Presentation to the Savannah River Site Citizens Advisory Board

Savannah River Ecology Laboratory (SREL)
FY22

January 24, 2023

Dr. Olin E. Rhodes, Jr. – Director SREL
Professor, University of Georgia (UGA)

1785
The University of Georgia
Savannah River Ecology Laboratory

Objectives

- Savannah River Ecology Lab (SREL) Mission
- Staffing
- Funding and Work Scope
- Significant Events
- Advances
- Opportunities For Fiscal Year 2023
- Challenges for Fiscal Year 2023
- REMOP Summary

Consistent with the Facilities Disposition and Site Remediation Committee's 2023 Work Plan

Acronyms

ACP	Area Closure Project
DOE	Department of Energy
DOE-HQ	Department of Energy – Headquarters
DOE-SR	Department of Energy – Savannah River
ERDA	U.S. Energy Research and Development Administration
HVAC	Heating, Ventilation and Air Conditioning
NNSA	National Nuclear Security Administration
SREL	Savannah River Ecology Laboratory
SRNL	Savannah River National Laboratory
SRMC	Savannah River Mission Completion
SRS	Savannah River Site
UGA	University of Georgia
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS-SR	U.S. Forest Service – Savannah River

SREL History

1951 - Atomic Energy Commission (AEC) had concerns about environmental impacts resulting from Savannah River Site (SRS) construction and operations.

1951 to present – Funding from AEC, ERDA, and Department of Energy (DOE)

1954 – Established permanent lab on the SRS

Dr. Eugene Odum

1977 – Established current lab facilities

SREL's Mission:

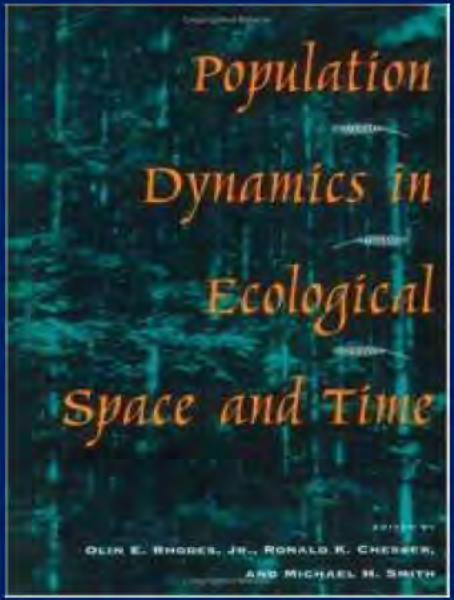
"To enhance our understanding of the environment by acquiring and communicating knowledge that contributes to sound environmental stewardship."

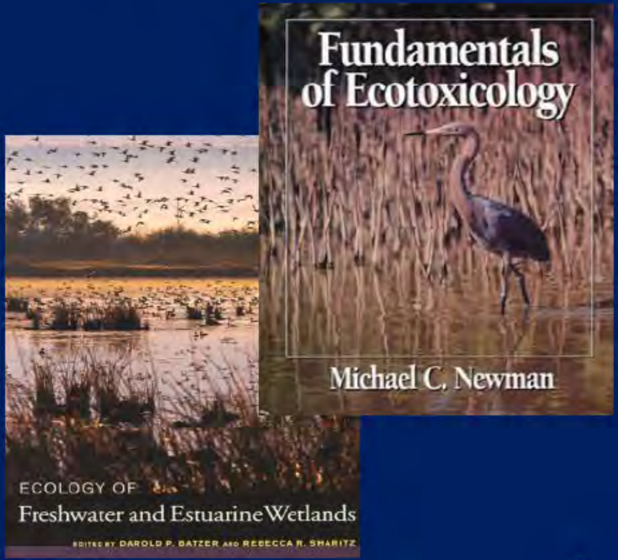
"To provide the public with an independent evaluation of the ecological effects of SRS operations on the environment"

- An interdisciplinary program of field and laboratory **Research** conducted largely on the SRS and published in the peer-reviewed scientific literature
- **Education** and research training for undergraduate and graduate students
- **Service** to the community through environmental outreach activities

SREL Research Program's

- >**3700** peer-reviewed scientific publications to date
- **66** books





SREL Education Program

- >600 Theses and Dissertations

- Over 700 undergraduates representing all 50 states have participated in SREL-sponsored experiential learning programs

- Thousands of post –baccalaureate research opportunities for temporary undergraduate technicians

SREL Environmental Outreach Program

- Integrates SREL research into presentations for the general public
- Provides hands-on classroom and field experience for students
- Conducts educator workshops

In FY22, SREL:

- Held 210 events reaching ~15,000 people
- Had ~19,000 social media followers – >660k media impressions
- 356 Media Mentions– 545 million media reach

SREL Normally Reaches >65,000 people per Year

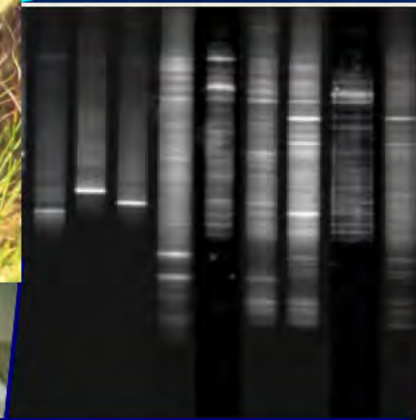
SREL in 2022

- UGA Employees
  - Research Faculty – **8**
  - Tenure Track Faculty - **10**
  - Emeritus Faculty - **3**
  - Post Docs – **6**
  - Outreach - **5**
  - Res. Professional - **27**
  - Research Support - **28**
  - Graduate Students - **69**
  - Admin & Support - **20**

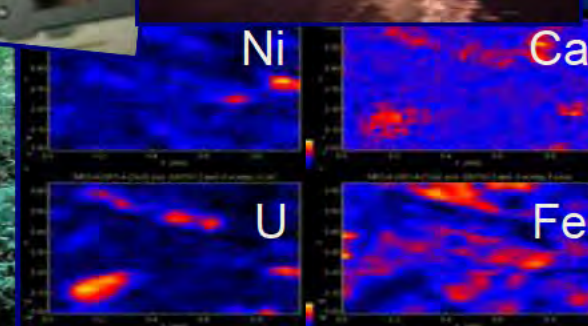
176 Staff & Students

Disciplinary Expertise

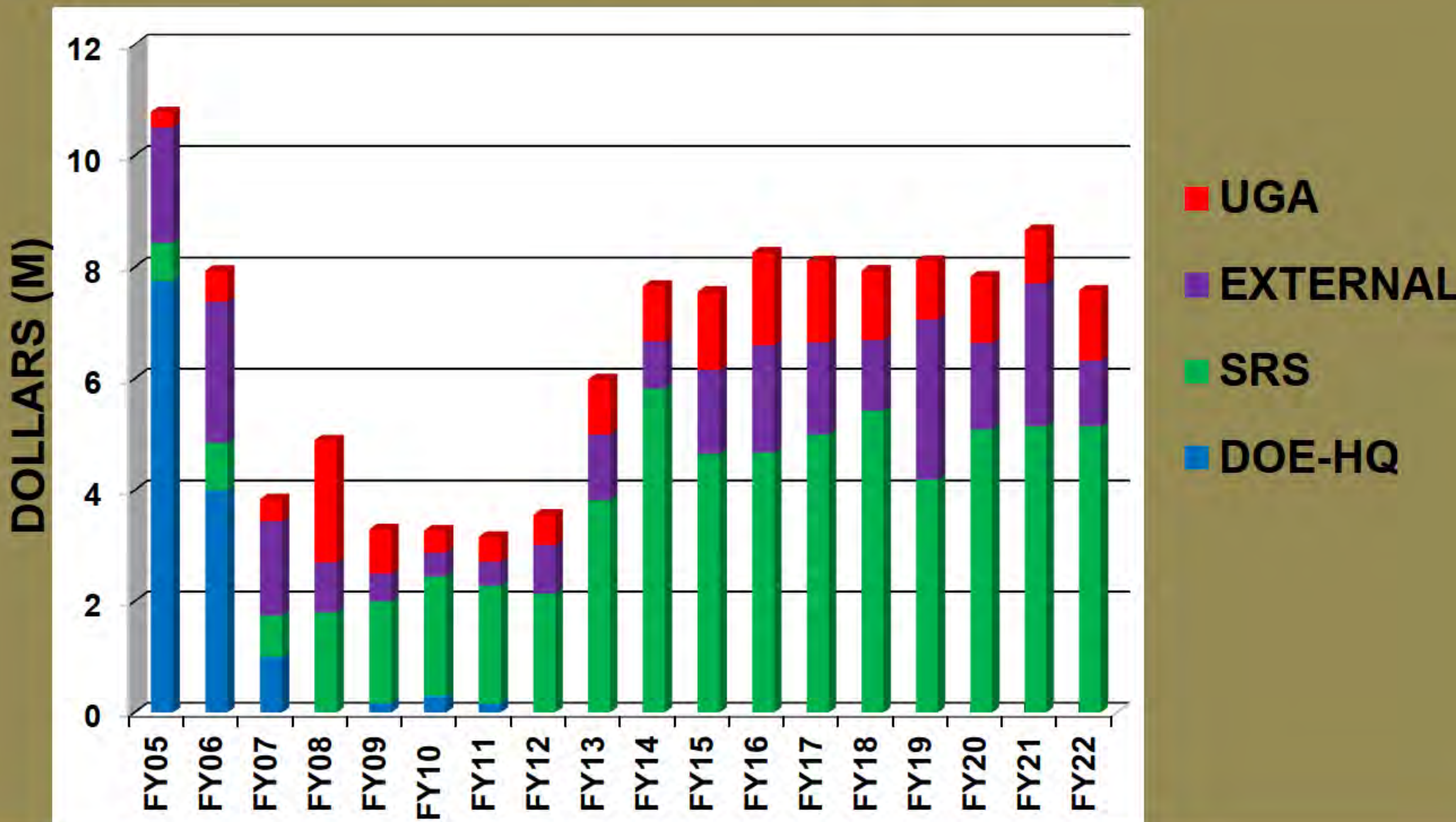
- Geology / Soil Science
- Environmental Microbiology
- Epigenetics
- Molecular Genetics
- Environmental Chemistry
- Radioecology
- Ecotoxicology and Risk Assessment
- Wildlife Ecology
- Disease Ecology
- Plant Physiology
- Proteomics and Glycomics

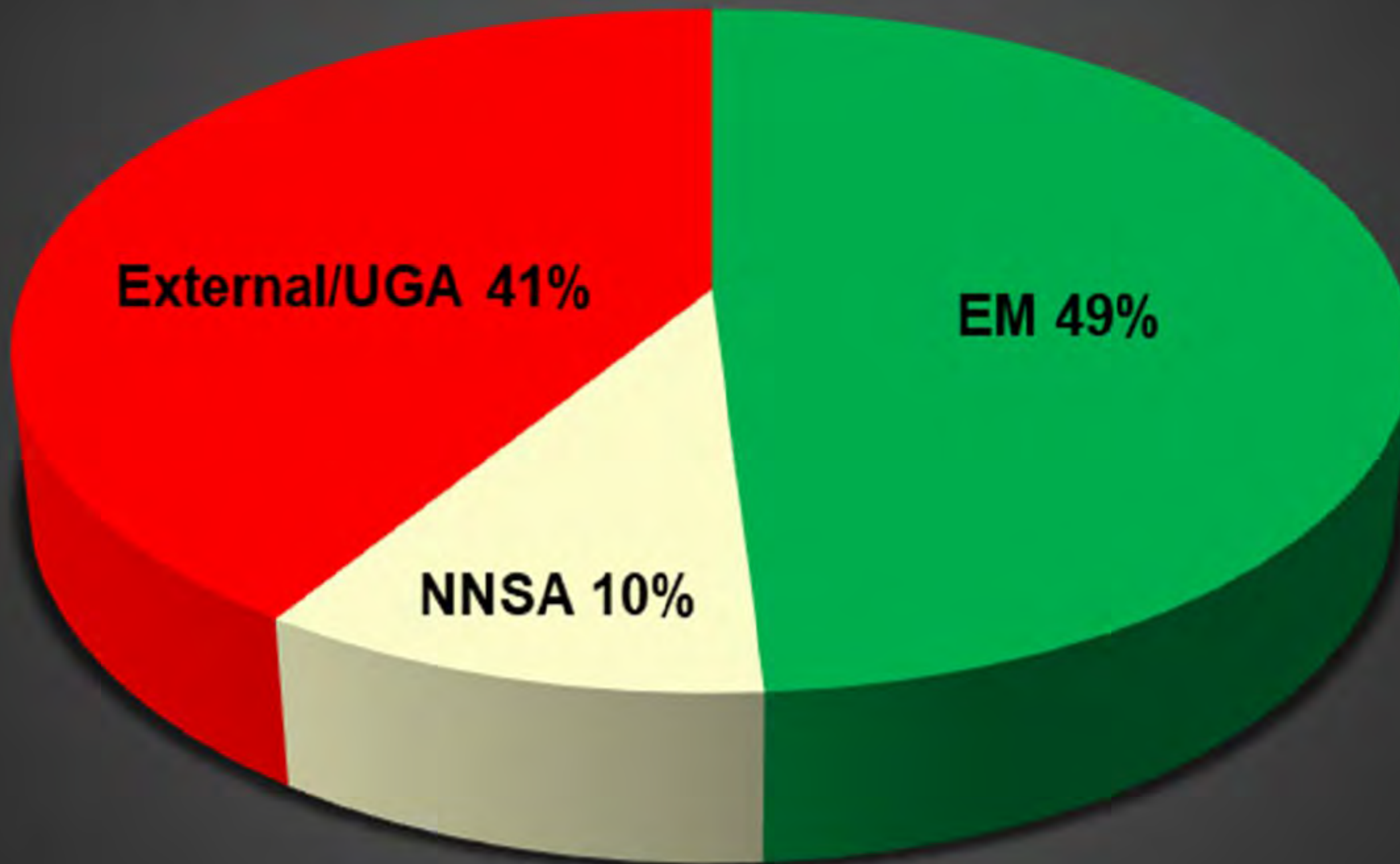


Recent Funding History



SREL FY22 Funding Breakdown



Significant Events in FY22

- UGA
  - Allowed majority (75%) of the 34% Indirect Costs to be retained by SREL
  - Cost-Shared 10 faculty positions with SREL
  - Provided funding for equipment and personnel
  - Cost-shared graduate student and postdoctoral positions
- DOE / SRS / External
  - Building, equipment, utilities, and site access
  - Funding provided by Department of Energy – Savannah River (DOE-SR) under 5-year Cooperative Agreement with DOE - EM
  - Funding provided by DOE – National Nuclear Security Administration (NNSA)
  - Continued project funding from Area Closure Project (ACP) and Savannah River Remediation (SRR)

Advancements in FY22

1. Work scope:

Research Set-Asides, Site Use Permitting

Enacted significant land management activities for set asides

Graduate and Undergraduate Education Programs

Advised 69 graduate students

Mentored over 115 graduate students total

Taught 18 courses on main UGA campus and 3 at SREL

Interdisciplinary Research

Continuing collaborative research programs with Savannah River National Laboratory (SRNL), U.S. Forest Service–Savannah River (USFS-SR), Savannah River Mission Completion (SRMC), UGA, U.S. Department of Agriculture (USDA), National Science Foundation (NSF), U.S. Army Corps of Engineers (USACE) & other university, federal, state, and private partners Involving research on radionuclide and metal remediation, feral swine control & radioecology

Advancements in FY22

1. Work scope: Continued

Site-wide Source of Ecological Expertise

- Provided ecological research support to Area Closures Project, SRMC, SRNL, etc.

Scientific Expertise

- Submitted 33 Proposals as PI or coPIs to External Granting Agencies
- Hired Three New Tenure Track Faculty– Biogeochemistry (2), Disease Ecology (1)
- Hired Two New Research Scientists – Biogeochemistry

Scientific Productivity

- SREL staff and students published over 86 scientific articles and gave over 170 scientific presentations in FY22

Analytical Services

- SREL staff and students analyzed over 3,241 samples for metal contaminants using ICP-MS or ICP-OES technologies
- SREL staff and students analyzed over 1,873 samples for total or methyl mercury using SREL-based equipment

Opportunities for FY23

1. Pursuing Land Lease Near Conference Center
2. Increasing UGA Collaboration with SRNL
3. Addition of 2 New Faculty Lines to SREL Through UGA Hiring Campus Initiatives
4. Continued Development of Core Missions on the SRS:
   a) Radioecology and Low Dose Radiation Effects
   b) Metal and Radionuclide Ecotoxicology
   c) Radionuclide Fate and Transport Studies
   d) Enhanced Biomonitoring Technologies
   e) Outreach and Education Programs

Opportunities for FY23 (cont.)

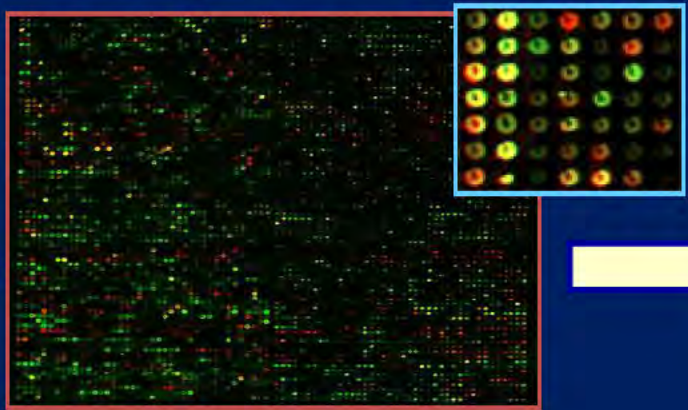
1. Enhanced Analytical Capabilities
   a) High Resolution Inductively Coupled Plasma Mass Spectroscopy
   b) Thermal Ionization Mass Spectroscopy
   c) High Resolution Mercury Isotope Analysis

2. Pursuit of New NERP Scholars Initiative

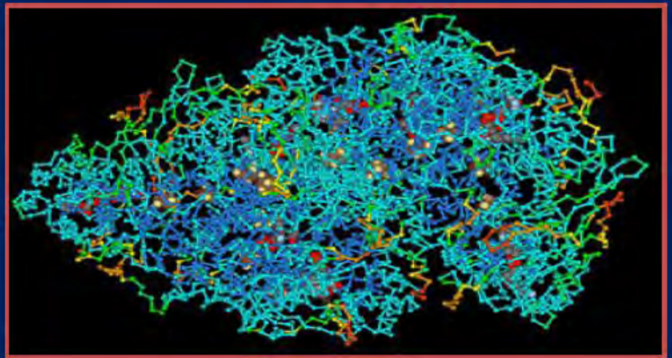
3. Expanded Outreach and Education Offerings

Low Dose Radiation Surveillance and Monitoring Research and Development

DNA molecule



DNA micro array



protein

organisms

ecosystem

methods and protocols

MDPI

Protocol

An Effective Protocol for Proteome Analysis of Medaka (*Oryzias latipes*) after Acute Exposure to Ionizing Radiation

Yeni Pérez-Gélvez [1,*], Shem Unger [2], Gerardo Gutiérrez-Sánchez [3], Robert Bridger [1], Olin E. Rhodes, Jr. [4] and Carl Bergmann [1]

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Abstract: All terrestrial organisms are subject to evolutionary pressures associated with natural sources of ionizing radiation (IR). The legacy of human-induced IR associated with energy, weapons production, medicine, and research has changed the distribution and magnitude of these evolutionary pressures. To date, no study has systematically examined the effects of environmentally relevant doses of radiation exposure across an organismal proteome. This void in knowledge has been due, in part, to technological deficiencies that have hampered quantifiable environmentally relevant IR doses and sensitive detection of proteomic responses. Here, we describe a protocol that addresses both needs, combining quantifiable IR delivery with a reliable method to yield proteomic comparisons of control and irradiated Medaka fish. Exposures were conducted at the Savannah River Ecology Laboratory (SREL, in Aiken, SC), where fish were subsequently dissected into three tissue sets (carcasses, organs and intestines) and frozen until analysis. Tissue proteins were extracted, resolved by Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis (SDS-PAGE), and each sample lane was divided into ten equal portions. Following in-gel tryptic digestion, peptides released from each gel portion were identified and quantified by Liquid Chromatography-Mass Spectrometry (LC-MS/MS) to obtain the most complete, comparative study to date of proteomic responses to environmentally relevant doses of IR. This method provides a simple approach for use in ongoing epidemiologic studies of chronic exposure to environmentally relevant levels of IR and should also serve well in physiological, developmental, and toxicological studies.

Keywords: in-gel digestion; ionizing radiation; medaka; *Oryzias latipes*; proteome

1. Introduction

Ionizing radiation (IR), from other than natural sources, has become an aspect of daily life over the course of the last century. While sites such as Fukushima and Chernobyl are well-known and well documented sources of exposure to radiation, there remain over 1000 locations within the United States alone that are contaminated with radiation and have yet to be sufficiently studied to fully understand the risk to human health and to the environment. Testing and manufacturing related to nuclear proliferation (for both energy and weapons) and rapid increases in the use of nuclear medicine [1], are becoming increasingly identified as sources of radionuclide contamination. Such contamination can have long lasting effects on public health and the environment, particularly in aquatic systems.

cells

MDPI

Article

Proteogenomic Analysis of *Burkholderia* Species Strains 25 and 46 Isolated from Uraniferous Soils Reveals Multiple Mechanisms to Cope with Uranium Stress

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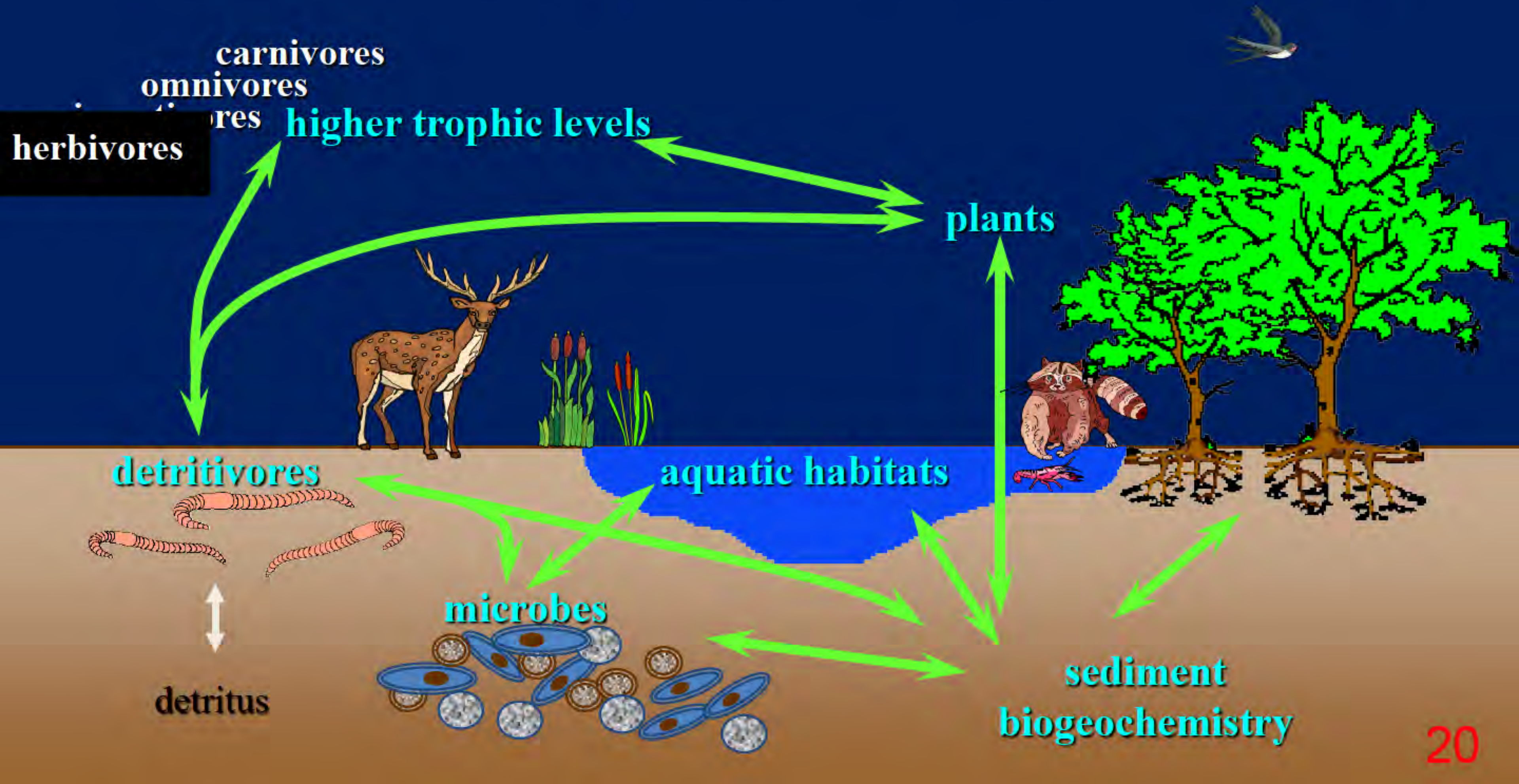
Abstract: Two *Burkholderia* spp. (strains SRS-25 and SRS-46) were isolated from high concentrations of uranium (U) from the U.S. Department of Energy (DOE)-managed Savannah River Site (SRS). SRS contains soil gradients that remain co-contaminated by heavy metals from previous nuclear weapons production activities. Uranium (U) is one of the dominant contaminants within the SRS impacted soils, which can be microbially transformed into less toxic forms. We established microcosms containing strains SRS-25 and SRS-46 spiked with U and evaluated the microbially-mediated depletion with concomitant genomic and proteomic analysis. Both strains showed a rapid depletion of U; draft genome sequences revealed SRS-25 genome to be of approximately 8,152,324 bp, a G + C content of 66.5, containing a total 7604 coding sequences with 77 total RNA genes. Similarly, strain SRS-46 contained a genome size of 8,587,429 bp with a G + C content of 67.1, 7895 coding sequences, with 73 total RNA genes, respectively. An in-depth, genome-wide comparisons between strains 25, 46 and a previously isolated strain from our research (*Burkholderia* sp. strain SRS-W-2-2016), revealed a common pool of 3128 genes; many were found to be homologues to previously characterized metal resistance genes (e.g., for cadmium, cobalt, and zinc), as well as for transporter, stress/detoxification, cytochromes, and drug resistance functions. Furthermore, proteomic analysis of strains with or without U stress, revealed the increased expression of 34 proteins from strain SRS-25 and 52 proteins from strain SRS-46; similar to the genomic analyses, many of these proteins have previously been shown to function in stress response, DNA repair, protein biosynthesis and metabolism. Overall, this comparative proteogenomics study confirms the repertoire of metabolic and stress response functions likely rendering the ecological competitiveness to the isolated strains for colonization and survival in the heavy metals contaminated SRS soil habitat.

Keywords: genomics; proteomics; uranium; *Burkholderia*

Ecosystems Approach to Ecotoxicology



Ecological Engineering 133 (2019) 32–38

The performance … How a young w…

Science of the Total Environment 668 (2019) 645–657

Removal of low levels o… elements – Implication…

Metal accumulation in dragon… constructed wetland effective…

Effects of industrial disturbances on … beetles

Environment International 126 (2019) 216–221

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Radiocesium (^{137}Cs) accumulation by fish within a legacy reactor cooling canal system on the Savannah River Site

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ARTICLE INFO

Keywords:
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Fish
Reactor cooling canals
Bioaccumulation

ABSTRACT

The aquatic cooling canal system associated with a nuclear reactor built in the early 1950s received accidental releases of radiocesium (^{137}Cs) from the reactor between 1954 and 1964, resulting in the dispersion of ~8.2 × 10^{12} Bq of ^{137}Cs into the associated canals and ponds. The primary purpose of this study was to document concentrations of ^{137}Cs in littoral zone fish currently occupying components of the cooling canal system, 3 canals and 2 impoundments, to determine how concentrations varied among these various components. Secondarily, we examined for potential influence of weirs within the canal system on concentrations in fish as well as the potential relationship between fish species and body size and on ^{137}Cs concentrations in fish. We collected samples of sediment, biofilm, and fish from each component of the R-Reactor cooling system and compared ^{137}Cs among sites and species in individual sites. Concentrations of ^{137}Cs in sediments, biofilms and mosquitofish varied significantly among sampling areas with higher concentrations in RCAN1, a canal segment that was the closest to the reactor and received reactor effluent for a longer period than other components. Comparisons among other components of the cooling system, and species comparisons relative to presumed trophic positions and fish length were not consistent. However, littoral zone fish in the cooling canal system continue to bioaccumulate ^{137}Cs > 50 years after the original releases of contamination.

1. Introduction

Radiocesium (^{137}Cs) accumulation by fish has been widely documented in large water bodies, but trends in accumulation rates varied considerably relative to the interaction of both biotic (e.g.; trophic position, size, feeding patterns, metabolic rates) and site-specific abiotic (e.g.; water chemistry, sediment types) factors (Elliott et al., 1992; Rowan and Rasmussen, 1994; Smith et al., 2002). Bioaccumulation typically occurs at a higher rate in more complex food webs and occurs at higher rates in piscivorous fish (Rowan and Rasmussen, 1994; Rowan et al., 1998). Studies have shown that bioaccumulation rates can change with dietary shifts (Rowan et al., 1998; Sundbom and Meili, 2005). Fish that feed on organisms that live in or near the sediments can have higher accumulation rates than those that feed on organisms in the water column (Rowan et al., 1998).

There is conflicting literature as to the extent to which ^{137}Cs biomagnifies within food webs of freshwater systems. Several studies suggested biomagnification does not occur or that evidence for biomagnification was weak (Reichle et al., 1970; Thomann, 1981; Mailhot et al., 1988), but these studies compared low numbers of trophic levels and/or compared systems with varying potassium (K) levels (Pinder III et al., 2011). The Whicker et al. (1990) study of the Pond B system on the Savannah River Site (SRS) reported biomagnification, and yet the highest concentration of ^{137}Cs was determined for a planktivorous fish (gizzard shad – *Dorosoma cepedianum*). Other studies providing evidence of ^{137}Cs biomagnification suggested it was exhibited among multiple species of different trophic position and within individual species and was related to body size and dietary differences. Rowan et al. (1998) found a 4-fold increase in ^{137}Cs with trophic level, with rates increasing 2-fold from planktivorous fish to benthivorous fish in the Ottawa River. Sundbom and Meili (2005) found an overall 2–4 fold increase in ^{137}Cs with trophic level, with the highest contamination in piscivorous fish populations in a Swedish Lake. Differences in concentrations among fish species may also be due to different metabolic/

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Environmental Toxicology

Sediment and Biota Trace Element Distribution in Streams Disturbed by Upland Industrial Activity

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Abstract: Extensive industrial areas in headwater stream watersheds can severely impact the physical condition of streams and introduce contaminants. We compared 3 streams that received stormwater runoff and industrial effluents from industrial complexes to 2 reference streams. Reference streams provide a benchmark of comparison of geomorphic form and stability in coastal plain, sandy-bottomed streams as well as concentrations of trace elements in sediment and biota in the absence of industrial disturbance. We used crayfish (*Cambarus latimanus*, *Procambarus raneyi*, *Procambarus acutus*) and crane fly larvae (*Tipula*) as biomonitors of 15 trace elements entering aquatic food webs. Streams with industrial areas were more scoured, deeply incised, and less stable. Sediment organic matter content broadly correlated to trace element accumulation, but fine sediments and organic matter were scoured from the bottoms of disturbed streams. Trace element concentrations were higher in depositional zones than runs within all streams. Despite contaminant sources in the headwaters, trace element concentrations were generally not elevated in sediments of the eroded streams. However, element concentrations were frequently elevated in biota from these streams with taxonomic differences in accumulation amplified. In eroded, sand-bottomed coastal plain streams with unstable sediments, single snapshots of sediment trace element concentrations did not characterize well bioavailable trace elements. Biota that integrated exposures over time and space within their home ranges better detected bioavailable contaminants than sediment. *Environ Toxicol Chem* 2019;38:115–131. © 2018 SETAC

Keywords: Stream; Aquatic invertebrates; Bioaccumulation; Sediment assessment; Trace elements; Stormwater runoff

INTRODUCTION

Streams and rivers draining watersheds with industrial/urban areas act as vectors for dispersal of contaminants from these areas (Taylor and Owens 2009). Diverse trace elements in non-point-source runoff from impervious surfaces can originate from numerous sources associated with buildings, automobile components, pavement, and land use; the source can be from the materials themselves or from atmospheric deposition that is subsequently washed off by rain (Paul and Meyer 2001; Davis et al. 2003; Walsh et al. 2005; Casey et al. 2006). Point sources such as industrial effluents or water treatment plants can further introduce a variety of contaminants into streams. For example, occurrence of coal combustion waste in watersheds has exposed aquatic organisms to increased levels of a variety of elements not only at the Savannah River Site, South Carolina, USA, where the present study was conducted, but worldwide (Rowe et al. 2002; Ruhl et al. 2012; Rowe 2014). Consequently, the broad number of contaminant sources in watersheds receiving both runoff from impervious surfaces and industrial effluents can result in contamination by a broad variety of trace elements. Surface runoff from impervious surfaces associated with urban areas can result in flow flashiness involving rapid and increased runoff volume and peak flows that in turn cause bottom scour, channel erosion, and subsequent deposition, reducing overall channel stability (Paul and Meyer 2001; Walsh et al. 2005). This channel instability can result in fine sediment and associated contaminants being mobilized and relocated during rain events (Taylor and Owens 2009). Large-scale industrial complexes in unpopulated areas may have similar effects on watersheds as urban areas. Evaluating contaminants in sediment and biota will provide critical information on contaminants that are stored in or have passed through a stream.

Contaminants in stream water may be low or even barely detectable but often accumulate to higher levels in sediments

This article includes online-only Supplemental Data.
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forests MDPI

Article

From Farms to Forests: Landscape Carbon Balance after 50 Years of Afforestation, Harvesting, and Prescribed Fire

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check for updates

Abstract: Establishing reliable carbon baselines for landowners desiring to sustain carbon sequestration and identify opportunities to mitigate land management impacts on carbon balance is important; however, national and regional assessments are not designed to support individual landowners. Such baselines become increasingly valuable when landowners convert land use, change management, or when disturbance occurs. We used forest inventories to quantify carbon stocks, estimate annual carbon fluxes, and determine net biome production (NBP) over a 50-year period coinciding with a massive afforestation effort across ~80,000 ha of land in the South Carolina Coastal Plain. Forested land increased from 48,714 ha to 73,824 ha between 1951 and 2001. Total forest biomass increased from 1.73–3.03 Gg to 17.8–18.3 Gg, corresponding to biomass density increases from 35.6–62.2 Mg ha^{-1} to 231.4–240.0 Mg ha^{-1}. Harvesting removed 1340.3 Gg C between 1955 and 2001, but annual removals were variable. Fire consumed 527.1 Gg C between 1952 and 2001. Carbon exported by streams was <0.5% of total export. Carbon from roots and other harvested material that remained in-use or in landfills comprised 49.3% of total harvested carbon. Mineral soil carbon accounted for 41.6 to 50% of 2001 carbon stocks when considering depths of 1.0 or 1.5 m, respectively, and was disproportionately concentrated in wetlands. Moreover, we identified a soil carbon deficit of 19–20 Mg C ha^{-1}, suggesting opportunities for future soil carbon sequestration in post-agricultural soils. Our results provide a robust baseline for this site that can be used to understand how land conversion, forest management, and disturbance impacts carbon balance of this landscape and highlight the value of these baseline data for other sites. Our work also identifies the need to manage forests for multiple purposes, especially promotion of soil carbon accumulation in low-density pine savannas that are managed for red-cockaded woodpeckers and therefore demand low aboveground carbon stocks.

Keywords: agrarian change; biomass; carbon cycle; carbon sequestration; inventory; reforestation; soil carbon

1. Introduction

The southeastern USA is an important region for assessing temporal dynamics of carbon (C) stocks in response to both management and natural processes. This region contains about 10% of national C stocks and produces over 60% of wood-based products in the USA [1,2]. Net C sequestration in southeastern USA exceeds most other regions but is expected to decline in the next few decades, primarily due to forest aging and conversions to urban and non-agrarian development [3,4]. Overall,

Research on Wildlife Movement, Behavior and Uptake

Archives of Environmental Contamination and Toxicology (2019) 77:14–21
https://doi.org/10.1007/s00244-019-00626-9

Examining the Ef… Used Stress Parar… *mississippiensis*)

John W. Finger Jr.[1,2,3] · … Tracey D. Tuberville[3]

Received: 11 December 2018 / Ac…
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Food Webs 18 (2019) e00107

Efficiency and compositior… interface in the Chernobyl…

Peter E. Schlichting[a,*], Cara N. Lov…

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Keywords:
Aquatic-terrestrial interface
Chernobyl exclusion zone
Fish carrion
Food webs
Mesocarnivore
Scavenging links

Variation in metal tolerance associat… Southern toads (*Anaxyrus terrestris*)

R. Wesley Flynn*, Cara N. Love, Austin Colema…
Savannah River Ecology Laboratory, University of Georgia, Aiken, SC, United Sta…

Keywords:
Amphibian
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Toxicology
Metal tolerance
Trace element
Maternal transfer

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Ecotoxicoparasitology of merc… mammals and their endopara…

Ernest J. Borchert[a,b,*], James C. Leapha…

HIGHLIGHTS

- Anthropogenic contaminants are threats to ecosystem health.
- Anthropogenic contaminants affect wildlife health and parasite communities.
- Trace element and parasite data were obtained for three mammal species.
- Hg biomagnified with assumed trophic position
- Hg and Se may influence host endoparasite communities but more study is needed.

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Trophic

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Effects of methylmercury on mosquito oviposition behavior: Maladaptive response to non-toxic exposure

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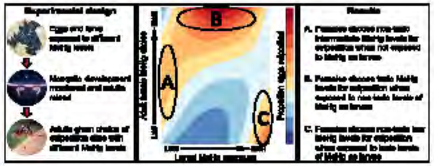
[b] Presbyterian College, Clinton, SC 29325, USA
[c] University of South Carolina Upstate, Spartanburg, SC 29303, USA

HIGHLIGHTS

- Methylmercury (MeHg) negatively impacts development and survival of mosquitoes.
- Adult female mosquitoes not exposed to MeHg avoid oviposition sites with high MeHg.
- Females exposed to non-toxic MeHg levels prefer oviposition sites with high MeHg.
- Females exposed to toxic MeHg levels prefer MeHg uncontaminated oviposition sites.
- MeHg exposure in one generation can impact MeHg exposure in subsequent generations.

GRAPHICAL ABSTRACT



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ABSTRACT

Animals can modulate their own exposure to environmental contaminants through behavioral plasticity such as diet and habitat choice. However, it remains unclear if behavior also has cascading effects on contaminant exposure across multiple generations. In insects, oviposition site selection is an important behavior females can use to modify offspring contaminant exposure risk. In this study, we use the yellow fever mosquito, *Aedes aegypti*, to test how methylmercury (MeHg) affects oviposition site selection. We found that mosquito larval development rate and survival were negatively affected at MeHg concentrations ≥100 ppb. Adult females not exposed to MeHg as larvae avoided oviposition sites with high MeHg concentrations (>50 ppb), but MeHg exposure at the larval stage significantly affected this oviposition site selection. Specifically, females raised from larvae exposed to non-toxic MeHg levels (i.e., five-50 ppb) showed a significant increase in preference for oviposition sites contaminated with toxic MeHg concentrations (≥500 ppb), compared to unexposed controls. This maladaptive behavioral response could be because, when conditioned with non-toxic MeHg concentrations, MeHg-associated olfactory cues act as a "supernormal" stimulus during oviposition site selection. Importantly, however, this maladaptive behavioral response is eliminated in female mosquitoes raised from larvae exposed to toxic MeHg concentrations (i.e. 100 ppb), and these mosquitoes showed a significant increase in preference for MeHg uncontaminated oviposition sites, compared to unexposed controls. Thus, in mosquitoes, the magnitude of MeHg exposure in one generation can impact MeHg exposure in subsequent generations by altering oviposition site selection behavior. Our results have broad implications for our understanding of how contaminant-mediated behavioral modifications can feedback on contaminant exposure risk across multiple generations, and

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Where Have All the Turtles Gone, and Why Does It Matter?

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Of the 356 species of turtles worldwide, approximately 61% are threatened or already extinct. Turtles are among the most threatened of the major groups of vertebrates, in general, more so than birds, mammals, fishes or even the much besieged amphibians. Reasons for the dire situation of turtles worldwide include the familiar list of impacts to other species including habitat destruction, unsustainable overexploitation for pets and food, and climate change (many turtles have environmental sex determination). Two notable characteristics of pre-Anthropocene turtles were their massive population sizes and correspondingly high biomasses, the latter among the highest values (over 855 kilograms per hectare) ever reported for animals. As a result of their numerical dominance, turtles have played important roles as significant bioturbators of soils, infaunal miners of sea floors, dispersers and germination enhancers of seeds, nutrient cyclers, and consumers. The collapse of turtle populations on a global scale has greatly diminished their ecological roles.

Keywords: biomass, ecological engineers, keystone species, tortoise, terrapin

Turtles are so universally recognized by virtually all cultures and age groups that it is easy to see them as merely commonplace animals, even though many are far from common. This prosaic status makes them easy to take for granted or even overlook as important ecosystem components worthy of protection. The word *turtle* applies to all animals with a bony shell and a backbone, whether they are locally referred to as turtles, tortoises, or terrapins (Ernst and Lovich 2009). That such remarkable and familiar animals are considered by many to be ordinary is unfortunate, because no vertebrate animal that has ever lived has possessed the unique architecture of turtles, with their limb girdles encased inside a bony shell. As previous paleontologists have noted, if they were known only from fossils, they would be cause for wonder. Turtles are an ancient group going back over 200 million years (Ernst and Lovich 2009). Their enduring success is due in no small part to a conservative morphology and time-tested adaptations that allowed them to outlive even the dinosaurs, which disappea red over 65 million years ago, when turtles were already an old lineage.

Turtles are struggling to persist in the modern world, and that fact is generally unrecognized or even ignored. Scientists identify 14 living families and many extinct ones. As of 2017, 356 turtle species were recognized worldwide (Turtle Taxonomy Working Group 2017), of which approximately 61% are threatened or have become extinct in modern times. Turtles are arguably the most threatened of the major groups of vertebrates in general and are proportionately more so than birds, mammals, fishes or even the much-besieged and heavily publicized amphibians (Hoffmann et al. 2010). The vulnerability of turtles, in part, is due to a global focus by conservation programs to prioritize and target areas that protect birds and mammals but do not adequately consider turtle diversity (Roll et al. 2017).

Specific examples of the recent plight of turtles are exemplified by several species worldwide. For example, some turtle species are no longer found in their native habitat and exist only in captivity. One such species, the Yangtze giant softshell turtle (*Rafetus swinhoei*) is reduced to perhaps four surviving individuals, and only one is known to be a female. For the past 8 or more years, she has not produced fertile eggs, despite international efforts to propagate the species, including the use of artificial insemination. Others, such as the beautiful Burmese star tortoise (*Geochelone platynota*) and the less-charismatic western swamp turtle (*Pseudemydura umbrina*), Australia's rarest reptile, are among the 25 most endangered turtles in the world (Turtle Conservation Coalition 2018), requiring captive breeding and intensive management to keep them from extinction. The death of "Lonesome George" in 2012, the last purebred Pinta giant tortoise (*Chelonoidis abingdonii*) in the Galápagos Islands, marked the extinction of yet another turtle species (Edwards et al. 2013).

Reasons for the dire situation turtles face worldwide include the familiar litany of impacts to other species (Gibbons et al. 2000) including habitat destruction, unsustainable overexploitation for food and the commercial pet trade, and climate change (many turtles have environmental sex determination). Disease has also contributed to the rapid

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Research Article

Survival and Movements of Head-Started Mojave Desert Tortoises

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ABSTRACT Head-starting is a conservation strategy in which young animals are protected in captivity temporarily before their release into the wild at a larger size, when their survival is presumably increased. The Mojave desert tortoise (*Gopherus agassizii*) is in decline, and head-starting has been identified as one of several conservation measures to assist in recovery. To evaluate the efficacy of indoor head-starting, we released and radio-tracked 68 juvenile tortoises from a 2015 cohort in the Mojave National Preserve, California, USA. We released 20 tortoises at hatching (control) in September 2015, and reared 28 indoors and 20 outdoors in predator-proof enclosures for 7 months before releasing them in April 2016. We monitored tortoises at least weekly after release until 27 October 2016, and documented survivorship, movement, and surface activity. We estimated survivorship by treatment and evaluated effects of treatment, proximity to a raven (*Corvus corax*) nest (predator) coincidentally established after release, distance moved between monitoring events, surface activity, and release size on individual fate in a generalized linear model. Although indoor head-start tortoises reached the size of 5–6-year-old wild tortoises by release at 7 months of age, survival did not differ significantly among the 3 treatment groups. Combined annual survival was 0.44 (95% CI = 0.34–0.58). Tortoises that were closer to an active raven nest were significantly more likely to die, as were those seen more often outside their burrows and active aboveground. Predicted estimates for short-term probability of survival approached 1.0 as distance from a raven nest exceeded approximately 1.6 km. Rearing treatment, movement distance, and body size were not significant predictors of fate over the 1-year monitoring period. Head-started tortoises released ≥1.6 km from areas of raven activity will likely have higher short-term survival. Population recovery through head-starting alone is unlikely to be successful if systemic ecosystem-level issues, such as habitat degradation and conditions that promote human-subsidized predators, are not ameliorated. © 2019 The Wildlife Society.

KEY WORDS chelonian, conservation, desert tortoise, endangered species, head-start, Mojave Desert, population augmentation, species recovery, threatened species, turtle.

Population interventions are often controversial as species recovery tools because outcomes of such measures are difficult to predict (Seddon et al. 2014) and are infrequently measured and reported. With ever-increasing anthropogenic effects on wildlife populations, however, interventions may be necessary to prevent extinctions. In recent years, there has been interest in reintroducing extirpated species (e.g., black-footed ferrets [*Mustela nigripes*]; Miller et al. 1994), facilitating dispersal in response to climate change (McLachlan et al. 2007, Hewitt et al. 2011, Seddon et al. 2014), and augmenting small populations (e.g., Kemp's ridley sea turtles [*Lepidochelys kempii*]; Caillouet et al. 2015).

Head-starting is one approach to population augmentation that involves protecting and rearing animals through early life stages when they are typically most vulnerable before releasing them into the natural environment at a more advanced state of development when survival is presumably greater (Burke 2015). Head-starting has been a useful conservation tool for several species, including California condors (*Gymnogyps californianus*; Cohn 1999), rock iguanas (*Cyclura* spp.; Pérez-Buitrago et al. 2008), Galapagos tortoises (*Chelonoidis hoodensis*; Gibbs et al. 2014), and Blanding's turtles (*Emydoidea blandingii*; Buhlmann et al. 2015). Chelonians, the most threatened group of vertebrates globally (Stanford et al. 2018), may be uniquely suited to head-starting because survivorship in the wild is typically low in early life and high during adulthood under most

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Outreach and Monitoring for Local Communities

A PROFILE OF SCIENCE POLICY CHANGES FOR THE U.S. DEPARTMENT OF ENERGY NATIONAL ENVIRONMENTAL RESEARCH PARKS

By

AMANDA L. KOMASINSKI

B.S., Purdue University, 2020

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2022

Challenges for FY23

1. Funding Environment for External Grants and Contracts
2. Long Term Stability of SREL Model (> Core Dollars)
3. Administrative Burden at Current Staff Levels
4. Staff Turnover
5. Additional Resources to Fulfill NERP Scholars Vision
6. Graduate and Undergraduate Housing Needs

[redacted]