using fluores cence spectroscopy to detect pharmaceutical contamination in water.

SYNOPSIS:

Pharmaceuticals and personal care products (PPCPs) are contaminants of emerging concern in U.S. water supplies. The health effects of chronic exposure to mixtures of these compounds are unknown. Testing for the large number of these compounds is a cost-prohibitive endeavor. The goal of this project is to develop a rapid, cost-effective screen ing method using fluorescence spectroscopy combined with parallel factor analysis to identify and quantify PPCP mix ture contamination in water samples.

P

Fluorescence Spectroscopy and Multivariate Analysis as a Rapid, Cost-Effective Method To Monitor Pharmaceuticals and Personal Care Products (PPCP) in Three Maine Rivers

OBJECTIVE(S)/RESEARCH QUESTION(S)

Pharmaceutical and personal care products (PPCPs) are contaminants of emerging concern in U.S. water supplies. In order to accurately assess the human and environmental hazards of PPCP mixtures, the identity and quantity of the individual pharmaceutical chemicals must first be determined. Because this is a diverse group of compounds that number in the thousands, it is cost-prohibitive to test for them using traditional mass spec-based methods. In this project, we propose to develop a rapid, cost-effective method using excitation emission matrix fluorescence spectroscopy combined with parallel factor analysis to screen for PPCP mixtures in natural water samples.

APPROACH

In the first stage of this project, standard concentration models will be generated from excitation emission spectra using parallel factor analysis (PARAFAC) by spiking natural water samples with varying concentrations of individual PPCP compounds. These models will be tested for predictive value by putting known concentration standards into the model. Thus far, predictive models have been created for 17α-ethinylestradiol. Samples will be collected from three Maine rivers and analyzed using these models. Gas chromatography/mass spectros- copy will be performed on the same samples and compared to the results of the new method. The second stage of the project will assess the strength of our models with the changing complexity of natural water samples. Different sites along the three rivers will be sampled monthly to asses both temporal and spatial changes in the water. Additionally, multi-factor PARAFAC models will be created by spiking chemical mixtures of varying concentrations into natural water samples to assess the strength of individual compound models against changing concen- trations of other compounds in the sample.

EXPECTED RESULTS

We propose to develop a new analytical method for identifying phar- maceutical compounds using fluorescence spectroscopy. This novel fluorescence spectroscopy technique will be used to identify individual compounds at low concentrations in natural waters. This approach is expected to produce a relatively low cost analytical method for screen- ing a large number of organic compounds to help water suppliers and regulatory agencies make accurate water quality assessments. Current methodology for identifying pharmaceutical compounds in natural water supplies is costly and can take several weeks to generate full results. In comparison, the proposed method is rapid and less expensive in terms of people and equipment. The potential time and cost benefit of the pro- posed method will allow for more frequent sampling and allow for the assessment of a wider range of potential contaminants to provide a more accurate analysis of water quality. Additionally, this method can analyze complex multi-component mixtures without resorting to prior separation procedures. If the methods and analysis show success for the studied compounds, they can be applied to other classes of chemicals found in water. Compounds that show distinctive fluorescence properties (e.g., VOCs and pesticides) are potential candidates for this analysis.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

In order to assess the health risks of potentially thousands of trace compounds in our natural water systems, thorough and comprehensive testing must be performed. Unfortunately, this is a cost-prohibitive endeavor. Rapid, inexpensive screening techniques for select compounds will allow for more sampling and data generation. More data will aid in the risk assessment of these compounds with regards to human and ecosystem health.

Keywords: *PPCP, PARAFAC, fluorescence spectroscopy, water quality*

Gregg Peter Kotchey

EPA Grant Number: FP917138
Institution: University of Pittsburgh (PA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Gregg Kotchey received his undergraduate degree in Chem istry from the University of Pittsburgh in 2004 with both University and Departmental Honors. He proceeded to enter the Ph.D. program in Analytical Chemistry at the University of Pittsburgh. Under the direction of Prof. Alexander Star, Gregg's research focuses on enzymatic degradation of car bon nanotubes utilizing horseradish peroxidase. In addition to research, he received the Safford Award for "Excellence as a Graduate Student Teacher."

SYNOPSIS:

Due to their unique properties, carbon nanotubes (CNTs) have been integrated in numerous applications. Toxicologi cal studies, however, have demonstrated that CNTs induce inflammatory responses and cellular apoptosis. As produc tion of CNTs increase to meet the growing demand, the risk of environmental contamination increases. This project aims to develop a mechanistic understanding of the enzy matic degradation of CNTs that can be applied in future environmental remediation schemes.

P

Enzymatic Degradation of Carbon Nanotubes To Mitigate Potential Toxicity

OBJECTIVE(S)/RESEARCH QUESTION(S)

Due to their unique properties, vast research has been conducted on nanomaterials, especially carbon nanotubes (CNTs). As the resulting electronic, composite, and sensor applications become commercialized, the demand for CNTs of all varieties has increased. The current output for large-scale production of CNTs has been given as 10,000 tons per manufacturing plant per year. With such a large amount of CNTs being produced and the associated handling involved in processing these nano-materials, not only do the workers increase their risk of point-source exposure through inhalation, but also the general public is at risk of the toxic effects of CNTs, when this material is introduced into non-point source aquatic environments such as rivers and streams. This research project will develop a mechanistic understanding and manipulation of the enzymatic degradation of CNTs that can be employed for future environmental remediation that aims to mitigate possible toxicological effects of CNTs before these materials enter the human body.

APPROACH

The basis for this research project is rooted in the findings by our research group that the enzyme, horseradish peroxidase (HRP), can degrade carboxylated CNTs in the presence of low concentrations (~40 μM) of hydrogen peroxide (H_2O_2). The focus of this project is to obtain a fundamental mechanistic understanding of this enzymatic degradation process, which will be accomplished by three approaches. First, the environmental and structural factors affecting the kinetics of CNT degradation using HRP will be identified. Next, to promote the degradation of pristine CNTs, HRP will be modified, and the CNTs will be noncovalently functionalized. Finally, the intermediate products of HRP-degradation of CNTs and their potential toxicity will be determined.

EXPECTED RESULTS

The factors impacting the mechanism of HRP catalyzed degradation of CNTs will be ascertained during this comprehensive study. By performing the research outlined in the first approach, the optimal pH, temperature, and concentration of H_2O_2 for maximizing the kinetics of *in vitro* HRP degradation of carboxylated CNTs will be ascertained. Second, modifying the cofactors of HRP to create a more hydrophobic active site should enhance its interaction with pristine CNTs resulting in their degradation. In addition, a precedent has been established for the coating of CNTs with natural organic matter (NOM), which enables CNTs to disperse in aqueous media. This increased hydrophilicity should promote favorable interaction between HRP and the coated-CNT conjugate, resulting in the degradation of pristine material that was functionalized through noncovalent approaches. Finally, because HRP is known to facilitate the heterolytic cleavage of H_2O_2 to form Compound I and water, it is expected that the majority of products from this reaction will consist of highly oxidized aromatic hydrocarbons and oxidized aliphatic hydrocarbons. Moreover, we expect to see CO_2 gas production as an indication of complete degradation. By examining the literature, the toxicity of the products of degradation will be ascertained.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

While production companies increase their output of CNTs to meet growing demand, the risk of environmental contamination of this toxic material is increased. Such contamination can subsequently diffuse through aquifers and residential drinking water. As a result, necessary precaution will have to be taken to insure that the public, as well as the manufacturers, are safe from the toxic effects associated with CNTs. This project comprehensively outlines a method to safely degrade CNTs employing the enzyme HRP. Armed with the findings of this work, environmental engineers will be well equipped to develop *in situ* remediation schemes for environmental systems to mitigate CNT toxicity.

Keywords: *carbon nanotubes, toxicity, enzymes, horseradish peroxidase, degradation, environmental contamination, environmental remediation*

Stephen R. Lantz

EPA Grant Number: FP917139
Institution: University of California, Berkeley (CA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
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BIO:

Stephen Lantz received his Bachelor's degree in Chemistry from SUNY Stony Brook in 2008. During the summer prior to completion of his degree he worked as an intern in the Toxicology and Drug Chemistry Laboratory of the Suffolk County Medical Examiner's Office in New York. He began a Ph.D. program in Molecular Toxicology at the University of California, Berkeley in fall 2008. His research aims to un derstand the interaction of a major herbicide (glufosinate) with the mammalian nervous system.

SYNOPSIS:

Genetically-modified (GM) plants, as well as herbicides used in conjunction with them, are often the tools of choice to increase crop yields and feed an expanding population. Weed resistance developed to the safest and most used her bicide (glyphosate) is requiring the deployment of less safe alternatives. This research defines the neurotoxicity of the main herbicidal alternative for GM crops, glufosinate. The results are necessary for informed human and environmen tal safety decisions.

P

Glufosinate Neurotoxicity Targets

OBJECTIVE(S)/RESEARCH QUESTION(S)

This research will determine if the neurotoxicity of the major organophosphorus herbicide glufosinate is primarily due to glutamate subtype *N*-methyl-*D*-aspartate (NMDA) receptor activation, glutamine synthetase inhibition or another high affinity glufosinate binding site interaction using radioligand binding and enzyme assays coupled with structure activity and molecular biology approaches.

APPROACH

Radiolabeled [^{3}H]glufosinate will be synthesized at 30-60 Ci/mmol and used in kinetic and competition binding assays of mouse brain membrane and cytosol fractions to characterize the binding site. Comparative assays with known NMDA or glutamate receptor radioligands will be carried out to further characterize the interaction of glufosinate with known molecular sites. Glutamine synthetase inhibition will be analyzed by colorimetric assay for glutamine formation. Interactions of glufosinate with glutamate receptors (binding assays) and glutamine synthetase (colorimetric assays) will be compared in sensitivity, localization and toxicological relevance.

EXPECTED RESULTS

Binding assays will define a high affinity glufosinate binding site in brain that is glycine concentration dependent, and inhibited by known NMDA receptor antagonists or agonists. I also expect to find that the characterized binding site is more important to neurotoxicity than glutamine synthetase inhibition. Conversion to the *N*-acetyl derivative of glufosinate by plants is the mechanism for resistance in GMO plants. *N*-Acetyl glufosinate is also more likely than glufosinate to cross the blood brain barrier. The interaction of glufosinate and the *N*-acetyl derivative with glutamate receptors and glutamine synthetase will be compared. These results will constitute a much better understanding of the relevant site(s) for glufosinate neurotoxicity than currently exists.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Increasing worldwide population and decreasing farmlands are leading to demands for increased crop yields. GM crops are being developed and utilized in response to this demand. Glufosinate-resistant and related GM crops are one of the leading solutions to date. The potential for human exposure to glufosinate crop applications and residues is high. The knowledge base on the glufosinate neurotoxic phenotype is incomplete. The projected increase in demand for GM crops, and thereby glufosinate, signals an increasing need to fully characterize the neurotoxic phenotype. In line with this need, this study aims to achieve a better understanding of glufosinate through characterization of the binding site and analysis of multiple target site relevance. With more complete knowledge about the neurotoxic effect, more educated use decisions can be made to protect humans and the environment.

Keywords: *glufosinate, glutamate receptor, neurotoxicity, radioligand, binding site*

Stacey Marie Louie

EPA Grant Number: FP917141
Institution: Carnegie Mellon University (PA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Stacey Louie received her B.S. in Chemical Engineer ing from the University of Texas at Austin in 2009. She has participated in undergraduate research programs in air quality and environmental remediation. She entered the Civil & Environmental Engineering Ph.D. program at Carnegie Mellon University in Fall 2009 and is currently researching nanoparticle fate and transport in Dr. Gregory Lowry's group as part of the Center for the Environmental Implications of NanoTechnology (CEINT).

SYNOPSIS:

The use of nanoparticles (NPs) in consumer products is in creasing, but their environmental impact remains to be fully characterized. NPs are typically coated with polymers (engi neered or incidental), which control their distribution in the environment. This project focuses on determining the role of the coated NP structure on fate and transport. This work will contribute to environmental modeling and exposure risk assessments, thus helping to advise regulatory guidelines for nanotechnology.

P

Deposition of Polymer- and NOM-Coated Nanoparticles to Environmental Surfaces: Conceptual Model Development and Validation

OBJECTIVE(S)/RESEARCH QUESTION(S)

Nanoparticles are typically engineered with polymer coatings and can become further coated with natural organic matter (NOM) upon release to the environment. These coatings control nanoparticle fate and transport and hence bioavailability and exposure risk; therefore, a comprehensive model to predict nanoparticle transport (as controlled by deposition) must consider the properties of the coating. This project will determine the effect of the morphology of the coated nanoparticles on their deposition to environmental surfaces.

APPROACH

The overall approach is to systematically create a model set of polyelectrolyte-coated nanoparticles over a range of morphologies and to measure their deposition onto silica surfaces on laboratory scale columns and Quartz Crystal Microbalance (QCM). The morphologies will range from individual polymer-decorated nanoparticles where the radius of gyration of the polymer is less than 0.1 times the diameter of the NP, to a nanoparticle-decorated polymer (two or more particles) where the radius of gyration of the polymer is 10 to 50 times the NP diameter. First, titanium dioxide nanoparticles will be coated using poly(acrylic acid) (PAA) of various molecular weights. These coated nanoparticle systems will be characterized by several methods, including transmission electron microscopy and atomic force microscopy, to determine their morphologies. Then, deposition of the coated nanoparticles will be measured in column and QCM studies to quantitatively determine the impact of morphology on deposition. After testing these model synthetic macromolecule coatings, various NOM coatings will be similarly tested to extend the study to natural environmental systems.

EXPECTED RESULTS

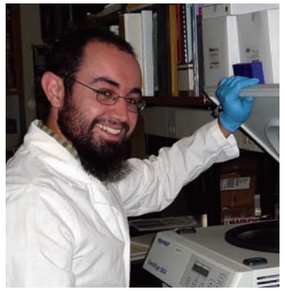
The two end member morphologies (polymer-decorated nanoparticles and nanoparticle-decorated polymers) are expected to show significantly different deposition behavior. Deposition of the polymer-decorated nanoparticle is expected to follow the extended DLVO model, which accounts for electrosteric interactions between the nanoparticle and the surface. Conversely, the nanoparticle-decorated polymer structure is expected to show deposition behavior more similar to that of the macromolecule itself. The effect of NOM coatings on morphology and deposition are expected to depend on the properties of the NOM (e.g. molecular weight and rigidity). The results of this research will contribute to models used to predict nanoparticle transport and partitioning in the environment.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Risk assessments for environmental and human health protection must account for both toxicity and exposure risks. The deposition behavior of nanoparticles, which is controlled by their macromolecule coatings, will determine their partitioning among environmental media and the risk of potential exposure and bioavailability to humans and ecological communities. Therefore, a thorough, quantitative understanding of the role of polymer and NOM coatings on nanoparticle deposition will contribute to exposure risk assessments for nanoparticles, which will provide guidance for environmental regulations.

Keywords: *environmental nanotechnology, nanoparticle fate and transport, nanoparticle deposition, nanoparticle coatings, polymer coating, natural organic matter*

Robert Alan Miranda



EPA Grant Number: FP917143
Institution: Northern Arizona University (AZ)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/30/2010 – 8/29/2013
Project Amount: $111,000.00
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BIO:

Robert Miranda grew up in San Antonio, Texas, and earned his B.S. and M.S. degrees in Biology in 2004 and 2006, respectively, from the University of the Incarnate Word (UIW) in San Antonio. He remained at UIW as an instruc tor before starting the Ph.D. program in Biology at Northern Arizona University (NAU) in Flagstaff. He earned a trainee ship from NAU's National Science Foundation (NSF)-fund ed IGERT program, which supported the development of his dissertation topic. Robert's current research examines the impact of exposure to environmental pollutants on verte brate social behaviors and related neuroendocrine signaling in the brain.

SYNOPSIS:

Environmental pollutants can disrupt normal functioning of the endocrine system. These endocrine disruptors can impact an organism's development, physiology, or behavior by mimicking or inhibiting natural hormone and chemical signaling. This project aims to understand how exposure to common environmental pollutants and the timing of expo sure during an organism's lifetime affects neuroendocrine regulated vertebrate social behavior and related gene ex pression using *Xenopus tropicalis* as a model.

P

Impacts from Exposure to Common Chemical Pollutants on Neuroendocrine-Regulated Behavior and Related Gene Expression

OBJECTIVE(S)/RESEARCH QUESTION(S)

Sex steroids play a critical role in developmental and adult expression of behavior through actions on the brain that impact the arginine vasotocin (AVT)/vasopressin (AVP) systems. Although several studies have investigated how estrogenic endocrine disrupting compounds impact gonadal development, almost nothing is known about how exposure to environmental estrogens impacts the AVT/AVP signaling system. Using *Xenopus tropicalis* as a model species, the objectives of this project are 1) to determine whether adult exposure to a human exposure concentration of individual common endocrine disrupting compounds or a mix of these compounds impacts AVT-mediated vocal behavior and genes involved in estrogen and AVT signaling in the brain, and 2) to determine the impact of developmental exposure to endocrine disrupting compounds on AVT and neuro-estrogen signaling systems and on adult behavior.

APPROACH

This project will examine the impact of exposure to a single known contaminant or a complex mix of contaminants on AVT/AVP sensitive social behaviors. Working from behavior to gene expression, the exposure effects on AVT-signaling systems and on the estrogenic components that may be involved in regulating social behavior will be evaluated. Using male Western clawed frogs as an animal model, one study will examine the impact of adult exposure on AVT-regulated sexual behavior, including vocalizations, and brain expression of related genes. In another study, behavior and gene expression will be evaluated after males are exposed to contaminants during their development.

EXPECTED RESULTS

Changes in vocal behavior and brain expression of related genes are expected after chemical exposure. Differential effects are also expected based on the time of exposure during the animal's life. Results from this study may lead to a better understanding of 1) how estrogen regulates development of the AVT/AVP behavioral system, 2) the molecular mechanisms involved in how environmental estrogens can modulate behavior, 3) how the timing of exposure to these compounds during an animal's life may be important in understanding their impacts, and 4) how mixes that are relevant to those found in human plasma impact behavior and neuroendocrine signaling processes.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

By evaluating multiple neuroendocrine endpoints in the same individuals throughout their life history and linking these results to behavior, the outcome of this research may help to understand the impacts of exposure to different compounds found in the environment, as well as the importance of the timing of exposure to these compounds. Because the AVT/AVP signaling system is so tightly conserved across vertebrates, results from this study may be applicable to our understanding of the impacts of chemical exposure on wildlife species and on human health.

Keywords: *endocrine disruptors, arginine vasotocin, arginine vasopressin, social behavior, vocalizations, Xenopus tropicalis, Western clawed frog*

Shannon Mary Mitchell

EPA Grant Number: FP917144
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EPA Project Officer: Gladys Cobbs-Green
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Project Amount: $111,000.00
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BIO:

Shannon Mitchell was raised in Union, OR, and was high school co-valedictorian in 2004. She then attended the University of Idaho and graduated with a B.S. in Biological and Agricultural Engineering in 2009. With her Engineer in-Training certification, she began the Ph.D. program in Biological Systems Engineering at Washington State Univer sity, Pullman. Her specific research interests are in studying organic contaminants in the environment. She currently is researching the fate and transport behaviors of some human and veterinary antibiotics.

SYNOPSIS:

Trace antibiotic levels in the environment are an increasing public health concern, as these pharmaceutical compounds have been linked to the promotion of antibiotic resistant bacteria. Moreover, their impacts on ecosystem functions remain unknown. This project studies antibiotic presence in environmental samples such as manure, compost, anaero bic digestion effluent and biosolids. It also analyzes antibi otic dissipation mechanisms in soil and water systems.

P

Anaerobic Digestion and Composting Treatment Efficiency of Cephalosporins

OBJECTIVE(S)/RESEARCH QUESTION(S)

Human and veterinary antibiotic excretion and the subsequent release of un-metabolized antibiotics into the environment following differ-ent waste management practices is a human and environmental health concern. Several studies have identified antibiotics in surface water and groundwater, but antibiotic quantification in environmental matrices such as biosolids, manure, compost, and anaerobic digestion effluent has been performed to a lesser extent. This research project will investigate antibiotic presence in processed and unprocessed solid waste products and analyze antibiotic persistence during composting and anaerobic di-gestion. It will also investigate antibiotic chemical behaviors in soil and water systems.

APPROACH

The first step in quantifying antibiotic presence from manure, compost, anaerobic digestion effluent, and biosolids will be to determine appropri-ate antibiotic extraction and sample clean-up methods. Then, environ-mental samples will be collected around Washington State and analyzed for selected human and veterinary antibiotics. By examining samples before and after waste treatment using scaled-down treatment units, antibiotic treatment efficiencies will be identified. Antibiotic dissipation mechanisms will also be tested under laboratory conditions by control-ling for chemical degradation, biological degradation, and sorption.

EXPECTED RESULTS

Processed and unprocessed solid waste products are land applied as fertilizer, and in many confined animal feeding operations compost is used for cattle bedding. This is concerning because antibiotic presence promotes antibiotic resistance. This research will quantify antibiotic presence in compost and other land-applied solids, and the results will be provided to resource managers, which will help facili-tate antibiotic exposure evaluation and risk assessments in confined animal feeding operations.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Antibiotics that are more mobile in soil may contaminate drinking water; however, less mobile antibiotics may persist in soils, where bio-accumulation and antibiotic resistance in soil bacteria are promoted. Antibiotic resistance has been increasing, and critically important medicines may no longer be first-line agents due to developed antibi-otic resistance in pathogens. This project has the potential to further human and environmental health protection by identifying antibiotic presence in environmental samples, investigating antibiotic persistence during waste treatment, and analyzing the compound mobility in soil and water systems.

Keywords: *antibiotic, biosolids, compost, anaerobic digestion waste, manure, treatment, soil, water, degradation, sorption, waste management practices, contaminant, fate and transport, antibiotic resistance, health risk*

Pamela Diane Noyes

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Project Amount: $111,000.00
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BIO:

Pamela Noyes received her B.S. from the University of Maryland and M.S. in Environmental Science from Johns Hopkins Uni versity in 2002. She worked as a scientist and project manager for the U.S. Environmental Protection Agency for several years where, over the course of her tenure, she assisted in developing and communicating Agency positions on ecological risk assess ment topics, providing scientific analysis to support water quality regulations and policies, and conducting and managing human health and ecological effects evaluations for pesticides. Subse quent to her work with EPA, Pam began her Ph.D. in Environ mental Toxicology and Chemistry at Duke University. Her research focuses on examining the aquatic effects of brominated flame retardant chemicals. She is currently researching the underlying mechanisms by which the polybrominated diphenyl ether (PBDE) flame retardants are metabolized in fish and are disrupting thy roid system regulation.

SYNOPSIS:

Polybrominated diphenyl ethers (PBDEs) are flame retardant chemicals added to consumer products such as furniture, car seats, and electronics to reduce their flammability. They are now widespread contaminants in both living and non living parts of the environment. The core questions I am seeking to answer center on determining: 1) how young and adult fish are breaking down PBDEs to more persistent and toxic products; and 2) how these compounds are potentially disrupting the fish thyroid system.

P

Metabolism of PBDEs in Fathead Minnows (Pimephales promelas) and Effects on Thyroid Regulation

OBJECTIVE(S)/RESEARCH QUESTION(S)

Polybrominated diphenyl ethers (PBDEs) are flame-retardant chemicals added to consumer products such as furniture foam, carpets, car seats, and electronics to reduce their flammability. PBDEs are released into the environment through numerous pathways, and they are now environmentally ubiquitous. This contamination is highest in people and wildlife in North America. Evidence suggests that PBDEs may be neurodevelopmental toxins. They also perturb the endocrine system of vertebrates by impairing thyroid function, which plays a key role in growth, development, and metabolism of all vertebrates. Core objectives of this research are to determine how young and adult fish, as important indicators of overall environmental health, are metabolizing PBDEs to more persistent, bioavailable, and potentially toxic metabolites, and how these compounds may disrupt fish thyroid regulation.

APPROACH

This research will focus primarily on decabromodiphenyl ether (BDE-209). BDE 209 is the primary congener in the high production volume mixture known as DecaBDE, which is the only commercial PBDE mixture still used today. The first phase of this research project will measure the accumulation of BDE-209 and its metabolites in fathead minnow (*Pimephales promelas*) adults, larvae, and juveniles receiving dietary exposures to BDE-209. This initial phase will also involve using *in vitro* assays of sub-cellular fractions to help identify enzyme systems catalyzing PBDE metabolism by examining the activity of potential biotransforming enzymes across different fathead minnow life stages. PBDE metabolism in rodents and humans appears to occur primarily through oxidative, cytochrome P450 (CYP)-mediated pathways, which generate hydroxylated metabolites (e.g., OH-BDEs). In fish, however, studies suggest that PBDE metabolism occurs via a reductive dehalogenation pathway. No hydroxylated metabolites have been observed to form metabolically in PBDE-exposed fish. An important hypothesis of this research is that deiodinase (DI) enzymes, which aid in vertebrate thyroid hormone homeostasis, may be involved in this reductive debromination pathway in fish. This will be the first study to apply liquid chromatography tandem mass spectrometry (LC/MS-MS) methods, recently developed in our laboratory, to measure DI activity and contaminant effects on DI activity. The second phase of this research will explore thyroidal effects and mechanisms of thyroid dysfunction at different levels of the thyroid axis of adult fathead minnows exposed to BDE-209 via the diet. This phase of the research will examine BDE-209 effects on circulating thyroid hormone levels (i.e., thyroxine (T4) and triiodothyronine (T3)) and thyroid follicle morphology. It will also examine whether these BDE-209 exposures alter the expression of genes encoding important thyroidal and hepatic proteins involved in thyroid hormone homeostasis. Genes that will be examined include those encoding DI enzymes, thyroid hormone receptors and transporters, thyroid stimulating hormone (TSH), and hepatic metabolizing enzymes. This research will be the first evaluation of the mRNA expression of DI isoforms in fish exposed to PBDEs.

EXPECTED RESULTS

PBDE effects on fish and other wildlife continue to be poorly understood, and this research will contribute to filling this data gap. It will increase our understanding of PBDE metabolic pathways and mechanisms of thyroid dysfunction in fish exposed to this important class of contaminants. Substantial differences in the biotransformation of PBDEs have been observed between mammals and fish. While the reductive debromination of PBDEs to potentially more persistent and bioactive congeners appears to be a major metabolic pathway in fish, the involvement and role of specific enzyme systems are largely unknown. This will be the first research to more clearly address why there appear to be substantial differences between how mammals and fish metabolize PBDEs. Moreover, DI-catalyzed metabolism of an environmental contaminant would be a novel pathway not observed previously in vertebrates. By examining PBDE metabolism across different life-stages, this research will help to elucidate whether early life-stages of fish may be especially sensitive to these contaminants. Finally, work under this project will further our understanding of PBDE effects across different levels of the fish thyroid system, including their potential to alter peripheral thyroid hormone levels, thyroid hormone-regulated gene transcription and metabolic activity, and thyroid follicle morphology.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Data collected under this research project will help to inform decision-making to balance the benefits gained from the use of PBDEs with their potential to cause adverse effects in sensitive wildlife populations and humans. Because the thyroid system is highly conserved across vertebrates, results of this work could have broader applications to elucidate PBDE effects on human health. Finally, this PBDE effects research will combine the use of chemical, biochemical, sub-cellular, histological, and molecular assays and techniques. This type of integrative approach may serve as a useful model for detecting contaminant impacts among wild fish populations and for evaluating the potential for other contaminants to cause thyroid disruption.

Keywords: *PBDE, brominated flame retardant, endocrine disruption, thyroid, hormone, aquatic toxicology, ecotoxicology, metabolism, bioavailability, bioaccumulation, pollution, contaminant*

Leila Margaret Nyberg

EPA Grant Number: FP917146
Institution: Purdue University (IN)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/16/2010 – 8/15/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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E-mail:

BIO:

Leila Nyberg received a Bachelor's degree from Kansas State University in 2001. Her ongoing Ph.D. work at Pur due University involves risk assessment of nanomaterials and other emerging contaminants, using molecular genetic techniques to detect changes in structure and function of microbial communities in response to these new materials. Ms. Nyberg received an M.S. degree from Purdue Univer sity in 2008. She also participates in an education and outreach project to address environmental issues in Native Alaskan Villages.

SYNOPSIS:

The environmental impact of single-walled carbon nano tubes (SWNT) is largely unknown. In this study, microor ganisms from an anaerobic wastewater treatment digester are exposed to SWNT functionalized with carboxyl groups (-COOH) and polyethylene glycol (-PEG). Gas formation is monitored and genetic tests are used to generate a micro bial community fingerprint, in order to determine whether or not these new materials affect the structure and function of the microbial community.

P

Advancing Techniques to Link Microbial Community Structure with Function to Assess the Impact of Emerging Contaminants using f-CNTs as Model Compounds

OBJECTIVE(S)/RESEARCH QUESTION(S)

My objective is to determine the effect of functionalized single-walled carbon nanotubes such as SWNT-PEG and SWNT-COOH on the structure and function of an anaerobic microbial community, in addition to directly assessing the bioavailability of SWNT-PEG. My first hypothesis is that community function will be affected by exposure to the functionalized nanotubes (f-CNTs), and my second hypothesis is that microbial community structure will be affected as well. Finally, I hypothesize that PEG diol dehydratase will be induced in response to SWNT-PEG.

APPROACH

Anaerobic digester sludge from the Greater Lafayette wastewater treatment plant is used to construct microcosms, which are exposed to SWNT-PEG and SWNT-COOH. All treatments and reference samples are assembled in triplicate. Community function is assessed by monitoring gas formation (methanogenesis), detecting genes related to methanogenesis and acetogenesis, and using the diol dehydratase assay. Community structure is assessed by using polymerase chain reaction with denaturing gradient gel electrophoresis (PCR-DGGE). Domain-level as well as group-specific primers will be used to detect microbial community shifts.

EXPECTED RESULTS

Preliminary results show that SWNT-COOH significantly increases gas formation, with DGGE results showing microbial community shifts over time. Continuing this analysis will elucidate the effect of SWNT-COOH over exposure times of a few months, while determining whether or not SWNT-PEG becomes bioavailable and exerts an impact on the microbial community over a longer period of time. This information will contribute to risk assessment of nanomaterials and inform their responsible manufacture and disposal.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Anaerobic digester microbial communities are receptors for emerging contaminants such as nanomaterials. These engineered microbial communities serve as important model systems for other anaerobic communities found in soil, in sediment, and in the stomachs of ruminant animals. Land application of sludge biosolids, and the importance of maintaining effective wastewater treatment systems, make understanding the effects of new chemicals in such environments important for human health as well as environmental management.

Keywords: *nanomaterials, nanotoxicology, anaerobic, emerging contaminants, nanotubes, wastewater treatment, molecular genetics*

Amber Ford Reogner

EPA Grant Number: FP917148
Institution: University of California, Davis (CA)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/15/2010 – 8/14/2013
Project Amount: $111,000.00
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BIO:

Amber Roegner received a B.S. in Environmental Engineering from Yale University in 2002. She worked for Cody Ehlers Group in environmental consulting and groundwater remediation until 2004. Prior to starting at the University of California, Davis Veterinary School in 2006, she participated in a Anadromous Fish Evaluation Project in Oregon and in a Fulbright-Hayes project in Nigeria. Her Ph.D. in Pharmacology and Toxicology began in 2008 and focuses on improving risk assessment and detection of the freshwater harmful algae bloom toxins, microcystins, and she will collaborate internationally to protect public health.

SYNOPSIS:

Microcystins (MCs) are potent liver toxins produced in freshwater blooms worldwide. MCs affect diverse species from fish to cows to humans in environmental waters and present a public health threat, as they persist in boiled drinking water. Over 80 structural variants exist, yet risk assessment relies on one variant. This project will evaluate comparative toxicity and species differences, screen for antidotes, and more thoroughly evaluate extent of exposure in human populations.

P

Development of Novel Risk Assessment and Screening Approaches for Microcystin Congeners in Freshwater Harmful Algae Blooms

OBJECTIVE(S)/RESEARCH QUESTION(S)

With rising global temperatures and surface nutrient runoff, harmful toxin-producing cyanobacterial blooms in freshwaters worldwide only stand to increase. The persistent microcystins, the most commonly identified family of toxins present in these freshwater blooms, continue to pose a public health threat in surface waters utilized for drinking and recreation worldwide. Yet huge gaps in risk assessment of the over 80 structural variants remain, along with many unknowns regarding mechanism of toxicity in the diverse species affected by the potent liver toxin. This project will evaluate comparative congener hepatotoxicity, probe species differences in hepatocellular uptake of the toxins to better understand mechanism of toxicity, and aim to improve available detection techniques in water and biological matrices. In addition to enabling screening for potentially effective antidotes in various species, the work will potentially improve evaluation of risk from drinking water and seafood in chronically exposed human populations through improved detection techniques.

APPROACH

The first stage of the research will compare congener hepatotoxicity *in vitro* relative to the most current marker of toxicity, protein phosphatase inhibition, and probe whether alternative markers offer a better predictor of hepatoxicity. Primary mammalian and piscine cells will be utilized to evaluate species differences in uptake and susceptibility to toxicity. In addition, the novel approach of aggregate culture will be utilized to facilitate more *in vivo*-like and sustained function of both primary hepatocytes and immortalized cell lines with potential application to direct toxicity screening of water samples. Finally, international work will include the development and application of a low-cost, easy-to-use, monoclonal ELISA to evaluate the extent of exposure via drinking water and seafood sources globally.

EXPECTED RESULTS

Because of previous case reports of animal intoxications linked to other congeners, it is expected that microcystin-LR will not be the congener with greatest hepatocellular toxicity and that protein phosphatase inhibition will not be a good predictor of relative congener hepatocellular toxicity. In addition, it is expected that hepatocellular uptake of the toxins will play a substantial role in species differences and be a good predictor of toxicity *in vitro*. Not only will these results provide guidance for monitoring and improved risk assessment, but also lend insight into mechanisms of toxicity and potential intervention strategies for both humans and veterinary species. The development of a low-cost, easy-to-use, monoclonal ELISA will facilitate detection in both drinking water and biological matrices in low-income areas of the world for improved detection and evaluation of chronic exposure.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The work will provide a more thorough evaluation of comparative congener toxicity in addition to species differences in toxicity that can directly be utilized to make improved monitoring and risk assessment suggestions for communities potentially exposed to the toxins in freshwaters worldwide. In the case of acute scenarios, it may lead to an antidote or alternative intervention strategy, while a more rugged, low-cost ELISA will enable a more thorough evaluation of chronic exposures through drinking water or food sources in developing nations.

Keywords: *microcystins, cyanotoxins, freshwater harmful algae blooms (HABs), microcystin LR, cyanobacteria, aggregate culture, drinking water, risk assessment, algae toxins, public health, detection methods, in vitro toxicity*

Greg L. Saylor

EPA Grant Number: FP917149
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EPA Project Officer: Gladys Cobbs-Green
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Project Amount: $111,000.00
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BIO:

Greg Saylor received his B.S. in Civil Engineering from the University of Cincinnati in 2010. He is currently com pleting the requirements for his M.S. in Environmental Engineering as part of a joint B.S./M.S. program. He was selected as the M.S. recipient of the 2010 American Wa ter Works Association (AWWA) LARS scholarship. As part of his undergraduate co op program, he began his Master's research studying the toxicity of by products generated from the electrochemical treatment of wastewater. His doctoral research focus will be understanding the toxic ef fects of pesticides in drinking water.

SYNOPSIS:

This project will consider the effects of drinking water treatment processes on the toxicity of pesticides that can be present in contaminated water sources. Water will be tested before and after treatment to understand how toxicity changes. One of the key aspects of this work will be studying the toxicity of mixtures. Understanding these mixtures will allow drinking water utilities to identify best management practices for producing the safest drinking water possible.

P

Combined Toxicity of Pesticides in Drinking Water: A Sustainable Optimization of Current Drinking Water Treatment Oxidation and Carbon Filtration Methods

OBJECTIVE(S)/RESEARCH QUESTION(S)

The purpose of this project is to address the toxic mixtures that are created in drinking water by pesticides and their degradates that have the potential of expressing greater toxicities when mixed. In addition, traditional oxidation practices used in drinking water treatment may worsen the situation through the creation of more toxic by-products. This project will explore the effects of chemical disinfection processes on pesticides present in drinking water.

APPROACH

The primary objective of this project is to learn more about the complex interactions of toxic substances in mixtures. The project will be completed in three phases. First, toxicity data will be obtained through testing single pesticides as well as controlled mixtures. Second, a laboratory treatment system will be used to determine the optimum operating conditions to minimize effluent toxicity with synthetic influent spiked with pesticides. The system will consist of two batch reactors: pre-disinfection using potassium permanganate, and post-disinfection using chlorine. A granular activated carbon (GAC) filter will be applied to simulate processes employed by a local, currently impacted drinking water treatment plant. This leads to the third phase, where the same system will be utilized to treat pesticide-impacted lake water samples.

EXPECTED RESULTS

There are two major expected results of this study. First, this study will provide a better understanding of the toxicity of commonly used pesticides, both individually and in mixtures. This information will be very important in assessing the toxic effect of multiple pesticides present in water samples. Second, this study will provide more information about the effect of drinking water treatment processes on pesticides that may be present in the influent. Understanding the effects of the treatment processes combined with the toxicity information will allow for the determination of an optimal treatment system/configuration that will minimize the toxicity of the finished drinking water.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This project directly relates to the safety of drinking water from pesticide-impacted sources. Many pesticides persist in soil and water and have been linked with both environmental and human health concerns. Understanding synergism, antagonism, and the impact of conventional oxidation practices on mixtures of pesticides will help regulators and water utilities produce the safest drinking water possible.

Keywords: *pesticides, drinking water, toxicity, disinfection, oxidation, microtox*

Natalia M. VanDuyn

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Institution: Indiana University (IN)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
E-mail:

BIO:

Natalia VanDuyn received her Bachelor's degree in Biol ogy from Indiana University in 2007. She then joined the Indiana University School of Medicine's Biomedical Gate way Program and chose to pursue her doctoral degree in the Department of Pharmacology and Toxicology under the guid ance of Richard Nass, Ph.D. Natalia is utilizing the nema tode *Caenorhabditis elegans* to identify and characterize the molecular pathways involved in methylmercury toxicity.

SYNOPSIS:

Methylmercury (MeHg) is a ubiquitous environmental toxi cant that can result in severe neurological and developmen tal defects. Although MeHg has been studied for decades, the molecular basis for the toxicity remains largely un known. My project utilizes the nematode *C. elegans*, a small worm whose genes and cellular response to stress are very similar to those of humans, to identify and characterize the molecular pathways involved in MeHg-induced developmen tal defects and neuropathology.

P

Mechanisms of Methylmercury-induced Cellular Stress in Caenorhabditis elegans

OBJECTIVE(S)/RESEARCH QUESTION(S)

Methylmercury (MeHg) is a ubiquitous environmental contaminant that poses a considerable threat to public health. MeHg easily crosses the blood brain barrier and the placenta, leading to developmental deficits and neuropathology. Although MeHg poisonings have been studied for decades, the molecular basis for the toxicity remains largely unknown. My objective is to identify and characterize the cellular and molecular components involved in MeHg toxicity.

APPROACH

I will utilize a novel *C. elegans* model for MeHg toxicity to identify and characterize the molecular pathways involved in MeHg toxicity. I will generate transgenic *C. elegans* animals and incorporate biochemical and genetic analysis to identify MeHg sensitive cells, and determine if the stress-responsive proteins GSTs, MAPKs, and SKN-1 may modulate toxicant-induced cellular vulnerability. I will also incorporate a reverse genetic screen to identify proteins involved in MeHg toxicity.

EXPECTED RESULTS

I have recently shown that the expression of particular GSTs and SKN-1 is involved in inhibiting MeHg-induced cellular stress. I expect that these proteins and their downstream targets will modulate DA and GABAergic neuronal vulnerabilities to the toxicant. GSTs and members of the MAPKs also likely play a role in the MeHg-induced developmental deficits and neurodegeneration, and I expect that decreases in gene expression will increase cellular stress and cellular dysfunction. Furthermore, the incorpo-ration of the reverse genetic screen will likely identify novel regulators of the MeHg induced cellular stress and neuron degeneration.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The cellular and molecular basis for MeHg-induced toxicity and devel-opmental defects are largely unknown. This proposal will likely eluci-date cellular sensitivities and novel molecular pathways involved in the toxicant-induced pathology. The identification of genes and molecules involved in the toxicity may provide novel MeHg-associated therapeutic targets. Furthermore, these studies may identify early molecular markers of MeHg-induced pathology that may be utilized to determine specific toxicant-associated exposures.

Keywords: *methylmercury, neurodevelopment, oxidative stress*

Erin Elizabeth Yost

EPA Grant Number: FP917151
Institution: North Carolina State University (NC)
EPA Project Officer: Gladys Cobbs-Green
Project Period: 8/16/2010 – 8/15/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Pesticides and Toxic Substances
E-mail: eeyost@gmail.com

BIO:

Erin Yost received a B.S. in Biology from the University of Kentucky in 2003. Following her graduation, she worked for several years as a laboratory technician and as an itinerant field biologist. From 2006 – 2008, she served as a Peace Corps volunteer in Madagascar, where she worked as an agricultural consultant in a rural village. She entered the Toxicology Ph.D. program at North Carolina State University in the fall of 2008. Her current research involves the fate, transport, and biological activity of estrogenic compounds derived from industrial hog farms.

SYNOPSIS:

Waste from industrial hog farms has been shown to contrain known endocrine distruptors, including animal hormones and bioavabilable nitrogen. Although the precise mechanism for endocrine disruption by nitrogen remains unclear, it has recently been observed that the nitrite anion (NO2-) may be able to activate the estrogen receptor (ER). This project examines the ability of NO2- to activate the ER, and explores the use of a mathematical model to predict toxicty of an estrogen-nitrite mixture.

P

Estrogen Receptor Agonists in Swine Waste: Using a Concentration Addition Model to Predict Mixture Effects

OBJECTIVE(S)/RESEARCH QUESTION(S)

Swine waste is known to contain numerous known and suspected endocrine-disrupting compounds, including animal hormones and bioavailable nitrogen. Although the precise mechanism for endocrine disruption by nitrogen compounds remains unclear, it has recently been observed that the nitrite anion may be able to directly activate the estrogen receptor (ER). I intend to test the hypothesis that a mixture of nitrite and hormonal estrogens, such as that which may be found in runoff or leachate from an industrial hog farm, will activate the ER in a manner that is predictable using a concentration addition model.

APPROACH

As part of a concurrent study of the fate and transport of estrogens in a swine feeding operation, I currently am determining the concentrations of estrogenic hormones present in swine waste lagoon slurry. In this proposed project, I will establish concentration-response curves for ER activation by these estrogens (e.g., estradiol, estrone, estriol) and nitrite as individual compounds. This will be done in vitro using a mammalian cell-based reporter assay, as well as *in vivo* using the male Japanese medaka as a model organism. Parameters from these concentration-response curves will then be plugged into a concentration addition model, and used to predict the effects of an estrogen-nitrite mixture. Validity of the model predictions will then be tested both *in vitro* and *in vivo.*

EXPECTED RESULTS

This project will quantify the ability of the nitrite anion to activate the ER in both *in vitro* and *in vivo* models, and will examine the utility of a concentration addition model in predicting the effects of an estrogen-nitrite mixture. If the concentration addition model fails, then the applicability of other models (e.g., an integrated addition and interaction model) will be examined. This project will also help determine whether activation of the ER is a relevant mechanism for nitrogen-mediated endocrine disruption in vivo. Additionally, it will examine the efficacy of using an in vitro bioassay to predict concentration additivity of a mixture *in vivo.*

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This study will advance our understanding of the links between nitrogen-polluted waters and endocrine disruption, and will help us understand the potential contribution of nitrite in an estrogenic milieu. Hormones and nitrogen are both ubiquitous contaminants of concern in aquatic environments, and it is realistic to assume that these two contaminants will often occur in tandem—not only downstream from industrial animal farms, but in many other sites as a result of human development. The U.S. EPA has acknowledged the importance of evaluating the health effects of chemical mixtures, and biological studies such as this one are needed to help us accurately predict the risk that these mixtures will pose in the environment.

Keywords: *swine, CAFO, estrogen, nitrogen, nitrite, chemical mixture, endocrine disruption, medaka, concentration addition model*

Science & Technology for Sustainability

- Green Engineering/Building/Chemistry/Materials

- Energy

- Environmental Behavior & Decision Making

Science & Technology for Sustainability Fellows



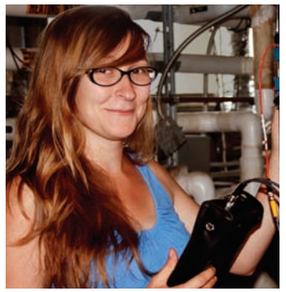
GREEN ENGINEERING/BUILDING/CHEMISTRY/MATERIALS

ENERGY

ENVIRONMENTAL BEHAVIOR & DECISION MAKING

Green Engineering/Building/Chemistry/Materials

Lindsay A. Baker



EPA Grant Number: FP917153
Institution: University of California, Berkeley (CA)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
E-mail: lindsay_baker@berkeley.edu

BIO:

Lindsay Baker is a doctoral student in the UC-Berkeley Col lege of Environmental Design, focusing in Building Science and the study of green schools. She received her M.S. in Architecture from UC-Berkeley, and her B.A. in Environ mental Studies from Oberlin College. She has worked for many organizations involved in green building, including the U.S. Green Building Council. She is a researcher at the Center for the Built Environment at UC-Berkeley, where she focuses on post-occupancy evaluation of buildings.

SYNOPSIS:

In recent years, a major shift has occurred in the American building industry, through the growth of 'green' building standards. However, studies in the past 2 years have found that many green buildings use much more energy than ex pected. This project aims to learn more about this problem, specifically in K-12 school buildings. It will examine occu pant influence on energy use, and aims to inform designers on how to build in a way that saves energy over the lifetime of a school building.

S Green Engineering/Building/Chemistry/Materials

Energy Efficiency in K-12 Public Schools: Investigating Behavioral and Operational Factors

OBJECTIVE(S)/RESEARCH QUESTION(S)

This research project will investigate how occupants interact with buildings in order to inform the building industry on how to better accommodate user's needs while optimizing energy performance. Specifically, it will address three interrelated questions: First, how does occupant behavior impact energy use in K-12 school buildings? Second, what design features and occupant comfort factors drive these behaviors? And finally, what best practices can be identified and disseminated that will contribute to enhancing building design in ways that will minimize energy consumption in buildings?

APPROACH

Taking a comparative case study approach and looking critically at occupant behavior (such as window opening and thermostat control), this investigation engages a group of representative school buildings across the country to identify triggers that are leading to increased energy use. Current trends in design are leading towards removing user control of building systems like lighting, heating, and cooling. However, this ultimately can lead to increased energy use, as users supplement their environments with personal equipment like space heaters. Through interviews, field measurements of indoor environmental quality, behavior pattern documentation and analysis of energy consumption data, profiles will be constructed that show how occupants affect energy consumption in buildings, and what conditions either enable or restrict occupants from helping to reduce the energy consumption of building systems.

EXPECTED RESULTS

This research project will ultimately provide documented behavior patterns and feedback from occupants that help to identify design strategies that have achieved high levels of occupant comfort and low energy consumption. Through a better understanding of how occupants use light switches, windows, thermostats, and other energy-related controls, designers will be more equipped to consider these factors in creating more efficient buildings.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The technology to build highly efficient buildings is available today, and yet buildings continue to contribute significantly to global climate change through excessive electricity use. This project will help identify ways to save electricity in buildings through strengthening the feedback loop between occupant needs and design approaches, to optimize energy consumption and indoor environmental quality in schools. Performing this study in schools yields the added benefit of educating younger generations on the importance of energy conservation and environmental responsibility.

Keywords: *Behavior, consumption, buildings, schools, occupant feedback, electricity loads, end-use efficiency, indoor environments, human health*

Lauren Elizabeth Hale

EPA Grant Number: FP917246
Institution: University of California, Riverside (CA)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
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BIO:

Lauren Hale graduated *summa cum laude* from North Caro lina State University in 2007 with a Bachelor's of Science in Microbiology. As an undergraduate, she focused on the bioremediation of environmental contaminants. In 2009, she began a Ph.D. program in Environmental Microbiology at the University of California, Riverside. Her studies ad dress the use of biochar, a sustainable, carbon-sequestering soil amendment, and its capability to serve as an inoculums medium for the application of plant-growth-promoting bac teria to agricultural soils.

SYNOPSIS:

The goal of this project is to optimize a combination of biological fertilizers and a soil amendment, biochar, to improve soil fertility of arid-zone soils. The extent to which bacteria produce enzymes that interfere with plant-stunting hormones and the ability of these microorganisms to thrive in the pores of biochar particles will be measured using quantitative PCR and fluorescent, transgenic bacteria. This system provides an eco-friendly soil treatment useful for sustainable agriculture.

S Green Engineering/Building/Chemistry/Materials

Advancing Soil Fertility: Biochar and Plant-Growth-Promoting Rhizobacteria as Soil Amendments

OBJECTIVE(S)/RESEARCH QUESTION(S)

Many studies have displayed the ability of plant-growth-promoting Rhizobacteria (PGPR) to serve as eco-friendly, biological fertilizers when applied to agricultural soils. Furthermore, a soil amendment, biochar, improves a soil's fertility and nutrient and water-use efficiencies and also has the potential to mitigate climate change by sequestering carbon into soils. The objective of this research is to develop a treatment of biochar inoculated with a bio-fertilizer that will optimize the positive benefits associated with PGPR.

APPROACH

This study is centered on the ability of PGPR to produce 1-aminocyclopropane-1-carboxylate (ACC) deaminase, an enzyme that degrades a precursor of plant hormone ethylene. Ethylene is produced by plants in response to drought or high salinity and causes stunted root growth, reducing crop yields drastically. The first phase of this study will employ quantitative PCR to enumerate ACC deaminase genes across soil bacterial populations in the rhizospheres of cowpea plants treated with combinations of bio-fertilizer and biochar. DNA will be isolated from zones soil directly affected by plant roots, the rhizosphere, in weekly intervals throughout a drought-simulated root-box experiment. The abundance of ACC deaminase genes in this DNA will be correlated with plant growth patterns, treatment type, and time. The second phase of this experiment will examine the expression of ACC deaminase genes by a bacteria modified to display bioluminescence when ACC deaminase is expressed. This will allow for the detection of gene expression in relation to location and time and will display the overall survival of the soil inoculates.

EXPECTED RESULTS

From the first phase of this study it should become apparent that there is a combination of biofertilzer and biochar treatments that maximize the ability of cowpea plants to thrive under stress from drought. Furthermore, the gene copy number of ACC deaminase necessary to influence cowpea survival can be quantified. Once this treatment is determined the second phase of this experiment should produce more evidence supporting the ability of these combined soil amendments to improve bacterial enzymatic promotion of plant growth. The observation of bioluminescence will give insight as to when and where microbial expression of ACC deaminase is the most influential. Furthermore, bacteria inoculated directly into soils often are not competitive with native microorganisms and their populations quickly diminish. It is expected that biochar will provide soil inoculants with pre-associated niches, increasing their survival in soil and attributing biological fertilizers with longer lasting benefits.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This research can be directly applied to arid-zone agriculture to combat the effects of desertification by rejuvenating soils and increasing their water and nutrient use efficiencies. Improved soil health lessens the need for chemical fertilizer applications which can help prevent disastrous environmental problems associated with eutrophication. Furthermore, insight into the potential of biochar to function as an inoculums medium can promote its production from biological wastes, preventing these materials from emitting large amounts of carbon dioxide into the atmosphere by being burned, composted, or stored in landfills.

Keywords: *biochar, biological fertilizers, PGPR, ACC deaminase, land use efficiency, biological-waste management, sustainable agriculture, mitigation of climate change*

Meghann Elizabeth Jarchow

EPA Grant Number: FP917160
Institution: Iowa State University (IA)
EPA Project Officer: Jose Zambrana
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
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BIO:

Meghann Jarchow received a Bachelor of Arts in Biology from Ripon College in 2003 and a Master of Science in Biology from Minnesota State University, Mankato in 2005. She then worked at Gustavus Adolphus College as a biology instructor for 2 years teaching and coordinating introductory biology laboratories. Meghann left Gustavus to pursue her Ph.D. at Iowa State University in June 2007. At Iowa State, she is co-majoring in Ecology and Evolutionary Biology and Sustainable Agriculture and studies how agroecological principles can be applied Midwestern agricultural systems.

SYNOPSIS:

The developing lignocellulosic biofuel industry provides an opportunity to reincorporate perennial vegetation into the Corn Belt. Reincorporating native prairies could ameliorate many of the negative environmental impacts caused by an nual row crops. The goals of this project are to compare the productivity and biofuel yields of prairie and corn cropping systems and to assess the relationships among diversity, nitrogen fertilization, and productivity of prairies managed for biofuel production.

S Green Engineering/Building/Chemistry/Materials

Comparing Ecological Processes and External Inputs as Mechanisms for Increasing Prairie Productivity for Biomass Production

OBJECTIVE(S)/RESEARCH QUESTION(S)

My broad research objective is to compare prairie and corn cropping systems with regard to their suitability as biofuel feedstocks. I am comparing the growth, phenology, productivity, and estimated biofuel yield of prairie and corn systems. I also am determining the relationships among species and functional diversity, nitrogen fertilization, and productivity in prairie systems.

APPROACH

My approach to understanding my research objectives is to conduct two field experiments in addition to laboratory analyses. Having two field experiments has allowed me to address my research objectives from multiple perspectives. In one field experiment, I am focusing specifically on the growth dynamics, phenology, and productivity of prairie, fertilized prairie, continuous corn, and continuous corn with rye cropping systems and on the effects of nitrogen fertilization on prairie species diversity. The second field experiment focuses on the effects of varying functional diversity and nitrogen fertilization on prairie phenology, productivity, and estimated biofuel yield and compares these characteristics to a continuous corn system. Laboratory analyses are used to determine carbon and nitrogen concentrations in the plant tissues throughout the growing season and are used to estimate the corn and prairie biofuel yields.

EXPECTED RESULTS

I am beginning my third field season with both experiments, so I now am able to comment on my observed results. I have found that prairie systems utilize more of the growing season than corn systems, but that corn systems produce more harvestable biomass than prairie systems. Nitrogen fertilization increases the productivity of the prairies, but reduces both species and functional diversity in terms of richness and evenness. Increasing functional diversity in the prairies does not increase prairie productivity beyond that of the most productive single functional group (i.e., transgressive overyielding) in the presence of nitrogen fertilization, but transgressive overyielding may occur in the most diverse unfertilized prairies. Both the functional groups present and whether nitrogen fertilization was applied affects the estimated biofuel yields of prairies, but the functional group affects the composition of the feedstock while fertilization affects the quantity of feedstock.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The trend in agriculture in the Midwestern United States for the last half century has been one of increasing simplification and intensification, which has resulted in cropping systems that are dominated by monocultures that require large inputs of fertilizers, herbicides, and other fossil-fuel derived inputs. Although these systems are incredibly productive with regard to saleable goods and are profitable with governmental subsidies, they cause a wide range of environmental degradation including increased nutrient pollution, increased soil erosion, and decreased biodiversity. Finding economically viable ways to reincorporate diverse, native prairies back into the landscape can ameliorate many of the environmental impairments caused by our current agricultural system while still benefiting farmers.

Keywords: *agroecology, biofuels, continuous corn, diversity-productivity relationships, ethanol, functional diversity, grasslands, prairies*

Sarah C. Taylor Lange

EPA Grant Number: FP917176
Institution: University of Texas, Austin (TX)
EPA Project Officer: Jose Zambrana
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
E-mail: staylorla@gmail.com

BIO:

Sarah is a native of the Napa Valley, California. She re ceived her Bachelor's degree in Civil and Environmental Engineering from the University of California, Davis, and her Master's degree in Civil Engineering from the University of California, Los Angeles. Prior to pursuing her doctorate degree at the University of Texas at Austin, she worked as a professional structural engineer. Sarah is a LEED Ac credited Green Building Professional, and a former Pacific Earthquake Engineering Researcher at Stanford University. Beyond academia, Sarah is an avid equestrian, who com peted internationally in the sport of dressage.

SYNOPSIS:

This project is a comprehensive study that focuses on understanding the effects of using calcined clays as sus tainable, green building materials. The developed materials will minimize energy demand and carbon dioxide emissions associated with cement manufacturing. In addition, radon emission, ozone interaction, and mold resistance of the new clay-cement blend will be investigated to assess its effects on indoor air quality.

S Green Engineering/Building/Chemistry/Materials

Calcined Clays as a Low Emission Cement Substitute

OBJECTIVE(S)/RESEARCH QUESTION(S)

The cement industry is responsible for 3.4 percent of the global an-thropogenic carbon dioxide emissions contributing to adverse climate changes. Moreover, the World Health Organization states that 1.5 mil-lion people die each year from causes directly attributed to indoor air pollution. My doctoral project aims to use calcined clays as a partial cement replacement in concrete, to reduce the energy demand and carbon dioxide emissions of cement manufacturing while meeting the structural functionality and indoor emissions criteria for use as a green building material.

APPROACH

The first phase of my research focuses on identifying inexpensive and abundant chemicals that will reduce the activation energy and duration of clay calcination, necessary for converting clay to display cement-like behavior. Then, concrete samples prepared with calcined clays will be tested to evaluate their structural functionality against ASTM standards. The overall energy demand and carbon dioxide emissions associated with these samples will be quantified and compared with those of cur-rent concrete manufacturing. The second phase of my research focuses on the emission characteristics of calcined clay-concrete affecting indoor air quality. In particular, the radon emission, ozone interaction, and mold resistance of the new clay-cement blend will be investigated to assess its effects on indoor air quality.

EXPECTED RESULTS

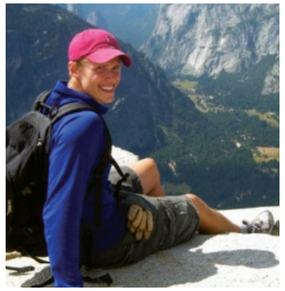
This study provides a better understanding of clay-cement materials including: (i) their associated energy demand and carbon dioxide emis-sions of their manufacturing and transport, (ii) their structural perfor-mance and properties, and (iii) their emission characteristics affecting indoor air quality. Preliminary research shows that clay requires half of the activation temperature necessary for limestone cement manufactur-ing. In addition, some supplementary cement materials decrease mate-rial porosity, aiding in both external durability and improved indoor air quality. Studies have demonstrated that some green materials, including clay substances, undergo significant oxidation, creating an indoor ozone sink, reducing the indoor ozone concentration levels. It is expected that the clay-cement will display similar qualities.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The development of green building materials based on calcined clays will have both environmental and health benefits. First, the environ-mental benefits will include: (i) the energy and carbon dioxide emis-sion reduction in cement manufacturing and transportation, and (ii) the use of local materials for sustainability. Finally, the health benefits will include: (i) minimization of worker health risks by using less toxic materials, and (ii) improved indoor air quality through use of non-emitting cement mixtures.

Keywords: *climate change, supplementary cement materials, pollution, indoor air quality, cement manufacturing, ozone, radon, carbon dioxide, green materials, sustainable building materials, health risks*

Aaron Travis Michel



EPA Grant Number: FP917165
Institution: Stanford University (CA)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
E-mail: atmichel@stanford.edu

BIO:

Aaron Michel received a B.S. in Civil Engineering from Oregon State University in 2006, and an M.S. in Structural Engineering from Stanford University in 2009. As a Ph.D. candidate at Stanford University, his research focuses on the design and manufacture of biobased polymers and com posites for use in the construction industry. His ultimate goal is to contribute to the development and incorporation of innovative sustainable technologies in structural engi neering.

SYNOPSIS:

Resource consumption and waste production by the con struction industry have motivated the investigation of in novative building materials. Biobased composites made from polyhydroxybutyrate (PHB) biopolymer and natural fibers have comparable mechanical properties to wood used in construction, and offer an alternative that requires less energy to produce, reduces landfill waste, and biodegrades anaerobically. This project examines efficient and effective uses for these biobased composites.

S Green Engineering/Building/Chemistry/Materials

Biobased Sandwich Panels for Construction Applications

OBJECTIVE(S)/RESEARCH QUESTION(S)

Biobased composite materials made from polyhydroxybutyrate (PHB) and natural fibers have useful mechanical characteristics while in service, and can rapidly biodegrade after their useful life. This project aims to replace what is a primarily linear system of construction (i.e., raw materials to built systems to waste materials), by using resources that are easily sustainable, harvestable, or otherwise readily available and will biodegrade rapidly and completely in an anaerobic environment after their useful life. Sandwich panels constructed from biobased composite face sheets and an insulating core will be investigated with the objective of increasing structural efficiency and thermal resistance.

APPROACH

The technical challenge of this project is in balancing (1) the engineering of a low-density structural element with comparable mechanical and thermal properties to traditional construction materials, with (2) the engineering of a useful structural material that possesses excellent structural properties while in service but rapidly biodegrades after its useful life. This work will be accomplished by designing and evaluating structural sandwich panels made from PHB-natural fiber composite face sheets and biodegradable foam cores. The work will consist of the following tasks: (1) sandwich panel design using experimentally determined material constitutive models and finite element analysis (FEA); (2) characterization of biobased sandwich panel mechanical, thermal, and weathered properties; (3) manufacturing analysis of production techniques at varying scales (i.e., laboratory vs. commercial); (4) design for long-term performance and rapid post-use biodegradation; (5) construction application case study using a scale pilot project.

EXPECTED RESULTS

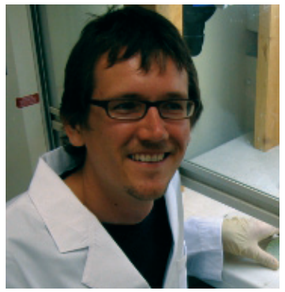
PHB-natural fiber biobased composite sandwich panels can be engineered to have comparable structural efficiency (i.e., strength/stiffness-to-weight ratio) and superior thermal performance to traditional construction materials, such as wood and engineered wood products. Long-term weathered panel performance will be improved by the addition of biodegradable chemical fiber modifications and sealants, while post-use anaerobic biodegradation will be accelerated by appropriate composite design and the selection of suitable environmental conditions (to be performed by others). A simplified design framework for engineering practitioners will be developed using classical composite theory, FEA analysis, and empirical test results. It is also expected that biobased sandwich panels can be manufactured using both lab and industrial scale hot presses, and that large-scale panel production is possible using the existing infrastructure for engineered wood products. Biobased composites and sandwich panels will be useful in many construction applications, such as formwork, scaffolding, lagging, paneling, flooring, and temporary housing.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The broad impacts of this project include (1) the introduction of a construction material that is fully recyclable and producible globally; (2) a reduction in construction resource consumption and demolition waste disposal in landfills; and (3) a reduction in greenhouse gas emissions associated with the production and use of traditional building materials and from un-captured methane from landfills. This research will also address underprivileged and minority groups by employing materials that can be grown locally, reducing the financial and environmental burden of shipping and the inequality imposed by local material availability.

Keywords: *biobased, biocomposite, sandwich panel, SIP, natural fiber, construction, anaerobic biodegradation*

Thomas Oliver Morse



EPA Grant Number: FP917166
Institution: Duke University (NC)
EPA Project Officer: Jose Zambrana
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
E-mail: thomas.morse@duke.edu

BIO:

Thomas Morse is a Ph.D. student working with Dr. Gunsch at Duke University. Before attending graduate school, Thomas spent 2 years as a Peace Corps volunteer in Panama. In Panama, Thomas worked with rural farmers on small scale reforestation, organic agriculture techniques, and composting latrine construction. Thomas received his B.A. from the University of Colorado at Boulder with *magna cum laude* honors for his thesis, which analyzed the variability of our current climate regime.

SYNOPSIS:

The efficiency of large-scale microalgal cultivation for biodiesel production is inhibited by invasive species. This project will use gene silencing to remove invasive species to permit the more efficient growth of high-lipid algae. The expected outcome of this project is the development of a green biocide compatible with large-scale microalgal culti vation techniques, which will provide a clean and sustain able source of energy, ultimately reducing U.S. dependency on foreign fuels.

S Green Engineering/Building/Chemistry/Materials

The Removal of Invasive Species Through Gene Silencing in Microalgae Cultivation for Biodiesel

OBJECTIVE(S)/RESEARCH QUESTION(S)

Recently, there has been an increased interest in biodiesel production due to the increasing environmental and economic costs of petroleum sourced fuels. Algae remain a promising feedstock for biodiesel production because the lipids in algae are easily converted into biodiesel. While the idea is technically feasible, invasive species such as viruses, bacteria, rotifers, and low-lipid algae outcompete the high-lipid strains causing a species collapse and a significant algal crop reduction. There have been many attempts to control invasive species using biocides. However, biocides are not selective enough to permit the growth of high-lipid algae. Therefore, there is a need for a selective biocide that will remove the invasive species, while permitting the high-lipid algae to grow. One specific tool that has the potential to fill this need is antisense gene silencing. This research project will investigate the feasibility of using antisense gene silencing for microalgal crop protection.

APPROACH

This research project will assess the feasibility of using gene silencing for microalgal crop protection. The first phase will be dedicated to elucidating the environmental parameters for optimal silencing. BLAST alignments will be performed to identify genes unique to the invasive species and to eliminate possible off targets. Once the genes have been selected for silencing, a suite of environmental parameters will be tested. In the second phase mixed culture experiments will be performed with a high-lipid algae and either a low-lipid algae or an invasive bacterium. The third phase of the experiment will compare two different delivery methods: direct diffusion and vector delivery. Initial work on vector delivery will focus on lentiviral delivery systems, because of their previous use in gene silencing experiments. The final phase will involve bench-scale experiments in a raceway pond. A plastic raceway pond will be constructed that measures 2 m × 0.5 m and that will be run for 120 days.

EXPECTED RESULTS

The successful completion of this project will be a significant advancement in promoting a domestic supply of sustainable biodiesel. Additionally, the "green" biocide proposed in this project is significantly less toxic to the environment compared to current biocides and algaecides.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This technology has potential uses for mitigating harmful algal blooms and for the removal of chlorine-resistant pathogens in industrial settings. Additionally, this technology has the potential to be used for inactivating pathogens in point-of-use water filtration systems. There are also many positive externalities in improving the delivery of gene silencing oligonucleotides, as the medical field is evaluating RNAi therapies (e.g., for the treatment of cancer), and a greater understanding of oligonucleotide delivery will have direct applications in the treatment of cancer.

Keywords: *algae, biodiesel, green engineering, gene silencing, RNAi, CRISPR*

Leanne Marie Pasquini

EPA Grant Number: FP917167
Institution: Yale University (CT)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
E-mail:

BIO:

Leanne Pasquini graduated from Hamilton College in 2007, where she majored in Chemistry and minored in Education. As the 2007 08 recipient of the George Watson's College Teaching Fellowship, she spent the year teaching at George Watson's College in Edinburgh, Scotland. After returning she taught Chemistry and AP Chemistry at St. James School. Leanne is currently enrolled in the Environmental Engineer ing Ph.D. program at Yale University. Under the guidance of Dr. Julie B. Zimmerman, Leanne's research focuses on the environmental implications of nanotechnology.

SYNOPSIS:

Advances in nanotechnology promise improved performance and novel applications in fields ranging from electronics to medicine. Studies report a variety of toxic responses upon exposure to nanomaterials, yet there is no cohesive body of research to verify the proposed human health and environ mental threat. This project will contribute to filling the void in comprehensive research and determine how engineered material modifications can decrease toxicity while maintain ing the material's applicability.

S Green Engineering/Building/Chemistry/Materials

Engineering a Greener Future One Carbon Nanotube at a Time: An In-Depth Study of Non-Toxic Single Walled Carbon Nanotube Design

OBJECTIVE(S)/RESEARCH QUESTION(S)

While the nanotechnology industry continues to expand, there remains uncertainty surrounding predicted environmental and human health risk upon exposure to various nanomaterials. It is imperative that research be conducted that brings assurance to the future incorporation of poten- tially harmful materials into consumer goods. It is known that several nanomaterials, in particular SWNTs, exhibit toxic effects. Research has also shown that certain chemical manipulations of the nanotube surface can decrease their toxicity. This aspect is of interest to the current work intended to facilitate safer design of carbon nanomaterials for the purpose of eliminating potential environmental and human health implications.

APPROACH

Full characterization of purchased and purified pristine unfunctional- ized SWNTs will provide the basis of comparison for future surface modified tubes. Characterization techniques will include Thermogravi- metric Analysis (TGA), Raman Spectroscopy, Zeta Potential, Scanning Electron Microscopy (SEM), Energy Dispersive X-Ray Analysis (EDX), Fourier Transform Infrared Spectroscopy (FTIR), Transmission Electron Microscopy (TEM), and X-Ray Photoelectron Spectroscopy (XPS). Pu- rified pristine tubes will be used as the starting material in a variety of chemical reactions that will modify the surface with desired functional groups. Characterization of these tubes using the techniques mentioned will elucidate the success and extent of surface functionalization. A fluo- rescent bacterial assay using *E. coli* K-12 exposed to the various SWNT samples will provide data for a comparative bacterial toxicity study. Physicochemical properties of the functionalized tubes are dependent upon the pH and ionic strength and composition of a given environment. Therefore, a systematic study will be conducted to see how such changes will affect the biotoxicity.

EXPECTED RESULTS

Full characterization of each tube sample will elucidate the physical and chemical differences among the pristine and functionalized tubes. It is anticipated that overall bacterial cell death will decrease with the ad- dition of certain surface functional groups and will vary depending on the properties and extent of the chemical modifications. In addition, it is likely that changes in environmental conditions, such as pH and ionic strength and composition, will alter the bacterial toxicity, as many of the surface modifications have acid base characteristics.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The research findings will help to fill the void in information surround- ing the toxicity of carbon nanotubes and offer a standard methodology that may be extrapolated to further toxicity studies. As the number and variety of nanomaterials entering consumer goods continue to grow, increased human and environmental exposure is inevitable. More com- prehensive information regarding nanomaterial toxicity will empower scientists and engineers to formulate a design scheme for future safe manufacture of nanomaterials.

Keywords: *nanotechnology, carbon nanotubes, toxicity, environment, human health, E. coli, characterization, green design*

Erika Danielle Roach

EPA Grant Number: FP917229
Institution: Pennsylvania State University (PA)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2012
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Green Engineering/Building/Chemistry/Materials
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BIO:

Erika Roach received her B.S. in Molecular Biology at Le high University. Looking to relate her knowledge of genetics and molecular biology to a more applied field, she began her work towards a Master's degree in Agronomy in the fall of 2009 at Pennsylvania State University. Her research uses her background in molecular biology as an analytical tool to learn more about sustainable agriculture systems. Her work focuses on differences in expression of a candidate group of genes in corn grown using conventional and sustainable management techniques. She hopes to uncover molecular mechanisms behind phenotypic differences often seen in corn grown in no-tillage and/or with cover crops versus corn grown in tilled fields without cover crops. This work spans the gap between plant biology and agronomy and could help promote sustainable agriculture to scientists, extension agents, and farmers.

SYNOPSIS:

Developing sustainable agricultural systems will lead to so lutions to environmental issues associated with convention al agriculture. I will examine the expression of candidate genes in maize grown in sustainable agricultural systems and conventional agricultural systems. If gene expression in corn changes to promote crop health and vitality as a result of sustainable farming methods, farmers, scientists, and extension agents will be provided with incentive to implement sustainable methods.

S Green Engineering/Building/Chemistry/Materials

Effects of Sustainable Soil Management on Gene Expression in Maize

OBJECTIVE(S)/RESEARCH QUESTION(S)

Project Objectives: 1. Determine the effect of a hairy vetch cover crop, no-tillage, and their interaction on soil and crop health and expression of a candidate group of genes in maize. 2. Be able to use gene expression results to help explain observed plant and soil health and quality results. 3. Determine how gene expression changes are manifested in protein level changes.

APPROACH

The field trial is a split-plot in a randomized complete block design. The main plots are cover crop (hairy vetch) versus no cover crop, and the sub-plots are no-tillage versus moldboard/disk/harrow tillage. Plant parameters I will measure include plant emergence regularly during the first 6 weeks after planting; plant population at 3 weeks after planting; plant height at 4 and 8 weeks after planting and at maturity; leaf carbon and nitrogen content at V6, silking, and grain fill stages; chlorophyll content at V6 and bi-weekly after V6; leaf area index at V6 and bi-weekly after V6; plant moisture content at V6, silking, and grain fill stages; and grain yield upon harvest of maize for grain. I will also score each plot regularly during the season to determine presence and extent of pests and disease infestation. Soil parameters I will measure include bulk density in the first month after planting and after harvest; surface soil moisture weekly; organic carbon and total soil nitrogen content once at the beginning of the season; active carbon and nitrate content monthly for the first 3 months after planting; available P, K, Ca, Mg, pH, and cation exchange capacity one time at the beginning of the season; aggregate stability at V6 and after harvest; soil temperature hourly with data loggers; and earthworm population one time at the beginning of the season. Gene expression analysis that I will conduct includes sampling leaves during V6, silking, and grain fill stages from the ear leaf or youngest fully developed leaf in V6. These samples will be frozen in liquid nitrogen and used for subsequent gene expression analysis, protein analysis, and carbon and nitrogen content evaluation. Gene expression analysis will be conducted initially only on samples taken during V6 stage to get a general idea of expected results while maintaining a manageable sample size. Candidate genes were chosen based on predicted environmental differences between treatments as well as results from similar research done studying gene expression in tomatoes planted in hairy vetch residue compared to no cover. In analyzing gene expression in my plant samples, I will isolate total RNA, synthesize cDNA, and conduct reverse transcriptase PCR and real-time PCR using primers designed specifically for the genes of interest. Objective 2: Plant and soil measurements will be compared to the results of the gene and protein expression analysis. Statistical analysis will be performed using analysis of variance (ANOVA) and other statistical tools. Objective 3: I will work with Dr. Autar Mattoo at the USDA ARS in Beltsville, MD, to study expression of proteins in plant samples in order to determine if gene expression differences are also manifested in protein expression differences.

EXPECTED RESULTS

I expect to see changes in gene expression due to environmental changes experienced by maize growing in different treatments. I expect to see higher expression of cold tolerance genes early in the season in maize growing in no-tillage and in fields with a cover crop mulch due to cooler soil temperatures experienced in these treatments. I expect to see higher expression of drought tolerance genes in maize grown in fields without a cover crop and in fields with tillage. This is due to higher temperatures and lower soil moisture associated with these treatments. I expect to see higher expression of nitrogen-responsive genes in fields with a hairy vetch cover crop due to the high levels of nitrogen supplied to the soil as hairy vetch breaks down. I expect to see the greatest difference early in the season before side-dress fertilization and later in the season when hairy vetch has had time to fully break down. I also expect to see higher expression of nitrogen-responsive genes in tilled fields with hairy vetch early in the season because tillage helps accelerate the breakdown of hairy vetch. I expect to see higher expression of nitrogen-responsive genes in no-tillage fields with hairy vetch later in the season when the hairy vetch on the tilled fields has broken down almost completely and the vetch mulch remains on the no-tillage fields to further provide nutrients. I expect to see genes associated with senescence expressed at lower levels in fields treated with hairy vetch mulch and no-tillage. This prediction is based on results of similar research in tomatoes grown in hairy vetch mulch. For the same reason, I expect to see higher expression of genes associated with defense against pests and disease in maize grown in no-tillage and with a hairy vetch cover crop. I expect to see results that indicate improved soil quality in fields treated with a hairy vetch cover crop and no-tillage. I expect to see higher presence of pest and disease issues in plants grown with a cover crop in no-tillage early in the season but I expect this difference to not be manifested in yield differences.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This study will supply novel information about how sustainable soil management practices affect crops grown for profit. This information will enable scientists to better understand the phenotypic changes in crops observed in sustainable systems. The results of this study can be used to better understand the fundamental mechanisms of sustainable agriculture. By providing sustainable agriculture with a stronger justification, wider implementation will likely follow. Conventional agricultural systems can contribute to environmental degradation such as air and water pollution, soil structure and health depletion, erosion, and reduction of natural biodiversity. The movement toward more sustainable systems will become increasingly important when considering the growing world population and rising importance of environmental stewardship. Cover crops benefit the health of the soil in which they are grown and the health of crops grown after. Cover crops supply nutrients to the following crop, provide organic matter to improve soil quality, and supply mulch to improve soil physical and biological properties. Legumes help to fix atmospheric nitrogen for the following crop. Hairy vetch fixes high levels of atmospheric nitrogen, has vigorous growth, fits well into diverse cropping rotations, has low fertility needs, and is winter hardy. Cover crop root systems assist in soil erosion prevention, retrieve available nutrients in the soil after a cash crop, and help to prevent runoff of agricultural chemicals over the winter. Erosion is a major cause of soil and crop quality depletion in much of the cropland in the United States. Using a no-till farming system not only helps in erosion control, it helps maintain soil aggregate and overall structure and helps maintain crop residue and organic matter on the soil surface. This research would help scientists, extension agents, and farmers better understand the effects of sustainable soil and crop management techniques on gene expression in a widely grown crop. Uncovering genetic explanations for negative and positive phenotypes resulting from use of cover crops or no-tillage could assist in the negation of negative responses and the enhancement of positive responses. The end result of this research would be to provide further incentive for farmers to implement environmentally sustainable farm management techniques and for scholars and extension agents to have a scientific basis to further promote their use.

Keywords: *sustainable agriculture, cover crops, no-tillage, gene expression, hairy vetch*

Energy

Jonathan Paul Badalamenti

EPA Grant Number: FP917152
Institution: Arizona State University (AZ)
EPA Project Officer: Jose Zambrana
Project Period: 8/19/2010 – 8/18/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Energy
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BIO:

Jonathan earned his Bachelor's degree in Biochemistry and Molecular Biology with honors from Penn State in 2007. He entered the Ph.D. program in Microbiology at Arizona State University the same year and was awarded a Graduate Research Fellowship from Science Foundation Arizona. His research examines the utilization of photosynthetic micro organisms in generating renewable energy. He is currently studying the application of these organisms in microbial fuel cells to produce hydrogen.

SYNOPSIS:

Renewable energy is one of the greatest challenges facing human civilization in the 21st century. The sun is Earth's most abundant power supply, yielding more energy in one hour than consumed by the planet in one year. This project seeks to develop a microbial photoelectric cell (MPC) to ex tract solar energy stored in waste biomass as electricity in a simultaneous process where photosynthetic microorganisms use sunlight to recapture electrical energy in a fuel such as hydrogen.

S Energy

Simultaneous Generation of Electricity and Hydrogen from Biomass and Sunlight via a Microbial Photoelectric Cell

OBJECTIVE(S)/RESEARCH QUESTION(S)

The numerous and potentially severe environmental threats associated with meeting energy needs by the continued combustion of fossil fuels are clear. These energy needs must be met from renewable sources well before fossil fuel supplies are exhausted in order to significantly reduce anthropogenic emissions of CO_2 into the atmosphere and mitigate harmful environmental impacts. This project will investigate the utilization of photosynthetic microorganisms in a microbial photoelectric cell (MPC) to generate electricity from biomass and, in a simultaneous process, use sunlight to re-energize electrons and produce hydrogen (H_2).

APPROACH

The first research stage will evaluate several consortia of photosynthetic bacteria for their ability to interact electrochemically with electrodes of a traditional microbial fuel cell (MFC). Bacterial electrochemical interactions with insoluble substrates, the mechanisms of which are poorly understood, appear to be ubiquitous in nature and occur among representatives of photosynthetic bacteria. MFCs generate electrical current when bacteria oxidize organic wastes and channel electrons to an electrode. In the reverse process, the reduction half-reaction can be catalyzed by bacteria fed electrons from an MFC to reduce oxidized contaminants such as nitrate, perchlorate, and uranium(VI). By overcoming unfavorable thermodynamics using sunlight as additional energy input to an MFC, the research will evaluate conditions under which photosynthetic bacteria may re-energize electrons from an MFC to yield a reduced product such as H_2.

EXPECTED RESULTS

High throughput screening of diverse samples enables facile detection of electrochemically active photosynthetic bacteria by monitoring electrical current. With evidence for current-generating and/or -consuming activities of photosynthetic bacteria in an MFC, conditions favoring growth and phototrophy can be optimized and applied to several environmental samples to investigate the ubiquity of electrochemical interactions with insoluble substrates. Such an approach is easily adaptable to several variable inputs such as light regime, electrochemical potential, temperature, and salinity. Moreover, the MPC presents a novel tool for isolating photosynthetic bacteria directly from natural habitats. Combining these results with analyses of microbial ecology using molecular methods on conserved genetic markers identifies and quantifies key microbial players and thus targets for further study and improvement of system performance. These findings will be critical for designing a robust MPC which couples generation of electricity from organic waste and sunlight-driven recapture of electrons in H_2.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Climate change poses arguably the greatest threat to the protection of environmental and human health in this century. Direct contribution of human activities to climate change provides a convincing case for urgent investigation into substitution of fossil fuel-based energy infrastructure with renewable alternatives. The MPC establishes a potential framework to lessen dependence on combustion of fossil fuels, a major contributor to climate change, by generating energy from only renewable inputs.

Keywords: *microbial fuel cell, hydrogen, photosynthesis, energy, solar, electricity*

William K. Epting

EPA Grant Number: FP917154
Institution: Carnegie Mellon University (PA)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Energy
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BIO:

William Epting graduated from the University of Pittsburgh in 2009 with a B.S. in Mechanical Engineering. During that time, he designed and built a micro-hydroelectric turbine for rain-based power, researched and installed a solar power system at a remote university outpost, and researched vibra tions and valves in turbines. As a Ph.D. student at Carnegie Mellon University, his research in the Department of Me chanical Engineering focuses on micro-diagnostics for fuel cell and battery electrodes.

SYNOPSIS:

This work addresses the fundamental understanding of chemical transport in the reaction zones of fuel cells and batteries. Improvements in these technologies could drasti cally reduce vehicle emissions. For example, understanding how oxygen travels in a fuel cell electrode will guide the design of lower cost fuel cells. This work uses a micro-scale electrochemical approach to take measurements in elec trodes. Key findings will be analyses of reactions and degra dation, and validation of theoretical models.

S Energy

A Method for Through-Plane Measurement of Species Concentration in Porous Electrodes for Fuel Cells and Batteries

OBJECTIVE(S)/RESEARCH QUESTION(S)

Polymer electrolyte membrane (PEM) fuel cells and lithium-ion (Li-ion) batteries, backed by a sustainable energy infrastructure, present an opportunity for a transportation sector free of harmful emissions and the volatility of the global oil market. However, through-plane mass transport issues in the porous electrodes of both PEM fuel cells and Li-ion batteries remain a substantial hurdle to bring the costs of these technologies to market-ready levels. This research aims to experimentally characterize mass transport through the thickness of these porous electrodes, fundamentally enhancing the understanding of mass transport limitations, reaction kinetics, and degradation mechanisms. The data will also be applied to properly validate theoretical electrode models.

APPROACH

This research will use a micro-structured electrode scaffold (MES) to measure the concentration of reactive chemical species at discrete intervals through the thickness of a porous electrode—a measurement that has not been previously demonstrated. The MES allows layers of sensing electrodes to come into contact with the porous electrode from the side. The sub-micron thick sensing layers are employed as ultra-microelectrodes to perform electroanalytical concentration-sensing techniques, such as pulsed amperometric detection. The MES concept will initially be applied to PEM fuel cells and later to Li-ion batteries as well as battery chemistries for grid-scale renewable energy storage.

EXPECTED RESULTS

At high fuel cell operating currents, the oxygen reactant concentration distribution in the cathode is expected to shift towards the gas diffusion layer (where the oxygen enters the electrode) and away from the electrolyte membrane. The distributions will be compared with predictions from porous electrode models, providing a measure of model accuracy and directions for improving the relevant theory. The technique will be used to elucidate the effect of concentration distribution on the evaluation of reaction kinetics parameters. Measurements of degradation species, such as hydrogen peroxide in PEM fuel cells, will enhance fundamental understanding of the degradation processes that are responsible for PEM fuel cells not reaching durability targets. These measurements are particularly important in next-generation electrodes using inexpensive non-platinum-group-metal catalysts, as mass transport and degradation are particularly troublesome issues in such electrodes. In Li-ion batteries, enhanced understanding of reactant transport will guide the design of thick electrodes with high energy density and power density.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

As the U.S. depends almost entirely on oil for transportation, that sector accounts for nearly a third of U.S. CO_2 emissions, and gives rise to local pollution issues and foreign oil dependence. Widespread adoption of electric vehicles using any combination of PEM fuel cells and Li-ion batteries would cut transportation sector CO_2 emissions dramatically, and almost completely if they are backed by sustainably generated electricity and hydrogen. Furthermore, local pollution from automobile traffic leads to health issues in high population areas—an issue that will be mitigated by the zero tailpipe emissions of fuel cell and battery electric vehicles.

Keywords: *fuel cells, PEM fuel cells, lithium ion batteries, electric vehicles, transportation, sustainable energy*

Thomas Edward Ferguson

EPA Grant Number: FP917155
Institution: Columbia University (NY)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Thomas Ferguson received his undergraduate degrees in Physics and Astronomy from Vassar College in 2007. He joined Columbia University's Earth and Environmental Engi neering graduate program in September 2008. His research has focused on the development of distributed energy conversion technology for biomass that produces fuel cell-ready hydrogen coupled with carbon capture. In May 2010, he completed his Master's degree, and he is continuing his research in his current program as a Ph.D. student.

SYNOPSIS:

Due to the issues of environmental sustainability associated with anthropogenic carbon emission and energy security, there is strong interest to develop a new generation of clean energy conversion technologies that utilize domestic re sources. This project explores a method in which biomass is reacted with a hydroxide to produce hydrogen, a clean-burn ing fuel that can be used to produce power via a fuel cell, while simultaneously capturing carbon as a solid, avoiding re-emission of CO_2.

S Energy

Carbon Negative Hydrogen Production from Biomass

OBJECTIVE(S)/RESEARCH QUESTION(S)

Due to the issues of environmental sustainability associated with anthropogenic carbon emission and energy security, there is strong interest to develop a new generation of clean energy conversion technologies that utilize domestic resources. This project explores a method in which biomass is reacted with a hydroxide to produce hydrogen, a clean-burning fuel that can be used to produce power via a fuel cell, while simultaneously capturing carbon as a solid, avoiding re-emission of CO_2.

APPROACH

My Master's work demonstrated the viability of this process, known as alkaline hydrothermal treatment. My Ph.D. research will continue to explore important scientific and engineering questions. First, a variety of hydroxides such as calcium hydroxide and magnesium hydroxide will be thermodynamically and kinetically evaluated for the proposed alkaline hydrothermal treatment of biomass, starting with the model biomass compounds glucose and cellulose. Next, iron-based nanocatalysts will be incorporated in order to improve the reaction rate. Once the studies with the model compounds are completed, the developed hydrogen production system will be evaluated on heterogeneous biomass such as green algae. Finally, both environmental and economic analyses will be performed. Particularly, a detailed life cycle analysis will determine the carbon footprint of the proposed biomass refining technology.

EXPECTED RESULTS

The aforementioned experimental studies will contribute to the development of a distributed energy conversion system based on biomass. The demonstrated reaction conditions for this process of low temperature and atmospheric pressure will allow for simple reactor design, and the high purity of the hydrogen stream produced eliminates purification reactors, allowing for compact design. Kinetically, it is expected that the weaker alkaline earth hydroxides will not perform as well as the stronger alkali hydroxides during hydrogen production. However, the weaker alkaline earth hydroxides have the advantage of a lower energy requirement for their hydroxide regeneration. Alternatively, magnesium hydroxide, an alkaline earth hydroxide, would for magnesium carbonate via the proposed process, a material ready for carbon sequestration. Heterogeneous biomass feedstocks will likely require additional pre-processing as well as the identification of other gaseous and solid products. Catalysts are expected to further enhance hydrogen conversion. Finally, as the proposed scheme captures carbon, it is expected that the carbon footprint will be smaller when compared to the traditional hydrogen-from-biomass production processes of fast pyrolysis and gasification.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

By reducing our dependence on the burning of fossil fuels to obtain energy, the proposed research stands to further protect both the environment and human health. Curtailment in fossil fuel utilization would result in the mitigation of particulate matter, fine particles, volatile organic compounds, and sulfur compounds, emissions that the EPA cites as detrimental to air quality. Also, the development of the proposed distributed energy conversion system would reduce greenhouse gas emission, in particular carbon dioxide, while providing sustainable energy.

Keywords: *biomass, hydrogen, alkaline hydrothermal treatment, carbon capture and storage*

Claudia Maria Hitaj

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Institution: University of Maryland, College Park (MD)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Energy
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BIO:

Claudia Hitaj graduated *magna cum laude* from Yale University in 2007 with a B.A. in Economics & Mathematics and a B.A. in Biology. The following year, she received her M.Phil. in Environmental Policy from the University of Cambridge. In 2008, she began the Ph.D. program in Agricultural and Resource Economics at the University of Maryland at College Park. Her research focuses on energy economics, particularly wind power development in the United States.

SYNOPSIS:

In the face of imminent climate change, developing low-carbon fuel sources is of great importance. One of the most promising renewable energy sources is wind. Most states offer a combination of policies to promote renewable energy, but state variability on the level and duration of policies is extensive. This project estimates the effects of each policy instrument and access to the electricity grid on wind power development. It also predicts wind power growth under a national carbon price.

S Energy

Wind Power Development in the United States – An Empirical Evaluation of the Effectiveness of State Renewable Energy Policies

OBJECTIVE(S)/RESEARCH QUESTION(S)

One of the most promising renewable energy sources in the United States is wind. In 2008, wind power contributed 42 percent of all new generating capacity. Most states have a combination of policies in place to promote renewable energy, but state variability on the level, duration, and combination of policies is extensive. There is a lack of consensus at a policy level about which instrument is most effective at promoting wind power. This research project will quantify the effects of different policy instruments and access to the electricity grid on wind power development. The project will analyze the cost-effectiveness of each policy instrument and identify current constraints to wind power development.

APPROACH

This project estimates the separate effect of each state-level renewable energy policy instrument on installed wind power capacity and explicitly accounts for windiness, access to the electricity grid, and grid deregulation status. The project uses county-level data from 1990 to 2007 and controls for local population and economic characteristics. The estimated model can be used to predict annual growth in wind power capacity across counties under a national carbon price.

EXPECTED RESULTS

The econometric analysis will shed light on which type of renewable energy policy incentive is most effective at promoting wind power. It will also determine the extent to which access to the electricity grid constrains wind power development. Investigating the counterfactual scenario of a national carbon price can identify regions in the United States that can expect large growth in wind power as a result of a greenhouse gas cap-and-trade program.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

By identifying the most cost-effective renewable energy policy instrument, this research would contribute to reducing the cost of climate change mitigation. Cost-effective policies are an important means to achieving the dual goal of economic prosperity and protection of the environment and human health through climate change mitigation.

Keywords: *Wind power, renewable resources, climate change, electric energy*

Eric S. Hittinger

EPA Grant Number: FP917157
Institution: Carnegie Mellon University (PA)
EPA Project Officer: Jose Zambrana
Project Period: 8/25/2010 – 8/24/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Energy
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BIO:

Eric Hittinger received a B.S.E. in Polymer Science and Engineering from Case Western Reserve University (CWRU) in 2002. He continued at CWRU synthesizing and charac terizing novel semiconducting polymers for use in electron ics. After acquiring an M.S. in Macromolecular Science, he worked for the U.S. Army as a Project Management Engi neer. In 2008, he entered the Ph.D. program in Engineering and Public Policy at Carnegie Mellon University where his research focuses on grid-level energy storage and integra tion of renewable generation.

SYNOPSIS:

There is a growing public and private interest in renew able energy deployment for a variety of reasons, such as carbon emission reduction and energy independence. But the variability of such technologies as wind and solar gen eration is a formidable barrier to large-scale deployment. This research examines the costs and emissions of specific systems providing fill-in power for wind farms and seeks to identify ways to affordable compensate for wind variability without increased emissions.

S Energy

Time-Series Modeling of Integrated Wind/Gas/Battery Systems for Minimization of CO2 and NOx Emissions

OBJECTIVE(S)/RESEARCH QUESTION(S)

In order to reduce carbon emissions, increasing amounts of renew-able electricity generation will be required. But most renewable energy systems, such as wind and solar, have variable power output and require dispatchable generation or energy storage to provide fill-in energy. This study examines the costs and emissions of generation/energy storage systems designed to support increasing amounts of wind generation.

APPROACH

This study will use time-series analysis of wind output, coupled with realistic modeling of gas generators and energy storage devices, for a realistic view of the potential capabilities of a composite wind/natural gas/energy storage system. By studying these composite systems with realistically modeled operation at a fine time resolution (10 seconds), we can determine the costs of operation, emissions, and operational param-eters of variously composed wind/gas/storage generation blocks. This data will help identify systems that have low emissions at a reasonable cost and can help inform policy and technology decisions.

EXPECTED RESULTS

Firstly, and most basically, this study will demonstrate that modeling varying and compensating resources using shorter time scales produces results notably different than modeling them in longer blocks. Secondly, it should demonstrate that a small amount of energy storage co-located with the fluctuating resources will reduce both the average cost of power and the emissions from compensating resources. Thirdly, a fully op-erational model as described above can immediately be used to study a number of effects related to these composite systems, such as the effect of emissions prices or improvement of energy storage technology.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Deploying renewable electricity generation is an important part of reducing carbon emissions. Thus, addressing the barriers to large-scale renewable generation is necessary to achieving a low-carbon electrical grid. This study examines methods to accommodate increased wind energy at a reasonable cost while using established technologies.

Keywords: *wind integration, energy storage, carbon emissions, wind variability, renewable portfolio standards*

Melissa Lauren Holtmeyer

EPA Grant Number: FP917159
Institution: Washington University, Saint Louis (MO)
EPA Project Officer: Jose Zambrana
Project Period: 8/1/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Energy
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BIO:

Melissa Holtmeyer received both her Bachelor of Science and Master of Science degrees in Mechanical Engineering from Washington University in St. Louis in 2006 and 2007. During her Master's work, she studied in China research ing distributed-power generation for rural communities in developing countries. She is presently pursuing a Ph.D. in Energy, Environmental & Chemical Engineering at Wash ington University in St. Louis. Her research is focused on advanced combustion techniques for emission reductions during oxy-coal combustion and biomass co-firing. Her research will involve both experiments and computational fluid dynamics (CFD) simulations.

SYNOPSIS:

Pollutant prevention and implications of power genera tion from renewable and non-renewable technologies are the focus of this project's research and teaching. Biomass co-firing with coal, a transition technology between today's coal-dominated and the future's renewable power, will be studied under air-fired and oxy-combustion conditions. The teaching component aims to educate about the challenges of various technologies through a techno-socio-economic-environmental approach to decision-making.

S Energy

Clean Energy Research and Education

OBJECTIVE(S)/RESEARCH QUESTION(S)

Geo-political stability and environmental sustainability are driving us towards a diverse energy portfolio that seeks to minimize CO_2 emissions while utilizing local and renewable resources. We quickly must make educated decisions about power generation in order to mitigate emissions and minimize the effects of climate change. My project features both research and education components to provide a well-rounded understanding of pollutant prevention and power generation. My research project focuses on understanding the potential emission reductions that can be achieved from biomass co-firing under air-fired and oxy-combustion conditions. The teaching component of my project aims to develop a course that teaches a practical approach to power generation decision-making, serving to identify the challenges in implementation of technologies, and educating the student about scientific, environmental, economic, cultural, and political issues.

APPROACH

Co-firing of biomass is an approach that can significantly limit and even reduce emissions, while minimizing disruption to the existing power infrastructure, which is primarily based around coal power plants. In addition, biomass co-firing is potentially a carbon negative process when coupled with carbon capture and sequestration. I propose to investigate co-firing of biomass with coal under both air-fired and oxy-combustion conditions for multi-pollutant prevention and control. The type of biomass co-fired, its preparation and the combustion process employed will be explored to determine the effects on flame stability, and formation of NOx and particulate matter.

With new technologies entering the energy market regularly, it is a daunting task to decide on one technology over another. To this end, a course will be developed that trains future entrepreneurs and scientists/engineers to understand how to identify truly promising technologies and to understand how they compare to alternative technologies.

EXPECTED RESULTS

Biomass in the form of agricultural waste or bioenergy crops grown specifically for energy production will constitute the majority of biomass fuels implemented. The chemical make-up of these materials is very different from coal in that they have less nitrogen, mercury, sulfur, and fixed carbon. However, they generally have increased volatiles and oxygen. Reductions in pollutants, such as SOx, Hg, and CO_2, should be seen with increasing biomass fraction. Other pollutants, such as NOx and particulate matter, are less clear. Results from this study will show trends between combustion conditions and pollutant formation based on experiments and numerical simulations.

Coupled with understanding the fundamentals of the combustion of biomass, a knowledge base of where this technology can be applied is important for directing research efforts. The development of the clean energy application course helps provide that information, while educating future decision-makers. Through this course, students will gain an appreciation of the challenges in the field of global clean energy; being able to distinguish when and where a technology offers opportunity while understanding the unique challenges that face the energy industry.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Emissions of greenhouse gases are at unprecedented levels, and although there are no direct adverse health effects, the public welfare is being affected through climate change and irreversible environmental damage. The crux of my Ph.D program is to contribute to research that can eliminate CO_2 emissions concurrently with other pollutants, while developing a course that will educate the next generation of decision makers about the appropriate choices for energy technologies.

Keywords: *biomass co-firing, oxy-coal combustion, NOx formation, energy economics, decision-making*

Markael Daniel Luterra

EPA Grant Number: FP917164
Institution: Oregon State University (OR)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Mark Luterra got an early start in environmental research, participating in citizen-science stream monitoring and bird surveys near his childhood home in rural southwestern Min nesota. He received a B.A. in Biology with a concentration in Environmental Studies from Carleton College in 2007. He worked as a natural resources specialist for the Bu reau of Land Management and the Minnesota Department of Natural Resources for a year before beginning a Ph.D. program in Biological and Ecological Engineering at Oregon State University. He is particularly interested in harnessing photosynthesis for bioenergy and in developing energy self-sufficient communities, and his current research focuses on improving hydrogen production from cyanobacteria.

SYNOPSIS:

Solar energy has strong potential to replace fossil fuels, but at present it is impossible to efficiently convert sunlight to liquid or gaseous fuel. Cyanobacteria can use sunlight to generate hydrogen gas, and the theoretical efficiency (around 10-15%) rivals that of PV panels. For efficient hy drogen production, the flow of energized electrons through competing metabolic pathways must be reduced. In this project I will downregulate two of these pathways, hopefully increasing hydrogen yields.

S Energy

Developing a Metabolic Switch for Photobiological Hydrogen Production

OBJECTIVE(S)/RESEARCH QUESTION(S)

Photobiological hydrogen production offers the promise of efficient, low-cost, and pollution-free solar energy conversion. Certain algae and cyanobacteria contain all of the required enzymes for this process, but several major challenges remain to be addressed, including redirection of electron flow to the hydrogenase enzyme. In this project I aim to increase hydrogen production from the cyanobacterium *Synechocystis* sp. PCC 6803 by downregulating electron flow through two alternative pathways and increasing hydrogenase expression.

APPROACH

I will replace the native promoter sequences of two genes essential for cyclic electron flow and electron flow to the Calvin cycle with a promoter that can be induced or repressed. I will then use microarrays to identify genes that are strongly upregulated when expression of these two genes is repressed. After confirming substantial upregulation with qRT-PCR, I will insert the promoter from an upregulated gene in place of the native hydrogenase operon promoter to obtain increased hydrogenase expression.

EXPECTED RESULTS

With downregulation of cyclic electron flow and electron flow to the Calvin cycle and increased hydrogenase expression, I expect to see dramatically increased hydrogen production under enforced anaerobic conditions and during dark-to-light transitions. While efficient hydrogen production under full light will not be achieved until oxygen tolerance of the hydrogenase is improved, the metabolic switch developed in this project will greatly enhance hydrogen production once that goal is reached. The two-way genetic switch developed here will be widely applicable to other cyanobacterial bioenergy projects, such as lipid accumulation for biodiesel, sunlight-to-ethanol, or butanol production.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Climate change, linked primarily to carbon dioxide emissions, is the largest environmental challenge facing humanity in this century. Current-generation biofuels have sunlight-to-energy conversion efficiencies of 0.1-0.2 percent, too low to meet our transportation fuel needs from available land even if substantial conservation measures are enacted. Photobiological hydrogen offers the potential for sunlight-to-fuel efficiencies exceeding 10 percent, which would greatly enhance our ability to meet our energy needs while eliminating carbon emissions.

Keywords: *hydrogen, cyanobacteria, microalgae, solar, bioenergy*

Stephen M. Rose

EPA Grant Number: FP917170
Institution: Stephen F. Austin State University (TX)
EPA Project Officer: Jose Zambrana
Project Period: 8/23/2010 – 8/22/2011
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Energy
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BIO:

Stephen Rose is an engineer interested in technical prob lems that affect public policy. He received a B.S. in Me chanical Engineering from the University of California, Berkeley and an M.S. in Mechanical Engineering from the Georgia Institute of Technology and worked for 5 years de signing control systems for large wind turbines. In his spare time, he coaches high school students in robotics contests and occasionally runs marathons.

SYNOPSIS:

The electrical power from large wind turbines varies un predictably, which can reduce the stability of the electrical power grid. This research investigates the cost-effectiveness of methods to smooth wind power variations without wind energy storage devices such as batteries. These cost com parisons will help guide policies that promote wind energy while minimizing electricity prices and maintaining the stability of the electrical system.

S Energy

Assessing the Cost-Effectiveness of Short-Term Smoothing of Wind Power

OBJECTIVE(S)/RESEARCH QUESTION(S)

The amount of wind power that can be accepted by the electrical grid is limited by the ability of other power plants to compensate for unpredictable variations in wind power. If the variability of wind power can be reduced, the electrical grid can accept more wind power without adding additional conventional power plants. This research will assess the cost-effectiveness of methods to reduce the short-term variability of wind power that can be implemented with existing technologies.

APPROACH

Three methods of smoothing wind power will be tested with a simulation of a large wind farm: wind turbine design, wind turbine control strategies, and the arrangement of turbines in a wind farm. The control strategies increase the operating cost of a wind farm, and the turbine designs and arrangement in a wind farm increase the initial cost of a wind farm. The cost-effectiveness of these methods will be compared to the cost-effectiveness of using energy storage, such as batteries, and small gas turbine power plants to compensate for wind power fluctuations.

EXPECTED RESULTS

Estimates of the cost of turbine design, operation, and placement strategies will guide policy and investment decisions. Other researchers have shown some of these strategies are technically effective for smoothing wind power, but this research will determine which ones are worth the cost. These results will guide electrical grid operators as they decide what types of new power plants to build and how to schedule them. These results will also guide government policy makers as they decide how to structure renewable energy subsidies, renewable portfolio standards, and research and development programs.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The results of this research should indirectly help to improve air quality and reduce greenhouse gas emissions by helping to increase the percentage of electricity generated from wind power. These results may also provide a cost-effective way to reduce NO_x emissions. Gas turbine power plants emit more NO_x when they rapidly vary their power output to compensate for wind power fluctuations than gas turbine power plants that output steady power.

Keywords: *wind energy, electrical grid, frequency regulation*

Lindsay Soh

EPA Grant Number: FP917173
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EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
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BIO:

Lindsay is a doctoral student in Environmental Engineer ing working with Julie Zimmerman at Yale University. She received her undergraduate degree at the University of Cali fornia, Berkeley in Environmental Engineering Science. Her research interests include green engineering and analytical chemistry, as well as the fate and impacts of anthropogenic compounds in the environment. Upon completion of her Ph.D., she hopes to pursue a career in academia.

SYNOPSIS:

Due to limited fossil fuel supplies and global climate change, alternative energy sources must be found. Biodiesel produced from algae shows great potential to sustainably replace petroleum-based transport fuel, but technological hindrances, including inefficient lipid extraction, have pre vented their implementation. This research aims to opti mize algal lipid extraction for efficiency, sustainability, and decreased hazard, focusing on using supercritical fluids as alternative, green solvents.

S Energy

Extraction of Algal Lipids for Use in Biodiesel Production

OBJECTIVE(S)/RESEARCH QUESTION(S)

Due to their high lipid content and ease of cultivation, algae are potentially ideal starting materials for the production of biodiesel that may be used to replace non-renewable petroleum based transport fuels. Though algae-based biofuels are promising, limitations in the technology needed to grow and harvest the algae as well as to extract the enclosed lipid have inhibited their implementation. The objective of this research is to contribute to the development of algal lipids into a viable energy source by optimizing lipid extraction techniques for efficiency, sustainability, decreased hazard, and selectivity, focusing on the use of supercritical fluids as alternative, green solvents.

APPROACH

In order to improve upon the current extraction methods, cell disruption, greener solvent systems, selective extraction, and simplified extraction-fuel conversion processes will be evaluated for their ability to increase efficiency and decrease hazard associated with lipid extraction. In particular, supercritical carbon dioxide ($scCO_2$) will be used as a non-polar solvent to solubilize the algal lipid. The supercritical extraction conditions will be modified by varying pressure, temperature, and co-solvent use, in order to find the most effective conditions in terms of efficiency and selectivity. The efficiency of extraction can be evaluated by assessing the fatty acid methyl ester (FAME) content of the lipid extraction and thus the algal biodiesel production potential. Further, the selectivity of each variation can be quantified by also assessing the full lipid profile of the extract, including triglyceride and phospholipid content.

EXPECTED RESULTS

While conventional solvents are effective at almost completely extracting lipids from algal cells, their drawbacks include inherent toxicity, poor selectivity, and difficult separation of the contaminants as well as solvents from the desired product. Due to their sensitivity to changes in pressure and temperature, $scCO_2$ conditions can be tuned to selectively extract the desired triglycerides, eliminating unwanted lipid-like materials such as phospholipids and pigments. Co-solvents can also be used to further enhance solubility and selectivity, raising the efficiency of extraction by $scCO_2$ closer to that of traditional solvents. Further, supercritical conditions may also be tuned to not only extract but also transesterify the algal lipids, found as triglycerides, into FAME that can be directly used as biodiesel, simplifying the multi-step process into one. In addition to triglycerides, the selectivity of supercritical fluid extraction can be used to selectively extract other materials from algae for use in products such as cosmetics, nutraceuticals, and polymers. Subsequent to extraction, the system can simply be brought back to atmospheric conditions to evaporate the carbon dioxide as a gas.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Upon successful completion of this research, an efficient, green, and sustainable means to extract algal lipid for biofuel will have been developed for implementation as a renewable alternative for transport fuel. Supercritical carbon dioxide extraction has already proven to be an effective and less hazardous means for lipid extraction, and by optimizing its use for lipid extraction, the potential for algal biodiesel as a sustainable alternative to fossil fuels increases. Finally, by using waste products from biodiesel production, environmental and economic impacts will be minimized and an efficient closed-system process implemented.

Keywords: *algae, biodiesel, biofuel, green engineering, supercritical fluid extraction, $scCO_2$*

Matthew Robert Strickland

EPA Grant Number: FP917175
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EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
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BIO:

Matt Strickland received his undergraduate degree in Civil Engineering from North Carolina State University in 2009. As an undergraduate, he was heavily involved in the Engineering Ambassadors program, recruiting high school students into engineering disciplines. In the fall of 2009, he joined the laboratory group of Dr. Marc Deshusses in the Pratt School of Engineering at Duke University. He is currently pursuing a Ph.D. in Environmental Engineering, focusing on engineered biofiltration technologies. Other research interests include wetland based water/wastewater treatment and water treat ment technologies for developing nations.

SYNOPSIS:

At many landfills or other methane generating facilities, biogas that is not economically upgradeable for use as a fuel source is often vented to the atmosphere or flared. The goal of this research is to develop a novel method by which methanotrophic bacteria, microorganisms that consume methane as an energy source and carbon source, may be engineered to instead convert methane into meth anol. The collected methanol may then be barreled and used as a fuel commodity.

S Energy

Biofiltration Incorporating Gene Silencing Technology for the Production of Methanol From Methane Containing Waste Gases

OBJECTIVE(S)/RESEARCH QUESTION(S)

The objective of this research is to develop a new method by which methanol can be generated biologically from methane. Specifically, by using gene silencing techniques, the metabolism of the methanotroph can be altered allowing for control of critical gene expression. Some questions that remain to be answered include: How will antisense silencing be deployed? What is the effect of interrupting the metabolism in such a way? Is this method sustainable? Is this method scaleable for application in industry? Could this method be applied to other areas of interest, such as the production of noxious gasses (hydrogen sulfide) by other microorganisms?

APPROACH

How will antisense silencing be deployed? In order to produce the necessary antisense strands as depicted in the original fellowship proposal, a plasmid has been engineered that will produce said antisense strands. Trial studies will be conducted during the summer. What is the effect of interrupting the metabolism in such a way? Most importantly, the inhibition of the MDH gene will prevent the cell from producing new cell mass or from regenerating NADH. One solution is to supplement the cells with a different metabolite downstream from methanol (pyruvate). Another solution is to control silencing with a solid promoter on the plasmid. In that way, partial silencing can be achieved where cells still grow, but they still excrete methanol. Is this method sustainable? If the system can be optimized in such a way that no other compounds (such as pyruvate) must be added, yes, it is theoretically sustainable. Is this method scaleable for application in industry? Given the large scale production of methane at many mid- and large-scale landfills or composting facilities, which cannot economically upgrade their biogas for injection into the natural gas grid, this approach could be applicable for industry. Part of the research will include inoculation and operation within a laboratory scale biotrickling filter that is supplied with synthetic biogas (methane and CO_2 supplemented with air). Could this method be applied to other areas of interest, such as the production of noxious gases (hydrogen sulfide) by other microorganisms? Yes, if this tool set is well developed, it could be applied to many biosystems where specific genes could enhance operations!

EXPECTED RESULTS

I expect the proposed and revised approach will work, as there are multiple examples of plasmid-based gene silencing systems in nature (HOK/SOK is a perfect example). The challenge will be in developing a strong plasmid for use in methanotrophs.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Again, this technology could be applied to many systems where biological degradation is not favored due to the production of secondary noxious gases or other interfering compounds. In a sense, we will be able to create better, smarter microbes for closed-system bioremediation.

Keywords: *plasmid, gene silencing, CRISPR, methane, methanol, biosynthesis, awesome*

Derek Richard Vardon

EPA Grant Number: FP917177
Institution: University of Illinois, Urbana-Champaign (IL)
EPA Project Officer: Jose Zambrana
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $74,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Energy
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BIO:

Derek Vardon received his undergraduate degree in Civil and Environmental Engineering from the University of Illinois at Urbana Champaign in 2010. Prior to returning to school, he served 6 years in the U.S. Navy as a nuclear power electri cian's mate while stationed in Charleston, SC. As an under graduate student, Derek was actively involved in research and educational outreach highlighting the potential of algae for bioenergy production and pollution remediation. His current research investigates the use of extended sur factants for the aqueous extraction of lipids from algae.

SYNOPSIS:

Algae offer a promising solution for renewable energy and pollution mitigation when used as a feedstock for biofuel production; however, sustainable algae biofuel production has yet to be realized due to the significant energy inputs required to dewater and extract oils from algae. To over come this challenge, this research seeks to develop novel extended surfactants to extract and recover algae oil in an aqueous environment.

S Energy

Extended Surfactants for Sustainable Aqueous Lipid Extraction From Algal Biomass

OBJECTIVE(S)/RESEARCH QUESTION(S)

Algae offer a promising solution for renewable energy and pollution mitigation when used as a feedstock for biofuel production; however, sustainable algal biofuel production has yet to be realized due to the significant energy inputs required to dewater and extract oils from algae. To overcome this challenge, this research seeks to develop novel extended surfactants to extract and recover algae oil in an aqueous environment.

APPROACH

The potential of extended surfactants for aqueous algal lipid extraction will be evaluated by conducting microemulsion phase behavior studies with surfactants and lipid profiles from various algal strains. Baseline lipid profiles for each species will be obtained by lyophilizing the biomass to preserve the chemical structure. The ideal surfactant concentration and extraction conditions will then be identified to maximize the yield and quality of lipid extract. Operating parameters such as reaction time, temperature, and biomass-to-surfactant ratio can be varied to reduce the amount of surfactant required and reach the critical microemulsion concentration. Performance of selected extended surfactants will then be compared against conventional organic solvents used for algal lipid extraction. Recovery and recyclability of the surfactant and separated culture water will then be examined to model the process sustainability. Loss of surfactant is expected during the recovery process and will be quantified to determine the input life cycle. The performance of the recovered surfactant will also be tested to measure the extract yield, lipid quality, and molecular integrity over repeated cycles. The recycled culture water will also be examined to determine its affect on cell growth parameters. Based on these factors, energy consumption and water recycle models will be generated to predict the scalability of lipid extraction methods using extended surfactants.

EXPECTED RESULTS

From this study I expect to identify extended surfactants that can effectively recover convertible lipids from high-moisture algal biomass when compared to typical organic solvents. This novel method will reduce the energy input and water consumption when dewatering and drying algal biomass, and mitigate the environmental, health, and safety hazards of industrial extraction solvents. The saline growth environment of algae can also allow for culture water recycle to enhance the sustainability of biomass production and processing.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Extended surfactants offer an environmentally benign method to extract and recover lipids from high-moisture algal biomass while alleviating the energy and water consumption concerns associated with dewatering. By developing algal biofuel technology, advancements can be made to provide a carbon-neutral fuel source compatible with the current diesel engines and fuel distribution infrastructure. Furthermore, the ability to integrate algal production into wastewater treatment systems offers a synergistic means to provide both nutrient remediation and the co-generation of renewable biofuels.

Keywords: *algae, biofuels, green chemistry, lipid extraction, surfactants*

Environmental Behavior & Decision Making

Michael Reed Coughlan

EPA Grant Number: FP917243
Institution: University of Georgia (GA)
EPA Project Officer: Brandon Jones
Project Period: 8/13/2010 – 8/12/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Environmental Behavior & Decision Making
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BIO:

Michael Coughlan received a Bachelor's degree in Anthro pology from Middlebury College in Vermont and a Master's degree in Applied Anthropology from Northern Arizona University. Michael has worked as an archaeologist for the U.S. Forest Service, the National Park Service, and a cul tural resources management firm. He is currently working on a P.h.D. in Ecological Anthropology at the University of Georgia. Michael's dissertation research concerns long term human-fire-landscape interaction in the French Western Pyrenees.

SYNOPSIS:

The proposed research investigates fire use among shep herds in the French Western Pyrenees using ethnographic, dendroecological, and geospatial methodologies. Pastoral fire practices have helped maintain landscapes conducive to conservation goals concerning biodiversity, watershed function, and carbon emissions. This research asks how lo cal knowledge, practice, and social relationships can medi ate the effects of broad-scale socioeconomic processes on long term fire ecology.

S Environmental Behavior & Decision Making

Socio-Ecological Dynamics of Pastoral Fire in the French Pyrenees

OBJECTIVE(S)/RESEARCH QUESTION(S)

The goal of my proposed research is to understand change and continuity in the relationships between humans, fire, and landscape over the long-term. The research asks how household level socioeconomic processes influence long term fire ecology through both land use and the practice of pastoral fire. I will answer this question by undertaking an historical ecological analysis of human-fire-landscape dynamics in the French Western Pyrenees.

APPROACH

The proposed research design relies on a combination of ethnographic, dendroecological, historical, and geospatial methodologies to collect and analyze data. The research is divided into four phases: (I) Archival and dendroecological data collection will provide the data necessary for historical analyses of household economic strategies, land use, and fire history. Data sets will include current and historical maps, demography, forest stand records, land-use records, and the natural archives recorded in the annual growth of trees. (II) Ethnographic data collection will include participant observation in pastoral fire events as well as interviews with key informants to document the ethnographic contexts of fire use. (III) Dendroecology samples will be processed and read in the GEODE lab at the University of Toulouse - Le Mirail. A standard procedure will be used that consists of drying, mounting, planning, and sanding samples with ever-finer sand paper until cellular details of the surface are exposed. Cores and cross-sections will be cross-dated and fire histories recorded using standard dendrochronological methods. (IV) Data will be analyzed and synthesized using a combination of Bayesian and local analyses, along with content- and network-focused ethnographic approaches.

EXPECTED RESULTS

My proposed research will contribute to our understanding of long-term socioecological interaction by identifying the historical parameters influencing human-fire ecology. Research will correlate dendroecological reconstructions of parcel-level fire history with a dynamic land use change model based on ethnographic and ethnohistoric data about household economic strategies and the fire practices they engender. These results will provide important and relevant information not only for understanding how people self-organize to achieve sustainable livelihoods, but also for understanding how local knowledge, practice, social organization, and landscape dynamically interact with broader-scaled environmental factors such as climate and political economy. This research also has relevance for defining the specific factors contributing to the recent decline in livelihoods-based fire management, a significant concern for forecasting future ecological conditions for the design of conservation policy.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Fire-related land management issues are global in scope and present a range of concerns and challenges from the conservation of biological diversity to human vulnerability and well-being. The proposed research will contribute a framework for modeling future fire management scenarios that can help design conservation policy that both draws from and is sensitive to the livelihoods, identities, and knowledge of local peoples.

Keywords: *Historical ecology, pastoral fire use, anthropogenic fire, agro-pastoral livelihoods, land use/land cover change (LULCC)*

Sarah L. Dumyahn

EPA Grant Number: FP917239
Institution: Purdue University (IN)
EPA Project Officer: Brandon Jones
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Environmental Behavior & Decision Making
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BIO:

Sarah Dumyahn received her undergraduate degree in Biology from Wittenberg University in 2002 followed by a Master's of Environmental Science from Miami University, Oxford (OH) in 2004. She has held internships with the Wisconsin Department of Natural Resources and the U.S. Forest Service and worked with the National Park Service as a biological science technician. Interested in public natural resource management, she is pursuing a Ph.D. at Purdue University, studying soundscape conservation by federal agencies.

SYNOPSIS:

The soundscape, or acoustic environment, is growing noisier and losing natural and unique sounds. This research stud ies the barriers and facilitators of soundscape conservation policy implementation focusing on the U.S. National Park Service. Using surveys and interviews of park and resource managers, the research will identify ways to improve sound scape conservation and assess the feasibility of implement ing similar policies within other natural resource agencies.

S Environmental Behavior & Decision Making

Beyond Noise Mitigation: Soundscape Conservation Implementation by U.S. Federal Land Management Agencies

Brandon

OBJECTIVE(S)/RESEARCH QUESTION(S)

The ability to experience natural and unique soundscapes is diminishing with the expansion of motorized transportation systems and conversion of natural habitats to human-dominated land uses. The U.S. National Park Service (NPS) has adopted soundscape conservation policies to address these issues. This research asks (1) what the role of individual parks in the implementation process is, (2) what the perceived barriers and facilitators to soundscape conservation are, and (3) could soundscape conservation policies feasibly be implemented by other federal land management agencies?

APPROACH

This research will use a mixed-methods approach incorporating surveys and interviews to understand barriers and facilitators to soundscape conservation efforts. The first part of the research focuses on the NPS, which has identified soundscapes as a resource and has adopted policies to protect them. However, the extent of policy implementation in each of the park units is unknown and the factors driving adoption are uncertain, as well. To answer these questions, the research will use park unit surveys and follow-up interviews with park and resource managers. This will identify explanatory variables of soundscape conservation implementation, such as perceived support and need, stakeholder group involvement, and innovative management. For the final phase of the research, this information will be integrated into an interview instrument for key personnel in the U.S. Forest Service and U.S. Bureau of Land Management to identify the feasibility of implementing soundscape conservation policies on other types of federal public lands.

EXPECTED RESULTS

The first part of this research will generate quantitative and qualitative data on the variables driving soundscape conservation implementation within NPS. Both explanatory variables and the extent of soundscape conservation efforts within NPS will be determined. This information will be used to better understand and improve soundscape conservation efforts by NPS. Additionally, an institutional framework of barriers and facilitators to soundscape conservation will be developed. This framework will be used to identify the feasibility of implementing soundscape conservation policies within other natural resource agencies. In particular, it will be tested for feasibility of implementation within the U.S. Forest Service and U.S. Bureau of Land Management.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The research on humans and some wildlife species impacts from noise provides quantifiable evidence of negative health and wellbeing effects. Identifying the barriers and facilitators of soundscape conservation policy implementation will aid in current and future efforts by natural resource agencies. The application of soundscape conservation as a broader policy and its utility in relation to noise mitigation is an important issue as natural and unique soundscapes diminish.

Keywords: *soundscape, acoustic environment, noise pollution, natural sounds, National Park Service, policy implementation, federal agencies, natural resource*

Justin MacLeod Foster

EPA Grant Number: FP917156
Institution: Boston University (MA)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Environmental Behavior & Decision Making
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BIO:

As a Ph.D. candidate in Systems Engineering at Boston University, Justin Foster is studying sustainable energy sys tems, environmental policy analysis, and electricity market design. His awareness of sustainable power systems began as a Research Associate at ICF International where he sup ported the U.S. Environmental Protection Agency in the de velopment and analysis of multi-pollutant trading programs. Justin received his undergraduate degree in Mathematics, *cum laude*, from Bowdoin College.

SYNOPSIS:

Reduction in greenhouse gas emissions requires the incor poration of clean energy technologies in the transportation and electric power sectors, which will strain the existing energy infrastructure. Embedded in the Smart Grid platform is the ability to manage these technologies in a way to mini mize the disruptive impact. This project develops the deci sion support tools necessary for the market-based coordina tion of intermittent renewable and distributed generation as well as demand response.

S Environmental Behavior & Decision Making

Decision Support for Plug-in Hybrid Electric Vehicle Charging in a Power Market Setting with Uncertainty: Cost Saving Opportunities and Synergies with Wind Generation

OBJECTIVE(S)/RESEARCH QUESTION(S)

This project develops decision-making support tools, which utilize Smart Grid data and hold promise towards a sustainable energy future. It explores the complementary nature of certain clean energy technologies across industry sectors in order to promote economically feasible opportunities for joint market penetration. In particular, it examines the ability of flexible-load to optimally provide the fast reserve capacity necessary for substantial increases in wind generation, while maintaining the quality of service the general public demands from electric utilities.

APPROACH

Preliminary research will focus on effective market-based coordination of plug-in hybrid electric vehicles (PHEVs) and renewable electricity generation — in particular, wind — that will contribute to the broad adoption of both technologies. Decisions must be managed and implemented across time-scales in the day-ahead market, intra-daily adjustment markets, and real-time market. The intermittent nature of wind generation requires additional capacity reserves, which can be called upon to insure the real-time balance of energy supply and demand. Given that fast reserve capacity prices range from $20 – $80 per megawatt-hour, these costs are likely to impose a significant barrier to wind generation expansion. In addition, the electrification of the light-vehicle fleet, in the absence of smart charging, will require costly distribution network infrastructure investments. This project will develop an optimal battery charging management strategy that will increase the supply of fast capacity reserves, thus controlling the costs, and result in energy cost savings for PHEV owners. This can be accomplished using load scheduling, which shifts demand in synchrony with system requirements and alleviates power system congestion in the transmission, distribution, and generation infrastructure.

EXPECTED RESULTS

The project will include simulation of the optimal PHEV charging decision support methodology to provide an important component in the evaluation of the costs and benefits associated with the electrification of the U.S. light-vehicle fleet and increased penetration of intermittent clean energy generation. The ideas of ‘smart-charging’ and ‘smart-use’ can be adapted to other types of load management, as well as to the management of distributed generation. Findings will provide important insight into the changes in energy market design necessary for demand-side participation in reserve markets and expanded retail markets at the distribution level. The research can be applied towards the development of comprehensive plans for expanding the existing distribution network and aid in the delay of costly expansion projects. Finally, and perhaps most importantly, the research will offer insight into efficient investment in the cyber infrastructure embedded in the Smart Grid.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

High renewable generation adoption will have a downward effect on wholesale energy prices. PHEV batteries can also increase the supply of capacity reserves and lower costs. Thus, in addition to the positive environmental impact, the cumulative effect on electricity markets will be in the direction of more affordable electric energy for the general public. Moreover, implementation of the proposed methodology in other developed and developing countries holds promise for dramatic global effects on sustainable energy.

Keywords: *sustainable power systems, renewable electricity generation, Smart Grid, demand-side response, decision theory, dynamic programming, optimization*

Eileen Rose Hlavka

EPA Grant Number: FP917158
Institution: Pardee RAND Graduate School (CA)
EPA Project Officer: Jose Zambrana
Project Period: 8/25/2010 – 7/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Environmental Behavior & Decision Making
E-mail:

BIO:

Eileen Hlavka's career focus is climate change policy. In the Ph.D. program at the Pardee RAND Graduate School, she studies a wide variety of mostly quantitative research meth ods in the belief that different facets of climate change policy require different approaches. She has done state-lev el policy work in California and holds a B.A. in mathematics and political science from Reed College. In her spare time she has been found playing taiko drums, cooking and insu lating her refrigerator.

SYNOPSIS:

In addition to conservation, improving technology holds promise for reducing greenhouse gases and thus climate change. This research implements a new measure of the rate of research on solar and wind electricity—counting research articles—and compares it with subsidies for those electricity sources over time. The results will show whether subsidies or other pricing policies may suffice to encourage the amount of technological change desired or whether ad ditional policies are required.

S Environmental Behavior & Decision Making

A New Approach To Measuring Technological Progress To Better Inform Climate Policy

OBJECTIVE(S)/RESEARCH QUESTION(S)

This research will measure how government subsidies have or have not affected the rate of early research on renewable electricity technologies over the past few decades. The number of journal articles published on a given technology will be used as a measure of the rate of research, using novel text analysis methods to categorize the journal articles.

APPROACH

The rate of published research on wind and solar electricity will be compared with government subsidies over time. First, the measure of rate of research will be constructed by using semi-automated text analysis to categorize hundreds of thousands of articles matching relevant keywords. Second, econometric time series methods will be used to compare these articles' publication dates with government subsidies and other factors. The results will be interpreted in terms of their implications for the effects of government subsidies on technological research as well as for future policy-related work using text analysis.

EXPECTED RESULTS

This research will suggest what percent of early renewable electricity research is attributable to government subsidies. Thus, it will either conclude that subsidies are already encouraging the amount of early research which is desired by policymakers, or that they are not encouraging sufficient research and other policies are needed. These results may be interpreted in the context of other subsidy-like potential policies, such as a cap-and-trade system.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Advances in wind and solar electricity technology may make it possible to reduce greenhouse gas emissions more cheaply, thus making it easier to meet emission targets and reduce climate change. This research will help in identifying what role subsidies or other price-based policies can play in fostering early research towards such technological advances.

Keywords: *climate change, technology, renewable energy, wind, solar, measurement, text analysis, subsidies, policy*

Mark Edward Huberty

EPA Grant Number: FP917188
Institution: University of California, Berkeley (CA)
EPA Project Officer: Ted Just
Project Period: 8/1/2010 — 7/31/2013
Project Amount: $111,000.00
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BIO:

Mark Huberty is a doctoral student in political science at the University of California, Berkeley. His research interests include the political economy of climate change, European politics, and statistical inference. He received his under graduate degree in Chemistry from Harvey Mudd College and spent 5 years with Accenture before studying interna tional relations at the Johns Hopkins University. He will be a visiting scholar at Breugel and Copenhagen University for 2010-2011, studying European Union climate policy.

SYNOPSIS:

Successful action to prevent global climate change will require replacing fossil fuels with other fuel sources. This will require replacing both the fuels and the technologies that depend on them. Studying the politics of how complex energy systems change can improve policies to expand the use of renewable energy and reduce emissions. This project will study past and present examples of energy systems, such as electrification and the European Union's transition to low-emissions fuels.

S Environmental Behavior & Decision Making

The Political Economy of Energy Systems Transitions: Implications for Climate Policy

OBJECTIVE(S)/RESEARCH QUESTION(S)

Climate change mitigation will require replacing fossil fuels with lower-emissions alternatives. Transforming the energy system at this scale poses major economic and political challenges, which may interfere with successful climate policy. How to reconcile climate, economics, and politics thus becomes a central concern for successful policymaking. This project will improve the understanding of the role of politics and policy in major energy systems transformations in order to inform better policy approaches for climate change.

APPROACH

This project takes two approaches to understanding energy systems transformation. First, it will study historical examples of energy systems transformation in industrial economies. Climate change requires energy systems transformation on par with earlier transitions from wood to coal, coal to oil, or electrification. These cases can illuminate our understanding of the roles played by politics and markets in large-scale changes to how we produce, distribute, and use energy. Second, the project will examine European Union policy presently underway to identify its origins, political characteristics, and prospects for success. In both cases, learning from past efforts can inform better choices about future action.

EXPECTED RESULTS

This research will identify characteristics common to major energy systems transformations. These will include both the economic and political barriers to transformation, and the public and private solutions that succeeded in overcoming those barriers. Given the essentially political nature of responses to climate change, this information will provide valuable input to the design and execution of long-term climate policy. Getting the mix of regulation, market pricing, technological innovation, and private initiative right is vitally important to effective and sustainable climate solutions. By drawing on past and present efforts to do so, this research can help inform the design of this policy mix for the future.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Pollution from fossil fuels has created some of the most widespread health and environmental risks of the modern age. But fossil fuels also power economic advances that generate substantial improvements to standards of living worldwide. A successful energy systems transformation must replace fossil fuels with other sources without disrupting economic prosperity. This research will seek to identify how earlier energy systems transformations have supported, not merely accommodated, improvements to human well-being.

Keywords: *climate change, renewable energy, energy systems*

Valerie Jean Karplus

EPA Grant Number: FP917161
Institution: Massachusetts Institute of Technology (MA)
EPA Project Officer: Jose Zambrana
Project Period: 8/1/10 -7/31/13
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Environmental Behavior & Decision Making
E-mail:

BIO:

Valerie Karplus studies how policy design choices can affect technology adoption and ultimately environmental out comes. As a doctoral candidate at the Massachusetts Insti tute of Technology (MIT), she is currently evaluating poli cies for reducing greenhouse gas emissions from passenger vehicles in the United States. Prior to MIT, Valerie spent several years in Beijing, China, where she wrote about the development and impact of advanced technology in China's energy and agricultural sectors. She holds a Bachelor's of Science from Yale University in Biochemistry and Political Science, and dual Master's degrees from MIT in Civil and Environmental Engineering and Technology and Policy.

SYNOPSIS:

Passenger vehicles (cars and light trucks) are a major con tributor of greenhouse gas (GHG) emissions in the United States. This project focuses on two policy instruments, fuel economy standards and a price on GHG emissions, and aims to identify the sentivity of economic and environ mental outcomes to assumptions about consumer vehicle purchase and usage behavior. A macroeconomic model with substantial vehicle fleet and fuel use detail will be devel oped to perform the analysis.

Climate Policy Design for U.S. Light-Duty Transportation: Representing Vehicles and Consumer Response in a Macroeconomic Model

OBJECTIVE(S)/RESEARCH QUESTION(S)

A detailed representation of the passenger vehicle fleet will be developed in a macroeconomic model to evaluate the impact of policies aimed at reducing greenhouse gas (GHG) emissions in the United States. There are two central research questions of this work: (1) What are the key elements of successful policies aimed at reducing GHG emissions from passenger vehicles over the next 40 years, based on explicit consideration of physical system constraints and the consumer response? (2) How are the impacts of different policies distributed across sectors, and can adverse sectoral affects be addressed without compromising cost-effectiveness?

APPROACH

The first stage of this project will involve developing a detailed represen tation of the passenger vehicle fleet and fuel system in a macroeconomic (computable general equilibrium) model. Using available econometric data, key relationships between expenditures on vehicles and number of vehicles in the fleet as well as economic growth and travel demand will be represented explicitly in the model in the base year and as they evolve over time. Low carbon vehicle and fuel technologies will be represented explicitly in the model to cover a wide range of abatement opportunities available to meet policy constraints. The second phase of the project will focus on representing fuel economy standards in the model and compar ing the economic and environmental impact of this vehicle-based policy approach with a price on GHG emissions, which bears primarily on the price of fuel.

EXPECTED RESULTS

The modeling work constitutes one of the first attempts to develop a gen eral equilibrium model with comprehensive physical detail in the passen ger vehicle transportation system. This work will help to develop intuition about the importance of capturing physical variables for any sector in a macroeconomic framework, and will illuminate problems associated with their omission. Policies will be evaluated in terms of their impact on new vehicle sales and vehicle fleet composition in each five-year time step, type and amount of fuel used, GHG emissions, welfare loss under policy, and carbon price. The sensitivity of policy outcomes to underlying assump tions about the cost and availability of different vehicle and fuel technolo gies, as well as consumer usage choices, will be assessed.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The outcomes of this work will be directly relevant to the design of policies aimed at reducing greenhouse gas emissions from passenger vehicles as part of national and international efforts to address global climate change.

Keywords: *climate change, passenger vehicles, fuel economy, alternative fuel vehicles, consumer choice*

Joseph Robert Kasprzyk

EPA Grant Number: FP917162
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EPA Project Officer: Jose Zambrana
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Project Amount: $111,000.00
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BIO:

Joseph Kasprzyk received a Bachelor of Science degree in Civil Engineering in 2007, graduating with honors from the Schreyer Honors College at the Pennsylvania State Univer sity (PSU). As part of his honors program, he participated in a research project that evaluated a new solution technique for monitoring groundwater contamination. He earned his Master of Science degree in Civil Engineering in May 2009 from PSU. During his Master's work, he used a case study in the Lower Rio Grande Valley in Texas to show how water market transfers can lower the cost and increase the reli ability of urban water supply systems dealing with droughts and growing population demands. Joseph is currently a doctoral candidate in Civil Engineering at PSU, where his research focuses on regional water supply planning under climate change in the Susquehanna River Basin.

SYNOPSIS:

The Susquehanna River Basin contributes services with an economic value of $6 to $8 billion per year. Groundwater resources play an important role in the region's water man agement but are not adequately modeled in existing tools. Current regional water management also lacks the ability to respond to climate and land use change for long term planning. The project will meet these challenges and con tribute to sustainable water management in the Susque hanna River Basin.

S Environmental Behavior & Decision Making

Balancing the Economic and Ecological Sustainability of Water Supply in the Susquehanna River Basin Under Climate Change

OBJECTIVE(S)/RESEARCH QUESTION(S)

The Susquehanna River Basin, which spans portions of Pennsylvania, New York, and Maryland, contributes services with an economic value of $6 to $8 billion per year. Groundwater resources play an important role in the region's water management but are not adequately modeled in existing management tools. The project will contribute to our understanding of how groundwater supply and water management are vulnerable to climate change and increasing water demands. The results of the project will lead to a better balance between competing uses of water resources to support the potentially conflicting objectives of sustainable economic development and ecological health while helping water systems stay resilient to future changes.

APPROACH

The proposed project will utilize multiobjective evolutionary algorithms (MOEAs) to discover key water management tradeoffs for the Susquehanna River Basin. A set of evolving problem formulations that explicitly consider multiple planning objectives and that can flexibly incorporate new problem insights will be generated for the Susquehanna River Basin. The framework will include groundwater modeling innovations under a range of coherent climate and land use scenarios. The scenarios will seek to clarify how climate change and increased water demand risks may potentially impact the Susquehanna River Basin's water supplies.

EXPECTED RESULTS

By building an improved water management framework for the Susquehanna River Basin, we will be able to test two major hypotheses that can lend insight into the vulnerabilities and future challenges for water management in this region. The first is that regional groundwater dynamics are modified by climate and land use change, with shorter winter-spring recharge periods and longer summer-fall drought periods. The implication of this hypothesis is that future changes can expose water users to heightened risk because of lower groundwater availability. The second hypothesis is that current decision-making strategies in the Basin reflect over-confidence in short term water planning heuristics that expose the system to long-term risks, including severe cost increases, ecological risks, and supply failures. The decision-making framework that will be created in this work will give water managers an improved ability to protect the water supply system from these risks while also seeking to maximize the ecological health of the Susquehanna's river systems.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

The project seeks to lower risks to the diverse users of the Susquehanna River Basin's water supply system: municipal supply, water for electricity generation, commercial use, and ecological systems. The change projections created in this work will aid long-term planning for the Basin's water managers, protecting the region's water supplies from risks due to climate change and growing population demands.

Keywords: *multiobjective decision support, water supply, climate change, land use change, environmental economics, sustainability*

Rachel Marie Krause

EPA Grant Number: FP917163
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EPA Project Officer: Jose Zambrana
Project Period: 8/31/2010 – 8/30/2013
Project Amount: $111,000.00
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BIO:

Rachel Krause is a Ph.D. candidate studying Public Affairs at Indiana University's School of Public and Environmen tal Affairs. She is currently engaged in research on local climate protection initiatives, the impact of urban forestry management on ecosystem services, and environmentally significant consumption. Prior to pursuing a Ph.D., Rachel was a program coordinator with the Texas Commission on Environmental Quality and a Fellow with the United Nations Institute for Training and Research. She holds a Master's degree from the University of Texas and Bachelor's degree from Rice University.

SYNOPSIS:

In the face of federal inaction and in apparent defiance of free-rider logic, over 1,000 local governments in the U.S. have voluntarily committed to reduce the greenhouse gas (GHG) emissions emanating from their jurisdictions. This research undertakes a data collection effort on the climate protection actions implemented by U.S. cities with popula tions over 50,000 in order to address what cities are doing in this regard, why they are becoming involved, and what impact local actions have on net emissions.

S Environmental Behavior & Decision Making

Municipal Involvement in Climate Protection: Local Decision Making and Policy Innovation

OBJECTIVE(S)/RESEARCH QUESTION(S)

Three broad questions warrant examination from research examining the phenomena of voluntary local involvement in climate protection: (1) What actions are municipal governments taking to reduce local greenhouse gas emissions? (2) Why are municipal governments becoming involved in climate protection and what explains variation in the type and extent of their actions? and (3) What impacts do/can local efforts have on GHG emissions?

APPROACH

A significant data gap exists regarding the type and extent of GHG reducing initiatives employed by municipal governments. Therefore, the initial step of this research involves a significant data collection effort. A web-based survey will be sent directly to the local government employee identified as in charge of environmental or sustainability programs in the 665 cities in the United States with populations over 50,000. The survey identifies the ways that municipal policy or programs can reduce GHG emissions and asks about local participation in each. Assuming a response rate of 50 percent, data from approximately 330 cities will be obtained. This data informs a 24-item index quantifying the extent of local climate protection in each municipality and serves as a basis to answer the study's three primary research questions. Cluster analysis, regression analysis, and stochastic simulations will be the primary statistical methodologies employed.

EXPECTED RESULTS

Expected results of the research are based on the outcome of a pilot study conducted in the state of Indiana. Although less than half of the pilot study cities use climate protection as an explicit frame, all are involved in some GHG-reducing activities. Considerable variation was found in the frequency of the use of different types of policy instruments. The direct provision of services, which enable the public to reduce GHG emissions, was a favored instrument, and incentive-based instruments were employed least often. Models of local decision-making which operationalize policy demand (e.g., interest group and risk-perception) explain observed variation in municipal climate protection better than supply models (e.g. government capacity, fiscal constraints, and policy entrepreneurs). The pilot study results may or may not preview the results of the proposed research, which will consider larger cities across the country.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Sub-national climate protection efforts are receiving increasing attention and support despite relatively little being known about their potential scope or ultimate effectiveness. This is particularly true of municipal GHG mitigation actions where a lack of widespread data has had the effect of focusing attention on a handful of largely unrepresentative cities. By collecting information on the type and extent of GHG reduction activities from a large number of cities, a more accurate picture can be formed about the effectiveness, drivers and obstacles of municipal climate protection. Ultimately, this research will be able to inform the decisions of policy makers at all levels of government as they try to design the best possible set of policies to mitigate human-induced climactic change.

Keywords: *local climate protection, policy, municipal decision making*

Andrew Samuel Peterman

EPA Grant Number: FP917168
Institution: Stanford University (CA)
EPA Project Officer: Jose Zambrana
Project Period: 9/1/2010 – 8/31/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Science & Technology for Sustainability: Environmental Behavior & Decision Making
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BIO:

Andrew Peterman is pursuing a Ph.D. in Civil and Environ mental Engineering with an emphasis on energy and envi ronmental policy. His research is closely tied to the experi ence he gained while doing corporate environmental policy for The Walt Disney Company. His research is currently looking at private sector participation in voluntary energy efficiency alliance programs and the effectiveness of these programs at reducing corporate-wide energy consump tion among the built environment. His work at the Natural Resources Defense Council (NRDC) this summer will be centered around passing comprehensive climate change legislation while developing further ties with the business community on environmental and energy-related issues. In his free time, he likes to play with his chocolate labrador, whitewater kayak, and mountain bike.

SYNOPSIS:

I intend to research the basic decision-making processes and structures employed by various private sector compa nies when evaluating their possible participation in volun tary energy efficiency programs. I propose that this line of research has the potential to break new ground in linking the relationship between government-sponsored voluntary energy efficiency programs and private company responses.

S Environmental Behavior & Decision Making

Corporate Adoption of Voluntary Programs to Enhance Energy Efficiency in Buildings

OBJECTIVE(S)/RESEARCH QUESTION(S)

This line of work proposes to analyze corporate perspectives of voluntary energy efficiency programs in buildings. This part of the research will attempt to understand how and why certain energy efficiency-related de cisions are made in a company. I intend to look at varying firm structures and how those independent structural components contribute to greater or lesser participation in energy efficiency programs. How do internal and external organizational structures, incentives, and policies influence cor porate participation in programs designed to encourage energy efficiency in buildings?

APPROACH

Phase 1 – In Depth Case Study #1 Walt Disney Company

- Detailed Interviews – Structured and Unstructured (ideal 10-20)
  - Upper Level Managers
  - Mid-Level Managers
  - Project Teams and Engineers
  - Operations/Maintenance Staff
- Detailed Survey/Questionnaire (ideal n > 50), Administered In-person
  - Same Span of Positions

Phase 2 – Comparative Case Study Method (5-10 Companies)

- Structured Interviews (5-15 per company)
- Survey/Questionnaire (30-50+ individuals)

Phase 3 – Develop Causal Relationships or Comparative Case Study (Correlations/Descriptive)

- Statistically (depending on N)
- Fuzzy Set Qualitative Comparison Analysis

EXPECTED RESULTS

Knowledge Contribution: Expand our understanding of organizational learning theories in a new application of energy efficiency. Develop a more comprehensive understanding of how macro-level organizational variables interact to contribute to greater or lesser participation in voluntary energy efficiency programs. Develop recipes leading to greater or lesser firm participation in energy efficiency programs that can then be tested in new fields in which participation from firms is important (e.g., health promo tion). Practice Contribution: How can government use knowledge about how companies will respond to voluntary energy efficiency programs to craft more effective policies that create maximum environmental, financial, and social value for the government and private sector companies? How can corporate organizational structures be improved to better take advantage of voluntary energy efficiency programs?

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

I believe that this line of research has the potential for broader societal impacts in addition to those mentioned above. Many are in agreement that the poor and minorities are disproportionately affected by environmental pollution and hazards (Pinderhughes, 1996). It is well within the scope of my dissertation research to look at how successful implementation of cor porate energy efficiency measures will help reduce global energy demand. A reduction in global energy demand will reduce the demand for new power plants and has the potential to reduce risk for those most affected by pollution and environmental hazards. It is my experience that individuals within a company want to take action to protect our environment. How ever, it is often the structure of an environmental program combined with the structure of the organization that hinders corporate decision makers' abilities to take that action. I believe that my work will help bridge that gap between public and private entities, providing greater opportunity for cooperation and enhancement of national environmental efforts based on the voluntary programs to improve energy efficiency. Drawing upon and potentially affecting areas of microeconomics, public policy, organization theory, technology, and engineering, the aim of this research is to further environmental protection while fostering a cooperative relationship among private and public sector entities.

Keywords: *energy efficiency, buildings, energy policy, strategic alliances, public-private partnerships*

Chelsea Lynn Schelly

EPA Grant Number: FP917171
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EPA Project Officer: Jose Zambrana
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Project Amount: $111,000.00
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BIO:

Chelsea Schelly is a P.h.D. student in the Department of Sociology at the University of Wisconsin-Madison. Both her undergraduate education and her M.A. in Sociology focused on integrating sociological insights with environ mental studies, and her current program continues this focus while blending interdisciplinary training (as an NSF-IGERT Fellow) with science and technology studies, history, and sociological theory. Her work is inspired by the belief that the technological systems that societies use to sustain residential life have important implications for how humans conceive of their relationship to the natural world. Her cur rent research explores the structural relationships shaping current technology use, how individuals choose to pursue alternative energy technologies, and how that choice re flects broader attitudes, opinions, and lifestyles. Through a career in both teaching and research, she hopes to continue exploring human decision-making processes and the way they relate to, affect, or change human-nature relationships.

SYNOPSIS:

This project examines the motivations for adopting residen tial solar electric technology through interviews with solar technology users in Wisconsin and Colorado, considering the relative importance of geography (solar radiation), policy (fiscal incentives), demographics (income, age, household composition), environmental values, and other factors in motivating solar energy technology adoption. This project aims to inform future policy intended to promote alternative energy technology adoption.

S Environmental Behavior & Decision Making

Residential Solar Technology Adoption: Motivations for Environmental Behavior and Experiences with Alternative Energy Systems

OBJECTIVE(S)/RESEARCH QUESTION(S)

In the United States, electricity is generated through three primary sources: coal, natural gas, and nuclear energy. However, alternative or renewable sources of electricity generation have been increasing in market share. Alternative energy technology adoption offers one potential means of addressing current dependence on fossil fuel-based, centralized electrical generation and transmission. This project will explore the historical development of electricity as a socio-technological system as well as its current structure, and examine the adoption of one form of renewable energy generation, residential photovoltaic (PV) solar technology, in order to understand several aspects of human decision making with broader implications for policy and the electric utilities industry.

APPROACH

In order to conduct the proposed research, home-owning residential PV technology adopters in two states (Wisconsin and Colorado) will be identified, contacted, and interviewed. Wisconsin and Colorado offer an ideal opportunity for comparison, as they differ in solar radiation, state policy promoting alternative energy, and political identity, which may all be significant in shaping solar energy technology adoption. Factors for consideration in the sampling frame include age, income, length of homeownership, whether the PV system is off-grid or grid-integrated, and whether the home is in a rural area, a suburban neighborhood, or a centralized urban area. While qualitative research sampling frames are not intended to be representative, these factors will be considered so that participants in both states are representational. Research questions will ask about the decision to adopt solar technology and the experiences of participants as solar technology users. Questions will focus on the extent to which various models of decision making help explain the decision to adopt PV technology.

EXPECTED RESULTS

Inductive qualitative research does not and cannot follow the same standards of hypothesis testing as quantitative statistical research. Nonetheless, we may consider some tentative hypotheses. The first hypothesis is that residential solar technology adopters do not fit an often-associated stereotype of 'greenies.' Solar technology adopters may be similar in socio-economic status (although not always and exclusively so), but may vary widely in lifestyle and commitment to environmental values. The second hypothesis is that ecological factors matter. Motivational factors are likely to vary for residents of different ecological regions. The third hypothesis is that no one current model of behavioral decision making is sufficient to explain PV adoption.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

This project seeks to understand the human dimensions of environmental issues and pro-environmental behavior. By asking users themselves about their motivations to adopt solar energy technology, and their experiences living with that technology, this work will improve our understanding of human decision making in the context of environmental behavior and technology adoption.

Keywords: *solar energy technologies, decision making, adoption of innovations*

Benjamin Elias Sharp

EPA Grant Number: FP917172
Institution: Clemson University (SC)
EPA Project Officer: Jose Zambrana
Project Period: 8/18/2010 – 8/17/2013
Project Amount: $111,000.00
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BIO:

In 1999, Ben Sharp received his B.S. in Mathematics from the University of Evansville in Evansville, IN. He spent the following eight years working in higher education adminis tration at Montana State University (MSU) in Bozeman, MT. During that time, he also earned a Master's degree in Sta tistics from MSU. With a passion for the outdoors and the environment, he changed careers and returned to graduate school full time to advance research efforts that assess sys tems for sustainability. He just completed his first year as a Ph.D. student in Environmental Engineering and Science at Clemson University.

SYNOPSIS:

Bioenergy production has had mixed success in terms of environmental impact, net energy generating, and economic costs. By performing careful analyses prior to alternative energy industries becoming established, we can estimate probable development scenarios. Resulting data will reveal opportunities and help avoid negative outcomes. This proj ect analyzes switchgrass production for bioenergy in South Carolina and will help to determine its potential environ mental impact and economic viability.

Modeling Switchgrass Production in South Carolina Based on Farmers' Decisions: A Stochastic and Spatial Analysis

OBJECTIVE(S)/RESEARCH QUESTION(S)

Some bioenergy development has resulted in economic and environmental backlash, such as with corn and sugar cane; yet in other cases, it remains a promising alternative energy solution. Examining future bioenergy systems before processes become established offers opportunities to better understand potential outcomes and reveal to stakeholders more desirable paths of development in terms of environmental and economic costs. This research will expand on traditional Life Cycle Assessment (LCA) for determining environmental impact. Making use of innovative LCA techniques will generate information that will translate to clear and meaningful information for emerging bioenergy systems.

APPROACH

South Carolina lacks a major energy source. It does have, however, a favorable agricultural climate, suggesting that bioenergy could be an option for the region. For this reason, it is important to explore the likelihood of South Carolina growers to begin producing switchgrass (*Panicum virgatum*) as an energy crop. Aggregate estimations will be based on a model that takes into account data on farmers' willingness to adopt new crops, the expected profitability, and the spatial compatibility of growing switchgrass. This stochastic model will be geared toward fitting results into an overall LCA of the switchgrass-for-energy industry.

EXPECTED RESULTS

By incorporating projected switchgrass production data into existing standards of life-cycle measures, it is possible to communicate relevant information about likely outcomes. The results will shed light on the environmental impact and the economic viability of growing switchgrass for bioenergy. Furthermore, these probabilistic scenarios of production can be adjusted according to different system perturbations such as incentives or technological breakthroughs. Subsequent results will inform farmers, processors, policy makers, energy providers, and energy consumers. With this type of shared knowledge, switchgrass-to-energy may become a sustainable bioenergy success for South Carolina.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Overcoming path dependency in energy production and consumption is a pressing challenge. Developing processes for understanding how alternatives are adopted and identifying the drawbacks are important for identifying how shifts to sustainable, renewable energy might be realized. Using the switchgrass-bioenergy industry in South Carolina as an emerging system, this research will offer a set of techniques to reveal important insights for the development of similar large-scale energy solutions.

Keywords: *bioenergy, biofuel, sustainable energy, spatial modeling, geographic information system, land use, switchgrass*

Timon Herrick Stasko

EPA Grant Number: FP917174
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EPA Project Officer: Jose Zambrana
Project Period: 8/25/2010 – 8/24/2013
Project Amount: $111,000.00
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BIO:

Timon Stasko received his B.S. in Civil Engineering from Cornell University in 2007. He proceeded into a Ph.D. program at Cornell specializing in transportation systems. Timon has worked on a range of projects, including supply chain work for corporations. His primary focus is on cost-ef fective strategies for emission reduction through vehicle ret rofits and replacements. He has worked with the New York City Department of Education regarding school buses, and the New York State Department of Transportation regarding their maintenance fleet.

SYNOPSIS:

While new diesel vehicles have dramatically lower emissions than their predecessors, much of the existing fleet contin ues to emit pollutants at high rates. Considerable efforts are being made to reduce emissions from older diesel vehicles through retrofits and early retirements. This research will develop an optimization framework for coordinating retrofit and replacement decisions with the process of assigning ve hicles to tasks, improving the efficiency of emission reduc tion projects.

Developing Green Fleet Management Strategies

OBJECTIVE(S)/RESEARCH QUESTION(S)

While new diesel vehicles have dramatically lower emissions than their predecessors, much of the existing fleet continues to emit numerous pollutants at high rates. Considerable efforts are being made to reduce emissions from older diesel vehicles through retrofits and early retirements. This research will examine how the way vehicles are assigned to tasks can influence the magnitude and distribution of emission reductions.

APPROACH

This research will involve creating a multi-period optimization framework for making both vehicle assignment and retrofit/replacement decisions. Potential mathematical techniques include linear and nonlinear programming, as well as dynamic programming and heuristic methods such as tabu search and genetic algorithms. Given the complex nature of the problem, it is likely that multiple techniques will be combined in a hybrid approach, such as approximate dynamic programming with linear programming used to solve subproblems at each state.

EXPECTED RESULTS

The completed model will be able to reveal the degree to which coordinating retrofit/replacement decisions with vehicle task assignment can influence the outcomes of emission reduction projects. Emission reductions might be increased by using retrofitted and new vehicles more heavily, or by altering duty cycles to create more favorable exhaust temperature profiles (allowing installation of more effective emission reduction technologies). The optimization framework developed may be applicable to a broader class of retrofit/replacement problems, such as those facing companies deciding how to manage groups of buildings, given energy reduction goals.

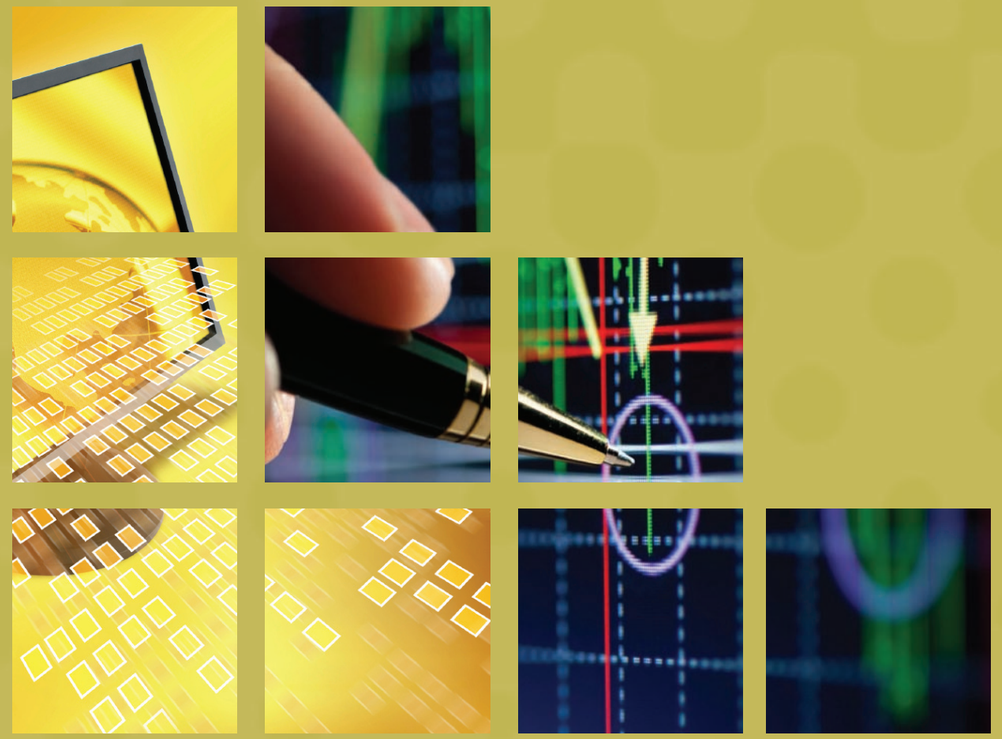
POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Fleet managers could use insights from the model to develop their own retrofit/replacement strategies. EPA staff could use the same insights when selecting which retrofit/replacement proposals receive grants. In so doing, greater reductions in emissions of pollutants such as particulate matter, carbon monoxide, and hydrocarbons could be achieved.

Keywords: *diesel retrofit, legacy fleet, vehicle task assignment*

Emerging Environmental Approaches

- Informatics



Emerging Environmental Approaches Fellows

INFORMATICS

Informatics

Erik Charles Franklin

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Institution: University of Hawaii, Manoa (HI)
EPA Project Officer: Brandon Jones
Project Period: 8/23/2010 – 8/22/2013
Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Emerging Environmental Approaches: Informatics
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BIO:

Erik Franklin has worked as an academic researcher and government scientist on a diverse suite of marine ecology and resource management projects over the last decade. He received an undergraduate degree in Ecology from the University of California, San Diego in 1996 and a Master's degree in Marine Biology and Fisheries from the University of Miami in 2004. His research focuses on the basic and applied ecology of coral reef ecosystems with particular emphasis on supporting sustainable marine resource man agement using empirical data, geospatial technologies, and statistical modeling. He currently is examining the utility of an ecoinformatics framework to the study of coral reef ecosystems for climate change studies, biocriteria develop ment, and marine spatial planning.

SYNOPSIS:

A key challenge in the effective management of coral reef ecosystems is determining appropriate biocriteria for the evaluation of ecosystem condition and then translating those criteria from small scale studies of distribution and dynamics to the regional scale of management action. This research applies an ecoinformatics approach that incorporates theory, models, and data to evaluate the environmental condition and management of coral reefs in the Hawaiian Archipelago.

E Informatics

Ecoinformatics To Evaluate the Environmental Health and Management of Coral Reef Ecosystems

OBJECTIVE(S)/RESEARCH QUESTION(S)

The objective of this research is to use an ecoinformatics approach to integrate empirical observations of coral species with environmental and anthropogenic covariates to model spatially-explicit coral distributions for biocriteria evaluation, climate change studies, and marine spatial planning.

APPROACH

This research will synthesize Hawaiian archipelago-wide data of coral reef surveys and develop continuous spatial models based on ecological niche modeling approaches for the dominant coral species. These data will be used to evaluate and enhance existing coral reef biocriteria approaches. Further, the species distribution data will be coupled with a climate forecast model to evaluate potential responses to climate change. Finally, the continuous maps of coral species distribution as well as environmental and anthropogenic covariate layers will be used with spatial-optimization routines to evaluate patterns of resilient marine landscapes in Hawaii.

EXPECTED RESULTS

It is anticipated that this research will generate four significant products: (1) A Hawaiian Archipelago-wide GIS database of coral distribution, benthic community data, fish surveys, and other data gathered by CRAMP, NPS (National Park Service), various divisions in NOAA, the Hawaii Division of Aquatic Resources, and other sources into a single GIS database; (2) Validated, predictive, and spatially continuous maps of coral species distribution throughout the HA; (3) A validated Ecological Gradient Model for coral reef biocriteria in the Northwestern Hawaiian Islands to extend the model development in the Main Hawaiian Islands; and (4) Prediction of coral community (biocriteria) response to climate change throughout the Hawaiian Archipelago, based on known and predicted coral distributions and the COMBO model. This work will be submitted for publication in scholarly journals as appropriate. For dissemination to managers and the public, we will take advantage of the relationships that HIMB has developed throughout Hawai'i: a research partnership with the state and federal managers of the NWHI, collaborations with the Hawai'i Division of Aquatic Resources, ongoing public presentations at the Bishop Museum and Hanauma Bay Visitor Center, citizen science collaborations with ReefCheck "Eyes of the Reef", and ongoing visitor tours and outreach onsite at Coconut Island. In addition to these products and outreach efforts, University of Hawai'i is a Native Hawaiian and Pacific Islander serving institution and Dr. Jokiel has an excellent track record in mentoring local students.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

Human populations in coastal tropical areas rely intimately on the diverse goods and services provided by coral reef ecosystems. This research explores the development of a holistic approach of theory, data, and models to evaluate the condition and dynamics of these systems to support their sustainable management in a changing world.

Keywords: *coral, reef, ecosystem, ecoinformatics, Hawaii, biocriteria, modeling, niche*

Brendan N. Reid

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Project Amount: $111,000.00
RFA: STAR Graduate Fellowships (2010)
Research Category: Emerging Environmental Approaches: Informatics
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BIO:

After receiving his undergraduate degree in Biology at Williams College in 2002, Brendan Reid went on to study Genetics and Conservation Biology at Columbia University. In collaboration with scientists at the American Museum of Natural History, he recently generated a genetic "barcode" for identifying over 200 species of turtles as a means of combating trade in endangered species. He received his Master's degree from Columbia in 2009 and is currently a Ph.D. student at the University of Wisconsin, Madison.

SYNOPSIS:

Degradation of a species' environment often has a profound negative impact on its adaptive potential. Genetic methods have recently emerged as valuable tools for identifying and managing these impacts. This research will use existing and novel conservation genetics techniques to gauge the effects of agricultural conversion and road construction on several species of wetland turtles, including the threatened Bland ing's turtle, across Wisconsin.

E Informatics

Development of Single Nucleotide Polymorphisms (SNPs) as Tools for Assessing the Impacts of Environmental Stressors on Native Species

OBJECTIVE(S)/RESEARCH QUESTION(S)

Degradation of a species' natural environment, through processes such as habitat destruction and pollution, often has a profound negative impact on its adaptive potential, as measured by genetic variability and connectivity. The field of conservation genetics provides useful tools for assessing genetic variability and connectivity as well as for determining the demographic history of populations affected by habitat degradation. This research project will assess the effects of agricultural conversion of wetlands on several species of Wisconsin turtles (including the threatened Blanding's turtle, *Emydoidea blandingii*). Novel genetic markers will be developed utilizing next-generation sequencing technology in these species as well as several others (sloths and spotted owls) of conservation interest, and a database suitable for storing both genetic data and related environmental data will be developed.

APPROACH

Turtles will be sampled from a well-studied population in Wisconsin's Sandhill Wildlife Area as well as from sites representative of the turtle's range. Microsatellite markers, the conventional "workhorse" markers used in conservation genetics, have already been developed for several of the turtle species to be studied, including Blanding's turtle. In addition to these, next-generation sequencing technology will be used to identify single-nucleotide polymorphisms, a potentially cheaper and more informative genetic marker in target species. All of the genetic data obtained will be combined with associated environmental data taken at the time of collection in what will serve as a prototype for an ecologically oriented version of more traditional data repositories such as Genbank.

EXPECTED RESULTS

As species with a wide range of terrestrial and aquatic habitat requirements, turtles have the potential to serve as indicator species for landscape-scale change. Their extraordinary life history (slow maturation and long lifespan), however, make even basic ecological research difficult. The research outlined here will help elucidate both the basic biology of these species and the impacts of continuing landscape change, both of which will contribute to the proper management of these species. Analysis of the well-studied population at Sandhill will help illuminate many long-standing questions in turtle biology, including how far juveniles and adults can disperse and whether females display fidelity to the nest sites at which they were born. Traditional measures of genetic differentiation will likely show little effect of land conversion on large-scale connectivity, as changes have occurred quite recently when measured against turtle generation time (although turtles with faster generation times may show a greater effect). These traditional measures, however, will still be useful insofar as they will provide information on how populations have historically been connected. Assignment- and kinship-based measures will provide better measures of migration on recent timescales and will likely show that major roads and extensive industrial agriculture prevent dispersal.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

As previously stated, turtles have the potential to serve as indicator species for discerning the effects of landscape change along sensitive aquatic/terrestrial boundaries. As long-lived species, turtles also have the potential to serve as indicators of the effects of agricultural pollution on time scales similar to that of a human lifetime. Overall, this research will provide invaluable information for preserving this piece of the biodiversity puzzle, as well as the habitat that sustains it.

Keywords: *turtles, threatened species, conservation genetics, habitat fragmentation, agricultural pollution, wetlands*

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