SAVANNAH RIVER
ECOLOGY LABORATORY

ANNUAL TECHNICAL PROGRESS REPORT OF ECOLOGICAL RESEARCH FOR FY22

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Director

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TABLE OF CONTENTS

SECTION I: Savannah River Ecology Laboratory – FY22 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 70 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 FY22 was fulfilled with the publication of 87 journal articles, proceedings articles, and book chapters by faculty, technical staff, students, and visiting scientists. Additional journal articles and books have been submitted or are in press. Significantly, SREL conducted over 182 outreach events reaching 14,269 people of all ages, and totaled 665,000 social media impressions. 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 FY22 was approximately 176 faculty, technicians, students, and support staff. Although the number of employees and level of funding has been reduced relative to its height of two decades 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, College of Veterinary Medicine, Franklin College of Arts and 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 FY22, DOE-SR funding was leveraged to acquire approximately 1 million dollars 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 five tenure track faculty lines at SREL and a portion of four 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 Mission Completion (SRMC) 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 Cooperative Agreement with DOE allows SREL/UGA access to the SRS through 30 September 2026. 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 FY22, SREL 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 33 new and continuing external grants during FY22. Sources of grant awards range from private foundations to federal and state agencies, including the US Department of Interior, the US Department of Agriculture, the National Science Foundation, and the US Department of Defense.

SREL faculty members hold positions in various departments at UGA. 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 115 graduate students from numerous colleges and universities in the United States during FY22.

The SREL Outreach Program communicates scientific awareness to area schools and the general public, an audience which differs significantly from science professionals. The SREL Outreach Program had a productive year, having conducted 182 outreach events to a total estimated audience of 14,269 participants in FY22. Also, the SREL Outreach Program greatly increased its social media impact in FY22, totaling 18,284 followers and approximately 665,000 media impressions. Topics for these outreach efforts 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. During the past year, SREL also conducted 31 scheduled tours for 599 attendees in total, including 10 SRS public tours for 228 employees and 21 tours for 371 on-site visitors and SRS employees.

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 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 proposed Savannah River Pit Production Facility, 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 SRMC 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 SRMC 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.

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 70 years.

The FY22 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 FY22, the Savannah River Ecology Laboratory received approximately 9.8 million dollars in funding from a variety of sources (Figure 2.1). These funds supported approximately 176 faculty, staff, and students conducting basic and applied environmental research for at least some portion of FY22 (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 35% of the laboratory's 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 FY22. Acronyms are as follows: University of Georgia (UGA), Savannah River Site Office of Department of Energy (DOE-SR), all combined sources of funding from sources external to the Savannah River Site (External), Department of Energy National Nuclear Security Administration, and Savannah River Nuclear Solutions Area Closures Project (ACP).

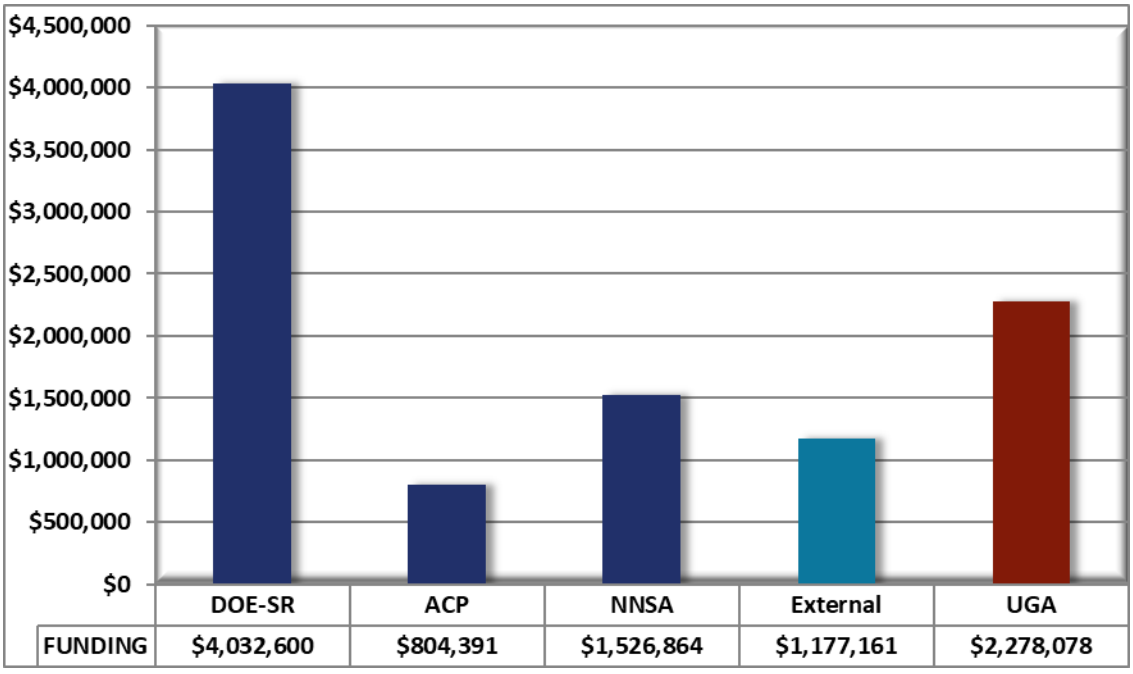

Table 2.2. SREL organizational structure for FY22. This table includes all research faculty, classified staff and Emeritus faculty in residence at the Savannah River Ecology Laboratory for any portion of the FY22 fiscal year.

SREL ORGANIZATIONAL CHART – FY22	
Director -- Dr. Olin E. Rhodes, Jr.	
Associate Director, Research Dr. T. DeVault **Research Faculty** Dr. R. Bier Dr. J. Seaman Dr. S. Lance Dr. Xiaoyu Xu Dr. T. Tuberville Dr. G. Dharmarajan Dr. D. Kaplan **Tenure Track Faculty** Dr. A. Dutta Dr. J. Abrams Dr. J. Beasley Dr. D. Aubrey Dr. J. Martin Dr. K. Capps Dr. B. Parrott Dr. B. Ferguson Dr. D. Peach **Emeritus Faculty in Residence** Dr. I. Brisbin, Jr. Dr. J.W. Gibbons **Post Docs** Dr. Z. Baddar Dr. F. Toledo Dr. J. Hill Dr. R. Saito Dr. D. Naha Dr. S. Gardner **Research Prof/Asst/Tech** Dr. K. Buhlmann M. Cromer M. Mason C. Kupferman D. Fletcher J. Skaggs R. Kennamer D. Scott A. Lindell P. Stankus L. Lee P. Robinson T. McIntosh B. Spencer J. Dirks P. Lyons E. Peck C. Sweeney J. Lott E. Spivey M. Strassburg M. Chapman P. Helm A. Lydeard M. Chapman R. Rimple M. Miller A. Bickle	**Assistant Director, Budget and Facilities** C. McBride **Safety** D. Mosser J. Kamps E. Peck **Computer Service and GIS Lab Manager** W. Taylor **Property Management** B. Morton **Outreach Program Staff** P. Perea V. Sutton-Jackson H. DeVault S. Poppy A. Hurst **Research and Facilities Technical Services** D. Kling D. Fraser M. Edwards M. Squires C. Cooper P. Carroll **Administrative Services** A. Thoerner M. Roberts J. Scott-Phillips C. Summer M. Wilburn V. Taylor M. Wead T. Clark **Temp. Research Technicians** 28 Temp. Techs were employed at SREL **Graduate Students** 69 Graduate Students advised by SREL faculty
	***As of 10/1/2022**

Table 2.3. Summary of professional activities and accomplishments by Savannah River Ecology Laboratory research faculty, research professionals, postdocs and students in FY22.

Publications and Reviews	Total
Peer Reviewed Journal Articles	75
Book and Book Chapters	1
Proceedings Articles	5
Primer or Other Scientific Notes	0
Non-Peer reviewed Articles	6
Articles In Press	11
Articles In Review	37
Peer Review of Manuscripts Conducted	74
External Funding (non-SRS)[1]	**Total**
External Grants Submitted but not funded as PI or CoPI	30
External Grant Funding Submitted but not funded as PI or CoPI	35,240,390
External Grants Funded as PI or CoPI[1]	32
External Grants Funded Dollars as PI or CoPI	7,292,352
Graduate Education and Postdocs	**Total**
MS Graduate Students Chaired – ongoing	42
MS Graduate Students Completed	9
PhD Graduate Students Chaired – ongoing	16
PhD Graduate Students Completed	1
Graduate Student Committee Memberships	76
Graduate Students Hosted at SREL	9
Post Docs Supervised	12
Presentations	**Total**
Invited Presentations	39
Professional Oral Presentations	84
Professional Poster Presentations	39
Extension Presentations	2
Extension Publications	5
Other	**Total**
Awards or Honors	24
Professional Society Committee Memberships	31
Courses Taught	21
Technical Research Consultations	11

[1] includes new grants and contracts, renewals and continuations associated with funding sources external to DOE. Total includes multi-year funding commitments received in FY22 and to be received in future fiscal years, and funding not directly in support of SREL research.

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 FY22 SREL faculty, staff, and students conducted and completed a diversity of environmental research projects on the SRS in support of the missions of SRNS, SRMC, 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 Projects, through subcontracts from SRMC 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 Closures Projects, SRMC, and DOE-SR

Accelerating remediation of tritiated water through silviculture

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
October, 2021; $100,000
PI and co-PIs
D. Aubrey – SREL
Objectives
Initiate field studies aimed at accelerating irrigation volumes at MWMF site. These studies will perform proof of concept field testing of (1) fertilization to expedite tree leaf area development and transpiration and (2) leaf litter removal to increase soil evaporation.
Summary of Research Activities
Twelve research plots were established prior to October 2021—six in the eastern expansion and six in the western expansion. Leaf area index (LAI) was measured monthly in each plot beginning in October 2021. Five trees in each plot were instrumented with thermal dissipation sap flow sensors to estimate whole-tree transpiration beginning in November 2021. Soil volumetric water content was monitored continuously across a soil depth profile in the center of each plot. A balanced fertilizer blend was broadcast across half of the plots in each expansion beginning in April, June, and August 2022. Leaf samples were collected from each plot for nutrient analysis in August 2022. We also instrumented one plot in the eastern expansion with six non-weighing soil lysimeters to estimate soil evaporation. We maintained leaf litter over the surface of three lysimeters and removed litter from the surface of three lysimeters. We estimated soil evaporation under these different conditions from October 2021 through September 2022. In FY23, we will continue fertilization and litter removal treatments, as well as the associated measurements mentioned above.
Conclusions
LAI began to increase after the initial fertilization occurred, but transpiration did not increase. We expect that LAI will continue to increase with additional fertilization and that transpiration will increase in response to fertilization during the second treatment year (i.e., FY23). Leaf nutritional responses are pending laboratory analysis. Removal of leaf litter from the soil surface increased soil evaporation by a factor of two relative to soil evaporation under intact litter layers.
Major Impact(s) of Research
Fertilization of forest stands and removal of leaf litter from the soil surface have potential to increase the amount of irrigation water applied at MWMF by accelerating evaporative water loss to the atmosphere.
Other Project Personnel
Fabio Toledo, Postdoctoral Research Associate, SREL

Tyler McIntosh, Research Technician, SREL
Marley Brown, Research Technician, SREL
Madeline Lyons, Research Technician, SREL
Jeffery Lott, Research Technician, SREL
Elizabeth Patton, Research Technician, SREL

External Collaborators

NA

Products (Publications, Presentations, Technical Reports)

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

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

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
October, 2021; $136,880
PI and co-PIs
Dr. Doug P. Aubrey and Dr. John C. Seaman – SREL
Objectives
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 2022, SREL worked collaboratively with the SRS-US Forest Service, SRNS-ACP, and DOE to complete the following activities: (1) collect, process, and analyze 11 soil cores collected to a depth of ≈ 3 m in ≈ 0.3 m increments twice annually to evaluate tritiated water (3H2O) distribution as an estimate of irrigation efficiency (≈ 220 samples annually); (2) maintain and update the Cornell Model for estimating irrigation efficiency; and (3) collect 11 surface soil samples on behalf of ACP for monitoring 1, 4-dioxane in.
Conclusions
1) When tritium leaching below the root zone was taken into account, the overall average ET efficiency for all plots was estimated to be ≈ 88.0 (± 10.1) and 88.1 (± 9.9) % for May and November 2021, respectively, based on soil core data.
2) Monthly efficiency results derived from the Cornell 1D model for December 2020 through December 2021 ranged from 67.1 to 88.8 % between plots, with lower efficiencies observed for the WEA plots with lower vegetation factors. The average efficiency for all plots was approximately 86.7 ± 1.2% for the original plots, 76.6 ± 3.7% for the EEA plots, and 68.8 ± 1.3% for the WEA plots, resulting in an overall of annual efficiency of 80.7 ± 7.4% for all 11 monitored plots.

Major Impact(s) of Research
Sampling, analyses, and modeling activities performed by SREL support the efficacy of the MWMF remediation effort.
Other Project Personnel
Christina Logan, Research Professional II, SREL
Jeffery Lott, Lab Technician, SREL
Michael Laird, Lab Technician, SREL
Fabio Toledo, Postdoctoral Researcher, SREL
Tyler McIntosh, Field Technician, SREL
Madeline Lyons, Field Technician, SREL
External Collaborators
NA
Products (Publications, Presentations, Technical Reports)
1) Logan, C. and J.C. Seaman. 2022. Estimating Evapo-Transpiration Losses for Tritium at the MWMF: 2021 End of Year Summary Report.

Efficacy of remedial actions on the bioavailability of ^{137}Cs and Hg within Lower Three Runs biota

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
November 2019; $77,913 (Year 1)
PI and co-PIs
Dr. Jim Beasley and Dr. Xiaoyu Xu – SREL
Objectives
Several aquatic systems on the Savannah River Site have been contaminated by low-level ^{137}Cs releases from nuclear production activities dating back to the late 1950s. In particular, given the high levels of ^{137}Cs maintained within the R-canal system and its sustained bioavailability, remedial actions are currently proposed for portions of the canal to reduce legacy ^{137}Cs remaining within the system. The proposed remedial actions would remove contaminated sediment from portions of R-canal, which if successful should substantially reduce the presence and bioavailability of ^{137}Cs, Hg, and any other contaminants present from prior industrial activities. The goal of this research is 1) to quantify accumulation and depuration rates of ^{137}Cs within biota and 2) to assess the efficacy of remedial efforts in R-canal at reducing the availability of ^{137}Cs and Hg in biota across trophic levels.
Summary of Research Activities
Field collections for this study were initiated in summer 2022 to collect baseline data on ^{137}Cs activity levels in biota prior to remedial activities, which are anticipated to occur in 2023. Field collections included American white water lilies (*Nymphaea odorata*), southern leopard frog tadpoles (*Lithobates sphenocephalus*), red swamp crayfish (*Procambarus clarkii),* and eastern mosquitofish (*Gambusia holbrooki*). Samples are currently being analyzed to quantify ^{137}Cs activity concentrations.
Conclusions
Sample analysis has not yet been completed; there are no conclusions at this time.
Major Impact(s) of Research
Data collected in this study will inform future remediation efforts on the SRS and other contaminated systems by evaluating the efficacy of the R-canal remediation efforts at reducing bioavailability of ^{137}Cs and Hg across a diverse assemblage of taxa. In addition, this research will produce novel information on the uptake and depuration of ^{137}Cs for taxa across multiple trophic levels inhabiting the Lower Three Runs system.
Other Project Personnel
Caitlin Kupferman, Research Professional, SREL
Katie Quinlin, M.S. student, SREL
External Collaborators
Danielle Hill, Ph.D. student, Griffith University
Products
Data from this research are currently being analyzed; thus, there are no products at this time.

D-Area ash plume: compilation of existing data and new ecological surveys to inform management decisions

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
October 2021; $77,913 (Year 1)
PI and co-PIs
Dr. Tracey D. Tuberville, Dr. Stacey Lance, David Scott, Dr. James Beasley and Dean Fletcher – SREL
Objectives
Our objectives as part of this project are to: 1) build upon the previously completed D-Area/Beaver Dam Creek Bibliography completed for ACP in 2011 and compile and synthesize the extensive existing data associated with the D-Area system including the DAB, DAP, DAPW, DAPF and nearby Beaver Dam Creek; 2) compare the biological communities of the DAP, DAPW, and down-gradient DAPF to reference sites through biotic surveys; and 3) quantify estimates of trace element concentrations in soil cores and targeted biota
Summary of Research Activities
We have summarized the results of peer-reviewed papers based on work in D-Area published since the last synthesis by SREL (Lindell et al. 2011, unpublished report). In addition, the graduate student has completed her course work and her research prospectus approved by her research committee. Other Year 1 (FY22) activities have focused on finalizing sampling design and reference site selection, installing passive and active sampling arrays for small vertebrates, and initiating monthly sampling efforts (July 2022). We have installed 15 sampling arrays plus and an additional 5 collection arrays for collecting target species for body burden analysis. To date, we have documented a total of 37 reptile, amphibian and small mammal species. We have added another reference site and will be installing two additional arrays early in FY23. Other FY23 activities will be continuing sampling to document community composition, collecting target biota across contamination gradient to quantify body burdens of ash-associated contaminants, and collecting soil arrays for contaminant analysis and evaluating the extent to which natural attenuation has occurred.
Conclusions
Sample analysis has not yet been completed; there are no conclusions at this time.
Major Impact(s) of Research
At the end of this project, we will be able to provide 1) a comprehensive report synthesizing research conducted within the D-Area System, 2) detailed comparisons of the plant and animal communities of the D-Area Plume to reference sites to evaluate community level differences between impacted and unimpacted sites, 3) quantify the extent to which natural attenuation has reduced contaminant levels or availability by comparing contemporary soil samples with historical soil contaminant levels; and 4) provide insight into best course action for managing this ash-contaminated site.
Other Project Personnel
Kelly Holland, MS Student, SREL
Ryne Huggins, Research Technician, SREL
External Collaborators
NA
Products (Publications, Presentations, Technical Reports)
This project is still in progress and sample analysis is not complete; there are no products at this time.

Benthic macroinvertebrates as indicators of stream health on the Savannah River Site

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
October 1, 2021; $269,244
PI and co-PIs
Dr. Raven L. Bier, Dean E. Fletcher and Dr. Stacey L. Lance – SREL
Objectives
The objective of this project is to continue the long-term monitoring of aquatic macroinvertebrates at Savannah River Site streams historically sampled by the Integrator Operable Units (IOUs) program to collect critical data to support and evaluate ongoing and future remedial action by the Area Completion Project.
Summary of Research Activities
This work builds on prior sampling and analysis of macroinvertebrate communities in stream ecosystems across the Savannah River Site that has been used in bioassessments of Savannah River Site stream ecosystem quality since the mid-1990s. Twenty-three sites from Fourmile Branch, Pen Branch, Steel Creek, and Upper Three Runs IOU areas have been identified for sampling, evaluated for outlying factors (e.g., beaver dams) and the selected sites have been marked. Personnel have trained on the Multihabitat Sampling Protocol (SCDHEC, 2000) and prepared for sample collection to happen in October-December 2022. Historical data have been received and are being prepared to use for evaluations of long-term trends in aquatic macroinvertebrate community richness and for a bioclassification rating based on the number of EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa.
Conclusions
Sample collection and analysis have not yet been completed; there are no conclusions at this time.
Major Impact(s) of Research
1) Supports ongoing remedial action by ACP by using macroinvertebrate community structure and diversity to assess the functional integrity of SRS streams.
2) Identification of native and non-native macroinvertebrate taxa that display a clear response to effects of anthropogenic activity, and which can be used as indicator taxa in future studies.
3) Comparison of taxa specificity and sensitivity of the Multihabitat Sampling Protocol and Hester-Dendy assessment approaches to provide guidance to future evaluations.

Other Project Personnel
Dr. Krista A. Capps, SREL
Viviana Bravo, MS student, SREL
Christian Swartzbaugh, MS student, SREL
Elise Webb, MS student, SREL
Andrew Lydeard, Research Technician, SREL
Destiny Willard, Research Technician, SREL
External Collaborators
NA
Products (Publications, Presentations, Technical Reports)
This project is still in progress and sample collection and analysis are not complete; there are no products at this time.

Fish assemblages and biotic integrity as indicators of stream health on the Savannah River Site

Funding Entity
SRNS Area Closures Projects
Start Date and Funding Amount
October 1, 2021; $269,244
PI and co-PIs
Stacey Lance, Krista Capps, Dean Fletcher, Ben Parrott and Raven Bier – SREL
Objectives
The primary objective of this project is to continue the long-term stream monitoring by conducting fish community bioassessments at sites historically sampled in the integrator operable units (IOU) program to support the Area Completion Project. Continuation of the bioassessment program will allow the site to monitor habitat quality and biotic integrity and make management decisions.
Summary of Research Activities
This project represents a continuation of long-term monitoring of streams on the Savannah River Site. The data are used to assess the ecosystem health and inform management decisions. To add another year of sampling effort we first coordinated with ACP to select 20 sampling sites across the IOUs. At each site we sampled the fish community by backpack electrofishing a total of 200 m per site by sampling in four 50 m stream segments. We made three passes while moving upstream and ensuring we sampled all microhabitats (e.g., riffles, runs, pools, etc.). We identified all fish to species in the field before releasing them back into the stream. In total we identified 8512 fish, representing 31 species. The field work required extensive assistance (see other project personnel). We also received the historical data which we will use to examine long-term trends and compare to current community attributes.
Conclusions
The project is in its first of three years, and we do not yet have conclusions.
Major Impact(s) of Research
The project is in its first of three years, and we do not yet have major impacts, but the data will support ongoing remedial action by ACP by using fish community structure and diversity to assess the functional integrity of SRS streams and identify native fish community characteristics that display clear responses to effects of land use change and pollution, and which may be used in future assessments.
Other Project Personnel
Christian Swartzbaugh, MS student, SREL
Viviana Bravo, MS student, SREL
Andrew Lydeard, Research Technician, SREL
E. Tucker Stonecypher, MS student, SREL
Elise Webb, MS student, SREL
Jonathon Skaggs, Research Professional, SREL
Ezmie Trevarrow, Research Technician, SREL
Padraic Robinson, Research Professional, SREL
Carson Pakula, MS student, SREL
Vienna Cartwright, MS student, SREL
Adam McFall, MS student, SREL
Emma Kelsick, MS student, SREL
Chris Smaga, PhD student, SREL
Kelly Holland, MS student, SREL
External Collaborators
Cody Whitlock, Undergraduate student, UGA
Products (Publications, Presentations, Technical Reports)
There are no products 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 FY22

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 to 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 (SREL Impacts) 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 have been on snakes and alligators, the programs have also provided information on raptors, plants, insects, spiders, turtles, and mammals of concern. During the 2022 fiscal year, the Outreach Program hosted three safety talks for SRS employees about wildlife and snake safety. In addition to these talks, Outreach Staff are available to assist SRS employees about a variety of wildlife questions that may come up.

The Outreach Program historically 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 biweekly throughout the year (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 FY22, the Outreach Program hosted 10 public tours with 228 people in attendance. In addition to public tours, the Outreach Program hosted 20 general and public tours for SRS, SRNL, SRMC, SRETE, Air Force Global Strike Command Interns, SRNS, DOE/NNSA, SRS Interns, ELDP SRNS, and SRS Security and Safety personnel with 371 attending.

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 FY22, the seminar program focused on the interview seminars given by candidates for the four joint faculty positions between SREL and departments on UGA main campus (Geology, Department of Infectious Diseases), the assistant director for outreach and education position, and a term-limited research scientist position in support of analytical services. SREL hosted 13 candidates who gave seminars as part of the interview process; these seminars featured the latest research in disease ecology, radio-ecology, ecotoxicology, subsurface contaminant transport, biogeochemistry, environmental education, and other topics relevant to the SRS. SREL students and faculty based on UGA main campus were also able to attend seminars remotely via Zoom. In addition to interview seminars, SREL hosted 10 graduate student defense seminars during FY22, and one campus-based SREL faculty member gave a research seminar via Zoom.

Other programs in which Outreach personnel participate include: the Let's Grow Together pollinator 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 and visit outdoor locations; 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; and 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, birds, small mammals, and invertebrates.

During FY22, The Let's Grow Together program expanded the pollinator garden at the SREL Conference Center and continued partnering with local schools in areas that are traditionally underrepresented in STEM education to present 28 engaging hands-on presentations. The outreach staff presented 20 Ecologist for a Day field excursions at the UGA Conference Center, 157 Ecotalks in the community, and participated in 5 community and civic events. The educational programs served 14,868 across the CSRA region. A total of 6,713 children and youth were specifically engaged with during FY22.

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, Instagram, YouTube, TikTok, and other emerging social media platforms. During FY22, the SREL outreach programs, press releases, media advisories, and staff appeared in 356 media mentions in newspapers, magazines, television shows, and radio programs with a media reach of 545.7 million. The media coverage spanned local, regional, national and international outlets. The SREL Facebook community grew to more than 1,800 followers and had a reach of over 18,000 people for its content. The SREL Twitter community grew to 692 followers and had more than 67,000 impressions of its content. The SREL Instagram community grew to more than 10,485 followers and generated more than 557,594 impressions of its content and directly engaged with over 171,000 comments, interactions, and responses to content. Several of Outreach posts went viral. The SREL YouTube Channel grew to 65 subscribers and generated more than 20,855 impressions of its videos. This year, the SREL Outreach team began a TikTok account and currently has 5,083 followers on this platform. The TikTok account was established midyear. The SREL Outreach Facebook page was consolidated with SREL Facebook page to streamline content on this platform.

The Outreach section of the SREL website, https://srel.uga.edu/outreach, receives many visitors, as it has links to ever popular outreach programs, outreach fact sheets and educational products, and the Ecoviews weekly newspaper column. It also invites questions about wildlife native to SRS that are answered by the Outreach personnel. This website is frequented by educators, researchers and news outlets from around the world, who utilize the materials in their classrooms, research and news platforms. SREL distributes thousands of educational products and materials worldwide to schools, organizations, and the general public.

TASK 5. SREL will maintain ecological databases 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 FY22

IT Infrastructure

The IT department at SREL is dedicated to providing a reliable IT network that effectively stores and protects our data, providing our employees with an efficient set of platforms with which to perform their job-related functions, and keeping us connected with the greater community with which we interact. To that end we have invested in several new IT components. We purchased 18 personal computers in the last year for our staff and researchers so we can continue to operate with the computer efficiencies required for much of our related research. We also increased our connectivity by adding computer network ports to several new locations and increasing our wireless antennae array for better wireless reception.

We also have strived over the last few years to integrate our IT functions into the University of Georgia's IT network. This historically has been difficult because we are located on a secure DOE facility rather than on campus. We worked with DOE a few years ago to create a direct fiber optic connection from our location to the Athens campus. Through this connection, the University of Georgia IT department has managed and maintained all of SREL's network switches and routers. This year they replaced the router between SREL and UGA campus with a faster and more manageable one, which allows us to operate seamlessly with the main campus network system. This increased our IT efficiencies and helped us to lower operational costs.

Over the past year we have continued the move to Microsoft OneDrive for cloud storage. With the addition of Microsoft Teams for virtual meetings and cloud storage we have greatly increased our cloud storage space. Microsoft Teams and OneDrive storage are provided to SREL by UGA at no cost. Prior to this cloud storage option, we maintained our own servers for data storage at a cost of $15,000-$20,000 annually. Also, over the past year we have continued the process of using a remote learning system at SREL. This remote conferencing capability is a Cisco Web -X system and we have configured one large classroom and one small conference room with this capability. This system allows our faculty to teach and interact virtually with the main UGA campus, greatly expanding our educational reach. It also allows our Outreach Program to hold virtual seminars with a wider range of public groups that were not normally within reach.

Efficient IT systems and networks are a necessary part of successfully operating in today's world and SREL remains committed to using our funds to develop the systems and platforms that effectively serve our stakeholders. Our recent accomplishments are significant steps in the direction of accomplishing that objective.

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.

In FY22 SREL continued to gather new data submissions via the checkout and manuscript notification processes. This includes a substantial collection from a retiring staff member. These data continue to be stored via the Excel data archiving template, until the data entry portal is complete.

We also continued work on legacy data, including examination and digitization of hard copies as well as retrieval and processing of digital files saved on legacy media. Through the UGA Library we obtained reads for many of our 5.25-inch floppies, although they were generally not usable due to lack of headers. We also obtained reads for our 9-track data tapes through a contractor and have analyzed them for usable material.

We are also working to preserve other legacy materials. This year we scanned the NERP/Set-Aside collection formerly located in the library. We were also able to obtain and scan important legacy NERP-related documents that had been stored offsite. These materials are now available in digital form, thus making them much more accessible as well as protecting the original copies from physical wear or other physical degradation; some of them are more than 50 years old. We also made a digital version of the SREL Radioecology Bibliography. Although these are older resources, a number of them were not available online. We also continue to scan theses/dissertations and relevant grey literature as discovered. We also began scanning and organizing SREL's photo and slide archives, which we are doing in-house with the acquisition of a bulk 35mm slide scanner.

Web forms for entering and revising metadata, uploading data files to the server, reviewing metadata submissions, and publishing metadata and data sets to the main database catalog have been uploaded to the SREL server and the web code has been integrated with the SREL website template. Additional web forms for self-registration and validation of new users, adding new personnel, and managing personnel status have recently been added to the web application. The system is in the final stages of debugging and testing and should be ready for production in the coming weeks. However, staff time conflicts continue to slow progress.

Features that are installed and currently being debugged include self-registration and validation of new database users, including secure password hashing and password resets based on emailed security codes; data file upload forms for new metadata submissions; data submission review forms, with automatic emailing of data manager decisions or requests for revisions to metadata submitters; automatic registration of approved submissions for display in the data catalog, including archiving of submitted data files to the primary data directory organized in subdirectories by metadata ID; management forms for revising status and release dates of archived data sets; management forms for adding new personnel and revising active/inactive status by SREL data managers; and MS Access 365-compatible forms for managing rarely-updated content in the database.

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 FY22

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.

- At the close of FY22 the Par Pond East (PPE) prescription, which includes four Set-Aside Areas (Mona Bay and Woodward Bay, Little Cypress Bay, Craig's Pond and Sarracenia Bay, and the Sandhills Fire Site) was nearing completion. Thinning is planned at all but the Sandhills Fire Site, including timber removal from the basin of Woodward Bay. Additionally, SREL researchers contributed recommendations for the rest of the PPE administrative watershed to improve habitat for gopher frog and snake populations, especially focusing on creating a corridor of suitable gopher frog habitat between the Craig's Pond and Sarracenia Bay Set-Aside and the Mona Bay and Woodward Bay Set-Aside Area, two important gopher frog sites.
- SREL and USFS filed a joint Site Use Permit (SU-22-37-R) for the establishment of seven gopher frog habitat management areas, three of which include three Set-Aside areas (Thunder Bay, Mona Bay and Woodward Bay, and Craig's Pond and Sarracenia Bay). This permit provides a defined geographic scope as well as framework for well-timed application of prescribed fire and other treatments needed to maintain upland habitat quality for this species. For the Set-Aside areas this will simplify management, as well as enhance adjacent habitat which will support gopher frog populations using the wetlands.
- SREL amphibian ecologists opened dialog with the adjoining landowner regarding gopher frog habitat management at lower Craig's Pond.

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.
- Partial drift fences installed at Craig's Pond in 2010 were removed. This project was a collaboration with SCDNR.
- The box turtle release study in the E. P. Odum Wetland Set-Aside remains active and has been extended for two years. This project is a collaboration with USFS-SR and SCDNR.
- A tributary in the E.P. Odum Wetland Set-Aside was used as a reference stream to assess the effects of stream incision on riparian hydrology and groundwater geochemistry.
- A tributary in the E.P. Odum Wetland Set-Aside was used as a reference site to assess effects of excessive stormwater runoff on aquatic insect emergence, stream trophic organization, and stream channel, riparian and hillside spider communities.
- Dragonfly nymphs and sediment from Flamingo Bay were used in studies assessing the effects of contaminated constructed wetlands on aquatic insects.
- The E. P. Odum Wetland Set-Aside provided sites for macroinvertebrate and fish sampling as part of long-term monitoring at sites historically sampled by the IOU program to collect critical data to support and evaluate ongoing and future remedial action by ACP. Macroinvertebrate surveys and habitat assessments are conducted at 23 sites distributed across SRS's five major stream systems.
- Streams in the E.P. Odum Wetlands Set-Aside and Ruth Patrick Meyers Branch Set-Aside provided field sites for a study examining effects of macroplastic surfaces on biofilm succession and microbial community composition.
- The E. P. Odum Wetland, Organic Soils, and Mature Hardwood Set-Asides provided field sites for a study of ecological factors affecting the success of rabies elimination in the southeastern US. This project has yielded three MS theses (D. Bernasconi, J. Helton, W. Dixon). FY22 was the final year of field data collection. This project was a collaboration with USDA APHIS.
- The E. P. Odum Wetland Set-Aside area provided several field sites for a study with UGA Warnell and the University of Hull, UK examining the problem-solving skills of raccoons and opossums through observation of species' behavioral responses to obtaining out-of-reach food rewards.
- The E. P. Odum Wetland Set-Aside area provided several field sites for a study with UGA Warnell examining the efficacy of commercially available deterrents in deterring deer from bait piles used to attract wild pigs.
- Craig's Pond, Sarracenia Bay, Mona Bay, and Thunder Bay, as well as nine 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, and as part of a regional southeastern population-status study. This year no egg masses were found at SRS because the wetlands did not receive adequate rainfall.
- 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 44 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, as well using telomeres as indicators of cellular aging and stress in the marbled salamander.
- 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 43 isolated wetlands across the SRS, including the following Set

Asides: Rainbow Bay Amphibian Reserve, Cypress Bay, Dry Bay, Ellenton Bay, Mona Bay and Woodward Bay, Flamingo Bay, Thunder Bay, Craig's Pond and Sarracenia Bay, Ginger's Bay, and Road 6 Bay.

- Amphibian species in Set-Aside Area bays 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.

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. In FY22 the graduate research assistant (Amanda Komasinski) studying the NERP program under the direction of SREL faculty member Dr. Jesse Abrams completed her thesis, entitled *A Profile of Science Policy Changes for the U.S. Department of Energy National Environmental Research Parks*.

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 FY22 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 former Mixed Oxide Fuel Fabrication Facility construction site 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 (NNSA)

H-02 Constructed Wetland Studies—Metal Biogeochemical Processes

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
October 2021; $275,000
PI and co-PIs
Dr. Xiaoyu Xu – SREL
Objectives
This research aims 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 the removal efficiency of metals, primarily copper (Cu) and zinc (Zn), for the wetland system, the chemical speciation and bioavailability of metals in water and sediment, the stability of sediment accumulated metals, and the potential for remobilizing sediment metals, the overall biogeochemistry of metals in the wetland ecosystem, and the relative environmental impacts of the free water surface constructed wetland.
Summary of Research Activities
Over the last six years, we collected surface water samples to monitor the H-02 wetland performances, took sediment cores to evaluate the stability and sequestration of metals, applied passive samples to track metal lability and movement, adopted multiple approaches to explore metal removal processes, and tracked the bioaccumulation and biomagnification of atmospheric mercury that was deposited in the wetland.
1) The function of the H-02 wetland system
Water samples were collected monthly over FY21 in the primary discharge pipes, retention basin, influent, effluent, both treatment cells, and the discharge stream connected to regulatory Upper Three Runs. Water quality parameters and metal concentrations (total and dissolved Cu and Zn) were measured. Generally, the H-02 wetland system still functioned well in FY22. The overall metal removal efficiencies were 66.4% for total Cu and 80.6% for total Zn; Zn removal efficiency even increased than FY21. The influent's concentration was higher than the effluent and stream, and the effluent concentrations were lower than the NPDES discharge permit. Water quality was improved after running through the wetland cells; the alkaline water became nearly neutral with noticeably decreased pH values.

2) Fate of metals: using passive samplers to study metal speciation and bioavailability

The detailed meta biogeochemical processes were studied in FY22 to fully understand metal removal processes and estimate the wetland lifespan. After wastewater is treated in the wetland cells, metals precipitate to the sediment and undergo complicated processes, forming multiple metal species and depositing to different layers of sediment. Ideally, all metal ions eventually become extremely stable meal-sulfur complexes (i.e., CuS and ZnS) by interacting with sulfur through microbial sulfate reduction reactions. However, other metal species co-exist in the water and sediment due to various chemical reactions, such as metal ions and metal complexes with organic matter, acid volatile sulfur, and iron. Exploring metal transportation among different compartments in the wetland helps us fully understand metal removal processes and estimate the wetland lifespan.

Diffusive Gradients in Thin Films (DGTs) were continuously used to measure labile/bioavailable metal concentrations in the water. Piston DGTs were deployed monthly in the same locations where surface waters were collected. Cu and Zn demonstrated different speciation. The DGT-indicated labile and/or bioavailable Cu (Cu_{DGT}) concentrations were much lower than total and dissolved Cu, but all most all dissolved Zn exist as Zn_{DGT}. This means Cu was less labile than Zn in the wetland water, and under the same environmental conditions, Zn more easily becomes bioavailable to organisms than Cu.

A monthly study on seasonal effects on metal bioavailability in the sediment porewater of wetland cells was conducted in FY22. Relatively high labile metal concentrations were observed in the sediment porewater. Labile Cu concentrations were higher than in previous years, indicating an increase in the deposition and bioavailability of Cu. We did not find any differences in labile Zn concentrations. Porewater chemistry, such as pH, oxygen, DOC, and anions, was closely related to metal speciation and bioavailability in sediment. We will run a generalized linear model to explore the dominating factors controlling metal speciation in sediment once all data are in place. Until now, with the results we have, we studied the temporal differences and spatial distribution for DOC, chloride, and sulfate in porewater.

3) Metal biogeochemistry and removal process: implications from microbial activities

The monthly study on sediment also includes the sampling of sediment cores, where samples from the flocculent and surface sediments were collected to perform microbial community structure analysis with quantitative polymerase chain reaction (qPCR) and the next generation sequencing (NGS). From the first seven years (2007-2014), SRB is the most prominent bacterial group in both seasons and all locations, indicating the primary metal removal process is forming the stable metal-sulfur complexes. However, MOB has become the most prominent group instead of SRB in 2020 and 2021. What is interesting is that although the dominant microbial group changed, the metal removal efficiency remained the same or even increased. So some other biogeochemical processes must have taken place to remove and stabilize metals in the wetland cells. But it is still being determined what processes play the role and if the newly formed metal complexes are as stable as metal-sulfur. Our future studies in FY23 will focus on this question.

4) Mercury: accumulation, methylation, and remediation

The H-02 wetland receives atmospheric mercury (Hg) from surrounding industrial activities and bioaccumulates Hg in the wetland ecosystem. We collected sediment, porewater, surface water, and giant bulrush in FY21 to investigate Hg accumulation in the wetland cells. Total Hg levels in the sediment were different among layers, high in the flocculent layer and low in the upper and bottom layers. Even so, the deposited Hg from the air can be continuously methylated and biomagnified in the ecosystem. We observed high total and methyl- Hg concentrations in the outside portion of the culms in giant bulrush and low concentrations in the inside portion of the culms. A lab-controlled study was conducted to explore the potential Hg methylation capacity of the sediment in the wetland cells. Compared to a natural aquatic system (stream), the wetland sediment showed lower methylation capacity due to the lower concentrations of the newly produced methyl-Hg.

Two studies on mercury remediation were conducted in FY22. (1) The coupling of duckweed for remediation and DGTs for abiotic monitoring makes an effective system for Hg remediation. The bioaccumulation of inorganic Hg by mono- and mixed populations of *Lemna minor* and *Spirodela polyrhiza* were compared. Both duckweed species appreciably decreased water Hg concentration over the four-day exposure, and the stronger remediation capability by duckweed was observed in the mixed

culture than in the mono- culture. (2) A mesocosm study was used to determine whether biochar is an effective method for the remediation of Hg from sediment during periodic flooding conditions. The primary results indicate that biochar is an effective remediation source for contaminated sediments. Specifically, the decrease in total Hg concentrations associated with sulfur-modified biochar is promising. However, sulfur-modified biochar may cause an increase in bioavailable Hg and methyl-Hg.

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, and water quality was improved after being treated by the wetland cells. Metal removal efficiencies are consistently high.
2) Metal bioavailability and toxicity were reduced due to the decreased concentrations of labile metals, such as DGT-measured labile and/or bioavailable metals.
3) Most deposited metals were retained in the surface sediment and were not transported to the sulfide mineral layer that was deeper in the sediment, which may lead to decreased removal efficiency and performance in the future when the surface sediment is saturated.
4) The metal-removal processes in both wetland cells are related to season, sulfur cycling in the sediment, biomass productivity, and routine maintenance.
5) Microbial community structure significantly changed compared to the first seven years of wetland construction, leading to the change of dominating metal removal processes.
6) The wetland treatment cells become sinks of the atmospheric Hg and sources of methyl-Hg to the wetland ecosystem and the surrounding environment. But the methylation potential so far is relatively low.

Major Impacts of Research

1) This research supports the use of cost-effective constructed wetlands for the treatment of metal-contaminated wastewater 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 surrounding environments and supports DOE's 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

Zeinah Elhaj Baddar, postdoctoral research associate, SREL
Chongyang Qin, postdoctoral research associate, SREL
Jake Smith, Ph.D. student, SREL
Cher Nicolson, M.S. student, SREL
Brittany Jensen, M.S. student, SREL
Erin Peck, lab manager, SREL
Breann Spencer, lab manager, SREL

External Collaborators

Anna Knox, SRNL
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Peter Hazelton, Warnell School of Forestry and Natural Resources, UGA
Lori Sutter, Warnell School of Forestry and Natural Resources, UGA
Valentine Nzengung, Geology Department, UGA
Douglas Dvoracek, Senior Research Scientist, Center for Applied Isotope Study (CAIS), UGA

Products (Publications, Presentations, Technical Reports)

Z.E. Baddar, X. Xu. 2022. Evaluation of changes in the microbial community structure in the sediments of a constructed wetland over the years. Archives of Microbiology. 204: 552. DOI: 10.1007/s00203-022-03157-5.

X. Xu, Z.E. Baddar. 2022. Metal fluxes at the sediment-water interface in a free water surface constructed wetland. *Environmental Monitoring and Assessment*. 194: 571. DOI: 10.1007/s10661-022-10258-7.

C. Qin, X. Xu, E. Peck. 2022. Sink or source? Insights into the behavior of copper and zinc in the sediment porewater of a constructed wetland by peepers. *Science of the Total Environment*, 821, 153127. DOI: 10.1016/j.scitotenv.2022.153127.

C. Qin, X. Xu, E. Peck. 2022. Metal removal by a free surface constructed wetland and prediction of metal bioavailability and toxicity with diffusive gradients in thin films (DGT) and biotic ligand model (BLM). *Environmental Management*, 69(5): 994-1004. DOI: 10.1007/s00267-021-01567-7.

Nicholson, C.M., X. Xu, E. Peck, A. Knox. 2022. Seasonal Sulfur Redox Cycling in Two Constructed Wetlands in the Southeastern U.S. Science of the Total Environment. (in review)

Z. Elhaj Baddar, E. Peck, and X. Xu. Deposition of copper (Cu) and zinc (Zn) in the sediments of metal removal constructed wetlands: a seven-year study. ASA, CSSA and SSSA Annual Meeting. Nov 2021. Salt Lake City, UT.

B. Jensen, X. Xu, and R. Bringolf. Utilization of biochars to remediate mercury and methylmercury contaminated soils on the Savannah River Site. North America SETAC 2021. Nov 2021.

C. Nicholson, X. Xu, R. Bringolf, and A. S. Knox. Sulfur redox cycling and metal remediation in two constructed wetlands in the Southeastern United States. North America SETAC 2021. Nov 2021.

H-02 Constructed Wetland Studies—Amphibian Ecotoxicology

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
October 1, 2021; $324,498
PI and co-PI's (and Affiliations)
Dr. Stacey Lance, Krista Capps, and David Scott – SREL
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 2021 to September 2022. Following up on previous research, during this year we finalized our analysis on amphibian communities and disease prevalence from 20 wetlands on the SRS. We will be submitting a manuscript for to *Ecology* in late 2022. We completed a multiple year study investigating whether environmental DNA techniques can be used to assess the presence/absence and relative abundance of amphibians in wetlands. To accomplish this, we conducted both controlled laboratory studies and field studies in the H-02 wetlands. We compared traditional catch per unit efforts to estimate abundance and with quantitative PCR and metabarcoding methods. Finally, we completed the 44thyear of monitoring at RB, and are analyzing the data for manuscripts on the context of community shifts in response to environmental change and subsequent impacts on nutrient cycling.

Conclusions
1) Ranavirus prevalence is driven by a combination of environmental factors (e.g. canopy cover, air and water temperature) and community level factors, (e.g. community competence, abundance of salamanders) but not by species richness.
2) 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.
3) Ignoring adult mortality in models of terrestrial flux of biomass leads to erroneous conclusions and the probability of terrestrial flux of nutrients due to amphibian movements is tightly linked to wetland hydroperiod and amphibian biomass, but not specific species
4) Environmental DNA can be used to estimate amphibian communities in the H-02 and other wetlands on the SRS.

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 provide critical results concerning the contentious biodiversity-disease relationship. We demonstrate that at intermediate scales erroneous conclusions are made if environmental factors are not included. Further, completely open canopy wetlands, like the H-02 wetlands, are at higher risk of sustaining an outbreak of ranavirus.

4) Our combined research at H-02, A-01 and D-Area are providing insight into how amphibian populations may locally adapt to metal contamination. Results from A-01 and D-Area suggest that within a few more generations amphibians at H-02 may be more tolerant of copper, however this may come with tradeoffs that reduce fitness in non-contaminated environments.
5) 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 NNSA-supported Project Personnel and Students

Tucker Stonecypher, MS student, SREL
Padraic Robinson, Research Professional, SREL

External Collaborators

Dr. Rebecca Hale, UNC Asheville
Dr. Sabrina Burmeister, UNC Chapel Hill

Products

Lance, S.L. Chernobyl wolves, toxic toads, and deformed frogs: how important are sublethal effects in conservation? 2021. University of Illinois, Program in Ecology, Evolutionary Biology, and Conservation.

Robinson, P., O'Bryhim, J., Scott, D., McFall, A., Rodriquez, G., Lance, S. eDNA concentration is moderately correlated to amphibian abundance in both the laboratory and in wetlands. Joint Meetings of Icthyologists and Herpetologists, Spokane, WA.

H-02 Constructed Wetland Studies—Ecosystem Health

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
October 1, 2021; $158,681
PI and co-PIs
Olin E. Rhodes and Dean E. Fletcher – SREL
Objectives
The H-02 wetland 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. However, their application for the treatment of metal contaminated wastewater is still being refined. Our overall goal is to evaluate wetland effectiveness, assess potential impacts on biota, and develop strategies to maintain or improve the treatment efficiency of the wetlands to ensure long-term sustainability. This research continues to use aquatic invertebrates as biomonitors to evaluate wetland efficiency, biological transport of contaminants, and the movement of metals into and through food webs. Additionally, we evaluate the effect of storm events and other biological and physical factors.
Summary of Research Activities
Excessive runoff from impervious surfaces can mobilize contaminants in depositional zones in streams, basins, as well as constructed wetlands. We are evaluating the dynamics of the accumulation of contaminants in these sinks and mobilization during storm events. The amount of contaminant being transported, chemical phase, mode of transport, and bioavailability can change throughout a storm event. Previous work found suspended solids and metals to be mobilized during rain storm events. During the early stages of large storms, suspended solid and metal flux was increased followed by substantial fluxes of metals. However, this work only evaluated influent and effluent of the treatment cells. This work has been expanded to evaluate transport of suspended solids and metals at 9 locations throughout the wetland system at base flow and during storm events. These analyses are identifying the sources of mobilized solids as well as total and dissolved metals. We are leveraging efforts with funding for NNSA stream studies to expand evaluations of contaminants pulsing through streams during storm events. Twenty-four sites distributed across 7 streams, including the H-02 receiving stream and spanning a gradient in severity of disturbance, were selected for evaluation. Data loggers were installed to continuously monitor water depth, temperature, and conductivity. Metals/metalloids were analyzed during an initial sampling at each site. Sampling will continue once discharge rating curves are developed to calculate discharge from water level. The potential influence of vegetation management of the treatment cell margins was evaluated using 79 peeper water samplers. Samplers were placed along the longitudinal flow gradient of the wetland cells in the cleared margins and vegetated areas. Samplers were placed at 2 depths at each location to evaluate surface flows.
Additionally, sample processing is in progress to evaluate metal accumulation and body condition in tetragnathid spiders that construct webs horizontally above the water's surface and capture diverse taxa of smaller emerging insects. Spiders are being analyzed from all sections of the H-02 wetland, Fire Pond as a non-contaminated reference system, and impacted wetlands in D and E Areas. Sediment samples were also analyzed for trace elements, organic matter content and sediment texture from these sites. Stable isotope analyses are also evaluating spider trophic position and food sources. Compound Specific Stable Isotope analyses are also being employed to evaluate the influence of stream disturbance on trophic organization. A total of 167 samples distributed across six species and five streams, including the H-02 receiving stream, were processed and sent to the University of California-Davis Stable Isotope Facility for analyses. In coordination with another funded study of PFAS distributions and the NNSA streams project, sediment and water were sampled for metal analyses sampled from 30 locations. Samples were collected from each site to measure trace elements including mercury. Sites likely to be sinks for

contaminants such as basins, ponds, and beaver ponds were targeted. This included the H-02 wetland and a basin at the head of the S Area branch of the H-02 receiving stream.

Conclusions

1) Storm events mobilize both solid materials as well as total and dissolved metal loads entering and leaving the constructed wetlands.
2) The source of the mobilized solids and metals that are mobilized varies among storms, but patterns in source and influence of flow path distance are emerging and will be further evaluated in FY23.
3) Analyses to date do not indicate that clearing vegetation from the sides is increasing flowrates and metal transport along the treatment wetland sides.

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) Use of biomonitors in addition to traditional water and sediment analyses 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) Overall, identifying factors that reduce constructed wetland efficiency or impact biota will allow evaluation of the potential need to implement management strategies for maximizing wetland efficiency.

Other Project Personnel

Erin Spivey, Research Technician, SREL
Andrew Lydeard, Research Technician, SREL
Dr. Xiaoyu Xu, Assistant Research Scientist, SREL
Dr. Guha Dharmarajan, Assistant Research Scientist, SREL
Paul Stankus, Research Professional, SREL

External Collaborators

Brian Bledsoe, Director of Institute for Resilient Infrastructure Systems, UGA

Products

Fletcher, D.E., A.H. Lindell, P.T. Stankus, C.M. Fulghum, and E.A. Spivey. 2022. Species- and Element-Specific Patterns of Metal Flux from Contaminated Wetlands versus Metals Shed with Exuviae in Emerging Dragonflies. Environmental Pollution 300 (2022) 118976.

Fletcher, D.E., E.A. Spivey, C.M. Fulghum, and, P.T. Stankus. 2022. Nearness to bottom sediment, vertically stratified water metal concentrations, and metal accumulation in dragonfly nymphs—a field caging experiment. Society of Environmental Toxicology and Chemistry Annual Conference. Nov. 14-18, 2021. Virtual.

Spivey, E.A, G. Dharmarajan, J.E. Dirks, and D.E. Fletcher. 2022. Copper accumulation through trophic vs. direct water exposure routes in a dragonfly nymph/mosquito larvae laboratory food chain. Society of Environmental Toxicology and Chemistry Annual Conference. Nov. 14-18, 2021. Virtual.

Fletcher, D.E., E.A. Spivey, C.M. Fulghum, F. Coutelot, and, P.T. Stankus. 2022. Nearness to bottom sediment, vertically stratified water metal concentrations, and metal accumulation in dragonfly nymphs—a field caging experiment. Joint Aquatic Sciences Meeting, Grand Rapids, MI, May 14-20, 2022.

Spivey, E.A, G. Dharmarajan, J.E. Dirks, and D.E. Fletcher. 2022. Copper accumulation through trophic vs. direct water exposure routes in a dragonfly nymph/mosquito larvae laboratory food chain. Society of Environmental Toxicology and Chemistry Annual Conference. Nov. 14-18, 2021. Virtual.

H-02 Constructed Wetland Studies—Terrestrial Food Web Monitoring

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
November 2021; $68,000
PI and co-PIs
Dr. O. E. Rhodes, Jr. and Dr. T. L. DeVault – SREL
Objectives
The objective of this project is to develop and assess methods for determining the extent to which metals sequestered in the H-02 treatment wetlands are transferred into the surrounding terrestrial environment via aquatic to terrestrial food webs. This information allows for more complete understanding of the potential impacts (or lack thereof) of Tritium Facility discharge effluent to the terrestrial environment surrounding Crouch Branch and Upper Three Runs to meet the regulatory compliance and DOE ecological stewardship goals.
Summary of Research Activities
The H-02 treatment wetland was constructed as a green technology initiative to remove metals, especially copper (Cu) and zinc (Zn), in discharge waters from the NNSA Tritium Processing facility. Constructed wetlands have been widely employed to reduce nutrients and prevent eutrophication of surface waters. However, their application for treatment of metal contaminated wastewater is relatively novel, and it is unclear if and how much of the sequestered metals are transferred from the aquatic food web into the surrounding terrestrial environment. Despite meeting regulatory compliance, a previous study showed that elevated levels of trace elements were bio-available downstream, as seen in bottom dwelling dragonfly nymphs and crayfish, showing the importance of assessing the extent of potential contamination to other species within and surrounding the wetlands.
We captured and sampled birds in areas beyond H-02 to evaluate the potential for birds to range widely and transfer contaminants to other areas, and as a basis for comparison with bird-metal dynamics previously evaluated at H-02 during FY21. We collected individuals from three locations along Fourmile Branch downstream from H-Area low-level waste effluent and H-Area and F-Area seepage basins. Birds were captured using mist-nets, banded with individually marked USGS bands, and sampled for blood and feathers. Blood samples were analyzed using an ICP-Mass spectrometer for a selection of metals, including Cu and Zn. Continued monitoring efforts will include the H-02 wetlands beginning November 2022.
In total, 101 samples from Fourmile Branch (FMB1: n = 28; FMB2: n = 27; FMB3: n = 46) were collected and analyzed, including four recaptured individuals. A total of nine species were collected, and mean sample abundance per species was approximately 11 and ranged from one (Red-bellied Woodpecker) to 22 (White-eyed Vireo). To compare heavy metal exposure and uptake at H-02 and the three Fourmile Branch sites, we used linear models (ANOVA) to test for statistical differences in mean Cu and Zn concentrations across sites. We found that mean Cu was 0.48 ppm lower at FMB2 compared to H-02 (β = -0.48, SE = 0.11, p = <0.001), and mean Zn was 2.24 ppm higher at FMB2 and 1.85 ppm higher at FMB3 compared to H02 (β = 2.24, SE = 0.88, p = 0.011 and β = 1.85, SE = 0.76, p = 0.015, respectively). Because of the large proportion of samples below MDL for Pb, we could not fit a linear model to these data. Instead, we compared the proportion of samples below MDL for Pb and found a similar pattern across all sites (FMB: 71%, 74%, 72%; H-02: 78%).
Conclusions
In general, Cu and Zn concentrations were similar between H-02 and FMB. We found that samples collected at FMB2 were lower in Cu than H-02, and samples collected at FMB2 and FMB3 were higher

in Zn compared to H-02. Because species community composition varies by site, we suspect that differences in metal concentrations observed in this study so far are likely due to differences in species collected, which vary in their behavior, diet, and physiology. Future work will explore the effect of sites and species on Cu, Zn, and Pb.

Major Impact(s) of Research

1) Determine whether H-02 contaminants are being transferred to the terrestrial environment through the avian community.
2) Understanding species level differences in metal contaminant uptake.

Other Project Personnel

Mary Chapman, Research Technician, SREL
Jonathon Skaggs, Research Professional, SREL

External Collaborators

N/A

Products (Publications, Presentations, Technical Reports

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

H-02 Constructed Wetland Studies—Assessing Effects of Copper Exposure in an Environmental Fish Model

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
October 2019; $68,000
SREL Collaborators
Dr. Ben Parrott, Dr. Olin Rhodes – SREL
Objectives
Metal contamination resulting from industrial use has the potential to impair water systems throughout the United States. Impacts to biota in these systems are often predicted using toxicological exposure models that do not fully capture complex interactions between environmental factors (e.g. temperature variability) and/or are limited to predicting bioavailability and uptake. Further, these models rely on a limited suite of endpoints that do not adequately assess sublethal impacts that have the potential to influence population dynamics in more subtle ways than lethality. The H-02 treatment wetland system on the Savannah River Site is designed to remove metals from waters discharged from the NNSA Tritium Processing Facility. Copper and zinc levels remain elevated in this system and understanding their sublethal effects on organismal health and fitness remain a concern.
Sub-lethal effects of contaminant exposure can alter health and survival of organisms and ultimately populations. In order to understand the biological impact and risk of contaminant exposures in nature, we must first determine how reliable markers of biological health relate to contaminant exposure under controlled conditions. Medaka fish (*Oryzais latipes*) are increasingly used as a model system in environmental toxicology applications due to the availability of genetic resources, stereotypical development, and their experimental tractability. Because fertilization of medaka eggs occurs externally, eggs can be collected shortly after fertilization, staged, and subsequently used for exposure assays incorporating a high degree of developmental resolution (e.g., hour time scale). The project objectives are centered on using the medaka fish model to investigate the sublethal impacts of copper exposure. Specifically, the project is aimed at revealing how exposures occurring during sequentially ordered temporal windows during development influence subsequent physiological function. The work will develop and validate biomarkers of organismal health in medaka fish and these tools will be used to test the hypothesis that developmental exposure to copper will exert negative impacts on organismal health in adult animals. More specifically, exposures occurring earlier in development are hypothesized to disproportionately impact organismal health relative to those exposures occurring later in life.
Summary of Research Activities
Two independent cohorts of medaka embryos were exposed to copper sulfate (10 ppb and 100 ppb) across a range of ambient temperatures (27°C, 30°C, and 33°C). Hatch rates, time to hatch, and absorbed Cu levels were tested and recorded. Further, subsets of exposed fish were reared to 4 months post fertilization at which point growth rates were recorded and fish underwent fin regeneration challenges. Fish were subsequently necropsied and gonadal, hepatic, and CNS tissues were collected for telomere measurements, gene expression assays, and gonadal histology. Data collection and analysis is complete and a manuscript is now published in *Environmental Toxicology and Chemistry*.
Basic toxicological data (e.g., LC_{50}) are not available for Cu exposure in the medaka model. In fall of 2020 and spring of 2021, LC_{50} assays were carried out to assess Cu toxicity for exposures occurring during three distinct ontogenetic timepoints: embryonic development, juvenile development, and reproductively mature adults. Based on these adult LC_{50} values, an age series of fish cohorts (2 months-18 months old) were exposed to assess age related susceptibility to Cu exposure. We find that tolerance to Cu varies across the medaka lifespan. Tolerance appears to be inversely correlated to reproductive activity, with two pronounced periods of decreased tolerance: one occurring in older individuals and the other coinciding with reproductive maturity and peak reproductive effort. These findings are now in press in *Environmental Toxicology and Chemistry.*

Conclusions

1) Temperature interacts with copper exposure to affect developmental dynamics in a model teleost.
2) Copper exposure exerts latent, but not acute, effects on regeneration rates in medaka.
3) Juvenile stages are more susceptible to Cu exposure (i.e., lower LC_{50}) when compared to embryos, and adult fish are more resistant than embryos.
4) Reproductive effort is inversely correlated to reproductive effort.

Major Impact(s) of Research

1) The work addresses the impacts of copper exposure under ecologically relevant temperature regimens on endpoints associated with health and reproduction in aquatic vertebrates.
2) This work advances our understanding regarding how exposures during development can have lasting effects on adult physiology.

Other Project Personnel

Emily Bertucci, PhD student, SREL
Marilyn Mason, Research technician, SREL
Abby Bickle, Research technician, SREL
Aisha Burrell, Research technician, SREL

External Collaborators (and Affiliations)

None

Products (Publications, Presentations, Technical Reports)

1) Mason MW, Parrott BB. Acute copper toxicity displays a non-monotonic relationship with age across the medaka (*Oryzias latipes*) lifespan. 2022. *Environmental Toxicology & Chemistry*. *In Press*
2) Mason MW, Bertucci EM, Leri FM, Parrott BB. Transient copper exposure during embryogenesis and temperature affects developmental rate, survival, and fin regeneration in Japanese medaka (*Oryzias latipes*). 2021. *Environmental Toxicology and Chemistry* 41:748-757 DOI: 10.1002/etc.5276
3) Parrott, B.B. Invited Seminar. January 14, 2020. Department of Physiological Sciences Seminar Series, University of Florida. Gainesville, FL, USA
4) Bertucci, E.M., Parrott, B.B. Characterization of the age-related DNA methylome and development of an epigenetic age predictor in medaka (Oryzias latipes). January 31, 2020. Oral Presentation. Odum School of Ecology Graduate Student Symposium, Athens, GA
5) Bertucci, E.M., Parrott, B.B. Characterization of the age-related DNA methylome and development of an epigenetic age predictor in medaka (Oryzias latipes). January 7, 2020. Oral Presentation. Society for Integrative and Comparative Biology Annual Meeting. Austin, TX, USA
6) Bertucci, E.M., Parrott, B.B. Is CpG density the link between epigenetic aging and lifespan? *Trends in Genetics* 36(10):725-727
7) Bertucci, E.M., Parrott, B.B. Characterization of the age-related DNA methylome and development of an epigenetic age predictor in medaka (*Oryzias latipes*). 2019. University of Alabama Birmingham Integrative Aging Symposium, Birmingham, AL, USA
8) Bertucci, E.M., Parrott, B.B. Characterization of the age-related DNA methylome in medaka (*Oryzias latipes*). 2019. Savannah River Ecology Laboratory Graduate Student Symposium, Aiken, SC, USA
9) Bertucci, E.M., Parrott, B.B. Effects of environmental stressors on aging trajectories in medaka. 2019. Odum School of Ecology Graduate Student Symposium, UGA, Athens, GA, USA
10) Parrott, B.B., Bertucci, E.M. Epigenetic aging clocks in ecology and evolution. 2019. *Trends in Ecology and Evolution* 34(9): 767-770

H-02 Constructed Wetland Studies—Microbial Decomposition

Funding Entity
NNSA - Tritium
Start Date and Funding Amount
October 1, 2021; $80,000
PI and co-PIs
Dr. Raven Bier
Objectives
The purpose of this project was to determine how the functional capabilities of the microbial community that decomposes organic matter changes seasonally and between the inflow and outflow of wetland cells in the H-02 constructed wetland at SRS that receives Tritium Facility discharge effluent and how that relates to copper (Cu) and zinc (Zn) concentrations of the wetland organic matter.
Summary of Research Activities
Prior work at the H-02 wetland (PIs Xu and Mills) had determined that during the cool months, metals primarily adsorb to organic matter rather than primarily react with reduced sulfate to create insoluble sulfide minerals that are buried in sediments. Here we measured seasonal changes in microbial carbon metabolism, pH, and decomposition in conjunction with metal (Cu and Zn) concentrations to determine how microbial communities alter organic matter availability for metal adsorption over time. Newly senesced bulrush (*Schoenoplectus californicus*) was collected, weighed, and deployed underwater in four evenly spaced locations between the inflow and outflow in each of the two wetland cells. After deployment, each month, water chemistry, organic floc, and bulrush decomposition bags were collected and processed. Collected bulrush was dried and weighed to calculate mass loss. Bulrush and floc were used to inoculate microbial community physiology plates, incubated, and measured daily for the rate and diversity of carbon metabolisms as a community physiological profile. Bulrush and floc samples were also extracted for microbial DNA and quantified using fluorescence as a proxy of microbial biomass to evaluate colonization. Each organic matter sample was additionally acid digested and analyzed using ICP-MS to quantify the concentrations of Cu or Zn per dry mass of bulrush or floc.
Conclusions
1) Microbial communities decomposing bulrush had a greater total capacity of the microbial community to decompose different carbon compounds than did microbial communities colonizing floc.
2) Metal concentrations of Cu and Zn decreased from inflow to outflow in both the decomposing bulrush and floc.
3) Functional richness of the carbon decomposition community decreased slightly in warmer seasons.

Major Impact(s) of Research
1) Carbon decomposition information for site management decision making in how constructed wetlands can continue to meet requirements for water quality of effluent discharge which supports the commitment to good ecological stewardship.
2) Metal concentrations of organic matter (decomposing bulrush and floc) indicate trends longitudinally within and between wetland cells.
3) Seasonal information about when carbon degradation is more likely to create byproducts for potential metal adsorption. This effort can assist implementation of management strategies for enhancing wetland effectiveness.

Other Project Personnel
Corinne Sweeney, MS Student, SREL
McKenzie Cromer, Research Technician, SREL
External Collaborators
NA
Products (Publications, Presentations, Technical Reports)

Cromer, M., C. Sweeney, and R. Bier. 2022. Carbon decomposition by microbial communities in a constructed wetland treating Cu and Zn. Society of Environmental Toxicology and Chemistry North America. November 13-17, 2022. Virtual.

Support for SREL Environmental Missions on the SRS

Funding Entity
NNSA
Start Date and Funding Amount
October 2021; $324,000
SREL PI and Co-PIs
Dr. Olin E. Rhodes, Jr. – SREL
Objectives
SREL will assist the SRS NNSA mission 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 service for 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 2022, the COVID-19 pandemic continued to affect SREL Outreach's ability to deliver programs. Schools were closed to outside groups for a portion fiscal year 2022, and many public events were canceled or rescheduled to reduce the spread of COVID-19. The SRS also closed a number of public programs and non-essential employees teleworked at home for a portion of the year. These conditions continued through much of fiscal year 2022. Late in fiscal year 2022, SREL resumed 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 NERP programs on the SRS. SREL also distributed educational resource materials to facilitate these goals. To address the challenges, the 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.
The Outreach Program was readily available to conduct Lunch and Learn presentations to site personnel, provided tours for DOE site interns, new SRS 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, and produced materials on specific research programs.
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 Impacts of Program

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 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
Amanda Hurst, Animal Caretaker, SREL
Holly DeVault, Outreach Coordinator, SREL
Margaret Wead, Administrator, SREL

Products (Publications, Presentations, Technical Reports)

1) Conducted 31 scheduled tours; number of attendees – 599 (includes 10 SRS Public Tours, attendees – 228; 21 tours for on-site employees/visitors, attendees – 371)
2) Provided 3 Wildlife Safety talks; number of attendees – 3,542 (includes 2 talks to SRS employees at SRS Safety Expo, number of attendees – 3,500)
3) Presented 128 STEM classroom education programs for elementary and secondary students; number of attendees – 6,658
4) Presented 27 environmental programs for college, professional and adult audiences; number of attendees – 926
5) Provided 7 STEM exhibits at local and regional events; number of attendees – 2,764
6) Conducted 17 Ecologist for a Day programs (school field trips to SREL's Conference Center); number of attendees – 379
7) SREL outreach programs, press releases, media advisories, and staff appeared in 356 media mentions in newspapers, magazines, television shows, and radio programs; media reach– 545.7 million
8) Reached digital audience through social media platforms;
   Facebook – 1,800 followers, 18,914 reach;
   Twitter – 692 followers, 67,800 media impressions; 2,308 people engaged with content;
   Instagram – 10,485 followers, 557,594 media impressions; 171,840 people engaged with content;
   YouTube – 65 followers, 20,855 media impressions;
   Facebook Outreach – 159 followers, 18,500 media impressions – page discontinued
   TikTok – 5083 followers

Restoration of NNSA Related Streams—Continuing Efforts

Funding Entity
NNSA
Start Date and Funding Amount
October 2021; $213,645
PI and co-PIs
Olin E. Rhodes Jr. and Dean E. Fletcher – SREL
Objectives
This research is providing a comprehensive assessment of the Upper Three Runs tributary that drains the former MOX construction site (hereafter referred to as tributary U8) and includes comparisons to other disturbed and reference systems. We are evaluating contaminant distributions and dynamics as well as impacts on hydrologic, geomorphic, and biologic stream features to develop potential restoration and enhancement strategies that could be applied to this and other SRS streams to improve and better protect their physical and biological integrity.
Summary of Research Activities
The U8 channel is severely eroded, unstable, and will continue to degrade until the excessive runoff from impervious surfaces is slowed. As additional land development occurs in the watershed, this disturbance will not only continue, but likely worsen without appropriate management. Buffering the stream channel of excessive storm flows over short periods will be the first step in improving and protecting this tributary from the effects of industrial operations and construction. Through collaboration with the University of Georgia's College of Engineering, continuous high-resolution stream discharge data is being collected at 5-minute intervals using instrumentation installed in tributary U8 and severely eroded tributary U6 channels. Preliminary hydrologic models are being developed for each tributary to calculate the size of stormwater basins required to sufficiently protect these streams from further physical damage. These analyses will improve our understanding of erosive flows that create instability in receiving stream channels and provide an assessment of hybrid gray and green stormwater control measures to mitigate these influences.
Additionally, our collaboration is evaluating the impact of stream incision on riparian groundwater level and geochemistry. Thirty-six piezometers of varied depth and four stream gages were installed in 2021 at tributary U8, disturbed and undisturbed reaches of McQueen Branch, and reference tributary U36. Data loggers placed in 22 piezometers have continuously monitored water depth at 5-minute intervals. Annual topographic surveys are being conducted to monitor changes in stream slope and cross-section dimensions. The floodplains were drier and the groundwater level lowered in eroded channels. For example, ground water in U8 was over 1.5 m below the floodplain surface, compared to less than 1 m deep in reference streams. Groundwater nitrogen concentrations at both McQueen transects are being monitored monthly and have been low (<2 mg/L total nitrogen), yet the floodplains in the eroded channel have shown a slightly decreased ability to remove nitrogen.
Previous work established elevated concentrations of some contaminants in aquatic invertebrates in U8 and other disturbed streams compared to reference streams. We are leveraging efforts with funding from NNSA Tritium to expand evaluations of contaminants pulsing through streams during storm events. Twenty-four sites distributed across seven streams, which span a broad gradient in disturbance severity were identified. Data loggers were installed to continuously monitor water depth, temperature, and conductivity. Metals/metalloids were analyzed during an initial sampling at each site. Sampling will continue once discharge rating curves are developed calculate discharge from water level. These efforts are evaluating the movement of contaminants from both current and legacy pollution sources. In coordination with another funded study of PFAS distributions and the NNSA Tritium work, sediment and water were sampled for metal analyses from 30 locations. Samples were collected from each site to measure trace elements, including mercury. Samples were collected from each site to measure trace elements including mercury. Sites likely to be sinks for contaminants such as basins, ponds, and beaver ponds were targeted.

We continued monitoring the impacts of excessive runoff on stream biota. Many aquatic insects have complex life cycles that involve an immature aquatic larval stage that emerges from the water as a flying adult and exports food resources from aquatic to terrestrial food webs. Consequently, stream disturbances impacting stream macroinvertebrate communities can also impact surrounding terrestrial food webs. Research evaluated the number and diversity of aquatic insects emerging from tributary U8 and Tinker Creek reference tributary TC5. This year we focused on collecting in early fall. Identifications and enumeration are in progress. Compound Specific Stable Isotope analyses are also being employed to evaluate the influence of stream disturbance on trophic organization. A total of 167 samples distributed across six species and five streams including the H-02 receiving stream were processed and sent to the University of California-Davis Stable Isotope Facility for analyses. Sample processing of tetragnathid spiders for contaminant accumulation in coordination with H-02 wetland studies continues. Sediment from nine ponds/basins were analyzed for trace elements, organic matter content and sediment texture.

Conclusions

1) U8 is severely degraded with impaired hydrology, channel form, and biological communities.
2) Scouring by excessive flows has flushed sediment organic matter from stream bottoms and influenced contaminant dynamics throughout the stream.
3) Stream disturbance reduces aquatic insect emergence, particularly of sensitive taxa, and thus affects aquatic to terrestrial food webs.
4) Channel incision caused by erosion from excessive stormwater flows is not only impairing the stream channel, but also degrading riparian hydrology by lowering groundwater levels.

Major Impact(s) of Research

1) This research provides a comprehensive baseline of the present condition of the U8 drainage including detailed contaminant distributions throughout the stream and basins. This will allow evaluation of effects of future industrial initiatives.
2) Comparison of streams across a disturbance gradient allows effective assessment of how sandhills streams respond to excessive runoff and will facilitate application of the research across the SRS and sandhills region.
3) Extensive contaminant analyses combined with physical characterization of U8 are establishing that current damage is primarily the result of excessive runoff rather than contamination.
4) Overall, identifying of specific stream impairments and establishing of baseline conditions will provide the foundation to restore the U8 system and subsequently monitor restoration effectiveness.

Other Project Personnel

Erin Spivey, Research Technician, SREL
Paul Stankus, Research Professional, SREL
Andrew Lydeard, Research Technician, SREL
Destiny Willard, Research Technician, SREL

External Collaborators

Brian Bledsoe, Director of Institute for Resilient Infrastructure Systems, UGA
Daniel Buhr, Ph.D. Student, College of Engineering, UGA
William Mattison, M.S. Student, College of Engineering, UGA
Matthew Chambers, Ph.D. Student, College of Engineering, UGA
James Fudge, SRNS

Products

New initiatives began, but no products were completed this year.

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 FY22, 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 numerous 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

Spatial ecology, reproduction, and social structure of invasive wild pigs

Funding Entity
NA
Start Date and Funding Amount
January 1, 2018; NFP
SREL Collaborators
Dr. James C. Beasley
Objectives
The goal of this study is to evaluate a broad suite of underlying factors contributing to the spatial ecology, reproductive dynamics, and social structure of wild pigs. Specific objectives include: 1) quantifying fine-scale movement behavior, home range structure, and resource selection of wild pigs, 2) quantifying biotic and abiotic factors contributing to reproductive rates of female wild pigs, 3) determining survival of neonate wild pigs, and 4) assessing the social structure of wild pigs using genetics and genomics and factors contributing to variance in reproductive rates among individuals.
Summary of Research Activities
This research builds upon previous spatial and genetic data collected for wild pigs on the SRS to advance our understanding of the ecology of this invasive species. We have completed analyses of GPS spatial data from nearly 50 wild pigs to quantify the underlying factors contributing to the movement behavior and resource selection of wild pigs in the southeastern US. In addition, we have been working with collaborators at USDA's NWRC to elucidate the social structure of wild pigs using SNP markers collected for several hundred individuals. Lastly, we have completed collections of reproductive data from female wild pigs as well field data needed to quantify survival of neonate wild pigs.
Conclusions
1) Female wild pigs primarily exhibit crepuscular activity patterns during periods of high food availability, and variable activity patterns during low forage, while males exhibit nocturnal activity patterns throughout the year. Both males and females primarily selected bottomland hardwood habitats and areas with dense canopy cover when foraging, resting, and travelling. Males used linear features such as roads while travelling.

2) Wild pig neonates have high survival; 44% during the first six weeks following parturition. Survival was positively influenced by pelage coloration, and sex, as males had higher survival. Sow size was positively correlated with litter size, and neonates born in warmer months than those born in colder months.
3) Wild pig social units were primarily female-dominated and related individuals, but some social units also included unrelated females. Male-dominated social units also were observed, which consisted of young, related individuals. These results suggest wild pig social groups are complex, dynamic, and likely variable across their range.

Major Impact(s) of Research

This research provides some of the most comprehensive data to date on the social structure and reproductive ecology of wild pigs, as well as novel assessments of the underlying factors contributing to the movement ecology of this important invasive species. Data derived from this study will used to better understand the ecology of wild pigs to improve the efficiency of management programs to mitigate damages caused by this destructive invasive species.

Other Project Personnel

Sarah Chinn, PhD student, SREL
Lindsay Clontz, MS student, SREL
Chelsea Titus, MS student, SREL

External Collaborators

Dr. Tim Smyser, USDA-APHIS-WS-NWRC
Dr. Stephen Webb, Noble Research Institute
Dr. Kurt VerCauteren, USDA-APHIS-WS-NWRC
Dr. Kim Pepin, USDA-APHIS-WS-NWRC

Products

Chinn, S., and Beasley, J. 2020. Parental investment strategies in a highly polytocous species: maternal attributes and resource availability modulate litter size and sex ratio. In Warnell Graduate Student Symposium. Athens, GA.

Chinn, S., and Beasley, J. 2020. Parental investment strategies in a highly polytocous species: maternal attributes and resource availability modulate litter size and sex ratio. In Society for Integrative and Comparative Biology Annual Meeting 2020. Austin, TX.

Chinn, S., and Beasley, J. 2020. Parental investment strategies in a highly polytocous species: maternal attributes and resource availability modulate litter size and sex ratio. In 2020 "Virtual" Wild Pig Conference.

Chinn, S.M., J.C. Kilgo, M. Vukovich, and J.C. Beasley. 2021. Influence of intrinsic and extrinsic attributes on neonate survival in an invasive large mammal. Scientific Reports: 11:11033

Clontz, L.M., K.M. Pepin, K.C. VerCauteren, and J.C. Beasley. 2021. Connecting the dots: behavioral state resource selection in wild pigs in the southeast United States. Scientific Reports: 11:6924

Yang, A., P. Schlichting, B. Wight, W.M. Anderson, S.M. Chinn, M.Q. Wilber, J.C. Beasley, R.K. Boughton, K.C. VerCauteren, G. Wittemyer, and K.M. Pepin. 2021. Effects of social structure and management on risk of disease establishment in wild pigs. Journal of Animal Ecology: 90:820-833

Bastille-Rousseau, G., P.E. Schlichting, D.A. Keiter, J.B. Smith, J.C. Kilgo, G. Wittemyer, K.C. VerCauteren, J.C. Beasley, KM Pepin. 2020. Multi-level movement response of invasive wild pigs (Sus scrofa) to removal. Pest Management Science

Chinn, S.C., and J.C. Beasley. Intrinsic and Extrinsic Factors Effect Neonate Survival of an Invasive Large Mammal. 2021. Society of Integrative and Comparative Biology. Virtual.

Chinn, S.M., J. Kilgo, M. Vukovich, and J.C. Beasley. 2021. Neonate survival of an invasive large mammal. Warnell Graduate Student Symposium, Athens, GA.

Clontz, L.M., K.M. Pepin, K.C. VerCauteren, and J.C. Beasley. 2021. Drivers of wild pig weekly home range size and shape. Warnell Graduate Student Symposium, Athens, GA.

Titus, C.L., C.F. Pierce, T.J. Smyser, S.L. Webb, and J.C. Beasley. 2021. What is a sounder: genomic relatedness of wild pig social groups. Warnell Graduate Student Symposium, Athens, GA.

Chinn, S.M., J. Kilgo, M. Vukovich, and J.C. Beasley. 2021. Neonate survival of an invasive large mammal. Wildlife Damage Management Conference (virtual)

Titus, C.L., C.F. Pierce, T.J. Smyser, S.L. Webb, and J.C. Beasley. 2020. What is a sounder: genomic relatedness of wild pig social groups. The Wildlife Society Annual Conference (virtual)

Clontz, L.M., K.M. Pepin, K.C. VerCauteren, and J.C. Beasley. 2020. Evaluating the connection between wild pig behavior and resource selection in the southeast, USA. The Wildlife Society Annual Conference (virtual)

Chinn, S.M., P.E. Schlichting, T.J. Smyser, C. F. Pierce, and J.C. Beasley. 2022. Factors influencing pregnancy, litter size, and reproductive parameters of invasive wild pigs. *Journal of Wildlife Management* 86:e22304.

Clontz, L.M., K.M. Pepin, K.C. VerCauteren, and J.C. Beasley. 2022. Influence of biotic and abiotic factors on home range size and shape of invasive wild pigs (*Sus scrofa*). *Pest Management Science* 78:914-928.

Titus, C.L., C.F. Bowden, T.J. Smyser, S.L. Webb, and J.C. Beasley. 2022. Genomic tools reveal complex social organization of an invasive large mammal (*Sus scrofa*). *Biological Invasions* 24:3199-3216.

Chinn, S.M., and J.C. Beasley. Submitted. Maternal investment strategies and sex ratio adjustment in a polytocous large mammal. *Royal Society Open Science*: In Review.

Chinn, S.M., J. Hepinstall-Cymerman, and J.C. Beasley. Submitted. Reproduction drives changes in space use and habitat selection in a highly adaptable invasive mammal. *Movement Ecology*: In Review.

Chinn, S., P. Schlichting, T. Smyser, C. Bowden, and J. Beasley. Factors influencing pregnancy, litter size, and reproductive parameters of wild pigs on the Savannah River Site, South Carolina. 2022. International Wild Pig Conference.

Efficacy of wildlife deterrents in minimizing white-tailed deer consumption of bait aimed at attracting wild pigs

Funding Entity
White Buffalo, Inc.
Start Date and Funding Amount
June 1, 2022; $13,000
SREL Collaborators
Dr. James C. Beasley
Objectives
Trapping is an effective tool for managing the invasive wild pig population in the U.S. Traps are often baited with whole-kernel corn or similar baits which can serve as attractants to non-target species such as white-tailed deer that may consume substantial portions of bait and reduce the likelihood of wild pig visitations, ultimately interfering with trap success. Therefore, the overall goal of this project is to assess the efficacy of commercially available wildlife repellants at reducing the consumption of bait by white-tailed deer, while maintaining visitation/consumption by wild pigs. This project is being conducted in collaboration with White Buffalo, Inc.
Summary of Research Activities
During summer 2022 we set 138 paired camera/bait stations across the Savannah River Site and analyzed remote camera images for species detections and bait consumption. We began analyses in fall 2022 to examine differences in bait consumption between deterrent treatments and control sites. Analyses will be ongoing into 2023.
Conclusions
This research is ongoing; however, analyses completed thus far have revealed that deer were detected significantly less frequently at bait sites containing deterrent than control sites. There were no differences in wild pig detections at deterrent bait sites compared to control sites.
Major Impact(s) of Research
This research will produce novel data on the effectiveness of wildlife deterrents in reducing non-target species consumption of bait used for wild pig management.
Other Project Personnel
Caitlin Kupferman, Research Professional, SREL
Owen Navarre, Research Technician, SREL
Taylor Aliferis, Research Technician, SREL
External Collaborators
Anthony DeNicola, White Buffalo, Inc.
Products
Analyses are ongoing; there are no products at this time.

Innovativeness of raccoons and opossums in solving novel challenges

Funding Entity
NA
Start Date and Funding Amount
May 2021, NFP
SREL Collaborators
Dr. James C. Beasley
Objectives
Some species have a proclivity towards being "innovative", in which members of those species readily use new or modified behaviors to solve new or existing challenges. Studies of animal innovation, particularly in the wild, can help us understand species' differences in intelligence, brain size, and changes in ecological niche due to climactic and ecological factors. This study aims to: 1) compare the innovativeness of two highly abundant yet poorly understood wild sympatric North American mammals, the Northern raccoon and Virginia opossum, and 2) determine whether differences in raccoon and opossum innovativeness are linked to species differences in relative brain size and ecological niche breadth. We will assess this by setting novel problem-solving tasks that require wild animals to use new or modified behaviors to obtain out-of-reach food rewards; problem-solving tasks will be set in the wild and species' responses recorded through remote video cameras. This project is being conducted in collaboration with the University of Hull.
Summary of Research Activities
During the summer and fall of 2021 we set 65 paired remote video camera/problem solving stations across the Savannah River Site; analyses will be ongoing through 2023.
Conclusions
Analyses are ongoing; there are no conclusions to report at this time.
Major Impact(s) of Research
This research will produce novel data on the innovativeness of opossums and raccoons in solving challenges.
Other Project Personnel
Caitlin Kupferman, Research Professional, SREL
External Collaborators
Dr. Blake Morton, Lecturer, University of Hull
Products
Morton, B., J. Beasley, C. Kupferman, and M. Snider. When are wild raccoons innovative? 2021. Association for the Study of Animal Behaviour Annual Meeting.

Evaluating attractants and baits for wild pigs

Funding Entity
USDA-APHIS-Wildlife Services-National Wildlife Research Center
Start Date and Funding Amount
September 5, 2019; $400,000
SREL Collaborators
Dr. James C. Beasley
Objectives
The goal of this study is to evaluate a broad suite of attractants and food-based baits across multiple seasons and geographic locations to identify the most effective feral swine attractants for improving the efficiency and efficacy of wild pig control efforts under the National Feral Swine Program. This research will encompass three overarching objectives: 1) evaluate the performance (i.e. visitation rates) of a broad suite of lures/attractants/baits in attracting wild pigs, and whether seasonal or geographic differences in performance exist, 2) determine differences in performance of lures/baits between male and female pigs, and 3) provide recommendations for specific lure/bait combinations to maximize trapping efficacy.
Summary of Research Activities
This research was initiated in spring 2020, with additional field sampling conducted fall 2020-spring 2021. During spring 2020 we conducted extensive field trials of >60 baits/attractants in South Carolina, resulting in a suite of 29 baits/attractants that were incorporated into further studies in late 2020-early 2021. In the fall of 2020 research continued in South Carolina and field trials began at the Chaparral Wildlife Management Area in Cotulla, Texas. Both study areas conducted trials in winter 2021. An additional round of sampling was conducted in Texas in spring 2021.
Conclusions
Data analysis revealed that strawberry and creosote bush oil increased the probability of pig visitations in Texas during the fall. No other baits/attractants performed better than the controls in either South Carolina or Texas. Further, these analyses revealed that specific locations where attractants are placed are a greater predictor of wild pig visitations than the type of attractant used.
Major Impact(s) of Research
1) This research provides the most comprehensive evaluation of a broad suite of attractants to date.
2) Data derived from this study will be integrated into national-level management of wild pigs by the USDA to mitigate damages caused by this invasive species.

Other Project Personnel
Caitlin Kupferman, Research Professional, SREL
Madeline Melton, Research Technician, SREL
Allison Stift, Research Technician, SREL
Clara Dawson, Research Technician, SREL
Brandon Maiersperger, Research Technician, SREL
Alejandro Plasencia, Research Technician, SREL
Joshua Benavidez, Research Technician, SREL
External Collaborators
Dr. Kim Pepin, USDA-APHIS-WS-NWRC
Dr. Nathan Snow, USDA-APHIS-WS-NWRC
Dr. Kurt VerCauteren, USDA-APHIS-WS-NWRC
Mr. Mike Lavelle, USDA-APHIS-WS-NWRC
Dr. Whitney Gann, TPWD-Chaparral WMA
Products
Snow, N.P, C.A. Kupferman, M.J. Lavelle, K.M. Pepin, M.H. Melton, W. Gann, K.C. VerCauteren, and J.C. Beasley. 2022. No panacea attractant for wild pigs, but season and location matter. *Applied Animal Behavior* 254:105705.

Snow, N., C. Kupferman, M. Lavelle, K. Pepin, M. Melton, W. Gann, K. VerCauteren, and J. Beasley. No panacea attractant for wild pigs, but season and location matter. 2022. International Wild Pig Conference.

Factors influencing vertebrate scavenging dynamics

Funding Entity
NA
Start Date and Funding Amount
January 1, 2020; NFP
SREL Collaborators
Dr. James C. Beasley, Dr. Travis DeVault, Dr. Olin Rhodes, Jr.
Objectives
The overarching objective of this study is to investigate factors influencing vertebrate scavenging dynamics. Specifically, 1) to evaluate the influence of carcass type on the composition and efficiency of vertebrate scavenging communities in the southeastern U.S. This aspect of the study aims to quantify differences in vertebrate scavenging dynamics between predator and prey carrion, to understand how carrion type influences the flow of nutrients among decomposer and scavenging guilds, as well as the underlying factors contributing to carcass use. 2) to assess anthropogenic effects (i.e. urbanization) on the efficiency and composition of scavenging communities. This study aspect of the study aims to quantify human impact on the efficiency and composition of scavenging species through comparative studies in a rural, pristine environment and an urban, imperiled environment.
Summary of Research Activities
Several dozen experimental carcass trials have been carried associated with this research. Both intact and altered carnivore (coyote) and herbivore (wild pig) carrion trials were conducted on the SRS to quantify differences in scavenging dynamics and community composition of scavengers between carcass types. In addition, experimental trials using fish carrion were conducted in northern Georgia within both an urban and rural environment to investigate the effects of urbanization on scavenging dynamics. Experimental trials and analyses of the data for all these experiments have been completed, and multiple manuscripts have been submitted for publication.
Conclusions
Our avian carrion study demonstrated higher trophic level carrion was scavenged slower and by a less diverse array of vertebrate species than lower trophic level carrion, suggesting carcass types from different trophic levels and guilds are used dissimilarly. Experiments investigating the differences in scavenging dynamics among carcass types revealed significantly reduced consumption of carnivore carrion by vertebrates, particularly mammals, resulting in increased persistence times of carnivore carcasses on the landscape. Experiments investigating the effects of urbanization on scavenging dynamics revealed carcass fate (whether the carcass was scavenged or not) and carcass persistence differed between suburban and rural landscapes, with carcasses being scavenged by vertebrates less often and persisting longer in rural landscapes.
Major Impact(s) of Research
1) This research produced novel insights into factors contributing to underlying differences in carcass use among vertebrate scavengers, as well as the mechanisms contributing to patterns of carrion use among vertebrate consumers.
2) This research also provides novel insight into the effects of human impact through urbanization on scavenging species and scavenging activity.

Other Project Personnel
Miranda Butler-Valverde, M.S. student, SREL
Jessy Patterson, Ph.D. student, SREL
External Collaborators
NA
Products
Butler-Valverde, M., T.L. DeVault, and J.C. Beasley. Assessing scavenging dynamics of avian carrion: Do scavengers avoid feeding on vulture carcasses? UGA Warnell Graduate Student Symposium, Athens, GA, February 2020

Butler-Valverde, M.J., T.L. DeVault, and J.C. Beasley. 2022. Trophic interactions at avian carcasses: do scavengers feed on vulture carrion? *Food Webs* 31:e00230.

Patterson, J.R., T.L. DeVault, and J.C. Beasley. 2022. Integrating scavenging ecology into contemporary wildlife conservation and management. *Ecology and Evolution* 12:e9122.

Butler-Valverde, M.J., T.L. DeVault, O.E. Rhodes, Jr., and J.C. Beasley. Submitted. Carcass appearance does not influence scavenger avoidance of carnivore carrion. *Scientific Reports*: In Review.

Experimental analysis of flight initiation and nighttime influence in mallard-vehicle collisions

Funding Entity
NFP
Start Date and Funding Amount
May 1, 2021; NFP
SREL Collaborators
Travis L. DeVault and James A. Martin
Objectives
Our objectives are to quantify the flight initiation distance of mallards and determine whether their flight response is spatial or temporal, as well as examine the effects of aircraft lighting and time of day on the flight initiation distance and time to flight of these birds.
Summary of Research Activities
Vehicle collisions with wildlife are financially costly and a danger to human and animal life. In the two decades leading up to 2010, more than 200 people were killed as the result of collisions between birds and aircraft alone, and collisions of commercial aircraft with birds in this time frame resulted in over $1 billion of damage per year. Many of the mechanisms behind these collisions are poorly understood, and there is a need to better understand how birds perceive and respond to an approaching vehicle in order to reduce future collisions. Mallards (*Anas platyrhynchos*) are a particular species of concern, as they consistently rank among the ten most hazardous bird species to aircraft and can serve as a model species for ducks, which to date are comparatively understudied in wildlife-vehicle collisions. In this study, we quantified the flight-initiation distance of mallards and determined whether their flight response is spatial or temporal, and examined the effects of aircraft lighting, time of day, and social cues on the flight-initiation distance and time to flight of these birds. In doing so, we hope to better anticipate duck behavior when encountering a vehicle, and reduce the number of dangerous bird strikes.
Conclusions
1) Simulated approach methods elicited results similar to real approach.
2) Mallards failed to effectively evade fast-moving vehicles.
3) The goal should be to separate ducks and vehicles in space or time.
Major Impact(s) of Research
1) Determined that innate avoidance behaviors of mallards are inadequate to escape fast-moving vehicles.
2) Produced management recommendations for mitigating aircraft collisions with waterfowl.
Other Project Personnel
Shane Guenin, M.S. student, SREL
Carson Pakula, M.S. student, SREL
Jon Skaggs, Research Professional, SREL
External Collaborators
Dr. Bradley Blackwell, USDA
Dr. Esteban Fernandez-Juricic, Purdue University
Dr. Takao Sasaki, Odum School of Ecology, UGA
Products (Publications, Presentations, Technical Reports)
Guenin, S., C. J. Pakula, J. Skaggs, E. Fernandez-Juricic and T. L. DeVault. Make way for ducks: the effect of speed and light on mallard reactions to oncoming vehicles. The Wildlife Society Annual Conference, November 2022. Oral Presentation.

Wild pig behavior and conspicuity during vehicle encounters in the southeastern United States

Funding Entity
SREL
Start Date and Funding Amount
May 1, 2021; NFP
SREL Collaborators
Travis L. DeVault, Olin E. Rhodes, Jr., and James C. Beasley
Objectives
The objectives associated with our project are to (1) quantify the distance at which humans can identify wild pigs at night along roads, and the factors that may influence that distance, and (2) describe the avoidance behavior of wild pigs in response to vehicles and determine whether dangerous encounters between vehicles and wild pigs can be reduced with increased vehicle illumination.
Summary of Research Activities
Wildlife-vehicle collisions (WVCs) are a major threat to the conservation of wildlife and are expensive and dangerous to humans. In the United States, WVCs cause billions of dollars in damages and injure thousands of people annually. Due to range expansion and population increases, wild pigs (*Sus scrofa*) have been identified as a species of concern within the context of WVCs. Past work has demonstrated that driver behavior, animal behavior, and vehicle characteristics can influence WVCs. However, few studies have evaluated these important elements of WVCs within the context of wild pig-vehicle encounters. In this study, we propose to first quantify driver perception of free-ranging wild pigs near the road at night. Second, we will quantify wild pig behavior during pig-vehicle interactions and evaluate the effect of a rear-facing light bar on wild pig flight initiation distance. For both objectives, we will use opportunistic sampling and a forward-looking infrared (FLIR) camera. This study will be the first to document the behavior of wild pigs to an approaching vehicle. Additional outcomes include advising safer speed limits by determining the distance that drivers can detect wild pigs and contributing to our understanding of how altering vehicle lighting can prevent dangerous animal-vehicle interactions.
Conclusions
1) At night, most drivers cannot detect wildlife, especially wild pigs, near roadways at safe distances.
Major Impact(s) of Research
1) Determine limitations of human detection of wild pigs along roads.
2) Determine how wild pigs respond to vehicle approach.
3) Evaluate effectiveness of rear-facing vehicle illumination on escape behaviors of wild pigs.
Other Project Personnel
Carson Pakula, M.S. student, SREL
Shane Guenin, M.S. student, SREL
Jon Skaggs, Research Professional, SREL
External Collaborators
Dr. Gino D'Angelo, UGA
Products (Publications, Presentations, Technical Reports)
Pakula, C. J., S. Guenin, J. Skaggs, O. E. Rhodes, Jr., and T. L. DeVault. Driver nighttime detection of free-ranging wildlife in the southeastern United States. The Wildlife Society Annual Conference, November 2022. Poster Presentation.

Comparative hydrologic budgets and water use efficiencies of developing bioenergy plantations

Funding Entity
USDA National Institute of Food and Agriculture
Start Date and Funding Amount
September, 2019; $498,663
SREL Collaborators
D. Aubrey
Objectives
Our overarching goal is to improve our understanding of how the major outputs of the forest hydrologic cycle change through stand development and manipulate those dynamics through silvicultural approaches to increase water use efficiency (WUE).
Summary of Research Activities
We are constructing hydrologic budgets by quantifying the hydrologic inputs (precipitation and interception) and outputs (tree transpiration, E_t; and soil evaporation, E_s) in experimental plots of the most promising alternative woody bioenergy crop species for production in the southeastern US (i.e., coppiced sweetgum and *Eucalyptus*) and comparing them with the current management system for this region (i.e., loblolly pine). In doing so, we are establishing the most comprehensive species comparisons of water use and WUE to date that consider dynamic changes in E_s and E_t that occur as forest stands transition through stand development from the point of establishment when leaf area is low and the soil surface is bare to the point of canopy closure when leaf area has maximized and soil surfaces contain years of litter inputs that impede E_s. In addition to comparing species, we are comparing silvicultural approaches that impose drastically different densities (i.e., coppice vs. standard row plantings of sweetgum; 6,364 seedlings ha^{-1} and 1,336 seedlings ha^{-1}, respectively). Different planting densities result in different rates of canopy leaf area development and, therefore, different dynamics in hydrologic budgets. We are also performing a series of manipulative experiments to gain a mechanistic understanding of how litter type, litter depth, shading, and boundary layer mixing influence E_s. Our research is generating rigorous data accounting for dynamic shifts in key hydrologic processes that occur through stand development and demonstrates silvicultural approaches to increase WUE, which will inform decisions on how to manage bioenergy production systems.
Conclusions
1) Leaf litter accumulation has a very strong impact on E_s.
2) High-density forest plantings can decrease rotation-length soil evaporation by 20%, but rotation-length E_t and total ET increase by 33% and 17%, respectively.
3) Retaining leaf litter on the forest floor from previous rotations can decrease subsequent rotation-length E_s by 54% without impacting E_t at all and decrease rotation-length ET increase by 16%.
4) The combination of high-density forest plantings and litter retention from the previous rotation can decrease rotation-length E_s by 54%, but rotation-length E_t and total ET increase by 33% and 6%, respectively.

Major Impact(s) of Research
1) By taking a systems approach to quantifying evapotranspiration and its components (soil evaporation and transpiration) in woody feedstock (loblolly pine, and American sweetgum), we will capture dynamic shifts occurring through stand development.
2) We hypothesize that inherent differences in leaf habit and area among species, coupled with silvicultural options related to density and resource availability, provide opportunity to reduce soil evaporation during early stand development, thereby increasing rotation-length WUE and reducing the overall ecological footprint of woody bioenergy production systems.
3) This project addresses the urgent need for quantitative information regarding trade-offs between maximizing forest production and maintaining sustainable water yields.

Other Project Personnel
Fabio Toledo, Postdoctoral Research Associate, SREL

Tyler McIntosh, Research Technician, SREL
Marley Brown, Research Technician, SREL
Madeline Lyons, Research Technician, SREL
Elizabeth Patton, Research Technician, SREL

External Collaborators

C.R. Jackson, Warnell School of Forestry and Natural Resources, UGA

Products

Aubrey, D.P., C.R. Jackson, and S.E. Younger. 2021. Consideration of forest water cycle dynamics throughout stand development can improve water use efficiency of woody bioenergy production systems. American Geophysical Union. New Orleans, LA. (Invited Presentation)

Aubrey, D.P., and M.J. Dix. 2021. Challenges and opportunities of estimating tree transpiration via sap flow. American Geophysical Union. New Orleans, LA. (Presentation)

Starr, G., R. Ruzol, D.P. Aubrey, C. Staudhammer, S. Younger, H. Loescher, and C.R. Jackson. 2021. Water use from an intensively managed loblolly pine plantation: Implications of silviculturally-enhanced tree growth on stand evapotranspiration. American Geophysical Union. New Orleans, LA. (Presentation)

Aubrey, D.P., C.R. Jackson, S.E. Younger, M.J. Dix, and P. Caldwell. 2022. Consideration of forest water cycle dynamics throughout stand development can improve water use efficiency of short rotation woody crop production systems. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Aubrey, D.P., C.R. Jackson, S.E. Younger, T. McIntosh, and F. Toledo. Evapotranspiration partitioning of three to five-year-old *Eucalyptus benthamii* and *Pinus taeda* in the southeast, US. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Jackson, C.R., D.P. Aubrey, S.E. Younger, G. Starr, K. Vache, M. Meles, N.A. Griffiths. 2022. Plot to Watershed-scale Effects of Forest Management on Water Budgets, Streamflows, and Nitrate Transport, SE U.S. Plenary Talk. DOE Environmental System Science PI Meeting, April 24-26. (Invited Presentation)

Ruzol, R., C. Staudhammer, S. Younger, D.P. Aubrey, H. Loescher, C.R. Jackson, and G. Starr. 2022. Water use in a young *Pinus taeda* bioenergy plantation: effect of intensive management on stand evapotranspiration. *Ecosphere*, 13(6):e4100.

Managing forests for ecological services and environmental sustainability

Funding Entity
USDA Forest Service
Start Date and Funding Amount
April, 2021; $383,871
SREL Collaborators
D. Aubrey
Objectives
Our overarching goal is to improve our understanding of how carbon inputs to soil influence soil organic carbon (SOC) accrual and storage dynamics through stand development and across multiple harvest rotations, thereby demonstrating how manipulating inputs through silvicultural approaches can influence the magnitude and timing of SOC equilibrium.
Summary of Research Activities
We developed a conceptual model, based on carbon inputs to soil and their decomposition rates, and parameterized it with empirical data to test the hypothesis that changing the silvicultural approach to increase carbon inputs to soil can result in increased equilibria of SOC inputs, and ultimately, increased SOC accrual and storage. To challenge/validate our model, we have established plots of intensively managed loblolly pine and sweetgum and have begun constructing belowground carbon budgets that account for all biomass inputs to soil, decay rates of those inputs, soil CO_2 efflux, and subsequent changes in SOC across multiple rotations.
Conclusions
Data continue to be collected and analyzed, thus there are no conclusions at this time.
Major Impact(s) of Research
Understanding how soil carbon can be accrued and maintained through forest management approaches is critical to improving the resilience of forest systems, maintaining forest soil health, and mitigating atmospheric carbon dioxide.
Other Project Personnel
Fabio Toledo, Postdoctoral Research Associate, SREL
Tyler McIntosh, Research Technician, SREL
Marley Brown, Research Technician, SREL
Madeline Lyons, Research Technician, SREL
Elizabeth Patton, Research Technician, SREL
External Collaborators
NA
Products
Aubrey, D.P., G.W. Ferreira, D.R. Coyle, and M.D. Coleman. Nitrogen pools of narrow and broad site adapted tree species in response to resource amendments across full harvest rotations. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Aubrey, D.P. and G.W. Ferreira. Potential benefits and considerations of integrating nitrogen-fixing cover crops and trees into short-rotation woody crop production systems. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Aubrey, D.P. 2021. Grass(stage)root movement to ensure future resilience of longleaf pine ecosystems. International Union of Forest Research Organizations: Forest Seedling Root Development and Function for Reforestation and Restoration. Virtual. (Invited Presentation)

Aubrey, D.P. 2022. Managing forests for fine-root inputs to enhance climate resilience. International Union of Forest Research Organizations: 8th International Symposium on Physiological Processes in Roots of Woody Plants. State College, PA. (Presentation)

Aubrey, D.P. 2022. Root Respiration is Underestimated in Forests Due to Internal Transport of CO2. International Union of Forest Research Organizations: 8th International Symposium on Physiological Processes in Roots of Woody Plants. State College, PA. (Presentation)

Aubrey, D.P. 2021. Belowground respiration is underestimated in forests due to xylem transport of root-derived CO_2. American Geophysical Union. New Orleans, LA. (Presentation)

Aubrey, D.P., C.R. Jackson, and S.E. Younger. 2021. Consideration of forest water cycle dynamics throughout stand development can improve water use efficiency of woody bioenergy production systems. American Geophysical Union. New Orleans, LA. (Invited Presentation)

Aubrey, D.P., and M.J. Dix. 2021. Challenges and opportunities of estimating tree transpiration via sap flow. American Geophysical Union. New Orleans, LA. (Presentation)

Starr, G., R. Ruzol, D.P. Aubrey, C. Staudhammer, S. Younger, H. Loescher, and C.R. Jackson. 2021. Water use from an intensively managed loblolly pine plantation: Implications of silviculturally-enhanced tree growth on stand evapotranspiration. American Geophysical Union. New Orleans, LA. (Presentation)

Aubrey, D.P., C.R. Jackson, S.E. Younger, M.J. Dix, and P. Caldwell. 2022. Consideration of Forest Water Cycle Dynamics Throughout Stand Development Can Improve Water Use Efficiency of Short Rotation Woody Crop Production Systems. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Aubrey, D.P., C.R. Jackson, S.E. Younger, T. McIntosh, and F. Toledo. Evapotranspiration partitioning of three to five-year-old *Eucalyptus benthamii* and *Pinus taeda* in the southeast, US. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Characterizing multiscale feedbacks between forest structure, fire behavior and effects: Integrating measurements and mechanistic modeling for improved understanding of pattern and process

Funding Entity
US Department of Defense
Start Date and Funding Amount
January, 2020; $329,320
SREL Collaborators
D. Aubrey
Objectives
The ultimate goal of this research is to provide a mechanistic understanding of surface fire behavior to increase managers' ability to manipulate fire behavior during prescribed fire operations to meet ecological objectives in an effective, efficient, and safe manner. The specific objective for SREL is to characterize dose-dependent fire effects of vegetative thermal environment on plant tissues and represent this characterization in a new modeling tool that predicts fire effects based on spatially explicit outputs of the FIRETEC model.
Summary of Research Activities
Experiments have been conducted in the field and lab and additional experiments are on-going.
Conclusions
1) Empirical stem mortality dose thresholds differ among species and with species according to stem diameter.
2) Theoretical stem mortality dose thresholds were lower than empirical thresholds.
3) Stem mortality can be predicted from empirical dose thresholds and information about potential fuel accumulation in forest plots.

Major Impact(s) of Research
The results of this research should aid in the development of spatially explicit management tools that mechanistically link vegetation structure, fuels, fire behavior and fire effects, which will result in novel knowledge and tools that will enhance fire and fuel managers' ability to develop effective, efficient, and safe fire management strategies.
Other Project Personnel
Ream Thomas, MS student, SREL
Jennifer McDaniel, PhD student, SREL
External Collaborators
C. Hoffman, Colorado State University
J.J. O'Brien, USDA Forest Service-Southern Research Station
J.K. Hiers & M. Varner, Tall Timbers Research Station
R. Lynn, Los Alamos National Lab
Products
Aubrey, D.P. and J.J. O'Brien. 2022. Loblolly: Another fire pine? North Georgia Prescribed Fire Meeting. (Invited Presentation)
Thomas, R., J.J. O'Brien, L. Loudermilk, D. Aubrey. 2022. Energy dose thresholds for causing stem mortality for small diameter trees. Warnell Graduate Student Symposium. (Presentation)
Thomas, R.W. 2022. Determining fire energy dose thresholds in southeastern tree species. Warnell School of Forestry and Natural Resources Master's Thesis.
Wilson, L. A., R.N. Spencer, D.P. Aubrey, J.J. O'Brien, A.M.S. Smith, R.W. Thomas, and D.M. Johnson. 2022. Longleaf pine seedlings are extremely resilient to the combined effects of experimental fire and drought. *Fire*, 5(5), 128.

Characterizing dose-dependent fire effects of vegetative thermal environment on tree stems

Funding Entity
USDA Forest Service
Start Date and Funding Amount
August, 2020; $76,880
SREL Collaborators
D. Aubrey
Objectives
The objective of this project is to characterize dose-dependent fire effects of vegetative thermal environment on tree stems.
Summary of Research Activities
Measurements have been made in the field and experiments have been performed in the laboratory.
Conclusions
1) Empirical stem mortality dose thresholds differ among species and with species according to stem diameter.
2) Theoretical stem mortality dose thresholds were lower than empirical thresholds.
3) Stem mortality can be predicted from empirical dose thresholds and information about potential fuel accumulation in forest plots.

Major Impact(s) of Research
Results from this study will be used to develop dose-dependent relationships between energy transfer and tree stem, which will be integrated into models of fire behavior to predict mortality.
Other Project Personnel
Ream Thomas, MS student, SREL
External Collaborators
J.J. O'Brien USDA Forest Service-Southern Research Station
Products
Aubrey, D.P. and J.J. O'Brien. 2022. Loblolly: Another fire pine? North Georgia Prescribed Fire Meeting. (Invited Presentation)

Thomas, R., J.J. O'Brien, L. Loudermilk, D. Aubrey. 2022. Energy dose thresholds for causing stem mortality for small diameter trees. Warnell Graduate Student Symposium. (Presentation)

Thomas, R.W. 2022. Determining fire energy dose thresholds in southeastern tree species. Warnell School of Forestry and Natural Resources Master's Thesis.

Wilson, L. A., R.N. Spencer, D.P. Aubrey, J.J. O'Brien, A.M.S. Smith, R.W. Thomas, and D.M. Johnson. 2022. Longleaf pine seedlings are extremely resilient to the combined effects of experimental fire and drought. *Fire*, 5(5), 128.

Spatial and temporal patterns and ecological implications of leaf litter dispersal

Funding Entity
The Jones Center at Ichauway
Start Date and Funding Amount
August, 2020; $24,024
SREL Collaborators
D. Aubrey
Objectives
The goal of this project is to analyze an existing long-term dataset of leaf litter dynamics in longleaf pine forests, explore the spatial and temporal patterns of that dataset, and use the dataset to parameterize a model predicting spatial patterns of leaf litter dispersal from stem mapping.
Summary of Research Activities
Preliminary analysis of leaf litter dataset has been completed. Models have been developed and challenged with independent datasets.
Conclusions
1) Spatial patterns of leaf litter dispersal are best predicted by individual tree-based models.
2) Interannual litter production varied considerably over a 10-year period and could not be easily explained by environmental factors.
3) Prevailing wind direction influences spatial patterns of leaf litter dispersal.

Major Impact(s) of Research
Results from this study will provide information regarding forest structure, fuel dynamics, fire behavior, and seedling regeneration in longleaf pine stands.
Other Project Personnel
Suzanne Henderson, MS Student, SREL
External Collaborators
J. Cannon, Assistant Scientist, The Jones Center at Ichauway
Products
Henderson, S., J. Cannon, D.P. Aubrey. 2021. Modeling pine litter dispersal and assessing impacts of needle loading on Longleaf pine seedlings after prescribed burn. Warnell Graduate Student Symposium. Athens, GA. (Presentation)

Blaydes, S.H., J. Cannon, R. Holdo, D. Aubrey 2022. Modeling needle fuel dispersal in longleaf pine-dominated forests. Warnell Graduate Student Symposium. (Presentation)

Blaydes, S.H.. 2022. Modeling needle fuel dispersal in longleaf pine-dominated forests. MS Thesis. Warnell School of Forestry and Natural Resources Master's Thesis.

Managing forest ecosystem processes through physiology

Funding Entity
USDA National Institute of Food and Agriculture McIntire Stennis
Start Date and Funding Amount
August, 2020; $350,561
SREL Collaborators
D. Aubrey
Objectives
The overarching goal of this project is to improve our understanding of how forest management decisions influence tree physiology, ecosystem processes, and ecosystem services. Our specific objectives are to: (1) develop nuanced conceptual models of forest water and carbon cycles and parameterize them with empirical data; (2) apply model results to identify sensitive processes of forest water and carbon cycles that require empirical investigation; and (3) challenge/validate conceptual models with empirical data collected in a high-density sweetgum (*Liquidambar styraciflua*) coppice system. Though we focus our research on regionally appropriate tree species, the fundamental processes we explore can be applied to forest systems across the globe.
Summary of Research Activities
We have delineated research plots for seedling planting in early 2021. Conceptual models have been developed and presented at meetings. Empirical data are being collected to challenge model assumptions.
Conclusions
1) Leaf litter accumulation has a very strong impact on E_s.
2) High-density forest plantings can decrease rotation-length soil evaporation by 20%, but rotation-length E_t and total ET increase by 33% and 17%, respectively.
3) Retaining leaf litter on the forest floor from previous rotations can decrease subsequent rotation-length E_s by 54% without impacting E_t at all and decrease rotation-length ET increase by 16%.
4) The combination of high-density forest plantings and litter retention from the previous rotation can decrease rotation-length E_s by 54%, but rotation-length E_t and total ET increase by 33% and 6%, respectively.

Major Impact(s) of Research
This project addresses McIntire-Stennis Forestry Research Topics: 1) Reforestation and management of land for the production of crops of timber and other related products of the forest. It also addresses two high priority issues identified in the current McIntire-Stennis strategic plan: 1) science of integration and 5) technological advancements, productivity, and forest applications. In addition to directly addressing a specific Forestry Research Topic and the "Ecosystem Service" Priority Area, our project will also strengthen the McIntire-Stennis Cooperative Forestry Research Program 2017 Strategic Plan critical goal to "create the future generation of forestry educators, scientists, and practitioners through graduate education" by training multiple graduate students in forest ecology and tree physiology at the highest levels through direct involvement in research activities and through the PI's graduate level courses on these topics (i.e., Advanced Forest Ecology and Advanced Tree Physiology).
Other Project Personnel
Fabio Toledo, Postdoctoral Research Associate, SREL
Tyler McIntosh, Research Technician, SREL
Marley Brown, Research Technician, SREL
Madeline Lyons, Research Technician, SREL
Elizabeth Patton, Research Technician, SREL
Ream Thomas, MS Student, SREL
External Collaborators
D. Johnson (co-PI), Warnell School of Forestry and Natural Resources, UGA
C.R. Jackson, Warnell School of Forestry and Natural Resources, UGA
Products

Aubrey, D.P., G.W. Ferreira, D.R. Coyle, and M.D. Coleman. Nitrogen pools of narrow and broad site adapted tree species in response to resource amendments across full harvest rotations. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Aubrey, D.P. and G.W. Ferreira. Potential benefits and considerations of integrating nitrogen-fixing cover crops and trees into short-rotation woody crop production systems. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Aubrey, D.P. 2021. Grass(stage)root movement to ensure future resilience of longleaf pine ecosystems. International Union of Forest Research Organizations: Forest Seedling Root Development and Function for Reforestation and Restoration. Virtual. (Invited Presentation)

Aubrey, D.P. 2022. Managing forests for fine-root inputs to enhance climate resilience. International Union of Forest Research Organizations: 8th International Symposium on Physiological Processes in Roots of Woody Plants. State College, PA. (Presentation)

Aubrey, D.P. 2022. Root respiration is underestimated in forests due to internal transport of CO_2. International Union of Forest Research Organizations: 8th International Symposium on Physiological Processes in Roots of Woody Plants. State College, PA. (Presentation)

Aubrey, D.P. 2021. Belowground respiration is underestimated in forests due to xylem transport of root-derived CO_2. American Geophysical Union. New Orleans, LA. (Presentation)

Aubrey, D.P., C.R. Jackson, and S.E. Younger. 2021. Consideration of forest water cycle dynamics throughout stand development can improve water use efficiency of woody bioenergy production systems. American Geophysical Union. New Orleans, LA. (Invited Presentation)

Aubrey, D.P., and M.J. Dix. 2021. Challenges and opportunities of estimating tree transpiration via sap flow. American Geophysical Union. New Orleans, LA. (Presentation)

Starr, G., R. Ruzol, D.P. Aubrey, C. Staudhammer, S. Younger, H. Loescher, and C.R. Jackson. 2021. Water use from an intensively managed loblolly pine plantation: Implications of silviculturally-enhanced tree growth on stand evapotranspiration. American Geophysical Union. New Orleans, LA. (Presentation)

Aubrey, D.P., C.R. Jackson, S.E. Younger, M.J. Dix, and P. Caldwell. 2022. Consideration of forest water cycle dynamics throughout stand development can improve water use efficiency of short rotation woody crop production systems. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Aubrey, D.P., C.R. Jackson, S.E. Younger, T. McIntosh, and F. Toledo. Evapotranspiration partitioning of three to five-year-old *Eucalyptus benthamii* and *Pinus taeda* in the southeast, US. 13th International Short Rotation Woody Crops Conference. Asheville, NC. (Presentation)

Wilson, L. A., R.N. Spencer, D.P. Aubrey, J.J. O'Brien, A.M.S. Smith, R.W. Thomas, and D.M. Johnson. 2022. Longleaf pine seedlings are extremely resilient to the combined effects of experimental fire and drought. *Fire*, 5(5), 128.

Gao, L., D.P. Aubrey, X. Wang, and H. Sun. 2022. Seasonal non-structural carbohydrate dynamics differ between twig bark and xylem tissues. *Trees*, 36:1231-1245.

Characterization and recovery of critical metals from municipal solid waste incineration ashes

Funding Entity
SRNL
Start Date and Funding Amount
November 2022; 30,000
SREL Collaborators
Xiaoyu Xu
Objectives
The dependence on international supplies of rare earth elements (REEs) has prompted the U.S. to explore alternative sources and sustainable technologies for domestic REE production. One potential source is the secondary electronic and industrial waste generated at high volumes across the US. Current management of these environmentally hazardous wastes requires huge resources/costs for their remediation and disposition, while their high-REE content offers unique opportunities for REE recovery. This project aims to develop novel functionalized mesoporous materials for the effective recovery and separation of REEs from complex acidic extracts of some typical electronic and industrial waste streams. Novel mesoporous materials will be synthesized and functionalized with selected organic ligands. The functional mesoporous materials will effectively recover and separate lanthanum (La), cerium (Ce), europium (Eu), yttrium (Y), neodymium (Nd), dysprosium (Dy), and praseodymium (Pr) from the complex acidic extracts of these electronic and industrial wastes and can be regenerated for repeated REE harvest.
Summary of Research Activities
Batch evaluation experiments will be conducted on the extraction and separation experiments, as well as the associated analytical characterization of the materials and effluents after reactions. The major lab work includes basic chemical measurements such as pH values, concentration determination with ICP-MS, material characterization with XRD and XRF, etc.
Conclusions
The data are still being collected.
Major Impact(s) of Research
This research project will develop a method that extracts REEs from municipal solid waste incineration ashes and other electronic/industrial waste, helping decrease the dependence on international supplies of REEs.
Other Project Personnel
Breann Spencer, SREL
External Collaborators
Dr. Dien Li, SRNL
Products
Publications, presentations, or reports have yet to be prepared.

Biogeochemical cycling of trace metals and sulfur in microniches at the water-sediment-rhizosphere nexus in wetlands with a three-pronged approach

Funding Entity
U.S. Department of Energy
Start Date and Funding Amount
October 2022; NFP
SREL Collaborators
Xiaoyu Xu, Zeinah Baddar
Objectives
This project aims to study the mechanisms involved in the biogeochemical cycling of trace metals and sulfur in the sediments of wetlands with a novel and accurate approach. The presence of microniches, along with the introduction of artefacts during sample collection and handling, result in conflicting and highly variable outcomes. We will apply a three-pronged approach where we select the study site, perform in situ measurements, and finally analyze the samples and collected data. We will measure physiochemical parameters and bioavailable metal concentrations and perform metabolomic and omics analyses to understand the role of macrophytes and microbial communities.
Summary of Research Activities
A related study was conducted on a constructed wetland on the Savannah River site. Passive samplers were deployed to study metal speciation in the sediment-water interface, and porewater chemistry was studied by measuring organic matter, anions, and water quality parameters. Microbial community structure analysis was also conducted with quantitative polymerase chain reaction (qPCR) and the next generation sequencing (NGS).
Conclusions
Relatively high labile metal concentrations were observed in the sediment porewater. Porewater chemistry, such as pH, oxygen, DOC, and anions, was closely related to metal speciation and bioavailability in sediment. Meanwhile, microbial community structure changes with time.
Major Impact(s) of Research
The results of this study 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, lab manager, SREL
Breann Spencer, lab manager, SREL
Cher Nicolson, M.S. student, SREL
External Collaborators
Anna Knox, SRNL
Products
Publications, presentations, or reports have yet to be prepared.

The multiple stressor risk assessment for bioaccumulative chemical mixtures: an endpoint driven bayesian network-relative risk model for humans (BN-RRM-H)

Funding Entity
U.S. Environmental Protection Agency
Start Date and Funding Amount
October 2022; NFP
SREL Collaborators
Xiaoyu Xu
Objectives
The proposed research is to develop a novel and powerful tool to quantitatively estimate the risks of bioaccumulative chemical mixtures for human beings. We adapt the approach developed for the multiple-source regional wildlife risk assessments to address human risk from mixtures of bioaccumulative chemicals. An endpoint driven Bayesian network-relative risk model for humans (BN-RRM-H) will be applied to integrate toxicities of different chemicals and generate a final risk distribution, which can be used to evaluate joint toxicities and facilitate decision-making. In this approach, a human body is considered a collection of multiple endpoints, so the final risks of chemical mixtures will be generated by integrating all endpoint-specific effects. The model components are chemical stressors, organ systems of the human body, and health effects and impacts. Bayesian networks (BNs) will be used to combine the risks from different chemical stressors.
Summary of Research Activities
One M.S. student was recruited to work on a related research project.
Conclusions
The data are still being collected.
Major Impact(s) of Research
The Bayesian network-relative risk model for humans (BN-RRM-H) is an innovative approach to evaluating the toxicity of the whole mixture for a target population. The risk scores and risk distributions generated by the BN-RRM-H approach establish a novel and powerful tool for evaluating the joint toxicities of chemical mixtures and communicating human health risks. The endpoint-specific risks provide detailed health advice to the population and regulatory recommendations for different management scenarios. The final risk distribution will be a convenient tool to compare risks among populations and help regulatory agencies assess health risks.
Other Project Personnel
NA
External Collaborators
Dr. Haidong Zhu, Augusta University
Dr. Kurt Pennell, Brown University
Products
Publications, presentations, or reports have yet to be prepared.

Characterization and recovery of critical metals from municipal solid waste incineration ashes

Funding Entity
SRNL
Start Date and Funding Amount
November 2022; 30,000
SREL Collaborators
Xiaoyu Xu
Objectives
The dependence on international supplies of rare earth elements (REEs) has prompted the U.S. to explore alternative sources and sustainable technologies for domestic REE production. One potential source is the secondary electronic and industrial waste generated at high volumes across the US. Current management of these environmentally hazardous wastes requires huge resources/costs for their remediation and disposition, while their high-REE content offers unique opportunities for REE recovery. This project aims to develop novel functionalized mesoporous materials for the effective recovery and separation of REEs from complex acidic extracts of some typical electronic and industrial waste streams. Novel mesoporous materials will be synthesized and functionalized with selected organic ligands. The functional mesoporous materials will effectively recover and separate lanthanum (La), cerium (Ce), europium (Eu), yttrium (Y), neodymium (Nd), dysprosium (Dy), and praseodymium (Pr) from the complex acidic extracts of these electronic and industrial wastes and can be regenerated for repeated REE harvest.
Summary of Research Activities
Batch evaluation experiments will be conducted on the extraction and separation experiments, as well as the associated analytical characterization of the materials and effluents after reactions. The major lab work includes basic chemical measurements such as pH values, concentration determination with ICP-MS, material characterization with XRD and XRF, etc.
Conclusions
The data are still being collected.
Major Impact(s) of Research
This research project will develop a method that extracts REEs from municipal solid waste incineration ashes and other electronic/industrial waste, helping decrease the dependence on international supplies of REEs.
Other Project Personnel
Breann Spencer, SREL
External Collaborators
Dr. Dien Li, SRNL
Products
Publications, presentations, or reports have yet to be prepared.

Biogeochemical cycling of trace metals and sulfur in microniches at the water-sediment-rhizosphere nexus in wetlands with a three-pronged approach

Funding Entity
U.S. Department of Energy
Start Date and Funding Amount
October 2022; NFP
SREL Collaborators
Xiaoyu Xu, Zeinah Baddar
Objectives
This project aims to study the mechanisms involved in the biogeochemical cycling of trace metals and sulfur in the sediments of wetlands with a novel and accurate approach. The presence of microniches, along with the introduction of artefacts during sample collection and handling, result in conflicting and highly variable outcomes. We will apply a three-pronged approach where we select the study site, perform in situ measurements, and finally analyze the samples and collected data. We will measure physiochemical parameters and bioavailable metal concentrations and perform metabolomic and omics analyses to understand the role of macrophytes and microbial communities.
Summary of Research Activities
A related study was conducted on a constructed wetland on the Savannah River site. Passive samplers were deployed to study metal speciation in the sediment-water interface, and porewater chemistry was studied by measuring organic matter, anions, and water quality parameters. Microbial community structure analysis was also conducted with quantitative polymerase chain reaction (qPCR) and the next generation sequencing (NGS).
Conclusions
Relatively high labile metal concentrations were observed in the sediment porewater. Porewater chemistry, such as pH, oxygen, DOC, and anions, was closely related to metal speciation and bioavailability in sediment. Meanwhile, microbial community structure changes with time.
Major Impact(s) of Research
The results of this study 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, lab manager , SREL
Breann Spencer, lab manager, SREL
Cher Nicolson, M.S. student, SREL
External Collaborators
Anna Knox, SRNL
Products
Publications, presentations, or reports have yet to be prepared.

Suitability of confiscated box turtles for release back into the wild

Funding Entity
SREL, Animal Welfare Institute, Greenville Zoo, Justin Congdon and Nancy Dickson Turtle Ecology Fund
Start Date and Funding Amount
August 2019, NFP; FY22 $825; FY22 $19,494
SREL Collaborators
Tracey D. Tuberville, Kurt A. Buhlmann, and Olin E. Rhodes Jr.
Objectives
The overall goal of this research is to determine whether turtles confiscated from illegal wildlife trafficking trade can be successfully released back into the wild, using box turtles released onto the SRS as a case study.
Summary of Research Activities
During FY22, we continued to radio-track 28 confiscated eastern box turtles released on the SRS in 2019, as well as 10 resident box turtles and 25 long-term captives released on the SRS in June 2021. The purpose of radio-telemetry is to monitor post-release survival and movement. We also incidentally captured, performed health assessments, and collected biological samples from all other resident box turtles incidentally captured on the SRS during field activities. The purpose of the incidentally captured residents is to compare baseline health of resident population with that of released confiscated and long-term captive turtles. Starting in April 2022, we began monitoring female eastern box turtles for signs of reproduction by conducting serial xrays every two weeks to detect and enumerate calcified eggs. This portion of the study will allow us to compare reproductive output and hatching success among the three groups of turtles. In FY23, we plan to perform parentage analysis on resulting offspring to evaluate reproductive integration of released box turtles. Transmitters were removed from all radio-tracked box turtles in August 2022, concluding the movement component of the study. All field components are completed but laboratory analyses (pathogen screening, parentage analysis) are still pending. FY23 will focus on analyzing and reporting movement, survival, health and reproductive components of the project.
Conclusions
Data have not yet been obtained for all project components, but the following patterns have emerged:
1) Mortality rates of released confiscated turtles is higher than in wild resident box turtles, likely due to their poor holding conditions prior to confiscation by law enforcement.
2) Confiscated turtles generally exhibited higher movement patterns during first year following release when compared to resident wild box turtles. However, when their initial exploratory period is excluded from home range estimation, they exhibit similar movement patterns in both Year 1 and Year 2 post-release.
3) Confiscated turtles can exhibit high prevalence with a complex array of pathogens and can potentially introduce new pathogens to naïve resident populations.
4) Released confiscated turtles exhibit similar reproductive parameters to residents, including clutch size, reproductive output and hatching success

Major Impact(s) of Research
1) Novel data on the fate of confiscated box turtles released back into the wild
2) Insight into the broader issue regarding the suitability of confiscated turtles for repatriation back to the wild and how they can contribute to the conservation of wild populations
3) A better understanding of the resident box turtle population on the SRS, which has received little attention despite long-term studies of aquatic turtles

Other Project Personnel
Emma Browning, MS student, SREL
Ryan Rimple, MS student, SREL
Ryne Huggins, Research Technician, SREL
External Collaborators

Will Dillman, SCDNR
Andrew Grosse, SCDNR
Charlie Davis, USFS-SR
Matthew Allender, University of Illinois College of Veterinary Medicine
Nicole Stacy, University of Florida College of Veterinary Medicine
Michel Kohl, UGA

Products

Browning, E.A., M.T. Kohl, K.A. Buhlmann, O.E. Rhodes Jr., R.J. Rimple, and T.D. Tuberville. 2022. Home range and site fidelity in confiscated and resident eastern box turtles. Annual Symposium on Conservation and Biology of Tortoises and Freshwater Turtles.

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Browning, E.A. 2022. Investigating the suitability of confiscated eastern box turtles for release into the wild. Academy for Lifelong Learning, University of South Carolina-Aiken.

Addressing reproductive dysfunction in an environmental model of endocrine disruption

Funding Entity
SREL
Start Date and Funding Amount
2018; NFP
SREL Collaborators
Dr. Ben 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
Samantha Bock, PhD student, SREL
Chris Smaga, MS student, SREL
External Collaborators

N/A

Products

Hale, M.D., Koal, T., Hai Pham, T., Bowden, J.A., Parrott, B.B. Transcriptional networks underlying a primary ovarian insufficiency disorder in alligators naturally exposed to EDCs. 2022. *Molecular and Cellular Endocrinology* In Press

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Hale, M.D., Parrott, B.B. Precocious estrogen signals underlie altered ovarian function in a model of environmental health. 2020. *Environmental Health Perspectives* 128(11):117003

Parrott, B.B., Hale, M.D. Precocious estrogen signaling during embryonic development underlies persistent alteration of ovarian transcriptional networks in an environmental model of endocrine disruption. 2019. Invited Talk. North American Society for Comparative Endocrinology Conference. Gainesville, FL, USA

Parrott, B.B. Wildlife as models for understanding mechanisms of reproductive disorders. 2019. Invited Seminar. University of Georgia, Department of Cellular Biology Seminar Series, Athens, GA, USA

Parrott, B.B. Adaptive and disruptive mechanisms underlying epigenome-by-environment interactions. 2019. Invited Seminar, University of South Carolina- Aiken, Department of Biology Seminar Series, Aiken, SC, USA

Galligan, T.M., Hale, M.D., Bermudez, D., Cloy-McCloy, J.A., Guillette L.G., Parrott, B.B. 2019. Assessing impacts of precocious steroid exposure on thyroid physiology and gene expression patterns in the American alligator. *General and Comparative Endocrinology* 271(15):61-72

Hale, M.D., Cloy-McCoy, J.A., Doheny, B.M., Galligan, T.M., Guillette, L.G., Parrott, B.B. 2019. Embryonic estrogen exposure recapitulates persistent ovarian transcriptional programs in a model of environmental endocrine disruption. *Biology of Reproduction* 100(1): 149-161

Hale, M.D., McCoy, J., Galligan, T., Bangma, J., Nilsen, F., Doheny, B., Guillette, L.J., Parrott, B.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. Poster Presentation. 8th International Symposium on Vertebrate Sex Determination (VSD); Kona, HI.

Hale, M.D., Galligan, T., Guillette, L.J., Parrott, B.B. 2018. Linking historical exposures to modern-day signaling: dioxin and the American alligator. Oral presentation. 22nd Odum School of Ecology Graduate Student Symposium; Athens, GA.

Hale, M.D., Cloy-McCoy, J.A., Doheny, B.M., Parrott, B.B. 2018. Reproductive Biology of Crocodilians, published in *Encyclopedia of Reproduction* (2nd edition)

Initial characterization of per- and polyfluoroalkyl substances on the Savannah River Site

Funding Entity
SREL
Start Date and Funding Amount
October 2020; $238,164
SREL Collaborators
Xiaoyu Xu, Ben Parrott
Objectives
Concern about per- and polyfluoroalkyl substances (PFAS) as persistent environmental contaminants has increased in recent years due to their widespread use, resistance to degradation, high mobility in ecosystems, and potential health risks to humans and wildlife. The overarching goal of the study is to characterize the spatial distribution of PFAS on the Savannah River Site (SRS), as well as the extent to which these compounds are biologically available.
Summary of Research Activities
Abiotic and biotic samples will be collected on SRS. Abiotic samples will be used as indicators of the legacy contamination of PFAS, and biota samples will indicate their biological availability. Surface water, sediment, and mosquitofish samples were collected from aquatic systems on SRS, including the identified PFAS contaminated streams in the D-Area firefighting training area, historic stream sites monitored by the SRS Integrator Operable Unit (IOU) program, non-stream sites like Par Pond and L Lake, and a reference site the H-02 constructed wetland. Sample process and PFAS analysis will be conducted in FY23.
Conclusions
The data are still being collected.
Major Impact(s) of Research
Findings from this study will provide an initial snapshot of PFAS on the SRS regarding their distributions, levels, bioaccumulation potential, and toxicity. Ultimately, the work will provide baseline levels of PFASs on the SRS landscape, inform potential remediation efforts on PFASs on the site, and reduce uncertainties in risk assessment regarding these long-lasting contaminants.
Other Project Personnel
Elise Webb, SREL
Dean Fletcher, SREL
External Collaborators
Dr. John Bowden, University of Florida
Products
Publications, presentations, or reports have yet to be prepared.

Forest health metrics: DNA methylation age predictors in loblolly pine

Funding Entity
USDA USFS-SRS
Start Date and Funding Amount
September 2019; $19,098
SREL Collaborators
Dr. Ben Parrott, Dr. Doug Aubrey
Objectives
The overall goal of this research is to assess age-associated DNA methylation patterning and develop a DNA methylation based epigenetic clock for Loblolly pine.
Aging is amongst the most universal biological processes, as organisms generally experience declines in molecular and physiological function over time, ultimately resulting in increased risk of death.
DNA methylation is perhaps the best-studied epigenetic modification and when genomic patterning of the DNA methylome is resolved at the nucleotide level, the stereotypical nature of age-associated changes can be modeled to generate "epigenetic clocks". Epigenetic clocks summarize the readout of age-associated hyper- and hypo-methylation from a selection of loci across the genome which are collectively capable of predicting chronological age with high accuracy. Interestingly, the degree to which an individual's "epigenetic age" exceeds their true chronological age (also called epigenetic-to-chronological age discordance) is associated with life-history traits (e.g., growth rate, size at birth) in humans as well as risk for a number of age-associated disease including cardiovascular disease, cancer, and even all-cause mortality (e.g., risk of dying). Thus, there is exciting potential for measures of epigenetic-to-chronological age discordance to advance our understanding of trait development in other species.
DNA methylation has well-studied roles in plants including the repression of transposable elements, as well as regulating gene expression, organismal development, and adaptive responses to environmental cues. However, the dynamics of epigenetic aging have not been fully described nor have attendant epigenetic clocks been developed in the plant kingdom. The overarching goal of the proposed work is to discover broadly conserved epigenetic signatures of aging in economically important tree species and to develop epigenetic clocks capable of predicting chronological age that can be used in ecological, conservation, and management contexts. Findings will provide insights into the basic biology underlying fundamental aging processes and will also provide a framework for exploring the consequences of accelerated epigenetic aging on traits associated with stand productivity, wood quality, and ecosystem processes and attributes, including resilience.
Summary of Research Activities
Tree tissue was sampled from a cohort of known-aged trees and subsequent DNA extraction, library preparation, and sequencing of the DNA methylome is now complete for 24 individuals. Reads were aligned to the Loblolly pine genome and 3,700 CpGs (cytosines immediately preceding guanines represent potential methylation sites) were covered across all individuals. Of these, only 5 CpGs acquire statistically significant age-dependent methylation patterns (all but one lose methylation with age). This is generally a weaker signal than observations in vertebrates. When coverage filtering requirements are relaxed to include CpGs that are covered in at least 2/3 samples in each age group (instead of 3/3), we increase the number of CpGs in our dataset to 27,000. Of these, the methylation status of ~400 CpGs have correlation coefficients > ±0.5 with age, indicating considerable age-related DNA methylation pattern in the Loblolly pine.
However, the modeling techniques typically used to develop age predictors (i.e., elastic net regularized regression) do not tolerate missing data, so an imputation technique that borrows data from other samples and nearby CpGs to substitute for missing data is being developed. Also of note, plants are unique in that they also have high levels of CHG methylation (where H corresponds to either an A, T, or C). CHG is relatively low in animals, but is much more frequent in plants. CHG methylation in our dataset appears variable (not all methylated or all unmethylated), which is interesting and means there is potential that CHG methylation might also correlate with age. To date, CHG methylation has not been examined in the

context of age or age-related traits. Thus, the Parrott Lab is developing a bioinformatic pipeline to analyze this dataset as well.

Conclusions

1) Age-associated DNA methylation patterns are observed in the Loblolly pine.
2) CpG and CHG methylation are age-dependent, whereas CHH methylation is not.
3) Age-associated DNA methylation patterns can be modeled to predict chronological age in plants.
4) Age-associated CHG methylation represents a promising path for investigation.

Major Impact(s) of Research

1) Establishing an epigenetic aging clock for trees will open the door for applications relevant to assessing commercial traits, forest productivity, plant disease, as well as the basic biology and evolution of life history traits.

Other Project Personnel

Emily Bertucci, PhD Student, SREL
Steven Gardner, Postdoctoral Researcher, SREL

External Collaborators

Dr. Andy Horcher, USDA USFS-SRS
Randall Sutton, USDA USFS-SRS

Products

Gardner, S.T., Bertucci, E.M., Sutton, R., Horcher, A., Aubrey, D.P., Parrott, B.B. Development of DNA methylation-based epigenetic age predictors in Loblolly pine (*Pinus taeda*). 2022. *Molecular Ecology Resources* 00:1-14

Environmental and ecological determinants of epigenetic aging

Funding Entity
National Science Foundation
Start Date and Funding Amount
September 2020; $853,295
SREL Collaborators
Dr. Ben Parrott
Objectives
Because of its near universal occurrence, understanding the causes and consequences of aging is central to broad biological, ecological, and evolutionary questions. Recent advances demonstrate a central role of the epigenome in mediating biological aging as it provides a molecular context for integrating both intrinsic and extrinsic forces. The purpose of this project is to discover fundamental mechanisms by which the environment directs epigenetic aging trajectories to ultimately impact organismal function. The project will utilize the tractable and ecologically relevant fish, Japanese medaka as a model system as much of their genome and physiology are broadly conserved across the animal kingdom. The study will support the training and mentoring of a postdoctoral researcher, two graduate students, and an undergraduate researcher, with recruiting efforts aimed at under-represented groups in the sciences. The project will develop a primer that introduces fundamental concepts in life history ecology and evolution, and will highlight variable life histories observed across the animal kingdom. The primer and project findings will be presented to students at area schools as part of an established outreach program. Together, this work will advance current understanding of how interactions between organisms and their environment affect biological aging and will provide training opportunities for the next generation of scientists.
Summary of Research Activities
The work will focus on recently developed epigenetic aging clocks to advance an ontogenetic- and endocrine-based understanding of how ecological and environmental challenges shape biological aging and attendant variation in the timing of live history events (e.g., age at maturity). Epigenetic aging clocks are based on age-dependent DNA methylation patterning and summarize the readout of age-associated hyper- and hypo-methylation from a selection of loci across the genome which are collectively capable of predicting chronological age with high accuracy. Despite their unprecedented accuracy, the age indicated by epigenetic clocks can differ from an individual's actual age. This is referred to as epigenetic-to-chronological age discordance, and the magnitude and directionality of this discordance are associated with physiological function and life history traits. The origins of epigenetic-to-chronological age discordance are not resolved, and this project aims to investigate the role of ecological and environmental dynamics in driving this discordance. Along with other ecologically relevant stressors, fish will be exposed to ionizing radiation at the SREL's Low Dose Irradiation Facility. The project will also test the role of specific endocrine signaling pathways in mediating the influence of the environment on epigenetic aging. Interactions between organisms and their environments can result in different outcomes depending on when during life they occur. Age-dependent epigenetic patterning appears especially dynamic during early life and experiments will test if environment-organism interactions exert disproportionate influences during specific life stages. Collectively, project findings will provide a novel perspective regarding the proximal mechanisms by which environmental factors are translated into aging trajectories to affect organismal function and produce variable life histories.
Conclusions
1) DNA methylation clocks have been developed and are highly accurate.
Major Impact(s) of Research
1) Findings will advance our understanding by demonstrating cause-and-effect relationships between age-associated methylation patterning and ecological and environmental conditions.
2) Findings will reveal the extent to which biological aging mechanisms influence life history traits.
Other Project Personnel

Emily Bertucci, PhD Student, SREL
Steven Gardner, Postdoctoral Researcher, SREL
Abby Bickle, Research Technician, SREL

External Collaborators

Kristen Navara, UGA

Products

Gardner, S.T., Bertucci, E.M., Sutton, R., Horcher, A., Aubrey, D.P., Parrott, B.B. Development of epigenetic age predictors in the Loblolly pine tree (*Pinus taeda*). 2022. *Molecular Ecology Resources* 00:1-14

Bertucci, E.M., Shealy, E., Parrott, B.B. Regional disorder in DNA methylation underlies epigenetic clock signals, but reveals distinct responses to epigenetic rejuvenation events. *Article In Preparation*

Bertucci, E.M., Parrott, B.B. The rate of epigenetic drift explains maximum lifespan in mammals. *Article In Preparation*

Gardner, S.T., Bertucci, E.M., Parrott, B.B. Life stage specificity of environment by DNA methylome interactions. *Article In Preparation*

Parrott, B.B. 2022. Department of Ecology, Evolution, & Organismal Biology, Kennesaw State University

Parrott, B.B. 2022. Gordon Conference on Endocrine Disrupting Compounds, Newry ME, USA

Bertucci, E.M., Parrott, B.B. Characterization of the age-related DNA methylome and development of an epigenetic age predictor in medaka (*Oryzias latipes*). 2019. University of Alabama Birmingham Integrative Aging Symposium, Birmingham, AL, USA

Bertucci, E.M., Mason, M.W., Rhodes, O.E., Parrott, B.B. Exposure to ionizing radiation disrupts normal epigenetic aging in Japanese medaka. 2021. *Aging* 13(19)22752-22771

Molecular level biodosimetry for national security: proteomic, glycomic, epigenetic, and metabolic approaches for quantitative assessment of low dose radiation exposure

Funding Entity
UGA Presidential Interdisciplinary Seed Grant Program
Start Date and Funding Amount
2021; $146,250
SREL Collaborators
Dr. Olin Rhodes, Dr. Ben Parrott
Objectives
The goals of this research are to utilize a combination of existing data from previously published experiments evaluating proteomic, glycomic, and epigenetic responses of a model organism (Medaka Fish) to a range of controlled low dose radiation exposures conducted by this team, in combination with new experiments examining the metabolomic responses of this model organism to these same exposure levels over a time course and differentiated by sex.
Summary of Research Activities
The project is directed at identifying and exploiting relationships between exposure to low doses of ionizing radiation (IR) and biological responses that individually or collectively may be used as biomarkers of low dose radiation exposure, and ultimately as quantitative tools for biodosimetry. Experiments accomplish this by employing state-of-the art mass spectrometric and molecular approaches to identify proteins, glycoprotein N-glycans, genes, and epigenetic marks whose expression or modification reflects organismal responses to low dose radiological exposure. These identifications then serve to illuminate the metabolic pathways, metabolites, and biochemical modifications that are impacted by low dose IR exposure. Our current and future research goals aim to experimentally verify and validate proteomic, glycomic, and other molecular responses to low dose IR exposure in the model organism Medaka fish (Oryzias latipes) and to translate this research to other impactful animal models and, eventually, to human subjects. The results obtained to date support the concept that low dose mechanisms are very different from high dose/dose rate mechanisms and support the use of glycosylation, protein expression, and lipid metabolism as biomarkers for radiation stress induced by environmentally relevant levels of IR.
To date, we have performed two series of exposure experiments at the SREL's Low Dose Irradiation Facility (LoDIF). Each experiment contains three replicates of >10 fish exposed to either low (~5 mG/day), medium (~50 mG/day), high (~500 mG/day) doses of gamma radiation along with negative controls consisting of background radiation. Fish are sampled at 2 and 10 weeks of exposure. After 10 weeks of exposure, irradiation is halted and fish are again sampled after two weeks of recovery to identify markers that are persistently affected, even after radiation exposure has ended. Fish have been necropsied (final necropsy date was October 28, 2022) are currently being analyzed by investigators on the main UGA campus as well as those at the SREL.
Conclusions
Fish experiments have just been completed and we are now transitioning to the analysis portion of the project. Thus, there are no conclusions to be made at time of reporting.
Major Impact(s) of Research
1) None yet
Other Project Personnel
Marilyn Mason, Research Technician, SREL
External Collaborators
Dr. Franklin Leach, UGA
Dr. Michael Tiemeyer, UGA
Dr. Lance Wells, UGA
Products
There are no products to report at this time.

Integrating environment-by-epigenome interactions into a tractable model of epigenetic aging

Funding Entity
National Institutes of Health
Start Date and Funding Amount
August 2022; $273,430
SREL Collaborators
Dr. Ben Parrott
Objectives
Test the hypothesis that chronic exposure to environmentally relevant doses of IR accelerate and shape epigenetic aging trajectories. The Savannah River Site's Low Dose Irradiation Facility is a unique outdoor facility designed for testing the effects of chronic IR exposure on aquatic organisms across replicate dose rates. Using a factorial design at this facility, the project seeks to assess the influence of radiation exposure under complex environmental conditions on epigenetic aging and other hallmarks of aging.
Summary of Research Activities
The overarching goal of the work is to discover fundamental principles by which complex environmental conditions interact with epigenetic processes to determine biological aging trajectories. By pairing high resolution measures of epigenetic aging with life history evolutionary theory, the work will advance a life course- and toxicological-based understanding of how commonly encountered environmental challenges accelerate biological aging and attendant organismal function. We will utilize newly developed epigenetic aging resources in an experimentally and genetically tractable fish model, Japanese medaka (*Oryzias latipes*), along with a straightforward experimental strategy to investigate the environmental determinants of epigenetic aging.
Recent advances demonstrate that age-associated alterations to the epigenome provide a molecular context for integrating intrinsic and extrinsic forces into aging programs. When genomic patterning of the DNA methylome is resolved at the nucleotide level, the stereotypical nature of age-associated changes can be modeled to generate "epigenetic clocks". Despite the unprecedented accuracy of epigenetic clocks in predicting chronological age, epigenetic age estimates frequently differ from an individual's actual age. The magnitude and directionality of this epigenetic-to-chronological age discordance are predictive of risk for age-associated diseases and all-cause mortality. However, the underlying causes, fundamental principles, and mechanisms driving epigenetic-to-chronological discordance are not yet resolved.
Many different environmental exposures have now been linked to epigenetic-to-chronological age discordance in clinical studies and tractable models are needed to establish the underlying cause-effect relationships. Ionizing radiation (IR) represents a ubiquitous stressor with which almost all life shares an evolutionary history, and yet contemporary risk stemming from radiation exposure is increasing due to medical testing, air travel, occupational exposure, and disasters resulting from warfare and nuclear accidents. Thus, IR not only represents a universal stressor with conserved biological responses, but is also a timely and relevant model for assessing environment-by-epigenome interactions as they relate to public health. Although not commonly studied in natural settings, the biological consequences of IR exposure are dependent upon complex interactions occurring across temporal, spatial, and social scales, and dynamic experimental approaches incorporating appropriate environmental complexity are needed.
Conclusions
The project has just started and there are no conclusions to be made at this time.
Major Impact(s) of Research
None yet
Other Project Personnel
Marilyn Mason, Research Technician, SREL
External Collaborators
None
Products
There are no products to report at this time.

Wetland restoration and seed bank analysis on the SRS: a case study on the impacts of tree removal and duff on revegetation of wetlands

Funding Entity
NA
Start Date and Funding Amount
July 2021, NFP
SREL Collaborators
Dr. Stacey L. Lance, Tucker Stonecypher
Objectives
The overall goal of this research is to experimentally examine how different wetland restoration techniques compare in terms of speed of recovery of plant and animal communities, cost, and labor. Our objectives are to conduct a two by four by four factorial experiment in four wetlands that have experienced pine encroachment over the last 50 years. Our factors in include tree removal (yes or no) combined with four different duff treatments: complete duff removal, duff disturbance, duff burn and control and four replicates per wetland. We have monitored the change in herbaceous vegetation in all treatment plots. In addition, we are examining the seed bank of each plot.
Summary of Research Activities
We established all plots, conducted pre-treatment vegetation surveys in all plots, removed trees from 1/8 acre in each wetland and applied the duff treatments. We collected soil cores for seed bank analysis and allowed the seed bank to express for 10 months. Tree removal was accomplished by a combined effort of SREL maintenance staff, USFS foresters and USFS wildlife services. We have begun analysis of the post-restoration vegetation survey data.
Conclusions
The data are still being analyzed but so far indicate a significant positive effect of tree removal and that removing duff is the best duff treatment. However, duff disturbance and fire may also provide improvement to herbaceous growth.
Major Impact(s) of Research
The data are still being analyzed but so far suggest that the seed bank is still viable, and that restoration will lead to rapid improvement of the wetlands, an important finding for stewardship both on and of the SRS.
Other Project Personnel
Linda Lee, Research Professional, SREL
Adam McFall, MS student, SREL
Kiersten Nelson, PhD student, SREL
External Collaborators
Charlie Davis, USFS
Jarvis Brown, USFS
Products
Stonecypher, E., Davis, C., Lee, L., Lance, S. 2022. Wetland Restoration: A New Approach to Restoring Gopher Frog Breeding Sites. UGA Odum School of Ecology Graduate Student Symposium, Athens, GA.

Stonecypher, E., Davis, C., Lee, L., Lance, S. 2022. Wetland Restoration: A New Approach to Restoring Gopher Frog Breeding Sites. Southeastern Partners in Reptile and Amphibian Conservation, Virtual meeting.

Stonecypher, E., Lee, L., Lance, S. Quantifying Habitat Degradation and Current Vegetative Communities of Breeding Sites for the Imperiled Carolina Gopher Frog (*Rana capito*). 2022. Joint Meetings of Icthyologists and Herpetologists, Spokane, WA

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

Funding Entity
SC DNR to Dr. Gino D'Angelo at UGA
Start Date and Funding Amount
January 2017; $50,000 routed to S. Lance. July 2018; $165,760 to UGA
SREL Collaborators
Dr. Stacey L. Lance
Objectives
The overall goals of this research are to 1) estimate coyote populations across three physiographic regions (including the SRS) in South Carolina using fecal genotyping and spatial capture-recapture, 2 relate coyote population abundance to land use and habitat characteristics across South Carolina and 3) assess population genetic structure of coyote metapopulations across three physiographic regions in South Carolina.
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. A PhD student, Jordan Youngmann, has now led a team to collect scat along transects in 8 different locations representing three ecoregions within the state in both 2019 and 2020. We extracted and genotyped DNA from all scats and are analyzing the data.
Conclusions
Most of the data are still being analyzed, but we have determined that genetically there appears to be a single population of coyotes in South Carolina.
Major Impact(s) of Research
1) Data will be acquired to estimate coyote abundance in different ecoregions
2) Data will be used to inform deer management policies
Other Project Personnel
Dr. Jason O'Bryhim, Research Professional, SREL
Adam McFall, MS Student, SREL
Gabriela Rodriguez, Undergraduate researcher, SREL
External Collaborators
Dr. Gino D'Angelo, Warnell School of Forestry and Natural Resources, UGA
Dr. Karl Miller, Warnell School of Forestry and Natural Resources, UGA
Dr. John Kilgo, USFS
Jordan Youngman, Warnell School of Forestry and Natural Resources, UGA
Products
Youngmann, J. L., G. J. D'Angelo, J. C. Kilgo, S. L. Lance, K. V. Miller, and C. Ruth. 2019.Use of non-invasive genetic sampling to estimate population density, resource selection, and genetic structure of coyotes in South Carolina. Georgia Department of Natural Resources Annual Meeting.

Youngmann, J.L., G.J. D'Angelo, J.C. Kilgo, S.L. Lance, K.V. Miller, and C. Ruth. 2019. Use of fecal genotyping and spatial capture-recapture to investigate population density, resource selection, and genetic structure of coyotes in South Carolina. 26th Annual Conference of The Wildlife Society, Reno, Nevada. (

Youngmann, J.L., G.J. D'Angelo, J.C. Kilgo, S.L. Lance, K.V. Miller, and C. Ruth. 2019. Use of fecal genotyping and spatial capture-recapture modeling to investigate coyote abundance in South Carolina. 42nd Annual Meeting of the Southeast Deer Study Group, Louisville, Kentucky.

Molecular diet analysis of coyote scat through implementation of DNA metabarcoding

Funding Entity
SC DNR to Dr. Gino D'Angelo at UGA.
Start Date and Funding Amount
July 2019; $80,059
SREL Collaborators
Dr. Stacey L. Lance
Objectives
The overall goal of this research is to use DNA metabarcoding to determine the diet of coyotes in three ecoregions of South Carolina. An emphasis is placed on assessing the percentage of coyotes that are feeding on turkeys and deer. A major sampling location includes the SRS.
Summary of Research Activities
We have extracted DNA from all scat samples and used a metabarcoding approach to identify vertebrate DNA. We were able to add gray fox and bobcats to the study. We have analyzed the frequency of occurrence of all vertebrate prey in each sample and are revising a manuscript.
Conclusions
1) Coyotes appear to focus on deer as prey during the spring season
2) Bobcat also consume deer but in low frequency
3) All three predators (coyotes, gray fox, bobcat) consumed turkey, but none frequently
4) Bobcats mostly ate rabbits and small mammals
5) Gray fox mostly ate herpetofauna

Major Impact(s) of Research
1) Predation on turkey by these mesopredators does not appear to be a management issue
2) Predation on deer by coyotes was confirmed to be a management concern
3) The mesopredators have little niche overlap during spring

Other Project Personnel
Dr. Jason O'Bryhim, Research Professional, SREL
Adam McFall, Research Technician, SREL
Gabriela Rodriguez, Undergraduate researcher, SREL
External Collaborators
Dr. Gino D'Angelo, Warnell School of Forestry and Natural Resources, UGA
Dr. Karl Miller, Warnell School of Forestry and Natural Resources, UGA
Dr. John Kilgo, USFS
Jordan Youngman, Warnell School of Forestry and Natural Resources, UGA
Charles Ruth, SC DNR
Products
Youngmann, J. L., S. L. Lance, J. C. Kilgo, C. Ruth, J. Cantrell, and G. J. D'Angelo. 2022. DNA metabarcoding to assess predator diets during fawning season in South Carolina, USA. 44th Annual Meeting of the Southeast Deer Study Group, Virtual.

Youngmann, J.L., S.L. Lance, J.C. Kilgo, C. Ruth, J. Cantrell, and G.J. D'Angelo. 2020. DNA metabarcoding of coyote (*Canis latrans*) scat to assess diet in South Carolina, USA. 2020 Warnell Graduate Student Symposium, Athens, GA.

Youngmann, J.L., S.L. Lance, J.C. Kilgo, C. Ruth, J. Cantrell, and G.J. D'Angelo. 2020. Diet analysis of coyote scat in South Carolina, USA through DNA metabarcoding. 27th Wildlife Society Conference.

Youngmann, J.L., S.L. Lance, J.C. Kilgo, C. Ruth, J. Cantrell, and G.J. D'Angelo. 2020. DNA metabarcoding of coyote (*Canis latrans*) scat to assess diet in South Carolina, USA. 43rd Annual Meeting of the Southeast Deer Study Group, Auburn, Alabama.

Conservation and management of gopher frogs in South Carolina

Funding Entity
Longleaf Alliance; National Fish and Wildlife Foundation, United States Fish and Wildlife Service
Start Date and Funding Amount
August 2018; $20,500; April 2019; $1000; September 2019; $19,500; September 2020 $107,287; July 2021 $25,000
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. 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, 3) make management recommendations, 4) optimize larval and juvenile headstarting protocols, 4) support headstarting by the Orangeburg National Fish Hatchery and 5) establish a rapid wetland assessment protocol.
Summary of Research Activities
To date we met with land managers at numerous plantations and surveyed over 20 wetlands across eight different properties. No gopher frogs have been documented. We provided support to the Orangeburg National Fish Hatchery and helped them rear and release over 500 metamorphs across two years onto the SRS. We have created a rapid wetland assessment form and implemented it at four properties. In 2021 our headstarting efforts resulted in 100% malformations and thus we did not release those animals and instead are now pursuing a line of research to investigate the cause of the malformations. We have ruled out several possible causes of the abnormalities and conducted an experiment to address a hypothesis that they were caused by high concentrations of retinoids from a cyanobacteria bloom. We are awaiting genomic data to examine the microbial communities associated with abnormalities. We also validated an abnormality scoring system for all headstarting facilities to use moving forward. In the summer of 2022 we examined the efficacy of soft-releasing juvenile gopher frogs into pens. We continued to survey private lands in 2022, but the drought prevented breeding by gopher frogs. We are currently designing studies for 2023.
Conclusions
1) To date we have not discovered any new gopher frog populations
2) The plant substrate used in headstarting facilities that experienced abnormalities produces leachate with very high phosphorus levels, which would promote growth of cyanobacteria
3) Soft-released gopher frogs move shorter distances than hard-released gopher frogs

Major Impact(s) of Research
1) Soft-releasing may be a conservation tool that improves juvenile success
2) Cyanobacteria may be contributing to amphibian abnormalities, work in progress

Other Project Personnel
Adam McFall, MS student, SREL
Tucker Stonecypher, MS student, SREL
Kiersten Nelson, PhD student, SREL
External Collaborators
Lisa Lord, Longleaf Alliance
Heather Latham, B.S. student, University of South Carolina, Aiken
Melanie Olds, USFWS
Jason Ayers, USFWS
Jarrett Hill, Orangeburg National Fish Hatchery

Products

McFall, M., Nelson, K., Stonecypher, E.T., Swartzbaugh, C., Latham, H., Lance, S. Abnormalities in the At-Risk Gopher Frog (*Lithobates capito*): What We Know and Where We're Going. 2022. Joint Meetings of Icthyologists and Herpetologists, Spokane, WA.

McFall, A.J., Nelson, K.N., Stonecypher, E.T., Swartzbaugh, C.S., Lance, S.L. Developmental abnormalities complicate conservation of the Carolina gopher frog (*Rana capito*). 2022. UGA Odum School of Ecology Graduate Student Symposium, Athens, GA.

Nelson, K., Bier, R., Weir, S., McFall, M., Stonecypher, E.T., Swartzbaugh, C., Lance, S. Headstarting Efforts for the Endangered Carolina Gopher Frog (*Lithobates capito*) Resulting in Developmental Abnormalities: Comparison of Water Quality & Microbial Communities. 2022. Joint Meetings of Icthyologists and Herpetologists, Spokane, WA.

McFall, A., K. Nelson, E. T. Stonecypher, C. Swartzbaugh, and S. L. Lance. 2021. Gopher frog developmental abnormalities. SEPARC Gopher Frog Task Force virtual meeting.

Lance, S. L. 2020. Conservation and restoration of the Carolina gopher frog: taking steps toward a longleaf forest with diverse wetland and upland ecosystems. 13th Biennial Longleaf Conference. Virtual meeting.

Upland and wetland habitat management recommendations to benefit at-risk amphibians and reptiles in the Par Pond East watershed

Funding Entity
NA
Start Date and Funding Amount
March 2022, NFP
SREL Collaborators
Dr. Stacey L. Lance, Tucker Stonecypher, Linda Lee, Adam McFall, Kiersten Nelson, Dr. Kurt Buhlmann, Dr. Tracey Tuberville and David Scott
Objectives
The Savannah River Site is home to three amphibian and two reptile species with the highest priority in the South Carolina State Wildlife Action Plan. Two of the amphibian species are being considered for listing on the federal Endangered Species Act. All five of these species, in addition to two others that are vulnerable, are primarily found in the Par Pond East (PPE) watershed unit on the SRS. That unit had its ten-year forestry operations plan decided upon in 2022. The objective of this project was to make management recommendations to improve habitat conditions for at-risk species.
Summary of Research Activities
We visited each wetland in the PPE watershed, documented the current level of degradation, and made specific recommendations for restoration efforts. Whenever possible we noted whether merchantable timber could be harvested. We then also visited all of the surrounding upland compartments to estimate current basal area and overgrowth of understory and midstory vegetation. After visiting each site we overlayed our data with maps of planned thinning operations and areas currently managed for red cockaded woodpeckers (RCW). The RCW habitat is closer to the type of habitat required by the at-risk herpetofauna (as well as numerous mammal and bird species). We then categorized every forest stand into one of four priority rankings based on how important the area was to the herpetofauna, while also minimizing potential negative impacts on USFS. We then assembled a document for the USFS that detailed 1) the habitat requirements for the at-risk herpetofauna (wetland and upland), 2) the prioritization categories for both habitat types, 3) the specific recommendations for restoring each wetland, 4) the recommendations for each priority class of uplands and 5) a list of every forest stand and its associated priority.
Conclusions
There are no specific data from this project. The overall conclusion was that the current management of the PPE area was not in line with habitat requirements for the at-risk species that inhabit it.
Major Impact(s) of Research
If one of the species up for federal listing is deemed Federally Endangered the USFS would be mandated to alter their habitat management plans. By pre-emptively producing this document we have assisted in providing a blueprint for what would need to be done. In addition, the USFS has taken our recommendations into consideration and is working with SREL to restore some wetlands and thin uplands around critical breeding habitat for the state endangered Carolina gopher frog. This project has also led to improved dialogue between SREL and USFS and paved a path forward for how SREL can continue to provide input on management of the SRS.
Other Project Personnel
NA
External Collaborators
Charlie Davis, USFS
Hannah Davis, USFS
Ray Geroso, USFS
Products

Stonecypher, E., Nelson, K., McFall, A., Lee, L., Buhlmann, K., Tuberbille, T.D., Scott, D, Lance, S. 2022. Par Pond East Observations and Recommendations from SREL, Part II: Management for At-Risk Amphibians and Reptiles. 18pp.

Biofilm succession on macroplastics in sandhills streams

Funding Entity
SREL
Start Date and Funding Amount
May 2022; NFP
SREL Collaborators
Raven Bier, Krista Capps
Objectives
The goal of this study is to determine how macroplastic pollution can influence the development of aquatic microbial biofilm communities and the implications of this for aquatic ecosystem functions.
Summary of Research Activities
In summer 2022, plastic and wood veneers were deployed in three Savannah River Site headwater streams in the Set Aside areas. Plastic veneers were smooth or rough surfaced HDPE and wood veneers were from regionally abundant tulip poplar trees (*Liriodendron tulipifera*). Biofilms were collected from blocks of veneers at three timepoints (weeks 2, 4, and 8) and processed for biomass and chlorophyll-*a*. Environmental data were also collected at the time of biofilm sampling including water chemistry and canopy cover. Biofilm samples were extracted for DNA and prepared for sequence analysis using Illumina MiSeq paired end sequencing to be used in microbial community analysis.
Conclusions
The data are still being collected.
Major Impact(s) of Research
1) Experimental evaluation of how macroplastic pollution substrates compare with wood substrates for biofilm development in reference streams
2) Enhanced understanding of anthropogenic effects on a critical stream ecosystem basal food source

Other Project Personnel
Fabiola López Ávila, M.S. Student, SREL
Viviana Bravo, M.S. Student, SREL
McKenzie Cromer, Research Technician, SREL
External Collaborators
NA
Products
No publications, presentations, or reports have been prepared yet.

Collaborations and Externally Funded Research Non-SRS

Effects of chronic radiation exposure on the movement behavior and 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; Environmental Radioactivity Research Network Center

Start Date and Funding Amount
May 1, 2018; $17,936

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 Daiichi nuclear accident, and the effects of land abandonment on animal movement. This work is being conducted in collaboration with researchers at Fukushima University, Colorado State University, Northern Michigan University, Fukushima Prefecture, and the University of Illinois, 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 were conducted in 2019 to collect additional samples to be used for this research. During 2019-2021 we have been conducting laboratory analyses and analyzing the results of the research for preparation of peer-reviewed manuscripts. In addition, during 2021 we began analysis of an extensive dataset of GPS locations collected from radio-collared wild boar; these analyses will be ongoing through 2022.

Conclusions
This research is ongoing; however, projects completed thus far suggest levels of radionuclide exposure in wild boar in Fukushima, Japan are insufficient to manifest in increased development of cataracts, levels of stress as measured through cortisol, or dicentrics. Further analyses of collected data will be used to quantify potential effects in other biological endpoints.

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
Helen Bontrager, M.S. Student, SREL
Dr. Rie Saito, Postdoctoral Researcher, SREL

External Collaborators
Dr. Thomas Hinton, Fukushima University
Dr. Kei Okuda, Fukushima University
Ms. Aryn Bordman, Colorado State University
Dr. Thomas Johnson, Colorado State University
Dr. Sami Pederson, Colorado State University
Ms. Maggie Roberts, Colorado State University
Dr. Rao Veeramachaneni, Colorado State University
Dr. Jodi Flaws, University of Illinois
Dr. Yui Nemoto, Fukushima Prefecture
Dr. Diana Lafferty, Northern Michigan University

Products

Pederson, S., 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)

Chinn, S.M., T.G. Hinton, K. Okuda, H. Ishiniwa, Y. Nemoto, and J.C. Beasley. 2019. Reproductive health of wild boar in response to chronic radiation exposure. Savannah River Ecology Laboratory Graduate Student Symposium. Athens, Georgia (poster presentation)

Pederson, S.L., M.C. Li Puma, J.M. Hayes, K. Okuda, C.M. Reilly, J.C. Beasley, L.C. Li Puma, T.G. Hinton, T.E. Johnson, and K.S. Freeman. 2020. Effects of chronic low-dose radiation on cataract prevalence and characterization in wild boar (*Sus scrofa*) from Fukushima, Japan. Scientific Reports 10:4055.

Nanba, K., Chinn, S., Beasley, J., Ambai, K., Nemoto, Y., McKenney, E., Gillman, S., Hinton, T, and Lafferty, D. 2020. Effects of radionuclide exposure on the microbiome community within the gastrointestinal tract of wild boar. In Environmental Radioactivity Research Network Center 2020 Web Kickoff Meeting. Fukushima, Japan (virtual).

Beasley, J., and Wakiyama, Y. 2020. Influences of Rooting Activity by Wild Boar on 137Cs Bioavailability. In Environmental Radioactivity Research Network Center 2020 Web Kickoff Meeting. Fukushima, Japan (virtual).

Cunningham, K., T.G. Hinton, J.J. Luxton, A. Bordman, K. Okuda, L.E. Taylor, J. Hayes, H.C. Gerke, S.M. Chinn, D. Anderson, M.L. Laudenslager, T. Takase, Y. Nemoto, H. Ishiniwa, J.C. Beasley, and S.M. Bailey. 2021. Evaluation of DNA damage and stress in wildlife chronically exposed to low dose, low dose rate radiation from the Fukushima Dai-ichi nuclear power plant accident. Environment International: 155:106675

Beasley, J.C. Radioactive Wildlife: Impacts of the Chernobyl and Fukushima Nuclear Accidents on Wildlife. 2021. Utah State University Ecology Center Seminar.

Lafferty, D. E. McKenney, S. Gillman, S.C. Chinn, K. Nanba, H. Ishiniwa, T.G. Hinton, Y. Nemoto, K. Okuda, and J.C. Beasley. 2021. Gut site and radionuclide exposure drive gut microbiome variation in wild boar. ERAN Kickoff Meeting. Fukushima, Japan (virtual).

Saito, R., and J.C. Beasley. 2021. A study of MIG-seq method using the fecal DNA of wild boars in difficult to return zone. ERAN Kickoff Meeting. Fukushima, Japan (virtual).

Beasley, J.C., H. Bontrager, and Y. Wakiyama. Influence of rooting activity by wild boar on 137Cs bioavailability. ERAN Kickoff Meeting. Fukushima, Japan (virtual).

Chinn, S.C., and J.C. Beasley. Intrinsic and Extrinsic Factors Effect Neonate Survival of an Invasive Large Mammal. 2021. Society of Integrative and Comparative Biology (virtual).

Anderson, D, S. Kaneko, A. Harshman, K. Okuda, T. Toshito, S.M. Chinn, J.C. Beasley, K. Namba, H. Ishiniwa, and T.G. Hinton. 2022. Radiocesium accumulation and germline mutations in chronically exposed wild boar from Fukushima, with radiation doses to human consumers of contaminated meat. *Environmental Pollution* 306:119359.

Lafferty, D.J.R., S.J. Gillman, E.A. McKenney, S.M. Chinn, H. Ishiniwa, K. Namba, T.G. Hinton, Y. Nemoto, K. Okuda, and J.C. Beasley. Submitted. Gut site and radiation dose shape wild boar gut microbiomes in the Fukushima Difficult-to-Return Zone. *Science of the Total Environment*: In Review.

Chinn, S., T. Hinton, H. Ishiniwa, Y. Nemoto, K. Okuda, J. Flaws, D. Rao Veermachaneni, and J. Beasley. Reproductive Health of Wild Boar in Response to Chronic Radiation Exposure. 2021. Fukushima 10 years: Forest, River, Ocean, and Food –Remaining Issues for Restoration (poster presentation).

Cunningham, K., T. Hinton, J. Luxton, A. Bordman, K. Okuda, L. Taylor, J. Hayes, H. Gerke, S. Chinn, D. Anderson, M. Laudenslager, T. Tsuglko, Y. Nemoto, I. Hiroko, J. Beasley, and S. Bailey. Evaluation of DNA damage and stress in wild boar chronically exposed to radiation from the Fukushima accident. 2021. Fukushima 10 years: Forest, River, Ocean, and Food –Remaining Issues for Restoration (poster presentation).

Lafferty, D., E. Mckenney, S. Gillman, S. Chinn, K. Nanba, H. Ishiniwa, T. Hinton, Y. Nemoto, K. Okuda, and J. Beasley. Wild boar gut microbiome dynamics are driven by gut site location and radiation dose in the Fukushima difficult-to-return zone. 2021. Fukushima 10 years: Forest, River, Ocean, and Food –Remaining Issues for Restoration (poster presentation).

Lyons, P., T. Hinton, J. Beasley, K. Okuda, and M. Hamilton. Fukushima's wildlife: population level response to a nuclear disaster. 2021. Fukushima 10 years: Forest, River, Ocean, and Food – Remaining Issues for Restoration (poster presentation).

Pederson, S., M. Li Puma, J. Hayes, K. Okuda, C. Reilly, J. Beasley, L. Li Puma, T. Hinton, T. Johnson, and K. Freeman. The ocular effects of radiation in wild boar of Fukushima, Japan. 2021. Fukushima 10 years: Forest, River, Ocean, and Food –Remaining Issues for Restoration (poster presentation).

Saito, R., M. Tamaki, and J. Beasley. A study of MIG-seq method using the fecal DNA of wild boars in the difficult-to-return zone. 2022. ERAN annual meeting.

Saito, R., M. Tamaki, N. Imato, R. Kumada, K. Nanba, and J. Beasley. A study of MIG-seq method using the fecal DNA of wild boars in the difficult-to-return zone. 2022. ERAN annual meeting.

Saito, R., N. Kondo, Y. Nemoto, R. Kumada, T. Takeda, J. Beasley, and M. Tamaoki. Relationships between genetic population structure of wild boar using DNA analysis in Fukushima Prefecture including evacuation zone and cesium-137 activity concentration in their body. 2022. 5th International Conference on Radioecology and Environmental Radioactivity.

Saito, R., N. Kondo, Y. Nemoto, T. Takeda, R. Kumada, J. Beasley, and M. Tamaoki. Examining barriers influencing wild boar (*Sus scrofa*) dispersal and gene flow through haplotype and population structure analysis. 2022. International Wild Pig Conference.

Beasley, J. Radioactive wildlife: impacts of the Chernobyl and Fukushima nuclear accidents on wildlife. 2022. Colorado State University, Seminar Series.

Beasley, J. Radioactive wildlife: impacts of the Chernobyl and Fukushima nuclear accidents on wildlife. 2022. University of Georgia, UGA Environmental Ethics Seminar Series.

Beasley, J. Radioactive wildlife: impacts of the Chernobyl and Fukushima nuclear accidents on large mammals. 2021. University of Georgia Plotters Seminar.

Bontrager, H., R. Saito, Y. Wakiyama, and J. Beasley. Influences of rooting activity by wild boar on 137 Cs bioavailability. 2022. ERAN annual meeting.

Wild pig management in Sumter and Francis Marion National Forest

Funding Entity
USDA-USFS
Start Date and Funding Amount
May 21, 2018; $70,759
SREL Collaborators
Dr. James C. Beasley
Objectives
The objective of this study is to assist USDA-USFS personnel working on the Long Cane Ranger District and the Enoree District in South Carolina in the management of wild pigs through collection of biological data needed to inform management activities.
Summary of Research Activities
During summer 2018-summer 2022 we collected samples from wild pigs captured by USFS personnel on the Long Cane Ranger District in SC. Samples will be incorporated into ongoing wild pig studies in South Carolina to elucidate the genetic structure of wild pig populations in the state. In addition, we deployed remote cameras throughout the study area to determine the presence and distribution of wild pigs in the region.
Conclusions
This research is still in progress; there are no conclusions at this time.
Major Impact(s) of Research
This research will provide data needed to inform management activities targeting invasive wild pigs on the Long Cane and Enoree Districts of the Sumter National Forest in South Carolina.
Other Project Personnel
Jakob Kemp. Amy Hilger, Research Technician, SREL
Kyle Cockrell, Research Technician, SREL
Camron Hawkins, Research Technician, SREL
Jordan Butler, Research Technician, SREL
Garrett Doolittle, Research Technician, SREL
External Collaborators
Donny Ray, USFS
Charles McKinney, USFS
Products
This research is ongoing; there are no products at this time.

Assessment of changes in population size, agricultural damage, and environmental impacts of wild pigs in response to control in Hampton County, SC

Funding Entity
NRCS, SCDNR
Start Date and Funding Amount
January 1, 2021; $260,000
SREL Collaborators
Dr. James C. Beasley
Objectives
Despite the extensive and widespread damages caused by wild pigs, currently there is a paucity of data on assessments of damage reduction related to population control efforts. Therefore, the overarching goal of this study is to work in collaboration with USDA-APHIS-WS, NRCS, and private landowners to quantify changes in wild pig population size and damages associated with wild pigs in response to control efforts. Specifically, this research will address the following research objectives to assess the impacts of wild pig removal efforts: 1) Quantify changes in wild pig population size across targeted areas in response to wild pig removal effort, 2) Quantify changes in wild pig damage to common agricultural crops (e.g., corn, peanuts, pasture/hay land) in response to wild pig removal efforts, and 3) Quantify changes in environmental damages caused by wild pigs across targeted areas in response to wild pig removal efforts.
Summary of Research Activities
This research is still ongoing at this time. Since 2021 we have initiated 1) remote camera surveys to determine abundance of wild pigs, 2) wild pig rooting surveys to determine environmental damages caused by wild pigs, 3) drone surveys of select agricultural fields, and 4) landowner surveys to determine the extent of wild pig damages on private lands.
Conclusions
This work is ongoing, there are no conclusions at this time.
Major Impact(s) of Research
This research is part of a broader effort by USDA and NRCS to quantify the efficacy of wild pig control on private lands at reducing economic and agricultural damages. Data from this research will be incorporated into national-level management decisions regarding the management of invasive wild pigs under the national Feral Swine Damage Management Program.
Other Project Personnel
Joseph Treichler, M.S. Student, SREL
Caitlin Kupferman, Research Professional, SREL
Charles Taylor, M.S. Student, SREL
Vienna Canright, M.S. Student, SREL
Taylor Aliferis, Research Technician, SREL
Brianna Roberson, Intern, SREL
External Collaborators
Noel Myers, USDA-APHIS-WS
Sylvia Harris, NRCS
Products
Wild Pig Fact Sheet (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – Newberry County, SC (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – Hampton County, SC (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – South Carolina (brochure). 2022.
Beasley, J. South Carolina pilot program. 2021. USDA NRCS, National Feral Swine Pilot Project Partner Meeting.
Beasley, J., J. Treichler, C. Taylor, and C. Kupferman. South Carolina farm bill pilot control program. 2022. South Carolina Wild Pig Task Force Meeting.

Canright, V., S. Chinn, A. Piaggio, R. Giglio, and J. Beasley. Using DNA metabarcoding to assess the food habits of invasive wild pigs (*Sus scrofa*) in the southeastern United States. 2022. International Wild Pig Conference.

Treichler, J., K. VerCauteren, and J. Beasley. Changes in wild pig (*Sus scrofa*) population size, crop damage, and environmental impacts in response to management. 2022. International Wild Pig Conference.

Treichler, J., K. VerCauteren, and J. Beasley. Influence of habitat attributes on the distribution of wild pig (*Sus scrofa*) rooting damage in forested and agricultural ecosystems. 2022. International Wild Pig Conference.

Canright, V., J. Beasley, S. Chinn, A. Piaggio, and R. Giglio. Using DNA metabarcoding to assess food habits of invasive wild pigs (*Sus scrofa*) in the southeastern United States. 2022. Warnell Graduate Student Symposium.

Treichler, J., and J. Beasley. Evaluation of changes in wild pig (*Sus scrofa*) population, crop damage, and environmental impacts in response to management in the southern US. 2022. Warnell Graduate Student Symposium.

Assessment of changes in population size, agricultural damage, and environmental impacts of wild pigs in response to control in Newberry County, SC

Funding Entity
NRCS, Newberry Soil and Water Conservation District
Start Date and Funding Amount
January 1, 2021; $190,000
SREL Collaborators
Dr. James C. Beasley
Objectives
Despite the extensive and widespread damages caused by wild pigs, currently there is a paucity of data on assessments of damage reduction related to population control efforts. Therefore, the overarching goal of this study is to work in collaboration with USDA-APHIS-WS, NRCS, and private landowners to quantify changes in wild pig population size and damages associated with wild pigs in response to control efforts. Specifically, this research will address the following research objectives to assess the impacts of wild pig removal efforts: 1) Quantify changes in wild pig population size across targeted areas in response to wild pig removal effort, 2) Quantify changes in wild pig damage to common agricultural crops (e.g., corn, peanuts, pasture/hay land) in response to wild pig removal efforts, and 3) Quantify changes in environmental damages caused by wild pigs across targeted areas in response to wild pig removal efforts.
Summary of Research Activities
This research is still ongoing at this time. Since 2021 we have initiated 1) remote camera surveys to determine abundance of wild pigs, 2) wild pig rooting surveys to determine environmental damages caused by wild pigs, 3) drone surveys of select agricultural fields, and 4) landowner surveys to determine the extent of wild pig damages on private lands.
Conclusions
This work is ongoing, there are no conclusions at this time.
Major Impact(s) of Research
This research is part of a broader effort by USDA and NRCS to quantify the efficacy of wild pig control on private lands at reducing economic and agricultural damages. Data from this research will be incorporated into national-level management decisions regarding the management of invasive wild pigs under the national Feral Swine Damage Management Program.
Other Project Personnel
Joseph Treichler, M.S. Student, SREL
Caitlin Kupferman, Research Professional, SREL
Charles Taylor, M.S. Student, SREL
Vienna Canright, M.S. Student, SREL
Taylor Aliferis, Research Technician, SREL
Brianna Roberson, Intern, SREL
External Collaborators
Noel Myers, USDA-APHIS-WS
Sylvia Harris, NRCS
Products
Wild Pig Fact Sheet (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – Newberry County, SC (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – Hampton County, SC (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – South Carolina (brochure). 2022.
Beasley, J. South Carolina pilot program. 2021. USDA NRCS, National Feral Swine Pilot Project Partner Meeting.
Beasley, J., J. Treichler, C. Taylor, and C. Kupferman. South Carolina farm bill pilot control program. 2022. South Carolina Wild Pig Task Force Meeting.

Canright, V., S. Chinn, A. Piaggio, R. Giglio, and J. Beasley. Using DNA metabarcoding to assess the food habits of invasive wild pigs (*Sus scrofa*) in the southeastern United States. 2022. International Wild Pig Conference.

Treichler, J., K. VerCauteren, and J. Beasley. Changes in wild pig (*Sus scrofa*) population size, crop damage, and environmental impacts in response to management. 2022. International Wild Pig Conference.

Treichler, J., K. VerCauteren, and J. Beasley. Influence of habitat attributes on the distribution of wild pig (*Sus scrofa*) rooting damage in forested and agricultural ecosystems. 2022. International Wild Pig Conference.

Canright, V., J. Beasley, S. Chinn, A. Piaggio, and R. Giglio. Using DNA metabarcoding to assess food habits of invasive wild pigs (*Sus scrofa*) in the southeastern United States. 2022. Warnell Graduate Student Symposium.

Treichler, J., and J. Beasley. Evaluation of changes in wild pig (*Sus scrofa*) population, crop damage, and environmental impacts in response to management in the southern US. 2022. Warnell Graduate Student Symposium.

Evaluating impacts of wild pig control on damage reduction in Jasper County, SC

Funding Entity
NRCS
Start Date and Funding Amount
May 24, 2021; $658,587
SREL Collaborators
Dr. James C. Beasley
Objectives
Despite the extensive and widespread damages caused by wild pigs, currently there is a paucity of data on assessments of damage reduction related to population control efforts. Therefore, the overarching goal of this study is to work in collaboration with USDA-APHIS-WS, NRCS, and private landowners to develop a pilot program for controlling wild pigs in Jasper County via landowner participation, and quantify reductions in wild pig damage in response to control efforts. Specifically, this will address the following research objectives: 1) Evaluate performance of estimators for quantifying wild pig abundance, 2) Quantify changes in wild pig damage to common agricultural crops (e.g., corn, peanuts, pasture/hay land) and property in response to wild pig removal efforts, and 3) conduct landowner workshops to facilitate participation in the program and inform landowners of wild pig impacts, project performance, and participatory opportunities.
Summary of Research Activities
This research is still ongoing at this time. Since 202 we have initiated 1) remote camera surveys to determine abundance of wild pigs, 2) landowner surveys to determine the extent of wild pig damages on private lands, and 3) impacts of wild pigs to private land ecosystems through analysis of wild pig diets.
Conclusions
This work is ongoing, there are no conclusions at this time.
Major Impact(s) of Research
This research is part of a broader effort by USDA and NRCS to quantify the efficacy of wild pig control on private lands at reducing economic and agricultural damages. Data from this research will be incorporated into national-level management decisions regarding the management of invasive wild pigs under the national Feral Swine Damage Management Program.
Other Project Personnel
Joseph Treichler, M.S. Student, SREL
Caitlin Kupferman, Research Professional, SREL
Charles Taylor, M.S. Student, SREL
Vienna Canright, M.S. Student, SREL
Taylor Aliferis, Research Technician, SREL
Brianna Roberson, Intern, SREL
External Collaborators
Noel Myers, USDA-APHIS-WS
Sylvia Harris, NRCS
Products
Wild Pig Fact Sheet (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – Newberry County, SC (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – Hampton County, SC (brochure). 2022.
Feral Swine Eradication and Control Pilot Program – South Carolina (brochure). 2022.
Beasley, J. South Carolina pilot program. 2021. USDA NRCS, National Feral Swine Pilot Project Partner Meeting.
Beasley, J., J. Treichler, C. Taylor, and C. Kupferman. South Carolina farm bill pilot control program. 2022. South Carolina Wild Pig Task Force Meeting.

Canright, V., S. Chinn, A. Piaggio, R. Giglio, and J. Beasley. Using DNA metabarcoding to assess the food habits of invasive wild pigs (*Sus scrofa*) in the southeastern United States. 2022. International Wild Pig Conference.

Treichler, J., K. VerCauteren, and J. Beasley. Changes in wild pig (*Sus scrofa*) population size, crop damage, and environmental impacts in response to management. 2022. International Wild Pig Conference.

Treichler, J., K. VerCauteren, and J. Beasley. Influence of habitat attributes on the distribution of wild pig (*Sus scrofa*) rooting damage in forested and agricultural ecosystems. 2022. International Wild Pig Conference.

Canright, V., J. Beasley, S. Chinn, A. Piaggio, and R. Giglio. Using DNA metabarcoding to assess food habits of invasive wild pigs (*Sus scrofa*) in the southeastern United States. 2022. Warnell Graduate Student Symposium.

Treichler, J., and J. Beasley. Evaluation of changes in wild pig (*Sus scrofa*) population, crop damage, and environmental impacts in response to management in the southern US. 2022. Warnell Graduate Student Symposium.

Human-carnivore interactions along the periphery of Etosha National Park, Namibia

Funding Entity
UGA
Start Date and Funding Amount
January 7, 2022; $22,495
SREL Collaborators
Dr. James C. Beasley
Objectives
Most large carnivore populations have declined over the last century due to habitat loss, poaching for illegal wildlife trade, and human-wildlife conflicts. This trend is especially true for lions, Africa's largest apex predator, with their habitat declining by >90% in the last 100 years. This project will address the issue of human-wildlife conflicts for a critically important population of lions and other vulnerable apex predators (e.g., cheetah, leopard, and hyena). Our objective is develop a human-carnivore coexistence model for the Greater Etosha Landscape through 1) understanding efficacy of fences relative to carnivore movement behavior and mitigation of human-carnivore conflicts, 2) improving understanding of carnivore-livestock interactions at the ENP interface, 3) establishing a standardized system for monitoring HCC along the ENP boundary, 4) determine the extent to which tourism influences wildlife behavior, and 5) to elucidate the movement ecology and population dynamics of carnivores within the Greater Etosha Landscape.
Summary of Research Activities
During 2021 we began deploying remote cameras along fence gaps surrounding Etosha National Park. In addition, GPS collars were deployed on lions and hyenas within Etosha National Park. Additional camera and GPS collar deployments are anticipated for 2023.
Conclusions
This research is ongoing, there are no conclusions to report at this time.
Major Impact(s) of Research
That this research will have a positive impact on the development of science-based solutions for mitigating human-wildlife conflicts and thus directly contribute to the enhancement of strategies for conserving a critical population of lions and other apex predators in northern Namibia. Research outcomes from this project will elucidate the extent to which apex carnivores within Etosha National Park interact with the surrounding shared-use landscape, identify hotspots of human-carnivore conflict, and provide novel information on the ecology of carnivore populations within the Greater Etosha Landscape to aid in the development of a human-carnivore coexistence model.
Other Project Personnel
Jessy Patterson, Ph.D. Student, SREL
Madeline Melton, M.S. Student, SREL
Dipanjan Naha, Postdoctoral Researcher, SREL
Caitlin Kupferman, Research Professional, SREL
External Collaborators
Stephanie Periquet, Researcher, Ongava Research Centre
Josef Ndjimba, M.S. Student, Namibia University of Science and Technology
Josephine Amwaalwa, Ongava Research Centre
Products
There are no products at this time.

Invasive species control on Blackbeard Island, Wassaw and Harris Neck National Wildlife Refuges

Funding Entity
U.S. Fish and Wildlife Service
Start Date and Funding Amount
January 1, 2022; $219,900
SREL Collaborators
Dr. James C. Beasley
Objectives
Coastal islands are critical nesting and stopover habitat for many species of conservation concern, particularly sea turtles and beach nesting shorebirds. However, islands are among the most sensitive ecosystems and thus highly vulnerable to impacts from wild pigs. In particular, Blackbeard Island and Wassaw NWRs are considered index beaches for threatened loggerhead sea turtles and also provide critical habitat for various migratory birds. The objectives of this research are 1) to reduce densities of wild pigs on Blackbeard Island NWR, and 2) quantify changes in wild pig population size and impacts following implementation of control efforts.
Summary of Research Activities
During 2022 we initiated control efforts to reduce densities of wild pigs. In attrition, we have deployed remote cameras across Blackbeard Island to monitor wild pig population dynamics and distribution, as well as deployed GPS collars to better elucidate wild pig movement patterns. Samples and damage assessments have been collected and will be analyzed during 2023. Control efforts and sample collection will be ongoing through 2023.
Conclusions
This research is ongoing, there are no conclusions to report at this time.
Major Impact(s) of Research
Invasive wild pigs represent the greatest threat to sea turtles and other threatened and endangered species on Blackbeard Island. This project will substantially reduce wild pig densities on the refuge, which will reduce the impacts of wild pigs on these sensitive species and ecosystems. Further, this work will provide a roadmap for better understanding the impacts of wild pig control for species of concern, as well as for the development of wild pig management programs on similar coastal ecosystems throughout the southeastern US.
Other Project Personnel
Caitlin Kupferman, Research Professional, SREL
Patrick Helm, Research Professional, SREL
External Collaborators
Chuck Hayes, Biologist, USFWS
Products
There are no products at this time.

Evaluating how conventional, conservation, and organic farming management practices enhance soil health and improve water quality

Funding Entity
William Penn Foundation
Start Date and Funding Amount
January 1, 2018; NFP
SREL Collaborators
Raven Bier
Objectives
The overall goal of this research is to identify how different agricultural management systems influence soil health and water quality.
Summary of Research Activities
Soil and water parameter data and crop yields from conservation, conventional, and 41-year-old certified and new transitional organic agriculture systems are collected. Each agriculture system also has tillage and cover crop treatments. Baseline data were collected in 2018 and experimental data are collected year-round for the subsequent five years. Soil health data include microbial community composition and nutrient cycling genes, soil aggregate stability, soil chemistry, temperature, and moisture, and infiltration rates. Water quality data include soil porewater nutrient and pesticide chemistry, overland flow, watershed discharge, stream water turbidity, water chemistry, and fecal indicator bacteria loads. Data are evaluated with paired field comparisons and temporally over the project duration.
Conclusions
The data are still being collected.
Major Impact(s) of Research
1) Data will address impacts of different agricultural techniques on water quality of streams and estuaries
2) Data will inform role of soil health in crop yields and water quality
3) Data will contribute to evaluating policies currently in place that promote organic agriculture

Other Project Personnel
Emma Kelsick, M.S. Student, SREL
McKenzie Cromer, Research Technician, SREL
External Collaborators
Dr. Jinjun Kan, Stroud Water Research Center
Dr. Melinda Daniels, Stroud Water Research Center
Dr. Diana Oviedo Vargas, Stroud Water Research Center
Dr. Marc Peipoch, Stroud Water Research Center
Dr. Andrew Smith, Rodale Institute
Dr. Yichao Rui, Rodale Institute
Products
Wang, H., R. Bier, L. Zgleszewski, M. Peipoch, E. Omondi, A. Mukherjee, F. Chen, C. Zhang, and J. Kan. 2020. Distinct distribution of Archaea from soil to freshwater to estuary: implications of archaeal composition and function in different environments. Frontiers in Microbiology 11: 576661.

Bier, R., A. Smith, E. Omondi, A. Mukherjee, and J. Kan. 2020. Connections between soil microbial communities and soil health indicators. American Society for Microbiology Microbe Conference. (poster presentation) – conference cancelled, COVID-19

Bier, R., D. Oviedo Vargas, M. Daniels, M. Peipoch, E. Omondi, A. Mukherjee, and J. Kan. 2020. Soil health and water quality under contrasting farming practices. Pennsylvania Sustainable Agriculture Conference. (oral presentation)

Bier, R., D. Oviedo Vargas, M. Daniels, M. Peipoch, and J. Kan. 2019. How does farming system choice affect water quality? A preliminary study of conventional to organic agriculture transition in a Pennsylvania catchment. Likens Symposium on Science Communication. (poster presentation)

Kelsick, E.N., R. Bier, D. Oviedo Vargas, and J. Kan. 2022. How precipitation events modify extracellular enzyme export from soils in an agricultural headwater stream. UGA Odum School of Ecology Graduate Student Symposium, Athens, GA, February 2022. (oral presentation)
Kelsick, E., D. Oviedo Vargas, J. Kan, and R. Bier. 2022. How precipitation events modify extracellular enzyme export from soils in an agricultural headwater stream. Joint Aquatic Sciences Meeting. (poster presentation)
Farming Systems Trial 40 Years Report. Rodale Institute.

Worldwide hydrobiogeochemical observation network for dynamic river systems (WHONDRS)

Funding Entity
Pacific Northwest National Laboratory
Start Date and Funding Amount
July 2019; NFP
SREL Collaborators
Raven Bier
Objectives
The goal of this global research consortium is to understand the interactions of microbial function, hydrology, and biogeochemistry in riverine ecosystems.
Summary of Research Activities
River water and sediment were collected in the summer of 2019 from global locations and sent to Pacific Northwest National Laboratory for analysis of microorganisms, water and sediment chemistry, and environmental parameters. Dissolved organic matter assemblages are being analyzed through machine learning to understand spatial occurrences and environmental controls.
Conclusions
1) Dissolved organic matter assemblages vary for sediment and surface water compartments.
2) Each dissolved organic matter cluster identified has unique percent composition and summary reactive metrics.

Major Impact(s) of Research
1) Classification of globally sourced dissolved organic matter assemblages using novel approach
2) Broad scale patterns of watershed characteristics related to organic matter assemblages
3) Baseline information for riverine dissolved organic matter to compare with perturbations

Other Project Personnel
NA
External Collaborators
Dr. Betsy Summers, University of New Mexico
Dr. Yuehan Lu, University of Alabama
Dr. Moritz Müller, Swinburne University of Technology
Dr. Christof Meile, University of Georgia
Dr. Jianjun Wang, Chinese Academy of Sciences
Malcom Barnard, Baylor University
Michaela de Melo, University of Quebec at Montreal
Erika Freeman, University of Cambridge
Kadir Bice, University of Georgia
Jacob Hosen, Purdue University
Yaqi You, State University of New York
Products
Toyoda, J.G., A.E. Goldman, R.K. Chu, R.E. Danczak, R.A. Daly, V.A. Garayburu-Caruso, E.B. Graham, X. Lin X, J.J. Moran, H. Ren, L. Renteria, C.T. Resch, M. Tfaily, N. Tolic, J.M. Torgeson, J. Wells, K.C. Wrighton, J.C. Stegen, The WHONDRS Consortium. (2020): WHONDRS Summer 2019 Sampling Campaign: Global River Corridor Surface Water FTICR-MS and Stable Isotopes. Worldwide Hydrobiogeochemistry Observation Network for Dynamic River Systems (WHONDRS). doi:10.15485/1603775

Borton, M.A., S.M. Collins, E.B. Graham, V.A. Garayburu-Caruso, A.E. Goldman, M. de Melo, L. Renteria, J.C. Stegen, and WHONDRS Crowdsourced Consortium. It takes a village: using a crowdsourced approach to investigate organic matter composition in global rivers through the lens of ecological theory. 2022. *Frontiers in Water* 4:870453.

Stegen, J.C., A. Sengupta, V.A. Garayburu-Caruson, S.J. Fansler, R.K. Chu, R.E. Danczak, M. Garcia, A.E. Goldman, E.B. Graham, M.H. Kaufman, H. Ren, L. Renteria, D.E. Sandborn, H.-S. Song, K.

Willi, M. Ross, J. Torgeson, J. Toyoda, Coastal Consortium, and WHONDRS Consortium. Multi-continent chemogeography of organic matter thermodynamics in river corridors. *PNAS*. *In Review*.

The WHONDRS Consortium. Abstract Accepted. Examining the ecological processes influencing the assembly of molecules into OM assemblages. Research Topic: Crowdsourced understanding of global river organic matter composition through the lens of ecological theory. Frontiers in Water. *In Preparation.*

Microbial carbon metabolism of resource pulses in Carolina bays

Funding Entity
SREL
Start Date and Funding Amount
July 2021; NFP
SREL Collaborators
Raven Bier
Objectives
Our objectives for this study were to determine how precipitation-driven resource pulses from wild pigs and river flooding influence the capacity of microbial communities to metabolize carbon in Carolina Bays.
Summary of Research Activities
Longitudinal transects were used to collect planktonic aquatic microbial communities from four Carolina Bays of varying hydroperiod and size in Tuckahoe Wildlife Management Area, GA. Unfiltered Carolina Bay water was used to establish microcosms and filtered water from a disturbance treatment (leachate from wild pig-disturbed soil surrounding the Bays or Savannah River water) was added or the original wetland source water was added as a control. Microcosms were incubated in the dark at room temperature for one and five days. From each incubation, microbial communities were assayed using Biolog Ecoplates to determine community physiological profiles of metabolism of 31 carbon sources. Water chemistry (nitrate/nitrite, phosphate, and dissolved organic carbon) were analyzed from each microcosm.
Conclusions
1) Precipitation-driven resource pulses were less likely to alter carbon metabolism than were the size and hydroperiod of the Carolina Bay.
2) Spatial distribution of sizes and hydrologic properties of depressional wetlands in the landscape may be more influential to understand their capacity to metabolize resource pulses in the short term.
3) Carbon metabolism diversity becomes more similar over time since disturbance.

Major Impact(s) of Research
1) Experimental evaluation of the potential for extreme precipitation events that connect oligotrophic Carolina Bays with excess macronutrients from wild pig disturbance or river flooding to alter microbial ecosystem processes

Other Project Personnel
Emma Kelsick, M.S. Student, UGA
External Collaborators
NA
Products
Bier, R. and Kelsick, E. 2022. Ecosystem size and hydroperiod frame microbial carbon metabolism and response to resource pulses. Joint Aquatic Sciences Meeting. (oral presentation)
Bier, R. and Kelsick, E. 2022. Microbes and macronutrients in Carolina Bays. Stroud Water Research Center Lunchtime Seminar. (oral presentation)

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. Ben 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
Work so far has modeled the influence of ecological and climatic factors on the thermal environment experienced by developing alligator embryos. When future climatic predications are integrated into the constructed model, sex ratios of alligator populations are predicted to be dramatically affected in the next 20 years. In the absence of significant compensatory behaviors in maternal nest site choice, skews in population sex ratios will likely negatively influence the ability of these populations to persist in the long-term.

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
Jameel Moore, Undergraduate Researcher/Technician, SREL
Junsoo Baie, Undergraduate Researcher/Technician, SREL

External Collaborators

N/A

Products

Bock, S.L., Smaga, C.R., McCoy, J.A., Parrott, B.B. Genome-wide DNA methylation patterns harbor signatures of hatchling sex and past incubation temperature in a species with environmental sex determination. 2022. *Molecular Ecology* In Press

Smaga, C.R., Bock, S.L., Johnson, J.M., Parrott, B.B. Sex determination and ovarian development in reptiles and amphibians: From genetic pathways to environmental influences. 2022. *Sexual Development* In Press

Bock, S.L., Hale, M.D., Rainwater, T.R., Wilkinson, P.M., Parrott, B.B. Incubation temperature and maternal resource provisioning, but not contaminant exposure, shape hatchling phenotypes in a species with temperature-dependent sex determination. 2021. *The Biological Bulletin* 241:43-54

Bae, J., Bertucci, E.M., Bock, S.L., Hale, M.D., Moore, J, Wilkinson, P.M., Rainwater, T.R., Bowden, J.A., Koal, T., PhamTuan, H., Parrott, B.B. Intrinsic and extrinsic factors interact during development to influence telomere length in a long-lived reptile. 2021. *Molecular Ecology* 00:1-14 [early access online]

LaVere, A.A., Hamlin, H.J., Lowers, R.H., Parrott, B.B., Ezenwa, V.O. Associations between testosterone and immune activity in alligators depend on bacterial species and temperature. 2021. *Functional Ecology* 34:1018-1027

Bock, S.L., Hale, M.D., Leri, F.M., Wilkinson, P.M., Rainwater, T.R., Parrott, B.B. 2020. Post-transcriptional mechanisms respond rapidly to ecologically relevant thermal fluctuations during temperature-dependent sex determination. *Integrative Organismal Biology* 2:033

Bock, S.L., Lowers, R.H., Rainwater, T.R., Stolen, E., Drake, J.M., Wilkinson, P.M., Weiss, S., Back, B., Guillette, L.J., Parrott, B.B. 2020. Ecological drivers of nest temperature variation in the American alligator: implications for future environmental change for a species with temperature-dependent sex determination. *Proceedings of the Royal Society B* 287:20200210

Bae, J., Bertucci, E.M., Bock, S.L., Hale, M.D., Moore, J., Wilkinson, P.M., Rainwater, T.R., Bowden, J.A., Koal, T., PhamTuan, H., Parrott, B.B. Intrinsic and extrinsic factors interact to determine telomere length in hatchling alligators. *In Review*

B.B. Parrott. Invited Seminar. February 25, 2020. Jekyll Island Authority Conservation and Georgia Sea Turtle Center Seminar Series. Jekyll Island, GA, USA

B.B. Parrott. Invited Seminar. January 24, 2020. Department of Biology and Marine Biology Seminar Series. University of North Carolina — Wilmington. Wilmington, NC, USA

Bock SL, Parrott BB. Epigenome-by-environment interactions underlying temperature-dependent sex determination in the American alligator. January 31, 2020. Oral Presentation. Odum School of Ecology Graduate Student Symposium, Athens, GA

Bae J, Bertucci EM, Moore JA, Bock SL, Rainwater TR, Hale MD, Parrott BB. The effects of the developmental environment on telomere length in Alligator mississippiensis. January 4, 2020. Poster Presentation. Society for Integrative and Comparative Biology Annual Meeting. Austin, TX, USA

Bock SL, Lowers RH, Rainwater TR, Hale MD, Leri FM, Parrott BB. Real-time responses to ecologically-relevant thermal fluctuations during temperature-dependent sex determination in the

American alligator. January 4, 2020. Oral Presentation. Society for Integrative and Comparative Biology Annual Meeting. Austin, TX, USA

Parrott, B.B. Environmental sex determination in the Anthropocene. 2019. Invited Seminar. Interdisciplinary Conservation Seminar Series. Athens, GA, USA

Bock, S.L., Lowers, R.H., Rainwater, T.R., Stolen, E., Drake, J.M., Wilkinson, P.M., Weiss, S. Back, B., Guillette, L.J., Parrott, B.B. Ecological drivers of nest temperature variation in the American alligator: predicting the impact of future climatic scenarios. 2019. Oral Presentation, Palmetto Alligator Research & Management Symposium, Georgetown, SC, USA

Bock, S.L., Lowers R.H., Rainwater, T.R., Hale, M.D., Parrott, B.B. Linking proximate mechanisms of developmental plasticity to environmental variation in nature. 2019. Oral Presentation, Odum School of Ecology Graduate Student Symposium, Athens, GA, USA

Bock, S.L., Lowers, R.H., Rainwater, T.R., Hale, M.D., Parrott, B.B. Insights from the field: using a multi-year dataset of nest thermal profiles to investigate temperature-dependent sex determination in the American alligator. 2019. Oral Presentation, Annual meeting of the Society for Integrative and Comparative Biology.

Bock, S.L., Lowers, R.H., Rainwater, T.R., Hale, M.D., Parrott, B.B. Proximate and persistent effects of ecologically-relevant thermal fluctuations during temperature-dependent sex determination in the American alligator. 2019. Poster Presentation, North American Society for Comparative Endocrinology Biennial Meeting, Gainesville, FL, USA

Bock, S.L and Parrott, B.B. *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.

Non-lethal tools to estimate the ages and lifespans of chondrichthyan fishes

Funding Entity
National Science Foundation
Start Date and Funding Amount
August 2022; $299,439
SREL Collaborators
Dr. Ben Parrott
Objectives
The proposed work seeks to develop epigenetic aging resources for chondrichthyans (e.g., sharks, skates, and rays) that will advance both the conservation of these species, many of which are critically impacted, and our evolutionary understanding of the aging process across species in taxonomic groups with highly variable lifespans and life histories.
Summary of Research Activities
All organisms undergo some form of aging. Yet, despite the near universality of the process, it is not yet understood how the proximal cellular processes associated with aging interact with environmental factors to shape the distribution of lifespans, both within species and across the tree of life. Progress on non-model species has been held back by the lack of analytical tools available to integrate molecular, ecological, and evolutionary processes. The recent development of DNA methylation (DNAm)- based aging models (e.g., "epigenetic clocks"), has opened an opportunity to explore and better understand the forces that shape aging, species-specific lifespans, and the evolution of various life history strategies. This project seeks to develop epigenetic models to accurately and non-lethally predict individual age and species lifespans in chondrichthyan fishes (sharks, skates, and rays), an understudied group containing a large fraction of endangered species, whose basal phylogenetic position can be leveraged to inform our understanding of life history evolution across vertebrates. Our immediate goal is to develop tools for the chondrichthyan conservation community to help them monitor the age structure of protected species that are recovering from adverse impacts. We also anticipate that the work will provide a framework for integrating epigenetic aging more broadly into modern conservation and management practices. Our long-term goal is to develop these models to understand the molecular and evolutionary determinants of variation in vertebrate longevity and life history evolution. The proposed work, however, is restricted to the following near-term proof-of-concept objectives:
Objective 1. Construct species-specific epigenetic age estimators ("clocks") for three species (SandTiger Shark, Zebra Shark, Small tooth Sawfish) of conservation concern.
Objective 2. Construct a chondrichthyan-wide epigenetic age estimator based on shared homologous loci that exhibit age-associated DNAm patterning.
Objective 3. Develop a preliminary lifespan predictor for chondrichthyans, based on species-specific DNAm patterns and genomic characteristics.
Conclusions
This project just began and there are no conclusions at this time.
Major Impact(s) of Research
This project just began and there are no major impacts to report at this time.
Other Project Personnel
Project personnel are currently being recruited. The project is expected to support a postdoctoral researcher.
External Collaborators
Dr. Gavin Naylor, University of Florida
Dr. Kady Lyons, Georgia Aquarium
Products
This project just began and there are no products at this time.

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

Funding Entity

National Park Service, California Energy Commission, NFWF, Bureau of Land Management

Start Date and Funding Amount

Nov 2010; $450,000 (NPS); $313,000 (CEC, Phase I); $493,089 (CEC, Phase II); $299,658 (National Fish and Wildlife Foundation); $91,367 (BLM)

SREL Collaborators

Tracey Tuberville, 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.
4) Characterize risk of raven predation based on landscape features and tortoise intrinsic factors.

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. Initial attempts at 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. However, combination 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) proved to be an efficient approach to produce juveniles of a size more resistant to predation and with high post-release survival. However, drought resulted in high juvenile mortality by coyotes, presumably due to their switching prey from rabbits (whose populations usually plummet in drought years) to tortoises.

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.
3) Continued advancement of the technique has resulted in a more time and cost-efficient head-starting protocol, increasing its likelihood of implementation as part of a recovery program for the species.

Other Project Personnel

Carmen Candal, M.S. Student, SREL
Collin Richter, M.S. Student, SREL
Susanna Mann, M.S. Student, SREL

External Collaborators

Brian Todd, University of California, Davis
Clint Moore, UGA
Michel Kohl, UGA
Clark Rushing, UGA

Products

Candal, C.M. 2021. Pressure to perform: the role of stress physiology in head-starting success for Mojave desert tortoises. M.S. Thesis, University of Georgia.

Mann, S., B. Todd, K. Buhlmann, C. Rushing, and T. Tuberville. 2022. A comparison of the post-release survival and behavior of indoor-reared and combination-reared head-started Mojave desert tortoises (*Gopherus agassizii*). Desert Tortoise Council Symposium (virtual).

Richter, C., M. Kohl, P.A. McGovern, C.M. Candal, K.A. Buhlmann, B.D. Todd, and T.D. Tuberville. 2022. Multi-year space use and survival of head-started Mojave desert tortoises following release in Mojave National Preserve, California, USA. Desert Tortoise Council Symposium (virtual).

Richter, C., M. Kohl, P.A. McGovern, C.M. Candal, K.A. Buhlmann, B.D. Todd, and T.D. Tuberville. 2022. Multi-year space use and survival of head-started Mojave desert tortoises following release in Mojave National Preserve, California, USA. Warnell School of Forestry and Natural Resources Graduate Student Symposium.

Mann, S., B. Todd, K. Buhlmann, C. Rushing, and T. Tuberville. 2022. A comparison of the post-release survival and behavior of indoor-reared and combination-reared head-started Mojave desert tortoises (*Gopherus agassizii*). Warnell School of Forestry and Natural Resources Graduate Student Symposium.

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; Animal Welfare Institute

Start Date and Funding Amount

May 2017; $90,424; currently NFP

SREL Collaborators

Tracey D. Tuberville, Kurt A. Buhlmann

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 to evaluate 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

The primary activities during FY22 (beyond continuing to add waifs to the recipient population) centered on preparing manuscripts for publication in peer-reviewed journals.

Conclusions

Waifs exhibited remarkably high survivorship on par with that documented for wild, unmanipulated populations as well as wild-to-wild translocated populations. In addition, only two pathogens were detected – both *Mycoplasma* species known from wild populations. We suggest that waifs can be used to build isolated viable populations of gopher tortoises when other options are not available. However, we still recommend use of waifs only in select circumstances, when released waifs are unlikely to interact with individuals from wild, stable populations. Conclusions regarding social integration of waifs from multiple release groups will be made once parentage analysis is completed.

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. Our research also helps address what to do with the growing waif population in captivity.

Other Project Personnel

Rebecca McKee, M.S. student, SREL

External Collaborators

Will Dillman, SCDNR
Hunter Young, SCDNR
Andrew Grosse, SCDNR
Matt Allender, University of Illinois
Nicole Stacy, University of Florida Department of Veterinary Medicine
Clint Moore, UGA, USGS
Jeff Hepinstall-Cymerman, UGA

Products (Publications, Presentations, Technical Reports)

McKee, R.K., K.A. Buhlmann, C.T. Moore, M.C. Allender, N.I. Stacy, and T.D. Tuberville. 2022. Island of misfit tortoises: waif gopher tortoise health assessment following translocation. Conservation Physiology 10:coac051.

Tuberville, T.D. 2022. Gopher tortoises in Aiken County, SC: building a viable population from scratch. Academy for Lifelong Learning, University of South Carolina-Aiken.

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 2021; $87,227
SREL Collaborator
Robert Kennamer, Travis L. DeVault
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 13 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, SREL
External Collaborators
D. Allen Saxon, Jr., Augusta, GA Utilities Department
Tim Weegar, Augusta Regional Airport
Products
Kennamer, R. A., M.D. Strassburg, and I. L. Brisbin, Jr. 2021. Abundance, Distribution, and Movement Patterns of Avifauna in the Vicinity of Bush Field Airport: 2020–2021 Report. Final report submitted to Augusta Utilities Department, 182pp.

Kennamer, R. A. and M.D. Strassburg. Review of the 2020-21 report on bird activity around AGS and the Constructed Wetlands. Wildlife Hazard Management Group Meeting, Augusta Regional Airport, GA. November 16, 2021. (Oral Presentation).

Kennamer, R. A. and M.D. Strassburg. An update of SREL's recorded bird activity around Augusta Regional Airport. Wildlife Hazard Management Group Meeting, Augusta Regional Airport, GA. May 24, 2022. (Oral Presentation).

Costs of incubation: linking incubation-induced alterations in phenotype to changes in fitness

Funding Entity
National Science Foundation
Start Date and Funding Amount
October 2021; 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.
Summary of Research Activities
In FY22, a manuscript was accepted for publication and a presentation was made at a meeting.
Conclusions
1) Our studies have determined how the early thermal and social environments interact to influence offspring behavior/performance and suggested that these factors may play an important role in shaping offspring metrics that are critical for survival.
2) Our studies have documented that significant variability in egg temperatures exists within incubated wood duck clutches, enough so that duckling phenotypes, including important survival-related traits, can be impacted.

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

Other Project Personnel
NA
External Collaborators
Jordy Groffen, Research Technician, Virginia Tech
Dr. Bill Hopkins, Virginia Tech University
Sydney Hope, Virginia Tech University
Products
Hope, S.F., F. Angelier, C. Ribout, J. Groffen, R.A. Kennamer, and W.A. Hopkins. 2022. Warmer incubation temperature and later lay-orders lead to shorter telomere lengths in wood duck (*Aix sponsa*) ducklings. Journal of Experimental Zoology Part A (In Press).

Hope, S., W. Hopkins, C. Ribout, J. Groffen, R. Kennamer, F. Angelier. Warmer incubation temperatures lead to shorter telomere lengths in wood duck (*Aix sponsa*) ducklings. Meeting in Animal Ecophysiology, 5th edition, Montpellier, France, November 2021 (Oral Presentation).

Halidon Hill wetland restoration: a case study on the impacts of tree removal strategies on amphibian communities

Funding Entity
USFWS
Start Date and Funding Amount
July 2019; $67,696
SREL Collaborators
Dr. Stacey L. Lance, Dr. Krista Capps
Objectives
The overall goal of this research is to experimentally examine how different wetland restoration techniques compare in terms of speed of recovery of plant and animal communities, cost, and labor. Our objectives are to 1) establish three treatments of restoration and apply them to 12-15 wetlands, 2) determine how amphibian communities and water chemistry respond to restoration treatments and 3) assess which treatment is the most appropriate (based on success, cost, and labor) for future restoration of longleaf ecosystem wetlands.
Summary of Research Activities
We have conducted site visits to categorize thirty wetlands, collected eDNA from eight wetlands over two years, and dipnet for amphibians at ten wetlands. In conjunction with land-owners, environmental consultant and army corp of engineers we defined our three treatment conditions finalized the 12 wetlands that will receive treatments along with 2 control wetlands. We have conducted wetlands assessments, deployed data loggers, and begun taking regular water samples for nutrient and eDNA analysis at the 14 wetlands.
Conclusions
The data are still being collected.
Major Impact(s) of Research
The data are still being collected.
Other Project Personnel
Padraic Robinson, Research Professional, SREL
Adam McFall, MS student, SREL
Kiersten Nelson, PhD student, SREL
Tucker Stonecypher, MS student, SREL
Ezmie Trevarrow, Research Technician, SREL
External Collaborators
Lisa Lord, The Longleaf Alliance
Richard Coen Sr., Halidon Hill
Richard Coen Jr., Halidon Hill
Travis Folk, Folk Land Management Inc.
Dr. Meredith Holgerson, Cornell University
Products
Burrow, A.K., Lance, S.L. 2022. Restoration of Geographically Isolated Wetlands: An Amphibian-Centric Review of Methods and Effectiveness. Diversity 14(10):79.

Distribution and genetic diversity of Chamberlain's Dwarf Salamander (*Eurycea chamberlaini*)

Funding Entity
USFWS
Start Date and Funding Amount
September 2022; $92,072
SREL Collaborators
Dr. Stacey L. Lance
Objectives
Chamberlain's Dwarf Salamander (*Eurycea chamberlaini*) has been petitioned for listing under the Endangered Species Act. To assess the conservation status of *E. chamberlaini*, it is important to better understand the geographic distribution of populations, the genetic diversity within populations, and divergence among populations. Our overall objectives are to: 1) survey for *E. chamberlaini* in apparent distribution gaps in South Carolina; 2) collect representative, range-wide population genomic data from South Carolina and North Carolina to evaluate genetic diversity within and divergence among populations.
Summary of Research Activities
We have compiled records of *E. chamberlaini* from scientific literature, museum records, citizen science databases, state natural heritage programs, and field notes. We have contacted authors of previous studies and museum collections managers to determine which tissues or DNA extracts are still available for additional analysis.
Conclusions
No data have been collected yet.
Major Impact(s) of Research
No data have been collected yet.
Other Project Personnel
Padraic Robinson, Research Professional, SREL
External Collaborators
Dr. Todd Pierson, Kennesaw State University
Andrew Grosse, South Carolina Department of Natural Resources
Products
No publications, presentations, or reports have been prepared yet.

External (non-SRS) Funding Received in FY22

Effects of chronic radiation exposure on the movement behavior and 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; Environmental Radioactivity Research Network Center

Start Date and Funding Amount

May 1, 2018; $17,936

SREL Collaborators

Dr. James C. Beasley (PI), Sarah Chinn (Ph.D. student), Helen Bontrager (M.S. Student), Dr. Rie Saito (Postdoctoral Researcher)

External Collaborators

Dr. Thomas Hinton, Fukushima University
Dr. Kei Okuda, Fukushima University
Ms. Aryn Bordman, Colorado State University
Dr. Thomas Johnson, Colorado State University
Dr. Sami Pederson, Colorado State University
Ms. Maggie Roberts, Colorado State University
Dr. Rao Veeramachaneni, Colorado State University
Dr. Jodi Flaws, University of Illinois
Dr. Yui Nemoto, Fukushima Prefecture
Dr. Diana Lafferty, Northern Michigan University

Wild pig management in Sumter and Francis Marion National Forest

Funding Entity

USDA-USFS

Start Date and Funding Amount

May 21, 2018; $70,759

SREL Collaborators

Dr. James C. Beasley (PI)

External Collaborators

Mr. Donny Ray, USFS
Mr. Charles McKinney, USFS

Evaluating attractants and baits for wild pigs

Funding Entity

USDA-APHIS

Start Date and Funding Amount

September 5, 2019; $400,000

SREL Collaborators

Dr. James C. Beasley (PI), Caitlin Kupferman (Research Professional)

External Collaborators

Dr. Kim Pepin, USDA/APHIS/WS National Wildlife Research Center
Dr. Nathan Snow, USDA/APHIS/WS National Wildlife Research Center
Dr. Kurt VerCauteren, USDA/APHIS/WS National Wildlife Research Center
Mr. Mike Lavelle, USDA/APHIS/WS National Wildlife Research Center
Dr. Whitney Gann, Texas Parks and Wildlife

Assessment of changes in population size, agricultural damage, and environmental impacts of wild pigs in response to control in Newberry County, SC

Funding Entity

NWRC, SCDNR, Newberry Soil and Water Conservation District

Start Date and Funding Amount

January 1, 2021; $190,000

SREL Collaborators

Dr. James C. Beasley (PI), Caitlin Kupferman (Research Professional), Joseph Treichler (MS student), Vienna Canright (MS student), Charles Taylor (MS student)

External Collaborators

Mr. Noel Myers, USDA–Wildlife Services
Ms. Sylvia Harris, NRCS

Assessment of changes in population size, agricultural damage, and environmental impacts of wild pigs in response to control in Hampton County, SC

Funding Entity

NWRC, SCDNR

Start Date and Funding Amount

January 1, 2021; $260,000

SREL Collaborators

Dr. James C. Beasley (PI), Caitlin Kupferman (Research Professional), Joseph Treichler (MS student), Vienna Canright (MS student), Charles Taylor (MS student)

External Collaborators

Mr. Noel Myers, USDA–Wildlife Services
Ms. Sylvia Harris, NRCS

Evaluating impacts of wild pig control on damage reduction in Jasper County, SC

Funding Entity

NWRC, SCDNR

Start Date and Funding Amount

May 24, 2021; $658,587

SREL Collaborators

Dr. James C. Beasley (PI), Caitlin Kupferman (Research Professional), Joseph Treichler (MS student), Vienna Canright (MS student), Charles Taylor (MS student)

External Collaborators

Mr. Noel Myers, USDA-Wildlife Services
Ms. Sylvia Harris, NRCS

Efficacy of wildlife deterrents in minimizing white-tailed deer consumption of bait aimed at attracting wild pigs

Funding Entity

White Buffalo, Inc.

Start Date and Funding Amount

June 1, 2022; $13,000

SREL Collaborators

Dr. James C. Beasley (PI), Caitlin Kupferman (Research Professional), Owen Navarre (Research Technician), Taylor Aliferis (Research Technician)

External Collaborators

Anthony DeNicola, White Buffalo, Inc.

Human-carnivore interactions along the periphery of Etosha National Park, Namibia

Funding Entity

University of Georgia

Start Date and Funding Amount

January 7, 2022; $22,495

SREL Collaborators

Dr. James C. Beasley (PI), Dipanjan Naha (Postdoctoral Researcher), Jessy Patterson (PhD Student), Madeline Melton (MS Student), Caitlin Kupferman (Research Professional)

External Collaborators

Stephanie Periquet, Researcher, Ongava Research Centre
Josef Ndjimba, M.S. Student, Namibia University of Science and Technology
Josephine Amwaalwa, Research Technician, Ongava Research Centre

Invasive species control on Blackbeard Island, Wassaw and Harris Neck National Wildlife Refuges

Funding Entity

U.S. Fish and Wildlife Service

Start Date and Funding Amount

January 1, 2022; $219,900

SREL Collaborators

Dr. James C. Beasley (PI), Caitlin Kupferman (Research Professional), Patrick Helm (Research Professional)

External Collaborators

Chuck Hayes, Biologist, USFWS

Wet weather septic study

Funding Entity

Metro North Georgia Regional Water Planning District

Start Date and Funding Amount

May 1 2022; $199,000

SREL Collaborators

K. Capps (PI)

External Collaborators

Nandita Gaur, UGA
Erin Lipp, UGA

Research experience for post-baccalaureate students (REPS) in the biological sciences supplemental funding opportunity

Funding Entity

National Science Foundation

Start Date and Funding Amount

August, 2021; $45,634

SREL Collaborators

K. Capps (Co-PI)

External Collaborators

NA

Collaborative research: scales and drivers of variability in dissolved organic carbon across diverse urban watersheds.

Funding Entity
National Science Foundation
Start Date and Funding Amount
August 2021; $1,412,039
SREL Collaborators
K. Capps (co-PI)
External Collaborators
Rebecca Hale, Idaho State University
Allison Roy, University of Mass.
Jen Morse, Portland State University
John Kominoski, Florida International University

CAREER: The impacts of anthropogenically-derived subsidies on freshwater ecosystems

Funding Entity
National Science Foundation
Start Date and Funding Amount
January 2020; $1,184,890
SREL Collaborators
K. Capps (co-PI)
External Collaborators
NA

At-risk, threatened and endangered species habitat restoration and optimizing headstarting efforts for gopher frog (*Lithobates capito*)

Funding Entity
Longleaf Alliance via USFWS Coastal Programs
Start Date and Funding Amount
May 20, 2022; $109,756
SREL Collaborators
S. Lance (PI)
External Collaborators
Lisa Lord, Longleaf Alliance

Assessing genetics, taxonomy, and population trajectories across the range of the gopher frog (*Lithobates [Rana] capito*) to inform the upcoming listing decision

Funding Entity
USFWS Candidate Conservation Fund
Start Date and Funding Amount
June 30, 2022; $132,000
SREL Collaborators
S. Lance (Co-PI)
External Collaborators
J.J. Apodaca, Tangled Bank Conservation
J. Maerz, UGA

Distribution and genetic diversity of Chamberlain's Dwarf Salamander (*Eurycea chamberlaini*)
Funding Entity
USFWS Candidate Conservation Fund
Start Date and Funding Amount
June 30, 2022; $92,072
SREL Collaborators
S. Lance (Co-PI)
External Collaborators
T. Pierson, Kennesaw State University
A. Grosse, SC DNR

Headstarting Carolina gopher frogs from the Savannah River Site metapopulation
Funding Entity
USFWS
Start Date and Funding Amount
June 28, 2022; $22,501
SREL Collaborators
S. Lance (PI)
External Collaborators
NA

Integrating environment-by-epigenome interactions into a tractable model of epigenetic aging
Funding Entity
National Institutes of Health
Start Date and Funding Amount
August 2022; $273,430
SREL Collaborators
Ben Parrott
External Collaborators
NA

Non-lethal tools to estimate the ages and lifespans of Chondrichthyan fishes
Funding Entity
National Science Foundations
Start Date and Funding Amount
August 2022; $299,439
SREL Collaborators
Ben Parrott
External Collaborators
Dr. Gavin Naylor, University of Florida
Dr. Kady Lyons, Georgia Aquarium

Molecular level biodosimetry for national security: proteomic, glycomic, epigenetic, and metabolic approaches for quantitative assessment of low dose radiation exposure

Funding Entity

UGA Presidential Interdisciplinary Seed Grant Program

Start Date and Funding Amount

August 2021; $146,250

SREL Collaborators

Ben Parrott, Olin Rhodes

External Collaborators

Dr. Franklin Leach, UGA
Dr. Michael Tiemeyer, UGA
Dr. Lance Wells, UGA

Environmental and ecological determinants of epigenetic aging

Funding Entity

National Science Foundation

Start Date and Funding Amount

September 2020; $853,295

SREL Collaborators

Ben Parrott

External Collaborators

Kristen Navara, UGA

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

Funding Entity

National Science Foundation

Start Date and Funding Amount

August 2018; $571,839

SREL Collaborators

Ben Parrott

External Collaborators

N/A

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 Collaborators

Dr. Tracey Tuberville (PI), Dr. Kurt Buhlmann (co-PI), Pearson McGovern (technician), Carmen Candal (student), Collin Richter (student), Susanna Mann (student)

External Collaborators

Dr. Brian Todd, UC-Davis
Ms. Gabby Barnas, UC-Davis

Size-dependent survival and impacts of ravens on head-started desert tortoises

Funding Entity

Bureau of Land Management (via subcontract from University of California, Davis)

Start Date and Funding Amount

October 2020; $299,658

SREL Collaborators

Dr. Tracey Tuberville (PI), Dr. Kurt Buhlmann (co-PI), Pearson McGovern (technician), Carmen Candal (student), Collin Richter (student), Susanna Mann (student)

External Collaborators

Dr. Brian Todd, UC-Davis
Ms. Gabby Barnas, UC-Davis
Ms. Erin Trimpe, UC-Davis

Reproductive ecology of eastern box turtles in the Coastal Plain of South Carolina

Funding Entity

Justin Congdon – Nancy Dickson Research Fund

Start Date and Funding Amount

June 2022; $4500

SREL Collaborators

Dr. Tracey Tuberville (PI), Ryan Rimple (student)

External Collaborators

NA

Evaluating the suitability of confiscated and rehabilitated box turtles (Terrapene carolina) for release back into the wild

Funding Entity

Animal Welfare Institute

Start Date and Funding Amount

December 2021; $14,994

SREL Collaborators

Dr. Tracey Tuberville (PI), Ryan Rimple (student)

External Collaborators

NA

CESU: Implications of mid-rotation pine plantation treatments for wildlife habitat and stand profitability

Funding Entity

GA Department of Natural Resources

Start Date and Funding Amount

July, 2016; $425,490

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Ecology of wild turkeys in the Piedmont region of Georgia

Funding Entity

GA Department of Natural Resources

Start Date and Funding Amount

August, 2016; $1,320,977

SREL Collaborators

Dr. James A. Martin (Co-PI)

External Collaborators

Dr. Michael J. Chamberlain, UGA

Gopher tortoise population dynamics and movements in production pine forest landscapes

Funding Entity

National Council for Air and Stream Improvements

Start Date and Funding Amount

September, 2017; $207,449

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

Dr. Michael J. Chamberlain, UGA, Dr. John C. Maerz , UGA

Outreaching the working lands for wildlife: bobwhite in pine savanna partnership

Funding Entity

USDA NRCS

Start Date and Funding Amount

August, 2018; $63,001

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Adaptive management to optimize northern bobwhite populations, hunter satisfaction, timber revenue, and other objectives

Funding Entity

GA Department of Natural Resources

Start Date and Funding Amount

January, 2019; $197,371

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

Dr. Bynum Boley, UGA

Status and management of ruffed grouse in the north Georgia

Funding Entity

GA Department of Natural Resources

Start Date and Funding Amount

January, 2019; $259,350

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

Dr. Tina Johannsen, GA Department of Natural Resources
Emily Rushton, GA Department of Natural Resources
Dr. Mark McConnell, Mississippi State Univ.
Dr. Richard Chandler, UGA

Effects of harvest and habitat condition on northern bobwhite

Funding Entity

State of Indiana

Start Date and Funding Amount

January, 2019; $360,277

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

Dr. Richard Chandler, UGA

Tall Timbers assistantship for Shelby Simons

Funding Entity

Tall Timers Research Inc.

Start Date and Funding Amount

May, 2019; $49,970

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Effects of stand-level characteristics on insect pollinator populations and communities in managed forests

Funding Entity

National Council for Air and Stream Improvements

Start Date and Funding Amount

November, 2019; $165,752

SREL Collaborators

Dr. James A. Martin (Co-PI)

External Collaborators

Dr. Kamal Gandhi, UGA

Evaluating the spatial availability of supplemental feed on northern bobwhite breeding season demographics (Matthew Portwood)

Funding Entity
Tall Timers Research Inc.
Start Date and Funding Amount
August, 2020; $44,664
SREL Collaborators
Dr. James A. Martin (PI)
External Collaborators
NA

Exploratory modeling to guide the design of a full annual cycle study of declining grassland birds in the midcontinent U.S.

Funding Entity
US Department of Interior
Start Date and Funding Amount
October, 2020; $23,952
SREL Collaborators
Dr. James A. Martin (PI)
External Collaborators
NA

Efficacy of song meters for statewide grassland bird population monitoring

Funding Entity
State of Indiana
Start Date and Funding Amount
October, 2020; $264,637
SREL Collaborators
Dr. James A. Martin (PI)
External Collaborators
NA

Wild turkey ecology in the Georgia Piedmont, phase 2

Funding Entity
GA Department of Natural Resources
Start Date and Funding Amount
January, 2021; $1,725,000
SREL Collaborators
Dr. James A. Martin (Co-PI)
External Collaborators
Dr. Michael J. Chamberlain, UGA

Ecosystem services (David Weber)

Funding Entity
Tall Timers Research Inc.
Start Date and Funding Amount
January, 2021; $22,332
SREL Collaborators
Dr. James A. Martin (PI)
External Collaborators
NA

Exploring the effects of post-hunting season disturbances on northern bobwhite Colinus virginianus behavior (Kyle Magdziuk)

Funding Entity

Tall Timers Research Inc.

Start Date and Funding Amount

January, 2021; $58,609

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Refining the sampling of northern bobwhite quail Colinus virginianus (Robin Schmitt)

Funding Entity

Tall Timers Research Inc.

Start Date and Funding Amount

June, 2021; $58,609

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Landscape factors driving raptor density and adult northern bobwhite mortality in central Florida (Marijean Leigh Hankins)

Funding Entity

Tall Timers Research Inc.

Start Date and Funding Amount

June, 2021; $58,609

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

The effects of supplemental feed on northern bobwhite Colinus virginianus demographics (Alex Jackson)

Funding Entity

Tall Timers Research Inc.

Start Date and Funding Amount

August, 2021; $76,463

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Common ground dove Columbina passerina movement on a quail managed landscape and their abundance across the Red Hills Region of Florida (Destinee Reann Kay Story)

Funding Entity

Tall Timers Research Inc.

Start Date and Funding Amount

August, 2021; $58,609

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Spatial prioritization and monitoring of northern bobwhites and associated birds in the context of working lands for wildlife

Funding Entity

USDA NRCS

Start Date and Funding Amount

September, 2021; $643,720

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Precision habitat and disturbance management for northern bobwhites

Funding Entity

GA Department of Natural Resources

Start Date and Funding Amount

July, 2022; $1,089,782

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

Dallas Ingram, GA Department of Natural Resources

Ruffed grouse population and genetic monitoring in north Georgia

Funding Entity

GA Department of Natural Resources

Start Date and Funding Amount

October, 2022; $730,894

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

Dr. Tina Johannsen, GA Department of Natural Resources
Emily Rushton, GA Department of Natural Resources
Dr. Richard Chandler, UGA
Dr. Helen Bothwell, UGA

The contribution of the NBCI's Coordinated Implementation Program to the restoration of the longleaf ecosystem: recovering the northern bobwhite

Funding Entity

National Fish and Wildlife Federation

Start Date and Funding Amount

October, 2022; $107,768

SREL Collaborators

Dr. James A. Martin (PI)

External Collaborators

NA

Technical Expertise Requests in FY22

SREL Investigator
T. Tuberville, K. Buhlmann
Date of Request
FY22 (Ongoing)
Requesting Entity
SCDNR
Nature of Request
Develop and implement research and monitoring program to evaluate fate of confiscated box turtles released back to the wild

SREL Investigator
R. A. Kennamer, T. L. DeVault
Date of Request
FY22 (ongoing)
Requesting Entity
Augusta Regional Airport at Bush Field
Nature of Request
Wildlife hazard consultant for Augusta Regional Airport at Bush Field. Members of Augusta Regional Airport Wildlife Hazard Management Group

SREL Investigator
T. Tuberville, K. Buhlmann
Date of Request
FY22 (ongoing)
Requesting Entity
SCDNR
Nature of Request
Serve as species expert on gopher tortoise population biology and reintroduction

SREL Investigator
K. Buhlmann, T. Tuberville
Date of Request
FY22 (ongoing)
Requesting Entity
National Park Service
Nature of Request
Participate in and provide ongoing guidance and technical expertise in long-term monitoring program for Texas tortoises at Palo Alto National Battlefield in Brownsville, TX

SREL Investigator
T. Tuberville, K. Buhlmann
Date of Request
FY22 (ongoing)
Requesting Entity
American Zoo and Aquarium Association (AZA)
Nature of Request
Assist with development of SAFE (Saving Animals from Extinction) program for North American Turtles

SREL Investigator
T. Tuberville, K. Buhlmann
Date of Request
FY22 (ongoing)
Requesting Entity
PARC Turtle Networking Team's Collaborative to Combat the Illegal Trade in Turtles
Nature of Request
Participate in monthly meetings to discuss ongoing issues and topics related to illegal turtle trade and whether (and under what circumstances) confiscated animals can be used for conservation or research purposes

SREL Investigator
T. Tuberville
Date of Request
June 2022
Requesting Entity
Argonne National Laboratory
Nature of Request
Serve on advisory committee for a project that (if funded) would be investigating wildlife-solar energy interactions and their population-level implications for North American tortoises

SREL Investigator
K.A. Buhlmann
Date of Request
January 2022
Requesting Entity
Natural Resource Conservation Service (NRCS), Vermont
Nature of Request
Provide information regarding management of riparian habitats for state-threatened wood turtles

SREL Investigator
K.A. Buhlmann
Date of Request
February 2022
Requesting Entity
Natural Resource Conservation Service (NRCS), New Jersey
Nature of Request
Request information regarding constructions of artificial nesting habitats for state-threatened wood turtles.

SREL Investigator
K.A. Buhlmann
Date of Request
March 2022
Requesting Entity
U.S. Fish and Wildlife Service, Great Swamp National Wildlife Refuge, NJ
Nature of Request
Assisted private landowners living adjacent to the National Wildlife Refuge, regarding how their land activities (i.e., mowing, haying) can be modified to minimize impacts to threatened turtle species

SREL Investigator
K.A. Buhlmann
Date of Request
February 2022
Requesting Entity
PARC-DOD
Nature of Request
Provided the DOD with habitat management recommendations for managing Blanding's turtles (a USFWS At-Risk species) on DOD facilities in the Northeast and upper Midwest.

SREL Investigator
K.A. Buhlmann
Date of Request
February 2022
Requesting Entity
American Zoo and Aquarium Association
Nature of Request
Assisted with editing draft proposals for dealing with large quantities of confiscated turtles

SREL Investigator
K.A. Buhlmann
Date of Request
April 2022
Requesting Entity
Department of the Navy, Holley OLF
Nature of Request
Provided flatwoods salamander habitat management recommendations post-prescribed burns carried out by US Navy Natural Resources staff

SREL Investigator
K.A. Buhlmann
Date of Request
Spring, Summer, Fall 2022
Requesting Entity
USFS- Savannah River and SCDNR (Crackerneck WMA)
Nature of Request
Assist with field recon of Carolina bays for restoration, assist with flagging of timber resources to retain, provide Google Earth imagery of ditches to fill, historic records of rare herp species from the Stewardship database, and participate in multiple discussions and field restoration activities

SREL Investigator
K.A. Buhlmann
Date of Request
April 2022
Requesting Entity
Louisiana Wildlife Department
Nature of Request
Advice on management of riverine nesting sandbars for Federally-threatened map turtles

SREL Investigator
K.A. Buhlmann
Date of Request
November 2021, January, June, July, September, October 2022
Requesting Entity
South Carolina Department of Natural Resources
Nature of Request
Physically help multiple times in 2022 to establish displaced gopher tortoises that South Carolina DNR obtained (either through confiscations, donations form nature centers, other state agencies, and especially displaced from development in Florida) to a SC state Natural Heritage Preserve with long-term intent to establish a viable population. Assist in building pens for establishing tortoise site fidelity

SREL Investigator
K.A. Buhlmann
Date of Request
2022 on-going
Requesting Entity
USFS- Savannah River
Nature of Request
Assist with evaluation of SRS timber management compartments that may represent the best locations for management and recovery of rare (At-Risk) snake species

SREL Investigator
O.E. Rhodes
Date of Request
2022
Requesting Entity
Smithsonian Institution
Nature of Request
Review Team member for evaluation of operations and finance at the National Zoo and the Smithsonian Conservation Biology Insititute

SREL Investigator
O.E. Rhodes
Date of Request
2022
Requesting Entity
National Rabies Program
Nature of Request
Participant on the planning team for the US National Rabies Strategic Plan

SREL Investigator
K.A. Buhlmann
Date of Request
September 2022
Requesting Entity
National Park Service, Gulf Coast Monitoring Network
Nature of Request
Assist with monitoring protocols for Berlandiers Tortoises on Palo Alto National Battlefield, Brownsville, Texas

SREL Investigator
K.A. Buhlmann
Date of Request
November 2021, Spring 2022
Requesting Entity
CCITT (Collaborative to Combat Illegal Trade in Turtles/Tortoises)-partnership among state herpetologists, federal biologists, and state and federal wildlife law enforcement officials
Nature of Request
Participation in on-going discussions regarding placement of confiscated turtles

SREL Investigator
K.A. Buhlmann
Date of Request
September 2022
Requesting Entity: USFWS Staff, Wallkill NWR, NJ
Nature of Request: Assessment of areas on the NWR Complex that would be potential sites for wood turtle reintroductions

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 FY22. Below we provide examples of specific activities that SREL personnel have conducted in FY22 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 personnel worked to sample potential locations on the SRS and perform evaluations of PFAS in biotic and abiotic media
- SREL leveraged DOE EM funding to procure UGA funding to hire five new faculty positions to be jointly appointed between UGA main campus units and SREL in support of the research, education, and outreach missions conducted by the laboratory
- SREL leveraged DOE funding against UGA funding to conduct 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 ~ 1.1 million dollars in new external funding during the FY22 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 the former MOX construction site on the viability of upper three runs creek
- SREL outreach personnel conducted extensive community outreach and education programs for NNSA and SRS

Savannah River Mission Completion

- SREL entered into a new 5 year agreement with SRMC to conduct research in support of the low level waste disposal mission on the SRS
- SREL personnel continued to assist SRMC on wildlife contamination issues requiring federal permits for relocation of avian nests

Savannah River Nuclear Solutions

- SREL personnel leveraged funding from ACP to conduct radioecology research programs involving environmental characterization, contaminants in wildlife, soil and water amendments, 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 several Wildlife Safety Talks to SRS site personnel

Savannah River National Laboratory

- SREL worked with the UGA Research Institute to establish new collaborative research teams, workforce development activities, and joint appointments with the Battelle Savannah River Alliance
- SREL faculty collaborated with various SRNL scientists to accomplish a variety of research projects focused on environmental remediation and monitoring

US Forest Service

- SREL personnel worked with the USFS-SR to create potential habitat improvements for the at risk gopher frog population on the SRS
- SREL personnel met multiple times with USFS personnel to discuss potential research initiatives to establish the 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 500 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 FY22, SREL faculty and staff mentored and supervised 115 graduate students (Table 10.1) from universities across the country. 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 FY22 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 FY22.

- SREL leveraged SRS site assets to acquire external resources to conduct UGA Maymester courses in wildlife ecology in May 2022

- SREL leveraged UGA funding against project specific funding from DOE and other sources to cost share over 20 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 6 faculty members to provide instructional support to UGA departments as a means to maintain critical environmental expertise on the SRS

Table 10.1. SREL Graduate Student Program Participants, FY22

STUDENT	DEGREE	UNIVERSITY	FACULTY	ROLE
Alejandro Collins	M.S.	University of Georgia	Abrams	Advisor
Amanda Komasinski	M.S.	University of Georgia	Abrams	Advisor
Behnoosh Abbasnezhad	Ph.D.	University of Georgia	Abrams	Advisor
Chase Cook	Ph.D.	University of Georgia	Abrams	Advisor
Destin Kee	M.S.	University of Georgia	Abrams	Advisor
Shinyeong Park	Ph.D.	University of Georgia	Abrams	Advisor
Akanksha Sharma	Ph.D.	University of Georgia	Abrams	Committee
Alexander Nelson	Ph.D.	University of Georgia	Abrams	Committee
Alyssa Quan	Ph.D.	University of Georgia	Abrams	Committee
Asif Sandeloo	Ph.D.	University of Georgia	Abrams	Committee
Camilia Rojas	M.S.	University of Georgia	Abrams	Committee
Elisabeth Evans	M.S.	University of Georgia	Abrams	Committee
Jackson Wright	M.F.R.	University of Georgia	Abrams	Committee
Joshua Uzu	Ph.D.	University of Georgia	Abrams	Committee
Maria Teresa Tancredi	Ph.D.	University of Georgia	Abrams	Committee
Mary Louise Hoffacker	M.N.R.	University of Georgia	Abrams	Committee
Maureen Essen	Ph.D.	University of Idaho	Abrams	Committee
Omer Ince	M.S.	University of Georgia	Abrams	Committee
Rachel Arney	M.S.	University of Georgia	Abrams	Committee
Jack Taylor	M.F.R.	University of Georgia	Aubrey	Advisor
Jennifer McDaniel	Ph.D.	University of Georgia	Aubrey	Advisor
Ream Thomas	M.S.	University of Georgia	Aubrey	Advisor
Scott Oswald	Ph.D.	University of Georgia	Aubrey	Advisor
Suzanne Henderson	M.S.	University of Georgia	Aubrey	Advisor
Tyler McIntosh	M.S.	University of Georgia	Aubrey	Advisor
Emilee Poole	Ph.D.	University of Georgia	Aubrey	Committee
Luke Wilson	M.S.	University of Georgia	Aubrey	Committee
Monica Harmon	Ph.D.	University of Georgia	Aubrey	Committee
Vanessa Gremler	MS	University of Georgia	Aubrey	Committee

Charles Taylor	M.S.	University of Georgia	Beasley	Advisor
Chelsea Titus	M.S.	University of Georgia	Beasley	Advisor
Chris Leaphart	Ph.D.	University of Georgia	Beasley	Advisor
Helen Bontrager	M.S.	University of Georgia	Beasley	Advisor
Jessica Patterson	Ph.D.	University of Georgia	Beasley	Advisor
Joe Treichler	M.S.	University of Georgia	Beasley	Advisor
Madeline Melton	M.S.	University of Georgia	Beasley	Advisor
Miranda Butler-Valverde	M.S.	University of Georgia	Beasley	Advisor
Kathryn Quinlin	M.S.	University of Georgia	Beasley	Co-Advisor
Kelly Holland	M.S.	University of Georgia	Beasley	Co-Advisor
Vienna Canright	M.S.	University of Georgia	Beasley	Co-Advisor
Chris Terrazas	M.S.	University of Georgia	Beasley	Committee
Daniela Guerrero	M.S.	University of Georgia	Beasley	Committee
Edda Baek	M.S.	Norwegian University of Life Sciences	Beasley	Committee
Jennifer Brown	M.S.	University of Georgia	Beasley	Committee
Josef Ndjimba	M.S.	University of Namibia	Beasley	Committee
Natalie Ramos	M.S.	University of Georgia	Beasley	Committee
Patrick Grunwald	M.S.	University of Georgia	Beasley	Committee
Sebastian Ortiz	M.S.	University of Georgia	Beasley	Committee
Anuja Mital	Ph.D.	University of Georgia	Capps	Advisor
Denzell Cross	Ph.D.	University of Georgia	Capps	Advisor
E. Madison Monroe	M.S.	University of Georgia	Capps	Advisor
Emily Martin	M.S.	University of Georgia	Capps	Co-Advisor
Fabiola Lopez Avila	M.S.	University of Georgia	Capps	Co-Advisor
Viviana Bravo Ortiz	M.S.	University of Georgia	Capps	Co-Advisor
Brandi Carr	M.S.	University of Georgia	Capps	Committee
Courtney Scott	Ph.D.	University of Georgia	Capps	Committee
Jeffery Beauvais	Ph.D.	University of Georgia	Capps	Committee
Lynda Bradley	Ph.D.	Emory University	Capps	Committee

Sophia Racey	Ph.D.	University of Georgia	Capps	Committee
Suneel Kumar	Ph.D.	University of Georgia	Capps	Committee
Carson Pakula	M.S.	University of Georgia	DeVault	Co-Advisor
Shane Guenin	M.S.	University of Georgia	DeVault	Co-Advisor
Adam McFall	M.S.	University of Georgia	Lance	Advisor
Kiersten Nelson	Ph.D.	University of Georgia	Lance	Advisor
Tucker Stonecypher	M.S.	University of Georgia	Lance	Advisor
Christian Swartzbaugh	M.S.	University of Georgia	Lance	Co-Advisor
Corinne Sweeney	M.S.	University of Georgia	Lance	Co-Advisor
Emma Kelsick	M.S.	University of Georgia	Lance	Co-Advisor
Matthew Tatz	Ph.D.	University of Georgia	Lance	Co-Advisor
Daniel Suh	Ph.D.	University of Georgia	Lance	Committee
Jordan Youngmann	Ph.D.	University of Georgia	Lance	Committee
Marissa Howard	M.S.	University of Georgia	Lance	Committee
Alex Jackson	Ph.D.	University of Georgia	Martin	Advisor
Anabelle Stanley	M.S.	University of Georgia	Martin	Advisor
Cara Stewart	M.S.	University of Georgia	Martin	Advisor
David Weber	M.S.	University of Georgia	Martin	Advisor
Destinee Story	M.S.	University of Georgia	Martin	Advisor
Garrett Roberts	M.S.	University of Georgia	Martin	Advisor
Justin Hill	Ph.D.	University of Georgia	Martin	Advisor
Kyle Magdziuk	M.S.	University of Georgia	Martin	Advisor
Marijean Hankins	M.S.	University of Georgia	Martin	Advisor
Michael Hazelbaker	M.S.	University of Georgia	Martin	Advisor
Robin Schmitt	M.S.	University of Georgia	Martin	Advisor
Shelby Simons	M.S.	University of Georgia	Martin	Advisor
Sierra Sico	M.S.	University of Georgia	Martin	Advisor
Alexandra Brown	M.S.	University of Georgia	Martin	Committee
Christine Favorito	M.S.	University of Georgia	Martin	Committee
Corrie Navis	Ph.D.	University of Georgia	Martin	Committee

Melanie Kunkel	Ph.D.	University of Georgia	Martin	Committee
Nancy Raginski	Ph.D.	University of Georgia	Martin	Committee
Nicolas Bakner	Ph.D.	University of Georgia	Martin	Committee
Nicole Nimlos	M.S.	University of Georgia	Martin	Committee
Patrick Wrightman	Ph.D.	University of Georgia	Martin	Committee
Sarah Watkins	M.S.	University of Georgia	Martin	Committee
Seth Wyckoff	M.S.	University of Georgia	Martin	Committee
Abigail Bickle	M.S.	University of Georgia	Parrott	Advisor
Chris Smaga	Ph.D.	University of Georgia	Parrott	Advisor
Emily Bertucci	Ph.D.	University of Georgia	Parrott	Advisor
Ethan Shealy	Ph.D.	University of Georgia	Parrott	Advisor
Josiah Johnson	M.S.	University of Georgia	Parrott	Advisor
Laura Kojima	M.S.	University of Georgia	Parrott	Advisor
Samantha Bock	Ph.D.	University of Georgia	Parrott	Advisor
Elise Webb	M.S.	University of Georgia	Parrott	Co-Advisor
Kristen Zemaitis	M.S.	University of Georgia	Parrott	Co-Advisor
Gabriela Martins	Ph.D.	University of Georgia	Parrott	Committee
Olivia Delgado	Ph.D.	University of Georgia	Parrott	Committee
Courtney Werner	M.S.	University of Georgia	Rhodes	Co-Advisor
Carmen Candal	M.S.	University of Georgia	Tuberville	Advisor
Collin Richter	M.S.	University of Georgia	Tuberville	Co-Advisor
Emma Browning	M.S.	University of Georgia	Tuberville	Co-Advisor
Ryan Rimple	M.S.	University of Georgia	Tuberville	Co-Advisor
Susanna Mann	M.S.	University of Georgia	Tuberville	Co-Advisor
Brittany Jensen	M.S.	University of Georgia	Xu	Co-Advisor
Cher Nicholson	M.S.	University of Georgia	Xu	Co-Advisor
Jake Smith	M.S.	University of Georgia	Xu	Co-Advisor

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

SREL is the custodian of twelve DOE owned buildings with the largest of these being our 45,000 square foot main laboratory and office complex. SREL also operates 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 is currently the custodian of building 772-25B in B-Area, an 8,000 square foot building that containing 12 laboratories in various states of functionality and renovation.

SREL operates its own maintenance staff consisting of three full time technicians, and three part-time temporary workers. This group is responsible for all ground maintenance, routine infrastructure repair, and preventive maintenance duties for over 120 infrastructure assets. The maintenance group also undertakes fabrication projects in support of research efforts. The maintenance crew has expertise in welding-fabrication, vehicle repair, construction-renovation, electrical-HVAC, and equipment operation. This capability allows SREL to manage facility issues in an efficient and cost-effective manner.

As a partner here on the Savannah River Site, SREL strives to maintain facilities that comply with all DOE guidelines for property use and safety standards. In FY22, SREL worked to develop facilities that are not only aesthetically pleasing, enjoyable, and safe to work in, but that lend themselves toward providing researchers with the best possible environment to conduct research. To that end, SREL sets aside funds from the overhead budget and dedicates personnel time to maintaining and renovation facilities.

The most substantial facility renovation in FY22 was the addition of 17 modular offices to the footprint of the SREL facility. With the recent growth of staff and anticipated future growth, management decided to convert a lightly used library space and the shipping and receiving room into office complexes. To complete the renovation, all the media and periodicals in the library area were relocated, all carpeting was replaced, walls were painted, and the electrical and computer wiring were reconfigured to fit the new offices. The shipping and receiving room was moved to another location and completely renovated. Finally, a contractor installed the 17 modular offices within these renovated rooms, furniture was added, and offices were assigned to existing staff. Several more modular offices will be added in the coming fiscal year.

Other major facility improvements in FY22 were centered around the continued renovation of the 772-25B laboratory. This facility located in B Area, which consists of 12 research laboratories, was claimed by SREL from site excess six years ago and has been used for laboratory expansion as SREL has grown. In prior years five of the laboratories were renovated, and in FY22 the renovation of the remaining facility was completed. This renovation included all new paint, floor tiles, four new HVAC units, one facility make-up air unit to operate the six new fume hoods, new lab furniture, new duct work for the fume hoods, and all new laboratory fixtures.

Over the last year SREL also has completed several other significant renovations to facilities, including:

Continued renovation of faculty and staff offices: This year SREL completely renovated another five offices. This included re-carpeting, painting, furnishing, and making any other necessary repairs. These renovations marked the 48th office renovation over the last seven years and marked the renovation of 88% of the office inventory.

Improvements to air handling infrastructure (HVAC): This year SREL replaced two of the HVAC distribution boxes with a new electronically controlled air damper distribution system, replacing 40-year-old manual air dampers that were performing poorly. The new system allows for better control over specific room temperatures and is ultimately more efficient. SREL also replaced one nonfunctioning 10-ton HVAC unit for one of the storage buildings, the first step in the renovation of the building which will be converted into a radioecology laboratory in FY23.

Installation of LED lighting: SREL maintenance continued the phased replacement of the fluorescent lighting throughout the facility with new LED fixtures. To date approximately 75% of the old fixtures have been replaced with LEDs, resulting in dramatically improved interior lighting throughout the facility. The goal is to eventually replace all the lighting in the main facility with efficient LED lighting.

Renovation of research ponds: Behind SREL are six 60' x 120' ponds that are used for various research purposes. In FY20 the fencing was replaced around one of the ponds which is used to house adult alligators. In FY21 the renovation of two other research ponds was begun, which required the removal of all the old fencing as well as a number of trees and overgrown vegetation. The effort was hampered by supply chain issues due to the pandemic, but these two enclosures were completed in early FY22 and are now operational

Relocation and renovation of SREL shipping and receiving: To make room for the aforementioned modular offices, the shipping and receiving center was moved to another location within our footprint. A storage room formerly used for document storage and computer GIS analysis was cleaned and renovated by replacing the carpet and painting. Custom furniture was installed to set up a more functional shipping and receiving area.

SREL also continued an emphasis on cleaning and proper organization in FY22, including disposal of unneeded supplies and excessing surplus equipment. SREL made significant progress in this area, and will continue to work diligently in the coming year to continue to improve the facilities in terms of proper organization and housecleaning. To that end the safety department was tasked with the review of the contents of a number of SREL legacy storage sheds located in B-Area. These sheds contained chemicals, field supplies, and other supplies. Over the past year, that group has removed, redistributed, or properly disposed of the excess items in over 10 of these portable storage sheds.

While much was achieved in FY22, SREL will remain committed to aggressively pursuing the development of facilities that comply with DOE guidelines and reflect positively on our staff and research efforts. To that end, SREL will continue to use our in-house maintenance staff and available funding to 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.

During FY22, SREL hired a new full time safety position to maintain the commitment of two, full-time safety support positions. The SREL EH&S Coordinators serve as the managers of SREL's safety and environmental compliance programs. The SREL Environmental Safety Coordinators provide focused laboratory research related safety and hazardous, radiological, and mixed waste management support to SREL science researchers. The SREL EH&S Coordinators interface 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 and oversee the safety and environmental compliance programs for SREL. Additionally, they interface with the SRNS Radiological Protection Department to implement the SRS Radiological Control Program at SREL.

SREL EH&S Coordinators interface with other SRS organizations to distribute 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 Coordinators electronically distributed **4 (four)** targeted lessons learned and safety notices in FY22 to specific worker groups at SREL.

SREL EH&S Coordinators provided weekly reports of recordable personnel accidents or injuries to DOE-SR line management. SREL personnel reported **3 (three)** work related, recordable injury/illness during FY22. This represents one additional injury/illness over the previous FY21 reporting period. SREL also experienced one reportable incident, a malfunctioning drying oven that caused a small fire contained within the oven. This represents one additional incident in FY22, whereas no incidents were reported in FY2021. SREL also provided monthly, SREL personnel work hour statistics to DOE-SR.

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 by their SREL supervisor. Approximately 38 SREL personnel received this required training during FY22. Additionally, SREL personnel received EH&S related training during FY22 in the following functional areas as their job tasks required:

- Radiological Training – Radiological Worker Training, Advanced 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 workplace.
- Resource Conservation Recovery Act (RCRA) training for employees involved in the management, handling, or manipulation of hazardous or universal wastes.

- Waste Minimization Training
- CPR/AED/Bloodborne Pathogens

SREL continues to refine their waste minimization and chemical disposal processes 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 chemical wastes while supporting the SRS's pollution prevention efforts. SREL generated approximately 1732 pounds of hazardous wastes in FY22. One hundred percent of the hazardous wastes generated was from disposal of laboratory research process generated wastes. In addition, SREL generated 1601pounds of radiological waste from experimental processes and lab clean ups. As part of SREL waste minimization efforts, and to ensure that chemical hazards are addressed prior to purchasing chemicals, the SREL EH&S Coordinators reviewed and approved 87 separate chemical purchase orders made by SREL personnel.

SREL received no Notices of Violation in FY22 as the result of external or internal reviews, inspections, or assessments. During FY22, 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.

Analytical Services

SREL 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 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 workspaces for all tasks associated with sample prep through analysis. One full-time position (SREL Analytical Services Manager) is dedicated to maintaining 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 and 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 FY22, 17 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 FY22, we analyzed 3,241samples that provided data for 12 research groups at SREL including graduate students, post docs, and principle investigators.

Mercury Analysis: A Milestone DMA-80 Tri Cell unit and a DMA-80 Evo unit directly measures total mercury following EPA Method 7473. This is a fee-for-service instrument 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 FY22, 12 researchers, including graduate students, post-docs, technicians and principle investigators, performed total mercury analysis on 1,873 samples. The Brooks Rand MERX Methyl Mercury Analyzer is currently utilized by one research group. In FY22, approximately 350 samples were analyzed for methyl mercury.

Sample Preparation for Metals and Mercury: Three laboratories house three chemical fume hoods, three 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. An additional lab houses four freeze dryers with a total capacity of 50 ports and 4 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.

Analytical Services FY22 Summary

Personnel Trained in FY 2022	Number of Individuals
Graduate Students	8
Undergraduate Students	2
Faculty	1
Post Docs	1
Technicians/Research Professionals	5
Total	17

Equipment Description	Number of Samples Analyzed	Number of Users/Research Groups	Number of Days/Times Used
ICP-MS	3,241	Samples from 12 Groups	94
DMA-80 Mercury Analyzers (2)	1,873	12 Users, 8 Groups	91
Methyl Mercury Analyzer	350	2 Users, 1Group	N/A
CEM Microwaves (2)	N/A	9 Users, 5 Groups	50
Freeze Dryers (4)	N/A	10 Users, 7 Groups	234

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 FY22. See Task 11 (above) for summary of facilities upgrades.

SECTION III. Cost Status Report

Reports are provided to the DOE-SR budget office monthly and the final FY22 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 FY22.

SECTION V. Changes in Approach or Goals

In FY22 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 10 tenure track faculty lines with UGA main campus units (6 housed at SREL and 4 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
- Leveraging 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 FY22, external funding (non-SRS or UGA dollars) totaled 35% of the laboratory's externally funded budget.

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

NA

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

Administrative
No Change
Support Staff
Hired – Tonya Clark
Hired – Ivy Blackwell
Separated – Ashley Thoerner
Tenure-track Faculty
Hired – Avishek Dutta
Hired – Daniel Peach
Hired – Brennan Ferguson
Research Faculty
Hired – Daniel Kaplan
Separated – John Seaman
Separated – Guha Dharmarajan
Postdoctoral Researchers
Hired – D. Naha
Hired – Fabio Toledo
Separated – D. Naha
Research Professionals
Hired – Madison Miller
Hired – Breann Spencer
Hired – Madeline Lyons
Hired – Padriac Robinson
Separated – Jon Skaggs
Separated – G. Ferreira
Separated – Marley Brown
Safety
Hired – Erin Peck
Separated – Donald Mosser
Separated – Rochelle Beasley
Outreach Personnel
Separated – Pacifico Perea
Research Technicians
Hired – Andrew Lydeard
Hired – Abigail Bickle
Hired – Patrick Helm
Hired – Ryan Rimple
Hired – Dylan Ricke
Separated – Jennifer Dirks
Separated – Christina Logan
Separated – Shayna Munoz
Separated – Chongyang Quin
Separated – Erin Spivey

SECTION VIII. Products or Technology Transfer Accomplished: Publications, Websites, Collaborations, Technologies, Inventions/patents, other Products

SREL faculty and staff added 46 new publications to the SREL reprint list in FY22

3665. Gibbons, J. W. (1997). "From fresh water to the sea; The turtle bridge is open." Velador Summer: 4-5.

3666 Brown, M. K., D. L. Haskins, A. L. Russell, M. L. Lambert, C. E. Quick, M. A. Pilgrim and T. D. Tuberville (2022). "Mercury and Radiocesium Accumulation and Associations with Sublethal Endpoints in the Florida Green Watersnake (*Nerodia floridana*)." Environmental Toxicology and Chemistry 41(3): 758-770.

3667 Bringolf, R. B., B. K. Raines, R. E. Ratajczak and D. L. Haskins (2022). "Major Ion Toxicity to Glochidia of Common and Imperiled Freshwater Mussel Species." Diversity 14(2): 95.

3668 Fletcher, D. E., A. H. Lindell, P. T. Stankus, C. M. Fulghum and E. A. Spivey (2022). "Species- and element-specific patterns of metal flux from contaminated wetlands versus metals shed with exuviae in emerging dragonflies." Environmental Pollution 300(2022): 118976.

3669 Mason, M. W., E. M. Bertucci, F. M. Leri and B. B. Parrott (2022). "Transient Copper Exposure During Embryogenesis and Temperature Affect Developmental Rate, Survival, and Fin Regeneration in Japanese Medaka (*Oryzias latipes*)." Environmental Toxicology and Chemistry 41(3): 748-757.

3670 Clontz, L. M., K. M. Pepin, K. C. VerCauteren and J. C. Beasley (2022). "Influence of biotic and abiotic factors on home range size and shape of invasive wild pigs (*Sus scrofa*)." Pest Management Science 78(3): 914-928.

3671 Anderson, D., S. Kaneko, A. Harshman, K. Okuda, T. Takagi, S. Chinn, J. C. Beasley, K. Nanba, H. Ishiniwa and T. G. Hinton (2022). "Radiocesium accumulation and germline mutations in chronically exposed wild boar from Fukushima, with radiation doses to human consumers of contaminated meat." Environmental Pollution 306(2022): 119359.

3672 Gerke, H. C., T. G. Hinton, K. Okuda and J. C. Beasley (2022). "Increased abundance of a common scavenger affects allocation of carrion but not efficiency of carcass removal in the Fukushima Exclusion Zone." Scientific Reports 12(2022): 8903.

3673 Snow, N. P., C. A. Kupferman, M. J. Lavelle, K. M. Pepin, M. H. Melton, W. J. Gann, K. C. VerCauteren and J. C. Beasley (2022). "No panacea attractant for wild pigs (*Sus scrofa*), but season and location matter." Applied Animal Behaviour Science 254(2022): 105705.

3674 Xu, X., A. L. Bryan, J. R. Parks and K. N. Gibson (2022). "Mercury Accumulation in a Stream Ecosystem: Linking Labile Mercury in Sediment Porewaters to Bioaccumulative Mercury in Trophic Webs." Water 14(13): 1-20.

3675 Congdon, J. D., K. A. Buhlmann and J. W. Gibbons (2022). "Comparing Life Histories of the Shortest-Lived Turtle Known (Chicken Turtles, *Deirochelys reticularia*) with Long-Lived Blanding's Turtles (*Emydoidea blandingii*)." Chelonian Conservation and Biology 21(1): 28-36.

3676 Patterson, J. R., T. L. DeVault and J. C. Beasley (2022). "Integrating terrestrial scavenging ecology into contemporary wildlife conservation and management." Ecology and Evolution 12(7): e9122.

3677 Sawyer, S. J., M. D. Eubanks, J. C. Beasley, B. T. Barton, R. T. Puckett, J. M. Tomecek and J. K. Tomberlin (2022). "Vertebrate and invertebrate competition for carrion in human-impacted environments depends on abiotic factors." Ecosphere 13(7): e4151.

3678 De Marco, A., P. Sicard, Z. Feng, E. Agathokleous, R. Alonso, V. Araminiene, A. Augustatis, O. Badea, J. C. Beasley, C. Branquinho, V. J. Bruckman, A. Collalti, R. David-Schwartz, M. Domingos, E. Du, H. G. Gomez, S. Hashimoto, Y. Hoshika, T. Jakovljevic, S. McNulty, E. Oksanen, Y. O. Khaniabadi, A. K. Prescher, C. J. Saitanis, H. Sase, A. Schmitz, G. Voigt, M. Watanabe, M. D. Wood, M. V. Kozlov and E. Paoletti (2022). "Strategic roadmap to assess forest vulnerability under air pollution and climate change." Global Change Biology 28(17): 5062-5085.

3679 McKee, R. K., K. A. Buhlmann, C. T. Moore, M. C. Allender, N. I. Stacy and T. D. Tuberville (2022). "Island of misfit tortoises: waif gopher tortoise health assessment following translocation." Conservation Physiology 10(1): 1-18.

3680 Baddar, Z. E. and X. Xu (2022). "Evaluation of changes in the microbial community structure in the sediments of a constructed wetland over the years." Archives of Microbiology 204:552(9): 1-12.

3681 Chapman, M., G. Dharmarajan, A. L. Bryan, T. L. DeVault, L. Lee and O. E. Rhodes Jr. (2022). Understanding the Role of Biotic Vectors in the Accumulation and Spread of Radioactive Contamination on the Savannah River Site - 22270. Waste Management 2022 Conference, Phoenix, AZ. p. 1-17

3682 Bernasconi, D. A., W. C. Dixon, M. T. Hamilton, J. L. Helton, R. B. Chipman, A. T. Gilbert, J. C. Beasley, O. E. Rhodes Jr. and G. Dharmarajan (2022). "Influence of landscape attributes on Virginia opossum density." The Journal of Wildlife Management 86(7): e22280.

3683 Moore, L., J. W. Finger Jr., D. L. Haskins, R. M. Elsey, S. B. Castleberry, T. C. Glenn, C. H. Jagoe and I. L. Brisbin Jr. (2022). "Tissue Distribution of Mercury in the Bodies of Wild American Alligators (*Alligator mississippiensis*) from a Coastal Marsh in Louisiana (USA)." Archives of Environmental Contamination and Toxicology 83(1): 13-20.

3684 Nafus, M. G., J. A. Daly, T. D. Tuberville, A. P. Klimely, K. A. Buhlmann and B. D. Todd (2022). "Habitat use by female desert tortoises suggests tradeoffs between resource use and risk avoidance." PLOSOne 17(8): e0263743.

3685 Meehan, T. D., S. P. Saunders, W. V. DeLuca, N. L. Michel, J. Grand, J. L. Deppe, M. F. Jimenez, E. J. Knight, N. E. Seavy, M. A. Smith, L. Taylor, C. Witko, M. E. Akresh, D. R. Barber, E. M. Bayne, J. C. Beasley, J. L. Belant, R. O. Bierregaard, K. L. Bildstein, T. J. Boves, J. N. Brzorad, S. P. Campbell, A. Celis-Murillo, H. A. Cooke, R. Domenech, L. Goodrich, E. A. Gow, A. Haines, M. T. Hallworth, J. M. Hill, A. E. Holland, S. Jennings, R. Kays, D. T. King, S. A. Mackenzie, P. P. Marra, R. A. McCabe, K. P. McFarland, M. J. McGrady, R. Melcer Jr., D. R. Norris, R. E. Norvell, O. E. Rhodes Jr., C. C. Rimmer, A. L. Scarpignato, A. Shreading, J. L. Watson and C. B. Wilsey (2022). "Integrating data types to estimate spatial patterns of avian migration across the Western Hemisphere." Ecological Applications 32(7): e2679.

3686 Ruzol, R., C. L. Staudhammer, S. Younger, D. P. Aubrey, H. W. Loescher, C. R. Jackson and G. Starr (2022). "Water use in a young *Pinus taeda* bioenergy plantation: Effect of intensive management on stand evapotranspiration." Ecosphere 13(6): e4100.

3687 Philipps, R. R., X. Xu, R. B. Bringolf and G. L. Mills (2019). "Evaluation of the DGT Technique for Predicting Uptake of Metal Mixtures by Fathead Minnow (*Pimephales promelas*) and Yellow Lampmussel (*Lampsilis cariosa*)." Environmental Toxicology and Chemistry 38(1): 61-70.

3688 Qin, C., X. Xu and E. Peck (2022). "Metal Removal by a Free Surface Constructed Wetland and Prediction of Metal Bioavailability and Toxicity with Diffusive Gradients in Thin Films (DGT) and Biotic Ligand Model (BLM)." Environmental Management 69(5): 994-1004.

3689 Xu, X. and Z. E. Baddar (2022). "Metal fluxes at the sediment-water interface in a free water surface constructed wetland." Environmental Monitoring and Assessment 194(8): 571.

3690 Haskins, D. L. and T. D. Tuberville (2022). "Metabolic responses to increased temperatures in three semi-aquatic turtle species from the southeastern United States." Journal of Thermal Biology 109(2022): 103331.

3691 Belovitch, M., S. Brantley and D. P. Aubrey (2022). "Interspecific variation in the timing and magnitude of hydraulic redistribution in a forest with distinct water sources." Plant and Soil 472(1-2): 451-464.

3692 Qin, C., X. Xu and E. Peck (2022). "Sink or source? Insights into the behavior of copper and zinc in the sediment porewater of a constructed wetland by peepers." Science of the Total Environment 821(2022): 153127.

3693 Pepin, K. M., V. R. Brown, A. Yang, J. C. Beasley, R. Boughton, K. C. VerCauteren, R. S. Miller and S. N. Bevins (2022). "Optimising response to an introduction of African swine fever in wild pigs." Transboundary and Emerging Diseases 69(5): e3111-e3127.

3694 Harris, S., X. Xu and G. L. Mills (2020). "Metal-sulfide dynamics in a constructed wetland in the Southeastern United States." Wetlands Ecology and Management 28(6): 847-861.

SECTION IX. Special Accomplishments by Laboratory Personnel

- Tracey Tuberville and Kurt Buhlmann jointly won the Robert C. Stebbins Research Award from the Desert Tortoise Council

- The peer-reviewed research article, *Understanding the role of biotic vectors in the accumulation and spread of radioactive contamination on the Savannah River Site*, published in the Proceedings of the WM2022 Conference by Mary Chapman, Guha Dharmarajan, Larry Bryan, Travis DeVault, Linda Lee, and Gene Rhodes, was among the 60 papers achieving a "Superior" rating of >300 papers submitted

- David Lee Haskins (PhD 2021) was awarded the 2022 Chris Lee Award for Metals Research by the Society of Environmental Toxicology and Chemistry and the International Copper Association. It is a global award given to a graduate student or recent graduate

- SREL graduate students won 11 competitive scholarships or received awards for presentations at regional, national or international meetings

- 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 39 invited presentations to professional audiences in FY22