Project Summaries

Brazil

Biodiversity and Adaptations of CYP Enzymes in the Amazon *Loricariidae* Fishes

PI: Thiago Parente, Fundação Oswaldo Cruz (Fiocruz)
U.S. Partner: Mark Hahn, Woods Hole Oceanographic Institution

The Hypancistrus zebra, an endangered Loricariidae species (Photo: Dr. Parente)

CYP1 enzymes are responsible for the biotransformation of natural compounds and anthropogenic pollutants. Usually the reactions catalyzed by CYP1 enzymes lead to detoxification, when the compound is eliminated from the body without causing harm. CYP1 enzymes, however, are also known to catalyze bioactivation reactions, in which one of the reaction products is more toxic than its parent compound. The equilibrium between the detoxification (beneficial) and bioactivation (detrimental) roles of CYP1 enzymes has been fine tuned for each and every vertebrate species over the course of evolution. This PEER Science project is closely aligned with the National Science Foundation-supported work of the U.S. partner, Dr. Mark Hahn, as both involve the study of different naturally evolved and selected solutions for the same issue: the balance between detoxification and bioactivation by CYP1 enzymes using fish species as vertebrate models. The adaptation of Killifish (studied by Dr. Hahn) is a well-documented event classified as dramatic, rapid, convergent, and triggered by anthropogenic pollutants that balance the dual role of CYP1 enzymes at the gene expression level. However, the adaptation of *Loricariidae* fish is poorly known and most probably can have the opposite classification: gradual, slow, divergent, and triggered by chemicals naturally present in the fish microhabitat. The goals of this project are to determine whether the adaptations of CYP1 enzymes in *Loricariidae* fishes are convergent or divergent and how they change the susceptibility of this species to the toxic effects of petrogenic compounds.

Dr. Parente and his research team will sequence the CYP1 genes of 100 *Loricariidae* species from the Amazon, and these gene sequences will be used to determine the enzyme sequences, which in turn will be aligned and compared for amino acids substitutions and interaction with classical CYP1 substrates. Selected *Loricariidae* species will be used for biological assays to evaluate the toxic effects of petrogenic derivates and their molecular mechanisms of action. Due to the current and future prospects for crude oil drilling activities in the Amazon region, it is imperative to understand the metabolism of petrogenic hydrocarbons by Amazonian biota. This is especially true in the case of *Loricariidae* fishes, as it is already known that those species have CYP1 enzymes with distinct affinity for substrates. It needs to be determined whether these changes will unbalance the evolved equilibrium of CYP1 dual roles to the beneficial or to the detrimental side. This knowledge will be crucial to better evaluate the risks of oil drilling activities for Amazonian biodiversity.

Biodiversity and Climate Change in the "Arc of Deforestation" of Brazilian Amazon

PI: Guarino Colli, Universidade de Brasília, with co-PIs Ben Hur Marimon Junior, Universidade do Estado de Mato Grosso, and Fernanda de Pinho Werneck, Instituto Nacional de Pesquisas da Amazônia (INPA)
U.S. Partner: Barry Raymond Sinervo, University of California, Santa Cruz

The expansion of agriculture poses serious threats to natural landscapes across the globe, and tropical forests are among the most affected ecosystems. They have declined to about 65% of their original cover worldwide and are expected to continue to dwindle this century. Biodiversity is concentrated in tropical forests, and the combined effects of habitat loss and climate change are presumably the primary drivers of the global biodiversity crisis. To reduce extinction threats due to climate change and expansion of agricultural frontiers, studies that quantify the extinction risk of populations/species must be a high priority. This research project focuses on the integrative approach to investigate the ecology, evolution, and conservation of the Amazon-Cerrado transition (ecotone) in Brazil, one of the most critical areas in the "Arc of Deforestation." This region provides a unique model system to investigate the origins and maintenance of high Neotropical biodiversity and the combined effects of climate change and habitat loss on the biota. In this collaborative project, the research team will characterize the herpetofauna (amphibians and reptiles) and assess its vulnerability to climate change and habitat loss. The goals of the project are: (1) to assess whether the biota of the Amazon-Cerrado ecotone is simply a filtered blend of species from the two neighbor biomes, or whether it also harbors unique (endemic) species; (2) to determine the importance of differentiation along this ecotone during evolutionary time and climatic cycles as a source of biodiversity; (3) to predict and test for contemporary extinctions arising from the combined impacts of habitat loss and climate change using ecophysiological models; (4) to identify evolved traits that enhance the extinction risk induced by habitat loss and climate change; and (5) to assess the role of indigenous land management practices, which resulted in "black earth" (Terra Preta), upon biodiversity levels and extinction risk.

The project will be led by an interdisciplinary team of Brazilian and U.S. researchers. The Brazilian team will conduct fieldwork at the selected sites to obtain biodiversity data, including species composition and abundances, ecological traits, tissue samples and ecophysiological data. In the lab, the researchers will obtain additional ecophysiological data and molecular data for phylogeographic and phylogenetic analyses. Ultimately, the goal is to develop the critical knowledge for scientists, policy makers, and the public to make informed decisions about how human activities are and will influence the biota and biosphere processes. The results of this research project are expected to increase public awareness of the combined impacts of climate warming and habitat loss on biodiversity at the "Arc of Deforestation" and forest-savanna ecotones and aid policy makers and landowners to make informed decisions about the creation and operation of reserves in the region. A webpage will be developed to integrate the results from several projects coordinated by the PI. Web-based tools will also be created, allowing conservation biologists to upload georeferenced data and obtain extinction forecasts for their species, based on validated extinction models. Data collected during this project will also facilitate a more precise calibration of existing global extinction models in under-sampled regions of the world that are at a high risk of biodiversity loss.

Biodiversity and Socio-economic Impacts of Palm Oil Bioenergy Development in the Brazilian Amazon

PI: Rodrigo Medeiros, Conservation International do Brasil, with co-PI Luciano Montag, Universidade Federal do Pará
U.S. Partner: Kathleen E. Halvorsen, Michigan Technological University

This research project focuses on biofuel development that impacts forested systems, one of the most controversial types of energy development today (NRC-NAS 2011). The research is expected to advance science sustainability and further the understanding of the impacts of palm oil biofuel development on socioecological systems in Brazil. Clean renewable energy policies, biodiversity conservation, and economic development are often studied, but generally in isolation. Using an in-depth case study approach, this project will fully integrate social and ecological scientific methods. The main benefits of this research will be: (1) understanding rural community level socioecological impacts of palm oil expansion; (2) designing policy measures that promote continuous social inclusion and biodiversity-friendly palm oil production; (3) developing new sustainability science indicators and metrics using results from the socioeconomic and biodiversity studies; and (4) increasing the research capacity of the Pan American partner institutions for graduate and postgraduate student education specializing in sustainability issues.

Project members interview local communities in the Brazilian palm oil production hubs. (Photo courtasy of Dr. Medeiros)

The results of this research project will have important consequences for the long-term sustainability of biofuel feedstock, human communities, and biodiversity conservation. The project's final results will be shared at relevant national and international conferences and also with key regional and local stakeholders in efforts to improve small landholders' economic benefits from palm oil and facilitate inclusion of marginalized groups in the palm oil sector. Policy recommendations from this research will assist Brazilian government institutions in policy development to increase local and national socioeconomic benefits, promoting energy independence, and small landholder's inclusion while minimizing impacts on existing biodiversity, hence achieving sustainability. The expected project impacts are closely aligned with USAID's interests, especially in the biodiversity, environment, and agriculture categories, since the project's final goal is to suggest a sustainable and economically viable palm oil agriculture model in Brazil that can be a model for other developing countries in the region. Consistent with USAID's approach, this project is taking a cross-sector approach to address a major threat to biodiversity conservation, economic growth, and, to a lesser extent, human health and global climate change.

Biodiversity Conservation and Scientific Capacity Development in the Brazilian Amazon using Ants as Bioindicators and Ecosystem Health Indicators

PI: Rodrigo Feitosa, Universidade Federal do Paraná
Project Representative: Gabriela Camacho, Universidade Federal do Paraná
U.S. Partner: Kenneth G. Ross, University of Georgia, Athens

The Amazon is one the most biodiverse regions in the world, yet it is under threat from human encroachment and global climate change. Biodiversity research has focused mostly on vertebrates, paying less attention to other taxa that are arguably more important for ecosystem health and function, such as insects. This is especially true of ants, which are incredibly species-rich, ecologically diverse, and have the highest biomass of any animal in the Neotropics. Ants are key ecosystem engineers, contain many different guilds, and are often highly sensitive to environmental perturbation, which makes them ideal bioindicators. Using ecologically relevant bioindicators allows highly sensitive insight into rapid changes in habitat health and ecosystem function. Unfortunately, a taxonomic impediment limits their use, since many tropical species are undescribed or new to science, greatly slowing morphological species identification. This research study seeks to address this shortcoming by conducting an inventory of ant diversity using DNA sequence data. The collected samples will form the nucleus for a growing entomology collection at the Universidade Federal do Paraná (UFPR), which will be developed into an active research collection to support the study of systematics, biodiversity, and natural history of the ant fauna of the Amazon and Brazil.

Ants contain several important tropical agricultural pests and invasive species. The project will thus be important for Brazilian agriculture and food security as potential pest species will be identified. Assessment of ant biodiversity at various levels and assigning species to functional guilds will lay the baseline for continued monitoring of ecosystem health and biodiversity under climate change, and will help inform conservation decisions by allowing rapid and efficient appraisal of ecosystems. The development of cheap and rapid genetic identification tools is expected to have an immediate and lasting impact on biodiversity assessment and conservation practices in the Amazon. Coupling genetic and species-level biodiversity assessments with ecological functional information will improve economic valuation and management impact of ecosystems. This will strengthen environmental governance and advance sustainable management of natural resources and biodiversity conservation in the face of environmental and global climate change. The use of genetic markers will allow in-depth understanding of pest and bioindicator population genetics and dynamics, which are important considerations when developing and applying control or conservation management plans. Additionally, the generation of high-throughput DNA barcoding and next-generation population genomic data will form the foundation for cutting-edge science, technology, and innovation in conservation genetics and bio control and will provide a long-term investment for the PI, Dr. Feitosa, to develop and train genomic capacity in Brazil.

Epiphyllic Communities on Leaves at Tropical Forests: Causes and Consequences for Leaf Functioning at Different Scales

PI: Bruno Rosado, Centro de Gestão de Pesquisa, Desenvolvimento e Inovação (CGPDI)
U.S. Partner: Scott Saleska, University of Arizona

This project focuses on improving our knowledge of the basic ecology of forests so we can better understand the response of plant species based on their interaction with epiphylls, identify their role in the carbon cycle in different scales, and anticipate the effects of climate change and different forest management practices on forests and their functioning in ecosystems. This study will provide several intellectual gains and broader impacts to scientists, environmental planners, and students. It should also provide a missing link in forest carbon models with the potential for better understanding atmosphere-vegetation relationships by examining the influence of leaf traits on epiphyllous communities and leaf functioning. Defining the spatial patterns of the influence of epiphyllous communities on leaf functioning among species and sites may be important to assess the overall carbon balance at a particular site. With this clearer understanding, more meaningful models of forest carbon processes can be formulated that incorporate leaf surface variables and epiphyllous communities.

Training of undergraduate students on how to measure stem increment growth in tagged trees, with steel dendrometer bands. (Photo courtesy of Dr. Rosado)

Dr. Rosado and his team expect to develop basic science investigations with relevant results for development goals and challenges. This goal will be reached by stimulating and supporting the development and dissemination of next-generation instrumentation and maintaining and modernizing the shared research and education infrastructure, including facilities and science and technology centers. A major and broad impact of this proposed study to the public is that it will provide the basis for new information that will enhance our understanding of carbon fluxes. This is especially important given that Brazil has recently approved a new Forest Code that will result in escalating deforestation, increasing the urgency to demonstrate the value and functioning of species. Considering the new paradigm of the green economy that now surrounds this discussion, these researchers expect to produce results on biodiversity research combining floristic, metagenomic, and functional ecology to screen forest leaves. They anticipate strengthening partnerships with science centers and similar institutions to develop exhibits in science and involve the public in research and education activities. Data will be made available in a timely manner by means of databases and digital libraries, and research and education results will be presented in formats useful to policy-makers and broader audiences.

Mycota Associated to Native *Hevea spp.*in the Brazilian Amazon Region

PI: Aristóteles Góes-Neto, Centro de Excelência em Bioinformática, Fundação Oswaldo Cruz--Fiocruz
U.S. Partner: Priscila Chaverri, University of Maryland, College Park

This project expects to characterize the mycota associated to the socially important and economically valuable rubber trees in the Brazilian Amazon region. The project will focus on characterizing endophytic and saprophytic fungi that naturally occur in Brazil and compare to fungal diversity in another region of Amazon basin, the Peruvian Amazon region. The idea is to corroborate the hypothesis that suggest that fungal endophytes have coevolved with their host plants to protect them from natural enemies.

The endophytic fungi associated to native rubber trees occurring in the Brazilian Amazon region can be utilized in biological control of *Microcyclus ulei*, the agent of South American leaf blight which is the scourge rubber trees. This project can add more aggregated value to this important tree of Amazonian forests, reinforcing the necessity of avoiding the potential loss of useful biodiversity due to deforestation and expansion of agricultural and livestock breeding frontier in the Brazilian Amazon region.

Colombia

Ecosystem Response to Climate Change in the Mountain Wetlands

PI: Juan Castaño, Universidad Tecnológica de Pereira
U.S. Partner: Jay Martin, Ohio State University

The research team trains children from the Asociación Scouts de Colombia in climate change identification (Photo courtesy Dr. Castano).

Since 2008, Colombia has experienced three extreme climate events that have resulted in droughts and flooding during which more than 400 human lives were lost. During these events, 15 percent of the country was inundated and more than $6 billion in economic losses were sustained. While such national and international impacts of climate change are frequently noted and predicted by large-scale models, the local communities that suffer greatly from these disasters and are ultimately responsible for human welfare lack tools to predict and respond to changes in climate. To better prepare local communities to predict climate impacts and develop responses, this project will develop an early alert system to forecast changes in the ecosystem services of water regulation and biodiversity in the Quebrada Dali watershed. This upstream watershed, located in the central Andes of Colombia, affects agricultural and urban downstream areas that have already seen climate impacts and can greatly benefit from tools to predict further impacts and plan proper responses to climate changes.

The long-term goal is to develop a sustainable local ecosystem study site to monitor and model short- and long-term effects of climate change on the ecosystem services provided by Quebrada Dali

watershed. The early warning system to be built will be based on permanent monitoring and adaptive modeling of the effect of climate chang e on the ecosystem services of water regulation in a watershed in the central Andes and its influence on water supply systems. A critical need for such a system at a local level is evidenced by the fact that many of the prediction models used to determine the effects of climate change on environmental services and society are based on global scale climate data, but they omit biophysical and social influences that determine local responses. As one of the most vulnerable countries to impacts of climate change, Colombia is an excellent location to examine human adaptation to impacts such as severe floods and drought.

Impacts of Climate Change on Tropical Wetlands: Tracking the Evolution of Two Andean Lakes and a Floodplain Cienaga in Columbia

PI: Julio Eduardo Cañón Barriga, Universidad de Antioquia
U.S. Partner: Francina Dominguez, University of Arizona

Project Overview

The group finishing their work on the digital station (Photo courtesy Dr. Cañón)

Communities in tropical regions along the Andean Cordillera in South America face an uncertain future, as mountain lakes and snow peaks exhibit receding trends and strong fluctuations associated with climatic drivers (i.e., climate change and El Niño) and local human activities. Such fluctuations are apparent in Colombia, where these changes will have direct impact on strategic ecosystems such as the Orinoco and Amazon basins and the highly populated Cauca and Magdalena River basins. Therefore, understanding how these water systems evolve in the near future is of critical importance for the communities that depend on them for their survival.

This project aims to develop long-term monitoring of the evolution of three natural water bodies: Colombia´s two main Andean lakes (Tota and Cocha) and the floodplain wetland of Ayapel. These natural reservoirs not only represent the accumulated effect of hydrological processes in their respective basins but also serve as examples of highly intervened environments from which several rural and urban communities derive their water resources and develop their economic activities. This project will gather data about the areas of interest by contacting local, national, and international agencies for technical reports, census information, hydrologic databases, and remote sensing imagery. The information gathered, as well as gauges installed at the lakes and visits to record geographical, geophysical, and socio-economic data, will be used to build models that describe the evolution of these bodies of water. The results of these studies will be available through technical and scientific papers as well as a website to be designed to offer easy access to geographically integrated and updated information useful for all interested parties locally and worldwide. The project should facilitate the

development of improved models to determine the lake stage as a function of climate drivers and human uses to serve as a basis for future decision support for the communities involved.

Integrated humanitarian logistics system for developing countries

PI: Victor Cantillo, Fundación Universidad del Norte
Project Representative: Luis Macea, Universidad del Norte
U.S. Partner: José Holguin-Veras, Rensselaer Polytechnic Institute

This project aims to contribute to the development of an integrated humanitarian logistics system for post-disaster relief response in developing countries. As part of the work, the research team will collaborate to propose humanitarian logistics models that explicitly incorporate a key aspect that has not been considered before: deprivation costs (i.e., the cost associated with lack of access to life-sustaining items). This is important in order to develop appropriate models capable of representing human suffering. The research is expected to produce algorithms and heuristics to solve and validate the proposed formulations and propose an effective emergency management system for post-disaster relief operations. This will lead to analytical formulations that properly consider the consequences of logistics decisions once populations have been impacted by disasters and, ultimately, to more effective and coordinated strategies to deliver critical supplies in developing countries. This research will be complemented with a plan to enhance project impacts by attracting students to careers in engineering at graduate level, integrating research and education, and reaching out to practitioners with training sessions in disaster response operations.

The importance and relevance of the proposed work has been evidenced by direct observations and field work conducted during recent humanitarian logistics efforts after super-storm Sandy, Hurricane Katrina, and the Joplin tornado, as well as the earthquake response in Haiti and the Dominican Republic and the response to the Japan earthquake and tsunami. Research conducted has highlighted the challenges of disaster relief systems in both developed and developing countries. These findings will be complemented with additional field work to be conducted by the team at ongoing disaster relief operations in Colombia. This proposal includes a close relationship with disaster relief operations agencies such as the local Emergency Disaster Response Office, which will work with the research team and social scientists in data collection regarding the last major disasters in Colombia. This work and coordination provides an excellent and unique opportunity, ase the number of disasters in the country has shown a notable increase in the last few years, especially due to climate changes. It is expected that the analysis of the datasets and case studies and a review of best practices will allow the team to adapt them to the needs of developing countries and be able to propose a disaster management system that minimizes human suffering. Furthermore, this system can be used to provide training to relevant agencies to make their response as effective and efficient as possible. In that sense, practitioners will have first-hand exposure to the problem and possible ways to resolve it.

Dominican Republic

Temperature Profile of the Ocean Seabed from the City of Puerto Plata, Dominican Republic, and Preliminary Design for a Commercial Exploitation of Cold Water to Supply for a Central Air Conditioning System

PI: Eduardo David Sagredo Robles, Universidad Tecnologica Santiago
U.S. Partner: Naphtali David Rishe, Florida International University

Electricity shortages represent one of the major problems facing the Dominican Republic. For more than 50 years, the country has experienced daily electric power blackouts lasting some four to five hours. The cost of electricity in the Dominican Republic is more than 2.5 times the average cost worldwide, which causes financial hardships not only for the general public but also for operators of the large hotels that contribute substantially to the country's economy. Air conditioning uses approximately 60% of the electricity consumed in tourist areas of the Dominican. Given the high cost of electricity and frequent power outages, implementation of a reliable, renewable, and nonpolluting energy source that can supply air conditioning to these hotels would represent the difference between economic survival versus bankruptcy, with its associated severe impacts on local employment.

The team at sea during a data gather expedition. (Photo courtasy of Prof. Sagredo)

This PEER Science project is designed to develop a model for how such an energy system could be designed and implemented. Dr. Sagredo and his team will place remote sensors at regular intervals along the sea bed to gather data to create an Ocean Temperature Profile from the city of Puerto Plata extending eight miles north until a depth of 1,000 meters is reached. The data collected will provide input to the design of a pipe along the sea floor that would extract the cold bearing water to the surface at Puerto Plata to provide a cold-water supply for air conditioning. Besides designing the pipe, the researchers will also study potential environmental impacts of their system, as well as optimization of the energy that would be needed to pump the seawater. Once their designs and models are complete, they will share their findings with local stakeholders, including hotel operators and entrepreneurs who might be interested in supporting implementation of the system after the PEER Science project is complete.

Mexico

NSF-PIRE Collaboration: Sustainability Evaluation of Jatropha Oil Production in Yucatan, Mexico

PI: Julio Sacramento-Rivero, Universidad Autonoma de Yucatan (UADY)
U.S. Partner: Kathy Halvorsen et al., Michigan Technological University (MTU)

Aparajita Banerjee and Mayra Sánchez carrying out a semi-structured qualitative interview with a housewife in Samaria, Tizimín, July 2013 (Photo courtesy Dr. Sacramento-Rivero).

This project relates to a five-year Partnerships for International Research and Education (PIRE) award entitled Sustainability, Ecosystem Services, and Bioenergy Development across the Americas, which was funded by NSF beginning in October 2012. Dr. Julio Sacramento-Rivero and his colleagues will work with Dr. Kathy Halvorsen and her group at Michigan Tech to address such questions as "How is bioenergy development affecting social systems?" and "What sustainability indicators and metrics best assess biofuel sustainability across highly variable Pan American socio-ecological systems?" This work will be performed in the context of the jatropha oil industry currently under development in the state of Yucatan, Mexico. This case study is unique in that it presents both universal and idiosyncratic aspects of sustainability to be evaluated. Although commercial-oil production is not expected to begin in Yucatan until 2014 or 2015, several communities have already been affected by the planting and cultivation stages, and it is uncertain how the currently planned commercialization model will impact sustainability in the region.

Mayra Sánchez and Aparajita Banerjee interviewing the eldest daughter of a family of 12 in Samaria, Tizimín, July 2013 (Photo courtesy Dr. Sacramento-Rivero).

Thus, this project aims to evaluate the sustainability of the production and commercialization process of jatropha oil, and the socioeconomic impacts of this activity on the local communities in Yucatan and the broader national system. Also, although the current commercialization model is primarily concerned with biodiesel sales, it has been strongly suggested that the economic viability of such systems can be greatly benefit from the integral use of the jatropha plant. In that sense, a biorefinery system will be designed and included in the sustainability assessment, as an alternative, expanded system. For this stage, fundamental engineering experiments will be performed on the local feedstock at the Faculty of Chemical Engineering at UADY and at MTU, which will generate characterization data of the local feedstock that will be required for evaluation of both biofuel-oriented and biorefinery-oriented systems. Funds from the PEER Science grant to UADY will support the purchase of new lab equipment, materials, and software; domestic and international travel for fieldwork and training; and PhD student stipend support.

Poverty and Climate Change in Mexico: The Implications of Mitigation Policy, Climate Impacts, and Development Pathways for Household Welfare

PI: Landy Sanchez, El Colegio de Mexico
Project Representative: Ana Escoto
U.S. Partner: Brian O'Neill, National Center for Atmospheric Research

Climate change will impact the Mexican population's wellbeing over the next decades. There are few worldwide studies that consider the impact of mitigation policy on poverty, and no estimation of corresponding scenarios for Mexico, since integrated analysis of climate impacts and mitigation policy is very novel. In order to design sound development policies, it is imperative to understand the linkages between poverty risks and climate change, as well as quantifying how mitigation targets would diminish or increase such risks in the short and long run. This research study will examine the combined implications of climate impact and mitigation policy for poor households through their effects on agriculture and energy, addressing the limitations of current research. The research team will aim to: (1) enhance the representation of Mexico's development trends for climate change scenarios, with an updated and detailed survey analysis of demographics, income, and consumption of Mexican households over time for iPETS; (2) develop climate and socioeconomic scenarios for Mexico in a global context; (3) examine the joint consequences of climate impacts and mitigation policy on households: variations in the number of poor households as food prices respond to impacts on crop productivity and land availability; energy prices impact on poverty headcounts under climate policy; and whether demographic and income transformations might offset food and energy prices effects, under different adaptation and mitigation policies that might alleviate negative consequences on poverty; and (4) foster capacity building for climate and socioeconomic scenario research among researchers and policy makers in Mexico.

The research team, in collaboration with the U.S. partner, will train, strengthen, and better inform researchers, graduate students, and policy makers on the use of climate and socioeconomic scenarios, fostering their capacity to evaluate the welfare implications of climate policy. In order to achieve this, the project will include different venues for presenting the fundamentals of scenario design using integrated assessment models (IAMs). The project will pay special attention to climate-change implications for households arising from socioeconomic pathways and demographic heterogeneity. Since the impacts are likely to be uneven, identifying differential effects across household groups would serve as an important input for development of better policies in Mexico, given its large demographic and social inequality. The research project will contribute to USAID's goal of decreasing vulnerability to poverty. Although Mexico has estimates about mitigation costs for the country, there is no study that evaluates how global climate policy will impact its population, and to what extent future social and economic transformations could balance such effects. This project, with its integrated approach, should help inform Mexican policy makers on mitigation and adaptation policies, and how they can be designed without harming poor household groups.

Nicaragua

Marine Biodiversity Initiative for Central America: International Partnership for Research and Training on Marine Biodiversity and Genomics

PI: Jorge Huéte-Pérez, Universidad Centroamericana (UCA)
U.S. Partner: Martin Polz, Massachusetts Institute of Technology

The goal of this initiative is to assemble an international network of scientists to train local researchers and assist them in the study of neglected Mesoamerican coastal marine biodiversity and the impact of climate change (e.g., via ocean acidification), specifically in Honduras, El Salvador, and Nicaragua. A cross-disciplinary approach that integrates taxonomy, molecular biology, and genomic techniques with biodiversity conservation will be used. This network will identify gaps in knowledge to determine the course of more in-depth research on the current status of marine biodiversity in Mesoamerica, leading to the development of collaborative programs on the sustainable use of marine resources and better understanding of anthropogenic influences on ocean biodiversity. The project will begin with the first International Conference on Central American Marine Biodiversity and Genomics to be held in Nicaragua. It will be followed by planning sessions and committee building to create an international network to develop a strategy for advancing marine biodiversity research and conservation in the region. The network will hold training and project development workshops during which students and scientists will be trained in sample collection, DNA sequencing, and data sharing, in addition to field training. The conference will present previously prepared discussion papers on priorities for research and the development of collaborative plans. Participants will discuss the scope and objectives, further training needs and outreach mechanisms, roles and responsibilities, expected development outcomes, data sharing, project sustainability, and funding.

The group takes water samples at Isla Juan Venado, Nicaragua (Photo courtesy Dr. Huéte-Pérez).

This initiative expects to advance scientific and technical knowledge for informing development-related policies by building regional capacities on marine biodiversity and conservation, improve the capacity of local institutions, enhance the technical infrastructure of local, and impact the broader community in the region through partnerships between researchers, community leaders, authorities, educators and students. An asset of this project is the current pilot work of Dr. Huéte-Pérez and his team in the Gulf of Fonseca, which is committed to fostering the "sustainable use of its marine and coastal resources and the integrated management of its ecosystems" through trinational cooperation. UCA has teamed with the European Union to work with communities in the Gulf to create a consciousness of the value of their marine resources. The expanded human resource capacity coupled with substantive advancement in the knowledge base relating to the coastal ecosystem will enable more appropriate public policies and decision making relating to the marine biodiversity coastal zones. The project will contribute to setting the stage for eventual commercial activities based on local stewardship of coastal resources and on diversification of the coastal economy.

Peru

Building Peruvian Capacity for Monitoring and Modeling the Effects of Climate Change on the Coropuna Glacier and Associated Watersheds in Arequipa, Peru

PIs: Roberto Zegarra Balcazar and Felio Carderon La Torre, Asociacion Especializada para el Desarrollo Sostenible (AEDES)
U.S. Partners: Joerg Schaefer, Columbia University, and Gordon Bromley, University of Maine

Installation of a weather monitoring station. {Photo courtesy of Dr. Julio Alegria)

Peru is especially vulnerable to the effects of climate change due to the dependence of 70 percent of its population on glaciers for dry season water; however, Peru lacks an integral vision that builds climate change resilience by linking investigation, local knowledge, and decision-making. In this project, AEDES is partnering with the Lamont-Doherty Earth Observatory of Columbia University with the goal of building Peru´s capacity for monitoring and modeling local climate change in its Pacific Basin. The objectives of this capacity building project are to (1) improve data collection and analysis through practical training, (2) foster knowledge and data exchanges between national and international scientists, and (3) contribute to more robust modeling of Coropuna-vicinity climate change scenarios. This project will facilitate quality data collection by local researchers that contributes to local models that should help decision makers to better prepare themselves for changing climate conditions.

Installation of wooden stakes in the axis of the glacier. (Photo courtesy of Dr. Julio Alegria)

To achieve their objectives, these researchers will carry out a series of joint data collection and field-based training during the summers of 2012 and 2013 and will maintain periodic monitoring of glacier mass at two sites and of hydrological data in two sub-basins. A highlight of the project will be the installation of a new weather and hydrology station installed on Coropuna, which should enhance data accuracy. The project will also provide support for the thesis research and training of two Peruvian master's degree students. One workshop will be organized on climate change, glaciers, and hydrology in the southern Andes, and another training workshop on climate change modeling will be conducted. Overall, it is expected that the U.S.-based researchers involved will benefit from improved logistical support and an expanded field season, while the Peruvian investigators will gain from improved precision in data collection and analysis, knowledge of international research results, and enhanced ability to model climate change scenarios. The project should also provide the international research and policy community with vital information for understanding the sensitivity of tropical glaciers in Peru´s highly valued freshwater reservoirs to climate warming.

Glacier Retreat and Water Resource Sustainability in the Peruvian Andes: Informing Adaptation Strategies through Collaborative Science

PI: Cirilo Pablo Lagos, Instituto Geofisico del Peru
U.S. Partner: Bryan G. Mark, The Ohio State University

Glaciers in the Peruvian Andes are shrinking faster than expected, and several of them have already disappeared. NSF-sponsored research on glacier studies in the Cordillera Blanca, the most glacierized region of Peru and the global tropics, shows that glacier recession reduces water supply and has far-reaching consequences for the mountain environment and communities. Additionally, the results have shown that during the dry season, hydrologic processes in the pro-glacial zone are often equal in importance as glacier melt water. These high-impact findings were enabled by the development of new Andes-specific methods to measure glacier volume changes, pro-glacier hydrology, and the development of a predictive hydrological model to estimate future river discharge. The results are very compelling and underscore the urgent need to better understand the climate-glacier-society interactions and effectively link them with human activity, policy and local community needs on a broader scale.

The research team in collaboration with the U.S. partner will transfer and apply this new knowledge and methodology in another Peruvian watershed, the Shullcas River watershed, which is also impacted by rapid glacier recession, growing population, and the existing social conflict due to water scarcity, wherein farmers seeking to maintain food security clash with an urban population demanding adequate water availability. The anticipated outcomes of the project include a better understanding of the glacier and groundwater sources of stream flow and a projection of the future Shullcas river discharge, extending to the year 2050. This information is very valuable for the design and implementation of adaptation strategies by water resource policy makers, farmers, global change specialists, development practitioners in the power generation community, as well as scientists who study related topics, such as chemical weathering and physical sedimentation. Furthermore, insight into the future hydrologic regime is a key element for informed decision making pertaining to adaptation to glacier recession and the dwindling water supplies in the Peruvian Andes due to climate change. The efforts of this project will include intensive research training for undergraduate students at Peruvian universities, as well as technical training for the local institution responsible for water resource management and policy.

Impact of Transboundary Biomass Burning Pollution Transport over the Central Andes of Peru

PI: Luis Suárez, Instituto Geofisico del Peru
U.S. Partner: Detlev Helmig, University of Colorado at Boulder

The team visits one of the Amazon atmospheric monitoring stations. (Photo: Dr. Suarez)

Biomass burning is the main source of air pollutants in tropical regions, and researchers worldwide have worked to determine its possible effects on air quality and climate. The Amazon basin is among the regions with the greatest need to better understand the effects of the transport of pollutants on air quality, radiative forcing, and precipitation patterns. This PEER Science project will focus on monitoring forest fires and evaluating the adverse effects of the resulting smoke and ash on climate change. Ing. Suárez and his research collaborators will conduct field work at two contrasting sites in the Andean and Amazon regions of Peru. These activities will not only promote intensive cooperation among representatives of the three major Peruvian universities involved but will also give them new opportunities for collaborating with U.S. counterparts.

The project will train and provide support for six Peruvian undergraduates and three Master's-level students as they work on their theses. Local laboratories will be upgraded with new equipment to facilitate a new long-term program for monitoring tropospheric ozone, aerosol optical depth, and ultraviolet spectral solar radiation at the Observatory at Huancayo. The researchers will make a detailed evaluation of tropospheric ozone and aerosol pollutants and will report to local policymakers on these findings, particularly as they relate to the impacts of deforestation in the Amazon. A planning workshop will also be held to discuss the creation of a new Institute of Antarctic and Andean Research (INSTAAR) Peru, which will serve to promote the sustainability of research and policy studies on these topics even after the PEER Science project is completed.

Strengthening Resilience of Andean River Basin Headwaters Facing Global Change

PI: Bram Willems, Universidad Nacional Mayor de San Marcos
U.S. Partner: Christopher Scott, University of Arizona

The team conducts field work during a visit to Cumbemayo's Canal (Photo Courtesy of Dr. Willems).

Decreasing water availability in Andean river basins, rising temperatures, increased probabilities of drought occurrence, and expanding water demand all indicate that Peru will experience a severe future water crisis. This PEER Science project considers Andean headwaters, particularly páramos and puna wetlands, as social-ecological systems (SESs) in which coupled natural and human processes like drought, flooding, water use and impoundment in reservoirs for irrigation, and mining act together to destabilize and threaten water availability and quality for human and ecosystem purposes. This project is expected to produce innovations in Andean headwaters characterization methodologies by combining use of satellite imagery (optical and radar), products derived from their analysis (e.g., land use and land cover change), and field data (e.g., precipitation, runoff, and water use, including socioeconomic characteristics). These methodologies will allow the researchers on the project to identify headwaters, quantify their extent, and define indicators for assessing their dynamics. In turn, cross-correlation analysis between these indicators and climatic and anthropogenic drivers, such as El Niño Southern Oscillation events and mining operations in headwaters, for instance, will lead to the establishment of characteristics that make Andean river basin headwaters vulnerable to global change. A second important contribution of the project will be the integrated assessment of Andean páramos and puna wetlands, which are far less studied than glaciers but play an even more crucial role in the hydrology of the majority of Peru's Andean basins and hence in the provision of water to coastal regions. According to the Autoridad Nacional del Agua, glaciers play a primary hydrological role in Vilcanota (Cusco) and El Santa (Ancash) basins, whereas headwaters wetlands are far more pervasive but not adequately identified, much less assessed from a water management perspective.

The results of the project will include development of a satellite-based monitoring system for assessing biophysical changes in Andean headwaters and creation of case-study documentation of human dimensions of global and local changes affecting the headwaters regions of the basins, with particular emphasis on water use and quality degradation. Capacity-building activities as part of the Geophysics Masters's Program at the Universidad Nacional Mayor de San Marcos will also be expanded.