SAVANNAH RIVER
ECOLOGY LABORATORY

ANNUAL TECHNICAL PROGRESS REPORT OF ECOLOGICAL RESEARCH FOR FY18

Final Report: Submitted January, 2019

Supported under Cooperative Agreement
DE-EM0004391

between
The University of Georgia
and
The U.S. Department of Energy
for the period of
1 October 2017 – 30 September 2018

Dr. Olin E. Rhodes, Jr.
Director

Prepared by
Savannah River Ecology Laboratory
P. O. Drawer E
Aiken, SC 29802

This report is provided for information only and is not to be considered formally published literature. We request that no citations be made of information contained herein without the express consent of the investigator.

TABLE OF CONTENTS

SECTION I: Savannah River Ecology Laboratory – FY18 Overview of Achievements

The Savannah River Ecology Laboratory (SREL) is a research unit of The University of Georgia (UGA). SREL has been conducting ecological research on the Savannah River Site (SRS) near Aiken, South Carolina for over 65 years. The overall mission of the laboratory is to enhance our understanding of the environment by acquiring and communicating knowledge of ecological processes and principles that contribute to sound environmental stewardship. In addition, as directed in the Cooperative Agreement with the U.S. Department of Energy (DOE), SREL will provide the public with an independent evaluation of the ecological effects of SRS operations on the environment. Toward these goals, SREL conducts fundamental and applied ecological research, as well as education and outreach programs.

The laboratory's research mission during FY18 was fulfilled with the publication of 78 journal articles and several book chapters by faculty, technical staff, students, and visiting scientists. One book was also authored by SREL faculty and staff. Additional journal articles and books have been submitted or are in press. Significantly, SREL conducted over 513 outreach events reaching over 68,000 people of all ages. Other noteworthy events took place as faculty members, staff, and graduate students received awards for the quality of their research. These are described in Section IX ***Special Accomplishments***.

The vision, structure, and operations of SREL continue to evolve since changes in funding structure were instituted in FY07. However, the five-year Cooperative Agreement between the University of Georgia's Research Foundation and the Department of Energy for support of the Savannah River Ecology Laboratory has allowed funding from the DOE and other SRS tenants to fund SREL to meet the specific needs of DOE Environmental Management (EM) and DOE National Nuclear Safety Administration (NNSA) on the Savannah River Site. The current funding model for SREL is entrepreneurial and interdisciplinary, and seeks to pursue funding strategies that are competitive, responsive to sponsors' requirements, and based on a diverse and sustainable foundation. This model has required restructuring of research and supporting infrastructure at the laboratory.

Today, a leaner, but robust SREL presence continues to operate on the SRS. SREL's total employment in FY18 was approximately 152 faculty, technicians, students, and support staff. Although the number of employees and level of funding is reduced relative to a decade ago, SREL continues progress toward stated objectives and does not compromise safety and security. New and continuing partnerships and collaborations with the Athens campus (Warnell School of Forestry and Natural Resources, UGA Complex Carbohydrates Center, Odum School of Ecology, College of Public Health, College of Agriculture and Environmental Sciences), other universities (University of South Carolina – Aiken, University of South Carolina – Upstate, Georgia Reagents University) and other agencies (US Department of Agriculture, US Army Corps of Engineers, US Department of Defense, Federal Aviation Administration) continue to be explored and developed in order to maximize the use of SREL assets. Graduate student programs have continued with funding provided by DOE, external grants, UGA, or the student's host university.

During FY18, DOE-SR funding was leveraged to acquire approximately $752,000.00 in salary and infrastructure investments from the University of Georgia, in addition to the 20% cost share negotiated under the terms of UGA's Cooperative Agreement with DOE. DOE funding also is being used to leverage cost shared faculty positions with UGA units on the main campus, resulting in three tenure track faculty lines at SREL and a portion of three tenure track faculty lines on the main UGA campus that will contribute to the SREL mission on the SRS during the coming years.

SREL faculty have responded to the revised funding structure for the laboratory and have sought financial support from multiple external funding agencies, DOE-EM, DOE-NNSA, Savannah River Nuclear Solutions-Area Closure Projects (SRNS-ACP), Savannah River Remediation (SRR) and UGA. In

addition, DOE-EM has provided additional infrastructure support to SREL to help revitalize aging facilities and meet safety standards for our working environment. Establishment of a new Cooperative Agreement with DOE allows SREL/UGA access to the SRS through 30 September 2021. The SREL continues to work closely with local community groups, local schools, and other area stakeholders on a number of research, environmental monitoring, education, and outreach activities.

During FY18, SREL has continued to optimize its research programs to address DOE and SRS concerns, maintain staff in critical research disciplines, and attract new personnel. SREL researchers are vigorously pursuing additional funding sources to leverage existing research funds, while continuing to focus the laboratory's research efforts on projects of interest to the SRS. In addition, personnel from SREL have been actively engaged in furthering DOE's SRS missions in Radioecology, Environmental Stewardship, Next Generation Cleanup Technologies and Renewable Energy.

Researchers at SREL received funding from 38 new and continuing external grants during FY18. Sources of grant awards range from private foundations to federal and state agencies including the U.S. Department of Interior, the U.S. Department of Agriculture, the National Science Foundation, and the Department of Defense.

SREL faculty members hold positions in varied departments at the University of Georgia. Several SREL faculty members (and emeritus faculty) have adjunct status at other colleges and universities. Faculty, staff, and students are active in providing outreach and service to the scientific community. Representatives from SREL hold editorial or committee positions in national groups and organizations and serve on several UGA academic and administrative committees. SREL faculty members continue to make scientific presentations, contribute posters to scientific meetings, and present seminars at colleges and universities.

SREL's Education Program continues to be successful with SREL faculty and staff mentoring 8 undergraduate students and over 87 graduate students from numerous colleges and universities in the United States during FY18.

The SREL Outreach Program communicates scientific awareness to area schools and the general public, an audience which differs significantly from science professionals. During the past year, SREL presented over 414 talks, 36 tours, 34 exhibits, and 34 ***Ecologist for a Day*** programs reaching a total of over 68,000 people. Topics for these presentations included ecological studies of reptiles and amphibians, southeastern plants and habitats, long-term research, safety, biodiversity, local wetlands and watersheds, conservation, and careers in ecology and research. In the past year, SREL has been a part of the SRS public tour program (approximately two tours per month of 30-40 attendees). SREL participates by providing presentations on the history and research of the lab as well as a "show and tell" session featuring research animals native to the SRS.

Continuing in FY18, SREL's DOE-funded Radiological Education, Monitoring and Outreach Program has been focused on increasing public awareness and education on the topic of radiation in the environment and radiological risks to the general public. The outreach coordinator for this program has been providing monthly talks in the local Waynesboro, GA community as well as ad hoc presentations to a variety of local audiences. This program began to conduct limited environmental monitoring in FY18 and will begin providing presentations to the local community later in FY19 using these data to explain and inform the public about monitoring programs that currently provide data to the region.

The UGA Conference Center continues to be a valuable asset to SREL and other entities on the SRS. SREL used the facility to host numerous meetings and environmental education programs for students, teachers, and other organizations this past year. The facility is also used by DOE, the USDA Forest Service, and other site tenants when available.

In summary, it is important to note that as one reads through the remainder of this document, the important roles that SREL plays on the SRS unfold prominently in several strategic areas. Such efforts by SREL staff play a critical role in helping the DOE and other SRS tenant organizations reduce costs and continue with their missions on the SRS by assisting them to maintain regulatory compliance, validating remediation efforts, providing basic research for the development of new technologies, promoting sound environmental stewardship of natural resources on the SRS, serving as an independent source of scientific expertise for reviews of technical data and monitoring programs, educating the next generation of radioecologists and nuclear biogeochemists, and conducting outreach efforts to educate local communities about the SRS, its missions, and environmental health. For example, as a critical source of scientific expertise for the Department of Energy on the SRS, SREL provides state of the art scientific support to both DOE-EM and DOE-NNSA. Examples include research on biogeochemical cycling and biological impacts of copper associated with the H-02 mitigation wetlands that provide data needed to validate regulatory compliance for the DOE-NNSA's Tritium mission on the SRS, research on the ecological impacts and potential options for recovery of function of the U-8 stream drainage associated with DOE-NNSA's construction efforts for the MOX fabrication facility on the SRS, research on the organismal effects (proteome and glycome) to aquatic organisms exposed to chronic levels of low dose radiation, research into the extent and impact of biovectors of contaminants on the SRS, and development of strategic management plans for Set Asides on the SRS to maintain the SRS designation as DOE's first National Environmental Research Park.

SREL also serves as a source of critical scientific expertise for other SRS tenant organizations, providing analytical and ecological expertise to assist these organizations with issues ranging from regulatory compliance to creative new technologies for remediation of contaminants on the SRS. Examples include research conducted in support of the SRR mission on the SRS to provide accurate and precise data for use in parameterization of models employed to comply with NRC requirements concerning long-term contaminant exposure risk from stored nuclear materials, research conducted in support of SRR and SRNS to assess biological exposure risks from leakage events involving stored nuclear materials into soil and groundwater, research on the design and efficiency of strategies for bioremediation of tritium in SRS groundwater for SRNS, and research conducted in support of SRNS ACP's remediation mission to assess radionuclide and heavy metal accumulation in long-lived vertebrates and game species to inform regulatory compliance and risk assessment issues associated with ecosystem and human health.

As a source of regional and national scientific expertise, SREL scientists attract external funding to conduct research that not only contributes to areas of national research priority, but also helps contribute to DOE's nuclear and environmental missions on the site. Examples include research on development of technologies for control of feral swine (funded by the US Department of Agriculture), which makes the SRS both a national focal point for feral swine research as well as a recipient of the technologies and strategies as they are developed, research on conservation and management of threatened and endangered species across the nation (funded by the US Department of Defense and the US Fish and Wildlife Service), which contributes to the strategies and tools available for environmental stewardship applications on the SRS, research on avian dispersal technologies (funded by the Federal Aviation Administration and the City of Augusta), which contributes to the ability of SRS tenants to manage nuisance wildlife populations, research on scavenging ecology (funded by the US Department of Agriculture and the Department of Defense), which provides insights into the role of scavengers in recycling of energy and contaminants in the environment and the potential transfer of contaminants off of SRS, and research on risk assessment models for heavy metals in avian species (funded by the US Army Corps of Engineers), which adds to the set of risk assessment modeling expertise available for study of fauna on the SRS.

Of special note in FY18 is that hosted the 19th International Conference on Heavy Metals in the Environment (ICHMET), the proceedings of which are available at ichmet2018usa.org. The ICHMET

conference is a continuation of the highly successful conference series that started in 1975 in Toronto, Canada. An invited plenary speaker started off each day of the conference. Session topics ranged from the environmental impact of manufactured nanoparticles to the bioavailability of trace elements and radionuclides in the environment, with more than 225 presentations representing contributors from over 20 different countries.

SECTION II. Cooperative Agreement Key Tasks

TASK 1. SREL will assess the impact of Site operations on the environment, and will continue to provide the public and DOE with an independent view of the environmental management of the SRS

Through a Cooperative Agreement between the Department of Energy and the University of Georgia Research Foundation, SREL provides an independent evaluation of the ecological effects of SRS operations through a program of ecological research, education, and public outreach. This program involves basic and applied environmental research, with emphasis upon expanding the understanding of ecological processes and principles, and upon evaluating the impacts of industrial and land use activities on the environment.

This is accomplished through a broad-based program of field and laboratory research conducted on the SRS and published in the peer-reviewed scientific literature; by providing education and research training for undergraduate and graduate students from colleges and universities throughout the United States and abroad; and by engaging in community outreach activities and service to professional organizations.

The quality of research conducted by SREL scientists is facilitated by their unique expertise in environmental sciences and ecology, the unparalleled field research opportunities at the SRS, and the long-term data sets, research tools, and capabilities that SREL has developed over the last 65 years.

The FY18 SREL research plan can be divided into three critical research areas:

Environmental Characterization

Characterization is a necessary first step in determining environmental and health risks and in devising appropriate remediation and restoration strategies. Environmental information is also needed to make informed decisions about long-term stewardship and land management, and is a critical component of NEPA (National Environmental Policy Act) reports, Records of Decision (ROD), and other regulatory documents. Environmental characterization is more than simply measuring contaminant concentrations in biota or other media, or reporting the presence of organisms at various locations. It includes developing an understanding of the processes that control distributions of contaminants, chemical forms, and their bioavailability. Characterization is also necessary to construct models of how natural and engineered systems function, both in the presence and absence of environmental contamination.

Ecological Risks and Effects

Estimated risks and effects determine the need for remediation and restoration efforts, while perceived risks and effects determine the public's acceptance and support of DOE policies and actions. Estimating ecological risks and effects on the basis of sound science helps to ensure that good decisions are made by reducing uncertainties associated with complex environmental processes. A 1999 report from the National Academy of Sciences stated that *"Ecological risks are better characterized at the Savannah River Site than at any other DOE installation, due in part to the designation of the site as a National Environmental Research Park and the presence of the Savannah River Ecology Laboratory."*

Remediation and Restoration

The knowledge and expertise at SREL are ideally suited to address the remediation and restoration of large land areas contaminated with relatively low levels of metals, organics, and radionuclides. SREL conducts multidisciplinary research designed to assist in the development, evaluation and stakeholder acceptance of remediation and restoration efforts that protect human and ecosystem health. Fundamental to the success of various bioremediation, natural attenuation, and *in situ* remediation applications is an understanding of the underlying scientific principles on which they are based.

TASK 2. SREL will continue basic and applied environmental research with emphasis upon expanding the understanding of ecological processes and principles, and upon evaluating the impacts of site activities, new mission, and land use practices on the environment

In FY18, the Savannah River Ecology Laboratory received approximately 8 million dollars in funding from a variety of sources (Figure 2.1). These funds supported approximately 152 faculty, staff, and students conducting basic and applied environmental research for at least some portion of FY18 (Table 2.2). In total, University of Georgia funding (both direct and indirect funds returned to the lab) and external dollars received from non-SRS sources were responsible for approximately 32% of the laboratories budget. Laboratory personnel were productive and successful in attracting external funding to the site, and very active in graduate student education and service to their communities and professions (Table 2.2). SREL continues to be a productive, independent partner to DOE on the SRS and an excellent value to both stakeholders on the SRS and taxpayers.

Figure 2.1. Overview of funding received by SREL in FY18. Acronyms are as follows: University of Georgia (UGA), Savannah River Site Office of Department of Energy (DOE-SR), all combined sources of funding received from sources external to the Savannah River Site (External), Department of Energy National Nuclear Security Administration's Mixed Oxide Fuel Production Facility (NNSA-MOX), Department of Energy National Nuclear Security Administration's Tritium Facility (NNSA-Tritium), Savannah River Nuclear Solutions Area Closures Project (ACP) and Savannah River Remediation (SRR).

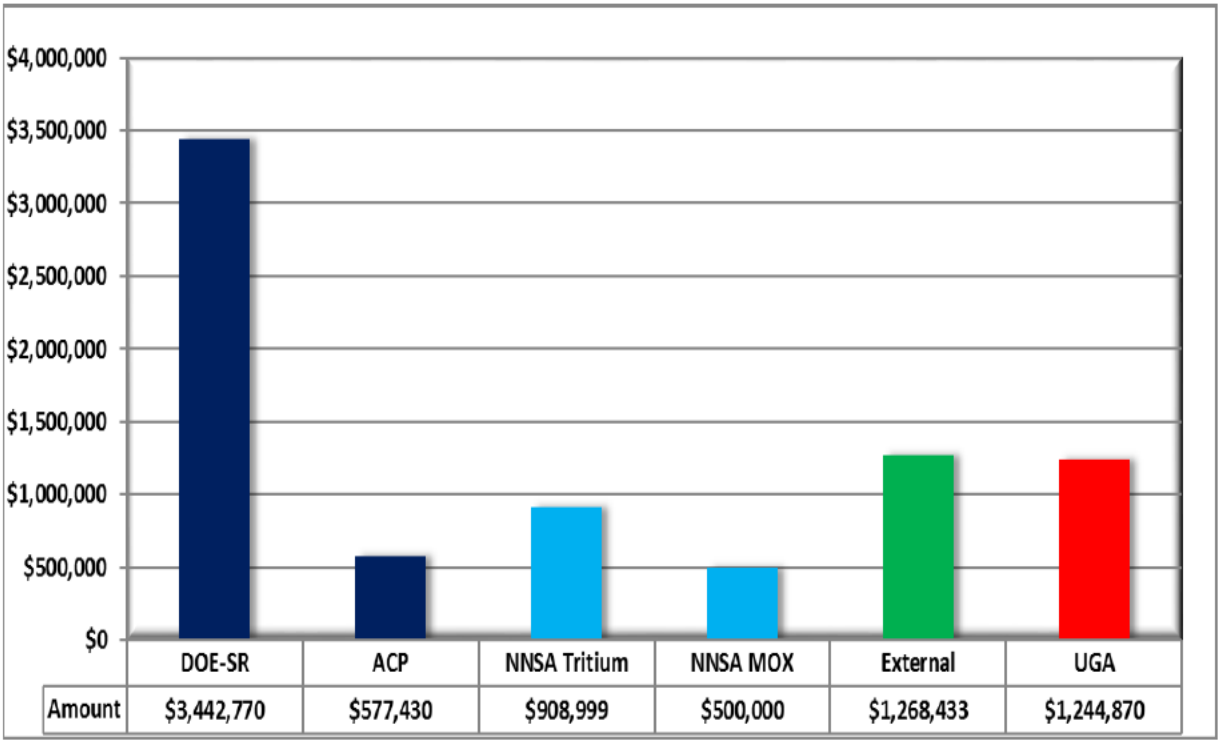

Table 2.2. SREL organizational structure for FY18. This table includes all research faculty, classified staff and Emeritus faculty in residence at the Savannah River Ecology Laboratory for any portion of the FY18 fiscal year.

SREL ORGANIZATIONAL CHART – FY18	
Director -- Dr. Olin E. Rhodes, Jr.	
Assistant Director Research	**Research Technicians (cont.)**
Dr. J. Seaman	K. White K. Bosch
Research Faculty	M. Brown R. DeMass
Dr. S. Lance	M. Day N. Herrington
Dr. J. Vaun McArthur	K. Kule V. Locke
Dr. G. Mills	E. McGee B. Lindell
Dr. T. Tuberville	J. Perry J. Helton
G. Dharmarajan	E. Peck J. Mills
Tenure Track Faculty	E. Kemp W Dixon
Dr. J. Beasley	C. Carter J Calloway
Dr. D. Aubrey	**Assistant Director Budget and Facilities**
Dr. J. Martin	C. McBride
Dr. K. Capps	**Safety**
Dr. B. Parrott	D. Mosser
Emeritus Faculty in Residence	K. Coble
Dr. D. Adriano	**Computer Service and GIS Lab Manager**
Dr. I. Brisbin, Jr.	W. Taylor
Dr. J.W. Gibbons	**Property Management**
Dr. K. McLeod	B. Morton
Dr. R. Sharitz	**Outreach Program Staff**
Post Docs	P. Perea
Dr. F. Coutelot	V. Sutton-Jackson
Dr. S. Mukherjee	C. Eldridge
Dr. P. Schlichting	M. Winzler
Dr. X Xu	J. Green-McLeod
Dr. A Ferreia	S. Poppy
Research Professionals	A. Tucker
Dr. K. Buhlmann	**Research and Facilities Technical Services**
R. Beasley A. Bryan	R. Christie D. Kling
D. Fletcher L. Lee	M. Edwards M. Squires
R. Kennamer D. Scott	C. Cooper P. Carroll
A. Lindell P. Stankus	D. Fraser C. Roberts
K. Price M. Hamilton	
C. Fulghum M. Baker	**Administrative Services**
A. Rakowski	L. LopezdeVictoria
Research Technicians	M. Roberts
C. Coakley C. Candal	B. Giddens
M. Dix C. Fulghum	M. Wilburn
A. Korotasz M. Hamilton	V. Taylor
A. Lavere M. Mason	M. Wead
B. Hurst J. Neirman	
K. Norris J. Parks	
M Strassburg M. Sams	
	(As of 10/1/2018)* Excludes Students

Table 2.3. Summary of professional activities and accomplishments by Savannah River Ecology Laboratory research faculty, research professionals, postdocs and students in FY18.

Publications and Reviews	Total
Peer Reviewed Journal Articles	77
Book and Book Chapters	6
Proceedings Articles	7
Primer or Other Scientific Notes	3
Non-Peer reviewed Articles	12
Articles In Press	31
Articles In Review	57
Peer Review of Manuscripts Conducted	68
External Funding (non-SRS)	**Total**
External Grants Submitted as PI or CoPI	54
External Grant Funding Submitted as PI or CoPI	$43,754,370
External Grants Funded as PI or CoPI[1]	38
External Grants Funded Dollars as PI or CoPI	$ 2,315,229
Graduate Education and Postdocs	**Total**
MS Graduate Students Chaired	36
MS Graduate Students Completed	7
PhD Graduate Students Chaired	18
PhD Graduate Students Completed	0
Graduate Student Committee Memberships	57
Graduate Students Hosted at SREL	40
Post Docs Supervised	9
Presentations	**Total**
Invited Presentations	43
Professional Oral Presentations	139
Professional Poster Presentations	65
Extension Presentations	32
Extension Publications	12
Other	**Total**
Awards or Honors	18
Professional Society Committee Memberships	26
Courses Taught	22
Technical Research Consultations	26

[1] – includes new grants and contracts, renewals and continuations associated with funding sources external to DOE. Total includes multi-year funding commitments received in FY18 and to be received in future fiscal years.

TASK 3. SREL will use the information collected in the environmental research to develop and test hypotheses that will contribute to the scientific foundation necessary to conduct meaningful ecological risk assessments and to understand the environmental consequences of energy technologies, remediation efforts, and other SRS activities

In FY18 SREL faculty, staff, and students conducted and completed a diversity of environmental research projects on the SRS in support of the missions of SRNS, SRR, and DOE-SR, specifically in the areas of risk assessment and elucidation of the environmental consequences of energy technologies, legacy contamination, and remediation activities on the SRS. Much of this work was funded through support to the SRNS Area Closures Project, through subcontracts from SRR to perform specialized sampling or analyses, and through commitment of funds received through SREL's Cooperative Agreement with the Department of Energy to address research topics of importance to the continuing missions of DOE on the SRS. The details of these projects are outlined below:

Research Support to SRNS Area Closure Projects, SRR, and DOE-SR

Population Modeling of Contaminant Uptake in Aquatic Turtles on the Savannah River Site

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
March 2018; $129,980
SREL PI and Co-PI's
Dr. G. Dharmarajan and Dr. Tracey Tuberville
Objectives
Understanding how the effects of contaminants at the individual-level scales up to affect population-level responses is critical because most environmental directives aim to protect local populations, rather than individuals. Individual based models can effectively link individual and population level processes within a mechanistic framework, and are thus increasingly being recognized as powerful tools for risk-based management of contaminated sites. In this study we propose to improve our understanding of contaminant exposure risk in aquatic turtles inhabiting the Savannah River Site using a Markov-Chain Monte-Carlo simulation approach in conjunction with Bayesian inference. To this end we will develop a spatially explicit, individual-based Monte-Carlo simulation model that incorporates prior information on the spatial heterogeneity and trophic transfer of contaminants, as well as parameters associated with turtle ecology that likely influence exposure risk (e.g., habitat utilization and demography)
Summary of Research Activities
The multiple sources of data for this project have been compiled, and these include: Capture locations of turtles from the SRS, turtle contamination data and environmental levels of the various heavy metals based on SRS monitoring programs. The GIS data required for the model have also been compiled, including publicly available landuse data and LIDAr data from the SRS. The first submodel for turtle movement and distribution has been developed, and the two remaining submodels (environmental exposure and bioenergetic models) will be developed in the coming year.
Conclusions
1) The project is at a very preliminary stage, and no conclusions can be drawn at this time
Major Impact(s) of Research
1) This study aims to produce ecologically relevant models of contaminant exposure in yellow bellied sliders wherein exposure is integrated over individual life-span taking into consideration age-specific bioenergetics and spatio-temporal heterogeneity contaminant exposure.
2) We hope to also identify parameters that critically impact model performance and help in identifying important deficiencies in existing data, thus helping to make future experimental research more focused.

Other Project Personnel
Amelia Russel, Research Technician – SREL
Austin Coleman, Research Technician – SREL
External Collaborators
None
Products
No presentations or publications are associated with this project currently

Hydrological Characterization of Beaver Dam Creek

Funding Entity
SRNS-Area Completion Projects
Start Date and Funding Amount
April 2018; $25,000
SREL PI and Co-PI's
Dean E. Fletcher
Objectives
Establish the hydrologic extent of Beaver Dam Creek after pumping has ceased, determine whether runoff from D Area is reaching perennial waters, and map primary runoff routes.
Summary of Research Activities
The 2009 LiDAR imagery as well as aerial photos from 1955 to current are being examined to determine potential runoff routes from D Area and the ash plume into Beaver Dam Creek. A series of maps were produced to allow identification of these areas in the field. Maps include potential areas of wetlands/seeps/springs that may be contributing significant amounts of water to the BDC channel. Field inspection has been establishing whether routes are active and the spatial extent of the water flows. Field survey is determining the extent of connection of water from the D Area Discharge Canal and the Savannah River at various water levels.
Conclusions
1) Conclusions are presently preliminary.
Major Impact(s) of Research
1) Establishing runoff routes and hydrologic state of this area will provide a better understanding of the risk of offsite transport of contaminants from this system.
Other Project Personnel
Christina Fulghum, Research Technician – SREL
Paul Stankus, Research Professional – SREL
External Collaborators
NA
Products
Preliminary GIS maps are being assembled.

Technical Support Provided by the Savannah River Ecology Laboratory (SREL) for R&D of Cementitious-Type Materials (i.e., Saltstone) and Soils

Funding Entity

Savannah River Remediation (SRR)

Start Date and Funding Amount

October 2017; $167,000

SREL PI and Co-PI's

Dr. John C. Seaman

Objective

At the Department of Energy's Savannah River Site (SRS) a mix of cementitious dry feed materials (i.e., portland cement, blast furnace slag (BFS) and fly ash) are combined with low-level radioactive saltwaste solutions to form a cementitious material known as saltstone, which is then deposited in a series of concrete vaults for long-term disposal at the Saltstone Disposal Facility (SDF). The objective for FY18 was to continue ongoing evaluations of contaminant leaching properties (^{99}Tc, ^{129}I, and ^{137}Cs) of saltstone simulants, produced utilizing Savannah River Remediation LLC (SRR) prescribed grout formulations, and actual saltstone samples collected from Saltstone Disposal Unit (SDU) Cell 2A. In FY18, activities in support of SRR expanded to include thermal testing of saltstone formulations (i.e., heat capacity, heat of hydration and thermal conductivity), thermodynamic modeling to predict potential solid phases controlling Tc solubility in saltstone based on DLM leaching data, and the development of XRD and XRF methods for characterizing the mineralogical composition of saltstone and saltstone components.

Summary of Research Activities

For FY18, ^{99}Tc/^{129}I spiked saltstone simulants were tested using SREL's Dynamic Leaching Method (DLM). In the DLM method a flexible-wall permeameter cell is used to achieve saturated leaching through the intact monolith under an elevated hydraulic gradient in an effort to evaluate the persistence of reductive capacity and subsequent changes in contaminant partitioning that is occurring within intact saltstone monoliths. The composition of the chemical leachates from both tests can then be analyzed in an effort to identify potential critical reactions and solid phases controlling contaminant partitioning through geochemical modeling.

DLM tests continue using both spiked saltstone simulants and actual saltstone collected from SDU2A. The first set of DLM data for ^{129}I was produced in FY18. SREL continued analysis of the mineralogical and elemental composition of saltstone materials using an x-ray diffractometer (XRD, D2 Phaser; Bruker Instruments) and an x-ray fluorescence instrument (XRF, S2 Puma; Bruker Instruments) originally purchased with a matching funding agreement between SRR and SREL.

SREL completed analysis of the thermal properties of various saltstone formulations, as impacted by compositional changes in the dry feed materials and water-to-dry feed material ratios, using a TAM Air calorimeter and a FOX50 Heat Flow Meter (TA Instruments, New Castle, DE 19720), both purchased using matched funds from SRR. This information will be used in updating a thermal model used in predicting heat generation and dissipation in the SDF.

Conclusions

1) Technetium leaching rates from saltstone are consistent Tc(IV) solid phases controlling solubility.
2) DLM leaching results are generally consistent with EPA 1315 tests in terms of the degree of contaminant retention within the saltstone grout, with nitrate leaching much faster than ^{137}Cs or ^{99}Tc; however, leaching rates for ^{129}I were similar to that of nitrate.
3) In general, the hydraulic conductivity (K_{sat}) values obtained by common test methods are higher than the values observed by the DLM testing.

Major Impact(s) of Research

1) Provided first DLM data set for ^{129}I leaching from saltstone, which was used to calculated a ^{129}I partition coefficient (Kd) for the upcoming SDF Performance Assessment.
2) Provided thermal data used in the development of a thermal model for SDU performance.
3) Conducted equilibrium modelling to illustrate potential solid phases controlling Tc leaching from saltstone, supporting the effectiveness of reductive immobilization in cementitious materials as an effective Tc immobilization method.

Other Project Personnel

Fanny Coutelot, Post Doc - SREL
Matt Baker, Research Professional III - SREL
Kimberly Price, Research Professional II - SREL

External Collaborators

Dr. D. Kaplan (SRNL)
Dr. D. Li (SRNL)
Dr. S. Simner (SRR)
Dr. J. Mangold (SRR)

Products

Simner, S.P., F.M. Coutelot, and J.C. Seaman. 2018. Dynamic Leaching Method for Intact Saltstone Samples. WM2018 Conference. March 18-22, 2018, Phoenix, AZ.

Simner, S.P., J. Cochran, F.M. Coutelot, and J.C. Seaman. 2018. Evaluating the Chemical Resistance of SDU Concrete and Polymeric Coatings. WM2018 Conference. March 18-22, 2018, Phoenix, AZ.

Seaman, J.C., D. Li, E. Dorward, J. Cochran, F.M. Coutelot, H.S. Chang, M. Tandukar, and D.I. Kaplan. 2018. Immobilization of Radioactive materials using Porous Iron Composite Media. WM2018 Conference. March 18-22, 2018, Phoenix, AZ.

Seaman, J.C, F.M. Coutelot, and R.J. Thomas. 2018. Thermal Properties of Saltstone Simulants. SREL R-18-0005. Submitted to SRR September 27, 2018.

Seaman, J.C. and F.M. Coutelot. 2018. Technetium Solubility in Saltstone as Function of pH and Eh: Summary of Modeling Efforts. SREL R-18-0004. Ver. 1.0. Submitted to SRR August 21, 2018.

Seaman, J.C, K. Price, and M. Baker. 2018. Estimating Evapo-Transpiration Losses for Tritium at the MWMF: 2017 End of Year Summary Report. Submitted to SRNS-ACP March 15, 2018.

Coutelot, F.M., J.C. Seaman, and S.P. Simner. 2017. Quantitative study of Portland cement hydration by X-Ray diffraction/Rietveld analysis and geochemical modeling. Annual Meeting of the American Geophysical Union. Dec. 11-15. New Orleans, LA.

Tritium Distribution at the Tritiated Water Management Facility - Southwest Plume Interim Measures

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
October 2017; $127,000
SREL PI and Co-PI's
Dr. John C. Seaman
Objective
Evaluate the efficacy of ongoing remediation efforts at the SRS Mixed Waste Management Facility (MWMF) to address the tritium and 1, 4 dioxane plume originating from the Old rad Waste Burial Ground.
Summary of Research Activities
In FY 2018, SREL worked collaboratively with the SRS-US Forest Service, SRNS-ACP and DOE to complete the following activities: (1) collect, process and analyze 22 soil cores collected to a depth of ≈ 3 m to evaluate tritiated water (^3H_2O) distribution as an estimate of irrigation efficiency (≈220 samples annually); (2) maintain and update the Cornell Model for estimating water-use efficiency, including updating the model to account for recent site expansion, i.e., the Western (WEA) and Eastern Expansion Areas (EEA); and (3) evaluate the persistence of 1, 4 dioxane in soils at the MWMF.
Conclusions
1) The estimated tritium evapo-transpiration efficiency for individual irrigation plots through the end of calendar year 2017 based on soil core samples ranged from ≈ 51.2 to 97.4 %, with lower tritium use efficiencies generally reflecting the limited vegetative cover associated with the Western Expansion Area.
2) Monthly efficiency results derived from the Cornell 1D model ranged from 64.7 to 88.8 % between plots, with lower efficiencies observed for the Western Expansion Area plots. The average efficiency for all plots was approximately 86.7 ± 1.2 % for the original plots, 77.1 ± 2.0% for the EEA plots, and 66.9 ± 1.4 % for the WEA plots, resulting in an overall of annual efficiency of 80.5 ± 7.8 % for all 11 monitored plots.

Other Project Personnel
Matt Baker, Research Professional III - SREL
Kimberly Price, Research Technician – SREL
R.J. Thomas, Graduate Student - SREL
External Collaborators
NA
Products
Seaman, J.C, K. Price, and M.R. Baker. 2018. Estimating Evapo-Transpiration Losses for Tritium at the MWMF: 2017 End of Year Summary Report. Submitted to SRNS-ACP March 15, 2018.
Seaman, J.C., F.M. Coutelot, M. Baker, R.J. Thomas. 2018. Evapotranspiration of Tritium in an Irrigated Forest. Seventh Organically Bound Tritium (OBT) Workshop. September 24-26, 2018. Toronto, Ontario, Canada.

Sorption Properties of Bimetallic Porous Iron (pFe) Materials

Funding Entity
SRNL – LDRD Program
Start Date and Funding Amount
October 2017; $34,000
SREL PI and Co-PI's
Dr. John C. Seaman and Dr. Fanny M. Coutelot
Objectives
Project objectives include: (1) prepare and characterize pFe materials with catalytic metallic nanoparticles (e.g., Cu, Zn, Ag, Sn and Pd) deposited into the pore structures; (2) evaluate the novel bimetallic pFe materials for Tc removal from a wide range of aqueous media; and (3) characterize Tc binding chemistry with bimetallic pFe materials using transmission electron microcopy (TEM) and synchrotron radiation X-ray absorption fine structure (XAFS) to provide information about its chemical speciation and bonding environment.
Summary of Research Activities
Remediation of Tc remains an unresolved technical challenge because it displays little or no adsorption to common environmental minerals and other synthetic sorbents. Porous iron composites (pFe) have macropores that provides reactive site heterogeneity, and consist of amorphous and alpha metallic iron. In batch studies, the pFe is much more effective in removing ReO_4^- and TcO_4^- from artificial groundwater than granular Fe. The second metal nanoparticles were successfully deposited on the porous iron by using chemical reduction methods. The bimetallic Zn-pFe was demonstrated to be more effective in removing ReO_4^- and TcO_4^- from artificial groundwater than pristine pFe and the other six bimetallic pFe materials.
Conclusions
1) Porous Fe is much more effective for removal of ReO_4^- and TcO_4^- from groundwater than granular zero valent iron (ZVI), with a removal capacity as high as 25 mg Tc/g Fe.
2) Tc K-edge XAFS data indicated that Tc species on the porous iron were both reduced Tc(IV) and Tc(VII), with Tc(IV) largely being incorporated into the structure of Fe oxy-hydroxide corrosion products and to a lesser degree Tc(IV) dioxide.
3) Zn-pFe was demonstrated to be superior among the six bimetallic pFe materials for removing ReO_4^- and TcO_4^- from groundwater.

Major Impact of Research
1) These results provide an applied scientific foundation for solving critical DOE and industrial needs related to nuclear environmental stewardship and nuclear power production.

Other Project Personnel
RJ Thomas, Graduate Student – SREL
E. Dorward, Graduate Student – SREL
External Collaborators
Dien Li (SRNL)
Simona Murph (SRNL)
Daniel I. Kaplan (SRNL)
H. Chang (Höganäs Environment Solutions, Inc.)
M. Tandukar (Höganäs Environment Solutions, Inc.)
Products
Li, D., S.N. Egodawatte, D.I. Kaplan, S.C. Larsen, S.M. Serkiz, J.C Seaman, K.G. Scheckel, J. Lin, and Y. Pan. 2017. Sequestration of U(VI) from Acidic, Alkaline and High Ion-Strength Aqueous Media by Functionalized Magnetic Mesoporous Silica Nanoparticles: Capacity and Binding Mechanisms. Environ. Sci. & Technol. (Web): November 20, 2017.
Li, D., J.C. Seaman, D.I. Kaplan, S.M. Heald, and C. Sun. C. 2019. Pertechnetate (TcO4−) sequestration from groundwater by cost-effective organoclays and granular activated carbon under oxic environmental conditions. Chemical Engineering Journal, 360, 1-9.

Li., D., J.C., Seaman, S.H. Murph. D. Kaplan, K. Taylor-Pashow, R. Feng, H. Chang, M. Tandukar. 2018. Porous Iron Material for TcO_4^- and ReO_4^- Sequestration from Groundwater Under Ambient Oxic Conditions. Accepted November 19 to Journal of Hazardous Materials.

Thomas, R.J., J.C. Seaman, F.M. Coutelot, E. Dorward, and D. Li. 2019. Using Porous Iron Composite (PIC) Material to Reduce Rhenium as an Analogue for Technetium. Submitted to Environment International.

Dickson, D., N. Conroy, B. Powell, J.C. Seaman, D. Li, D.I. Kaplan. 2018. Structural Organo-Modified Feldspathoid for Selective Removal of Technetium-99 and Iodine-129. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Li, D., D.I. Kaplan, J.C. Seaman, A. Knox, B. Powell, A. Sams. 2018. Sequestration of Pertechnetate (TcO_4^-), Iodide (I^-) and Iodate (IO_3^-) from Groundwater by Organoclays and Granular Activated Carbon: Capacity and Chemical Speciation. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Kaplan, D.I., P. Santschi, T. Ohnuki, K. Roberts, D. Li, K.A. Price, C. Xu, P. Lin, K. Tanaka, J.C. Seaman. 2018. Influence of Aqueous Radioiodine Speciation on Uptake by Silver-Granulated Activated Carbon. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Thomas, R.J., J.C. Seaman, F.M. Coutelot, E. Dorward. Using Porous Iron Composite (PIC) Material to Reduce Rhenium as an Analogue for Technetium in Environmental Batch Experiments. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Dorward, E., J.C. Seaman, F.M. Coutelot. Porous Iron Composite Material for Removal of Uranium and Chromium from Groundwater. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Dorward, E., R.J. Thomas, J.P. Cochran, H.S. Chang, M. Tandukar, F.M. Coutelot, and J.C. Seaman. 2017. Removal of Radioactive materials from Groundwater using Porous Iron Composite Media. Annual Meeting of the American Geophysical Union. Dec. 11-15. New Orleans, LA.

Contaminant burdens and sub-lethal effects of chronic contaminant exposure in semi-aquatic mammals

Funding Entity
SRNS Area Closure Project
Start Date and Funding Amount
April 2016; $130,000
SREL PI and Co-PI's
Dr. Jim Beasley and Larry Bryan
Objectives
Our overall objective in this project is to quantify radionuclide and trace element concentrations in tissues of beaver, raccoons, and river otters from the SRS as well as select locations throughout Georgia and South Carolina. These data will be used to assess whether differences in contaminant burdens exist among semi-aquatic mammals occupying variable trophic levels. We also will quantify parasite burdens as a function of species and contaminant burden.
Summary of Research Activities
This research began in spring of 2016 and all trapping, specimen collection activities, necropsies, and chemical analyses have been completed. We collected 62 beaver, 49 otters, and 86 raccoons, of which 22 beaver, 8 otters, and 47 raccoons were collected on the SRS; the remaining individuals were collected from several counties in Georgia and South Carolina. Muscle and/or liver tissues were collected from all individuals, and necropsies were performed to collect endoparasites. Trace element analyses were performed on all liver samples, and muscle samples were tested for radiocesium activity levels.
Conclusions
Mercury was the only element to clearly demonstrate biomagnification based on trophic position, with otters exhibiting the highest Hg levels, intermediate levels in raccoons, and the lowest Hg levels in beaver. However, we observed differences in concentrations of other trace elements among species and sampling sites. Mercury concentrations in otters were generally higher than previous studies conducted in the northern U.S. and Canada, but our data revealed differences among our sampling sites, with samples collected from the Coastal Plain having higher concentrations than samples collected from the Piedmont region. The maximum concentration of hepatic Hg in otters from our study was found to be 15.63 ppm w.w., which is below the threshold of 33 ppm w.w. associated with lethality. Radiocesium levels were higher in raccoon (0.28 Bq/g d.w.) and otter (0.20 Bq/g d.w.) muscle than in beaver muscle (0.08 Bq/g/ d.w.).
Major Impact(s) of Research
1) Our study is the first to directly compare trace element concentrations among semi-aquatic mammals of varying trophic levels in the Southeastern United States, where elevated Hg levels are pervasive throughout many aquatic environments
2) Observed concentrations of trace elements and radiocesium in raccoons, beaver, and especially river otters will be used to parameterize environmental risk assessment models for various ecosystems on the SRS.

Other Project Personnel
Ernest Borchert, MS Student – SREL
Katie Mcmanners, Undergraduate Student – UGA
External Collaborators
Chris Cleveland (UGA)
Dr. Michael Yabsley (UGA)
Products
Borchert, E.J. and J.C. Beasley. 2017. Raccoon Spatial Ecology and Contaminant Exposure. Savannah River Ecology Laboratory's Annual Touch an Animal Day (TAAD). Aiken, South Carolina, USA. (poster presentation)

Borchert, E.J. 2018. Anthropogenic contamination in semi-aquatic mammals in the southeastern United States: impact of contaminant burdens on parasite communities and influence of space use on contaminant uptake. M.S. Thesis. 166 pg.

Contaminants in Wild Pigs and Eastern Wild Turkeys

Funding Entity
SRNS Area Closure Project
Start Date and Funding Amount
October 2017; $176,290
SREL PI and Co-PI's
Dr. Jim Beasley, Larry Bryan, and Dr. James Martin
Objectives
The primary objective of this research is to quantify levels of Hg, trace elements, and radiocesium in wild turkeys and wild pigs on the SRS, and compare contaminant burdens in these species on the SRS to populations off-site to assess potential risks to hunters.
Summary of Research Activities
To date we have collected samples from >40 wild turkeys harvested from various locations on the SRS during annual turkey hunts. A subset of these samples have been analyzed for Hg, trace elements, and radiocesium, and additional samples are currently being prepared for analyses. Collection of SRS and off-site wild pig samples was initiated in summer 2018, and off-site wild turkey samples will be collected during spring 2019.
Conclusions
Data analyses are incomplete; thus there are no conclusions at this time.
Major Impact(s) of Research
1) This research will provide the first assessment of contaminant burdens in wild turkeys on the SRS, data necessary to assess potential risks to hunters consuming birds harvested during annual hunts on site.
2) Spatial analyses will be used to determine whether spatial variability in contaminant burdens exists among wild turkeys inhabiting various locations on the SRS.
3) Additional data on Hg, trace elements, and Radiocesium in wild pigs will be combined with data from an earlier study to provide an updated assessment of potential risks to hunters consuming pigs collected on/near the SRS.

Other Project Personnel
Kevin Eckert, Research Technician – SREL
Chris Leaphart, Ph.D. student – SREL
Cody Tisdale, M.S. student – SREL
Allison Rakowski, Research Professional - SREL
External Collaborators
Robert Byrd (USDA)
Products
This research has just begun, there are no products available at this time.

Watersnakes as ecological receptors for mercury contamination and bioaccumulation on the SRS

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
January 2018; $92,500
SREL PI and Co-PI's
Dr. Tracey D. Tuberville
Objectives
The overarching objective is to explore the value of watersnakes (*Nerodia* spp.) as receptor species for mercury (Hg) contamination across the Savannah River Site (SRS) and in the Savannah River area. We are targeting three primary aquatic system types: 1) the Savannah River and its tributaries, in which the brown watersnake (*N. taxispilota*) is the dominant snake species; and 2) former nuclear cooling reservoirs in which the green watersnake (*N. floridana*) is the dominant species; and 3) isolated ephemeral wetlands (i.e., Carolina bays) in which the banded watersnake (*N. fasciata*) is the dominant species. All three species are strictly carnivorous but they vary in the degree of specialization on fish vs amphibians – some of which may be due to prey composition in their aquatic habitat. These three systems also vary in their source and degree of Hg contamination, which will also influence Hg bioaccumulation in our target species. We will compare Hg body burdens in *Nerodia spp.* across these three system types and evaluate the effects of system type, species, body size, and sex on Hg concentrations.
Summary of Research Activities
This fiscal year focused on collection of aquatic snakes from the Savannah River system and nuclear cooling reservoirs. We completed preliminary analysis of Hg concentrations in tail tips and blood samples from *N. taxispilota*. Two graduate students are using data from this project to form the basis of their thesis or dissertation. We also hosted 1 REU student who assisted with sampling in nuclear cooling reservoirs.
Conclusions
We have only begun preliminary analysis of samples and associated data. However, based on these preliminary analyses, the following patterns have emerged:
1) Hg concentration in both blood and tail tips is positively and significantly correlated with individual body size in both *N. taxispilota* from Savannah River and *N. floridana* from nuclear cooling reservoirs.
2) Hg concentrations in tail tips are higher than in blood samples collected from the same individuals.
3) Tail tip Hg concentrations in *N. taxispilota* varies spatially along the Savannah River, with highest concentrations near Lower Three Runs Landing, followed by Steel Creek Landing and Ellenton Bay Landing (which were similar), and finally the Jackson Landing upstream of the SRS.
4) Based on stable isotope analysis, *N. floridana* exhibit a shift in trophic level over the body sizes we sampled, indicating an ontogenetic shift in diet.
5) Among liver, kidney, muscle, tail tip and scale clip sample types collected from *N. floridana*, muscle has the highest Hg concentrations. However, Hg concentrations in tail tips are strongly, positively correlated with muscle Hg concentration. Thus, tail tips are an ideal non-invasive sample to collect for monitoring Hg bioaccumulation in this species.

Major Impact(s) of Research
The following students were recognized for their research:
1) David Haskins, 3rd place oral presentation, UGA Interdisciplinary Toxicology Program Spring Workshop. April 2018.
2) Kyle Brown, 1st place oral presentation, Warnell Graduate Student Symposium. 2018.
3) Kip Callahan, 1st place platform presentation in Natural Sciences. 14th Annual SC Upstate Research Symposium. April 2018.
4) David Haskins, 1st place oral presentation, Warnell Graduate Student Symposium. 2018.
5) Kaiya Cain was selected to represent the 2018 cohort from SREL's Radioecology REU at the national Research Experiences for Undergraduates Conference in Fall 2018.

Other Project Personnel

David Haskins, Ph Student – SREL
M. Kyle Brown, MS Student - SREL
Kaiya Cain, REU Intern - USC-Beaufort

External Collaborators

Dr. Robert Gogal (UGA)
Dr. Melissa Pilgrim (USC-Upstate)

Products

Lech, M.E., T.D. Tuberville, and M.A. Pilgrim. 2017. Investigating biomagnification of Hg and Cs-137 in *Nerodia floridana* using stable isotopes. *USC Upstate Research Journal* 10:17-25.

Haskins, D.L., R.M. Gogal, and T.D. Tuberville. *In review*. Snakes as novel biomarkers of mercury contamination: a review. Submitted to: *Reviews of Environmental Contamination and Toxicology*.

Tuberville, T.D. Accumulation of Cs-137 in Florida green watersnakes (*Nerodia floridana*) inhabiting three former nuclear cooling reservoirs. Presentation to visiting researchers from Fukushima Prefecture, Savannah River Ecology Lab, Aiken, SC. 22 Mar 2018. Platform presentation.

Callahan, K., M. Lech, M.K. Brown, J.C. Leaphart, M. Pilgrim, and T. Tuberville. Mercury and Cs-137 concentrations among tissues of *Nerodia floridana* inhabiting former nuclear cooling reservoirs. 14th Annual SC Upstate Research Symposium, Spartanburg, SC. April 2018. Platform presentation.

Lech, M.E., T.D. Tuberville, M.A. Pilgrim. Investigating biomagnification of Hg and 137Cs in *Nerodia floridana* using stable isotopes. 14th Annual SC Upstate Research Symposium, Spartanburg, SC. April 2018. Platform presentation.

Quick, C., D. Haskins, M. Pilgrim, and T.D. Tuberville. The effects of mercury and radiocesium on the probability of hemoparasite infections in *Nerodia floridana*. 14th Annual SC Upstate Research Symposium, Spartanburg, SC. April 2018. Platform presentation.

Haskins, D.L., M.K. Brown, M.A. Pilgrim, K. Meichner, R.M. Gogal, and T.D. Tuberville. Mercury tissue bioaccumulation and body size influence peripheral blood leukograms in the brown watersnake (*Nerodia taxispilota*). Interdisciplinary Toxicology Program Annual Spring Workshop, Athens, GA. April 2018. Platform presentation.

Haskins, D.L., M.K. Brown, M.A. Pilgrim, and T.D. Tuberville. Mercury bioaccumulation and *Hepatozoon* spp. presence in the brown watersnake (*Nerodia taxispilota*). Southeastern Partners in Amphibian and Reptile Conservation, Helen, GA. 22-25 February 2018. (speed talk). Platform presentation.

Brown, K., A. Russell, M. Lambert, T. Tuberville, and M. Pilgrim. Bioaccumulation of 137Cs in Florida green watersnakes (*Nerodia floridana*) inhabiting former nuclear cooling reservoirs on the Savannah River Site. UGA's Warnell Graduate Student Association Symposium. Athens, GA. 31 Jan – 2 Feb 2018. Platform presentation.

Haskins, D.L., M.K. Brown, M.A. Pilgrim, and T.D. Tuberville. Mercury bioaccumulation and effects in the brown watersnake (*Nerodia taxispilota*). UGA's Warnell Graduate Student Association Symposium. Athens, GA. 31 Jan – 2 Feb 2018. Platform presentation.

Cain, K.L., M.K. Brown, D.L. Haskins, M.A. Pilgrim, and T.D. Tuberville. ^{137}Cs whole body burdens and plasma biochemistry profiles of *Nerodia floridana* occupying a former nuclear cooling reservoir. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018. Poster presentation.

Callahan, K., M. Lech, K. Brown, J.C. Leaphart, M.A. Pilgrim, and T.D. Tuberville. Mercury and Cs-137 concentrations among tissues of *Nerodia floridana* inhabiting former nuclear cooling reservoirs. Joint Meeting of Ichthyologists and Herpetologists, Rochester, NY. July 2018. Poster presentation.

Lech, M., T.D. Tuberville, and M.A. Pilgrim. Investigating biomagnification of Hg and ^{137}Cs in *Nerodia floridana* using stable isotopes. Joint Meeting of Ichthyologists and Herpetologists, Rochester, NY. July 2018. Poster presentation.

Brown, M.K., A.L. Russell, M.L. Lambert, T.D. Tuberville, and M.A. Pilgrim. Bioaccumulation of radiocesium in Florida green watersnakes (*Nerodia floridana*) inhabiting former nuclear cooling

reservoirs on the Savannah River Site. Southeastern Partners in Amphibian and Reptile Conservation, Helen, GA. 22-25 February 2018. Poster presentation.

Tracking Sources of Mercury in Contaminated Aquatic Systems on the Savannah River Site

Funding Entity
SRNS Area Closure Project
Start Date and Funding Amount
April 2017; $31,954
SREL PI and Co-PI's
Dr. Xiaoyu Xu and Larry Bryan
Objectives
The Savannah River Site (SRS) has received mercury (Hg) contamination from multiple sources, including atmospheric deposition (local and non-local), off-site pollution (Savannah River – Olin Canal) and on-site activities. Accumulation of Hg by SRS biota has been documented frequently, occasionally at levels of regulatory concern, but the sources of Hg remain unclear. Our objective is to utilize a relatively new technique, Hg stable isotope analysis, in an attempt to confirm sources of Hg found in SRS biota. The isotope analysis will occur at the Center for Applied Isotope Studies at UGA after custom-fabricated accessories are installed on their existing instrumentation.
Summary of Research Activities
1) We collected sediment samples from the Savannah River (above and below Olin Canal) and Fourmile Branch, and their total Hg and MeHg (methylmercury) concentrations were analyzed.
2) We collected biota samples from Fourmile Branch in FY2017, and their total Hg and MeHg (methylmercury) concentrations were analyzed.
3) The stable carbon and nitrogen isotope signatures were determined for all samples, and the δC^{13} and δN^{15} ratios in the sediment were statistically different than that in the biota samples.
4) All sediment and biota samples were digested with mixed acid (HCL and HNO_3) and prepared for the future Hg isotope analysis.
5) We had the needed accessories for Hg isotope analysis fabricated, they have been installed on the existing instrumentation, and the system has been calibrated and tested. But the accuracy of the system still needs to be improved and the QCQA of a new standard reference material also needs to be certified.
6) We anticipate the instrument will be adjusted well before the summer of 2019 so the samples can be analyzed.

Conclusions
1) We collected the sediment and biota samples and customized the instrumentation to analyze for Hg isotopes.
2) Sample analysis is pending.
Major Impact(s) of Research
1) Impacts cannot be determined prior to the analyses of the samples.
2) Assuming we can isotopically differentiate among the various sources of Hg, when completed, we will have a better understanding of Hg sources in biota found on the SRS biota.
Other Project Personnel
NA
External Collaborators
Kathy Loft (UGA)
Products
No publications, presentations, or reports have yet been prepared.

Examination of Mercury/Methylmercury in Aquatic Biota Associated with Fourmile Branch

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
April, 2018; $20,000
SREL PI and Co-PI's
Larry Bryan, Dr. Xiaoyu Xu and Dr. Gary Mills
Objectives
We received the final year of five years of funding in February of 2018. During the initial year of the study, we performed a preliminary survey of total mercury (THg) in biota in the three areas of concern (H-Area seepline, F-Area seepline, Savannah River swamp system [SRSS]) along the gradient of Fourmile Branch (FMB). In each of the three subsequent years, we examined THg in environmental samples (sediments, biofilms, aquatic invertebrates and fish) in one of the SRSS, H-Area, and F-Area sites, and analyzed a subset of the samples for methymercury (MHg). In this the final year of study, we filled data gaps from the previous years and initiated data summary.
Summary of Research Activities
Year 1 was a general survey of THg in biota in the three areas of concern. In Year 2, within the SRSS, we compared environmental samples from sites in the area associated with Fourmile to samples collected in sites in Crackerneck (up-river from Fourmile). We found THg concentrations were generally higher in Fourmile SRSS samples than samples from Crackerneck, although not consistently so, demonstrating a pattern of a patchy distribution of Hg in the SRSS. H-Area environmental samples were consistently higher in THg than similar samples collected from a control stream, Mill Creek (Year 3), but THg in F-Area samples (Year 4) were considerably lower than those H-Area. We also deployed Diffusive Gradients in Thin Films (DGT) in SRSS, FMB, and Mill Creek. Mill Creek exhibited constant concentrations of DGT measured Hg (DGT-Hg) through selected sediment depth intervals, but profiles at contaminated sites showed sharp increases at the sediment-water interface (SWI), demonstrating the importance of SWI as it indicated the accumulation and/or generation of DGT-Hg in the pore water gradient.

In this the final year of study, we filled data gaps from the Year-4 monitoring (e.g., MHg analyses), acquired supplemental data (e.g., stable isotope values of selected samples) to enhance and/or confirm our understanding of mercury bioavailability. The food web magnification factor calculated with sample MHg concentrations and $\delta^{15}N$ values in FMB is 3.5, meaning MHg concentration increased approximately 3.5-fold for each trophic level. We continue to summarize selected aspects of our findings. Meanwhile, passive samplers (peepers) were deployed to measure concentrations of labile Hg species, major anions (chloride and sulfide), dissolved organic carbon in the sediment pore waters. We have completed the analysis of anions and part of the Hg measurements. Once all analysis was completed, the vertical profile of anions and organic matter in pore waters can be explored, which will provide implications on Hg biogeochemistry in selected sites, especially the anaerobic methylation and demethylation of Hg.
Conclusions
1) Mercury concentrations in the SRSS associated with Fourmile Branch were elevated, yet "hot spots" were patchily distributed.
2) Mercury concentrations associated with biota in the H and F-area seeplines were elevated above a control stream, but H-Area biota concentrations was > F-Area biota concentrations.
3) Research based on DGTs indicated increases in Hg concentrations at the sediment-water interface (SWI), demonstrating the importance of SWI in the accumulation and/or generation of DGT-Hg in the pore water gradient.
4) The food web magnification factors of MHg, based on trophic data (biofilm, invertebrates, and fish) were 9.6 (95% CI: 4.0 - 23.4) and 4.4 (95% CI: 2.5 - 7.7) for the Fourmile and the control stream, respectively.

Major Impact(s) of Research

1) DGT-Hg concentrations in the water were positively correlated to biofilm Hg concentrations, which can be used to generate a modified biomagnification model. Therefore, MHg accumulation at different trophic positions can be estimated with DGT-Hg concentrations in the water.
2) We provide here a better understanding of abiotic and biotic interactions related to THg and MHg bioavailability within the Fourmile Branch system.

Other Project Personnel

Alexis Korotasz, Research Assistant – SREL

External Collaborators

NA

Products

Xu, X., G. Mills and A.L. Bryan. Applying diffusive gradients in thin films (DGT) to study mercury bioavailability in a stream system on the southeastern coastal plain. Oral presentation at the Society of Environmental Toxicology and Chemistry annual meeting, Minneapolis, MN, November 2017.

Xu, X., A.L. Bryan, G. L. Mills, and A.M. Korotasz. Mercury speciation, bioavailability, and biomagnification in contaminated stream systems on the Savannah River Site (S.C., U.S.A.). Submitted to *Science of the Total Environment*, September 2018.

Examination of Selected SRS Aquatic Habitats for Metal Contamination and Bioaccumulation

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
April, 2018; $20,000
SREL PI and Co-PI's
Larry Bryan, Dean Fletcher, and Dr. Stacey Lance
Objectives
The primary objectives of this study were to fill in data gaps relative to metal contamination in drainages and/or aquatic systems on the SRS for SRNS-ACP. Specifically, we (1) analyzed archived fish samples from Fourmile Branch and Beaver Dam Creek for metals and Radiocesium, (2) collected and analyzed samples from the upper tributaries of Fourmile Branch, areas with environmental conditions potentially conducive or indicative of increased metals availability, and (3) examined environmental factors (e.g., hydroperiod, size, depth, water chemistry)that influences background levels of mercury in Carolina Bays, wetlands presumably contaminated by atmospheric deposition. This is a second installment of funding for this project.
Summary of Research Activities
1) We analyzed additional archived fish samples from Fourmile Branch for metals and Radiocesium as well as additional archived fish samples from two sites on Beaver Dam Creek.
2) We have now analyzed sediment (N=4), biofilm (N=12), aquatic invertebrate (N=12), amphibian (N=3), and fish (N=57) samples from 4 sites in the upper tributaries of Fourmile Branch for a suite of metals.
3) We analyzed THg in sediment (96) and biofilm (36) samples from three locations within 12 ephemeral wetlands. We extended a previous study examining THg in amphibians and examined additional samples. In total, we now have measured THg in southern leopard frogs (103), marbled salamanders (104) and mole salamanders (114). For a subset of amphibian samples we have measured methyl Hg (meHg). We are currently analyzing the sediment samples for meHg.

Conclusions
1) Assessment of new metal concentration data from archived fish is on-going.
2) Trace element accumulation varies between and within fish families; feeding strategy and habitat use appear to be factors in some taxa, but patterns tended to be element and species specific The amount of THg in sediments and biofilms was not related to wetland hydroperiod, but there is significant variation among the wetlands
3) The amount of THg in amphibians is significantly related to wetland hydroperiod with larvae developing in shorter hydroperiod wetlands accumulating more Hg.
4) The among of THg accumulated in amphibian tissues differs among species with southern leopard frogs having the highest body burdens. However, levels of meHg were similar across species.

Major Impact(s) of Research
1) When completed, we will have a better understanding of metal accumulation in aquatic biota from two SRS drainages to aid in assessment of risk from legacy contaminants.
2) When combined with previous work, a solid baseline of D Area pre-closure contaminant accumulation in Beaver Dam Creek biota will available.
3) For the Fourmile headwaters sites, we will determine if conditions presumed conducive to metal bioavailability actually resulted in higher metal concentrations in aquatic biota
4) When completed, we will have a better understanding of what drivers influence variation in background mercury concentrations in ephemeral wetlands. As initially predicted, amphibians inhabiting short hydroperiod wetlands are at a higher risk of accumulating levels of THg that may cause sublethal effects. More data are needed to determine what is driving patterns of THg deposition on the wetlands.

Other Project Personnel

Cara Love, PhD Student – UGA
Demetrius Calloway, Research Assistant – SREL
David Scott, Research Professional – SREL
Christina Fulghum, Research Technician – SREL
Brooke Lindell, Research Technician – SREL
Paul Stankus, Research Professional – SREL
Michaela Day, Research Assistant - SREL
Alexis Korotasz, Research Assistant – SREL

External Collaborators

NA

Products

Lance, S.L, D.C. Calloway, X. Xu, C. Love, M. Winzeler, A. Coleman, C. Tapia, R. Beasley, P. Walkup, and D.E. Scott (2018) Distribution of total and methyl mercury in sediment and amphibians from ephemeral wetlands on the Savannah River Site. South Carolina Water Resources Conference, Columbia, SC. [oral presentation]

Calloway, D., C. Love, D. Scott, and S. Lance. (2018) The fate of atmospheric mercury (Hg) in ephemeral wetlands. Emerging Researchers National Conference. Washington, DC. [oral presentation] **Won 3rd place for best undergraduate platform presentation.**

Calloway, D., C. Love, D. Scott, and S. Lance. (2018) The fate of atmospheric mercury (Hg) in ephemeral wetlands. Minorities in Agriculture Natural Resources and Related Sciences. Greensboro, NC. [oralpresentation] **Won 2nd place for best undergraduate platform presentation.**

Calloway, D., C. Love, D. Scott, and S. Lance. (2018) The fate of atmospheric mercury (Hg) in ephemeral wetlands. Society of Toxicology. San Antonio, TX. [poster]

Calloway, D., C. Love, D. Scott, and S. Lance. (2017) The fate of atmospheric mercury (Hg) in ephemeral wetlands. Southeastern Society of Toxicology. Fort Valley, GA. [poster] **Won 2nd place for best undergraduate poster.**

Lindell, B.E., A.H. Lindell, C.M. Fulghum, P.T. Stankus, JV. McArthur, and D.E. Fletcher. (2018). Variability of trace element accumulation among invertivorous fishes from a coastal plain stream contaminated by coal combustion waste. Society of Freshwater Science, Detroit, MI [poster].

Lindell, B.E., A.H. Lindell, C.M. Fulghum, P.T. Stankus, JV. McArthur, and D.E. Fletcher. (2018). Variability of trace element accumulation among invertivorous fishes from a coastal plain stream contaminated by coal combustion waste. International Conference on Heavy Metals in the Environment, Athens, GA [poster].

Literature Review of Radionuclide Levels in SRS Fauna

Funding Entity
SRNS Area Closure Project
Start Date and Funding Amount
April 2016; $78,000
PI and co-PI's
Larry Bryan, Dr. John Seaman and Dr. I. Lehr Brisbin, Jr.
Objectives
The overall goal of the project is to compile the known published information of radionuclides by SRS fauna, primarily from peer-reviewed literature, these/dissertations and SREL technical/final project reports.
Summary of Research Activities
To date, over 250 published articles, technical reports, theses/dissertations have been complied. Summarization of radionuclide concentrations in SRS has been completed for some elements (e.g., Pu, Sr), but remains on-going for others, including ^{137}Cs, the primary radionuclide found in fauna on the SRS.
Conclusions
1) We have generally completed the search for pertinent documents as well as the categorization of those documents, although new literature is added as it becomes available.

Major Impact(s) of Research
1) When completed, information pertaining to radionuclide concentrations in SRS fauna from 1960-2018 will be available in one document.

Other Project Personnel
A.M Korotasz, Research Technician - SREL
External Collaborators
NA
Products
No publications, presentations, or reports are available at this time.

TASK 4. SREL public outreach and communication programs will focus on the SRS environment and ecological research to increase the public's understanding of scientific issues affecting the Site and to increase general ecological awareness

SREL Outreach Activities in FY18

SREL's public outreach and communication programs focus on habitats and environments on the SRS and the ecological research that is conducted by SREL, with the purpose of increasing public understanding of scientific issues affecting the site and bringing general ecological awareness to the general public. Historically, the program's mission has been to educate the public about ecological research and environmental issues. SREL has also worked with the Citizens Advisory Board, various onsite organizations, state and federal regulatory authorities, and other stakeholder groups to raise awareness of the SRS and of regional ecological issues and opportunities for environmental stewardship. The program highlights SREL's ecological research on the SRS through oral presentations, exhibits, tours, and various electronic media. Outreach programs facilitate and encourage participation by students, regional teachers, resident and visiting faculty and training programs. SREL actively communicates information to the media via UGA Public Affairs and local and regional media outlets. To accomplish these goals and provide an overall educational outreach program, SREL has focused on the following specific objectives since its inception:

A. Publish articles on environmental issues and ecological research in popular press outlets including newspaper columns, popular magazines, University of Georgia publications, Department of Energy publications, encyclopedias, special publications such as alumni magazines and ancillary publications of scientific societies.

B. Provide news releases to newspapers and other appropriate media that relate to environmental activities of SREL, with particular emphasis on the SRS.

C. Develop and present an on-site tour program that focuses on the environments of the SRS and the ecological projects of SREL —conveying SREL's role as an independent evaluator.

D. Give presentations to the public, including schools, civic groups, and other organizations that focus on environments of the SRS region and on SREL's ecological projects.

E. Develop portable and permanent exhibits appropriate for use at special presentations at SREL, schools, other organizations, and special events.

F. Develop video and multimedia shows for presentations to groups or for use by onsite organizations, emphasizing SREL environmental programs and projects on the SRS.

G. Investigate opportunities for broadcast programs that focus on environmental issues, SREL's ecological research, and ecological projects on the SRS.

H. Develop and distribute brochures and publications that are informative the public and on-site tenants of SREL's ecological research, and the environments on the SRS.

I. Develop and establish displays of SREL research projects in appropriate areas of the SREL facilities.

J. Publish an internal newsletter (*The GrapeVine*) as a means of enhancing internal

communications— promoting individual as well as organizational achievement.

K. Develop the UGA conference center as a focal site for environmental education.

L. Establish a photograph collection that tells SREL's story, is informative of plants, animals, and habitats of the SRS region, and that emphasizes current ecological projects of SREL.

M. Maintain a collection of live plants and animals that can be used to educate the public about environmental issues and ecological research.

N. Maintain an area of the website for education on wildlife native to the SRS to include identification of regional species and information on wildlife safety.

O. Develop and present SRS wildlife safety talks for site tenants and visitors.

In accomplishing the goal of communicating ecological information to non-scientists, the Outreach program has provided on-site training and services to demonstrate the potential sources of injury from animals and plants found on the SRS and the CSRA that could occur to remote workers engaged in field activities or to employees and their families at home. The Outreach program has conducted workshops and training sessions and has attended SRS monthly safety meetings to deliver PowerPoint presentations and introduce live animals and native plants. The Outreach program has also developed and distributed safety materials (protocol badge cards and safety fact sheets) to SRS employees, and has managed an educational section on the SREL website. While the primary focus of most of these wildlife safety programs has been on snakes and alligators, the programs have also provided information on plants, insects, spiders, snapping turtles, and mammals of concern. During the 2018 fiscal year, the Outreach program hosted 12 safety talks for SRS employees and contractors.

The Outreach Program has been a participant in SRS's outreach to the general public via the ***SRNS Public Tours*** program, with SREL providing a 45 to 60-minute presentation bimonthly year-round (24 scheduled and up to 20 additional lab tours and impromptu presentations). These presentations provide a general introduction about the history and ongoing mission of SREL and the lab's involvement with research, teaching, and community service. The programs conclude with a question and answer period for participants on wildlife identification, site environmental research programs, safety, and other ecological matters of public interest. During the 2018 fiscal year, the Outreach Program hosted 36 tours, including 17 SRNS public tours and 19 lab tours and presentations for SRS partners.

SREL also hosts a series of scientific seminars, which are open to SRS employees, on a variety of research and educational topics which are pertinent to the SRS mission. Speakers include SREL research scientists, invited scientists from other university or agency programs, and graduate students who are conducting research on the SRS. During the 2018 fiscal year, the Outreach Program hosted 21 seminars, featuring current research from the SRS to the latest research in genetics, toxicology, herpetology, invasive species management, environmental monitoring, and radioecology. During the 2018 fiscal year, the Outreach Program hosted 21 seminars, featuring current research from the SRS to the latest research in genetics, toxicology, herpetology, invasive species management, environmental monitoring, and radioecology.

Other programs in which Outreach personnel participate include: ***REMOP***, a community outreach

program designed to educate Burke County, Georgia, residents about environmental monitoring, including metals and radioactive elements; the ***Let's Grow Together*** program, a collaboration with the USDA Forest Service that provides pollinator gardens and education programs to local schools as well as encourage families to participate in outdoor adventures at National Parks, Historic Sites and federal properties through the ***Every Kid in a Park*** free pass program; ***Ecotalk***, an opportunity for students to have nature brought into their classroom for a face-to-face lesson on a variety of live animals found in local habitats; the ***Ecologist for a Day*** program allows students to spend the day in the field gaining hands-on knowledge of the plants and animals of the unique Upper Three Runs Creek area at the off-site UGA Conference Center. The conference center also hosts civic group presentations and ecological tours. All school programs incorporate science standards and curricula for particular school districts. Most of these programs provide an opportunity for participants to work with SREL staff as they catch, mark, and measure various species of reptiles, amphibians, fish, small mammals, and invertebrates. In addition, Outreach offers an annual free program, ***Touch an Animal Day***, to the local and regional community at the UGA Conference Center, which allows individuals of all ages to interact with live animals and plant species, to meet site researchers, and to learn more about SRS efforts, including our research and education components. Lastly, the Outreach Program offers tours of SREL facilities, as well as exhibits and workshops for the general public as well as onsite personnel.

During the 2018 fiscal year, the REMOP program held 55 stakeholder, education and general public events in Burke County. The program brought together the Burke County community, Georgia Power, Savannah River Site scientists, local educators, and special interest groups. The Let's Grow Together program created four pollinator gardens and curriculum at local schools in areas that are traditionally underrepresented in STEM education. In addition, the Outreach program distributed more than 1,600 Every Kid in a Park passes in the CSRA region. The outreach staff presented more than 300 Ecotalks in area classrooms, hosted 34 Ecologist for a Day programs and participated in 24 CSRA Summer Library Programs. The annual Touch an Animal Day brought more than 700 visitors to the UGA Conference Center. The educational programs reached more than 68,000 students, teachers and members of the public in the CSRA region.

The communications program has worked to increase the visibility of the SREL and its role on the SRS through traditional media such as newspapers, magazines, and regional/local TV and radio outlets. In addition, the communications program has greatly increased its digital presence on social media such as Facebook, Twitter, and other emerging social media platforms. During the 2018 fiscal year, the SREL outreach programs, press releases, media advisories, and staff appeared in 54 newspapers, magazines, television shows, and radio programs. The media coverage spanned local, regional, national and international outlets reaching millions of people. The SREL Facebook community grew to more than 1,000 followers and had more than 61,000 views of its content. The SREL Twitter community grew to more than 150 followers and had more than 123,000 views of its content.

The Outreach section of the SREL website, ***https://srel.us.edu***, receives numerous hits, as it has links to the popular ***Ecologist for a Day*** program, Outreach fact sheets and educational products, the ***Ecoviews*** weekly newspaper column. It also invites questions about wildlife native to the SRS that are answered by the Outreach personnel. This website is frequented by educators, bloggers, researchers and news outlets from all over the world, who use the materials in their classrooms, blogs, research and news platforms. SREL distributes thousands of educational products and materials worldwide to schools, organizations, and the general public. During the 2018 fiscal year the website experienced a significant surge in traffic due a great increase in marketing on the social media platforms. The SREL website garnered enough

attention to finish among the top 10 websites managed by the University of Georgia among the hundreds of websites that represent the UGA community.

TASK 5. SREL will maintain ecological data bases for use by the public, SRS, governmental, academic, and private organizations. These databases incorporate more than 60 years of data collection on the SRS and provide a resource for understanding changes impacting ecosystems on the SRS and elsewhere in the southeastern United States

SREL Data Management Activities in FY18

IT Infrastructure

Over the past year, the Savannah River Ecology Laboratory continued to improve our IT capabilities. We worked with UGA networking to manage all of our local network switchgear and our Metro E connection to campus. We also worked with UGA network security for firewalls and security protection. We also made several other improvements to our IT systems in FY18 and they include:

1. **Partnered with Dropbox.**
   This not only increase our data storage capabilities at a reasonable cost it will also give our researchers and students secure access to the data from anywhere in the world.

2. **Upgraded Backupexec to version 20.3**.
   This gives us full technical support and all of the latest features.

3. **Upgrades to Zenworks 2017.**
   This gives us full technical support and all of the latest features.

4. **Use Zenworks for Patch Management of all network computers**.
   This not only keeps Microsoft products up to date, but all software installed on the computer. It also gives the Administrator the ability to choose what software in updated.

5. **Upgraded to I-Print 2.1**
   This gives us full technical support and makes it easier for our users to find and install network printers.

Database Management

Responsible management of research data plays an important role in preserving SREL's institutional memory. Data archiving supports DOE's mission, contributes to future research ecological research, and is now often required by funding agencies. SREL's current challenge is to rebuild the technological and policy infrastructure to support an active archiving program, as well as to address existing legacy data.

During FY2018 a fully functional draft version of the metadata submission tool was completed, and at the close of the FY testing was in progress. This test version deposits entries into a dummy catalog that can be easily deleted after testing is complete. It is linked from the main data management page, but unlike data retrieval, this area requires a user-created login. Since access is already limited to those with SREL intranet credentials, the login is primarily a handle for storing data and assigning privileges. Once registered, users can add and submit new metadata entries, as well as edit and re-submit their existing submissions. They can also save incomplete entries to edit and submit at a later time. Until datasets are published in the catalog, users can only view and edit their own submissions. For some fields such as personnel or location, users can select from registered values or enter their own. However, user-supplied values only exist within the session. Only an administrator account will be able to edit the tables of registered values. File upload capability has not been added yet, nor have the administrator tools. The data manager is notified via email when a new project is submitted.

During FY18 SREL continued to develop policy infrastructure to support data archiving. In addition to the previously established checkout process, as of FY18 the SREL data manager receives notification of accepted publications, along with information to determine whether the work requires data archiving. During FY18 the SREL data management committee also developed a draft policy that more clearly articulates data archiving requirements, and defines several data classes with proposed access policies for each. Data management has also been added to the check-in list, so that new employees will be aware of the requirement.

During FY18 SREL also continued work on existing legacy data. File headers from the 1998 CD discovered last FY have now been parsed and added to the legacy data files to create csv-formatted files with data, column labels, and column descriptors. These files are being manually checked for parsing errors, and repaired as needed. They are also being checked manually for other problems, including inadequate information, and repaired or improved to the extent possible.

TASK 6. SREL will serve as the point-of-contact for the "DOE Research Set-Aside" areas that are protected from site impacts so that they are available for environmental research and can serve to establish representative standards for comparison to impacted areas on the SRS. Currently SRS has 30 "set-aside" areas. SREL will also continue to promote the role of the SRS as a National Environmental Research Park.

SREL Set Aside and National Environmental Research Park Activities in FY18

The SRS's Set-Aside Program began in the 1960s when the Atomic Energy Commission (AEC) established 10 relatively small SREL Reserve Areas to represent the various habitats on what was formerly known as the Savannah River Plant and to secure study sites for conducting long-term ecological research. The program was expanded in the 1980s to 30 DOE Research Set-Aside Areas to better protect sensitive species habitats, preserve the biological integrity of Upper Three Runs Creek, and to buffer SREL's long-term research sites from forest management activities. These areas are a significant component of the SRS landscape (7% of SRS, totaling 14,560 acres/5,892 ha) and are found in 43 of the site's 89 timber resource compartments. There are approximately 275 miles (443 km) of posted boundary line. Set-Asides provide sites for long-term research, habitat for sensitive species, and protection for several archaeological sites.

Administration and Management of the Set-Aside Areas – SREL serves as the point of contact for the 30 Set-Asides and provides custodial oversight of the SRS Set-Aside Program. SREL chairs the DOE's Set-Aside Task Group, which approves management prescriptions, evaluates proposed ecological research, and ensures protection from onsite land use activities. SREL serves as the representative for the Set-Aside program in the SRS Site Use process and in the military training coordination meetings, reviewing activities in both venues for potential impacts.

Set-Aside Oversight – In recent years SREL has taken a more active approach to managing these areas, with wider application of prescribed fire, as well as some timber management. Management is conducted with an adaptive approach that gives the flexibility to address changing environmental conditions as well as research needs.

- The 8-acre thin prescribed for Thunder Bay has been completed.
- The Risher Pond Set-Aside Area was burned to reduce the growth of wisteria and privet.
- After the Risher Pond Set-Aside was burned, the remains of the old drift fence and other research debris were removed from the non-forested portion of the Set-Aside.
- Compartment 24 section of the E. P. Odum Wetland Set-Aside was not burned in growing season FY18. It has been placed on the schedule for dormant season FY19. Although a growing season burn would be preferable, the dormant season provides more opportunities.
- Mona Bay and Woodward Bay Set-Aside Area was not burned in FY18, but has been put on the schedule for FY19. Two previous burns and adequate rainfall have resulted in greatly reduced cover of maidencane and recovery of other species in Mona Bay.
- Craig's Pond and Sarracenia Bay Set-Aside have been placed on the burn schedule for FY19. Portions of the Craig's Pond ecotone have returned to herb-dominated conditions since the last burn.
- Prolonged wet conditions in FY17 and FY18 have resulted in roughly 90% mortality of invading loblolly pines in the ecotone of Sarracenia Bay, including the small off-site portion of the bay. Some

mortality has occurred in the offsite portion of Craig's Pond as well, but is limited compared to the reduction by fire on the DOE side.

Current research in SRS Set-Asides

- SRARP continues to catalog artifacts previously recovered from Flamingo Bay SA. No additional excavations have occurred there this FY. Long term archaeological research at Flamingo Bay has provided a wealth of information on early inhabitants of the CSRA, as well as information on bay formation.

- Research on habitat use of state-endangered gopher frogs (*Lithobates capito*) continues at Craig's Pond and Sarracenia Bay SA.

- The final report for SCDNR acoustic monitoring of historical gopher frog breeding sites conducted during FY16-17 has been received. Set-Aside wetlands monitored were Craig's Pond, Sarracenia Bay, Rainbow Bay, Mona Bay, Flamingo Bay, Ellenton Bay, and Risher Pond. Mona Bay was monitored for one breeding season; the others were monitored for two. Calls were recorded for Craig's Pond, Sarracenia Bay, and Mona Bay, for all seasons monitored. These were the only SRS wetlands in this study where gopher frog calls were recorded.

- Researchers from SREL, USFS-SR, and the University of Kentucky continue stream characterization in the E.P. Odum Wetland Set-Aside. This research will be used to inform future DOE restoration and mitigation efforts.

- Trace element analyses were conducted on sediment samples from the E.P. Odum Wetland Set-Aside in support of NNSA-MOX funded stream work.

- Researchers collected aquatic insects from the E. P. Odum Wetland Set-Aside for a stream ecology station at SREL's annual lab-wide outreach event, Touch an Animal Day.

- The E. P. Odum Wetland, Organic Soils, Beech-Hardwood, Mature Hardwood, and Flamingo Bay Set-Asides provided field sites for a study of ecological factors affecting the success of rabies elimination in the southeastern US.

- Craig's Pond, Sarracenia Bay, Mona Bay, and Thunder Bay, as well as 9 non-SA wetlands in the central and northeast regions of the SRS, continue to be monitored as egg-laying sites for the state-endangered gopher frog, *Lithobates capito*, and as part of a regional southeastern phylogeographic study. Egg masses were only observed at Sarracenia Bay in spring of 2018.

- Rainbow Bay, Ellenton Bay, Ginger's Bay, and Flamingo Bay continue to serve as reference sites for several amphibian ecotoxicology studies, including effects of copper in the Tritium Facility's H-02 Treatment Wetlands and metals uptake in the D-Area Ash Basin system.

- The amphibian community at the Rainbow Bay Amphibian Reserve Set Aside has been monitored for 40 consecutive years, during which time local species extinctions, colonizations, and dramatic population fluctuations have occurred. Researchers are currently investigating how amphibian community changes and hydroperiod fluctuations over time have influenced nutrient fluxes between the wetland and upland habitats.

- SREL researchers continue collecting amphibian tissue samples from multiple wetlands for studies of amphibian landscape genetics and effects of future climate change. Samples from eight species have been collected from approximately 42 isolated wetlands across the SRS, including the following Set Asides: Rainbow Bay Amphibian Reserve, Cypress Bay, Dry Bay, Ellenton Bay, Mona and Woodward Bays, Flamingo Bay, Thunder Bay, Craig's Pond and Sarracenia Bay, Ginger's Bay, and Road 6 Bay.

- Amphibian species in bay Set-Asides and other site wetlands are being monitored for two amphibian diseases of concern, chytrid and ranavirus, to determine disease prevalence on the SRS and possible relationships to contaminant distributions.

- Rainbow Bay, Ellenton Bay, Thunder Bay, Flamingo Bay, and Mona Bay provided sites for a summer REU project investigating mercury bioavailability in geographically isolated wetlands, which receive mercury from atmospheric deposition.

National Environmental Research Park Support - SREL serves as the official SRS point of contact for the DOE National Environmental Research Park System. In its role as a point of contact, SREL conducts a variety of functions, one of which is the improvement and archiving of critical historical research data on the SRS. For more information on this subject, see the Data Management section elsewhere in this report.

TASK 7. Through general research and public outreach programs, SREL will increase scientific understanding in the general areas of environmental characterization, ecological risk assessment, and environmental remediation and restoration. This will require research on topics such as terrestrial and aquatic ecology, environmental chemistry, molecular ecology and genetics, microbial ecology, radiation ecology, and ecotoxicology. SREL will also continue to communicate and coordinate with SRS contractors and the public on these issues

In FY18 SREL faculty, staff, and students conducted and completed a diversity of outreach and education programs for the public and environmental research projects on the SRS in support of the missions of DOE (EM & NNSA) on the site. Specifically, outreach programs were conducted for local community residents on behalf of DOE as part of ongoing community education programs to increase environmental awareness of citizens and provide independent information to community residents relative to the activities of site tenants. In addition, specific research programs were conducted for NNSA to assess the environmental consequences of the Mixed Oxide Fuel Fabrication Facility on local stream quality and function as well as to assess the function, performance, and environmental consequences of constructed wetland treatment systems for metal sequestration associated with the NNSA Tritium facility on the SRS. These programs were funded by NNSA and the details of these projects are outlined below:

Research Support to DOE National Nuclear Security Agency

Environmental Outreach Programs

Funding Entity
NNSA-MOX
Start Date and Funding Amount
March 2018; $285,355
PI and co-PI's
Dr. Olin E. Rhodes, Jr. and P.J. Perea
Objectives
SREL will assist the SRS NNSA mission and MOX Project by educating the public through community outreach activities that include organizing tours and exhibits featuring the local ecology and associated research; conducting environmental education workshops for teachers, students, and the general public, as well as for site personnel; development of a variety of environmental education materials for diverse audiences; increasing internet accessibility of information; distributing ecological information; presentation of data and reports on the local and regional environment; and assisting in educational efforts about the importance of environmental stewardship and National Environmental Research Park (NERP) programs at the SRS. Accomplishments relative to these tasks will be summarized in an annual report.
Summary of Program Activities
The SREL Environmental Outreach Program utilizes information from SREL's ongoing research and long-term research efforts to provide training and services to MOX and other SRS employees. The program also educates the public locally, regionally, and nationally about ecological research findings associated with on-site activities.

NNSA has continued to provide critical funding that has facilitated SREL's ability to achieve the goal of maintaining informative outreach programs for SRS personnel and stakeholders, as well as programs that educate the public through outreach. These programs enhance an individual's understanding of environmental issues affecting the SRS and increase general ecological awareness. In fiscal year 2018, SREL conducted engaging educational presentations to K-12 schools and adult audiences. These outreach efforts achieved DOE and NNSA goals of enhancing the public's knowledge and understanding of the ecological health of the SRS, and the importance of

environmental stewardship and the National NNSA has continued to provide critical funding that has facilitated SREL's ability to achieve the goal of maintaining informative outreach programs for SRS personnel and stakeholders, as well as programs that educate the public through outreach. These programs enhance an individual's understanding of environmental issues affecting the SRS and increase general ecological awareness. In fiscal year 2018, SREL conducted engaging educational presentations to K-12 schools and adult audiences. These outreach efforts achieved DOE and NNSA goals of enhancing the public's knowledge and understanding of the ecological health of the SRS, and the importance of environmental stewardship and the National Environmental Research Park (NERP) programs on the SRS. SREL also distributed educational resource materials to facilitate these goals.

The Outreach Program was readily available to conduct Lunch and Learn presentations to site personnel at the MOX Facility, provided tours for DOE site interns, new MOX employees, and children of SRS personnel. SREL developed and distributed literature and developed displays on animals and plants native to the SRS and the surrounding communities, produced materials on specific research programs, and maintained the MOX Conservation Garden at the facility.

The SREL Outreach Program is designed to enhance SREL's overall mission of acquiring and communicating environmental knowledge and to highlight NNSA's and DOE's focus on environmental issues on the SRS. To accomplish these goals, education initiatives are used that include 1) Environmental Safety on the SRS, 2) On-site outreach to the general public and site personnel, and 3) Off-site outreach activities at schools, civic organizations, and community events. Issues as diverse as wildlife safety in the field, wildlife population declines, potential responses of organisms to contamination, distribution of abundance of sensitive species, impacts of invasive species, wetland dynamics and remediation, water quality, and dispersal of organisms from radioactively or chemically contaminated sites are all important to on-site personnel and the general public.

Major Impact(s) of Program

1) SREL has been heavily involved in assisting the MOX project by facilitating the environmental component of the LEED (Leadership in Energy and Environmental Design) certification requirements.
2) SREL's Outreach program has consistently communicated information about the environmental activities on the SRS based on ecological research conducted on the site by SREL scientists. Regardless of format — presentations, tours, or exhibits, the SREL Outreach program's numerous efforts continue to succeed in raising awareness through education of the rich ecological diversity of the SRS MOX area and the region. The program continues to succeed in developing the general public's knowledge of and appreciation for the fauna and flora native to the area and in so doing develops an active interest in environmental stewardship, and an interest in protecting the integrity of the environment on the SRS and the communities that surround it.

Other Project Personnel

Vicky Sutton-Jackson, Public Relations Coordinator – SREL
Sean Poppy, Outreach Coordinator – SREL
Angela Tucker, Animal Caretaker – SREL
Judy Greene-McLeod, Research Professional – SREL
Megan Winzeler, Outreach Coordinator - SREL

Products

1) Conducted 36 scheduled tours; number of attendees – 948 (includes 17 SRS Public Tours, attendees – 599; 19 tours for on-site employees/visitors, attendees – 349)
2) Provided 12 Wildlife Safety talks; number of attendees – 2,950 (includes 5 talks to SRS employees, number of attendees – 2,158; 7 talks to professional groups, number of attendees – 792)
3) Presented 265 classroom education programs for elementary and secondary students; number of attendees – 16,745

4) Presented 57 environmental programs for college, professional and adult audiences – 9,615
5) Provided 33 exhibits at local and regional events; estimated number of attendees – 30,848
6) Conducted 34 Ecologist for a Day programs (school field trips to SREL's Conference Center); number of attendees – 874

7) Conducted 1 Touch an Animal Day event (August 25, 2018 at SREL's Conference Center); number of attendees – 713
8) Provided 56 STEM programs for the public (including 53 REMOP programs, 2 pollinator programs and 1 job shadow) – 3,439
9) Provided 24 presentations at regional library summer reading programs – estimated number of attendees – 2,169

***Total Outreach events: 518; total estimated attendance: 68,301**

Restoration of the MOX stream (Tributary U8): Initial efforts

Funding Entity
NNSA - MOX
Start Date and Funding Amount
April 2017; $213,645
PI and co-PI's
Dean E. Fletcher, Dr. J Vaun McArthur and Dr. Olin E. Rhodes Jr.
Objectives
Our overall goal is to provide a comprehensive assessment of the Upper Three Runs tributary (U8) that originates beside the MOX construction site. Contaminants accumulating in stream sediments and biota are being assessed as well as impact on hydrologic, geomorphic, and biologic stream features. The potential of restoration or enhancement strategies that would improve and better protect the integrity of the system is being evaluated.
Summary of Research Activities
Integration of our work on tributary U8 into additional SRS stream studies has expanded the geographic scope as well as incorporated additional critical expertise into our collaborative effort. The NNSA-MOX funded study, while providing a nucleus for the U8 work to be built around, has benefited by contaminant analyses that placed it into a broader spatial perspective with comparisons to other stressed SRS streams. Use of the same study taxa and environmental media along with identical laboratory and field protocols has allowed seamless comparison of data among these efforts. Overall, our contaminant assessments have included five streams in the Upper Three Runs basin along with the main stem of Upper Three Runs. The latter evaluates whether U8 is increasing contaminants in the main stem of Upper Three Runs. Geomorphic and hydrologic analyses of these streams have also been conducted in collaboration with the University of Kentucky and funded by the USDA Forest Service-SR in a project aimed at setting up a mitigation bank for SRS headwater streams. The restoration potential of U8 is being evaluated.

Evaluating impacts of environmental contamination is an essential component of assessing the need of and potential for stream restoration or enhancement and in determining whether risk of contaminant mobilization exists during enhancement efforts. A total of over 260 sediment samples from U8, Upper Three Runs (UTR), and McQueen Branch were analyzed. Total mercury concentrations were determined with a direct mercury analyzer and Cs-137 analyzed using an auto-gamma counter. Safe and consistent laboratory standard operating procedures for total sediment digestions were established. Following these efforts, concentrations of 18 trace elements (Be, Mg, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Sr, Cd, Ba, Pb, and U) were determined by inductively coupled plasma mass spectrometry. Water velocity at each sample location was measured at the time of sampling. Percent organic matter was determined by measuring the dry weight of the sediment and the ashed weight after four hours in a muffle furnace. Clay content of each sediment sample was determined using the micro-pipette method. Our efforts include a comprehensive baseline of contaminant distribution in the U8 system with 181 sediment samples analyzed from the U8 drainage basin. A total of 96 sediment samples were analyzed from the U8 stream channel distributed from the Upper Three Runs confluence to the ditches above the F Area coal fly ash basin. Additionally, 80 sediment samples were analyzed from 9 sedimentation/retention basins and a borrow pit in the U8 drainage. Because ash was observed on the sides of the coal fly ash basin where it could be readily washed into the stream, we also analyzed 5 samples from the sides of this basin. We put the U8 drainage into a larger spatial perspective by analyzing 37 sediment samples distributed longitudinally down Upper Three Runs from the northern site border to below Road C. Another 36 samples were analyzed from McQueen Branch and 8 from Meyers Branch to evaluate background contaminant levels and to clarify the role of ponds and basins in the storage and redistribution of contaminants. All chemical analyses were completed in FY18 and will be statistically analyzed in FY19.

Many aquatic insects have complex life cycles that involve an immature aquatic nymph or larval stage that emerges from the water as a flying adult. This emergence connects aquatic and terrestrial food webs and results in aquatic habitats subsidizing food resources to terrestrial organisms. Consequently, stream

disturbances that impact stream macroinvertebrate communities have the potential of also impacting the surrounding terrestrial food webs. Our previous work established impacts to the aquatic biota. We are now assessing whether these impacts are influencing the number and taxonomic composition of aquatic insects emerging from tributary U8. Traps to capture insects emerging from streams were first designed, and then their effectiveness tested. Ten traps were deployed in each tributary U8 and Tinker Creek reference tributary TC5. Traps were deployed over a total of 8 weeks with 28 trapping days. Identification and counting of captured insects is in progress. Preliminary results are indicating an adverse effect of stream disturbance on insect emergence.

Conclusions

1) U8 is severely degraded with impaired hydrology, channel form, substrate composition, and biological communities; impacts on stream macroinvertebrate communities and life histories have been observed.
2) Scouring by excessive flows has reduced organic matter content in the streams, influencing contaminant dynamics and potentially stream energetics.
3) Evaluation of sediments throughout the U8 indicated no concern of Cs-137 contamination.
4) Cs-137 levels in UTR sediments were low and not elevated below the U8 confluence.
5) Mercury concentrations in sediments of the U8 perennial did not exceed the Ecological Screening Values.
6) Substantially elevated Hg concentrations were found in locations upstream of the MOX construction site; any assessment of contaminants potentially originating from the MOX construction site must account for contaminants originating from upstream.
7) Patterns of trace element accumulation will be statistically evaluated in FY19.

Major Impact(s) of Research

1) We are providing a comprehensive base line of the present status of the U8 drainage and are assessing potential impacts of MOX construction and other activities in the U8 drainage.
2) Extensive contaminant analyses combined with the physical characterization are helping distinguish whether contaminants are involved in the observed biological impairments or the impacts are primarily the result of excessive runoff.
3) A group of onsite and offsite collaborators are assessing the potential of a restoration plan for tributary U8.

Other Project Personnel

Paul Stankus, Research Professional – SREL
Christina Fulghum, Research Technician – SREL
Brooke Lindell, Research Technician – SREL
John Seaman, Senior Scientist – SREL
Danielle Pitt, Research Technician – SREL

External Collaborators

Christopher Barton (University of Kentucky)
Richard Biemiller (University of Kentucky)
James Fudge (SRNS)
John Blake (USFS-SR)
Andy Horcher (USFS-SR)

Products

Fletcher, D. E., A. H. Lindell, J. C. Seaman, P. T. Stankus, N. D. Fletcher, C. D. Barton, R. A. Biemiller, and J V. McArthur. (in press). Sediment and Biota Trace Element Distribution in Streams Disturbed by Upland Industrial Activity. Environmental Toxicology and Chemistry.

H-02 Constructed Wetland Studies: Amphibian Ecotoxicology

Funding Entity
NNSA Tritium
Start Date and Funding Amount
October 2017; $297,698
PI and co-PI's (and Affiliations)
Dr. Stacey Lance and David Scott
Objectives
Our research at the H-02 constructed wetland complex focuses primarily on several questions related to these treatment wetlands: 1) Over time, what amphibians, reptiles, and plants have become established in the wetlands? 2) Do the elevated trace metal levels (e.g., copper and zinc) in the wetlands affect amphibian reproductive success, disease ecology, and population dynamics? 3) How do the amphibian diversity and numbers compare to other, more natural, wetlands? and 4) As the constructed wetlands age, how will the amphibian community respond?
Summary of Research Activities
This report summarizes our amphibian studies related to the H-02 treatment wetlands from October 2017 to September 2018. Following up on previous research, during this year we continued analyzing data on amphibian communities and disease prevalence from 20 wetlands on the SRS. These data will be critical for establishing a baseline for amphibians in natural ephemeral wetlands. We sampled over 30,000 individuals and screened several thousand for ranavirus. Similarly, we continued work to examine the landscape genetics of two species, the Southern toad and Southern leopard frog, from across the SRS. We have collected individuals from >20 wetlands and targeted several contaminated wetlands as well as wetlands from increasing distance from a contaminated wetland. We used subsets of these individuals to create genomic libraries for next-generation sequencing to identify single nucleotide polymorphism loci. We have identified thousands of loci and are currently designing capture baits for ~5,000 loci. We will use those baits to "capture" the same loci from all of our sampled individuals across the SRS. From these data, we will be able to establish baseline levels of genetic diversity in both species and examine patterns of gene flow across the SRS. These data are critical for establishing whether the contaminated wetlands on the SRS, such as the H-02 wetlands, are acting as ecological sinks or traps. In addition to these site-wide studies, we undertook a more targeted experimental analysis. We reared larval southern toads in two reference wetlands, Fire Pond and Bay 52, and two contaminated wetlands, H-02 and Pond B. The toads were reared *in situ* for several weeks and we monitored growth and development photographically. Upon metamorphosis, we returned toads to the lab and exposed half of them to ranavirus. Previously we had documented higher prevalence of disease in contaminated wetlands of the SRS. Our data indicate that growth and development of southern toads was not delayed in either contaminated wetland. Rather, it was accelerated in the H-02 wetlands. However, toads reared in the H-02 wetlands tended to have higher viral loads after exposure to ranavirus. Finally, we completed the 40th year of monitoring at RB, and finished analyzing the data in the context of community shifts in response to environmental change and subsequent impacts on nutrient cycling.
Conclusions
1. Southern toad juveniles exposed to copper as larvae grew faster but were more susceptible to ranavirus than larvae grown in reference sites.
2. Ranavirus remains present in multiple wetlands on the SRS and poses a risk to cause population die-offs.
3. Amphibian species richness ranges from 4-12 species and is largely driven by wetland hydroperiod.
4. The amphibian community at Rainbow Bay has shifted from long- to short-hydroperiod species over four decades in response to drought and associated shortened wetland hydroperiods.
5. Ignoring adult mortality in models of terrestrial flux of biomass leads to erroneous conclusions.
6. The probability of terrestrial flux of nutrients due to amphibian movements is tightly linked to wetland hydroperiod and amphibian biomass, but not specific species.

Major Impact(s) of Research

1. Our continued time series of metal concentrations in the H-02 system (in sediments, water, and biota) will enable informed assessment of how this type of constructed treatment wetland functions, and whether it provides suitable wildlife habitat in addition to enhancing water quality.
2. Our *in situ,* mesocosm and laboratory studies demonstrate the importance of looking a) at multiple stressors, b) beyond the larval period, and c) at multiple source populations. We have found significant latent effects that lead to completely different conclusions than the larval study alone—effects on juvenile survival were apparent five months later, largely due to Cu effects on body size at metamorphosis.
3. Our disease studies are ongoing, but are demonstrating the complexity of variables involved with disease incidence and prevalence in amphibians. The nature of the wetland—metal-contaminated vs. clean, permanent vs. ephemeral, and constructed treatment wetland vs. natural— impacts disease prevalence and variables are confounded with each other.
4. Exposure to a stressful environment may lead to accelerated growth of tadpoles but that may come at a cost of weakened immune responses.
5. Ranavirus exposure can cause serious sub-lethal effects such as growth rate, and more studies are required to determine if these effects can influence population dynamics.
6. Our understanding of the factors that drive the population dynamics of amphibians in natural systems, based on the long-term RB study, will allow predictions of the effects of climate change on isolated wetlands and provide insights to land managers who may need to design protective measures for rare species.

Other Project Personnel

Wes Flynn, PhD Student - SREL
Cara Love, PhD Student - SREL
Austin Coleman, MS Student - SREL
Kris Weekes, NSF REU Student

External Collaborators

Dr. Scott Weir (Queens University)
Dr. Krista Capps (UGA)
Dr. Schyler Nunziata (University of Kentucky)
Julie Ziemba (UGA)
Gabriela Rodriguez (USC-Aiken)
Adam McFall (USC-Aiken)
Mariela Muñiz-Gonzalez (USC-Aiken)

Products

Flynn, R.W., C.N. Love, A. Coleman, and S.L. Lance. (In review) Intraspecies Variation in Amphibian Metal Tolerance Associated with Population Exposure History. Submitted 10/2018 to *Aquatic Toxicology* for consideration for publication in special issue on "Intraspecies variability in aquatic toxicology."

Smith, L.L., A.L. Subalusky, C.L. Atkinson, J.E. Earl, D.M. Mushet, D.E. Scott, S.L. Lance, and S.A. Johnson. (Online early) Biological connectivity of seasonally ponded wetlands across spatial and temporal scales. *Journal of the American Water Resource Association.*

Rumrill, C.T., D.E. Scott, and S.L. Lance (2018) Delayed effects and complex life cycles: How the larval aquatic environment influences terrestrial performance and survival. *Environmental Toxicology and Chemistry*. 37:2660-2669.

Winzeler, M.E., D. Haskins, S.L. Lance, and T.D. Tuberville (2018) Survey of aquatic turtles on the Savannah River Site, SC for presence of ranavirus. *Journal of Wildlife Disease*s 54:138-141

Nunziata, S.O., S.L. Lance, D.E. Scott, E.M. Lemmon and D. Weisrock D (2017) Genomic data detect corresponding signatures of very recent population size trends in two salamander species impacted by climate change. *Molecular Ecology* 26:1060-1074.

Coleman, A.C., K. Capps, A. Park, D. Scott, and S. Lance (2018) Ranavirus and amphibians: Is there a dilution effect? Annual meeting of the Wildlife Disease Association, St. Augustine, FL.

Weekes, K., D.E. Scott and S. Lance (2018) Bioaccumulation of copper and zinc in amphibians inhabiting constructed wetlands: is bioavailability increasing with time? International Conference on Heavy Metals in the Environment, Athens, GA.

Muñiz-Gonzalez, M., J.L. Ziemba, and S.L. Lance. (2017) The impact of contaminants on growth, development, and disease susceptibility of southern toads. Southeastern Society of Toxicology. Fort Valley, GA. Won 1st place for best undergraduate poster.

Muñiz-Gonzalez, M., J. Ziemba, and S.L. Lance (2017) The impact of contaminants on growth, development, and disease susceptibility of Southern toads. SREL NSF REU Undergraduate Research Symposium, Aiken, SC. (Platform presentation)

Scott, D.E. (2017) Body size variation in pond-breeding salamanders: Implications for individual fitness and population dynamics. University of Miami, FL (Invited seminar speaker)

H-02 Constructed Wetland Studies—Ecosystem Health

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
October 2017; $152,811.78
PI and co-PI's
Dr. Gene Rhodes and Dean Fletcher
Objectives
The H-02 wetland water treatment system was constructed as a green technology initiative to remove metals and buffer pH in discharge waters from the NNSA Tritium Processing facility. Constructed wetlands have been widely employed to reduce nutrients and prevent eutrophication of surface waters. Their application for treatment of metal contaminated wastewater is still being refined. Our overall goal is to assess wetland effectiveness and develop strategies to maintain or improve treatment efficiency of the NNSA constructed wetlands to ensure long-term sustainability. Information is needed to evaluate: (1) the distribution of biologically available contaminants throughout and below the system, (2) effects of disturbance events (e.g., storms) on wetland effectiveness, (3) the potential export of metals to terrestrial or downstream food webs by aquatic biota, (4) effects of daily discharge fluctuations on wetland efficiency, (5) the potential of managing the retention basin as a pre-filter for the treatment cells. Previous work indicated considerably higher levels of biologically available Cu below the wetland than expected. Efforts are focusing on identifying the conditions under which metals leave the wetland system and on developing strategies to improve wetland treatment efficiency.
Summary of Research Activities
Metal Mobilization by Stormwater Flows -- Previous preliminary work demonstrated changes in metal transport flux during storm events. Such events have the potential of explaining the higher than expected levels of bioavailable metals below the wetland treatment cells. ISCO sampling units equipped with 24 bottle carousels are in operation immediately above and below the treatment cells and were used to collect high resolution time series of water samples along with water quality data from associated multi-parameter probes. The 290 water samples collected at the end of FY17 were analyzed and data used to refine our methodology. Subsequent sampling test runs worked out methodology of combining data from sampled water with water quality data collected from the multi-parameter probes. Sampling units were triggered by rainfall events when at least 0.3 cm of rain fell in 45 minutes or less. Samples were simultaneously collected from the treatment cell influents and effluents. We collected hourly composite samples composed of subsamples taken every 15 minutes; this evens out any momentary spikes uncharacteristic of overall discharge. Such a spike could result from an unusually large amount of suspended solid being sucked into the intake tube during a single sampling. Concurrently the multi-parameter probes collected rainfall, discharge and water quality parameters every 15 minutes. These measures were averaged to coincide with the hourly water sample composite. In late summer, 385 water samples were collected and analyzed. Of these, 96 were analyzed for Cu, Zn, and Pb. All Pb concentrations were well below the EPA drinking water action level, so Pb was excluded from the remaining 289 samples. Total and dissolved metal concentrations were determined for each element. Flux is the mass of an element that is entering or leaving the wetland at a point in time. In our case, it was calculated from metal concentrations in the hourly samples and average discharge during the hourly sampling. Load is the amount of element passing a point over an interval of time. Because of the high resolution of our sampling, we simply added the hourly flux measures to determine the load of element entering or leaving the treatment cells over the 24 or 48-hour sampling periods. Water samples were also filtered to determine the total suspended solids (TSS) in each sample.

Two smaller storm events (Storms 1 and 2) were sampled for 24-hour periods and one large storm event associated with hurricane Florence for 48 hours. The latter storm (Storm 3) was sampled for a longer period, because of high water levels in the retention basin and the resultant sustained high discharge level. In this event, 3.5 cm (1.4 inches) of rain fell during the first two hours and a total of 7.77

cm (3.06 inches) during the first 24 hours. A "first flush" resulted from a rapid rise in discharge after the initial rain event. Discharge ranged from 0.025-0.028 m^3/sec during the 24-hour period before the first rain event after which discharge raised to 0.039 m^3/sec, then further elevated to 0.043 m^3/sec after a 2nd event. During 48 hours after rain started, influent total Cu (tCu) concentrations averaged 18.96 ppb (9.37-246.45), whereas treatment cell effluents averaged 7.15 ppb (5.66-26.69). The first flush of tCu lasted 2 hours and was substantial. During the first two hours, influent TCu concentrations were elevated to 246.4 and 85.4 ppb and effluent concentrations to 26.7 and 12.1 ppb. It is important to note that we are collecting samples from the treatment cell outfall, not the SCDHEC collection site located above Road 4. Concentrations at the SCDHEC location will likely be diluted by additional surface runoff that enters the water course below the treatment cell outfall. Concentrations for the next 46 hours did not exceed 10 ppb in the effluents. Despite discharge being higher during the second rain event (hours 9 and 10), the highest concentrations and fluxes were associated with the first flush during hours 1 and 2. This illustrates the importance of the first initial elevated pulse of water passing through the wetlands. Because both flows and concentrations were elevated, hourly fluxes and the 48-hour load were substantial. During the first 2-hour flush, 46.4 g of TCu entered the wetland cells with 5.4 g leaving in the effluents. Over the duration of the 48-hour period, 123.6 g of tCu entered the treatment cells and 45.9 g left. To put this into perspective, a Cu mass equivalent of 49.9 pennies entered the treatment cells and 18.5 pennies left.

A pulse of suspended solid materials leaving the retention basin during the first flush is evident by an average TSS of 211 mg/L during the first two hours, but only an average of 14.3 mg/L during the next 46 hours. TSS was reduced in treatment cell effluents, but was still elevated to 30.0 mg/L during the first flush followed by an average of 5.74 mg/L. These fluctuations in TSS caused significant changes in the form of Cu entering and leaving the treatment cells during the 48-hour sampling event. During the first 2-hour flush, only 5% of the Cu entering the treatment cells was dissolved, thus 95% of the Cu was associated with particulate materials. During the next 46 hours, only 36% of the Cu was associated with particulates. Concurrently in the treatment cell effluents, 77% of the Cu was associated with particulate materials in the first flush, but only 19% in the following 46 hours. Treatment cell efficiency was calculated from the tCu load entering the treatment cells versus that leaving. During the first flush, 88% of the tCu was removed from the effluent line by the treatment cells. This subsequently decreased to 48% over the next 46 hours. This reduction in efficiency could be due to either the treatment cells more effectively removing particulate materials of the first flush than dCu of subsequent hours or by the treatment cells being overwhelmed with continued elevated discharge.

Total Zinc (tZn) concentrations during the 2-hour first flush were 638 and 282 ppb in the influents and 37.7 and 14.8 ppb in the effluents. During the next 46 hours, tZn averaged 51.3 ppb in the influents, but only 6.10 in the effluents. Effluent tZn concentrations did not exceed 90 ppb after the forth hour. During the first flush, 128 g of tZn entered the treatment cells, and 7.33 g left. During the entire 48-hour period 444 g entered (mass equivalent 179 pennies) and 44.8 g (18 pennies) left. Similar to Cu much of the tZn was associated with particulates during the first flush (averaged 96% in influents and 83% in effluents), but during the next 46 hours this reduced to averages of 54% and 33% in the influents and effluents, respectively. Removal efficiencies of tZn averaged 94% during the first flush and 88% during the next 46 hours.

In Storms 1 and 2, a total of 0.55 and 1.25 cm of rain fell after the samplers were triggered. Discharge ranged from only 0.020 to 0.028 m3/sec during Storm 1 and 0.25-0.29 during Storm 2. Influent tCu concentrations reached maximums of 41.0 and 23.2 ppb and effluents maximums of 7.58 and 5.14 in these storms, respectively. Over the 24-hour sampling periods 61.3 and 53.9 g (24.7 and 21.7 pennies) of tCu entered the treatment cells and 11.2 and 13.2 g (4.5 and 5.3 pennies) left in the effluents. Influent TSS was 25.3 and 16.1 mg/L in the first flush versus14.7 and 16.0 mg/L in the following 22 hours. In the influent first flush, 46% and 44% of the tCu was associated with particulates followed by 37% and 49% in the next 22 hours in these storms, respectively. In the effluent first flush, 39% and 20% of the tCu was associated with particulates followed by 15% and 30% in the next 22 hours. Influent tZn concentrations reached maximums of 88.4 and 51.2 ppm and effluent maximums of only 13.6 and 1.16 ppm in these storms respectively. Over the 24-hour sampling periods 139 g and 112 g of tZn entered the wetlands and

9.19 and 4.00 g left in the effluents. In the influent first flush, 61% and 54% of the tZn was associated with particulates followed by 50% and 65% in the next 22 hours. In contrast, the effluent first flush contained 62% and 29% of the tZn associated with particulates followed by 31% and 83% in the next 22 hours. The elevated Zn associated with particulates in effluents of Storm 2 illustrates variability that can occur, but it should be noted that concentrations of both tZn and dZn were relatively low in this weak storm.

Results show that large amounts of both Cu and Zn can leave the treatment cells during storm events. Severity of the storm influences discharge, metal concentrations and fluxes as well as the form of metal leaving the treatment cells. In only 2 samples (in Storm 3) were TSS in the effluents greater than the influents. Thus, the treatment cells generally removed a portion of the TSS from the water course. Additionally, even though significant amounts of metal left the wetlands in the effluents, more metals were entering than leaving the wetland cells. Thus, the wetland system was functioning to lessen impacts on the receiving stream. Treatment cells appeared to be overloaded over the course of a larger storm event. The high levels of TSS and metal fluxes leaving the retention basin may indicate better management of the retention basin is warranted. Much work remains to be done evaluating effects of factors such as level of rainfall, time since last rainfall as well as seasonal variability. Since water and sediment chemistry changes seasonally this could greatly influence what leaves the wetlands during storm events. The metal load of the suspended solids also must be better evaluated.

Metal Accumulation in Macroinvertebrates – We are continuing our work examining the export of contaminants from the wetlands to terrestrial food webs by emerging insects. In addition to analyzing whole-body concentrations of metals/metalloids in the teneral (emerging) dragonflies, we are also analyzing concentrations in exuviae (nymph exoskeleton) that is shed upon emergence. The latter indicates what proportion of the nymph's contaminant load was shed in the exuviae and left behind compared to what actually left the wetlands in the emerging teneral. In FY18, we completed analyses of the remaining exuviae. Trace element concentrations were analyzed in a total of 249 teneral dragonflies and 195 exuviae. Analyzed teneral dragonflies were distributed across 2 families, 6 subfamilies, 11 genera, and 14 species. Last year's report summarized much of these results in detail. Some elements (e.g. Al, Fe, Ba, Pb) were largely shed in the exuviae, whereas others tended to leave the wetland in the teneral (e.g. Cu, Zn, Mg, B). Proportion of trace elements that accumulated in/on exuviae versus teneral differed among species, but similarities within subfamilies were found. The amount of Cu or Zn accumulating on the exuviae varied more among sections than that accumulating in the teneral. No differences between offshore and nearshore habitats, or between sexes were apparent. Overall, trace element body burden of nymphs are indicative of trophic doses when preyed upon directly, but not necessarily to that of predators preying on emerging dragonflies. Future work will evaluate temporal variability in trace element distribution in teneral versus exuviae and evaluate causes of interspecific variation of trace element accumulation. Four species of emerging damselflies and their shed exuviae were collected in sufficient numbers to compare trace element accumulations in each. These samples have been identified, measured, freeze dried and weighed. Sample preparation, digestion, and analyses on an ICP-MS will be completed in FY19.

Our work conducted in streams and wetlands frequently found taxa associated with sediments, particularly fine sediments rich in organic matter, to accumulate higher concentrations of metals/metalloids. We have constructed 200 cages and 10 frames to hold the cages at four different levels above the sediment. White oak leaves were collected and dried to use as a habitat substrate in each cage. Water diffusion samplers are being constructed to continually sample water at each level on each frame. Samplers for collection of sediment pore water at each frame are also being developed. Cages will be stocked with dragonfly nymphs early in FY19. This study will examine the importance of exposure of contaminants in sediment versus water on aquatic biota.

Conclusions

1) Severity of the storms influenced outfall discharge, metal concentrations, and consequently fluxes of metals that entered and left the treatment cells.

2) During a more severe storm event, elevation of both metal concentrations and discharge rate caused a more substantial metal load to enter and leave the wetlands.
3) Metal concentrations and fluxes were most elevated in a "first flush" that occurred early in the storm event. Higher concentrations of suspended solids leaving the wetland during the first flush resulted in a greater portion of tCu being associated with particulate material. During later hours, a larger portion of the tCu was dissolved. Wetland metal removal efficiency also changed over the course of the storm events.
4) Even though substantial amounts of metals left the wetlands, greater masses of metals entered the treatment cells than left in the effluents. Thus in the evaluated storm events, the H-02 wetlands functioned to lessen impacts on the receiving stream. Future work will evaluate whether the heavy loads entering the treatment cells during storms are originating from the retention basin or water entering it.
5) Elements differed in their propensity to accumulate in dragonfly exuviae that are shed during emergence and remains in the wetland versus being transferred to terrestrial food webs by the tenerals.
6) Concentrations of trace elements accumulating in nymphs are indicative of trophic doses when preyed upon directly, but not necessarily to that of predators preying on emerging dragonflies.

Major Impacts of Research

1) This research supports the use of cost effective constructed wetlands for the treatment of metal contaminated waste water and supports DOE's goal of employing "green technologies" for waste cleanup and remediation. Constructed wetlands play an important role in the SRS environmental plan to achieve regulatory compliance for the discharge of effluent waters.
2) Our research evaluates the potential transport of contaminants from constructed wetlands to downstream waters or terrestrial environments and supports DOE commitment to good ecological stewardship. Evaluations are aimed at developing management strategies to maximize wetland effectiveness.
3) Results of our studies support the EPA's goal of advancing our understanding of metal dynamics in wetland systems and developing better tools for predicting the fate and effects of metals in aquatic ecosystems.

Project Collaborators

Christina Fulghum, Research Technician III - SREL
Paul Stankus, Research Professional I – SREL
Dr. J Vaun McArthur, Senior Ecologist – SREL
Dr. Fanny Coutelot, Postdoctoral Research Associate – SREL
Dr. Xiaoyu Xu, Postdoctoral Research Associate – SREL
Danielle Pitt, Research Technician III – SREL
Brooke Lindell, Research Assistant – SREL
Angela Lindell, Research Professional III– SREL

External Collaborators

NA

Products

Fletcher, D.E., D.B. Pitt, A.H. Lindell, P.T. Stankus, and B.E. Lindell. Export of Trace elements by emerging dragonflies from a wetland constructed for Cu and Zn effluent treatment. Annual Meeting of the Society of Environmental Toxicology and Chemistry, Minneapolis, MN, November 2018. (Poster).

Fletcher, D.E., A.H. Lindell, D.B. Pitt, P.T. Stankus, and B.E. Lindell. Trace elements shed in exuviae versus exported from contaminated wetlands by emerging dragonflies. Annual Meeting of the Society of Freshwater Science, Detroit, MI, May 2018. (Oral presentation).

Fletcher, D.E., A.H. Lindell, D.B. Pitt, P.T. Stankus, and B.E. Lindell. Trace elements shed in exuviae versus exported from contaminated wetlands by emerging dragonflies. International Conference on Heavy Metals in the Environment, Athens GA, July 2018. (Oral presentation).

Stankus, P.T., A.H. Lindell, G.L. Mills, D.B. Pitt, and D.E Fletcher. Trace element accumulation in dragonfly nymphs and crayfish as indicators of constructed wetland effectiveness. International Conference on Heavy Metals in the Environment, Athens GA, July 2018. (Poster).

H-02 Constructed Wetland Studies— Biogeochemical Processes

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
October 2017; $293,240
PI and co-PI's
Dr. Xiaoyu Xu
Objectives
The goal of this research is to support, assess and improve operations of the NNSA constructed wetlands to maintain treatment efficiency and ensure long-term sustainability. Our primary objectives are to study: (1) the removal efficiency of metals for the studied wetland system, (2) the chemical speciation and bioavailability of metals in surface waters, (3) the stability of sediment accumulated metals and the potential for remobilizing sediment metals, (4) the overall biogeochemistry of metals in the sediment and water, and (5) the relative environmental impacts.
Summary of Research Activities
Metal Biogeochemistry in the Water -- Water samples were collected and Diffusive Gradients in Thin Films (DGT) were deployed monthly from Oct 2017 to Sept 2018 in the primary discharge pipes, retention basin, influent, effluent, both wetland cells, and the discharge stream that carries the effluent to Upper Three Runs. Water quality parameters including temperature, pH, oxidation-reduction potential (ORP), alkalinity, dissolved organic carbon (DOC), sulfate, and chloride were measured, and concentrations of total, dissolved, and labile metals (Cu and Zn) were determined. Generally, the H-02 wetland system functioned well in FY2018. Water collected from influent prior to the wetland treatment cells showed higher total Cu concentrations (95%CI: 13.6 to 20.5 µg/L) than the monthly discharge permit setup by USEPA (12.3 µg/L, NPDES), and water samples in the effluent (95%CI: 4.0 to 6.5 µg/L) and stream (95%CI: 4.3 to 8.2 µg/L) after the wetland treatment showed lower concentrations than this regulatory criteria. Total Zn concentrations from all sampling locations were consistently below the NPDES permit (110 µg/L). Total and dissolved (<0.45 µm) metal concentrations tended to decrease following the flow path in the wetland system, and the mean removal efficiency were 70.6% and 73.9% for Cu and Zn, respectively. Meanwhile, water quality parameters were modified after the wetland treatment. The alkaline waters became nearly neutral after running through the wetland cells as the pH values in the effluent (95%CI: 6.6 to 6.8) decreased significantly compared to that in the influent (95%CI: 8.3 to 9.3). ORP values in the pipe (95%CI: 289 to 503) were highest among all sampling locations but decreased significantly in the wetland cells (95%CI: 26 to 117). There were no statistical differences of water temperature, alkalinity, DOC, sulfate, and chloride among sampling locations.

Metal speciation also indicated the reduction of metal toxicity. Although the major species of total metal were in dissolved phase (99.9% of total Cu and 67.5% of total Zn), labile metal concentrations measured by DGT device were statistically lower in the stream (95%CI: 0.4 to 0.8 µg/L for DGT-Cu and 1.8 to 4.5 µg/L for DGT-Zn) compared to that in the influent (95%CI: 1.1 to 3.2 µg/L for DGT-Cu and 3.6 to 8.1 µg/L for DGT- Zn). However, the chronic toxicant units of Cu calculated by Windermere Humic Aqueous Model (WHAM) in all sampling locations were higher than 1, and they were not statistically different between the effluent stream and the source pipes, indicating a potential exceedance of the particular Cu Water Quality Criteria.
Metal Biogeochemistry in the Sediment -- We found out the metal-removal process in wetland cells is season-related and regulated by sulfur cycling in last fiscal year: composition of metal-sulfide minerals is the major removal process during the "warm" season (Feb to Aug) of a year and adsorption to organic matters became the primary process for removal during the "cold" season (Sept to next Mar). In FY2018, multiple approaches were applied to thoroughly understand metal (Cu, Zn, and Hg) biogeochemistry in the sediment, including how the depth profile of labile metal concentrations and their co-vary parameters, and how they change with seasons and locations. The sediment DGT, two types of pore water samplers (tube peeper and plate peeper), and sediment cores were applied monthly to measure the concentrations of labile

metal species, DOC, sulfate, and chloride. Vertical profile of DGT-metal and peeper-metal concentrations indicated an obvious increase in the sediment depth of -10 cm to -13 cm below the sediment-water interface. There were no statistical differences of DGT-metal and peeper-metal concentrations between the wetland cells. Seasonally, DGT-metal concentrations peaked in Mar in both wetland cells, and they were higher in spring and early summer (Feb to June) compared to that in early fall (July to Sept).

Water quality parameters measured by peeper deployment suggested DOC and sulfate concentrations in sediment pore waters changed seasonally: sulfate concentrations were higher in spring and early summer (Feb to June) than that in early fall (July to Sept); DOC concentrations peaked in June and they were lower in spring (Feb to Mar) than that in summer (Apr to Aug). There were not statistical differences of DOC, sulfate, and chloride concentrations in pore waters between the two wetland cells. However, in wetland cell 1 pore-water Cu concentrations were highly correlated to both DOC and sulfate concentrations, but in wetland cell 2 pore-water Cu concentrations were only correlated to sulfate concentrations. We did not observe any relationship between pore-water Zn concentrations and water quality parameter.

Controlled Studies -- We continued using DGT exposures coupled with aquatic organism bioassays to assess the use of DGT as a tool for monitoring metal contamination and estimating metal bioavailability in FY-18. Cu and Zn concentrations in yellow lampmussel (*Lampsilis cariosa*) were compared with DGT accumulated metals after 12 days of exposure in the stream, wetland cells, influent, and retention basin during the wet and dry seasons. DGT accumulated metals include free ions, labile inorganic complexes, and complexes between metal and labile dissolved organic matters when compared to metal speciation output from the WHAM. Regressions of DGT-metal and mussel accumulated metal or WHAM predicted labile metal demonstrated linear relationships in wet season (June 2018), when metal concentrations were relatively low in surface water. This suggest the *in-situ* field deployment of DGT is useful to indicate contamination and meanwhile assess bioavailability and bioaccumulation of heavy metals. Experiments in dry season when metal concentrations were high in the surface water will be conducted in Nov 2018 to further evaluate the usefulness of DGT device.

Mercury (Hg) in the Wetland Cells -- Mercury (Hg) was included in the study of FY2018. The only sources of Hg to H-02 wetland system is the atmospheric deposition of industry released Hg. We found out the wetland cells served as a huge trap of deposited Hg, and meanwhile anaerobic bacteria in the sediment transfer inorganic Hg to methylmercury and moves methylmercury from lower trophic position to higher trophic position through the wetland food web. Bioaccumulation of Hg was observed in Mayfly. The average total Hg was 88.4 ng/g in wetland cell 1 and 883 ng/g in wetland cell 2. Percentage of total Hg present as methylmercury differs between the two wetland cells (85.0% in wetland cell 1 and 15.8% in wetland cell 2), suggesting different Hg methylation rates in the sediment. Further studies need to be conducted to find the reason of difference. DGT deployment and equilibrium calculation indicated that labile Hg concentrations were 2.1 ng/L (95%CI: 1.8 to 2.3 ng/L) in sediment pore waters, which was lower than the 7.8 ng/L (95%CI: 6.5 to 9.2 ng/L) in the historically contaminated Fourmile Creek on SRS. However, the wetland cells will keep trapping atmospheric Hg and methylating inorganic Hg in the sediment, so labile Hg in pore waters and methylmercury in food web will continue to increase in the future. There is a potential risk that the wetland treatment cells become an important source of Hg to the surrounding environment.

Conclusions

1) The H-02 constructed wetland effectively reduces total Cu and Zn concentrations in the surface water released by Tritium Facility to achieve NPDES regulatory limits.
2) Metal toxicity were also reduced due to the decreased concentrations of labile metals, such as free metal ion and inorganic metal species.
3) The ability of removing metals and reducing toxicity by wetland cells decreased in the summer.
4) The metal-removal processes in both wetland cells are related to season and sulfur cycling.
5) The metal-removal processes in the two wetland cells and between Cu and Zn are slightly different. Cu-removal in wetland cell 1 is related to sulfur cycling and organic matters, and Cu-removal in wetland cell 2 is only related to sulfur cycling. Zn-removal in both wetlands are also related to some unknown parameters.

6) The different methylation rate of Hg between the two wetland cells provides implications on engineer design of constructed wetland.
7) The wetland treatment cells may become an important source of Hg to the surrounding terrestrial environment in the future.
8) DGT device is a convenient, precise and accurate passive sampler that can indicate metal contamination and access metal bioavailability, so it should be included in routine monitoring.

Major Impacts of Research

1) This research supports the use of cost effective constructed wetlands for the treatment of metal contaminated waste water and supports DOE's goal of employing "green technologies" for waste cleanup and remediation. Constructed wetlands play an important role in the SRS environmental plan to achieve both federal and state regulatory compliance for the discharge of effluent waters.
2) This research evaluates the potential transport of contaminants from constructed wetlands to terrestrial environments and connected effluent streams, and supports DOE commitment to good ecological stewardship.
3) Results of our studies support the EPA's goal of advancing our understanding of metal biogeochemistry in wetland systems and developing better tools for predicting the fate and effects of metals in aquatic ecosystems.

Other Project Personnel

Erin Peck, Research Technician - SREL
John Perry, Research Technician - SREL

External Collaborators

NA

Products

X. Xu, G. Mills. 2018. Do constructed wetlands remove metals or increase metal bioavailability? *Journal of Environmental Management*, 218(15): 245-255.

R. R. Philipps, X. Xu, G. L. Mills, R. B. Bringolf. 2018. Evaluation of diffusive gradients in thin-films for prediction of copper bioaccumulation by yellow lampmussel (*Lampsilis cariosa*) and fathead minnow (*Pimephales promelas*). *Environmental Toxicology and Chemistry*, 9999: 1-10.

R. R. Philipps, X. Xu, R. B. Bringolf, G. L. Mills. 2017. Impact of natural organic matter and increased water hardness on DGT prediction of copper bioaccumulation by yellow lampmussel (*Lampsilis cariosa*) and fathead minnow (*Pimephales promelas*). *Environmental Pollution*, 241:451-458.

R. R. Philipps, X. Xu, G. L. Mills, R. B. Bringolf. 2018. Bioaccumulation of copper and lead by fathead minnow (*Pimephales promelas*) and yellow lampmussel (*Lampsilis cariosa*): evaluation of DGT technique for predicting uptake of metal mixtures. *Environmental Toxicology and Chemistry*. (In publication).

X. Xu, G. L. Mills, A. Lindell, E. Burgess. Metal removal by a constructed wetland from 2007 to 2018: how a young constructed wetland becomes mature. *Water*. (Submitted).

S. Harris, X. Xu, G. L. Mills. Metal-sulfide dynamics in a constructed wetland: seasonal surveys of AVS and SEM in surface sediments. *Wetland*. (In Prep)

Tritium Distribution and Cycling on the Savannah River Site

Funding Entity

NNSA

Start Date and Funding Amount

October 2017; $78,000

PI and co-PI's

Dr. John C. Seaman

Objectives

The objective of the current project is to develop and refine monitoring protocols for evaluating organically bound tritium (OBT) levels in various plant and animal receptor species. The SRS provides an excellent setting for evaluating low-level tritium cycling dynamics in the environment, including the transformation of tritiated hydrogen gas (HT) and tritiated water (HTO) to OBT.

Summary of Research Activities

Continued analysis of biological samples from the SRS, including samples from the SRS Mixed Waste Management Facility (MWMF) Tritium Irrigation Site (i.e., irrigation source pond, soil profile, pine needles, limbs, leaf litter, etc.). Continue to have problems with limited tritium recovery in standard materials. In 2018, n 2018, SREL participated in the biennial 7th International Organically Bound Tritium Workshop conducted in Ontario, Canada. At the OBT Workshop Dr. Seaman gave the invited presentation, *Evapotranspiration of Tritium in an Irrigated Forest*, coauthored with SREL colleagues F.M. Coutelot and M.R. Baker. The presentation highlighted ongoing research activities supported by NNSA and ACP. The SREL research team will produce and refine plant tissue materials to be submitted for the next round of CRM test material evaluations between the working group partners. Furthermore, SREL is under consideration to host one of the next the OBT Workshops in either 2020 or 2022.

Project Conclusions

1) HTO levels in soils and plants tissues were lower than tritium source (dilution from precipitation)
2) OBT ≠ HTO (OBT reflects long-term exposure)
3) HTO and OBT levels in control samples quite low despite proximity to NNSA source

Major Impact(s) of Research

1) Provide data for estimating tritium dose calculations in risk assessment scenarios, particularly under specific management strategies where OBT may be released to the environment in a more available form (e.g., water vapor).
2) Enable site management to estimate potential human and ecological tritium exposure levels associated with new SRS mission activities, ongoing site cleanup efforts, accidental release, and routine site custodial activities.

Other Project Personnel

Fanny Coutelot, Postdoc - SREL
Matt Baker, Research Professional III - SREL
Kimberly Price, Research Technician – SREL
R.J. Thomas, Graduate Student - SREL

External Collaborators

Dr. S.B. Kim (Chalk River Laboratories)
Dr. Robin Brigmon (SRNL)

Products

Seaman, J.C., F.M. Coutelot, M. Baker, R.J. Thomas. 2018. Evapotranspiration of Tritium in an Irrigated Forest. Seventh Organically Bound Tritium (OBT) Workshop. September 24-26, 2018. Toronto, Ontario, Canada.

Seaman, J.C., F.M. Coutelot, and M.R. Baker. 2018. Tritium Distribution and Cycling on the Savannah River Site: Evaluating Organically Bound Tritium. Submitted to NNSA.

TASK 8. SREL will continue to serve as a regional resource for scientific expertise and environmental research. SREL staff scientists will continue to provide special technical assistance to other site contractors, area stakeholders, other researchers, and the public. SREL will also continue to collaborate with scientist from other institutions

In FY18, SREL faculty, staff, and students conducted a diversity of environmental research projects both on and off of the SRS in support of their mission to pursue collaborations and funding to serve as a regional source of scientific expertise and to provide technical assistance to other site contractors, stakeholders, other researchers, and the public. Due to both the specific technical expertise represented by research faculty and staff at SREL and the unique opportunities for scientific research represented on the Savannah River Site, SREL scientists are often sought out as potential collaborators by researchers across the globe. SREL staff served as collaborators on both funded and non-funded research involving environmental remediation, ecotoxicology and environmental stewardship and, as Principal Investigators or co-Investigators on funded research all over the United States and internationally. In addition, SREL faculty, staff and students served as hosts for over 231 researchers from other universities, federal and state agencies, and non-governmental organizations to discuss and conduct collaborative research and funding. Research, external funding, and requests for technical assistance conducted in support of this task are outlined below:

Collaborations and Externally Funded Research on the SRS

Levels of Alpha-gal in Amblyomma americanum ticks collected from the Savannah River Site and adjoining areas: Implications for red meat allergy

Funding Entity
SREL
Start Date and Funding Amount
October 2016; NFP
SREL Collaborators
G. Dharmarajan
Objectives
The purpose of this study was to characterize α-gal in *Amblyomma americanum* and *A. maculatum* ticks reared in the lab and those collected naturally from hunter killed deer on the SRS and adjoining areas
Summary of Research Activities
Delayed anaphylaxis linked red meat is a newly recognized allergic disease. Individuals bitten by the lone star tick (Amblyomma americanum) may develop IgE antibodies to the carbohydrate galactose-α-1,3-galactose (α -Gal; a carbohydrate moiety). Upon exposure of sensitized subjects to mammalian meat containing α -Gal on glycoproteins or glycolipids, delayed anaphylaxis may ensue, often three to six hours after ingestion. Tick saliva and salivary gland samples were processed to recover N-glycans. The N-linked glycans were permethylated for structural characterization by mass spectrometry. Briefly, the permethylated glycans were reconstituted in 100% MeOH and introduced to the mass spectrometer (Thermo Fusion Tribrid Orbitrap) with offline emission. These data were used to search for a Hex-Hex-HexNAc signature, and when glycoforms matching a Hex-Hex-HexNAc signature were found in some of the samples, the rest of the samples were rerun and manually fragmented at masses corresponding to each of the possible N-linked glycoforms.
Conclusions
1) A large number of N-glycans was found in each of the tick samples, and these varied greatly from extended high mannose structures to highly complex and hybrid structures.
2) No indications of the α -Gal glycoforms were found in any of the samples from the Amblyomma maculatum (Gulf Coast Tick) samples, either by not finding a mass corresponding to the glycoform,

or if the mass was found, MS/MS fragmentation indicated that the glycoform did not contain the Hex-Hex-HexNAc signature fragment.

3) No indications of the α -Gal glycoforms were found in the salivary glands from unfed *Amblyomma americanum*. However, multiple alpha-Gal glycoforms were found in salivary glands and saliva from partially or fully blood fed *Amblyomma americanum.*

Major Impact(s) of Research

1) Our preliminary data reveal α -Gal glycoforms are only associated with saliva and salivary glands of partially or fully fed *A. americanum.*
2) The presence of α –Gal in *A. americanum* has significant implications for red meat allergy in South Carolina, especially amongst individuals that have high risk of exposure to being bitten by these ticks (e.g., hunters)

Other Project Personnel

Amanda Hurst, Research Technician – SREL

External Collaborators

P. Azadi (UGA)

S. Karim (University of Southern Mississippi)

Products

Archer-Hartmann, S. A., G. Crispell, S. Karim, G. Dharmarajan and P. Azadi (2018) Tick Bites and Hamburgers: N-Glycosylation analysis of saliva and salivary glands from the ticks responsible for Alpha-Gal Syndrome. Society for Glycobiology. November 5-8, 2018. New Orleans, LA

Restoring Headwater Streams and Riparian Corridors at the Savannah River Site, SC: Part A-Mitigation Plan Proposal Supporting Documentation

Funding Entity
USDA Forest Service-Savannah River
Start Date and Funding Amount
June 2017; $27,042
SREL Collaborators
Dean E. Fletcher
Objectives
Our overall goal has been to provide assessments of legacy and current stream disturbances to enable Savannah River Site management organizations and regulatory oversight agencies to move forward with specific restoration/enhancement treatments and a monitoring plan for a stream restoration-mitigation project.
Summary of Research Activities
Stream restoration and enhancement provides opportunity to correct or improve previous alterations that have destroyed, diminished, or impaired the character and function of stream systems. The Savannah River Site (SRS) provides an ideal research opportunity for restoration of coastal plain streams. SRS stream disturbances span a temporal range from pre-SRS legacy impacts, through the early infrastructure development in the early 1950s, to more recent and current industrial activities. In a collaborative effort, a multiphase program was conducted to characterize SRS streams, identify risks of legacy and recent disturbances, and identify disturbed stream reaches with potential for restoration. Three levels of assessments were completed with each level providing an increased level of detail and scientific rigor. A Level I assessment involved a broad scale survey of potential stream disturbances and stream basin characterization. Level II assessments assessed the effects of stream alterations on physical stream condition in a subset of Phase I identified streams. Level III assessments further evaluated a selected subset of stream reaches by measuring additional hydrology, physicochemistry, biology, and geomorphology features. This comprehensive stream evaluation identified management options and is guiding prescriptions for potential restorative actions.

Our work has identified enhancement/restoration opportunities that span a broad range of complexity, cost, and risk. Current plans are being developed for some of the more cost effective opportunities with lower levels of risk of environmental disturbance by the management activities. Experience gained by these restoration and enhancement efforts in less complex situations, may be applied to more costly systems in the future. The headwaters of Tinker Creek offer several suitable areas/reaches for restoration and enhancement that could be performed cost effectively, in a timely fashion and with overarching goals that could improve stream and riparian condition. Restoration opportunities in the Tinker Creek watersheds include ditch filling, in-stream habitat enhancement, and potentially dam removal. Riparian enhancement would involve opening of the closed-canopy forest to release native cane in the understory. Use of fire to manage forest understory including cane stands will be evaluated. Prescriptions for these specific stream enhancements as well as required permit materials are being assembled.
Conclusions
1) Amount of industrial area in a drainage has a strong influence on instream geomorphology, chemistry, and macroinvertebrate communities; streams receiving excessive stormwater runoff are generally the most disturbed streams within our study systems.
2) Basin and valley characteristics interact with landscape disturbance to influence level of stream disturbance.
3) Enhancement of tributaries of Tinker Creek represent cost-effective options for establishment of a mitigation bank.

Major Impact(s) of Research
1) We have identified effects of legacy and current disturbances on stream chemistry, hydrology, geomorphology, and biology on select SRS streams.

2) Through an effort with onsite and offsite collaborators, we are proposing restoration plans including post-treatment monitoring for 4 headwater streams while using a fifth as a reference system.
3) A framework upon which a headwater stream mitigation bank can be built is being developed.

Other Project Personnel

Paul Stankus, Research Professional – SREL
Christina Fulghum, Research Technician – SREL
J Vaun McArthur, Senior Research Scientist – SREL

External Collaborators

Christopher Barton (University of Kentucky)
Richard Biemiller (University of Kentucky)
Andy Horcher (USFS-SR)
John Blake (USFS-SR)

Products

Fletcher, D. E., A. H. Lindell, J. C. Seaman, P. T. Stankus, N. D. Fletcher, C. D. Barton, R. A. Biemiller, and J V. McArthur. (in press). Sediment and Biota Trace Element Distribution in Streams Disturbed by Upland Industrial Activity. Environmental Toxicology and Chemistry.

Comparative Analysis of Bioconversion and/or Bioprecipitation Strategies for In-Situ Bioremediation of Uranium

Funding Entity

DOE - Minority Serving Institutions Partnership Program (MSIPP)

Start Date and Funding

October 2017; $54,000

SREL Collaborators

Dr. John C. Seaman and Dr. Fanny M. Coutelot

Objectives

Project objectives include: 1) establishing lab-controlled, anoxic, iron-replete and PO_4-amended serum bottle microcosms using SRS soils colonized by the wetland macrophyte- Sparganium americanum; 2) growing Sparganium americanum under iron-replete and PO_4-amendments in greenhouse mesocosms to monitor dynamics of U cycling; 3) using whole cell bacterial bioreporter to identify U bioavailability; 4) delineating SRS site-specific environmental, biogeochemial and microbial drivers promoting bioconversion/bioprecipitation and stable maintenance of insoluble U(IV) or U/P-mineral and; 5) training under-represented students in the field of environmental biotechnology and environmental restoration.

Summary of Research Activities

Radionuclide and heavy metal contaminated environments are remnants of the nuclear weapons production era and the Department of Energy (DOE) is charged with rehabilitation of such co-contaminated environments, such as the Savannah River Site (SRS). Such environments are difficult to remediate using conventional excavation and disposal or pump-and-treat approaches. Less expensive in-situ remediation, by applying additives, can alter contaminant speciation or microbial activities enhancing solid-phase partitioning to reduce migration, bioavailability and associated hazards. Towards this end, effectiveness of PO_4 minerals/compounds to stabilize heavy metals and radionuclides through sorption and/or the formation of secondary phosphate precipitates has been successfully demonstrated. However, the use of sparingly soluble, solid-phase PO_4 limits the effectiveness to surficial materials. To overcome these limitations, a range of soluble P materials, such as phytate has been evaluated with varied success. Moreover, in-situ remediation requires long-term monitoring of contaminants and the native microbiota that underpin biogeochemical transformations of contaminants.

Conclusion

1) Demonstrated the effectiveness of PO_4 based amendments in immobilizing U in SRS soils.
2) Identified potential problems associated with the use of soluble PO_4 sources for U immobilization.
3) Identified additional SRS microbial isolates that are insensitive to U and Ni contamination, and developed a U biosensor.

Major Impact of Research

1) The current research has the potential to impact the long-term disposition of U contaminated areas within Steeds Pond/Tims Branch watershed on the SRS, and other U contaminated sites associated with DOE Facilities.

Other Project Personnel

Fanny Coutelot, Postdoc - SREL

M.B. Baker, Research Professional III - SREL

External Collaborators

Dr. Victor Ibeanusi (Florida A&M University)

Dr. Ashvini Chauhan (Florida A&M University)

Dr. Charles Jagoe (Florida A&M University)

Dr. Dan Kaplan (SRNL)

Products

Ibeanusi, V., A. Pathak, A. Chauhan, J. Hoyle-Gardner, T. Cooper, L. Turker, H. Howard, O. Obinegbo, G. Chen, and J.C. Seaman. 2018. Genome-Centric Evaluation of Bacillus sp. strain – ATCC55673 and Response to Uranium Biomineralization. Significance of Bioengineering & Biosciences. 2(3). ()

Chauhan, A., A. Pathak, R. Jaswal, B. Edwards, D. Chappell, C. Ball, R. Garcia-Sillas, P. Stothard, J.C. Seaman. 2018. Physiological and Comparative Genomic Analysis of Arthrobacter sp. SRS-W-1-2016 Provides Insights on Niche Adaptation for Survival in Uraniferous Soils. Genes 2018, 9, 31. (3.191)

Coutelot, F.M., J.C. Seaman, and M. Baker. 2018. Uranium(VI) adsorption and surface complexation modeling onto vadose sediments from the Savannah River Site. Environmental Earth Science, 77:148.

Kaplan, D.I., C. Xu, P. Santschi, D. Li, J.C. Seaman, P. Jaffe. 2018. Seasonal Changes in Uranium Porewater Chemistry in a Contaminated Wetland. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Li, D., D.I. Kaplan, H. Chang, J.C. Seaman, P.R. Jaffe, De-Tong Jiang, N. Chen, K.G. Scheckel, M. Newville, A. Lanzirotti, C. Segre. 2018. Chemical Speciation of U in Savannah River Site (SRS) Wetland Sediments. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Baker, M., F.M. Coutelot, J.C. Seaman. 2018. The Use of Phosphate Amendments for Chemical Immobilization of Uranium in Contaminated Soil. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Ibeanusi, V., J. Hoyle-Gardner, H. Howard, A. Chauhan, R. Jaswal, C. Jagoe, J.C. Seaman. Analysis of Growth Dynamics and Protein Expressions of Microbial-Mediated Biomineralization of Uranium Contaminated Soils at Savannah River Site, Aiken SC. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Cochran, J.P., A. Chauhan, F.M. Coutelot, B. Parrott, T. Glenn, J.C. Seaman. Immobilization of Uranium in Terrestrial Environment Through the Mineralization of Inositol Hexaphosphate. International Conference on Heavy Metals in the Environment. July 22-25, 2018, Athens, GA.

Chauhan, A., C. Jagoe, V. Ibeanusi, J.C. Seaman, and John White. 2018. Evaluation of Microbial Community Structure and Functions as Indicators of Ecosystem Health and Processes in Uraniferous Soils of the Savannah River Site (SRS), USA. International Conference on Methods and Applications of Radioanalytical Chemistry (MARC). April 8-13, 2018. Kailua-Kona, Hawaii.

Baker, M., F.M. Coutelot, and J.C. Seaman. 2017. The Use of Phosphate Amendments for Chemical Immobilization of Uranium in Contaminated Soil. Annual Meeting of the American Geophysical Union. Dec. 11-15. New Orleans, LA.

Cochran, J.P., A. Chauhan, F.M. Coutelot, B. Parrott, T. Glenn, and J.C. Seaman (2018) Immobilization of Uranium in Terrestrial Environment Through the Mineralization of Inositol Hexaphosphate. April 3, 2018. Interdisciplinary UGA Toxicology Program Annual Spring Workshop.

Agarwal, M., A. Pathak, R. Rathore, O. Prakash, R. Singh, R. Jaswal, J. Seaman, and A. Chauhan. 2018. Proteogenomic Analysis on Burkholderia species Strains 25 and 46 Isolated from Uraniferous Soils Reveals Multiple Mechanisms to Cope with Uranium Stress. Submitted to Cells.

Baker, M.B., F.M. Coutelot, J.C. Seaman, and A Chauhan. 2019. The Use of Phosphate Amendments for Chemical Immobilization of Uranium in Contaminated Soil. Submitted to Environment International.

REU Site: Radioecology supplement

Funding Entity
National Science Foundation
Start Date and Funding Amount
May 2018; $69,040
SREL Collaborators
Dr. Tracey Tuberville and Dr. Stacey Lance
Objectives
To obtain a supplement to continue the only Radioecology Research Experiences for Undergraduates (REU) program in the United States. This REU provides hands on training in radioecology at the Savannah River Ecology Lab. Our REU aims to train a new generation of researchers prepared to meet the emerging energy and security demands of our planet through interdisciplinary research that merges ecology and environmental chemistry. The previous REU proposal funded the program for three years and had outstanding student outcomes, but lacked in meeting the target student base. The objectives of the current project are to demonstrate our increased focus on developing a diverse cohort of students by implementing a new recruiting approach and student selection process. In addition, the objectives included increasing the applicant pool.
Summary of Research Activities
We provided seminars at regional universities that highlighted the NSF REU program in general, our REU program specifically with examples of previous students' projects, and application procedures. In addition, we held meet and greet opportunities schools where students could ask questions about the REU program. We directly contacted faculty at ~50 colleges and universities in the southeast. We pre-screened applicants and then forwarded applications of selected students to their prospective mentor. At the end of the program we met with mentors to discuss changes needed to broaden the application rate and agreed to alter the title from "Radioecology" to "Interdisciplinary research in ecology, environmental chemistry and ecosystem health." We hosted eight students through the Radioecology REU. SREL hosted a half-day research symposium at the SREL Conference Center in which REUs presented their research to SREL staff and on-site cooperators. In addition, REUs were able to present poster presentations in a special session at the International Conference on Heavy Metals in the Environment held in Athens, Georgia.
Conclusions
The objectives were met and the 2018 REU cohort consisted of students that were 100% from primarily undergraduate universities, 75% under-represented minority groups, and 50% underclassmen. Based on these results we were able to submit a new proposal to renew the REU program with a new theme. It is too early to determine if that will be successful in increasing the application rate.
Major Impact(s) of Research
None at present
Other Project Personnel
Matt Hamilton, Research Professional II - SREL
External Collaborators
NA
Products
Proposal submitted: Lance, S.L., and T.D. Tuberville. National Science Foundation. REU Site: Interdisciplinary Research in Ecology, Environmental Chemistry and Ecosystem Health. ($264,167)

Use of fecal genotyping and spatial capture-recapture modeling to investigate coyote abundance in South Carolina

Funding Entity
SC DNR
Start Date and Funding Amount
January 2017; $50,000
SREL Collaborators
Dr. Stacey L. Lance
Objectives
The overall goals of this research are to estimate coyote densities among regions in South Carolina and to evaluate densities relative to landscape composition and other variables.
Summary of Research Activities
Coyote scats from a previous study on the SRS were collected over four seasons for two years on the SRS. To date we have extracted DNA from all scats have completed an initial screen of all samples across 9-10 microsatellite loci. We have confirmed recaptures of individuals across seasons and years. The new project is an extension of that work and will include those samples. This year a PhD student was recruited and began his program at UGA in Fall of 2018. Lance and O'Bryhim are focusing efforts on developing methods of analyzing single nucleotide polymorphisms from DNA extracted from scat.
Conclusions
The data are still being collected.
Major Impact(s) of Research
Until the data are fully acquired and analyzed we will not know the major impacts.
Other Project Personnel
Rochelle Beasley, Research Professional - SREL
Dr. Jason O'Bryhim, Research Professional - SREL
External Collaborators
Dr. Gino D'Angelo (UGA)
Dr. Karl Miller (UGA)
Dr. John Kilgo (USFS-SR)
Jordan Youngman (UGA)
Products
Manuscripts will be prepared at a later date.

Differences in the physiological response of Liquidambar styraciflua caused by season of burn.

Funding Entity
USDA Forest Service-Southern Research Station
Start Date and Funding Amount
August 2015; $60,000
SREL Collaborators
Dr. Doug Aubrey
Objectives
The goal of this project was to determine how the season of burning influenced mortality, resprouting, and subsequent growth of American sweetgum.
Summary of Research Activities
Planted seedlings in 20 L pots in spring 2016 and maintained them for an entire growing season. Subjected a subset of seedlings to experimental burns prior to leaf-out in early March 2017. Subjected another subset of seedlings to experimental burns after leaf-out and leaf expansion in June 2017. Whole plant carbon budgets were collected using gas exchange. Whole-plant harvests were conducted routinely throughout the growing season following experimental burns.
Conclusions
1) Contrary to the hypothesis—and previous reports—the dormant season burn resulted in higher mortality than the growing season burn and fire intensity did not explain differences in mortality.
2) Root mass of burned trees increased after burning, but was lower than controls at the end of the year and season of burn did not impact root mass at the end of the season.
3) Root carbohydrate reserves decreased during leaf-out, but quickly returned to pre-burn levels and, regardless of season, root carbohydrate reserves were similar to controls at end of season.

Major Impact(s) of Research
1) Results from this study will provide scientists and land managers empirical data to support or reject current thoughts on timing of prescribed fire and its efficacy in controlling sweetgum in southeastern forests.

Other Project Personnel
S. Ruswick, MS Student - SREL
External Collaborators
R.O. Teskey (UGA)
J.J. O'Brien (USDA Forest Service-Southern Research Station)
Products
Aubrey, D.P., S. Ruswick, and J. O'Brien. 2018. Does season of burn influence the efficacy of prescribed fire in controlling sweetgum? Ecological Society of America, New Orleans, LA. (Poster presentation)
Ruswick, S., J. O'Brien, D.P. Aubrey. 2018. Sweetgum saplings burned in the growing season have lower mortality and similar biomass to those burned in dormant season. Warnell Graduate Student Symposium. Athens, GA. (Oral presentation)

Completion of data analysis and publication of soil chemical and physical properties associated with production of short rotation woody crops for bioenergy.

Funding Entity
USDA Forest Service-Savannah River
Start Date and Funding Amount
August 2016; $107,897
SREL Collaborators
Dr. Doug Aubrey
Objectives
The goals of this project were to complete processing, analysis, and manuscript preparation from a USDA FS project looking at fundamental drivers of forest productivity. The resulting manuscripts include: (1) nitrogen budgets for forest stands following 12 years of intensive forest management; (2) soil carbon dynamics following 12 years of intensive management; and (3) dynamics of perennial and ephemeral tissues through stand development under different resource availabilities. Another objective was to re-establish experimental plots with new planting stock.
Summary of Research Activities
Two of the three manuscript drafts are nearly complete and will soon be ready to submit for consideration in peer-reviewed journals. Experimental plots are currently being prepped for future planting in October 2018. An experimental plan is currently being drafted and planting material will be ordered before the end of the 2017 calendar year.
Conclusions
1) Soil carbon decreased in the surface 0-30 cm of 10 metric tons per hectare but an increase at depth of 12 metric tons per hectare.
2) Soil nitrogen changed very little, a surprising result given the large N inputs but also a result possibly reflecting high plant N demand.
3) Both soil P and K increased with fertilization through 105 cm.

Major Impact(s) of Research
1) Results from this study will provide scientists and land managers empirical data to support or reject current thoughts on timing of prescribed fire and its efficacy in controlling sweetgum in southeastern forests.
2) This nearly net zero carbon balance in soil is important to demonstrate carbon neutrality but is only really correct if subsoil C is from new root growth.
3) This study clearly indicates a capacity for short rotation woody crops to contribute to bioenergy feedstocks but to do so sustainably will require continued study of tree demand and soil supply.

Other Project Personnel
NA
External Collaborators
Dr. Daniel Markewitz (UGA)
Dr. David Coyle (UGA)
Products
Coleman, M.D. and D.P. Aubrey. 2018. Stand development and other intrinsic factors largely control fine-root dynamics with only subtle modifications from resource availability. (In Press at Tree Physiology).

Markewitz, D., D.P. Aubrey, D.R. Coyle, and M.D. Coleman. 2018. Soil Carbon and Nutrient Change after 11-years of a Short-Rotation Woody Crop Cycle. 21st World Congress of Soil Science. Rio de Janeiro, Brazil. (Oral presentation)

Getting to the root of the matter: Determining the global significance of internal carbon dioxide transport in trees.

Funding Entity
UGA Research Foundation
Start Date and Funding Amount
July 2017; $9,829
SREL Collaborators
Dr. Doug Aubrey
Objectives
The main objective of this proposed research is to develop and validate the foundational methodology necessary to investigate the global significance of internal carbon dioxide (CO_2) transport in trees and to collect preliminary data that will help formulate and support testable hypotheses. This is a seed grant to prepare a larger external funding effort.
Summary of Research Activities
We have begun investigating methods and approaches to collect xylem sap pH and methods to collect and measure carbon dioxide from tree stems.
Conclusions
1) Data were collected and have so far been used in two external funding proposals (DOE and NSF).
Major Impact(s) of Research
1) The novelty in this proposed study is that we currently lack an understanding of the global significance of internally transported CO_2, whereas the appeal of my approach is that we can examine this flux globally with a modest budget by leveraging existing instrumentation through a network of collaborators with the deployment of relatively simple and inexpensive sampling kits.

Other Project Personnel
Mackenzie Dix, Research Assistant – SREL
Tae Yoon Lee, PhD Student – SREL
External Collaborators
NA
Products
None at this time.

Survival and Cause-Specific Mortality of Juvenile Wild Pigs

Funding Entity
USDA – Wildlife Services – National Wildlife Research Center
Start Date and Funding Amount
September 2014; $25,300.00
SREL Collaborators
Dr. James C. Beasley
Objectives
The objective of this study is to develop methods for quantifying survival and cause-specific mortality of juvenile wild pigs. Once appropriate techniques are developed, survival will be evaluated as a function of a suite of demographic and environmental attributes.
Summary of Research Activities
During fall 2014 through summer 2015 we placed ear tag transmitters on juvenile wild pigs 4-5 weeks of age. Since 2015 we have begun evaluating the performance of several additional VHF transmitter attachment methods for monitoring piglets <1 week of age when mortality is expected to be highest. In addition, we have evaluated the potential utility of vaginal implant transmitters (VITs) for use in pigs for locating newborn piglets. During 2016 we also began evaluation of surgical implantation of transmitters for monitoring survival of newborn piglets, and are currently evaluating a new form of ear-tag transmitter designed for neonate piglets.
Conclusions
This study is ongoing, however, we have observed very low mortality of piglets >4 weeks of age. VITs have proven successful as a tool for locating litters of wild pigs and we have successfully located several litters for which we have evaluated various VHF transmitter attachment methods. Specifically, previous ear tag transmitter models are suitable for piglets several weeks old, but are not a viable option for neonates. We are currently evaluating a new form of ear-tag transmitter specifically designed for neonates as a potential alternative, and have deployed several of these transmitters on neonate pigs. Additional deployments of these transmitters will be ongoing for the next 1-2 years.
Major Impact(s) of Research
1) This research will provide the first data to date on the survival of juvenile wild pigs, data that are essential to the development of robust population growth models.
2) This research will evaluate multiple transmitter attachment methods for monitoring piglet survival and provide future researchers with recommendations for a model from which future studies can be based.

Other Project Personnel
Sarah Chinn, M.S. Student - SREL
Peter Schlichting, Postdoc - SREL
External Collaborators
Dr. John Kilgo (USFS-SR)
Mark Vukovich (USFS-SR)
Dr. Frederick Cunningham (USDA)
Products
Keiter, DA, JC Kilgo, MA Vukovich, FL Cunningham, and JC Beasley. 2017. Development of known-fate survival monitoring techniques for juvenile wild pigs (*Sus scrofa*). *Wildlife Research* 44:165-173
Chinn, S., D. Keiter, J. Kilgo, M. Vukovich, and J.C. Beasley. 2018. Determining Survival of Wild Piglets. International Wild Pig Conference. Oklahoma City, Oklahoma (oral presentation)
Chinn, S., J. Kilgo, M. Vukovich, and J.C. Beasley. 2018. Determining Survival of Neonate Wild Piglets. Warnell Graduate Student Symposium. Athens, Georgia (oral presentation)

Post-Translocation Movement Behavior of Wild Pigs

Funding Entity
USDA APHIS – Wildlife Services – Veterinary Services, National Wildlife Research Center
Start Date and Funding Amount
September 2014; $108,350.00
SREL Collaborators
Dr. James C. Beasley
Objectives
The objective of this study is to quantify the movement behavior of wild pigs post-translocation to elucidate the movement behavior of translocated individuals, as well as shifts in movement behavior in response to translocation.
Summary of Research Activities
This study is in the final year of the project. During January 2015 we deployed GPS transmitters on 8 wild pigs that were translocated ~15 km from their capture site, as well as several pigs that were left in situ as control animals. Translocated and in situ pigs were monitored for a minimum of 2-3 months and we have collected the majority of transmitters. An additional 12 translocation and 8 control pigs were fit with GPS transmitters in spring/summer 2016. We are currently analyzing these data to reveal shifts in movement rates home range, path tortuosity, etc. in translocated wild pigs. Additional GPS collars were deployed in 2017-2018 to assess movement behavior of translocated groups of wild pigs.
Conclusions
Although this study is still underway, data collected thus far clearly reveal translocated wild pigs make extensive movements post-release. Specifically, home range sizes of translocated pigs average several times larger than those of non-translocated individuals and move an average maximum distance of 13 km from their point of release. Several individuals have relocated back to their original point of capture (~15km). Extensive home ranges and movements are maintained for ~1 month, after which movements more closely resemble those of control animals. However, the magnitude of the post-translocation response is modulated by habitat, with pigs translocated to less preferred habitats tending to exhibit more extensive movements.
Major Impact(s) of Research
1) This research will produce the first comprehensive data to date on the spatial ecology of wild pigs subsequent to translocation.
2) This research will provide important insights to guide future management of invasive wild pigs and will produce critical data to better develop disease transmission models for wild pigs throughout the U.S.

Other Project Personnel
Dr. Josh Smith, Postdoc - SREL
David Keiter, M.S. Student - SREL
Kevin Eckert, Research Technician – SREL
Peter Schlichting, Postdoctoral Research Associate – SREL
Sarah Chinn, Ph.D. Student – SREL
External Collaborators
Dr. Ryan Miller (USDA)
Steve Sweeney (USDA)
Products
Beasley, J.C. 2018. Beasley Wild Pig Lab. South Carolina Wild Pig Task Force. Columbia, South Carolina (oral presentation)

Effects of sounder removal on the movement behavior of wild pigs

Funding Entity
USDA – Wildlife Services – National Wildlife Research Center
Start Date and Funding Amount
February 2016; $70,852.00
SREL Collaborators
Dr. James C. Beasley
Objectives
The objectives of this study are to evaluate the movement behavior of wild pigs following the removal of adjacent social groups, to simulate real-world trapping activities to control this invasive species. These data also will be used to evaluate the degree of territoriality among adjacent wild pig social groups (i.e. sounders).
Summary of Research Activities
During spring 2016 we selected 2 study sites on the SRS and trapped the majority of adjoining sounders in each site. We fit at least 1 adult female in each group with a GPS transmitter and also collared several boar within each study area. Subsequent to trapping we established bait stations to assess density using remote cameras. After 2-3 months we selectively removed pigs from the core of each study site. Since 2017 we have been recollecting GPS collars and are now beginning to analyze the data for this study.
Conclusions
Data analyses are still ongoing; there are no conclusions at this time.
Major Impact(s) of Research
1) This research will provide important data on the home range overlap of neighboring wild pig sounders, data that will provide inferences on the degree of territoriality exhibited by this species.
2) Data collected during this study will provide information on how wild pig movements are impacted by the removal of adjacent social groups, data essential to the development of robust management plans for this species.
3) Data derived from this study will be integrated into national-level research by the USDA to implement management of wild pigs.

Other Project Personnel
David Keiter, M.S. Student - SREL
Peter Schlichting, Postdoctoral Research Associate – SREL
Kevin Eckert, Research Technician – SREL
External Collaborators
Kim Pepin (USDA)
Amy Davis (USDA)
Kurt Vercauteren (USDA)
Dr. John Kilgo (USFS-SR)
Products
McRae, J., P. Schlichting, N.P. Snow, A.J. Davis, K.C. VerCauteren, J.C. Beasley, D.A. Keiter, J.C. Kilgo, and K.M. Pepin. *In Review*. Factors affecting visitation by wild pigs to bait sites: The area of influence of baits.
Beasley, JC. Wild Pig Research on the Savannah River Site. 2018. South Carolina Wild Pig Task Force Meeting, Columbia, SC (oral presentation)

Evaluation of contact structure and disease dynamics in free-ranging wild pigs

Funding Entity
USDA – Wildlife Services – National Wildlife Research Center
Start Date and Funding Amount
February 2017; $58,883
SREL Collaborators
Dr. James C. Beasley
Objectives
The objectives of this study are to quantify the contact structure of invasive wild pig populations, and the influence of supplemental feeding and experimental population reduction on contact rates among groups. These data also will be used to evaluate the degree of territoriality among adjacent wild pig social groups (i.e. sounders).
Summary of Research Activities
During spring 2017 we captured 7 adjacent sounders as well as several adult male wild pigs on the SRS and fitted 1-3 members of each group with a GPS transmitter and contact logger. Samples were collected from all trapped pigs for DNA and disease analyses. After several months of establishing baseline data, we created bait stations to assess the influence of baiting on movements. Beginning in September 2017 we began culling groups at the core of the distribution of collared animals to assess the impact on animal movements. Collars automatically fell off of pigs in mid-November 2017, and we are currently analyzing the data collected from these collars.
Conclusions
This research has just begun; there are no conclusions at this time.
Major Impact(s) of Research
1) This research will provide some of the first data to date on the contact structure of wild pig social groups.
2) Data collected during this study will provide information on how wild pig movements are impacted by the removal of adjacent social groups, data essential to the development of robust management plans for this species.
3) Data derived from this study will be integrated into national-level research by the USDA to implement management of wild pigs.

Other Project Personnel
Sarah Chinn, Ph.D. Student - SREL
Peter Schlichting, Postdoctoral Research Associate – SREL
External Collaborators
Dr. Toni Piaggio (USDA)
Dr. Kim Pepin (USDA)
Dr. Amy Davis (USDA)
Dr. Samantha Wisely (University of Florida)
Dr. Raoul Boughton (University of Florida)
Dr. Kurt VerCauteren (USDA)
Products
Eckert, K.D., D.A. Keiter, and J.C. Beasley. *In Press*. Animal visitation to wallows and implications for disease transmission. Journal of Wildlife Diseases
Beasley, JC. Wild Pig Research on the Savannah River Site. 2018. South Carolina Wild Pig Task Force Meeting, Columbia, SC (oral presentation)

Capture-Mark-Recapture Studies of Large Mouth Bass on Par Pond Reservoir

Funding Entity
DOE-EM Support to SREL
Start Date and Funding Amount
October 2017; $30,000
SREL Collaborators
Dr. Olin E. Rhodes, Jr. and Matt Hamilton
Objective(s)
To estimate the population size and characterize movement patterns of largemouth bass, Micropterus salmoides, in relation to the distribution of contaminants on Par Pond reservoir.
Summary of Research Activities
We have individually marked >1400 largemouth bass from Par Pond with a RFID (Radio-frequency identification) PIT (Passive Integrated Transponder) tag. With each capture, morphometric data (e.g., length, weight, sex), GPS coordinates, and physical condition (i.e., health status) are recorded before each individual is released at the point of capture. This initial capture effort is ongoing and will provide baseline data for characterizing movement patterns and estimating largemouth bass abundance on Par Pond.
Conclusions
1) This research is in the initial stages of data collection.
Major Impact(s) of Research
1) This research will provide insight into the seasonal distribution and the potential for contaminant exposure and transport of largemouth bass on a man-made reservoir.
Other Project Personnel
Chris McBride, Assistant Director – SREL
Dr. Peter Schlichting, Post Doc – SREL
Dr. Fanny Coutelot, Post Doc – SREL
Megan Winzeler, Project Coordinator II – SREL
Brian Morton, Property Management Coordinator – SREL
Wes Flynn, Ph.D. Student – UGA
Sarah Webster, Ph.D. Student – UGA
Austin Coleman, MS Student – UGA
External Collaborators
NA
Products
No publications, presentations, or reports have yet been prepared.

Ecological factors affecting the success of rabies elimination in the Southeastern US

Funding Entity
USDA-APHIS-WS
Start Date and Funding Amount
October 2017; $76,902
SREL Collaborators
Dr. Olin E. Rhodes, Jr., Dr. Guha Dharmarajan and Dr. James Beasley
Objective(s)
1) Quantify variance in raccoon densities among three major habitat types found commonly in the Southeastern US and evaluate the latitudinal change in raccoon density from riparian to primarily upland pine habitats.
2) Evaluate the role of isolated wetlands surrounded by presumably inhospitable upland pine habitats in supporting raccoon populations in the Southeastern US.
3) Quantify realized levels of rabies vaccine bait uptake by raccoons occurring at varying densities and in various habitats in the presence of bait competition from opossums and other mesopredators and mammals in the Southeastern US

Summary of Research Activities
We have completed two seasons of field research, trapping raccoons and opossums across 24 field sites on the Savannah River Site, including collection of whiskers for dye marker analyses, tissues for genetic and disease analyses, and capture-mark-recapture data for abundance estimation. We also have deployed 24 downloadable GPS collars to assess movement behavior of opossums in various habitats on the SRS.
Conclusions
1) This research is still in the initial stages of data collection.

Major Impact(s) of Research
1) This research will provide insight into the densities of raccoons and opossums across four different habitats that are common in the Southeastern US and will quantify levels of bait completion between raccoons and other mesopredators to inform the application of rabies vaccination baits for the Oral Rabies Vaccination program conducted by the USDA.

Other Project Personnel
Kelsey Turner, Ph.D. Student – UGA
Matt Hamilton, Research Technician – SREL
David Bernasconi, MS Student – UGA
External Collaborators
Dr. Amy Gilbert – USDA
Rich Chipman – USDA
Products
Rhodes, O.E., Jr., G. Dharmarajan, J.C. Beasley, and D. Bernasconi. 2018. Year 2 Annual Report for Ecological Factors Affecting the Success of Rabies Elimination in the Southeastern US. Submitted September 10, 2018.

Low dose radiation effects on Medaka

Funding Entity
DOE
Start Date and Funding Amount
October 2016; NFP
SREL Collaborators
Dr. Olin E. Rhodes, Jr. and Dr. Ben Parrott
Objective(s)
1) Evaluate the proteomic, glycomic, histopathological and epigenetic effects of 6 months of low dose radiation on Medaka.
2) Evaluate the proteomic, glycomic, histopathological and epigenetic effects of 6 months of low dose radiation on Medaka that have been pre-exposed to environmentally relevant levels of mercury

Summary of Research Activities
We have completed a six month exposure of Medaka to three levels of low dose radiation in combination with set of fish pretreated with aqueous mercury exposure to a constant level of tissue concentrations. The tissues from these fish are currently being evaluated in various laboratories at the SREL and UGA.
Conclusions
1) This research is in the initial stages of data collection subsequent to the field exposures.

Major Impact(s) of Research
3) This research will provide insight into the physiological response of Medaka to varying low doses of radiation which are similar to those that are chronically present in contaminated environments around the world.

Other Project Personnel
Marilyn Mason, Research Technician – SREL
External Collaborators
Dr. Carl Bergman – UGA
Dr. Al Calmus – UGA
Dr. Michael Tiemyer – UGA
Dr. Lance Wells – UGA
Dr. Gerardo Gutierrez-Sanchez – UGA
Yeni Natalia Carolina Perez-Gelvez - UGA
Products
No Products have yet been produced from this research

Assessing Radiocesium in Various Biota in unstudied reaches of the R-Canal System

Funding Entity
NFP
Start Date and Funding Amount
April 2018; NFP
SREL Collaborators
Larry Bryan
Objectives
The overall goal of the project was to examine Radiocesium accumulation and potential biomagnification in biota within largely unstudied portions of the R-Reactor cooling canal/pond system. Previous studies have focused on aquatic fauna. We focused this year on aquatic plants, specifically comparing Radiocesium concentrations in a floating-leaved plant (Watersheild, *Brasenia schreberi*) with an emergent plant (Common Rush, *Juncus effusus*) among sites with varying contamination levels, including a control. Finally, we compared current *Brasenia* Radiocesium concentrations to historical counts (~1984).
Summary of Research Activities
1) We compared Radiocesium concentrations from samples of both plant species from each of the following sites: Pond B (three locations), Pond A, Pond C, and Pond 2. We also collected samples from an uncontaminated site, Fire Pond.
2) We examined current concentrations of *Brasenia* in Pond B to historical data collected in 1984 (Whicker *et al*. 1998).
Conclusions
1) *Brasenia* Radiocesium concentrations were significantly higher than *Juncus* Radiocesium concentrations in all sites except Fire Pond.
2) *Brasenia* Radiocesium concentrations in the current study had decreased by a factor of 6 in the ~34 years since the Whicker *et al*. study.

Major Impact(s) of Research
1) Legacy Radiocesium contamination within this SRS aquatic system continues to be accumulated by these plants and thus remains bioavailable to fauna that consumes them.
2) Greater uptake by *Brasenia* is likely due to its ability to acquire Radiocesium directly from the water column.
3) *Brasenia* in Pond B demonstrated an expected downward trend in accumulation when compared to historical data based on the physical and biological half-lives of this element.

Other Project Personnel
Trevarus Brown, REU Student - SREL
Michaela Day, Research Assistant - SREL
External Collaborators
NA
Products
Brown, TJ, and AL Bryan. Comparison of ^{137}Cs uptake by *Juncus effuses* and *Brasenia schreberi* in aquatic habitats on the SRS. Oral presentation at the SREL Undergraduate Research Symposium, July 2018.

Brown, TJ, and AL Bryan. Comparison of ^{137}Cs uptake by *Juncus effuses* and *Brasenia schreberi* in aquatic habitats on the SRS. Poster presentation at the International Conference on Heavy Metals in the Environment, Athens, GA, July 2018.

Collaborations and Externally Funded Research Non - SRS
Evolutionary moving envelopes to predict range expansion (EMERGE)

Funding Entity
SREL, Department of Environmental Health Sciences UGA
Start Date and Funding Amount
August 2017; NFP
SREL Collaborators
G. Dharmarajan
Objectives
Emerging infectious diseases impact the lives of millions of people globally. Close to a third of emerging infectious diseases are those caused by pathogens transmitted by vectors, such as mosquitoes and ticks, and this number is only expected to rise due to the rapidly expanding ranges of many vectors. The aim of this study is to develop a new approach – Evolutionary Moving Envelopes to predict Range Expansion (EMERGE) to better predict range expansion of disease vectors.
Summary of Research Activities
We have carried out a thorough analysis of the patterns of range expansion in three tick species : the lone star tick (*Amblyomma americanum*), black-legged tick (*Ixodes scapularis*) and the cattle fever tick (*Rhipicephalus microplus*) . Our analyses revealed that climate change alone is not sufficient to explain the observed patterns of range expansion in these species over the past several decades. We have also completed the development of the preliminary EMERGE model. The model uses an explicit, and novel, evolutionary genetic framework to integrate two powerful established methods: environmental niche modeling and landscape resistance. We have also used the 3RAD workflow to obtain RADseq data from seven *A. americanum* individuals from two populations. We obtained data from 128,899 loci in total, with 19,843 polymorphic loci genotyped in ≥75% of individuals. The polymorphic loci contained a total of 69,815 SNPs.
Conclusions
1) Climate change alone is insufficient to explain observed range expansion in ticks, and that dispersal and adaptation play important roles
2) Patterns of range expansion are not gradual but take the form of discrete jumps, an indication of gene swamping (i.e., the negative effects of migrant load on local adaptation)
3) Large allele frequency differences between source and edge populations at selectively neutral loci, an indication of allele surfing (i.e., the combined effects of low density and strong founder effects)

Major Impact(s) of Research
1) Initial tests with EMERGE reveal that range expansion of ticks is likely driven by intricate interactions between climactic factors, dispersal and local adaptation.
2) EMERGE's novel framework in conjunction with its ability to explicitly integrate genomic information, provides us with a unique opportunity of obtaining a more mechanistic understanding of the factors driving range expansion in vectors.
3) By integrating niche modelling and genomic approaches our study will culminate in a robust new approach to modeling range expansion that can readily be applied to other species of epidemiological (e.g., other vector species) and ecological (e.g., invasive species) importance.

Other Project Personnel
NA
External Collaborators
T. Glenn (UGA)
M. Yabsley (UGA)
J. Busch (Northern Arizona University)
P. Olafson (USDA)
D. Thomas (USDA)
L. Eisen (CDC)

R. Eisen (CDC)

Products

Three proposals are currently have been submitted based on the EMERGE model to USDA-AFRI and NIH.

Interspecific competition in ticks: implications for tick-borne disease dynamics

Funding Entity
SREL
Start Date and Funding Amount
October 2016; NFP
SREL Collaborators
Dr. G. Dharmarajan and Dr. James C. Beasley
Objectives
Ticks are obligatory parasites whose development and reproduction depends upon obtaining a blood meal from a vertebrate host. In the US, ticks transmit a greater diversity of pathogens and are responsible for more cases of human disease than any other arthropod vector, including mosquitoes. Research on tick-borne diseases (TBD), and hence public health policy, has focused on tick species that are competent at transmitting a pathogen to humans. This study questions this prevailing paradigm which ignores effects of non-competent vectors on TBD dynamics. Indeed hosts are a heterogeneous landscape for ticks, wherein only a few specific sites are suitable for a tick to attach and feed (e.g., areas protected from host grooming). Consequently, whenever two species of ticks infest a common host, interspecific competition for these feeding sites is expected. The objective of this study is to test how competitive interactions amongst ticks are affected by: (a) Direct competition for optimal feeding sites on a host; (b) Immune-mediated competition; (c) Pathogen-mediated competition
Summary of Research Activities
We have carried out preliminary mathematical modeling and spatial epidemiological analyses at local and regional scales to test how interspecific competition amongst ticks can impact tick-borne disease dynamics in human populations. Our analyses currently focus on Lyme disease (a TBD caused by *Borrelia burgdorferi*), the most important vector-borne disease in the US responsible for over 300,000 cases annually
Conclusions
1) Our mathematical model reveals that competition between non-competent and competent vectors for limited feeding sites on a host can lead to reduced prevalence, or even elimination, of a TBD in a host community, irrespective of whether hosts are themselves limiting.
2) Our analyses reveal that this reduction in TBD is because from a tick-borne pathogen's perspective, feeding sites occupied by non-competent ticks are "wasted". Thus, as the proportion of non-competent vectors increases the risk of pathogen transmission from infected to uninfected hosts, and hence disease prevalence, decreases.
3) Our analyses also reveal that some paradoxical spatio-temporal patterns associated with Lyme disease (e.g., the Lyme disease gradient) can be effectively explained by competitive interactions between competent (*Ixodes scapularis*) and non-competent (*Amblyomma americanum*) vectors of this disease.

Major Impact(s) of Research
1) Our models reveal that non-competent vectors for disease can critically impact the persistence of a vector-borne disease in natural populations
2) Our analyses reveal how interspecific competition between vectors at the individual host level scales up to alter pathogen dynamics at the level of population and communities
3) Our analyses has critical implications for US *public health policy* because it is expected to provide an ultimate explanation for some enigmatic spatial patterns associated Lyme disease,

Other Project Personnel
NA
External Collaborators
R. Ostfeld (Cary Institute of Ecosystem Studies)
M. Lynn (University of Southern Florida)

Products

The preliminary data was used to submit a grant to the National Science Foundation, a resubmission is planned in 2019 based on Reviewer comments

Pathogen-mediated behavioral modification in ticks: implications for tick-borne disease dynamics

Funding Entity

SREL, Department of Environmental Health Sciences UGA, University of Southern Mississippi

Start Date and Funding Amount

March 2017; NFP

SREL Collaborators

Dr. G. Dharmarajan

Objectives

Lyme disease is a bacterial infection transmitted by ticks to more than 300,000 Americans annually. In the eastern US, the pathogen causing Lyme disease (*Borrelia burgdorferi*) is transmitted by the black-legged tick (*Ixodes scapularis*). This study proposes that behavioral manipulation of ticks will impact the spread and persistence of Lyme disease. Thus, the main aims of this study are to test if *I. scapularis* ticks colonized from natural populations in the North vs. the South: (1) differ in pathogen load when infected, and fitness (i.e., ability to survive desiccation and freezing) when infected or uninfected by *B. burgdorferi,* and how these factors are likely to impact vector competence; and (2) differ in tissue-specific gene expression profiles when infected or uninfected by *B. burgdorferi*, and if there is evidence of positive or negative selection at differentially expressed genes using genomic approaches

Summary of Research Activities

Initial mathematical modeling of the system has been completed, and these results have been analyzed within a spatial epidemiological framework. We have also collected preliminary data of tissue-specific transcriptomics from the lone star tick (*Amblyomma americanum*), which reveals that environmental stress and infection with pathogens **interact strongly to affect tick gene expression profiles.** We assembled 344 million Illumina reads, totaling over 34 billion nucleotides derived from 4 cDNA libraries constructed from adult female *A. americanum* that were unfed, or blood-fed for 12-48 hrs, 72-144 hrs, and 6-11 days. The libraries were assembled, and 5,792 coding sequences (CDS) that mapped 143 million reads were extracted. Digital expression of GRPs in four libraries revealed 9 differentially regulated *grp* genes, these differentially regulated *grp* genes were validated using qRT-PCR. We have also used the 3RAD workflow to obtain RADseq data from 16 Ixodidae individuals from four species (*I. scapularis, Amblyomma americanum, A. maculatum,* and *Dermacentor variabilis*). We obtained data from 332,057 loci in total, with 4,484 polymorphic loci genotyped in ≥75% of individuals (i.e., polymorphic loci shared among three genera of ticks). These loci contained a total of 13,136 SNPs.

Conclusions

1) The project is at a very preliminary stage, and no conclusions can be drawn at this time

Major Impact(s) of Research

1) This project will help improve our understanding of Lyme disease mechanisms and dynamics, and is especially timely given rapid northward range expansion by *I. scapularis*

Other Project Personnel

T. Kiernan, PhD Student – UGA

N. Vasquez, Postdoc – UGA

External Collaborators

T. Glenn (UGA)

S. Karim (University of Southern Mississippi)

Products

No publications, presentations, or reports have yet been prepared. The preliminary data was used to submit a grant to National Institutes of Health (October 2017), and a resubmission is planned based on reviewer comments.

Ecological and evolutionary dynamics of Avian malaria, an emerging infectious disease in wild bird populations

Funding Entity

SREL, Department of Science and Technology and Department of Biotechnology, Govt. of India

Start Date and Funding Amount

October 2015; $150,000

SREL Collaborators

Dr. G. Dharmarajan

Objectives

Emerging infectious diseases are considered to be one of the greatest challenges of our times, and their recent proliferation has been associated with anthropogenic factors such as global climate change. Avian malaria (AM) – a vector-borne disease caused by protozoan parasites *Plasmodium* spp. (Plasmodiidae) and *Haemoproteus* spp. (Haemoproteidae) is an important emerging disease in bird populations where the pathogen has been recently introduced (e.g., Hawaii). However, avian malaria is relatively benign in its native range, and previous research has shown that introduced *Plasmodium* parasites associated with large-scale mortalities originated from India, This study will characterize patterns of avian malaria in a natural bird community in India to improve our understanding of the disease. Birds were sampled using mist netting in the sky islands located in the southern 600 km mountain range of Western Ghats. The objective of this study is to elucidate the ecological and evolutionary dynamics of avian malaria in bird communities in the tropical sky-islands of the Western Ghats, India

Summary of Research Activities

Blood, sampled (50-100 µl) from the ulnar vein of birds was used to genomic DNA using Qiagen Blood and tissue extraction kit (Qiagen, Hilden, Germany) following manufacturer's protocol and screened for avian malaria infection. A nested Polymerase chain reaction (PCR) approach was employed to amplify the partial mitochondrial cytochrome b gene (478bp) of avian haemosporidian parasitesPositive samples were sequenced in both forward and reverse direction using BigDye v. 3.1 on an ABI 3130 automated DNA sequencer. Paired DNA sequences were aligned, trimmed and assembled in Geneious 9.1.5 for analyses.

Conclusions

1) A total of 1177 birds from 28 bird species were sampled, and our data revealed that 24 out of 28 species were infected with avian malaria parasites (*Plasmodium* spp. and *Haemoproteus* spp.) with an overall prevalence of 41.6% (490 individuals).
2) We identified a total of 47 different mitochondrial cytb lineages, with 18 *Plasmodium* and 29 *Haemoproteus* parasites, but only six *Plasmodium* and four *Haemoproteus* lineages showed identity with sequences available in the Genbank/Malavi database
3) *Haemoproteus* lineages showed greater levels of species specificity as compared to *Plasmodium*

Major Impact(s) of Research

1) Our data reveal that relatively few lineages of avian malaria are shared between India and areas where the parasite has been newly introduced, thus indicating that disease emergence is associates with rare *Plasmodium* lineages
2) Our data also reveal that *Plasmodium* is generally less species specific compared to *Haemoproteus,* which could explain why EIDs are generally associated with the former rather than the latter pathogen.

Other Project Personnel

P. Gupta, PhD Student - SREL

External Collaborators

R. V. Vijayan (Indian Institute of Science Education and Research Tirupati)

Products

Two publications are in preparation based on this data, and one grant has been submitted to Department of Biotechnology, Govt. of India

The global phylogeography of Plasmodium relictum and related Plasmodium species

Funding Entity

SREL and Department of Environmental Health Sciences UGA

Start Date and Funding Amount

May 2017; NFP

SREL Collaborators

Dr. G. Dharmarajan and Dr. S. Lance

Objectives

Haemosporidians (Phylum: Apicomplexa) are a diverse yet specialized group of vector borne protozoan parasites that infect numerous vertebrate hosts, including mammals, birds and reptiles via dipteran vectors (Perkins 2014). Most common haemosporidian genera include *Plasmodium* (mammal and bird hosts), *Haemoproteus* and *Leucocytozoon* (bird hosts), *Hepatocystis* (mammal and bat hosts), among others. About 300 species have been described across 20 haemosporidian genera, with over 200 species belonging to just one genus: *Plasmodium*. In addition to lack of well resolved phylogenies for haemosporidian parasites in general, the taxonomy and evolutionary origins of avian haemosporidians, in particular, remains unresolved. There is a huge gap in our understanding of avian malaria parasites and its relationship with other malaria parasites, due to the lack of good quality genomic data and limited number of informative molecular markers. The objective of this study is to optimize target enrichment approach and next generation sequencing for avian malaria parasites and examine its utility in field bird samples

Summary of Research Activities

Based on the evolutionary relationships, shared and conserved regions of four *Plasmodium* (*P. chaubadi*, *P. falciparum*, *P. vivax* and *P. gallinaceum*) and one *Haemoproteus* genome (*H. tartakovskyi*) were examined to design target capture probes. Baits (size ~160 bp) were designed to capture the shared conserved loci (as identified at the previous step) across malaria genomes by optimizing tiling density and gene overlap. Resulting baits were filtered to remove baits containing repetitive sequences (>25% repeat content) and having a high GC content ((30 % > GC > 70%) will be removed. Any duplicate baits generated at this stage were also removed from the bait set. The final bait set were used to perform an *in silico* analysis for testing the ability of these baits to capture the desired loci and infer phylogenetic relationship across the five malaria genomes (used for generating baitset) and other eight *Plasmodium* genomes of interest (*P. ashfordi*, *P. relictum*, *P. berghei, P. yoelii*, *P. knowlesi, P. ovale, P. malaria, P. reichenowi*. Baits have been synthesized as 'MYBaits' (MYcroarray, Inc.), and initial screening of the baits in several *Plasmodium* species (i.e., *P. falciparum, P. malaria, P. berghei, P. gallinaceum* and *P. relictum*) has been completed.

Conclusions

1) The project is still at a preliminary stage, and no conclusions can be drawn at this time

Major Impact(s) of Research

1) This project is expected to improve our understanding of the global phylogeography of *Plasmodium*
2) Specifically, the study will provide the tools to improve our understanding of the evolutionary dynamics of disease emergence in *P. relictum*

Other Project Personnel

P. Gupta, PhD Student –SREL

External Collaborators

T. Glenn (UGA)
M. Yabsley (UGA)
B. Faircloth (Louisiana State University)
R. Rickleffs (University of Missouri-St. Louis)
R. V. Vijayan (Indian Institute of Science Education and Research Tirupati)

Products

No publications, presentations, or reports have yet been prepared.

Using population genetics to explore the origins of macrocyclic lactone resistance in Dirofilaria immitis

Funding Entity

SREL, Filariasis Reagent and Resource Center UGA, Department of Infectious Diseases UGA

Start Date and Funding Amount

January 2017; NFP

SREL Collaborators

Dr. G. Dharmarajan

Objectives

Canine heartworm (*Dirofilaria immitis*) is the single most important parasite of dogs in the United States. Prevention of heartworm is based on compliant administration of macrocyclic lactone (ML) drugs, and all products are labeled as 100% effective. However, over the past 10-15 years we have seen a dramatic rise in numbers of 'lack of efficacy' cases, and resistance to ML drugs is now proven definitively. The large majority of ML-resistance cases have been diagnosed in dogs living in the Mississippi Delta region, however at present the distribution of resistant heartworms remains uncertain. The objective of this study is to test if drug resistance in the canine heartworm (*Dirofilaria immitis*) is associated with a single event with subsequent spread (hard selective sweep), or as several independent events (soft selective sweep).

Summary of Research Activities

We developed a panel of highly polymorphic microsatellite markers specific to *D. immitis* to examine the population genetics of canine heartworm. The top 24 sets of markers were initially confirmed using pools of 500 microfilariae from three susceptible and two resistant laboratory strains of *D. immitis*. Fragment analysis was conducted using the ABI 3730xl system, and a total of 15 novel highly polymorphic markers were identified. These markers were used in combination with two previously published microsatellite markers to screen microfilariae from 2 resistant and 3 susceptible laboratory isolates, and from 32 high-suspect resistant and 10 likely-susceptible field isolates, based on case history and/or results of microfilariae suppression tests.

Conclusions

1) Analyses of the microsatellite data reveal weak spatial structuring of *D. immitis* populations in the US.
2) Our analyses also reveal relatively weak signatures of genetic differentiation between drug resistant and susceptible strains of *D. immitis,* indicating that soft selective sweeps are the most likely cause of drug resistance in this parasite

Major Impact(s) of Research

1) This project improves our understanding of the epidemiology of drug resistance in *D. immitis*. Evidence of soft selective sweeps indicates that there are multiple origins of drug resistance in this parasite, and this finding has important implications for the control of this disease in the US.

Other Project Personnel

Julie Sanchez, MS Student – UGA

External Collaborators

R. Kaplan (UGA)

A. Wolstenholme (UGA)

Products

J. Sanchez, M.M. George, G. Dharmarajan, J.S. Gilleard, and R.M. Kaplan. Using population genetics to explore the origins of macrocyclic lactone resistance in Dirofilaria immitis. The American Association of Veterinary Parasitologists, Annual Meeting, July 22-25, 2017, Indianapolis, IN, USA.

Kin structure in wild turkey populations

Funding Entity
SREL, Warnell School of Forestry UGA
Start Date and Funding Amount
August 2017; NFP
SREL Collaborators
Dr. G. Dharmarajan
Objectives
Kin-selection is an evolutionary strategy of natural selection where an individual exhibits altruistic behavior towards close relatives, resulting in an increase in the individual's genetic contribution to sequential generations and fitness. Kin-selection was recently observed to occur within a wild turkey population in the United States. Specifically, previous research has identified several mating coalitions of 2 to 4 similar-aged males, where subordinate males supported a single dominant male in the mating process without direct reproductive benefit. The coalition groups were observed to court and defend females against other coalition groups or solitary males. Using genetic measures of relatedness and reproductive success from both subordinate and dominant males within a coalition and solitary males on the landscape, analyses have shown that the conditions of Hamiliton's rule re met, showing the net benefit of a subordinate male helping a dominant male was +1.7 offspring per male. Additionally, dominant males within coalitions mated with more females and produced more offspring than solitary males. However, if the dominant male within a coalition group disappears or is harvested, the remaining subordinate(s) transition into solitary males which could ultimately change mating dynamics. The objective of this study is to evaluate the role of kin selection in the behavior and ecology of wild turkeys in the US, with a specific focus on the implications for managing wild turkey populations.
Summary of Research Activities
In 2016, we collected blood from 23 males (14 toms, 9 jakes) translocated to Angelina National Forest (ANF) in east Texas. Of the 23 males released into ANF, 16 individuals (13 toms, 3 jakes) were affixed with µGPS-telemetry transmitters. Additionally, we collected blood from 60 translocated females (34 adults, 26 subadults) affixed with µGPS-telemetry transmitters into ANF. During the nesting season, we collected egg shells from every nest initiated by females for genotyping. Using telemetry data collected from the males and genetic data collected from eggshells, we would like to determine the extent of which kin-selection or reproductive cooperation occurs within a translocated population. Extraction of DNA from these samples has been started, and we hope to complete genotyping all individuals by mid-2018.
Conclusions
1) The project is at a very preliminary stage, and no conclusions can be drawn at this time
Major Impact(s) of Research
1) This study has important implications for the management of wild turkeys in the US. For example, does the success of translocation depend upon the maintenance of kin-structured populations (e.g., factors affecting the breeding and reproductive success of wild turkey populations and factors impacting success of translocation efforts).
2) This study will also shed important insights into the basic ecology of wild turkeys including occurrence or rate of multi-paternal vs. single paternal clutches, and the occurrence of nest/brood parasitism as survival strategy and its effect on genetic diversity.

Other Project Personnel
Daniel Sullivan, PhD student - UGA
Pooja Gupta, PhD Student - SREL
Austin Coleman, Research Technician - SREL
External Collaborators
M. Chamberlain (UGA)
Products
No publications, presentations, or reports have yet been prepared.

Mosquito Biological Investigations using Technology and Engineering (Mosquito-BITE)

Funding Entity
SREL and Tucker Middle School, Atlanta
Start Date and Funding Amount
July 2017; NFP
SREL Collaborators
Dr. G. Dharmarajan and P. J. Perea
Objectives
Mosquitoes transmit some of the most deadly diseases globally (e.g., malaria) and are responsible for the spread of many new and emerging infectious pathogens in human populations worldwide and in the US (e.g., Zika, Dengue and Chikungunya viruses). Thus, mosquito control remains one of the most important public health challenges especially in urban areas. The control of mosquito populations is particularly critical for Atlanta, a city that has the dubious distinction of topping Orkin's list of Top 50 Mosquito Cities for past four years. It has long been recognized that environmental hygiene and sanitation are the foundation for successful and sustainable mosquito control in urban environments. It has also been recognized that the broad adoption of good practices related to hygiene and sanitation require the active participation of local communities. We propose that empowered children can be the most effective catalysts of change in their own communities. Thus, educating students in the broader public health issues related to mosquito control and actively engaging them in mosquito monitoring and control programs can bring about rapid and lasting social change to support ongoing mosquito control efforts by local communities, as well as Federal, State and Local government agencies.
Summary of Research Activities
We have initiated a pilot project at the Tucker Middle School in Atlanta, to obtaining data on mosquito abundance at fine spatial (e.g., neighborhood) scales. is a critical need for local communities and mosquito control authorities. The project engages high school students in the school to monitor mosquitoes in their own backyards and neighborhoods using established methods (e.g., mosquito oviposition traps) and/or novel techniques developed by the students themselves.
Conclusions
1) The project is at a very preliminary stage, and no conclusions can be drawn at this time
Major Impact(s) of Research
1) The long-term goal is to expand the network of schools so as to create a city-wide mosquito index for the media similar to a pollen index and UV index to keep the public better informed about public health risks in their locality.
Other Project Personnel
NA
External Collaborators
E. Knapp, Teacher – Tucker Middle School Atlanta
Products
G. Dharmarajan, The most deadly animal. August 29, 2017. Tucker Middle School, Atlanta, GA (Invited talk)
G. Dharmarajan, Harnessing citizen science to monitor and control urban mosquitoes. August 30, 2017. EPA Regional Office, Atlanta, GA (Invited talk)
E. Knapp (Tucker Middle School), G. Dharmarajan (SREL) and P.J. Perea (SREL). Mosquito Monitoring- Biology Investigations using Technology and Engineering (BITE). Integrated STEM Instruction Workshop. 2017 Georgia STEM/STEAM Forum. Athens, GA. October 23, 2017
Mosquito-Bite, Atlanta Science Festival, Atlanta GA, March 9-24, 2018
G. Dharmarajan, The most deadly animal. May 8, 2018. Tucker Middle School, Atlanta, GA.

Factors affecting parasite resistance and tolerance in mosquitoes: implications for vector competence

Funding Entity

SREL, Filariasis Reagent and Resource Center UGA, Department of Infectious Diseases UGA

Start Date and Funding Amount

August 2017; NFP

SREL Collaborators

Dr. G. Dharmarajan

Objectives

Recent decades has seen the reemergence of many mosquito-borne diseases in human and animal populations (e.g., filariasis and malaria) The evolution of resistance against anti-parasitic drugs is one of the most important drivers of reemergence In the US the dog heartworm (*Dirofilaria immitis*; DI) is an important filarial parasite transmitted by mosquitoes which impacts the health of over 100,000 dogs in the US alone. The rising incidence of DI strains that are resistant to commonly used chemoprophylatic drugs (e.g., macrocyclic lactones and ivermectin) is a major concern in the US An improved understanding of the factors contributing to the evolution of drug resistance in this filarial parasite is critical from the perspective of veterinary epidemiology. The epidemiological dynamics of vector-borne diseases is affected by three biological entities: the vertebrate host, the parasite and the mosquito. Research on the evolution of drug resistance has primarily focused on the host (e.g., drug exposure and/or compliance) and the parasite (e.g., the rise of resistance genes). However, our understanding of the role of mosquitoes on the evolution of drug resistance remains limited. The focus of this study is to test if mosquitoes act to enhance or reduce the risk of a drug resistant parasite genotype spreading in the vertebrate host population. The objectives of this study are to: (1) Test if resistant and susceptible strains of DI differ in terms of their pathogenicity and virulence in mosquitoes, and test how these differences impact mosquito vector competence; (2) Test if there are competitive interactions between the strains within an individual mosquito, and determine if these competitive interactions impact vector competence; (3) Test if natural mosquito populations reveal signatures of local adaptation to sympatric vs. allopatric parasite populations, and test if local adaptation tends to increase or decrease vector competence

Summary of Research Activities

The experimental study design has been finalized, and the drug resistant and susceptible strains of DI have been identified. These strains are currently being maintained in infected dogs at the Filariasis Reagent and Resource Center, UGA. The student in the project is currently being trained in mosquito infection and dissection procedures. Initial experiments will commence in January 2018.

Conclusions

1) The project is at a very preliminary stage, and no conclusions can be drawn at this time

Major Impact(s) of Research

1) This study will elucidate the role of the mosquito vector in the rise and spread of drug resistant genotypes of mosquito-borne parasites in natural populations, and will thus improve the control of these diseases.
2) The study has important implications for our understanding of the factors affecting the evolution of parasite resistance and tolerance in mosquitoes, and hence has implications for our understanding of the evolution of vector competence.

Other Project Personnel

Erik Neff, MS Student – SREL

External Collaborators

A. Moorehead (UGA)
R. Kaplan (UGA)

Products

G. Dharmarajan, Do disease hotspots breed more deadly mosquitoes? July 27, 2017. SCDHEC, Columbia, SC (Invited talk)

Effects of methylmercury on development and oviposition behavior of yellow fever mosquitoes (Aedes aegypti)

Funding Entity
SREL and NSF-REU
Start Date and Funding Amount
June 2017; NFP
SREL Collaborators
Dr. G. Dharmarajan and Dr. X. Xu
Objectives
To quantify the effects of methylmercury on early-life mortality and oviposition behavior of yellow fever mosquitoes (*Aedes aegypti*)
Summary of Research Activities
In this study we use the yellow fever mosquito, *Aedes aegypti*, to test how methylmercury (MeHg) affects oviposition site selection. We found that mosquito larval development rate and survival were negatively affected at MeHg concentrations $\geq$ 100 ppb. Adult females not exposed to MeHg as larvae avoided oviposition sites with high MeHg concentrations (> 50 ppb), but MeHg exposure at the larval stage significantly affected this oviposition site selection. Specifically, females raised from larvae exposed to non-toxic MeHg levels (i.e., 5-50 ppb) showed a significant increase in preference for oviposition sites contaminated with toxic MeHg concentrations ($\geq$ 500 ppb), compared to unexposed controls. Importantly, however, this maladaptive behavioral response is abolished in female mosquitoes raised from larvae exposed to toxic MeHg concentrations (i.e. 100 ppb), and these mosquitoes showed a significant increase in preference for MeHg uncontaminated oviposition sites, compared to unexposed controls. Thus, in mosquitoes,
Conclusions
1) Methylmercury (MeHg) negatively impacts development and survival of mosquitoes
2) Adult female mosquitoes unexposed to MeHg avoid oviposition sites with high MeHg
3) Females exposed to non-toxic MeHg levels prefer oviposition sites with high MeHg, but females exposed to toxic MeHg levels prefer MeHg uncontaminated oviposition sites

Major Impact(s) of Research
1) The magnitude of MeHg exposure in one generation can impact MeHg exposure in subsequent generations by altering oviposition site selection behavior.
2) To our knowledge, this is the first study to demonstrate transgenerational effects of behavior on contaminant exposure
3) Our results have broad implications for our understanding of how contaminant-mediated behavioral modifications can feedback on contaminant exposure risk across multiple generations, and how behavior can affect the evolution of organisms inhabiting a heterogeneous environments.

Other Project Personnel
E. Neff, MS Student – SREL
R. Maness, REU Student - Presbyterian College
External Collaborators
M. Tanelus (University of South Carolina Upstate, SC)
Products
M. Tanelus and G. Dharmarajan. Effects of Methylmercury on early life mortality of yellow fever mosquitoes (*Aedes aegypti*). 2017 Summer Research Symposium. July 27, 2017. University of South Carolina, Columbia, SC.

Tanelus, M., Dharmarajan G. and Pilgrim, M (submitted) Effects of Methylmercury on early life mortality of yellow fever mosquitoes (Aedes aegypti). University of South Carolina Upstate Student Research Journal

Maness, R., X. Xu and G. Dharmarajan (2018) The Effect of Methylmercury on Mosquito Oviposition Behavior. Intern. Conference on Heavy Metals in the Environment. July 21-25, 2018. Athens, GA

Addressing Modern Day Health Risks Stemming from Historical Dioxin Contamination

Funding Entity
South Carolina Department of Health and Environmental Control
Start Date and Funding Amount
February 2017; $12,194
SREL Collaborators
Dr. Benjamin B. Parrott
Objectives
The overall goal of this research is to determine if dioxin levels are correlated to biomarkers of exposure in developing alligator embryos.
Summary of Research Activities
2,3,7,8-tetrachlorodibenzo-*para*-dioxin (TCDD, or "dioxin") is the most toxic congener of the class of chemical chemicals known as dioxins, and is one of the most toxic anthropogenic contaminants known. With an array of deleterious effects associated with exposure, including mortality, multi-organ toxicity, carcinogenicity, teratogenicity, and tumor-promotion, US Federal and state regulatory agencies initiated a series of surveys in the late 20th century to characterize the scope of dioxin contamination in the environment and its sources. This investigation uncovered the role of Kraft pulp mills as sources of high levels of dioxin contamination in receiving waters and downstream aquatic systems (US EPA 1989). Of the 104 total surveyed, the International Paper Company's Georgetown facility (Georgetown County, SC) had the highest levels of dioxin (TCDD) in its effluent (US EPA 1989, 1990a, 1990b) at 0.640ppt.

We have recently detected significantly elevated gene expression of an established biomarker of dioxin exposure, *CYP1A2*, in liver tissue from embryonic American alligators at a site directly adjacent to this historically-dioxin contaminated system. This project directly measures TCDD and dioxin-like congeners and seeks to connect them to previously established biomarkers of exposure and developmental processes.

Questions: (1) At what levels are 2,3,7,8-TCDD and other dioxin-like congeners associated with a historical point source detectable as maternally-deposited contaminants in alligator egg yolk from the Tom Yawkey Wildlife Center and Heritage Preserve (TYWCHP)? (2) Do these levels in yolk correlate to hepatic expression of *CYP1A2* in the matching embryo?
Conclusions
We have found significantly elevated levels of dioxins at TYWCHP relative to a reference site. While yolk contaminant levels were not correlated to hepatic *AHR* or *CYP1A* expression, we found an unexpected association between the relative amount of yolk utilized by an embryo and expression of both the *AH* receptor isoform *AHR1B* and *CYP1A2*. This latter point is suggestive of possible novel mechanisms modulating the effects of dioxin exposure in the alligator.
Major Impact(s) of Research
1) Connecting specific dioxin congener levels in alligator yolks to alterations in embryonic development
2) Estimate the presence of historical contaminants in biological systems
3) Provide data and rationale for studies assessing human exposure and potential health impacts.

Other Project Personnel
Matthew Hale, PhD Student - SREL
External Collaborators
Dr. Thomas Rainwater (Clemson University)
Products
Hale MD, Galligan TM, Rainwater TR, Moore BC, Wilkinson PM, Guillette LJ, Parrott BB. 2017. AHR and CYP1A expression link historical contamination events to modern day developmental effects in the American alligator. *Environmental Pollution* 230: 1050-1061

Hale MD, Bertucci EM, Rainwater TR, Wilkinson PM, Parrott BB. Relationship between maternally deposited dioxins and AhR signaling in alligator embryos from a historically contaminated landscape. *Manuscript in Prep.*

Hale MD, Galligan T, Guillette, Jr. LJ, Parrott BB. 2018. Linking historical exposures to modern day signaling: dioxin and the American alligator. 22nd Odum School of Ecology Graduate Student Symposium; Athens, GA. February 2-3, 2018 (oral presentation)

Impact of long-term chronic exposure to low dose ionizing radiation on organismal health

Funding Entity
DOE
Start Date and Funding Amount
October 2017; NFP
SREL Collaborators
Dr. Benjamin B. Parrott, Dr. Olin E. Rhodes and Marilyn Mason
Objectives
The overall goal of this research is to assess the effects of chronic low dose ionizing radiation over long periods of time on the epigenome.
Summary of Research Activities
Environmental stressors influence developmental and aging trajectories leading to either health or disease. Ionizing radiation (IR) represents perhaps the most universal ecological stressor. With background levels present since the dawn of evolution, highly conserved pathways act to repair DNA damage caused by UV and other sources of IR. This project aims to assess how long-term chronic exposures to low doses of IR impact organismal health through altering epigenetic and genomic processes in a model fish (*Oryzais latipes*).
Epigenetic mechanisms mediate genome-by-environment interactions, and due to recent advances in sequencing technologies, the molecular modifications underlying these interactions can be assessed at genomic scales. DNA methylation is the best characterized epigenetic modification with roles in regulating gene expression and promoting chromosomal stability, and alterations to DNA methylation patterning characterize specific malignancies and in some cases, predict cancer prognosis. We will resolve epigenetic responses and genome-wide changes to gene regulation across IR doses and across different dose lengths. In addition to identifying biomarkers of IR exposure, these findings are expected to provide fundamental insights into how IR affects genomic processes associated with disease in environmentally, occupationally, and ecologically relevant exposure contexts.
Conclusions
Fish exposed to IR in the LoDIF system (ranging from 3-6 months, and 3 months recovery) have been collected and necropsied. Effects of IR exposure are observed on reproductive function and overall body condition. Global shifts in DNA methylation in response to ionizing radiation are not observed. RNA-seq analysis on hepatic tissue reveals an influence of IR exposure on gene expression patterns. Ongoing analyses are focused on identifying molecular pathways and markers that underlie organismal responses to IR.
Major Impact(s) of Research
1) Establishing a IR model to assess impacts of chronic low-dose exposure. Once established, the model can be extended to examine impacts of combinatorial exposures.
2) The project will produce findings that are relevant to both wildlife as well as human health.
Other Project Personnel
Emily Bertucci, PhD Student - SREL
External Collaborators
NA
Products
Topolski, C.R., M.W. Mason, E.M. Bertucci, O.E. Rhodes, Jr., and B.B. Parrott. Impacts of chronic exposure to gamma radiation on the DNA methylome using the medaka fish model. July 25, 2017. Savannah River Ecology Laboratory NSF REU symposium. Savannah River Ecology Laboratory, Aiken, SC, USA

Topolski, C.R., M.W. Mason, E.M. Bertucci, O.E. Rhodes, Jr., and B.B. Parrott. Impacts of chronic exposure to gamma radiation on the DNA methylome using the medaka fish model. July 27, 2017. University of South Carolina Summer Research Symposium; University of South Carolina, Columbia, SC, USA

Bertucci, E.M. and B.B. Parrott. Using small fish to understand environmental impacts of ionizing radiation. Poster presented at SREL's Touch An Animal Day. 2017.

Effects of chronic low dose irradiation on the global DNA methylome in medaka (*Oryzias latipes*). *Manuscript in Prep*

Adaptive and disruptive epigenome-by-environment dynamics: molecular mechanisms to ecological impacts

Funding Entity
National Science Foundation
Start Date and Funding Amount
August 2018; $571,839
SREL Collaborators
Dr. Benjamin B. Parrott
Objectives
The overall goal of this research is to determine the origins of natural variation in the epigenome.
Summary of Research Activities
The developmental environment can have profound impacts on an individual. For example, in many non-mammalian vertebrates including some fish, most turtles, and all crocodilians, environmental temperatures occurring during a specific period of incubation will determine if individuals develop as either a male or female. Previous findings have revealed a critical role for the endocrine system and epigenetics, heritable changes in gene function without changes in DNA sequence, in determining how the environment impacts traits. This project will determine the mechanisms by which environments and hormone signaling act on epigenetic processes to shape developmental trajectories and produce phenotypic diversity. The project focuses on species displaying temperature-dependent sex determination, to address how temperature induces and coordinates radically different phenotypic trajectories. The study will support the training and mentoring of two graduate students and two undergraduate researchers, with recruiting efforts aimed at under-represented groups in the sciences. The project will develop a primer focused on communicating common misperceptions about epigenetics. The findings will be presented to students at area schools as part of an established outreach program. Together, this work will advance the understanding of the mechanisms that determine how organisms interact with the environments and will provide training opportunities for the next generation of scientists.

The work will employ state of the art sequencing approaches to advance a developmental- and endocrine-based understanding of how adaptive epigenetic responses occur in nature, and how epigenetic responses are disrupted by environmental stressors for which a shared evolutionary history is absent. The Parrott Lab has previously observed widespread sexually dimorphic DNA methylation patterning across the gonadal genome. However, the developmental and molecular processes by which a bipotential genome acquires a sexually dimorphic epigenome is unclear. Developmental windows of environmental sensitivity will first be identified by resolving the temporal dynamics of the DNA methylome during temperature-dependent sex determination and reproductive development. Combinatorial treatments of temperature and hormones will then reveal the degree to which temperature and endocrine signals act on overlapping or distinct regions of the epigenome. Finally, the project will investigate the influence of environmental quality on the sexually dimorphic methylome. Given the inherent environmental sensitivity of temperature-dependent sex determination, it is hypothesized that environmental variables (other than temperature) also influence this process to affect the development and subsequent function of the reproductive system. Together, experiments will reveal how environmental and biological signals are integrated into developmental processes that result in phenotypic diversity. Findings from this work will be disseminated in peer-reviewed publications, presentations at national and international scientific, and more broadly via outreach activities in partnership with area schools.
Conclusions
This research has just begun, thus there are no conclusions at this time.
Major Impact(s) of Research
1) Establish fundamental insights into how environmental cues are sensed and integrated into developmental trajectories
2) Provide a basic understanding of how natural environmental conditions interact with contaminant exposures in biological systems

Other Project Personnel

Samantha Bock, PhD Student - SREL

External Collaborators

NA

Products

Bock, S.L. *Characterizing variation in nesting thermal dynamics of the American alligator and consequences for reproductive development.* 2-3 February, 2018, Oral Presentation, Odum School of Ecology Graduate Student Symposium, Athens, GA.

Investigating the developmental mechanisms underlying reproductive dysfunction in an environmental model of endocrine disruption

Funding Entity
DOE
Start Date and Funding Amount
October 2017; NFP
SREL Collaborators
Dr. Benjamin B. Parrott
Objectives
The overall goal of this research is to determine how ecologically relevant thermal dynamics impact developmental responses to endocrine disrupting contaminant exposures.
Summary of Research Activities
The etiology of many reproductive disorders is complex and likely involves interactions between an individual's genetics and external environmental factors, including exposures to anthropogenic stressors. Environmental contaminants that interfere with the native functioning of the endocrine system have been linked to reproductive abnormalities and population declines in wildlife and humans globally. Alligators from environments contaminated by endocrine disrupting compounds (EDCs) display disorders of the reproductive system including alterations in circulating sex hormone levels, a decreased robustness of sexually dimorphic gene expression, and morphological abnormalities of ovarian follicles. Investigations into a population of alligators inhabiting a contaminated system in Florida, Lake Apopka, have uncovered the roots for a subset of these abnormalities in altered estrogen signaling during embryonic development, including shifts in ovarian function and transcription that persist into later life stages.

Using a model in which juvenile alligators, collected as eggs from Lake Apopka and a reference site, were raised under identical laboratory conditions and challenged with either a vehicle control or a gonadotropin hormone (FSH) that stimulates ovarian function, we employed targeted gene expression analyses and a non-biased RNAseq-based method to uncover the depth and possible etiology of population-level differences in ovarian function associated with contaminant exposure. After identifying core transcriptional networks shared between both populations, including FSH-responsive genes involved in steroid hormone production, cell proliferation, and oocyte development, we uncovered a cohort of responsive genes unique to each site that are putatively linked to developmental contaminant exposure. Furthermore, in the non-challenged ovary, we identified a large proportion (~40%) of transcripts that differ by population. Collectively, these findings indicate a substantial role for developmental contaminant exposure in shaping future ovarian function. Given prior evidence in the alligator linking similar functional shifts to precocious estrogen signaling, next steps entail identifying cohorts of dysregulated genes at Apopka that are recapitulated in estrogen-exposed reference animals and functional pathways enriched in population-specific responses.
Conclusions
To date, findings show widespread transcriptomic divergence between ovaries from a contaminated site and a nearby reference site. Further, we show that treating embryos from the reference site with estrogen recapitulates alterations observed in those animals from a contaminated site, suggesting that exposure to estrogenic contaminants during developmentally sensitive windows underlies reproductive abnormalities observed in alligators from Lake Apopka.
Major Impact(s) of Research
1. Establish fundamental insights into how EDC exposure during development affects reproductive development and reproductive health
2. Provides a basic understanding of how variable environmental conditions interact with contaminant exposures in biological systems

Other Project Personnel
Matthew Hale, PhD Student – SREL
Samantha Bock, PhD Student - SREL

External Collaborators

NA

Products

Hale MD, Cloy-McCoy JA, Doheny BM, Galligan TM, Guillette Jr., LJ, Parrott BB. 2018. Embryonic estrogen exposure recapitulates persistent ovarian transcriptional programs in a model of environmental endocrine disruption. *Biology of Reproduction*; https://doi.org/10.1093/biolre/ioy165

Hale MD, McCoy J, Galligan T, Bangma J, Nilsen F, Doheny B, Guillette Jr. LJ. Parrott B. 2018. Precocious estrogen signaling during sex determination leads to persistent alterations in ovarian function in an environmental model of endocrine disruption, the American Alligator. 8th International Symposium on Vertebrate Sex Determination (VSD); Kona, HI. April 16-20, 2018 (**poster**)

Hale MD, Galligan T, Guillette, Jr. LJ, Parrott BB. 2018. Linking historical exposures to modern-day signaling: dioxin and the American alligator. 22nd Odum School of Ecology Graduate Student Symposium; Athens, GA. February 2-3, 2018 (**oral presentation**)

Hale MD, Cloy-McCoy JA, Doheny BM, Parrott BB. 2018. Reproductive Biology of Crocodilians, published in *Encyclopedia of Reproduction* (2nd edition)

Multi-year mating dynamics and population structure in a coastal population of* Alligator mississippiensis *at the Tom Yawkey Wildlife Center

Funding Entity
MUSC, SC-DNR, The Yawkey Foundation
Start Date and Funding Amount
October 2017; $74,020
SREL Collaborators
Dr. Stacey L. Lance, Dr. Ben Parrott and Joshua Zajdel
Objectives
The overall objectives in this project are 1) identify parentage for clutches of alligators from the Yawkey Wildlife Center (YWC) collected from 2011-2015, 2) characterize the breeding population with respect to animal size, range, and multiple paternity and 3) quantify the genetic diversity of alligators at YWC and compare to populations from other parts of South Carolina and Florida.
Summary of Research Activities
We have completed the objectives of identifying parentage and characterizing the breeding population at YWC. In total we examined 151 nests and were able to assign a mother to 78 nests and at least one father to 38. The majority of maternity assignments matched the female that was caught at the nest (80%). HoweverTo develop a panel of markers for the population genetics analyses we have completed an initial analysis of single nucleotide polymorphisms in 24 alligators and designed ~2000 baits to use for screening animals from all localities sampled. We have ~200 DNA samples prepped and will develop libraries and do captures in December 2018. We expect to finalize
Conclusions
A few large males are achieving most of the male reproductive success. Females appear to pay a cost of mating multiply in that offspring from multiply sired nests are smaller and in lower body condition than those from singly sired nests. Data are still being collected for the population genetics objective.
Major Impact(s) of Research
Our findings will provide valuable information regarding the structures of coastal alligator populations in the northern range of this species. Effective management for the long-term preservation of a species attempts to conserve genetic diversity and adaptive potential our findings may have potentially large impacts on management practices moving forward as pressure increases to expand the hunting of alligators.
Other Project Personnel
NA
External Collaborators
Dr. Thomas Rainwater (Clemson University)
Phil Wilkinson (SC DNR)
Jamie Dozier (SC DNR)
Products
Zajdel, J., S.Lance, T.Rainwater, P.Wilkinson and B.Parrott. Multiple paternity within American alligator nests at the Tom Yawkey Wildlife Center. 2018 Annual meeting of the Southeastern Partners in Amphibian and Reptile Conservation in Helen, GA. (Platform presentation).

Lance, S.L., B. Parrott, J. O'Bryhim, T. Rainwater, P. Wilkinson, and L. Guillette. Parentage analyses in Yawkey gators: Take 3! 2016 Palmetto Alligator Research and Management Symposium. Georgetown, SC. (Platform presentation).

Lance, S.L., T.R. Rainwater, P.M. Wilkinson, and B.B. Parrott. Mating dynamics and population genetics in a coastal population of *Alligator mississippiensis* at the Tom Yawkey Wildlife Center. IUCN Crocodilian Specialist Group Meeting. Kruger, South Africa. (Platform Presentation).

Panmixia, promiscuity, and nest parasitism among Wood Storks (*Mycteria americana*)

Funding Entity
University of South Carolina
Start Date and Funding Amount
May 2016; $14,988
SREL Collaborators
A. Lawrence Bryan Jr. and Dr. Stacey Lance
Objectives
To sample US Wood Storks (nestlings) from selected colonies throughout their range and use a subset of storks to develop a panel of SNP (single nucleotide polymorphism) capture probes. These probes will then be used for capturing loci from additional stork DNA samples for genotyping via next generation sequencing to provide a robust examination of genetic structure and mating system in US WOST colonies as well as in other parts of their range.
Summary of Research Activities
Blood samples were obtained from > 130 total stork nestlings from 4 southeastern U.S. colonies in 2016 and will be compared to archived samples from 2 additional colonies. Additionally, samples from Brazil have been acquired. A subset of 24 stork samples were used to create genomic libraries for sequencing and identification of SNP loci. A total of 12,228 capture probes were designed to target 6114 loci. Currently, library preps are being prepared to use with the capture probes.
Conclusions
None at present, pending completion of genetic analyses.
Major Impact(s) of Research
When completed, will have a thorough analyses of the genetic structure of the US population of Wood Storks and should know the prevalence, if any, of non-standard mating strategies.
Other Project Personnel
NA
External Collaborators
Dr. Kristina Ramstad (USC-A)
Dr. Natalia Bayona (UGA)
Products
No publications, presentations, or reports have yet been prepared.

Conservation and management of gopher frogs in South Carolina

Funding Entity
Longleaf Alliance
Start Date and Funding Amount
August 2018; $20,500
SREL Collaborators
Dr. Stacey Lance
Objectives
Gopher frogs (*Lithobates capito*) are an uncommon species historically distributed throughout the southeastern coastal plain of the United States. Gopher frog populations have been declining due to loss of both their terrestrial uplands and their breeding sites. They are now listed as endangered at the state level and being considered for listing at the federal level. Within SC, gopher frog conservation is a high priority of the Department of Natural Resources and the population strongholds are the Savannah River Site and Francis Marion National Forest. It is unclear whether populations exist between these two widely separated areas. Our objectives are to 1) identify private lands with suitable gopher frog wetland and upland habitat, 2) survey for gopher frogs on these lands and 3) make management recommendations.
Summary of Research Activities
To date we have compiled a list of potential landowners to work with based on habitat suitability models for the gopher frogs. We have narrowed the list to five potential landowners for initial work and are in discussions with the land manager at Okeetee Club about working there. Money has not been transferred to UGA as of yet and the sampling will begin in the spring.
Conclusions
None at present.
Major Impact(s) of Research
None at present
Other Project Personnel
NA
External Collaborators
Lisa Lord (Longleaf Alliance)
Robert Abernethy (Longleaf Alliance)
Products
No publications, presentations, or reports have yet been prepared.

Evaluation of head-starting as a recovery tool for the Mojave desert tortoise

Funding Entity
National Park Service, California Energy Commission
Start Date and Funding Amount
October 2017; $493,089
SREL Collaborators
Dr. Tracey Tuberville and Dr. Kurt Buhlmann
Objectives
1) Determine behavior, survivorship, and habitat use of head-started juvenile desert tortoises compared to direct-release hatchings (i.e., juveniles released shortly after hatching).
2) Develop habitat suitability models for juvenile desert tortoises to identify optimal desert tortoise habitat.
3) Evaluate the efficacy of indoor rearing as a head-starting technique.

Summary of Research Activities
Our research activities included monitoring of hatchling and juvenile desert tortoises in outdoor rearing pens, indoor rearing facilities, and radio-tracking of juveniles released into the wild.
Conclusions
Based on preliminary data analysis, most movement occurred within 30 days of release, and those with the greatest movements during that time were less likely to survive through the winter dormancy period. Animals head-started for 1 year in outdoor pens exhibited greater post-release survivorship than animals released immediately after hatching, but rearing animals for longer than 1 year in the enclosures may significantly reduce native forage inside pens. Indoor head-starting was effective in increasing growth, but did not result in increased survival compared to smaller outdoor head-starts when released at 1 yr of age. Hybrid head-starting (involving 1 year of indoor head-starting to increase growth followed by 1 yr outdoor head-starting to harden shells and provide natural cues) may prove a more effective head-starting method.
Major Impact(s) of Research
1. Important life history data for a poorly understood life stage of a federally listed species
2. Improve management for species by factoring juvenile requirements into management and policy decisions, such as identifying habitats likely to serve as important areas of juvenile recruitment. These data will be helpful when selecting potential solar development sites by identifying areas to avoid.

Other Project Personnel
Pearson McGovern, M.S. Student - SREL
External Collaborators
Dr. Brian Todd (University of California, Davis)
Mark Peaden (University of California, Davis)
Products
Nafus, M.G., T.D. Tuberville, K.A. Buhlmann, and B.D. Todd. 2017. Precipitation quantity and timing affect native plant production and growth of a key herbivore, the desert tortoise, in the Mojave Desert. *Climate Change Responses* 4:4.

Tuberville, T.D., K.A. Buhlmann, R. Sollmann, M.G. Nafus, J.M. Peaden, J.A. Daly, and B.D. Todd. *In press*. Effects of short-term outdoor head-starting on growth and survival in the Mojave Desert Tortoise (*Gopherus agassizii*). *Herpetological Conservation and Biology*.

Daly, J.A., K.A. Buhlmann, B.D. Todd, C.T. Moore, J.M. Peaden, and T.D. Tuberville. *In press*. Comparing growth and body condition of indoor-reared, outdoor-reared, and free-ranging juvenile Mojave desert tortoises. *Herpetological Conservation and Biology*.

Tuberville, T.D. Keynote address: Conservation lessons from 20+ years with turtles. Southeastern Partners in Amphibian and Reptile Conservation annual meetings. Helen, GA. February 2018.

Tuberville, T.D. Population manipulations as recovery tools for reptiles. Invited seminar by Clemson University, Natural Resources Graduate Student Association. Clemson, SC. 1 February 2018.

Peaden, J.M., T.D. Tuberville, K.A. Buhlmann, and B.D. Todd. Update on desert tortoise head-starting studies at the Mojave National Preserve. Desert Tortoise Council Symposium, Las Vegas Nevada. 23-25 Feb 2018. Platform presentation.

McGovern, P., K. Buhlmann, B. Todd, C. Moore, J. Hepinstall-Cymerman, and T. Tuberville. Changing the survival formula of the Mojave desert tortoise (*Gopherus agassizii*) through head-starting. Southeastern Partners in Amphibian and Reptile Conservation, Helen, GA. 22-25 February 2018. Poster presentation.

McGovern, P., K. Buhlmann, B. Todd, C. Moore, J. Hepinstall-Cymerman, and T. Tuberville. Changing the survival formula of the Mojave desert tortoise (*Gopherus agassizii*) through head-starting. UGA's Warnell Graduate Student Association Symposium. Athens, GA. 31 Jan – 2 Feb 2018. Poster presentation.

Status of and threats to gopher tortoise populations on military installations in the southeastern U.S.

Funding Entity
US Department of Navy
Start Date and Funding Amount
August 2013; $162,00
SREL Collaborators
Dr. Tracey Tuberville
Objectives
1) Estimate population sizes of gopher tortoises on specific Department of Navy lands as part of their long-term monitoring efforts.
2) When available, compare historical data to contemporary date to document population trends.
3) When requested by Navy, provide in-depth evaluation of threats to existing populations on Navy lands and provide management recommendations based on those threats.

Summary of Research Activities
We submitted our report from a 12-month assessment of threats to gopher tortoise populations on Kings Bay Naval Submarine Base, FL using remote wildlife cameras at 20 gopher tortoise burrows. As part of the remote camera monitoring, we have also characterized the non-tortoise species that used tortoise burrows. We also completed surveys to map and estimate population size of gopher tortoises on Pensacola NAS. We also published a paper documenting bird use of gopher tortoise burrows based on previous surveys at Whiting NAS and Holley OLF in the Florida panhandle.

Conclusions
Populations on all surveyed properties are unlikely to be viable in long-term without significant intervention, including increase habitat management efforts and potentially even translocations or augmentations. Over 50 species of vertebrates were associated with gopher tortoise burrows, including several previously undocumented species.

Major Impact(s) of Research
This work will contribute to the commitment by the Department of Navy, who is a signatory on the gopher tortoise Memorandum of Understanding, to provide population assessment data for populations occurring on their lands.

Other Project Personnel
Kyle Brown, Temporary Research Technician – SREL
Nicole White, Graduate Student / Temporary Research Technician – SREL
Matt Hamilton, Temporary Research Technician - SREL

External Collaborators
NA

Products
White, K.N., and T.D. Tuberville. 2017. Birds and burrows: gopher tortoise burrow use and visitation by avifauna at two military sites in the Florida panhandle. *Wilson Journal of Ornithology* 129:792-803.
Brown, M.K., and T.D. Tuberville. *Apalone ferox* (Florida softshell turtle). Behavior. *Herpetological Review* (as a Natural History Note).
Brown, M.K., and T.D. Tuberville. 2018. Final Report: 2017 Gopher tortoise (*Gopherus polyphemus*) survey of Naval Air Station Pensacola. Cooperative Agreement #W9126G-16-2-0030, Department of Navy. 45 pp.
Brown, M.K., and T.D. Tuberville. 2018. Final Report: Vertebrate associates of gopher tortoise burrows monitored with remote wildlife cameras at Kings Bay Naval Submarine Base, Georgia. Cooperative Agreement #N69450-15-2-0015, Department of Navy, 23 pp.

Head-starting to augment gopher tortoise populations on protected areas in Georgia

Funding Entity
Georgia Department of Natural Resources
Start Date and Funding Amount
October 2013; $177,158
SREL Collaborators
Dr. Tracey Tuberville and Dr. Kurt Buhlmann
Objectives
Evaluate the effectiveness of head-starting as a means of establishing viable populations of gopher tortoises on protected lands in Georgia.
Summary of Research Activities
We protected and hatched nests from three donor sites in Georgia. We have released head-starts from 2013 and 2014 cohorts as well as hatchlings from the 2015 cohort, and are monitoring them using radio-telemetry post-release. We are also head-starting animals from the 2015 and 2016 for release in FY19.
Conclusions
Head-starting appears to be an effective way of increasing juvenile survivorship, although site-specific predator pressures from raccoons and fire ants can exert strong influence on outcome.
Major Impact(s) of Research
This work is among the first to evaluate post-release site fidelity and survival of released head-started gopher tortoises. Our results will help determine whether head-starting can be used as a potential recovery tool for the species. Several agencies have now asked for technical assistance and advice regarding initiating head-starting programs for tortoises.
Other Project Personnel
NA
External Collaborators
John Jensen (Georgia Department of Natural Resources)
Dr. Terry Norton (Georgia Sea Turtle Center)
Products
Quinn, D.P., K.A. Buhlmann, J.B. Jensen, T.M. Norton, and T.D. Tuberville. 2018. Post-release movement and survivorship of head-started gopher tortoises. *Journal of Wildlife Management* 82:1545-1554.

Can waifs be used to restore viability of gopher tortoise populations?

Funding Entity

South Carolina Department of Natural Resources / US Fish and Wildlife Service / Riverbanks Zoo Conservation Support Fund

Start Date and Funding Amount

May 2017; $76,559.

SREL Collaborators

Dr. T.D. Tuberville, Dr. K.A. Buhlmann and Rebecca McKee

Objectives

Wild gopher tortoises are frequently translocated when they are displaced by development and these animals have been successfully used to augment depleted wild populations elsewhere. However, waif tortoises – formerly captive tortoises, rehabilitated, or those of unknown origin – are rarely considered for population augmentation due to heightened disease and genetic concerns. However, for peripheral populations that do not have available wild donor populations, waif tortoises may represent the only option for stabilizing populations. We have been releasing waif gopher tortoises at the Aiken Gopher Tortoise Heritage Preserve since 2006. The purpose of this project is 7yEvaluate the survivorship, site fidelity, and health metrics of translocated waif gopher tortoises used to build a viable population of state-protected land in South Carolina.

Summary of Research Activities

We completed comprehensive burrow surveys of the entire preserve, and marked and mapped them. We completed a second field season of trapping gopher tortoises to evaluate survival and site fidelity. We collected several biological samples and submitted oral and cloacal swabs for testing for a panel of common chelonian and other reptile diseases.

Conclusions

None to date. Preliminary analyses planned for Winter 2017-18; further work planned for Summer 2018.

Major Impact(s) of Research

Waif adult tortoises represent valuable animals from a species recovery perspective, but methods need to be explored that use them for species recovery, even when these individuals cannot be returned to their original populations of origin.

Other Project Personnel

Rebecca McKee, Masters Student - SREL

External Collaborators

Will Dillman (SCDNR)
Barry Kesler (SCDNR)
Andrew Gross (SCDNR)
Dr. Matt Allender (University of Illinois)
Dr. Nicole Stacy (University of Florida)

Products

Small, M.F., J.W. Dillman, K.A. Buhlmann, T.D. Tuberville, and J.B. Kesler. 2018. Effects of canid damage on thermal characteristics of gopher tortoise (*Gopherus polyphemus*) burrows at the northern extent of its range. *Herpetological Review* 49:224-229.

Gaillard, D., J.R. Ennen, B.R. Kreiser, C.P. Qualls, S.C. Sweat, R. Birkhead, T.D. Tuberville, M. Aresco, E. McCoy, H. Mushinsky, and T.W. Hentges. 2017. Range-wide and regional patterns of population structure and genetic diversity in the gopher tortoise (*Gopherus polyphemus*). *Journal of Fish and Wildlife Management* 8:497-512.

Tuberville, T.D. Keynote address: Conservation lessons from 20+ years with turtles. Southeastern Partners in Amphibian and Reptile Conservation annual meetings. Helen, GA. February 2018.

McKee, R., K.A. Buhlmann, J.W. Dillman, J.B. Kessler, C. Moore, N. Stacy, and T.D. Tuberville. An island of misfit tortoises: health and survival of waif gopher tortoises following translocation. Integrative Conservation Conference, Athens, GA. September 2018.

McKee, R., K. Buhlmann, W. Dillman, B. Kesler, C. Moore, N. Stacy, and T. Tuberville. Health and stress of waif gopher tortoises following translocation. Annual Symposium of UGA Student Chapter of Wildlife Disease Association, Athens, GA. April 2018.

McKee, R., K. Buhlmann, W. Dillman, B. Kesler, C. Moore, and T.D. Tuberville. Waif tortoise health following translocation. Southeastern Partners in Amphibian and Reptile Conservation, Helen, GA. 22-25 February 2018.

McKee, R., K. Buhlmann, W. Dillman, B. Kesler, C. Moore, and T. Tuberville. Waif tortoise health following translocation. UGA's Warnell Graduate Student Association Symposium. Athens, GA. 31 Jan – 2 Feb 2018.

McKee, R., K. Buhlmann, W. Dillman, B. Kesler, C. Moore, and T. Tuberville. An island of misfit tortoises: using waif animals to recover populations on the brink. Gopher Tortoise Annual Meeting, Edgefield, SC. October 2017.

Tuberville, T.D. and R. McKee. Ecology of and conservation of gopher tortoises. Birds and Butterflies Nature Store, Aiken, SC. 20 March 2018. (outreach presentation to public)

Tuberville, T.D. Ecology of gopher tortoises and tools used to recover their populations. Aiken-Augusta Audubon Society. 8 March 2018. (outreach presentation to public)

Herpetofaunal surveys of Kings Bay Naval Submarine Base, Georgia

Funding Entity
US Department of Navy
Start Date and Funding Amount
September 2016; $75,742
SREL Collaborators
Dr. Tracey Tuberville and Larry Bryan
Objectives
1) Conduct herpetofaunal surveys of Kings Bay Naval Submarine Base, focusing on upland snakes and diamondback terrapins
2) Identify within-range species that were not documented but are likely to occur on Kings Bay based on nearby locality records or availability of suitable habitat.
3) Provide management recommendations and guidance for future research or inventory efforts

Summary of Research Activities
We completed our herpetofaunal surveys using a variety of techniques, including aquatic and terrestrial traps, coverboards, and road-cruising.
Conclusions
We documented 44 species of reptiles and amphibains, including 42 native and two introduced species. The documented species included 12 anuran, 3 salamander, 12 snake, 8 lizard, 8 turtle and 1 crocodilian species. Twenty-three of the species had been previously documented.
Major Impact(s) of Research
This work is the first herpetological inventory for the installation, providing valuable information that the Department of Navy can incorporate into their Integrated Natural Resources Management Plan.
Other Project Personnel
Nicole White, Temporary Research Technician – SREL
External Collaborators
NA
Products
White, K.N., T.D. Tuberville, and A.L. Bryan. 2018. Final report: Reptile and amphibian surveys at the Naval Submarine Base, Kings Bay, GA. Department of Navy, 33 pg.

Savannah Harbor Expansion Project: Cadmium in Birds

Funding Entity

U.S. Army Corps of Engineers

Start Date and Funding Amount

February 2018; $61,968

PI and co-PI's

Dr. O.E. Rhodes, Jr. and A.L. Bryan

Objectives

To monitor potential uptake of cadmium and other metals available in harbor dredging material by birds, including resident and migratory species. We examined during both spring/summer and winter periods. A known cadmium "layer" in harbor sediments will be deposited in the Savannah Harbor dredge material containment areas (DMCAs) in 2019/2020. This was the 5th and final year of avian monitoring prior to the deposition of the contaminant layer, although it only incorporated the Spring/Summer season.

Summary of Research Activities

We completed the 4th and 5th year of sample collections and analysis (for cadmium and other metals).

Conclusions

1) Overall, the majority (70-80%) of the avian samples were below our instrument detection limits (MDL).
2) A greater percentage of our spring/summer samples tended be above MDLs, likely due to greater consumption of insects during that period.
3) Analyses of cadmium concentrations in kidney samples from lethally-collected birds from the DMCAs suggested that these birds are also accumulating cadmium from off-site locations and/or during other parts of their life history (e.g., migratory birds).
4) Preliminary analyses of insects and plant material indicate that cadmium is bioavailable on the DMCAs, but that it is patchily distributed.

Major Impact(s) of Research

1) We have provided a 4-5 year baseline of data pertaining to existing cadmium levels in avifauna utilizing the Savannah Harbor DMCAs for eventual comparison to levels during and after the deposition of cadmium contaminated dredge material.

Other Project Personnel

Matt Strassburg, Research Technician – SREL
Alexis Korotasz, Research Technician – SREL
Brigette Haram, Graduate Student – UGA
Melissa Martin, Graduate Student – UGA
Karsen Weems, Graduate Student - UGA

External Collaborators

Dr. Susan B. Wilde (UGA)

Products

Rhodes, OE Jr., SB Wilde, and AL Bryan Jr. 2018. Monitoring potential cadmium levels in avian tissues associated with the Savannah Harbor Expansion Project: Year 5 of monitoring annual report. Annual project report to the U.S. Army Corps of Engineers, Savannah District, Savannah, GA.

Rhodes, OE Jr., SB Wilde, JC Seaman, and AL Bryan Jr. 2018. Monitoring potential cadmium levels in avian tissues associated with the Savannah Harbor Expansion Project: Year 4 of monitoring annual report. Annual project report to the U.S. Army Corps of Engineers, Savannah District, Savannah, GA.

Kings Bay Rare, Threatened and Endangered Wildlife Surveys: Wood Storks and Wading Birds

Funding Entity

DoD-Navy/LG2 Environmental Solutions

Start Date and Funding Amount

September 2018; $30,160

PI and co-PI's

Larry Bryan

Objectives

SREL has monitored Wood Stork use of selected aquatic habitats of the Kings Bay Submarine Base (coastal Georgia) periodically for >15 years. In this installment, we will be monitoring along the same survey route as the previous two monitoring years for comparison, as well as (1) monitoring breeding attempts at a historical colony site and (2) monitoring roost use at two known roosts. Other species of wading birds also will be monitored during all activities.

Summary of Research Activities

We have just initiated these surveys, and have completed two sets of monthly surveys (October and November) to date. We have documented locations (habitat use) of Wood Storks, Roseate Spoonbills, White Ibis as well as herons (Great Blue, Little Blue, & Tricolor) and egrets (Great, Snowy, & Cattle).

Conclusions

The project has just started, thus no conclusions at present.

Major Impact(s) of Research

The project has just started, thus no impacts at present.

Other Project Personnel

NA

External Collaborators

NA

Products

No publications, presentations or technical reports at this time.

Movements of Wood Storks Associated with Colony Modifications at the Savannah International Airport

Funding Entity
Savannah Airport Commission
Start Date and Funding Amount
June 2017; $49,750
PI and co-PI's
Larry Bryan and Dr. James Beasley
Objectives
To employ satellite telemetry to document long-term movement patterns of wood storks, a federally-listed (ESA-Threatened) species, inhabiting a breeding colony destined for removal due to its proximity to active airport runways. Originally, we were to determine if these birds returned to the same area to breed and/or determine where they breed in the future. We also documented general flight behaviors of the birds based on telemetry.
Summary of Research Activities
We deployed two transmitters on storks in the summer of 2017. One exhibited travel from the Savannah area throughout the South Carolina coastal plain until the transmitter ceased to function in September of 2017. The other stork shifted to coastal marshes off Savannah (north end of Skidaway Island) and stayed through October, and then flew south into central Florida. It remained in south-central Florida until the transmitter ceased to function in February of 2018. We will employ the two remaining transmitters in the spring of 2019 in coastal Georgia for the purpose documenting long-term movements and general flight behaviors.
Conclusions
The project has not been completed, thus no conclusions at present.
Major Impact(s) of Research
The project has not been completed, thus no conclusions at present.
Other Project Personnel
NA
External Collaborators
NA
Products
Bryan, A.L. and J.C. Beasley. 2018. Movements of wood storks captured near the Savannah Airport, Savannah, Georgia. Project report to the Savannah Airport Commission on 19 October 2018.

Costs of Incubation: Linking Incubation-Induced Alterations in Phenotype to Changes in Fitness

Funding Entity
National Science Foundation
Start Date and Funding Amount
October 2017; NFP
SREL Collaborator
Robert Kennamer
Objectives
Our overall goals have been to examine the importance of incubation temperature during early development, and to provide a better understanding of how reproductive tradeoffs made by females influence their fitness. In a recent part of the project, we collected eggs from SRS wood duck nests and artificially incubated the eggs at different temperatures known to influence phenotype. Following hatching, the ducklings were subjected to a battery of challenges that are typical for wood duck ducklings, including for example, the ability to successfully exit a nest cavity and make vocalizations to attract the attentions of an attending adult female (all challenge events were timed and video-taped).
Summary of Research Activities
In FY18, results were presented at a meeting and manuscripts were published.
Conclusions
1) Clutch size is an important moderator of incubation temperature for individual eggs within naturally incubated clutches, with larger clutches having greater variation in individual egg temperatures, and resulting in varying duckling quality at hatching.
2) This is the first study to determine how the early thermal and social environments interact to influence offspring behavior and suggests that these factors may play an important role in shaping offspring behaviors and performance metrics that are critical for survival.
3) In another analysis, we found that egg-laying sequence interacted with incubation (artificial) temperature to affect embryonic development and hatching synchrony, implying that egg characteristics (egg components) differed with laying sequence to facilitate better hatching synchrony in a precocial bird species.

Major Impacts of Research
1) Illustrates the potential importance of incubation as related to offspring quality/performance.

Other Project Personnel
John Hallagan, Research Technician - Virginia Tech
Sydney Hope, MS student - Virginia Tech
External Collaborators
Dr. Bill Hopkins (Virginia Tech University)
Dr. Sarah DuRant (Oklahoma State University)
Products
Hope, S.F., R.A. Kennamer, S.G. Van Montfrans, and W.A. Hopkins. Incubation temperature and social context affect nest exodus performance of precocial ducklings. The 2018 Society for Integrative and Comparative Biology Annual Meetings, San Francisco, CA. January 2018. (Oral presentation).

Hepp, G.R. and R.A. Kennamer. 2018. Laying sequence interacts with incubation temperature to influence rate of embryonic development and hatching synchrony in a precocial bird. *PLoS ONE* 13(1): e0191832. doi: 10.1371/journal.pone.0191832.

Hope, S.F., S.E. DuRant, J.J. Hallagan, M.L. Beck, R.A. Kennamer, and W.A. Hopkins. 2018. Free-moving artificial eggs containing temperature loggers reveal remarkable within-clutch variance in incubation temperature. *Journal of Avian Biology* 49(6). doi: 10.1111/jav.01685.

Hope, S.F., R.A. Kennamer, I.T. Moore, and W.A. Hopkins. 2018. Incubation temperature influences the behavior traits of a young precocial bird. *Journal of Experimental Zoology-Part A* 329: 191–202. doi: 10.1002/jez.2176.

The Ecological Study of Birds in the Vicinity of Augusta Regional Airport at Bush Field

Funding Entity
City of Augusta, GA
Start Date and Funding Amount
October 2017; $87,682
SREL Collaborator
Robert Kennamer
Objectives
Conduct bird hazard research associated with the placement of a wastewater treatment wetland system adjacent to a commercial airport and provide wildlife hazard consultation to airport and wastewater treatment plant personnel.
Summary of Research Activities
Since December 2001, we have been monitoring temporal and spatial activities of birds around Augusta Regional Airport. Within 2 years of the 2001 completion, the 360-acre wastewater treatment wetlands served as a nighttime roost for millions of migratory blackbirds that crossed the airfield daily at sunrise and sunset during fall/winter periods. We have been investigating the use of habitat alteration techniques to displace blackbirds, including use of airboats since 2008 to mechanically crush wetland vegetation in treatment wetlands each fall. Results have been highly significant, with long-term post-crush bird monitoring indicating that blackbird roosting within the wetlands became almost non-existent and blackbird activity around the airport was reduced. The ability of the wetland vegetation to process wastewater effluent was not negatively affected by vegetation alteration.
Conclusions
1) Long-term monitoring showed a reduction in blackbirds around the airport by 2 orders of magnitude and this reduction has been maintained for seven years now.
2) Fall crushing of wastewater treatment wetlands vegetation has not harmed the vegetation and regrowth has been experienced each subsequent spring.

Major Impacts of Research
1) The work demonstrated that with thoughtful wildlife hazard management, including the use of novel techniques, one can mitigate undesirable wildlife attraction associated with certain land-use activities.
2) Successful reduction of the bird-aircraft strike hazard was accomplished through non-lethal means.
3) Wastewater effluent concentrations of TSS, NH_3-N, and BOD_5 were reduced (improved) as a result of the vegetation crushing (i.e., vegetation crushing contributed an added benefit).

Other Project Personnel
Matthew Strassburg, Research Technician III - SREL
External Collaborators
D. Allen Saxon, Jr. (Augusta Utilities Department)
Tim Weegar (Augusta Regional Airport)
Products
Kennamer, R. A., M.C. Oberkircher, C.S. Eldridge, and I. L. Brisbin, Jr. 2017. Abundance, Distribution, and Movement Patterns of Avifauna in the Vicinity of Bush Field Airport: 2016–2017 Report. Final report submitted to Augusta Utilities Department, 166pp.

Kennamer, R. A. A review of the SREL annual report on bird activity around AGS. Wildlife Hazard Management Group Meeting, Augusta Regional Airport, GA. November 16, 2017. (Oral Presentation).

Kennamer, R. A. Bird activity at AGS and constructed wetlands during fall 2017–spring 2018.Wildlife Hazard Management Group Meeting, Augusta Regional Airport, GA. May 17, 2018. (Oral Presentation).

Total water use and source partitioning in woody bioenergy crops determined by coupled mass flux and stable isotope signatures.

Funding Entity
USDA National Institute of Food and Agriculture
Start Date and Funding Amount
September 2015; $915,593
SREL Collaborators
Dr. Doug Aubrey
Objectives
The overall goal of this proposed research is to compare the water relations and the impact on local hydrology of intensively managed pine and eucalypt woody bioenergy crops over stand development. Specifically, we will quantify total water use and determine water sources for two preeminent woody bioenergy crops. Loblolly pine is the cornerstone of southern US forest production, whereas eucalypts represent even greater productivity potential. Our results will be used to parameterize a process based model to predict watershed-scale changes that might occur to the hydrologic cycle based on increasing the intensity of management and planting a woody crop species with even higher production potential than loblolly pine.
Summary of Research Activities
We just began year 6 of this 5 year project under a no-cost extension. Experimental plots were prepped and planted in year 1. Silvicultural treatments were applied in years 1 through 5. Experimental instrumentation to measure hydrologic inputs and outputs was deployed at the beginning of the third growing season in year 3 of the project. During the fourth year of our project, we continued water balance measurements that are central to this project. This includes the continued monitoring of precipitation, throughfall, and soil moisture, as well as continued monitoring of six trees of each species (loblolly pine and *Eucalyptus benthamii*) per plot (6 plots per species) to measure whole tree water use. It also includes the routine collection of water from plant tissues, soils, and groundwater for isotope analysis. We have been measuring leaf area index of the experimental plots monthly since May 2016. We will continue measuring these variables to complete a second growing season and will then try and maintain a subset of these measurements (sapflow and leaf area index) through a third growing season. A new cryogenic vacuum extraction method has been implemented for the purposes of extracting water from plants and soils for the comparison of stable isotopes of ^{2}H and ^{18}O. These stable isotopes are conservative tracers that can be used to tease out where trees are sourcing water from within the soil column. This method can then be used to model tree water usage and inform sustainable land management practices with respect to water resources and woody crops. We are continuing to work on evaluating issues of bias in the sampling and extraction of xylem water.
Conclusions
In addition to the work related to water budgets, we continue to learn a great deal about *Eucalyptus* and its potential as a production plantation species in the southeast US. We have found (and reported through a journal article) that *Eucalyptus* is susceptible to a fungus that causes a leaf disease that severely impacts growth. We have also found that non-native *Eucalyptus* leaf beetle populations find and exploit *Eucalyptus* stands in the southeast. These issues, along with the issues of frost tolerance, make *Eucalyptus* a rather risky choice for landowners and, despite the larger impact on the hydrologic budget compared to a native species like loblolly pine, we do not expect this species to become a large part of the forest production in the southeast until these issues are overcome. Finally, we have shown that it is not just the non-natives that exhibit significantly larger impacts on water resources than the widely planted loblolly pine. We have shown that native species, like sweetgum (*Liquidambar styraciflua* L.) may exhibit much lower water use efficiencies and use a much larger amount of soil water to produce similar amounts of biomass as loblolly pine.

Major Impact(s) of Research

1) Provides quantitative information on how the hydrologic cycle would be influenced by land-use shifts away from standard, low-input, forestry management for pulpwood and timber toward intensively managed forest stands for bioenergy production
2) Provides general information about production potential of Eucalyptus in southeast US.

Other Project Personnel

Mackenzie Dix, Research Assistant – SREL
Scott Oswald, PhD Student – SREL
Seth Younger, PhD Student - SREL

External Collaborators

P. Caldwell (USFS)
R. Jackson (UGA)
J. McDonnell (University of Saskatchewan)
C. Miniat (USFS)

Products

Griffiths, N.A., B.M. Rau, K.B. Vaché, G. Starr, M.M. Bitew, D.P. Aubrey, J.A. Martin, E. Benton, and C.R. Jackson. 2018. Environmental effects of short-rotation woody crops for bioenergy: What is and isn't known. (In Press at Global Change Biology Bioenergy).

Caldwell, P.V., C.R. Jackson, C.F. Miniat, S.E. Younger, J.A. Vining, J.J. McDonnell, and D.P. Aubrey. 2018. Woody bioenergy crop selection can have large effects on water yield: A southeastern United States case study. (Biomass and Bioenergy, 117: 180-189.

Oswald, S.W. and D.P. Aubrey. 2018. Increasing biomass production on limited land area through an optimal planting arrangement. BioEnergy Research, 11(1): 13-21.

Younger, S., D.P. Aubrey, and C.R. Jackson. 2018. Water budget comparison of early rotation Loblolly Pine and Eucalyptus benthamii in the Upper Coastal Plain of South Carolina. Warnell Graduate Student Symposium. Athens, GA. (Poster presentation)

Brockman, L.E., S.E. Younger, C.R. Jackson, D.P. Aubrey, K.F. Janzen, and J.J. McDonnell. 2018. Stable isotope and mass balance applications in describing soil water contributions to loblolly pine and sweetgum xylem water. Warnell Graduate Student Symposium. Athens, GA. (Poster presentation)

Brockman, L., S. Younger, C.R. Jackson, K. Janzen, D.P. Aubrey, and J. McDonnell. 2017. Systematic errors associated with scaling soil CO2 efflux in forest ecosystems and their impact on the global carbon cycle. American Geophysical Union, New Orleans, LA. (Poster presentation)

Aubrey, D.P. 2017. Forest Ecophysiology at the Savannah River Ecology Laboratory. Joseph W. Jones Ecological Research Center. (Invited seminar)

Aubrey, D. P., C.R. Jackson, C. R. Miniat, J.J. McDonnell, and P.V. Caldwell. 2016. Hydrologic Budgets for Short Rotation Loblolly Pine and Eucalyptus. USDA-NIFA AFRI Sustainable Bioenergy Annual Project Director Meeting. Tampa, FL. (Invited oral presentation)

Interspecific variation in hydraulic redistribution and its importance to ecosystem processes in a xeric longleaf pine savanna

Funding Entity

Joseph W. Jones Ecological Research Center

Start Date and Funding Amount

August 2016; $40,643

SREL Collaborators

Dr. Doug Aubrey

Objectives

The goal of this project is to quantify the importance of hydraulic distribution to the plant communities of the longleaf pine ecosystem. Specifically, we aimed to determine: (1) which mature tree species of the longleaf ecosystem performed hydraulic redistribution and the absolute quantity of water redistributed; (2) how the water status of understory plants were influenced by hydraulic redistribution; and (3) if a portion of the water being hydraulically redistributed originated from groundwater sources.

Summary of Research Activities

Bidirectional sapflow sensors were fabricated and installed to measure water transport in roots and stems of longleaf pine and co-occurring oaks. Sapflow was measured throughout the 2017 growing season. Trenched plots were created to eliminate potential hydraulic redistribution and water status of understory plants in these plots were compared with those in untrenched controls. Water samples from precipitation, soil, groundwater, and tree xylem water were collected routinely and analyzed to determine the origins and relative contributions of evapotranspiration water.

Conclusions

1) Hydraulic redistribution varied among species and was highest in longleaf pine.
2) Stand-level hydraulic redistribution was equivalent to ~39% of transpiration and 31% of precipitation during the study period.
3) Isotopes indicated that shallow groundwater was a major water source for trees.
4) Understory plants co-located with intact tree roots were less water stressed, indicating that hydraulic redistribution may be an ecologically important source of water for forest understories.

Major Impact(s) of Research

1) In longleaf pine dominated savanna, hydraulic redistribution may moderate effects of soil moisture stress during times of water scarcity, especially in excessively well-drained soils.
2) Access to a water subsidy may affect ecosystem level processes, such as evapotranspiration and net ecosystem exchange, and provide valuable data to complete a full water budget for the region.

Other Project Personnel

M. Belovitch, MS Student - SREL

External Collaborators

S. Brantley (Joseph W. Jones Ecological Research Center)

Products

Belovitch, M., D.P. Aubrey, and S. Brantley. 2018. Interspecific variation in hydraulic redistribution and its importance to ecosystem processes in a xeric longleaf pine savanna. Warnell Graduate Student Symposium. Athens, GA. (Oral presentation)

Ecophysiology of longleaf pine.

Funding Entity
Joseph W. Jones Ecological Research Center
Start Date and Funding Amount
March 2018; $6,042
SREL Collaborators
Dr. Doug Aubrey
Objectives
The goal of this project was to complete ecophysiological research at the Joseph W. Jones Ecological Research Center and engage with resident scientists.
Summary of Research Activities
Collected, processed, and analyzed data related to carbon dynamics in longleaf pine ecosystems published one manuscript during the reporting period and another published just after the reporting period.
Conclusions
1) Belowground respiration can be maintained for extended periods through utilization of stored carbohydrates in the root system.
2) Mature longleaf pine have larger belowground storage reserves than other southern pines and this is likely a relic of their seedling strategy.

Major Impact(s) of Research
1) Provided data that challenges a contemporary paradigm in ecophysiological literature by showing that belowground respiration can be completely decoupled from canopy photosynthesis.
2) Demonstrated that the mechanism responsible for decoupling belowground respiration from canopy processes was the mobilization of stored carbohydrates from larger roots to smaller, more metabolically active roots.
3) Demonstrated that root mortality occurs with substantial amounts of stored carbohydrates still present in the form of starch, but that this substrate may be unavailable for use due to lack of water for hydrolysis and mobilization.
4) Demonstrated that traits which have been linked to ecosystem resilience in mature longleaf pine are likely a result of selection at the seedling stage.

Other Project Personnel
NA.
External Collaborators
S. Brantley (Joseph W. Jones Ecological Research Center)
Products
Mims, J.T., J.J. O'Brien, and D.P. Aubrey. 2018. Belowground carbohydrate reserves of mature southern pines reflect seedling strategy to evolutionary history of disturbance. Forests, 9: 653.

Aubrey, D.P., and R.O. Teskey. 2018. Stored root carbohydrates can maintain root respiration for extended periods. New Phytologist, 218(1):142-152.

Oswald, S.W. and D.P. Aubrey. 2018. From cell to whole-plant carbon allocation. Warnell Graduate Student Symposium. Athens, GA. (Oral presentation)

Gray wolf movement behavior in relation to kill sites, raccoon dog spatial ecology, scavenging dynamics, and demography of Przwalski's horses in Chernobyl

Funding Entity
University of Georgia
Start Date and Funding Amount
October 2016; NFP
SREL Collaborators
Dr. James C. Beasley
Objectives
The objectives of this research are to 1) quantify kill rates of gray wolves inhabiting the Chernobyl Exclusion Zone and elucidate the movement behavior gray wolves relative to kill site locations, 2) quantify home ranges, resource selection patterns, and movement behavior of raccoon dogs and relative radiation exposure, 3) assess demographic rates of endangered Przwalski's horses in Chernobyl and use of abandoned buildings, and 4) quantify the efficiency and community composition of vertebrate scavengers.
Summary of Research Activities
During fall 2016 we travelled to the CEZ and deployed GPS collars on wolves and raccoon dogs throughout the CEZ. We collected samples from captured wolves and other wildlife and also deployed remote cameras to elucidate the efficiency and composition of the vertebrate scavenging community. We also deployed remote cameras to assess use of abandoned barns by Przwalski's horses as well as develop preliminary assessments of population demography. During fall 2017 we returned to Belarus to collect GPS collars. We are currently analyzing data collected on these research trips and are preparing various publications from this work. Collaborators at the National Academy of Science in Belarus are continuing to aid in collection of field data.
Conclusions
This research is still ongoing, but some analyses are now complete. We recorded >50 kill site locations from GPS-collared wolves, and collected tens of thousands of GPS locations on collared animals that will be incorporated into analyses. Additionally, we completed a scavenging study using remote cameras as well as a study assessing use of abandoned buildings by Przwalski's horses in the CEZ. Results of our scavenging study suggest a highly efficient and diverse scavenging community exists within the CEZ, and that fish carrion is an important resource used by terrestrial vertebrates, thus transporting aquatic nutrients into terrestrial ecosystems. Further, we documented extensive use of abandoned buildings by Przwalski's horses and other large mammals in Fukushima, suggesting these structures are important to wildlife in the CEZ, particularly during periods of inclement weather.
Major Impact(s) of Research
1) This research will provide critical data on the demography of one of the world's only free-ranging populations of Przwalski's wild horses.
2) Wolf and raccoon dog GPS data will provide novel information on the movement behavior and diet of carnivores inhabiting the CEZ, data that will be valuable for future management of populations in the CEZ.
3) Conducted the first study of vertebrate scavenging ecology in the CEZ, revealing an intact and highly efficient scavenging community.

Other Project Personnel
Sarah Webster, M.S. Student – SREL
Cara Love, Ph.D. Student – SREL
Peter Schlichting, Postdoctoral Research Associate – SREL
External Collaborators
Dr. Thomas Hinton (Fukushima University)
Dr. Dima Shamovich (Belarus)
Dr. Valery Dombrovski (National Academy of Science, Belarus)

Products

Schlichting, P.E., C.N. Love, S.C. Webster, and J.C. Beasley. In Press. Efficiency and composition of vertebrate scavengers at the land-water interface in the Chernobyl Exclusion Zone. Food Webs

Beasley, J.C., M. Byrne, S. Webster, T. Hinton, D. Shamovich, P. Schlichting, S. Lance, and C. Love. 2017. Home Range Size and Movements of Wolves in the Chernobyl Exclusion Zone. Workshop to develop a management plan for wolves in Belarus. Minsk, Belarus (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. SREL Research Experiences for Undergraduates. Aiken, SC (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. Colorado State University. Fort Collins, Colorado (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. Warnell Seminar. Athens, GA (oral presentation)

Webster, S., and Beasley, J. C. (2017). Ecological effects of the Chernobyl accident. Grovetown Middle School (oral presentation)

Beasley, J.C. 2018. 137Cs Accumulation in Wildlife. International Atomic Energy Agency Mission to Fukushima Prefecture, Japan. Fukushima City, Japan (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Animals in Chernobyl and Fukushima. NASA Goddard Space Flight Center. Greenbelt, Maryland (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Animals in Chernobyl and Fukushima. Citizens for Nuclear Technology Awareness Up and Atom. Aiken, South Carolina (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. Reactor Tech Reunion. North Augusta, South Carolina (oral presentation)

Occupancy and distribution of wildlife in Fukushima along a gradient of contamination and human land-use intensity, and spatial ecology of invasive civets

Funding Entity
University of Georgia Office of the Vice President for Research, Office of International Partnerships
Start Date and Funding Amount
June 2016; $15,350
SREL Collaborators
Dr. James C. Beasley
Objectives
The overall objectives of this project are to quantify the distribution and relative abundance of mammals and other scavengers in Fukushima, Japan across a gradient of radiation contamination and level of human disturbance. In addition, we will deploy radio collars on civets and potentially wild boar to assess their movement behavior and radiation exposure, which will be used to assess potential sub-lethal effects of chronic radiation exposure.
Summary of Research Activities
During spring 2016 we travelled to the Fukushima exclusion zone and conducted 120 2-month remote camera trials. Data from these cameras have now been analyzed, and we are preparing manuscripts for submission. During fall 2016 and summer 2017 we returned to Fukushima to conduct additional camera trials and attached GPS transmitters to civets and wild boar in the exclusion zone.
Conclusions
Preliminary results suggest numerous species of mammals are abundant within the exclusion zone, and that the density of some species, especially wild boar, differs considerably between the exclusion zone and areas that remain occupied by humans. Further, resource selection patterns by civets and raccoons show selection of abandoned croplands and urban areas. Radiation was not found to be a factor driving occupancy, abundance, or movement patterns among the wildlife species we have studied.
Major Impact(s) of Research
This research represents the first assessment of the occupancy and abundance patterns of wildlife communities inhabiting the Fukushima Exclusion Zone. Further, this research is one of the first studies of the spatial ecology of civets and raccoons in Japan. Thus, data generated from this research will provide important insights into the management and conservation of wildlife in Fukushima.
Other Project Personnel
Phillip Lyons, M.S. Student – SREL
Matthew Hamilton, Research Professional – SREL
External Collaborators
Dr. Thomas Hinton (Fukushima University)
Dr. Kei Okuda (Fukushima University)
Products
Lyons, P., T.G. Hinton, K. Okuda, M. Hamilton, and J.C. Beasley. 2018. Fukushima's Wildlife: Camera Analysis of Species in and Around the Exclusion Zone. Georgia Chapter of the Wildlife Society. Tifton, GA (oral presentation)
Lyons, P., T.G. Hinton, K. Okuda, M. Hamilton, and J.C. Beasley. 2018. Fukushima's Wildlife: Mammalian Species in and Around the Exclusion Zone. Warnell Graduate Student Symposium. Athens, Georgia (oral presentation)
Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. SREL Research Experiences for Undergraduates. Aiken, SC (oral presentation)
Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. Colorado State University. Fort Collins, Colorado (oral presentation)
Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. Warnell Seminar. Athens, GA (oral presentation)

Webster, S., and Beasley, J. C. (2017). Ecological effects of the Chernobyl accident. Grovetown Middle School (oral presentation)

Beasley, J.C. 2018. 137Cs Accumulation in Wildlife. International Atomic Energy Agency Mission to Fukushima Prefecture, Japan. Fukushima City, Japan (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Animals in Chernobyl and Fukushima. NASA Goddard Space Flight Center. Greenbelt, Maryland (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Animals in Chernobyl and Fukushima. Citizens for Nuclear Technology Awareness Up and Atom. Aiken, South Carolina (oral presentation)

Beasley, J.C. 2018. Radioactive Wildlife: The Secret Life of Wildlife Inhabiting Chernobyl and Fukushima. Reactor Tech Reunion. North Augusta, South Carolina (oral presentation)

^{137}Cs Activity Levels, Movement Behavior, and Efficiency of Vertebrate Scavengers in the Fukushima Exclusion Zone

Funding Entity
University of Georgia, Office of International Education
Start Date and Funding Amount
May 2018; $5,000
SREL Collaborators
Dr. James C. Beasley
Objectives
The objectives of this project are to 1) quantify the composition and efficiency of vertebrate scavengers within the Fukushima Exclusion Zone, 2) deploy GPS transmitters on rat snakes within the Exclusion Zone to assess their movement behavior, and 3) quantify activity levels of ^{137}Cs in snakes throughout Fukushima Prefecture, Japan.
Summary of Research Activities
During summer 2018 we travelled to the Fukushima exclusion zone and conducted remote camera trials, as well as attached GPS transmitters to snakes. We also collected ^{137}Cs activity data from both live and road-kill collected snakes. Data from these efforts are currently being analyzed.
Conclusions
This research has just begun; there are no conclusions at this time.
Major Impact(s) of Research
This research represents the first assessment of the efficiency of vertebrate scavengers within the Fukushima Exclusion Zone, and thus will produce novel data on the diversity and efficiency of vertebrate scavengers. These data will inform whether the introduction of radionuclides into the environment has disrupted basic ecological functions such as nutrient cycling. This research also will produce some of the first data to date on the movement behavior of snakes in Japan with GPS telemetry.
Other Project Personnel
Hannah Gerke, M.S. Student – SREL
Wes Dixon, Research Technician – SREL
External Collaborators
Dr. Thomas Hinton (Fukushima University)
Dr. Kei Okuda (Fukushima University)
Products
Gerke, H., and J.C. Beasley. 2018. Radiocesium Accumulation and Spatial Ecology of Elaphe spp. in Fukushima, Japan. 2018 Annual Southeastern Partners in Amphibian and Reptile Conservation. Helen, Georgia (poster presentation)
Gerke, H., and J.C. Beasley. 2018. Effects of Anthropogenic Activity on the Efficiency and Composition of Vertebrate Scavenging Communities in Fukushima, Japan. Warnell Graduate Student Symposium. Athens, Georgia (poster presentation)

Effects of Chronic Radiation Exposure on the Health of Wild Boar in Fukushima Prefecture, Japan

Funding Entity
Fukushima University, Institute of Environmental Radioactivity; University of Georgia, Office of International Education; University of Georgia, Graduate School

Start Date and Funding Amount
May 2018; $9,570

SREL Collaborators
Dr. James C. Beasley

Objectives
The overall goal of this project is to assess the health impacts of chronic radiation exposure in wild boar inhabiting the area surrounding the Fukushima Dai-ichi nuclear accident. This work is being conducted in collaboration with researchers at Fukushima University and Colorado State University, where we are testing captured wild boar for a broad suite of potential health impairments at the molecular through individual level.

Summary of Research Activities
During summer 2018 we travelled to the Fukushima exclusion zone to begin capturing boar and collecting samples to be used for this research. Additional research expeditions are planned for 2019 to continue to collect samples.

Conclusions
This research has just begun; there are no conclusions at this time.

Major Impact(s) of Research
This research will produce novel data on the impact of chronic radiation exposure on a large mammal. Thus, data generated from this research will provide important insights into the management and conservation of wildlife in Fukushima, as well as other sites impacted by radiological contamination.

Other Project Personnel
Sarah Chinn, Ph.D. Student – SREL

External Collaborators
Dr. Thomas Hinton (Fukushima University)
Dr. Kei Okuda (Fukushima University)
Aryn Bordman (CSU)
Dr. Thomas Johnson (CSU)
Dr. Sami Pederson (CSU)
Maggie Roberts (CSU)

Products
S. Pederson, M. Li Puma, J. Hayes, T. Hinton, K. Okuda, J.C. Beasley, T. Johnson, L. Li Puma, and K. Freeman. 2018. Cataracts in Boar following the Fukushima Dai-ichi Nuclear Disaster. Radiation Research Society Conference. Chicago, Illinois (Poster presentation)

Evaluation of crop damage by wild pigs

Funding Entity
USDA-APHIS – Wildlife Services – National Wildlife Research Center
Start Date and Funding Amount
February 2017; $36,000
SREL Collaborators
Dr. James C. Beasley
Objectives
The objectives of this study are 1) to quantify timing and spatial distribution of wild pig damage to corn and peanut fields in SC, as well as 2) assess the utility of UAV's for quantifying wildlife damage to agricultural crops.
Summary of Research Activities
During spring 2017 we contacted landowners and selected crop fields adjacent to the Congaree National Forest and Savannah River Site in SC. Damage assessments were conducted throughout spring, summer, and fall of 2017, and an additional surveys are being conducted through fall 2018. During 20184 we also conducted aerial surveys of fields using UAV's, to evaluate the efficacy of UAV's for quantifying wildlife damage to crops.
Conclusions
This research has just begun; there are no conclusions at this time.
Major Impact(s) of Research
1) This research will provide important data on the timing and spatial distribution of wild pig damage to corn and peanut fields, two important agricultural crops in the southeast
2) Data derived from this study will be integrated into national-level management of wild pigs by the USDA to mitigate damages caused by invasive wild pigs.

Other Project Personnel
Chris Boyce, M.S. Student - SREL
External Collaborators
Dr. Kurt VerCauteren (USDA)
Steve Smith (USDA)
Products
Beasley, JC. Wild Pig Research on the Savannah River Site. 2018. South Carolina Wild Pig Task Force Meeting, Columbia, SC (oral presentation)
Boyce, C., and J.C. Beasley. 2018. Agricultural damage timing and extent by wild pigs along the Congaree River. Warnell Graduate Student Symposium. Athens, Georgia (oral presentation)

External (non-SRS) Funding Received in FY18

Savannah Harbor Expansion Project: Cadmium in Birds
Funding Entity
U.S. Army Corps of Engineers
Start Date and Funding Amount
April 2017; $99,980
SREL Collaborators and Roles
Dr. Olin E. Rhodes, Jr. (PI)
A. Lawrence Bryan, Jr. (Co-PI)
Co-Investigators, Roles, and Affiliations
Dr. Susan Wilde, UGA, (Co-PI)

Desert tortoise head-starting as a mitigation strategy
Funding Entity
California Energy Commission
Start Date and Funding Amount
September 2017; $493,089
SREL Investigators and Roles
Dr. Tracey Tuberville (PI)
Dr. Kurt Buhlmann (co-PI)
Co-Investigators, Roles, and Affiliations
Dr. Brian Todd, UC-Davis (Co-PI)
Pearson McGovern, MS Student, UGA
Dr. Mark Peaden, Postdoctoral Fellow, UC-Davis

Evaluation of head-starting as a recovery tool for the Mojave desert tortoise
Funding Entity
National Park Service
Start Date and Funding Amount
June 2013; $450,000
SREL Investigators and Roles
Dr. Tracey Tuberville (PI)
Dr. Kurt Buhlmann (Co-PI)
Co-Investigators, Roles, and Affiliations
Dr. Brian Todd, UC-Davis (Co-PI)

Ecophysiology of longleaf pine.
Funding Entity
Joseph W. Jones Ecological Research Center
Start Date and Funding Amount
March 2018; $6,042
SREL Investigators and Roles
D. Aubrey (PI)
Co-Investigators, Roles, and Affiliations
N/A.

Gopher tortoise population survey and habitat management at NAS Pensacola and associated properties.
Funding Entity
US Department of Navy
Start Date and Funding Amount
September 2016; $33,847
SREL Investigators and Roles
Dr. Tracey Tuberville (PI)
Co-Investigators, Roles, and Affiliations
N/A

Herpetofaunal surveys of Kings Bay Naval Submarine Base, Georgia.
Funding Entity
US Department of Navy
Start Date and Funding Amount
September 2016; $75,742
SREL Investigators and Roles
Dr. Tracey Tuberville (PI)
Larry Bryan (Co-PI)
Co-Investigators, Roles, and Affiliations
N/A

Head-starting to augment gopher tortoise populations on protected areas in Georgia
Funding Entity
Georgia Department of Natural Resources
Start Date and Funding Amount
October 2013; $177,158
SREL Investigators and Roles
Dr. Tracey Tuberville (PI)
Dr. Kurt Buhlmann (Co-PI)
Co-Investigators, Roles, and Affiliations
Dr. Terry Norton, Georgia Sea Turtle Center, Jekyll Island, GA
John Jensen, GADNR

REU Site: Radioecology supplement
Funding Entity
National Science Foundation
Start Date and Funding Amount
May 2018; $69,040.
SREL Investigators and Roles
T. Tuberville (PI)
S. Lance (Co-PI)
Co-Investigators, Roles, and Affiliations
Dr. Kristina Ramstad, Senior Personnel, University of South Carolina, Aiken

Conservation and management of gopher frogs in South Carolina

Funding Entity
Longleaf Alliance
Start Date and Funding Amount
August 2018; $20,500.
SREL Investigators and Roles
S. Lance (PI)
Co-Investigators, Roles, and Affiliations
Lisa Lord (Co-PI) Longleaf Alliance
Robert Abernethy (Co-PI) Longleaf Alliance

Multi-year mating dynamics and population structure in a coastal population of* Alligator mississippiensis *at the Tom Yawkey Wildlife Center

Funding Entity
South Carolina Department of Natural Resources and the Yawkey Foundation
Start Date and Funding Amount
April 2017; $74,020.
SREL Investigators and Roles
S. Lance (Co-PI)
B. Parrott (Co-PI)
J. Zajdel (Graduate Student)
Co-Investigators, Roles, and Affiliations
Dr. Thomas Rainwater (Co-PI), Clemson University

Use of fecal genotyping and spatial capture-recapture modeling to investigate coyote abundance in South Carolina

Funding Entity
South Carolina Department of Natural Resources and Warnell School of Forestry and Natural Resources.
Start Date and Funding Amount
January 2017; $50,000.
SREL Investigators and Roles
S. Lance (Co-PI)
Co-Investigators, Roles, and Affiliations
Dr. G. D'Angelo (PI), UGA
Dr. J. Kilgo (Co-PI), USFS-SR
Dr. K. Miller (Co-PI), UGA
Jordan Youngman (Ph.D. student), UGA

Savannah Harbor Expansion Project: Cadmium in Birds

Funding Entity
U.S. Army Corps of Engineers
Start Date and Funding Amount
February 2018; $61,968
SREL Collaborators and Roles
Dr. Olin E. Rhodes (PI)
A. Lawrence Bryan (Co-PI)
Co-Investigators, Roles, and Affiliations
Dr. Susan B. Wilde, UGA (Co-PI)

Kings Bay Rare, Threatened and Endangered Wildlife Surveys: Wood Storks and Wading Birds

Funding Entity
DoD Navy/LG2 Environmental Solutions
Start Date and Funding Amount
September 2018; $30,159
SREL Collaborators and Roles
Larry Bryan (PI)
Co-Investigators, Roles, and Affiliations
N/A

Movements of Wood Storks Associated with Colony Modifications at the Savannah International Airport

Funding Entity
Savannah Airport Commission, Savannah, GA
Start Date and Funding Amount
June 2017; $49,750
SREL Collaborators and Roles
Larry Bryan (PI)
Dr. James Beasley (Co-PI)
Co-Investigators, Roles, and Affiliations
N/A

The Ecological Study of Birds in the Vicinity of Augusta Regional Airport at Bush Field

Funding Entity
City of Augusta, GA
Start Date and Funding Amount
October 2017; $87,682
SREL Investigators and Roles
R. A. Kennamer (PI)
Co-Investigators, Roles, and Affiliations
D. A. Saxon, Jr. Augusta, GA Utilities Department

Total water use and source partitioning in woody bioenergy crops determined by coupled mass flux and stable isotope signatures.

Funding Entity
USDA National Institute of Food and Agriculture
Start Date and Funding Amount
September 2015; $915,593
SREL Investigators and Roles
D. Aubrey (PI)
Co-Investigators, Roles, and Affiliations
P. Caldwell (CoPI), USDA Forest Service
R. Jackson (CoPI), University of Georgia
J. McDonnell (CoPI), University of Saskatchewan
C. Miniat (CoPI), USDA Forest Service.

Differences in the physiological response of Liquidambar styraciflua caused by season of burn.

Funding Entity
USDA Forest Service-Southern Research Station
Start Date and Funding Amount
August 2015; $60,000
SREL Investigators and Roles
D. Aubrey (PI)
Co-Investigators, Roles, and Affiliations
R.O. Teskey (CoPI), UGA
J.J. O'Brien (CoPI), USDA Forest Service Southern Research Station.

Interspecific variation in hydraulic redistribution and its importance to ecosystem processes in a xeric longleaf pine savanna.

Funding Entity
Joseph W. Jones Ecological Research Center
Start Date and Funding Amount
August 2016; $40,643
SREL Investigators and Roles
D. Aubrey (PI)
Co-Investigators, Roles, and Affiliations
N/A.

Completion of data analysis and publication of soil chemical and physical properties associated with production of short rotation woody crops for bioenergy.

Funding Entity
USDA Forest Service-Savannah River
Start Date and Funding Amount
August 2016; $107,897
SREL Investigators and Roles
D. Aubrey (PI)
Co-Investigators, Roles, and Affiliations
D. Markewitz (CoPI), UGA

Getting to the root of the matter: Determining the global significance of internal carbon dioxide transport in trees.

Funding Entity
UGA Research Foundation
Start Date and Funding Amount
07/01/2017; $9,829
SREL Investigators and Roles
D. Aubrey (PI)
Co-Investigators, Roles, and Affiliations
None

Survival and Cause-Specific Mortality of Juvenile Feral Swine

Funding Entity
USDA-APHIS – Wildlife Services – National Wildlife Research Center
Start Date and Funding Amount
September 2014; $25,300.00
SREL Investigators and Roles
Dr. James C. Beasley (PI)
David Keiter (M.S. Student)
Sarah Chinn (Ph.D. Student)
Dr. Peter Schlichting (Postdoc)
Co-Investigators, Roles, and Affiliations
Dr. John Kilgo (Collaborator), USFS-SR
Mark Vukovich (Collaborator), USFS-SR
Dr. Fred Cunningham (Collaborator), USDA

Post-Translocation Movement Behavior of Feral Swine

Funding Entity

USDA-APHIS – Wildlife Services – Veterinary Services, National Wildlife Research Center

Start Date and Funding Amount

September 2014; $108,350.00

SREL Investigators and Roles

Dr. James C. Beasley (PI)
David Keiter (M.S. Student)
Dr. Josh Smith (Postdoc)
Dr. Peter Schlichting (Postdoc)
Sarah Chinn (Ph.D. Student)

Co-Investigators, Roles, and Affiliations

Dr. Ryan Miller (Collaborator), USDA
Dr. Steven Sweeney (Collaborator), USDA

Effects of sounder removal on the movement behavior of wild pigs

Funding Entity

USDA-APHIS – Wildlife Services – National Wildlife Research Center

Start Date and Funding Amount

May 2014; $70,852.00

SREL Collaborators

Dr. James C. Beasley (PI)
David Keiter (M.S. Student)
Dr. Peter Schlichting (Postdoc)

Co-Investigators, Roles, and Affiliations

Kim Pepin (Collaborator), USDA
Amy Davis (Collaborator), USDA

Evaluation of contact structure and disease dynamics in free-ranging wild pigs

Funding Entity

USDA-APHIS – Wildlife Services – National Wildlife Research Center

Start Date and Funding Amount

February 2017; $58,883.00

SREL Collaborators

Dr. James C. Beasley (PI)
Sarah Chinn (Ph.D. Student)
Dr. Peter Schlichting (Postdoc)

Co-Investigators, Roles, and Affiliations

Dr. Toni Piaggio (Collaborator), USDA
Dr. Kim Pepin (Collaborator), USDA
Dr. Amy Davis (Collaborator), USDA
Dr. Samantha Wisely (Collaborator), UF
Dr. Raoul Boughton (Collaborator), UF
Dr. Kurt VerCauteren (Collaborator), USDA

Evaluation of crop damage by wild pigs

Funding Entity

USDA-APHIS – Wildlife Services – National Wildlife Research Center

Start Date and Funding Amount

February 2017; $58,883.00

SREL Collaborators

Dr. James C. Beasley (PI)
Chris Boyce (M.S. Student)

Co-Investigators, Roles, and Affiliations

Dr. Kurt VerCauteren (Collaborator), USDA
Steve Smith (Collaborator), USDA

Distribution and relative abundance of wildlife in Fukushima along a gradient of contamination and human land-use intensity, and spatial ecology of invasive civets

Funding Entity

University of Georgia, Office of International Partnerships, Office of the Vice President for Research

Start Date and Funding Amount

June 2016; $15,350.00

SREL Collaborators

Dr. James C. Beasley (PI)
Phillip Lyons (M.S. Student)
Hannah Gerke (M.S. Student)

Co-Investigators, Roles, and Affiliations

Dr. Thomas Hinton (Collaborator), Fukushima University
Dr. Kei Okuda(Collaborator), Fukushima University

^{137}Cs Activity Levels, Movement Behavior, and Efficiency of Vertebrate Scavengers in the Fukushima Exclusion Zone

Funding Entity

University of Georgia, Office of International Education

Start Date and Funding Amount

May 2018; $5,000

SREL Collaborators

Dr. James C. Beasley (PI)

Co-Investigators, Roles, and Affiliations

Dr. Thomas Hinton (Collaborator), Fukushima University
Dr. Kei Okuda (Collaborator), Fukushima University

Effects of Chronic Radiation Exposure on the Health of Wild Boar in Fukushima Prefecture, Japan

Funding Entity

Fukushima University, Institute of Environmental Radioactivity; University of Georgia, Office of International Education; University of Georgia, Graduate School

Start Date and Funding Amount

May 2018; $9,570

SREL Collaborators

Dr. James C. Beasley (PI)

Co-Investigators, Roles, and Affiliations

Dr. Thomas Hinton (Collaborator), Fukushima University
Dr. Kei Okuda (Collaborator), Fukushima University
Aryn Bordman (Collaborator), CSU
Dr. Thomas Johnson (Collaborator), CSU
Dr. Sami Pederson (Collaborator), CSU
Maggie Roberts (Collaborator), CSU

Technical Expertise Requests in FY18

SREL Investigator
R. A. Kennamer
Date of Request
October 2017
Requesting Entity
Augusta Regional Airport at Bush Field
Nature of Request
Wildlife hazard consultant for Augusta Regional Airport at Bush Field. Member of Augusta Regional Airport Wildlife Hazard Management Group.

SREL Investigator
Drs. Tracey Tuberville
Kurt Buhlmann
Date of Request
October 2017
Requesting Entity
SCDNR
Nature of Request
Serve as species expert on gopher tortoise population biology and reintroduction

SREL Investigator
Drs. Kurt Buhlmann
Tracey Tuberville
Date of Request
October 2017
Requesting Entity
USFWS
Nature of Request
Serve as species expert on Blanding's turtle population biology and reintroduction

SREL Investigator
Dr. Tracey Tuberville
Date of Request
October 2017
Requesting Entity
Gopher Tortoise Council
Nature of Request
Participate in working group and subsequent workshop on identifying range-wide conservation targets for gopher tortoises.

SREL Investigator
Drs. Tracey Tuberville, Kurt Buhlmann
Date of Request
October 2017
Requesting Entity
USFWS
Nature of Request
Participate in Species Status Assessment for southern hognose snake (*Heterodon simus*)

SREL Investigator
Drs. Tracey Tuberville
Kurt Buhlmann
Date of Request
October 2017
Requesting Entity
Longleaf Amphibian and Reptile Conservation Project / UGA
Nature of Request
Participate in workshop and provide data records for conservation planning for reptile and amphibian species associated with longleaf pine ecosystem.

SREL Investigator
Dr. Tracey Tuberville
Date of Request
October 2017
Requesting Entity
Gopher Tortoise Council / USFWS
Nature of Request
Member of Gopher Tortoise Target Population Working Group for identifying and developing conservation targets for gopher tortoises across the species' range.

SREL Investigator
Drs. Tracey Tuberville
Kurt Buhlmann
Date of Request
September 2018
Requesting Entity
USFWS / Eglin Air Force Base
Nature of Request
Provide guidance and technical assistance in developing gopher tortoise head-starting program at a National Wildlife Refuge facility for release at Eglin Air Force Base, FL.

SREL Investigator
Drs. Tracey Tuberville
Kurt Buhlmann
Date of Request
February 2018
Requesting Entity
Department of Navy / Eglin Air Force Base
Nature of Request
Provide advice regarding gopher tortoise translocation on Eglin Air Force Base, FL.

SREL Investigator
Dr. Tracey Tuberville
Date of Request
October 2017
Requesting Entity
Gopher Tortoise Council
Nature of Request
Member of Gopher Tortoise Demographic Working Group. Help identify major gaps in demographic parameters and outline strategy for developing data warehouse for demographic data collected from throughout the species' range

SREL Investigator
Dr. Jim Beasley
Larry Bryan
Date of Request
October 2018
Requesting Entity
Susan Blas, SRNS-ACP
Nature of Request
Requested summary of Radiocesium data in off-site pigs

SREL Investigator
Larry Bryan
Dr. Stacey Lance
Dr. Xiaoyu Xu
Date of Request
August 2018
Requesting Entity
Susan Blas, SRNS-ACP
Nature of Request
Requested brief summary of mercury-related research on the SRS

SREL Investigator
Larry Bryan
Date of Request
January 2018
Requesting Entity
Susan Blas, SRNS-ACP
Nature of Request
Requested brief summary of mercury-related research on the SRS specific to the Lower Three Runs drainage/IOU

SREL Investigator
Dr. James C. Beasley
Date of Request
February 2018
Requesting Entity
International Atomic Energy Association
Nature of Request
Consult with Fukushima Prefecture, Japan

SREL Investigator
Dr. James C. Beasley
Date of Request
July 2018
Requesting Entity
International Atomic Energy Association
Nature of Request
Consult with Fukushima Prefecture, Japan

SREL Investigator
Dr. Jim Beasley and Larry Bryan
Date of Request
October 2018
Requesting Entity
Susan Blas, SRNS-ACP
Nature of Request
Requested summary of Radiocesium data in off-site pigs

SREL Investigator
Dr. James C. Beasley
Date of Request
October 2017
Requesting Entity
Susan Blas, SRNS-ACP
Nature of Request
Requested samples of white-tailed deer bones from off-site for Strontium analyses

SREL Investigator
Dr. James C. Beasley
Date of Request
March 2018
Requesting Entity
Fukushima Prefecture, Japan
Nature of Request
Requested development of a workshop to provide information and presentations on radioecology research on the SRS

SREL Investigator
G. Dharmarajan
O. E. Rhodes, Jr.
Linda Lee
Date of Request
December 2017
Requesting Entity
SRR
Nature of Request
Requested assistance with determination of fate and transport of radionuclides by wildlife species.

TASK 9. SREL scientists will work closely with SRS personnel to assist DOE and other SRS contractors in making wise and informed decisions concerning land and facilities management. SREL will continue to publish its scientific findings in peer-reviewed scientific journals to aid the public and to assist DOE in making policy decisions by providing a basis of independent, verifiable science

Please see SECTION VIII of this report for a list of SREL publications in FY18. Below we provide examples of specific activities that SREL personnel have conducted in FY18 to assist DOE and other SRS tenants with ongoing missions and to leverage federal funding provided to SREL to attract non-federal funding to conduct research activities on the SRS.

Department of Energy – EM

- SREL Director provided presentations to the Citizens Advisory Board on the Radiological Education, Monitoring and Outreach program, SREL's annual status and pollinators on the SRS
- SREL Director participated in meetings with various visitors from EM headquarters to provide an overview of SREL and its mission on the SRS
- SREL personnel participated in site visits with USDA personnel to evaluate potential research on wild pig control technologies on the SRS
- SREL leveraged DOE funding against UGA funding to conduct research on the development of pilot projects in proteomics/metabolomics at the SREL low dose facility to examine consequences of low dose exposures to aquatic species on the SRS
- SREL leveraged DOE funding and SRS site assets to obtain ~ 1.2 million dollars in new external funding during the FY18 fiscal year
- SREL personnel hosted multiple DOE personnel to tour SREL's analytical capabilities that might be used in support of SRS missions

Department of Energy – NNSA

- SREL personnel leveraged funding from NNSA to conduct research on biogeochemical cycling and efficiency of metal treatment of the HO2 wetland associated with the regulatory requirements of tritium production on the SRS
- SREL personnel leveraged funding from NNSA to conduct ecotoxicological research on amphibians utilizing the HO2 metal treatment wetlands to elucidate the biological effects of copper and other metals associated with tritium production on the SRS
- SREL personnel leveraged funding from NNSA to conduct studies of ecosystem health associated with the HO2 metal treatment wetlands
- SREL personnel leveraged funding from the NNSA to conduct research focused on the impacts of MOX construction on the viability of upper three runs creek
- SREL outreach personnel conducted extensive community outreach and education programs for NNSA and SRS

Savannah River Remediation

- SREL provided a support to SRR on technical aspects of saltstone weathering and radionuclide release over time
- SREL personnel provided technical support to SRR on addressing wildlife contamination issues

Savannah River Nuclear Solutions

- SREL personnel leveraged funding from ACP to conduct radioecology research programs involving long-lived reptiles, game species, Four Mile Branch, waterfowl and tritium mitigation activities at the Mixed Waste Facilities on SRS
- SREL provided tours and presentations as requested to provide support to ACP during visits by regulators to the SRS
- SREL provided support to SRNS Corporate Communications by providing programs for 36 public tours to the general public or site visitors

Savannah River National Laboratory

- SREL collaborated with Dr. Larry Lowe to provide research opportunities on the SRS in support of the SRNL's Minority Serving Institution Initiative
- SREL faculty collaborated with various SRNL scientists to accomplish a variety of research projects focused on environmental remediation and monitoring

US Forest Service

- SREL hosted a workshop and dinner with USFS-SR personnel to explore potential areas of collaboration and mission synergy
- SREL personnel worked with staff from the USFS-SR to provide funding to support a project to make historical rare species data easily accessible to SRS Forest Managers and to discuss methods to use digital technologies to collect, record, and make available rare species observations as they are encountered going forward.
- SREL personnel continue to inform USFS of habitat conditions at the Gopher Tortoise (*Gopherus polyphemus*) reintroduction site (Compartment 24).
- SREL personnel met multiple times with USFS personnel to discuss potential funding opportunities for SRS as a center for development of feral swine control methods
- SREL personnel worked with USFS personnel to plan and implement habitat management objectives for various Set-Aside areas on the SRS to facilitate environmental stewardship objectives of the site

TASK 10. SREL will provide stipend support to college undergraduates, graduate students, and visiting faculty to conduct research on the Savannah River Site in association with ongoing environmental research studies. The objective of the program will be to provide participants, including minority students and Historically Black Colleges and Universities, with an opportunity to pursue ecological research and training under the direction and supervision of SREL scientific staff members

The objectives of the SREL Education Program are to (1) recruit and develop additional professionals to the environmental sciences and (2) enhance environmental awareness and research opportunities among undergraduate and graduate students with emphasis on conducting ecological research important to the DOE and Savannah River Site mission. We have made special efforts in the recruitment from under-represented minority groups and our faculty members have worked with both students and faculty from Historically Black Colleges and Universities (HBCU) throughout the Southeast.

SREL has a long history of graduate and undergraduate education, training over 400 graduate and over 600 undergraduate researchers since 1967. Undergraduate students from more than 275 different colleges and universities have coauthored more than 170 peer reviewed research publications and more than 200 of these students have gone on to pursue careers in science. SREL offers students state-of-the-science laboratory facilities, a wide variety of natural and impacted habitats for field research, a diversity of faculty expertise, and more than sixty years of experience in ecological research. Since 1967, an average of six students per year have completed graduate studies at SREL, resulting in a total of more than 335 dissertations and theses. Since 1985, our graduate students have won over 200 awards from regional, national, and international competitions at numerous professional societies and foundations. In recent years, SREL has undergone significant changes in administrative infrastructure and transitioned to self-supporting funding model. Throughout this transition period, SREL has maintained its commitment to student research and education as an integral component of its mission. In fact, many of the current graduate students initiated their program of study in the past fiscal year.

In FY18, SREL faculty and staff mentored and supervised 8 undergraduate students (Table 1) from a variety of universities. These students were supported from several funding sources including DOE supported projects and other extramural grants (see REU: Radioecology below) and projects. In addition, SREL faculty provided research support and mentoring for over 87 graduate students (Table 2) from universities across the country in FY18. In many cases, this included formal involvement by serving as major advisors/co-major advisors and committee members for M.S. and Ph.D. candidates and in a few cases students received stipend support. However, support for students also included various activities in less formal relationships such as assistance at and access to field sites, use of field equipment, temporary lab space, as well as analytical and GIS resources for their studies.

During the FY18 fiscal year, an emphasis has been placed on finding creative ways to cost share graduate students by leveraging UGA funding with federal funding acquired through SREL's cooperative agreement with the Department of Energy. In addition, new emphases have been placed on enhancing participation of SREL Research Faculty in both graduate and undergraduate instruction. To these ends, SREL accomplished the following in FY18.

- SREL leveraged SRS site assets to acquire external resources to conduct UGA Maymester courses in wildlife ecology and genetics in May 2018

- SREL leveraged SRS site assets to acquire external resources to conduct a Spring Break course in Prescribed Fire during the spring of 2018

- SREL leveraged UGA funding against project specific funding from DOE and other sources to cost share over 50 graduate students all of whom have projects which will contribute to the knowledge base and needs of the SRS

- SREL leveraged DOE dollars to obtain salary support for 7 faculty members to provide instructional support to UGA departments as a means to maintain critical environmental expertise on the SRS

- SREL personnel successfully conducted activities under a National Science Foundation Grant to develop a *Research Experience For Undergraduates* internship program for undergraduates in radioecology and the third cohort of 8 students were funded to participate in this program during the summer of FY18. Details on this effort are below:

REU: Radioecology

Funding Entity
National Science Foundation
Start Date and Funding Amount
May 2018; $69,040
SREL PI ad CoPI's
Dr. Tracey Tuberville and Dr. Stacey Lance
Objectives
For each participant, the primary research activity was an independent research project. Students worked with their mentors to develop the scope of their independent research projects and were involved in all stages of the research process—from articulating the hypotheses and project objectives, designing the study, collecting data, analyzing and synthesizing data, and communicating results to their colleagues and other on-site researchers. In addition to conducting independent research projects, students participated in recurring activities designed to provide them with the foundation needed to perform critical research activities during the REU program and in their future scientific endeavors. These include a radioecology seminars series, weekly professional development workshops and the Odum memorial lecture.
Summary of Research Activities
During our fourth summer of funding we hosted 8 students using NSF funds and an additional student from other funds. Each student completed RAD Worker II training and job specific safety training. Each participant conducted individual independent research on a diversity of topics. Students presented their research as both platform presentations (at an SREL-hosted symposium) and poster presentations at a conference held on UGA main campus.
Conclusions
1) The results from these studies are varied and cover a range of scientific import. Some of these studies may become stand-alone publications while others will be built upon either by other future REU students or by graduate students.

Major Impact(s) of Research ([1]2015 cohort, [2]2016 cohort, [3]2017 cohort, [4]2018 cohort)
1. Kip Callahan[3] was recognized for best oral presentation in the natural sciences category at the 14th Annual SC Upstate Research Symposium, April 2018.
2. Demetrius Calloway[3] won 2nd place for best undergraduate poster at the Southeastern Society of Toxicology meeting, Fall 2017.
3. Jessica Gray[3] was selected to represent the 2017 Radioecology REU cohort at the Research Experiences for Undergraduates Symposium hosted by the Council on Undergraduate Research, Fall 2017.
4. Mariela Muñiz-Gonzalez[3] won an award for best undergraduate poster at the Southeastern Society of Toxicology meeting, Fall 2017.
5. Kaitlin Wilms[3] won first place for her poster (based on her REU project) at the Texas Chapter of The Wildlife Society Meetings, February 2018.

6. Amelia Russell[2] began working as a research technician at SREL in February 2018.
7. Caleigh Quick[3] accepted a research internship at the Georgia Sea Turtle Center for 2018.
8. Elizabeth DiBona[3] worked as an intern for South Carolina Department of Natural Resources during Summer 2018.
9. Collin Tapolsky[3] is employed to work in a research laboratory at Embry-Riddle Aeronautical University while he continues his undergraduate degree program.

Other Project Personnel

Dr. James Beasley, Faculty - SREL
Dr. John Seaman, Faculty - SREL
Dr. Tracey Tuberville, Faculty - SREL
Dr. Stacey Lance, Faculty - SREL
Dr. Guha Dhamarajan, Faculty - SREL
Dr. O.E. Rhodes, Faculty - SREL
Larry Bryan, Research Professional III - SREL
Dean Fletcher, Research Professional III - SREL
Matt Hamilton, Research Professional II - SREL
Margaret Wead, Admin. Support - SREL

External Collaborator

Dr. Melissa Pilgrim (USC-Upstate)
Dr. Kristina Ramstad (USC-Aiken)

Products

Listed below are the outcomes during FY18 for Radioecology REU undergraduate students funded by NSF are in bold italics with superscripts indicating their cohort (2015 cohort[1], 2016 cohort[2], 2017 cohort[3]). Other participating undergraduates are underlined. A list of comprehensive outcomes since program initiation can be found at: http://srel-reu.uga.edu/outcomes.html

Publications

Smith, J.B., *L.J. Laatsch*[1], and J.C. Beasley. 2017. Spatial complexity of carcass location influences vertebrate scavenger efficiency and species composition. *Nature-Scientific Reports* 7(10250):1-8.

McArthur, J V., *C.A. Dicks*[2], A.L. Bryan, and R.C. Tuckfield. In press. The effects of low-level ionizing radiation and copper exposure on the incidence of antibiotic resistance in lentic biofilm bacteria. To appear in *Environmental Pollution*.

Cochran[1], J.P., D.L. Haskins, N.A. Eady[1], M.T. Hamilton, M.A. Pilgrim, and T.D. Tuberville. 2018. Coal combustion residues and their effects on trace element accumulation and health indices of eastern mud turtles (*Kinosternon subrubrum*) exposed to coal combustion residues. *Environmental Pollution* 243:346-353.

Lech, M.E.[3], T.D. Tuberville, and M.A. Pilgrim. 2017. Investigating biomagnification of Hg and Cs-137 in *Nerodia floridana* using stable isotopes. *USC Student Research Journal* Volume 10:17-25.

Tanelus, M.[3], M.A. Pilgrim,and G. Dharmarajan. 2017. Effects of methylmercury on early life mortality of yellow fever mosquitoes (*Aedes aegypti*). *USC Upstate Student Research Journal* Volume 10:40-47.

Oral Presentations

Thomas, R.J., J.C. Seaman, F.M. Coutelot, and *E. Dorward*[1]. Using Porous Iron Composite (PIC) Material to Reduce Rhenium as an Analogue for Technetium in Environmental Batch Experiments. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Dorward[1]*, E.,* J.C. Seaman, F.M. Coutelot. Porous Iron Composite Material for Removal of Uranium and Chromium from Groundwater. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Seaman, J.C., D. Li, *E. Dorward*[1], J. Cochran, F.M. Coutelot, H.S. Chang, M. Tandukar, and D.I. Kaplan. Immobilization of Radioactive materials using Porous Iron Composite Media. Waste Management Symposium, Phoenix, AZ. March 2018.

Dorward[1]*, E.*, R.J. Thomas, J.P. Cochran, H.S. Chang, M. Tandukar, F.M. Coutelot, and J.C. Seaman. Removal of Radioactive materials from Groundwater using Porous Iron Composite Media. Annual Meeting of the American Geophysical Union, New Orleans, LA. Dec 2017.

Brown[2]*, M.K.*, A.L. Russell[2], *M.L. Lambert*[2], T.D. Tuberville and M.A. Pilgrim. Bioaccumulation of ^{137}Cs in Florida green watersnakes (*Nerodia floridana*) inhabiting former nuclear cooling reservoirs on the Savannah River Site. Warnell Graduate Student Symposium. University of Georgia, Athens, GA. February 2018.

Fulghum[2]*, C.*, *E.R. DiBona*[3], J.C. Leaphart, A.M. Korotasz, J.C. Beasley, and A.L. Bryan. Radiocesium (^{137}Cs) accumulation by fish within legacy reactor cooling canal system on the Savannah River Site. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Callahan[3]*, K.*, *M. Lech*[3], M.K. Brown, J.C. Leaphart, M. Pilgrim, and T.D. Tuberville. Mercury and Cs-137 concentrations among tissues of *Nerodia floridana* inhabiting former cooling reservoirs. 14th Annual SC Upstate Research Symposium, Spartanburg, SC. April 2018.

Lech[3]*, M.E.*, T.D. Tuberville, and M.A. Pilgrim. Investigating biomagnification of Hg and ^{137}Cs in *Nerodia floridana* using stable isotopes. 14th Annual SC Upstate Research Symposium, Spartanburg, SC. April 2018.

Quick[3]*, C.*, D.L. Haskins, M.A. Pilgrim, and T.D. Tuberville. The effects of mercury and radiocesium on the probability of hemoparasite infections in *Nerodia floridana*. 14th Annual SC Upstate Research Symposium, Spartanburg, SC. April 2018.

Tanelus[3]*, M.*, G. Dharmajaran, and M.A. Pilgrim. Parasites as potential indicators of ecosystem health: a case study with largemouth bass (*Micropterus salmoides*). 14th Annual SC Upstate Research Symposium, Spartanburg, SC. April 2018.

Britt[4]*, S.*, A.L. Bryan, and S. Lance. Temporal trends in accumulation of ^{137}Cs in largemouth bass and bluegill from a cooling reservoir. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Brown[4]*, T.J.*, and A.L. Bryan. Comparison of ^{137}Cs update by *Juncus effusus* and *Brasenia schreberi* in aquatic habitats on the SRS. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Cain[4]*, K.L.,* M.K. Brown, D.L. Haskins, M.A. Pilgrim, T.D. Tuberville. 137Cs whole body burdens and plasma biochemistry profiles of *Nerodia floridana* occupying a former nuclear cooling reservoir. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Maness[4]*, R.,* X. Xu, and G. Dharmajaran. The effect of methylmercury on mosquito oviposition behavior. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Moreno Gomez[4]*, C.Y.*, M.T. Hamilton, O.E. Rhodes Jr. Spatial variation in bioaccumulation of radiocesium and mercury in largemouth bass (*Micropterus salmoides*) from a former nuclear effluent cooling reservoir, Par Pond. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Stabler-Tindal[4]*, L.C.*, B.E. Lindell, and D.E. Fletcher. Sample processing methodological influences on Cs-137 and trace element analyses of small fish. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Tharp[4]*, H.I.,* J.C. Leaphart, J.K. Tomberlin, and J.C. Beasley. Influence of invertebrate scavengers on the fate and transport of ^{137}Cs within food webs. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Tucker[4]*, F.,* M. Baker, F.M. Coutelot, and J.C. Seaman. Immobilization of 137Cs in water reservoir sediments using illicit clays. SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Weekes[4], K., D. Scott, and S. Lance. Bioaccumulation of copper and zinc in amphibians inhabiting constructed wetlands: is bioavailability increasing with time? SREL Summer Undergraduate Research Symposium, Savannah River Site, SC. July 2018.

Poster Presentations

Callahan[3], K., M. Lech[3], K. Brown, J.C. Leaphart, M.A. Pilgrim, and T.D. Tuberville. Mercury and Cs-137 concentrations among tissues of *Nerodia floridana* inhabiting former nuclear cooling reservoirs. Joint Meeting of Ichthyologists and Herpetologists, Rochester, NY. July 2018.

Lech[3], M., T.D. Tuberville, and M.A. Pilgrim. Investigating biomagnification of Hg and ^{137}Cs in *Nerodia floridana* using stable isotopes. Joint Meeting of Ichthyologists and Herpetologists, Rochester, NY. July 2018.

Calloway, D.[3], C. Love, D. Scott, and S. Lance. The fate of atmospheric mercury (Hg) in ephemeral wetlands. Southeastern Society of Toxicology. Fort Valley, GA. October 2017.

Calloway, D.[3], C. Love, D. Scott, and S. Lance. The fate of atmospheric mercury (Hg) in ephemeral wetlands. Emerging Researchers National Conference. Washington, DC. February 2018.

Calloway, D.[3], C. Love, D. Scott, and S. Lance. The fate of atmospheric mercury (Hg) in ephemeral wetlands. Minorities in Agriculture Natural Resources and Related Sciences. Greensboro, NC. April 2018.

Gray[3], J., B.E. Lindell[2], M.R. Christianson[3], P.T. Stankus, O.E. Rhodes, and D. E. Fletcher. Comparison of contaminant accumulation in reservoir fishes of different trophic levels and habitats. Research Experiences for Undergraduates Symposium hosted by the Council on Undergraduate Research. Arlington, VA. October 2017.

Muñiz-Gonzalez[3], M., J.L. Ziemba, and S.L. Lance. The impact of contaminants on growth, development, and disease susceptibility of southern toads. Southeastern Society of Toxicology. Fort Valley, GA. October 2017.

Tanelus[3], M., G. Dharmarajan, and M. Pilgrim. Parasites as potential indicators of individual and ecosystem health: a case study with largemouth bass (*Micropterus salmoides*). Joint Meeting of Ichthyologists and Herpetologists, Rochester, NY. July 2018.

Wilms[3], K., J. Leaphart, A. Bryan, and J.C. Beasley. Accumulation of radiocesium in bullfrog tadpoles (*Lithobates catesbeianus*) in a contaminated effluent canal on the SRS. Texas Chapter of The Wildlife Society Annual Meeting. Dallas, TX. February 2018.

Britt[4], S., A.L. Bryan, and S. Lance. Temporal trends in accumulation of ^{137}Cs in largemouth bass and bluegill from a cooling reservoir. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Brown[4], T.J., and A.L. Bryan. Comparison of ^{137}Cs update by *Juncus effusus* and *Brasenia schreberi* in aquatic habitats on the SRS. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Cain[4], K.L., M.K. Brown, D.L. Haskins, M.A. Pilgrim, T.D. Tuberville. 137Cs whole body burdens and plasma biochemistry profiles of *Nerodia floridana* occupying a former nuclear cooling reservoir. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Maness[4], R., X. Xu, and G. Dharmajaran. The effect of methylmercury on mosquito oviposition behavior. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Moreno Gomez[4], C.Y., M.T. Hamilton, O.E. Rhodes Jr. Spatial variation in bioaccumulation of radiocesium and mercury in largemouth bass (*Micropterus salmoides*) from a former nuclear effluent cooling reservoir, Par Pond. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Stabler-Tindal[4], L.C., B.E. Lindell, and D.E. Fletcher. Sample processing methodological influences on Cs-137 and trace element analyses of small fish. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Tharp[4], H.I., J.C. Leaphart, J.K. Tomberlin, and J.C. Beasley. Influence of invertebrate scavengers on the fate and transport of ^{137}Cs within food webs. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Tucker[4], F., M. Baker, F.M. Coutelot, and J.C. Seaman. Immobilization of 137Cs in water reservoir sediments using illicit clays. International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Weekes[4], K., D. Scott, and S. Lance. Bioaccumulation of copper and zinc in amphibians inhabiting constructed wetlands: is bioavailability increasing with time? International Conference on Heavy Metals in the Environment, Athens, GA. July 2018.

Graduate Degrees / Positions / Fellowships in STEM

Naya Eady[1] started a PhD program in Cornell University's Biological and Biomedical Science Program in Fall 2017.

Alexis Korotasz[1] started a PhD program in the Department of Integrative Biology at University of South Florida in Fall 2018.

Kyle Brown[2] started a MS program in January 2018 in Forestry and Natural Resources at University of Georgia with his REU mentor, Dr. Tracey Tuberville.

Sheldon Davis[2] began a MS program in the Department of Forestry and Environmental Conservation in January 2018 at Clemson University.

Elizabeth DiBona[3] has been accepted into graduate school at Texas A&M-Corpus Christi working on fish and contaminants.

Table 10.1 SREL Undergraduate Student Program Participants, FY18

Undergraduate	University	Mentor
Sierra Britt	USC-Beaufort	Lance
Trevaris Brown	Allen University	Bryan
Kaiya Cain	USC-Beaufort	Tuberville
Ryne Maness	Presbyterian College	Dharmajaran
Christian Moreno Gomez	USC-Beaufort	Rhodes
Laura Stabler-Tindal	USC-Aiken	Fletcher
Heaven Tharp	University of Hawaii Hilo	Beasley
Fredericka Tucker	Florida A&M	Seaman
Kristopher Weekes*	Fort Valley State University	Lance

*Funded through another REU program

Table 10.2. SREL Graduate Student Program Participants, FY18

Student	Degree	University	SREL Faculty	Role
Seth Younger	Ph.D.	University of Georgia	Aubrey	Advisor
Scott Oswald	M.S.	University of Georgia	Aubrey	Advisor
Michael Belovitch	M.S.	University of Georgia	Aubrey	Advisor
Stephen Ruswick	M.S.	University of Georgia	Aubrey	Advisor
Elliot Lewis	M.S.	University of Georgia	Aubrey	Advisor
Tae Yoon Lee	Ph.D.	University of Georgia	Aubrey	Advisor
Joseph Hanson	M.S.	University of Georgia	Aubrey	Advisor
Mackenzie Dix	M.S.	University of Georgia	Aubrey	Advisor
Laura Fowler	M.S.	University of Georgia	Aubrey	Advisor
Ashley Rae	Ph.D.	University of Georgia	Aubrey	Committee
Callie Oldfield	Ph.D.	University of Georgia	Aubrey	Committee
Karuna Paudel	Ph.D.	University of Georgia	Aubrey	Committee
Lauren Brockman	M.S.	University of Georgia	Aubrey	Committee
Chris Leaphart	Ph.D.	University of Georgia	Beasley	Advisor
Sara Chinn	Ph.D.	University of Georgia	Beasley	Advisor
Pooja Gupta	Ph.D.	University of Georgia	Beasley	Co-Advisor
Sara Webster	Ph.D.	University of Georgia	Beasley	Advisor
Eric Neff	M.S.	University of Georgia	Beasley	Co-Advisor
David Bernesconi	M.S.	University of Georgia	Beasley	Co-Advisor
Chris Leaphart	M.S.	University of Georgia	Beasley	Advisor
Phillip Lyons	M.S.	University of Georgia	Beasley	Advisor
Chris Boyce	M.S.	University of Georgia	Beasley	Advisor
Hannah Gerke	M.S.	University of Georgia	Beasley	Advisor
Cody Tisdale	M.S.	University of Georgia	Beasley	Advisor
Jacob Hill	PhD.	Mississippi State University	Beasley	Committee
Chris Cleveland	M.S.	University of Georgia	Beasley	Committee
Sarah Sapp	M.S.	University of Georgia	Beasley	Committee
John Grinder	M.S.	University of Georgia	Beasley	Committee
Juan Sebastian Ortiz	M.S.	University of Georgia	Beasley	Committee

Student	Degree	University	SREL Faculty	Role
Madeline Pfaff	Ph.D.	University of Georgia	Beasley	Committee
Kyle Lundsford	M.S.	University of Georgia	Beasley	Committee
Darren Fraser	M.S.	University of Georgia	Beasley	Committee
Rebecca McKee	M.S.	University of California-Davis	Buhlmann	Committee
Jacob Daly	M.S.	University of Georgia	Buhlmann	Committee
Pearson McGovern	M.S.	University of Georgia	Buhlmann	Committee
Keysa Rosa-Rodriguez	Ph.D.	University of Georgia	Capps	Advisor
Julie Ziemba	Ph.D.	University of Georgia	Capps	Advisor
Denzell Cross	Ph.D.	University of Georgia	Capps	Advisor
Christine Fallon	M.S.	University of Georgia	Capps	Advisor
Rachel Gauer	Ph.D.	University of Georgia	Capps	Committee
Greg Jacobs	Ph.D.	University of Georgia	Capps	Committee
Suneel Kumar	Ph.D.	University of Georgia	Capps	Committee
Megan Hopson	M.S.	University of Georgia	Capps	Committee
Austin Coleman	M.S.	University of Georgia	Capps	Committee
Eric Neff	M.S.	University of Georgia	Capps	Committee
Matt Baker	M.S.	University of Georgia	Coutelot	Committee
Robert Thomas	M.S.	University of Georgia	Coutelot	Committee
Eric Neff	M.S.	University of Georgia	Dharmarajan	Co-Advisor
David Bernesconi	M.S.	University of Georgia	Dharmarajan	Co-Advisor
Pooja Gupta	Ph.D.	University of Georgia	Dharmarajan	Co-Advisor
Chris Leaphart	M.S.	University of Georgia	Dharmarajan	Committee
Julie Sanchez	M.S.	University of Georgia	Dharmarajan	Committee
Daniel Sullivan	Ph.D.	University of Georgia	Dharmarajan	Committee
Hannah Gerke	M.S.	University of Georgia	Gibbons	Committee
Sydney Hope	M.S.	Virginia Tech	Kennamer	Host
Wesley Flynn	Ph.D.	University of Georgia	Lance	Advisor
Cara Love	Ph.D.	University of Georgia	Lance	Advisor
Joshua Zajdel	M.S.	University of Georgia	Lance	Co-Advisor
Austin Coleman	M.S.	University of Georgia	Lance	Advisor
Matt Hale	Ph.D.	University of Georgia	Lance	Committee
Julie Ziemba	Ph.D.	University of Georgia	Lance	Committee
Zoe Cooper	M.S.	University of Georgia	Martin	Advisor

Student	Degree	University	SREL Faculty	Role
B. Roberts	M.S.	University of Georgia	Martin	Advisor
K. Lunsford	M.S.	University of Georgia	Martin	Advisor
J. Mohlman	M.S.	University of Georgia	Martin	Advisor
N. Wilhite	M.S.	University of Georgia	Martin	Advisor
D. Orlando	M.S.	University of Georgia	Martin	Advisor
A. Gordy	M.S.	University of Georgia	Martin	Advisor
J. Hill	M.S.	University of Georgia	Martin	Advisor
E. Prosser	M.S.	University of Georgia	Martin	Advisor
R. Gardner	M.S.	University of Georgia	Martin	Advisor
D. Sisson	M.S.	University of Georgia	Martin	Advisor
R. Chitwood	M.S.	University of Georgia	Martin	Committee
A. Lohr	M.S.	University of Georgia	Martin	Committee
C. Wakefield	M.S.	University of Georgia	Martin	Committee
J. Webb	M.S.	University of Georgia	Martin	Committee
K. McClearn	M.S.	University of Georgia	Martin	Committee
L. Gingerella	M.S.	University of Georgia	Martin	Committee
Jesse Thomas	Ph.D.	University of Georgia	McArthur	Committee
Matthew Hale	Ph.D.	University of Georgia	Parrott	Advisor
Emily Bertucci	Ph.D.	University of Georgia	Parrott	Advisor
Samantha Bock	Ph.D.	University of Georgia	Parrott	Advisor
Will Thompson	Ph.D.	University of Georgia	Parrott	Advisor
Kristen Zemaitis	M.S.	University of Georgia	Parrott	Advisor
Josh Zajdel	M.S.	University of Georgia	Parrott	Co-Advisor
Cara Love	Ph.D.	University of Georgia	Parrott	Committee
Jarad Cochran	M.S.	University of Georgia	Parrott	Committee
Ashley LeVere	Ph.D.	University of South Carolina	Parrott	Committee
Marty Brown	M.S.	University of Georgia	Parrott	Committee
Jesse Thomas	Ph.D.	University of Georgia	Rhodes	Co-Advisor
Wes Flynn	Ph.D.	University of Georgia	Rhodes	Committee
Matt Beard	Ph.D.	Purdue University	Rhodes	Committee
Daniel Sullivan	Ph.D.	University of Georgia	Rhodes	Committee
David Bernesconi	M.S.	University of Georgia	Rhodes	Committee
Pooja Gupta	Ph.D.	University of Georgia	Rhodes	Committee

Student	Degree	University	SREL Faculty	Role
Jacob Hill	Ph.D.	Mississippi State University	Rhodes	Committee
Liyun Zhang	Ph.D.	University of Georgia	Seaman	Advisor
Matt Baker	M.S.	University of Georgia	Seaman	Advisor
R.J. Thomas	M.S.	University of Georgia	Seaman	Advisor
Emily Dorward	M.S.	University of Georgia	Seaman	Advisor
Jarad Cochran	M.S.	University of Georgia	Seaman	Advisor
Rebecca McKee	M.S.	University of Georgia	Tuberville	Advisor
David Haskins	Ph.D.	University of Georgia	Tuberville	Advisor
Pearson McGovern	M.S.	University of Georgia	Tuberville	Advisor
Marty Brown	M.S.	University of Georgia	Tuberville	Advisor
Lance Padan	Ph.D.	University of Georgia	Tuberville	Committee
Rebecca Cozad	M.S.	University of Georgia	Tuberville	Committee
Chris Leaphart	M.S.	University of Georgia	Tuberville	Committee
Rick Bauer	M.S.	University of Georgia	Tuberville	Committee
Chris Leaphart	Ph.D.	University of Georgia	Xu	Committee
Meenakshi Agarwal	M.S.	Florida A&M University	Xu	Host

TASK 11. The participant will operate and maintain the SREL facilities on the SRS to efficiently and successfully perform the research, education and outreach programs described in this project description (Appendix A of the Cooperative Agreement)

Facilities Maintenance

The Savannah River Ecology Laboratory (SREL), is the custodian of eleven DOE owned buildings with the largest of these being our 45,000 square foot main laboratory and office complex. We also have a 4,000 square foot radioecology laboratory located near Par Pond, four animal holding facilities, a greenhouse complex, two office buildings, and an assortment of utility buildings (maintenance shops, receiving building, and storage sheds). SREL also assumed the custodianship of building 772-25B in FY 17. This facility had been under SREL's custodianship at one time, but recently SRNL had operated the facility until they turned it over to facility excess in 2017. 772-25B is an 8000 square foot building that contains 12 laboratories that are in various states of functionality. Our biggest facilities project for FY 18 involved creating a special laboratory space in this facility to work with mosquitos and other insects.

At SREL We operate our own maintenance staff which consists of three full time technicians, three-part time temporary workers, and one full time custodial worker. This group is responsible for all grounds maintenance, custodial duties, routine infrastructure repair, and preventive maintenance duties for over 115 infrastructure assets. Our maintenance group also undertakes a limited number of fabrication projects in support of our research efforts. Our maintenance crew has expertise in the areas of welding-fabrication, vehicle repair, construction-renovation, electrical-HVAC, and equipment operation. This capability allows us to handle facility issues in an efficient and cost effective manner.

As a partner here on the Savannah River Site, we strive to maintain our facilities in such a way that they comply with all of the DOE guidelines for property use and safety standards. We have also worked to develop facilities that are not only aesthetically pleasing, enjoyable, and safe to work in, but facilities that lend themselves toward providing our researchers with the best possible environment to conduct their research. To that end, we have set aside significant parts of our overhead budget and dedicated many man-hours to the maintaining and renovation of our facilities.

In FY 18 we carried out two major facility improvement projects to help us achieve the above standard. The first of these was the renovation of our avian holding facilities. We have a brooder house and four outdoor aviaries that are used to house a wide variety of birds and animals that are used in SREL research activities. Largely these facilities have been in an unused, mothballed state for over a dozen years. The first step of this process was to remove over a decade worth of plant growth that had taken over the facilities and prevented their effective use. The SREL maintenance crew utilized an aerial man lift with a sixty-foot lift capacity, and used this to remove foliage, vines, limbs, and straw from the sides and tops of the outdoor aviaries. Over a half dozen full grown trees were removed from the surrounding area as well. Scaffolding was also used to allow the pruning and removal of trees and vegetation that had taken over the inside of the aviaries. The Brooder house also underwent extensive cleaning and the removal of overgrown vegetation that was impacting the facility. Once the cleaning and minor repairs to this facility were done, its exterior was painted and repaired. While there are still improvements to complete on these facilities, they are now operational and currently housing research projects.

The second major facility effort in FY 18 was the construction of a 650 square foot specialty laboratory in our 772-25B complex. This lab is known as an ACL (Arthropod Containment Lab),

and was constructed to allow research using various types of insects, particularly mosquitos. Engineering support and oversight from UGA Lab safety helped us develop a unique and versatile lab with multiple capabilities. This lab is essentially a clean room that contains an environmental chamber, biosafety hood, dedicated HVAC system, and a variety of laboratory casework to facilitate ACL research. While clean room contractors were used for the bulk of the lab installation, SREL maintenance handled the extensive demolition of the existing lab casework and infrastructure that this laboratory will replace.

Over the last year we have also completed a number of other significant renovations to our facilities. Some of these significant projects include:

Installation of modular offices to increase Graduate Student space: Over the past year we reconfigured some of our office spaces to include two new modular office units which have the capability of providing offices to 16 Graduate Students.

The completion of the vinyl floor replacement in our laboratory wing: In FY 17 we began a renovation effort aimed at replacing the 40+ year old vinyl floor in our laboratory wing hallways. Approximately 70% of the floor was replaced in FY 17 and the remaining part of this renovation effort was finished in FY 18. This new flooring will not require the traditional buffing and maintenance that our old flooring required and the removal of the old floor eliminated the asbestos mastic associated with the original flooring. SREL maintenance abated the asbestos under the guidelines of a SC DHEC issued permit.

The continued renovation of our faculty and staff offices: This year we completely renovated another four offices. This included re-carpeting, painting, furnishing, and making any other necessary repairs. These renovations marked our 33rd office renovation over the last four years. These offices marked the completed renovation of 60 percent of our office inventory.

Laboratory Renovations: SREL maintenance began the renovation of the laboratory that houses our Mass Spectrometer instrument. This included removal and replacement of the vinyl tile floor with new LVT flooring, repainting, and installation of a new sampling hood. While most of the fundamental renovations are complete, we still plan to improve some of the furniture and case work in this work space.

Improvements to air handling infrastructure (HVAC): This year we replaced a 7-ton non-functioning HVAC that supported our Distance learning class room facility.

Installation of LED lighting: SREL maintenance continued the phased replacement of the fluorescent lighting throughout our facility with new LED fixtures. To date approximately 20% of the old fixtures have been replaced with LED's and the new fixtures have dramatically improved the interior lighting through the facility. Our goal is to eventually replace all of the lighting in our main facility with efficient LED lighting.

We also continued our emphasis on cleaning and proper organization this year. Our property coordinator is tasked to lead our efforts to clean our laboratories and storage facilities by disposing of any unneeded supplies and excessing any surplus equipment. We made significant progress in this area and we will continue to work diligently in the coming year to continue to improve our facilities in terms of proper organization and housecleaning.

While much has been achieved this past year, we will still remain institutionally committed to

aggressively pursuing our goal of developing facilities that comply with DOE guidelines, as well as reflect positively on our staff and research efforts. To that end, we will continue to use our in-house maintenance staff and available funding to cost effectively maintain the DOE owned facilities that we occupy.

Environmental Health and Safety (EH&S) Program

The Savannah River Ecology Laboratory (SREL) continues to operate successfully under safety and environmental requirements and standards established by The University of Georgia, the SREL Safety Manual, and the Savannah River Site Policy Manual promulgated by the U.S., Department of Energy. These standards continue to address the hazards associated with SREL operations by permitting a focused effort on the health and safety issues most pertinent to SREL operations. SREL supports and promotes an integrated approach to SRS environmental health and safety issues as a signatory to the SRS Workplace Safety, Health and Security Policy and the SRS Environmental Management System Policy Statement.

SREL maintained a commitment of two, full-time positions (SREL EH&S Manager and SREL Radiation Safety Specialist) during FY 2018, dedicated to the support of the SREL EH&S Program. The SREL EH&S Manager serves as the manager of SREL's safety and environmental compliance programs. The SREL EH&S Manager interfaces with The University of Georgia's safety programs, The U.S. Department of Energy (Savannah River) Safety and Compliance oversight programs, and SRS Contractor Environmental Health and Safety Programs, Committees, and Professionals to implement the over safety and environmental compliance programs for SREL. The SREL Radiation Safety Specialist serves as SREL's Radiation Safety Officer and interfaces with the SRNS Radiological Protection Department to implement the SRS Radiological Control Program at SREL.

The SREL EH&S Manager functions as an interface with other SRS organizations in receiving and distributing applicable safety and environmental related Lessons Learned information. By integrating with other SRS organizations to share Lessons Learned information, SREL takes advantage of the collective experience and improvements identified by other organizations for similar work processes and controls at SREL. SREL's internal computer network was used to provide targeted safety information to specific groups in the laboratory. The SREL EH&S Manager electronically distributed **11 (eleven)** targeted lessons learned and safety notices in FY2018 to specific worker groups at SREL. Additionally, in excess of **38 (thirty-eight)** SRS operational safety and environmental related announcements and notices were communicated to all SREL personnel.

The SREL EH&S Manager provided weekly reports of recordable personnel accidents or injuries to DOE-SR line management. SREL also provided monthly, SREL personnel work hour statistics to DOE-SR. SREL personnel reported **2 (two)** work related recordable injury/illness during FY2018. This represents a decreased injury/illness rate over the previous FY2017 reporting period (total of three recordable injuries). The FY2018 recordable injuries included two, hypodermic needle-stick related injury (field research). The needle-stick related injuries, resulted in the review and changes to hypodermic needle handling procedures and supervisory reinforcement of task hazards and controls within the affected SREL research programs.

The SREL EH&S Program continues to place an emphasis on safety and environmental training of SREL personnel. All new SREL personnel receive an initial, SREL-specific orientation on the topic of SREL safety and environmental programs, policies, and procedures in addition to the SRS required General Employee Training (GET). New SREL personnel also receive general SREL safety training and job specific safety training provided for by their SREL supervisor. Approximately **56 (fifty-six)** SREL personnel received this required training during FY2018. Additionally, SREL personnel received EH&S related training during FY2018 in the following functional areas as their job tasks required:

- Radiological Training – Radiological Worker Training, Advance Radiological Worker Training, Radioactive Sealed Source User Training, and Radiation Generating Device training
- Remote worker training in accordance with SRS remote worker requirements
- Georgia Right-To-Know Law (GRTK- HAZCOM equivalent) chemical specific training for UGA/SREL employees who utilize hazardous chemicals in the work place.
- Resource Conservation Recovery Act (RCRA) training for employees involved in the management, handling, or manipulation of hazardous or universal wastes.

SREL waste minimization and chemical disposal issues continue to be refined to promote sound environmental practices and support SRS environmental initiatives. Waste minimization techniques such as source reduction continue to be incorporated into experimental protocols, reducing the generation of chemicals wastes while supporting the SRS's pollution prevention efforts. SREL generated approximately **900 (Nine hundred)** pounds of hazardous wastes in FY2018. **100 (one hundred)** percent of the hazardous wastes generated was from disposal of laboratory research process generated wastes. Approximately **8 (eight)** percent of SREL's hazardous wastes was generated from active waste streams while **92 (ninety-two)** percent of SREL's hazardous wastes was from Lab Pack disposal of excess laboratory chemicals or hazardous wastes from active waste streams which was generated in previous fiscal years. As part of SREL waste minimization efforts and to ensure that chemical hazards are addressed prior to purchasing chemicals, the SREL EH&S Manager reviewed and approved **370 (three hundred and seventy)** separate chemical purchase orders made by SREL personnel.

SREL received no Notices of Violation in FY2018 as the result of external or internal reviews, inspections, or assessments. During FY2018, SREL's assigned DOE Facility Representative (FR) conducted periodic walk-down inspections of SREL operated SRS facilities in which minor safety issues were identified and promptly corrected. Additionally, SREL conducted assessments in the areas of chemical and radiological air emissions, community right-to-know, and the Georgia Right-to-Know law in compliance with state and federal requirements.

Savannah River Ecology Laboratory Analytical Services

The Savannah River Ecology Laboratory Analytical Services was established to assist SREL researchers with sample preparation and to provide in-house analysis of metals/metalloids and mercury from environmental samples. Fee for Service analysis by Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) provides researchers with data on metals/metalloids. Total mercury analysis employing one of two Milestone DMA-80 Direct Mercury Analyzers is also available with a fee for service. Multiple research programs at SREL rely on metals and mercury analysis for a wide range of research projects through multiple funding agencies.

Six laboratories have dedicated workspace for all tasks associated with sample prep through analysis. One full-time position (SREL Analytical Services Manager) is dedicated to maintain these lab spaces and to operate and maintain the equipment. The manager maintains Standard Operating Procedures, Project Safety Appraisal Forms, and provides and documents Job Specific Training in sample preparation and equipment operations. In addition, the manager performs chemical coordinator duties: maintains all safety related information including chemical inventories and safety data sheets. The manager coordinates equipment operation schedules and maintenance. These services allow students and other researchers to receive hands-on experience in sample preparation and equipment operation. In FY18, 22 people received training in order to utilize the analytical services labs.

Instrumentation, services and sample preparatory equipment include:

ICP-MS Analysis: The Perkin-Elmer NexION 300X is a fee for service ICP-MS. The Analytical Services manager maintains this instrument, performs calibrations, quality control checks, and analyzes samples for a fee. In FY18, we analyzed 5,132 samples that provided data for seven research groups at SREL including undergraduate students, graduate students, and principle investigators.

Mercury Analysis: Two Milestone DMA-80s measure total mercury following EPA Method 7473. These are fee for service instruments with charges per sample for analysis. The manager is responsible for maintenance, calibration, quality control checks, and data output. The manager provides training to students and researchers for operation of these instruments. In FY18, 17 researchers, including undergraduate and graduate students and principle investigators, performed total mercury analysis on 1,776 samples. The Brooks Rand MERX Methyl mercury analyzer, is currently utilized by two research groups. In FY18, approximately 250 samples were analyzed for methyl mercury.

Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES): The Perkin Elmer Optima 4300DV analyzes samples for trace and major elements. This instrument is available on a supply reimbursement basis with a small fee imposed for argon use. In FY18, 484 samples were analyzed providing data for two research programs at SREL.

Sample Preparation for Metals and Mercury: Four laboratories house three chemical fume hoods, two laminar flow clean hoods, and two CEM microwave digestion ovens. These are used for acid digestions for metals analysis and for sample and calibration standards preparation. Four freeze dryers with a total capacity of 50 ports, 5 drying ovens, sample-grinding equipment, and an analytical balance are available for use for sample preparation. Consumables are supplied by either the researchers or are provided on a supply reimbursement basis in lieu of fees for lab use. Multiple research programs benefit from these dedicated lab spaces that allow for streamlined sample processing in a well-equipped setting while following SREL lab safety guidelines.

In FY18, one laboratory space was renovated for the ICP-MS. New flooring was installed as well as a hood for the ICP-MS auto-sampler.

Analytical Services FY 2018 Summary

Personnel Trained in FY 2018	Number of Individuals
Graduate Students	5
Undergraduate Students (REU Program)	7
Principle Investigators	3
Technicians/Research Professionals	7
Total	22

Equipment Description	Number of Samples Analyzed	Number of Users/Research Groups	Number of Days/Times Used
ICP-MS	5,132	Samples from 7 Groups	181 days
DMA-80 Mercury Analyzer	1,776	17 users, 8 groups	78
Methyl Mercury Analyzer	250	4 users, 2 groups	n/a
ICP-OES	484	2 groups	16
CEM Microwaves (2)	n/a	10 users, 5 groups	105 times
Freeze Dryers (4)	n/a	27 users, 11 groups	284 days

Equipment Acquisition and Maintenance

Each year SREL reviews its capital equipment resources to ensure we maintain the analytical instrumentation as well as the laboratory and field equipment needed to meet the goals and objectives of our research programs. Regular review of our equipment infrastructure is important for maintaining and improving our research productivity, completing the tasks and objectives of our grants and contracts, and acquiring new equipment that employs technological advances needed to maintain the high quality of SREL's research programs. Based on input from the SREL research staff and prioritization by the Capital Equipment Committee the following equipment was approved for purchase by the SREL Director. The lists include a mix of new instruments as well as equipment upgrades and/or repairs that allowed us to best achieve our priority equipment needs within our budget constraints. The total expenditure for FY18 was $63,726.

Table 11.1. SREL Equipment Purchases in FY18.

Description	Total Cost	Purpose	Programs Served
Cryogrinder	$30,638	Sample Grinding	Ecotoxicology Biogeochemistry Environmental Chemistry Wildlife Ecology
AquaMini	$8,939	Quantify respiration in aquatic species	Ecotoxicology Environmental Chemistry Wildlife Ecology
Electrofisher	$10,133	Sample Fish	Ecotoxicology Biogeochemistry Environmental Chemistry Wildlife Ecology
Incubator	$5,021	Hatch Eggs	Ecotoxicology Wildlife Ecology
Nanodrop	$8,995	Measure DNA quantity	Ecotoxicology Biogeochemistry Environmental Chemistry Wildlife Ecology
Totals	**$63,726**		

TASK 12. UGARF will be responsible for management and engineering services for the planning, design, and construction of approved projects as may be required to repair, modify, or upgrade existing facilities or construct new facilities, not to include line item projects, necessary to support the UGARF scope of work, as approved by the Contracting Officer and appropriate DOE program personnel. Funding for major repairs and new construction will be provided by DOE

No new construction was undertaken in FY18. See Task 11 (above) for summary of facilities upgrades.

SECTION III. Cost Status Report

Provided to DOE-SR budget office monthly and final FY18 report was submitted on time.

SECTION IV. Schedule Status Report

No significant changes in the schedule of deliverables or achievement of milestones were experienced by SREL in FY18.

SECTION V. Changes in Approach or Goals

In FY18 SREL continued to implement a number of cost sharing initiatives with main campus units at UGA designed to improve accountability, facilitate the conduct of business, and focus resources and procedures within those areas deemed most critical to carrying out the mission of the laboratory. These initiatives include:

- Cost sharing of 6 tenure track faculty lines with UGA main campus units (3 housed at SREL and 3 housed at UGA)
- Cost sharing graduate student stipends with UGA main campus units to leverage additional graduate students working on research issues on the SRS
- Leveraged research funding with UGA main campus faculty and with external funding agencies to increase SREL-based research activities on the SRS in mission critical areas such as radioecology and human wildlife conflict resolution
- Cost sharing support personnel salaries such as the Outreach Program and equipment costs with the Office of the Vice President for Research at UGA to increase the quality of SREL programs

In addition, the director of SREL has challenged the research scientists and staff at the laboratory to increase the proportion of total funding received by the laboratory from sources external to the SRS in an effort to both diversify funding streams for the laboratory and effectively leverage federal dollars to attract external funding to the SRS. In FY18, external funding (non-SRS or UGA dollars) totaled 23% of the laboratories budget. It is the intent of laboratory management to increase this proportion to >30% in future fiscal years.

SECTION VI. Actual or Anticipated Problems, Delays and Remedial Actions

Savannah River Nuclear Solutions has withdrawn their support for SREL participation in public tours on the SRS. As a result, the SREL director chose to redirect DOE-SR funding to cover the deficit and continue to provide SREL support for the SRNS program. In the latest Facilities Service Agreement with SRNS, SREL has indicated that it will continue to try and provide support for public tours as long as it (SREL) has the funding to support these activities.

SREL continues to work with SRNS to achieve a balance in Site Services that meets the needs of the laboratory as it increases in size and work scope to meet the needs of the SRS site tenants. Delays have occurred in delivery of services to SREL for a variety of activities despite the availability of funding. The inability to get these issues resolved has resulted in delays in research activities as well as unexpected costs to SREL's operating budget to prepare facilities for renovation or repairs. The SRS Interface Management Team has been helpful in resolving a number of these issues and with their help, there have been some success stories in FY18, despite these delays.

SECTION VII. Absence or Changes in Key, non-temporary Personnel or Team Arrangement.

Administrative
No Change
Support Staff
Separated - B. Giddens
Separated – K. Coble
Separated A. Tucker
Tenure-track Faculty
Hired – Jesse Abrams
Research Faculty
Retired – J Vaun McArthur
Hired – Xiaoyu Xu
Postdoctoral Researchers
Separated – S. Mukherjee
Separated – P. Schlichting
Separated – Xiaoyu Xu
Research Professionals
Hired - A. Rakowski
Hired – M. Baker
Hired – M. Hamilton
Hired – C. Fulghum
Separated – K. Price
Research Technicians
Separated – M. Brown
Separated – J. Nierman
Separated – K. Norris
Separated - J. Parks
Separated – M. Sams
Separated – K. White
Hired/Separated – R. DeMass
Hired/Separated – C. Coakley
Hired/Separated – A. Hurst
Hired/Separated – A. Korotasz
Hired/Separated – B. Lindell
Hired/Separated – J. Mills
Hired/Separated – E. Kemp
Hired/Separated – W. Dixon
Hired/Separated – C. Carter
Hired/Separated – J. Calloway
Hired – K. Bosch
Hired – M. Day
Hired – N. Herrington
Hired – K. Kule
Hired – V. Locke
Hired – E. McGee
Hired – J. Perry
Hired – J. Helton
Hired E. Peck

SECTION VIII. Products or technology transfer accomplished: Publications, websites, collaborations, technologies, inventions/patents, other products

SREL faculty and staff added 67 new publications to the SREL reprint list in FY18

3406 DeGregorio, B. A., J. H. Sperry, T. D. Tuberville and P. J. Weatherhead (2017). "Translocating ratsnakes: does enrichment offset negative effects of time in captivity?" Wildlife Research 44(5): 438-448.

3407 Haskins, D. L., M. T. Hamilton, N. I. Stacy, J. W. Finger Jr. and T. D. Tuberville (2017). "Effects of selenium exposure on the hematology, innate immunity, and metabolic rate of yellow-bellied sliders (*Trachemys scripta scripta*)." Ecotoxicology 26(8): 1134-1146.

3408 Oldenkamp, R. E., A. L. Bryan Jr., R. A. Kennamer, J. C. Leaphart, S. C. Webster and J. C. Beasley (2017). "Trace Elements and Radiocesium in Game Species Near Contaminated Sites." Journal of Wildlife Management 81(8): 1338-1350.

3409 Thompson, M., M. Reed, M. A. Pilgrim, S. D. Unger and O. E. Rhodes Jr. (2015). "Mastering Medaka Culture: Improved Techniques for Increasing Egg and Fry Production in Japanese Rice Fish (*Oryzias latipes*)." USC Upstate Student Research Journal 8(Fall): 26-33.

3410 Keiter, D. A., A. J. Davis, O. E. Rhodes Jr., F. L. Cunningham, J. C. Kilgo, K. M. Pepin and J. C. Beasley (2017). "Effects of scale of movement, detection probability, and true population density on common methods of estimating population density." Scientific Reports 7(9446): 1-12.

3411 Smith, J. B., L. J. Laatsch and J. C. Beasley (2017). "Spatial complexity of carcass location influences vertebrate scavenger efficiency and species composition." Scientific Reports 7(10250): 1-8.

3412 Abernethy, E. F., K. L. Turner, J. C. Beasley, T. L. DeVault, W. C. Pitt and O. E. Rhodes Jr. (2014). Impacts of Invasive Species on Ecosystem Energy Flow on the Big Island of Hawai'i: Excuse Me, But Are You Going to Eat That Cane Toad? 26th Vertebrate Pest Conference, Davis, CA, University of California. Pp.40-42

3413 Abernethy, E. F., K. L. Turner, J. C. Beasley and O. E. Rhodes Jr. (2017). "Scavenging along an ecological interface: utilization of amphibian and reptile carcasses around isolated wetlands." Ecosphere 8(11): 1-12.

3414 Mayer, J. and J. C. Beasley (2018). Wild Pigs. *Ecology and Management of Terrestrial Vertebrate Invasive Species in the United States*. W. C. Pitt, J. C. Beasley and G. W. Witmer, eds. Boca Raton, FL, CRC Press, Taylor & Francis Group: 221-250.

3415 DeVault, T. L., T. W. Seamans, K. E. Linnell, D. W. Sparks and J. C. Beasley (2017). "Scavenger removal of bird carcasses at simulated wind turbines: Does carcass type matter?" Ecology 8(11): 1-10.

3416 Minton, R. L., R. R. Beasley, S. L. Lance and K. E. Perez (2017). "Development, characterization, and utility of 13 polymorphic microsatellite loci in *Praticolella* (Gastropoda: Polygyridae) species from South Texas, U.S.A." American Malacological Bulletin 35(2): 158-162.

3417 Nunziata, S. O., S. L. Lance, D. E. Scott, E. M. Lemmon and D. W. Weisrock (2017). "Genomic data detect corresponding signatures of population size change on an ecological time scale in two salamander species." Molecular Ecology 26(4): 1060-1074.

3418 Obae, S. G., M. H. Brand, B. A. Connolly, R. R. Beasley and S. L. Lance (2017). "Microsatellite Markers for *Aronia melanocarpa* (Black Chokeberry) and Their Transferability to Other *Aronia* Species." HortScience 52(1): 20-23.

3419 O'Bryhim, J. R., D. H. Adams, J. L.Y. Spaet, G. L. Mills and S. L. Lance (2017). "Relationships of mercury concentrations across tissue types, muscle regions and fins for two shark species." Environmental Pollution 223(2017): 323-333.

3420 Pathak, A., A. Chauhan, P. Stothard, S. Green, M. Maienschein-Cline, R. Jaswal and J. C. Seaman (2017). "Genome-centric evaluation of *Burkholderia* sp. strain SRS-W-2-2016 resistant to high concentrations of uranium and nickel isolated from the Savannah River Site (SRS), USA." Genomics Data 12(2017): 62-68.

3421 Somers, C. M., C. F. Graham, J. A. Martino, T. R. Frasier, S. L. Lance, L. E. Gardiner and R. G. Poulin (2017). "Conservation genetics of the eastern yellow-bellied racer (*Coluber constrictor flaviventris*) and bullsnake (*Pituophis catenifer sayi*): River valleys are critical features for snakes at northern range limits." PLos ONE 12(11): e0187322.

3422 Unger, S. D., E. F. Abernethy, S. L. Lance, R. R. Beasley, B. A. Kimball, T. W. McAuliffe, K. L. Jones and O. E. Rhodes Jr. (2015). "Development and characterization of 33 novel polymorphic microsatellite markers for the brown tree snake *Boiga irregularis*." BMC Research Notes 8(658): 1-4.

3423 Brown, M. K., M. Lambert, A. L. Russell, T. D. Tuberville and M. A. Pilgrim (2016). "Bioaccumulation of ^{137}Cs in Florida green watersnakes (*Nerodia floridana*) inhabiting former nuclear cooling reservoirs on the Savannah River Site." USC Upstate Student Research Journal 9(Fall): 19-28.

3424 Carter, A. W., B. M. Sadd, T. D. Tuberville, R. T. Paltz and R. M. Bowden (2018). "Short heatwaves during fluctuating incubation regimes produce females under temperature-dependent sex determination with implications for sex ratios in nature." Scientific Reports 8(3): 1-13.

3425 Gaillard, D., J. R. Ennen, B. R. Kreiser, C. P. Qualls, S. C. Sweat, R. Birkhead, T. D. Tuberville, M. Aresco, E. D. McCoy, H. R. Mushinsky and T. W. Hentges (2017). "Range-Wide and Regional Patterns of Population Structure and Genetic Diversity in the Gopher Tortoise." Journal of Fish and Wildlife Management 8(2): 497-512.

3426 Russell, A. L., M. K. Brown, M. M. Lambert, T. D. Tuberville and M. A. Pilgrim (2016). "Mercury Bioaccumulation in Florida Green Watersnakes (*Nerodia floridana*) inhabiting Former Nuclear Cooling Reservoirs on the Savannah River Site." USC Upstate Student Research Journal 9(Fall): 43-52.

3427 Webster, S. C., F. L. Cunningham, J. C. Kilgo, M. Vukovich, O. E. Rhodes Jr. and J. C. Beasley (2017). "Effective Dose and Persistence of Rhodamine-B in Wild Pig Vibrissae." Wildlife Society Bulletin 41(4): 764-769.

3428 White, K. N. and T. D. Tuberville (2017). "Birds and Burrows: Avifauna Use and Visitation of Burrows of Gopher Tortoises at Two Military Sites in the Florida Panhandle." The Wilson Journal of Ornithology 129(4): 792-803.

3429 Winzeler, M. E., D. L. Haskins, S. L. Lance and T. D. Tuberville (2018). "Survey of Aquatic Turtles on the Savannah River Site, South Carolina, for Prevalence of *Ranavirus*." Journal of Wildlife Diseases 54(1): 138-141.

3430 Brown, M. K., M. Lambert, A. L. Russell, T. D. Tuberville and M. A. Pilgrim (2016). "Bioaccumulation of ^{137}Cs in Florida Green Watersnakes (*Nerodia floridana*) from Three Wetlands on the Savannah River Site." USC Upstate Student Research Journal 9(Fall): 19-28.

3431 Cochran, J. P., N. A. Eady, M. A. Pilgrim, T. D. Tuberville and D. L. Haskins (2012). Influence of coal ash contamination on metabolic rates of eastern mud turtles (*Kinosternon subrubrum*). Oral presentation at the Annual SC Upstate Research Symposium; printed proceedings, Spartanburg, SC.

3432 Chauhan, A., A. Pathak, R. Jaswal, B. Edwards III, D. Chappell, C. Ball, R. Garcia-Sillas, P. Stothard and J. C. Seaman (2018). "Physiological and Comparative Genomic Analysis of *Arthrobacter* sp. SRS-W-1-2016 Provides Insights on Niche Adaptation for Survival in Uraniferous Soils." Genes 9(1): 1-19.

3433 Kierepka, E. M., J. C. Kilgo and O. E. Rhodes Jr. (2017). "Effect of Compensatory Immigration on the Genetic Structure of Coyotes." The Journal of Wildlife Management 81(8): 1394-1407.

3434 Hepp, G. R. and R. A. Kennamer (2018). "Laying sequence interacts with incubation temperature to influence rate of embryonic development and hatching synchrony in a precocial bird." PLoS ONE 13(1): e0191832.

3435 Coutelot, F., J. C. Seaman and M. Baker (2018). "Uranium (VI) adsorption and surface complexation modeling onto vadose sediments from the Savannah River Site." Environmental Earth Sciences 77(4): 1-12 Article 148.

3436 Yabsley, M. J., R. E. Vanstreels, E. S. Martinsen, A. G. Wickson, A. E. Holland, S. M. Hernandez, A. T. Thompson, S. L. Perkins, C. J. West, A. L. Bryan Jr., C. A. Cleveland, E. Jolly, J. D. Brown, D. McRuer, S. Behmke and J. C. Beasley (2018). "Parasitaemia data and molecular characterization of *Haemoproteus catharti* from New World vultures Cathartidae) reveals a novel clade of *Haemosporida*." Malaria Journal 17(12): 1-10.

3437 Fairbanks Jr., D. O., J. V. McArthur, C. M. Young and R. B. Rader (2018). "Consumption of terrestrial organic matter in the rocky intertidal zone along the central Oregon coast." Ecosphere 9(3): 1-20.

3438 Lech, M. E., T. D. Tuberville and M. A. Pilgrim (2017). "Investigating Biomagnification of Hg and ^{137}Cs in *Nerodia floridana* Using Stable Isotopes." USC Upstate Student Research Journal X(Fall): 17-25.

3439 Hill, J. E., T. L. DeVault, J. C. Beasley, O. E. Rhodes Jr. and J. L. Belant (2018). "Effects of vulture exclusion on carrion consumption by facultative scavengers." Ecology and Evolution 8(5): 2518-2526.

3440 Haskins, D. L., E. W. Howerth and T. D. Tuberville (2018). "Experimentally Induced Selenosis in Yellow-Bellied Slider Turtles (*Trachemys scripta scripta*)." Veterinary Pathology 55(3): 473-477.

3441 Congdon, J. D., G. H. Keaton, O. M. Kinney, R. D. Nagle and J. W. Gibbons (2018). "Tools and Techniques for Turtle Studies: Adjustable Locks for Hoop Trap Poles, Nylon Fencing for Drift Sets, and Stick-on Temporary Identification." Herpetological Review 49(1): 29-31.

3442 Xu, X. and G. L. Mills (2018). "Do constructed wetlands remove metals or increase metal bioavailability?" Journal of Environmental Management 218(2018): 245-255.

3443 Beasley, J. C., S. S. Ditchkoff, J. Mayer, M. D. Smith and K. C. Vercauteren (2018). "Research Priorities for Managing Invasive Wild Pigs in North America." The Journal of Wildlife Management 82(4): 674-681.

3444 Aubrey, D. P., S. W. Fraedrich, T. C. Harrington and R. Olatinwo (2017). "*Cristulariella moricola* associated with foliar blight of Camden white gum (*Eucalyptus benthamii*), a bioenergy crop." Biomass and Bioenergy 105(2017): 464-469.

3445 Aubrey, D. P. and R. O. Teskey (2018). "Stored root carbohydrates can maintain root respiration for extended periods." New Phytologist 218(1): 142-152.

3446 Finger Jr., J. W., M. T. Hamilton, M. D. Kelley, Y. Zhang, A. N. Kavazis, T. C. Glenn and T. D. Tuberville (2018). "Dietary Selenomethionine Administration and Its Effects on the American Alligator (*Alligator mississippiensis*): Oxidative Status and Corticosterone Levels." Archives of Environmental Contamination and Toxicology 75(1): 37-44.

3447 Ingwers, M. W., M. A. McGuire, D. P. Aubrey, R. A. Bhuiyan and R. O. Teskey (2017). "Half-sibling loblolly pine clones exhibited intraspecific variation, a G x E interaction, and differences in stable isotope composition in response to soil moisture availability." Environmental and Experimental Botany 138(2017): 88-98.

3448 Li, G. Y., D. P. Aubrey and H. Z. Sun (2017). "Predictive capability of a leaf optical meter for determining leaf pigment status during senescence." Photosynthetica 55(3): 543-552.

3449 Oswald, S. W. and D. P. Aubrey (2018). "Increasing Biomass Production on Limited Land Area Through an Optimal Planting Arrangement." Bioenergy Research 11(1): 13-21.

3450 Pattathil, S., M. W. Ingwers, D. P. Aubrey, Z. Li and J. Dahlen (2017). "A quantitative method for analyzing glycome profiles of plant cell walls." Carbohydrate Research 448(2017): 128-135.

3451 Philipps, R. R., X. Xu, G. L. Mills and R. B. Bringolf (2017). "Evaluation of Diffusive Gradients in Thin Films for Prediction of Copper Bioaccumulation by Yellow Lampmussel (*Lampsilis cariosa*) and Fathead Minnow (*Pimephales promelas*)." Environmental Toxicology and Chemistry 37(6): 1535-1544.

3452 Smith, J. B., T. D. Tuberville and J. C. Beasley (2018). "Hunting and Game Consumption Patterns of Hunters in South Carolina." Journal of Fish and Wildlife Management 9(1): 321-329.

3453 Teskey, R. O., M. A. McGuire, J. Bloemen, D. P. Aubrey and K. Steppe (2017). Respiration and CO2 Fluxes in Trees. Chapter 9. Pp. 181-207. In: *Plant Respiration: Metabolic Fluxes and Carbon Balance*. G. Tcherkez and J. Ghashghaie, (eds.) Springer International Publishing.

3454 Viner, B., M. Parker, G. Maze, P. Varnedoe, M. Leclerc, G. Starr, D. P. Aubrey, G. Zhang and H. Duarte (2016). "Intermediate time scale response of atmospheric CO2 following prescribed fire in a longleaf pine forest." Journal of Geophysical Research: Biogeosciences 121: 2745-2760.

3455 Janzen, F. J., L. A. Hoekstra, R. J. Brooks, D. M. Carroll, J. W. Gibbons, J. L. Greene, J. B. Iverson, J. D. Litzgus, E. D. Michael, S. G. Parren, W. M. Roosenburg, G. F. Strain, J. K. Tucker and G. R. Ultsch (2018). "Altered spring phenology of North American freshwater turtles and the importance of representative populations." Ecology and Evolution 8(11): 5815-5827.

3456 Korotasz, A. M. and A.L. Bryan Jr. (2018). "Accumulation of ^{137}Cs by Carnivorous Aquatic Macrophytes (*Utricularia* spp. on the Savannah River Site." Archives of Environmental Contamination and Toxicology 75(2): 273-277.

3457 Small, M., J. W. Dillman, K. A. Buhlmann, T. D. Tuberville and J. B. Kesler (2018). "Effects of Canid Damage on Thermal Characteristics of Gopher Tortoise (*Gopherus polyphemus*) Burrows at the Northern Extent of the Species' Range." Herpetological Review 49(2): 224-229.

3458 Nigenda-Morales, S. F., Y. Hu, J. C. Beasley, H. A. Ruiz-Piña, D. Valenzuela-Galván and R. K. Wayne (2018). "Transcriptomic analysis of skin pigmentationn variation in the Virginia opossum (*Didelphis virginiana*)." Molecular Ecology 27(12): 2680-2697.

3459 Brisbin Jr., I. L., H. D. Pratt and T. B. Mowbray (2002). American Coot, Hawaiian Coot. The Birds of North America: Life Histories for the 21st Century. A. F. Poole and F. B. Gill, eds. Philadelphia, PA, The Birds of North America, Inc. 697: 1-43.

3460 Bréchnignac, F., D. Oughton, C. Mays, L. Barnthouse, J. C. Beasley, A. Bonisoli-Alquati, C. Bradshaw, J. Brown, S. Dray, S. Geras'kin, T. C. Glenn, K. Higley, K. Ishida, L. Kapustka, U. Kautsky, W. Kuhne, M. Lynch, T. Mappes, S. Mihok, A. P. Møller, C. Mothersill, T. A. Mousseau, J. Otaki, E. Pryakhin, O. E. Rhodes Jr., B. Salbu, P. Strand and H. Tsukada (2016). "Addressing ecological effects of radiation on populations and ecosystems to improve protection of the environment against radiation: Agreed statements from a Consensus Symposium." Journal of Environmental Radioactivity 158-159(2016): 21-29.

3461 Hope, S. F., S. E. DuRant, J. J. Hallagan, M. L. Beck, R. A. Kennamer and W. A. Hopkins (2018). "Free-moving artificial eggs containing temperature loggers reveal remarkable within-clutch variance in incubation temperature." Journal of Avian Biology 49(6): 1-8.

3462 Kierepka, E. M., S. J. Anderson, R. K. Swihart and O. E. Rhodes Jr. (2016). "Evaluating the influence of life-history characteristics on genetic structure: a comparison of small mammals inhabiting complex agricultural landscapes." Ecology and Evolution 6(17): 6376-6396.

3463 Bossle, B. L., R. R. Goforth, S. D. Unger and O. E. Rhodes Jr. (2015). "The Effects of Suspended Sediment on Japanese Medaka (Oryzias latipes) and Mosquitofish (Gambusia affinis) Metabolism." Journal of the South Carolina Academy of Science 13(1): 28-32.

3464 Philipps, R. R., X. Xu, G. L. Mills and R. B. Bringolf (2018). "Impact of natural organic matter and increased water hardness on DGT prediction of copper bioaccumulation by yellow lampmussel (*Lampsilis cariosa*) and fathead minnow (*Pimephales promelas*)." Environmental Pollution 241(2018): 451-458.

3465 Cochran, J. P., D. L. Haskins, N. A. Eady, M. T. Hamilton, M. A. Pilgrim and T. D. Tuberville (2018). "Coal combustion residues and their effects on trace element accumulation and health indices of eastern mud turtles (*Kinosternon subrubrum*)." Environmental Pollution 243: 346-353.

3466 Quinn, D. P., K. A. Buhlmann, J. B. Jensen, T. M. Norton and T. D. Tuberville (2018). "Post-Release Movement and Survivorship of Head-Started Gopher Tortoises." The Journal of Wildlife Management 82(7): 1545-1554.

3467 Sutherland, D. A. T., C. F. Honaker, B. Dorshorst, L. Andersson, I. L. Brisbin Jr. and P. B. Siegel (2018). "Growth patterns for three generations of an intercross between red junglefowl and chickens selected for low body weight." Journal of Animal Breeding and Genetics 135(4): 300-310.

3468 Hamilton, M. T., J. W. Finger Jr., R. M. Elsey, G. F. Mastromonaco and T. D. Tuberville (2018). "Corticosterone in American alligator (*Alligator mississippiensis*) tail scutes: Evaluating the feasibility of using unconventional samples for investigating environmental stressors." General and Comparative Endocrinology 268(2018): 7-13.

3469 Hope, S. F., R. A. Kennamer, I. T. Moore and W. A. Hopkins (2018). "Incubation temperature influences the behavioral traits of a young precocial bird." Journal of Experimental Zoology 329(2018): 191-202.

3470 Rumrill, C. T., D. E. Scott and S. L. Lance (2018). "Delayed Effects and Complex Life Cycles: How the Larval Aquatic Environment Influences Terrestrial Performance and Survival." Environmental Toxicology and Chemistry 37(10): 2660-2669.

3471 Schultz, I. R. and M. C. Newman (1997). "Methyl Mercury Toxicokinetics in Channel Catfish (*Ictalurus punctatus*) and Largemouth Bass (*Micropterus salmoides*) After Intravascular Administration." Environmental Toxicology and Chemistry 16(5): 990-996.

3472 Willson, J. D., S. E. Pittman, J. C. Beane and T. D. Tuberville (2018). "A novel approach for estimating densities of secretive species from road-survey and spatial-movement data." Wildlife Research 45(2018): 446-456.

SECTION IX. **Special Accomplishments by Laboratory Personnel**

- Gene Rhodes received the Ceasar Kleberg Award for Excellence in Wildlife Resaerch from The Wildlife Society
- James Beasley received the Fred C. Davison Early Career Scholar Award from UGA.
- Krista Capps recieved the Odum School of Ecology Instructor of the Year Award in FY18
- Krista Capps was selected as a Lilly Teaching Fellow in FY18
- Whitt Gibbons was awarded first place by the Southeastern Outdoor Press Association for Best Weekly Newspaper Column
- James Martin was awarded the Early Career Teaching Award by the Warnell School of Forestry and Natural Resources
- James Martin was awarded the Research Award by the Warnell School of Forestry and Natural Resources
- Over 20 SREL graduate students won competative scholarships or received awards for presentations at regional, national or international meetings or
- SREL research was highlighted in print, TV, and web-based media hundreds of times
- Numerous SREL faculty were asked to serve as peer reviewers on national funding panels for NSF, USDA, and other entities
- SREL Faculty were asked to give over 43 invited presentations to professional audiences in FY18