

NRT-INFEWS: Training in Theory and Application of Cross-scale Resilience in Agriculturally Dominated Social Ecological Systems

University of Nebraska

PI – Craig Allen

ABSTRACT

This National Science Foundation Traineeship (NRT) award to the University of Nebraska - Lincoln establishes a new graduate training program that focuses on understanding the resilience of agricultural systems. Nebraska's agricultural system in the Platte River Basin is of economic, social and natural value; but the river basin's ability to resist damage from outside threats (e.g. pollution, pests, draught) and recover rapidly is unknown. This training program at the University of Nebraska will examine resilience of agricultural landscapes through the disciplines of agronomy, natural resources, computer sciences, engineering and public policy. The program anticipates training 25 PhD and 25 MS students, including 23 funded trainees, from natural resources, environmental science, agronomy, entomology, plant sciences, geosciences, biosystems engineering, computer science, and public policy. Trainees will engage with external partners from the agricultural industry, government agencies, and other organizations that have an interest and stake in maintaining productive agricultural systems. This broad graduate training will help develop a workforce and agricultural industry better capable of managing future demands on food, energy, and water systems.

This NRT program will focus on understanding aspects of resilience in water-stressed and energy-demanding agricultural landscapes and will utilize resilience and panarchy theory, adaptive management, novel sensing technologies and modeling, and policy interventions. Such interdisciplinary training is rare in graduate programs in the United States, but is vital to prepare the next generation of natural resource scientists, producers, managers, engineers, and policymakers so they may respond to the challenges created by increasing demands for diminishing and interconnected resources, and the need to maintain and build resilience in stressed watersheds. This NRT program will serve as the innovative foundation for a permanent interdisciplinary graduate program in the resilience of agro-ecosystems. The program will ensure that students, academic programs, government agencies, and the private sector engage in building and preserving natural and agricultural ecosystems to meet local and global demands for water, clean energy, food, and ecosystem services. Graduate student research will focus on the complex and intertwined ecological, technical, and societal systems involved in managing resources in the 21st century, particularly in complex landscapes managed for agricultural production. Further, the program will help develop innovative tools for data collection, analysis, and synthesis to support management and restoration decisions in agricultural systems.

The NSF Research Traineeship (NRT) Program is designed to encourage the development and implementation of bold, new potentially transformative models for STEM graduate education training. The Traineeship Track is dedicated to effective training of STEM graduate students in high priority interdisciplinary research areas, through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs.

This proposal is co-funded by the Alliances for Graduate Education and the Professoriate (AGEP), the Division for Education and Human Resources (EHR) Core Research (ECR) program, and the Established Program to Stimulate Competitive Research (EPSCoR). AGEP funds research and the development, implementation, and investigation of models to transform the dissertation phase of doctoral education, postdoctoral training and/or faculty advancement of historically underrepresented minorities (URMs) in STEM and/or STEM education research. The ECR program (NSF 15-509) of fundamental research in STEM education provides funding in critical research areas that are essential, broad and enduring. EHR seeks proposals that will help synthesize, build and/or expand research foundations in the following focal areas: STEM learning, STEM learning environments, STEM workforce development, and broadening participation in STEM. EPSCoR co-funds projects that advance excellence in science and engineering research and education. Fostering sustainable increases in research, education, and training capacity and competitiveness within EPSCoR jurisdictions will enable EPSCoR participants to have increased engagement in areas supported by the NSF.

NRT INFEWS: UM BRIDGES: Bridging Divides across the Food, Energy, and Water Nexus

University of Montana

PI – Laurie Young

ABSTRACT

Growing demand for food, energy, and water and increasing stresses on these resources have created critical needs at the food, energy, and water nexus. This National Science Foundation Research Traineeship (NRT) award to the University of Montana will address global challenges and national needs by training a network of STEM graduate students to contribute to more sustainable and secure food, energy, and water systems in a range of careers. The University of Montana NRT program will train the next generation of scholars and practitioners by teaching graduate students how to bridge the divides needed to advance innovations at the nexus of food, energy, and water systems. Graduates will be prepared to bridge divides across sectors within the food/energy/water nexus; scales, from local to global; disciplines, including physical, biological, and social sciences; science, practice, and policy to ensure decision-relevant science and science-informed practice; and audiences, to communicate effectively across diverse constituencies and multiple platforms. The project anticipates training forty-eight (48) MS and PhD students, including twenty-eight (28) funded trainees, from the biological, physical, and social sciences. An additional seventy-five (75) STEM graduate students will participate in specific program elements alongside the forty-eight (48) NRT trainees.

The University of Montana NRT will be built around a set of linked training elements and research initiatives. Integrative, interdisciplinary campus and field-based coursework will develop core knowledge at the food/energy/water nexus and translational skills. In addition, internships and international experiences will bridge science and practice, collaborative lab experiences will build interdisciplinary skills, and workshops will build cutting-edge quantitative, computational, and digital communication expertise. These training elements will connect evidence-based educational activities to program goals and use rigorous assessment and adaptive learning to ensure success. Trainee research will examine and address critical food, energy and water problems through decision-relevant science that addresses land use, climate change, uncertainty, governance, and adaptability. Four broad research themes will be targeted: (1) tradeoffs between food, energy, and water in river and rangeland systems; (2) energy transitions, fossil-fuel switching, and the implications for agriculture and water; (3) agricultural system resilience in the face of drought and climate-variability; and (4) tribal and indigenous issues at the food/energy/water nexus.

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Collaborative Research: NRT-INFEWS: Sustainable Food, Energy, and Water Systems (SFEWS)

Purdue University/Florida Agricultural & Mechanical University

PI – Rakesh Agrawal/Aavudai Anandhi Swamy

ABSTRACT

Large areas of land are needed to satisfy the food, energy, and water (FEW) needs of an increasingly populated earth. This can lead to challenging land use competition where local FEW needs cannot be met with current land use practice. For instance, in areas where solar energy is produced, standard solar panels can cast large ground shadows on agricultural land throughout the day, which greatly impedes crop growth. An urgent need exists to develop solutions for sustainable FEW systems (SFEWS) where food, energy, and water needs can be met using available land collaboratively rather than competitively. One approach could be to use the entire solar spectrum to maximize resource production from a given land area. Achieving such solutions requires effective interdisciplinary education and training to generate the resources and human capital for leadership for a sustainable solar economy. This National Science Foundation Research Traineeship (NRT) award to Purdue University and Florida A&M University will form an interdisciplinary traineeship program that will train graduate students in the skills needed to produce sustainable supplies of food, energy and water (FEW) for a more heavily populated earth. The project anticipates training 48 PhD students, including 24 funded trainees, from agronomy, agricultural and biological engineering, electrical and computer engineering, chemical engineering, materials science and engineering, chemistry, and agricultural economics.

The SFEWS project aims to meet food, energy and water management needs locally with local solar energy. Achieving this state requires studying highly complex systems with previously unappreciated interdependencies and then developing innovative solutions by combining basic scientific and technical principles from the diverse fields of agriculture, engineering, and science. Out of many possibilities, solutions will be identified based on their system-wide simplicity, economic impact, and environmental footprint, in light of government policy and social impact. The SFEWS cohorts performing these studies will provide a workforce trained in interdisciplinary skills to identify underlying factors leading to competition for land, to suggest innovative solutions, and then lead in global implementation as researchers, business and industry leaders, policy makers, teachers and entrepreneurs. The new scientific and technical knowledge, unique systems analysis methods, and tools developed from this program will have impact well beyond the SFEWS NRT. This team will develop new interdisciplinary courses and training modules, globally disseminated through vehicles such as nanoHUB.org. Through well-planned diversity recruiting and engagement, the SFEWS NRT will help underrepresented and women students to help forge a sustainable FEW economy. Successful execution of this program will introduce a new paradigm where local FEW needs can increasingly be met with local solar energy for a highly resilient economy, with the U.S. serving as a world leader in sustainably meeting FEW needs.

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This project is co-funded by the Louis Stokes Alliances for Minority Participation (LSAMP) program. The LSAMP program supports comprehensive, evidence-based, and sustained approaches to broadening participation of students from racial and ethnic groups historically underrepresented in STEM.

Collaborative Research: NRT-INFEWS: Systems Training for Research ON Geography-based Coastal Food Energy Water Systems (STRONG-CFEWS)

University of South Florida/University of the Virgin Islands

PI – Maya Trotz/Sennai Habtes

ABSTRACT

With 40% of the world's population residing within 100 kilometers of a coast, these environments are critical to local and global economies. In China, the world's largest exporter, more than half of the country's population lives along its industrialized coastlines. Population densities in the United States are highest in coastal counties, representing 39% of the U.S. population. In such densely populated areas, human activity related to the generation and use of food, energy and water has been linked to impacts such as nitrogen pollution that degrades the quality of coastal waters. This degradation affects reef ecosystems, fisheries, and people's economic livelihoods and health. Replenishment requires innovative systems thinking and better consideration of the way food, energy, and water systems are integrated in terrestrial and coastal environments. Systems thinking considers the whole system including engineered infrastructure, the environment, and sociocultural aspects, rather than an assembly of isolated parts. Integrating sociocultural dynamics and meaningful engagement of community stakeholders is fundamental to this approach. This National Science Foundation Research Traineeship (NRT) award to the University of South Florida (USF) and the University of the Virgin Islands (UVI) will develop a community-engaged training and research program in systems thinking. Graduate Science, Technology, Engineering and Mathematics (STEM) students will design innovative, holistic solutions (e.g., technological, organizational) to better manage complex and interconnected food, energy, and water systems in coastal locations. The project will train 109 graduate students, including 23 funded PhD-level trainees from engineering and applied anthropology at USF and 6 MS-level trainees from marine and environmental sciences from the Historically Black University partner, UVI in four locations: Tampa, Florida, the U.S. Virgin Islands, Barbados and Belize. This award will prepare students to create innovative systems to address complex problems and will serve as a model for training a STEM-focused workforce.

The research supporting this training program focuses on the leverage points (technological, policy, and organizational) in designing food-energy-water systems in a specific geographic context to improve the sustainability of the overall system across different scales. This NRT will advance graduate training through: 1) a transformative research training framework guiding students to conceptualize the interactions between food-energy-water systems and define their research questions from a systems perspective; 2) a context based interdisciplinary training approach including newly developed co-taught courses, multi-discipline field-based training and research experiences that take place in the U.S. and internationally, and strong partnerships with local practitioners and community-grounded organizations; and 3) learning outcomes of our program in terms of interdisciplinary, 21st century, and local and global competency skills of graduate students and impactful research in the management of resources for food, energy, and water security.

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NRT-INFEWS: Paths to Sustainable Food-Energy-Water Systems in Resource-Limited Communities

University of Iowa

PI – David Cwiertny

ABSTRACT

The complex interconnectivity of society's food, energy and water resources, as well as their inextricable link to socioeconomic factors, present both grand challenges and opportunities that demand new paradigms in problem solving and cooperation across non-traditional disciplines. Nowhere will this challenge be greater than in resource-constrained communities, not only in the developing world but also in the often-overlooked populations of rural America and poor urban centers, where solutions to food/energy/water challenges will need to be tailored to specific communities. This National Science Foundation Research Traineeship (NRT) award to the University of Iowa will produce a new generation of water sustainability professionals specifically trained to promote sustainable development of food, energy and water resources in these underserved communities, not only as researchers and professors, but also as entrepreneurs, consultants, and civic, professional and global engineers. This project anticipates training fifty (50) MS and PhD students via new graduate degree and certificate programs in Sustainable Water Development, including twenty (20) funded trainees, by leveraging university expertise in all facets of water sustainability including engineering, economics, policy, law, public health, geography, ecology and informatics.

This research aims to re-envision STEM graduate education in fields related to water sustainability at the nexus of food and energy resources. We propose a new training paradigm in which educational and research activities at all degree levels (MS and PhD) are focused on experiences that connect trainees directly to the most vulnerable communities in need, thereby satisfying students' stated desires to engage in work that addresses social injustices arising from disparities in resource security. Courses, research projects, community service, and professional training experiences will all be tailored to the trainees' desired career paths. To launch this model, we will create a new graduate degree program at the University of Iowa focused on the development of sustainable water resources in resource-limited communities (e.g., rural and poor communities). The Sustainable Water Development degree will be housed in the Department of Civil and Environmental Engineering, while building upon strengths across the campus in the area of water sustainability and emphasizing the critical roles of both water quality and quantity as well as food and energy production. Major research efforts will address high priority research needs for such communities, including: forecasting, mitigating and adapting to climate variability; innovative solutions for minimizing waste streams and promoting resource recovery; new water treatment infrastructure suitable in scale and associated energy demand for small communities; and management of biogeochemical cycles and agro-ecosystem structure to promote environmental quality. In addition, we will develop a graduate certificate program in Sustainable Water Development available to the entire graduate STEM population at the university, thereby adding valuable specialization to existing degree programs in water-relevant STEM fields (e.g., chemistry, biology, physics and mathematics).

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NRT INFEWS: computational data science to advance research at the energy-environment nexus

University of Chicago

PI – Elisabeth Moyer

ABSTRACT

In the near future, humanity will be confronted with unprecedented challenges as we seek to maintain the economic growth that drives prosperity while managing increasing environmental stresses. In particular, continuing development is necessarily accompanied by rising demand for food, energy, and water. Advancing the understanding of these complex and interacting systems requires training a next generation of interdisciplinary scientists with the computational skills required to exploit growing torrents of relevant data. This National Science Foundation Traineeship (NRT) award to the University of Chicago will produce students who are fully grounded in their respective disciplines and who have the computational skills and breadth of knowledge needed to address and communicate the food-energy-water system in all of its complexity. This project anticipates providing training for thirty (30) MS and PhD students, including fifteen (15) funded trainees, from across the physical, biological, and social sciences, uniting them with a common focus on computation and data analysis. The project's vision is to create a new model for interdisciplinary training that gives students the ability to collaborate and work across fields and to apply cutting-edge computational methods.

The trainees' educational program is structured to generate a cohesive community of young researchers who have regular, in-depth interactions and opportunities to share expertise across disciplines. Program components include: (1) two-week bootcamps prior to the start of each Fall quarter that provide skills training and introduce cross-disciplinary material, including modules on computing, data analysis, and statistics; (2) a year-long core course sequence consisting of an introduction to the food-energy-water system followed by a data analysis practicum in which students work in interdisciplinary teams to analyze datasets; (3) communication and professional development training; (4) international experience opportunities; and (5) community building activities. All educational elements will be opened to students across the University of Chicago whenever possible. An important goal of the program is to improve the recruitment and retention of graduate students from underrepresented groups. Finally, to enable dissemination of the educational model to other institutions, the project will quantitatively evaluate the benefits of the education program and publicly disseminate all educational material to facilitate its use.

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NRT-INFEWS: STEM Training for Actionable Research and Global Impact

University of California, Berkeley

PI – Alice Agogino

ABSTRACT

This National Science Foundation Research Traineeship (NRT) award to the University of California at Berkeley will address challenges at the nexus of food, energy, and water systems (FEWS) through the lens of alleviating poverty and promoting equity. Poor communities often face extreme challenges accessing nutritious food, clean and reliable energy, and safe water, which will be amplified with additional climate variability, population growth, stress on infrastructures, and pollution in the future. Through collaborative and immersive interdisciplinary training, graduate students will develop novel and lasting interdisciplinary approaches and technologies for solving FEWS challenges and reducing poverty with positive global impact. The program will engage over 400 students with up to 80 trainees, including 32 funded trainees, from engineering, social sciences, environmental sciences, business, and beyond. This effort enhances US leadership in basic research, human capacity building, and technical development to meet energy, water, and food access needs worldwide with positive environmental and economic sustainability benefits.

The research theme of this program addresses grand challenges in the design, implementation and coordination of food, energy and water systems within spatial and temporal constraints. Trainees will research topics such as capturing and reusing nutrients and water in organic waste products, development of small-scale water and energy technologies necessary for the agricultural sector and developing infrastructures and lifecycle methodologies to collect integrated information and data on food, energy, and water systems. Integrating human-centered design, innovative business models, and technological advancements with an interdisciplinary framework of development and continual impact analysis, this program provides cross-cultural learning, prototyping and scaling, and new models for productive multi-stakeholder collaboration. The model for STEM graduate education is one that emphasizes immersive interdisciplinary training, featuring team-taught courses that pair faculty in a technology discipline with one in business/social sciences using hands-on project-based learning approaches. Specific training components include: (1) interdisciplinary research activities and field training, (2) formal coursework, (3) creation of a FEWS concentration as a PhD minor, (4) creation of a FEWS masters' level certificate, (5) career development, (6) online modules & tools, and (7) formative assessment and evaluation of the program's effectiveness. Trainees will master the interdisciplinary skills needed to create actionable and impactful research that is transferable from the lab to the field at scale. These skills will be highly transferable to contexts beyond poverty alleviation and will contribute to 21st century workforce development.

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NRT-INFEWS: Indigenous Food, Energy, and Water Security and Sovereignty

University of Arizona

PI – Karletta Chief

ABSTRACT

About 35% of homes in the Navajo Nation are not connected to central power or drinking water systems. To address this issue, the National Science Foundation Research Traineeship (NRT) award to the University of Arizona, in partnership with Diné College and Navajo Technical University, will develop a diverse STEM workforce with intercultural awareness and multidisciplinary knowledge/skills for high priority research in sustainable food, energy, and water systems (FEWS). Such systems are appropriate in many remote regions of the world. By partnering with Diné College and Navajo Technical University, the project will directly engage underrepresented minorities in science, technology, engineering, and mathematics. Trainees will major in traditional disciplines while completing the program, which consists of internships, a FEWS-themed minor, professional development, and immersion in indigenous communities. Trainees will participate in the design and construction of pilot-scale capstone projects in dispersed water purification and greenhouse system design in underserved areas of the Navajo Nation. The projects will produce learning models for FEWS infrastructure development in areas that cannot be served from central facilities. The traineeship will provide stipends for 12 MS and 14 PhD students from several related science and engineering disciplines. Eleven students not funded by NSF will complete the program (6 MS and 5 PhD). It is anticipated that an additional 40 students will complete the FEWS minor and about 400 students will be impacted through participation in enriched courses cross-listed in multiple departments.

The traineeship centers on the development of novel, sustainable solutions for off-grid production of safe drinking water and controlled environment agriculture systems. Research will focus on innovative photovoltaics, holographics, sensors and controls, desalination of brackish water, brine treatment and disposal, and materials and systems resiliency. Food-energy-water systems will be integrated with cultural norms, working collaboratively with indigenous communities using a coupled natural human systems approach to design/build culturally acceptable technology. The research program will employ (1) the use of semi-transparent organic photovoltaic materials sheets as greenhouse cover to provide light of sufficient intensity and quality to achieve substantial, high-quality crop yields while powering off-grid controlled environment agriculture systems, and (2) solar-driven nanofiltration devices operated with algal bioreactors to produce potable and irrigation water using a treatment strategy tailored to the use of the water. In both areas, the program will draw on indigenous knowledge of land and water practices to make these technical innovations acceptable for widespread public use.

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NRT-INFEWS: Integrated Urban Solutions for Food, Energy, and Water Management

University of California, Los Angeles

PI – Laurent Pilon

ABSTRACT

By 2030, 60% of the world's population will live in cities requiring the supply of large amounts of food, water, and energy (FEW) from locations currently far from urban centers. The complex and intimate connection between food, energy, and water is becoming increasingly central in socioeconomic and urban planning decisions. Unfortunately, there exists a void in the workforce and leadership with broad technical, economic, and social perspectives on such complex societal problems. This National Science Foundation Research Traineeship (NRT) award to the University of California, Los Angeles (UCLA) will combine research, education, and communication training to educate future leaders who can deliver innovative solutions to achieve sustainable supply of food, energy, and water to growing urban centers under the pressure of global climate change. The project anticipates training 110 MS or PhD students, including 33 funded trainees, from engineering, physical and life sciences, social sciences, public affairs, and public health.

This program will provide graduate students with classroom and hands-on training with a focus on urban systems. Three new FEW graduate courses and a Business and Entrepreneurship Seminar Series will be developed using project-based and peer-to-peer methodology. Hands on training will consist of academic research and institutionalized non-academic graduate internships with domestic partners. Three main interdisciplinary research thrusts will be pursued: (1) FEW wastes reduction and up-scaling, (2) urban sustainability, and (3) integrated solutions for FEW systems management in Los Angeles. The research effort will result in a comprehensive scientific and technological portfolio addressing high priority needs including (1) decaying food sensors and behavioral science to reduce food waste, (2) novel polymeric gels for enhancing soil hydration, (3) integrated technology solutions for urban agriculture, water treatment, biofuel production, and zero-net energy buildings, and (4) system-level understanding of UCLA and LA as testbeds to provide practical ideas and actionable recommendations to stakeholders. Moreover, trainees will gain experience in the art of communicating science and technology by (1) developing the social media series FEW and Far Between, (2) organizing the UCLA Sustainability Day, and (3) through the Urban FEWSing© outreach activity, in which they will interact with the general public at urban farms and food deserts in LA. This approach will align the focus of UCLA and local industrial and community partners on delivering innovation in FEWS, in line with campus and city wide initiatives. This program will impact UCLA and the broader community beyond its funded period, as the UCLA Institute of Environment and Sustainability will adopt the new graduate courses for a newly approved Ph.D. program and UCLA Extension will offer the courses online.

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