SAVANNAH RIVER ECOLOGY LABORATORY

ANNUAL TECHNICAL PROGRESS REPORT
OF ECOLOGICAL RESEARCH

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SAVANNAH RIVER ECOLOGY LABORATORY
FY2007 OVERVIEW

The Savannah River Ecology Laboratory (SREL) is a research unit of The University of Georgia (UGA) that has been conducting ecological research on the Savannah River Site (SRS) near Aiken, South Carolina for almost 56 years. The overall mission of the Laboratory is to acquire and communicate knowledge of ecological processes and principles. SREL conducts fundamental and applied ecological research, as well as education and outreach programs, under a Cooperative Agreement with the U.S. Department of Energy (DOE).

The Laboratory's research mission during the 2007 fiscal year was fulfilled with the publication of 65 journal articles and book chapters by faculty, technical staff, students, and visiting scientists. Two books were also published with SREL faculty members as authors. Additional journal articles have been submitted or are in press. Significantly, SREL outreach activities reached almost 22,000 people. Other noteworthy events took place as faculty members, staff, and graduate students received awards. These are described in the section titled Special Accomplishments of SREL Personnel.

During the past year, several faculty members had accomplishments worthy of special note:

Dr. John C. Seaman was promoted in 2007 to Senior Research Scientist. Dr. Seaman's research interests include a number of active agricultural and environmental research areas: the application of animal waste and coal combustion by-products; solute and contaminant transport modeling; reclamation of Cr(VI) contaminated aquifers and soils; in situ contaminant immobilization; and the physicochemical factors controlling heavy metal and radionuclide adsorption/migration, including colloid-facilitated transport of contaminants in soil and groundwater. His research focuses on discerning the physicochemical processes controlling solute and colloid migration within soil and groundwater environments, with ongoing studies that span the range of investigation from the molecular to the field scale.

Stepanauskas, R., T. C. Glenn, C. H. Jagoe, R. C. Tuckfield, **A. H. Lindell, C. J. King** and **J V. McArthur**. 2006. Coselection for microbial resistance to metals and antibiotics in freshwater microcosms. *Environmental Microbiology* 8:1510-1514 was recently listed on the website "Faculty of 1000 Biology" ", which evaluates what are considered the most important papers published in biology. The paper was cited because it was the first to report experimental evidence that exposure of freshwater microbial assemblages to individual toxic metals or antibiotics can result in multiresistant bacteria, and further suggests that anthropogenic release of toxic metals, rather than antibiotics, may be more important in environmental selection for antibiotic resistant bacteria. While genes encoding heavy metal and antibiotic resistance are known to be often on the same plasmid conferring co-selection, this study extends previous observations by an experimental demonstration of coselection in natural assemblages. This is SREL publication #2986.

Dr. Thomas G. Hinton was recently invited to become a member of a new Nuclear Expert Group of NATO's Science for Peace and Security Programme. Members of the group provide guidance and advice on NATO projects dealing with radioactivity in the environment.

Dr. Paul M. Bertsch was recently elected president of the Soil Science Society of America (SSSA). The SSSA is a 6000-member professional society dedicated to advancing the discipline and practice of soil science by acquiring and disseminating information about soils in relation to crop production, environmental quality, ecosystem sustainability, bioremediation, waste management and recycling, and wise land use.

FY07 was also a year of significant change in the vision for SREL, as well as its structure and operations. Funding from DOE-EM was capped at $1M for FY07, necessitating change to programs that are entrepreneurial and interdisciplinary, and a funding strategy that is competitive, responsive to sponsors' requirements, and based on a diverse and sustainable foundation. This recognition required restructuring of research and supporting infrastructure, including downsizing of personnel and implementation of operational efficiencies.

Although many of these changes were difficult, a smaller SREL on-site presence was achieved in FY 07, and the SREL budget was reduced by as much as two-thirds through a reduction of senior administrative and technical/clerical positions and elimination of laboratory buildings. This achieved a level that is lean but which ensures continued progress toward stated objectives and does not compromise safety and security. Some faculty members and laboratory work that is not site-specific to the SRS are transitioning to the UGA Athens main campus, while new partnerships and collaborations with the Athens campus departments and other agencies are being explored in order to fully utilize SREL assets. Graduate student programs have continued, with all costs paid by external grants, UGA, or the student's host university.

Continued financial support from external grants, DOE-NNSA, and UGA has maintained SREL through this transition. A Cooperative Agreement with DOE was finalized permitting SREL/UGA access to the SRS through 30 September 2011. The local community strongly supported continued funding for SREL in its role in research, environmental monitoring, and education/outreach programs for local schools and the general public.

Many challenges remain for SREL, including reorganizing research programs to address DOE and SRS-specific concerns, maintaining current research staff, and attracting new personnel. SREL researchers are also very actively 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.

Researchers at SREL had funding from 48 grants during FY07. Sources of grant awards range from private foundations such as the National Fish and Wildlife Foundation to federal agencies such as the U.S. Department of Interior, the National Science Foundation, and the Department of Defense.

In addition to holding faculty positions in numerous departments at the University of Georgia, many SREL faculty members have adjunct status at other colleges and universities. Faculty, staff, and students also are active in providing outreach and service to the scientific community. Representatives from the laboratory hold editorial or committee positions in national groups and organizations and also serve on several UGA academic and administrative committees. Many scientific presentations and posters were presented during the past year at scientific meetings, colleges, and universities, including minority institutions.

Participants in the SREL Education Program during FY07 included 8 undergraduate students and 24 graduate students from schools located throughout the United States. The graduate students came from three different universities in the United States. In the past year four graduate students from SREL earned Doctor of Philosophy Degrees. A National Science Foundation grant from the Research Experiences for Undergraduates Program for a proposal titled "The Impact of Energy Technologies on Natural Environmental Systems" provided funding for the undergraduate program at SREL.

The SREL Outreach Program reaches an audience different from science professionals in its efforts to communicate scientific awareness to the general public. During the past year, SREL scheduled 94 talks, 173 tours, 92 exhibits, and 25 workshops, reaching a total of 21,904 people. Topics for these presentations included reptiles, amphibians, southeastern plants and habitats, long-term research, safety, biodiversity, local wetlands and watersheds, conservation, and careers in ecology and research.

The SREL Conference Center has continued to see wide use, both by SREL personnel and the local community. The facility was used to host numerous meetings and environmental education programs for students, teachers, and the general public this past year.

Please recognize that in the current financial situation, many research programs have had seriously reduced funding during FY07 and hence may have little or no progress to report for the past year. This may be reflected in minimal text or omission of the section if the Principal Investigator is no longer employed by SREL.

SPECIAL ACCOMPLISHMENTS OF SREL PERSONNEL

FACULTY

The Florida Chapter of The Wildlife Society presented the first Paul Moler Herpetological Conservation Award to Mark Bailey, **Kurt Buhlmann**, Jeff Holmes, and Joe Mitchell, for their publication, Habitat Management Guidelines for Amphibians and Reptiles of the Southeastern United States. The guidelines present ideas and methods to help landowners improve the conservation value of their land for the wide variety of habitats and herpetofauna present in the southeastern U.S. **Dr. Buhlmann** is a Research Scientist at SREL.

Dr. Jason M. Unrine is participating in several activities with the North American Industry Selenium Working Group, which consists of representatives from the electric utilities, coal companies, mining companies, and other industries with environmental issues related to selenium. For example, he recently presented a seminar on selenium biochemistry and speciation in biological tissues to the group in Montreal, and he will be coauthoring a manuscript for the group about Se speciation, biogeochemical cycling, and recommendations for standardizing Se analysis techniques. Jason will also be involved in activities aimed at developing approaches for implementing EPA's proposed water quality criteria for Se based on fish tissue concentrations. At the national meeting of the American Chemical Society, Jason presented an invited talk about nanotechnology.

Dr. D. C. Adriano was elected as Honorary President of the International Society for Trace Element Biogeochemistry (ISTEB) in July 2007 in Beijing, China during the 9th International Conference on the Biogeochemistry of Trace Elements (ICOBTE). He founded ICOBTE in 1990 in Orlando, Florida and ISTEB in 1999 in Vienna, Austria. The 10th ICOBTE is scheduled for the summer of 2009 in Chihuahua, Mexico.

The Board of Regents approved **Dr. John C. Seaman's** promotion to Senior Research Scientist at its April meeting. In addition, John was a member of the Program Committee for the 2007 Georgia Water Resources Conference held March 27-29, 2007 at the University of Georgia. The conference included a session on "Savannah River Site Issues" that included four presentations by scientists from SREL and SRNL. The three-day event was sponsored by the U.S. Geological Survey, Natural Resources Conservation Service, Georgia Department of Natural Resources, Georgia Tech, and UGA.

Dr. Paul M. Bertsch was recently elected president of the Soil Science Society of America (SSSA). The SSSA is a 6000-member professional society dedicated to advancing the discipline and practice of soil science by acquiring and disseminating information about soils in relation to crop production, environmental quality, ecosystem sustainability, bioremediation, waste management and recycling, and wise land use. Paul was also appointed chair of the U.S. National Committee for Soil Science by the National Academy of Sciences. Among other things, the committee provides leadership in the advancement of soil science nationally and internationally, and identifies innovative solutions to solve environmental and societal problems.

SREL publication #2986 (**Stepanauskas, R., T.C. Glenn, C.H. Jagoe**, R.C. Tuckfield, **A.H. Lindell, C.J. King** and **J V. McArthur**. 2006. Coselection for microbial resistance to metals and antibiotics in freshwater microcosms. *Environmental Microbiology* 8:1510-1514) was recently listed on the website "Faculty of 1000 Biology" (http://www.f1000biology.com/article/id/1033966), which evaluates what are considered the most important papers published in biology. The paper was cited because it is the first to report experimental evidence that exposure of freshwater microbial assemblages to individual toxic metals or antibiotics can result in multiresistant bacteria, and further suggests that anthropogenic release of toxic metals, rather than antibiotics, may be more important in environmental selection for antibiotic resistant bacteria. While genes encoding heavy metal and antibiotic resistance are known to be often on the same plasmid conferring coselection, this study extends previous observations by an experimental demonstration of coselection in natural assemblages.

Dr. Chuanlun Zhang was part of a team of researchers led by Dr. Tommy Phelps from Oak Ridge National Laboratory that recently received an R&D 100 Award for one of the 100 most technologically significant new products of the year in 2006. The prestigious award was presented to the team by R&D Magazine for development of "NanoFermentation: a Bioprocess for Manufacturing Inorganic Nanomaterials."

Former SREL postdoctoral fellow and frequent collaborator at SREL, **Dr. Michael E. Dorcas**, received a Senior Research Award from the Association of Southeastern Biologists for his research on diamondback terrapins at Kiawah Island. Mike is now an Associate Professor at Davidson College. The award was based on a manuscript coauthored by J. D. Willson and J. W. Gibbons, both based at SREL.

Dr. Thomas G. Hinton was recently invited to become a member of a new Nuclear Expert Group of NATO's Science for Peace and Security Programme. Members of the group provide guidance and advice on NATO projects dealing with radioactivity in the environment. In addition, Tom was an invited luncheon speaker during the Transatlantic Science Week 2006: Arctic Meltdown--Global Warming Conference, held in Washington D.C. from October 2-5. The event was sponsored by the Royal Norwegian Embassy and the U.S. Carnegie Institution. Tom spoke on "Multiple Stressors, When 1 + 1 Can Equal 3." Tom then traveled to Minsk, Belarus and participated in a NATO Advanced Research Workshop on the effects of multiple contaminants, where he gave a talk on "Radioecology and Multiple Stressors."

Dr. Lee A. Newman will serve as Honorary Theme Editor for the Encyclopedia of Life Support Systems (EOLSS), an interdisciplinary guide and reference for a wide range of users that is coordinated by UNESCO (www.eolss.net). EOLSS currently has about 200 themes, each managed by an internationally-recognized expert in the field. Lee will coordinate preparation of a new theme on Phytoremediation and Ecosystem Restoration.

Dr. Travis C. Glenn was recently appointed to the technical advisory committee for the Environmental Genomics Laboratory at the University of South Carolina.

The U.S. Forest Service recently named **Dr. Rebecca R. Sharitz, Dr. Barbara E. Taylor** and **Adrienne DeBiase** recipients of the Regional Forester's 2006 Natural Resource Stewardship Award for completion of the Carolina Bay Restoration Project at the Savannah River Site. The award recognizes the major contribution of the team members in ecological restoration and stewardship of wetlands in the southeastern United States. **Dr. Sharitz** was also awarded the Order of the Cypress by the Friends of the Congaree Swamp in recognition of her efforts to promote research in the Congaree National Park.

STUDENTS AND TECHNICIANS

Tracey Tuberville received the Larry Landers Student Research Award, presented by the Gopher Tortoise Council for her research on the 'Landscape scale conservation genetics of *Heterodon platirhinos* and *H. simus*: A comparison of two closely related sympatric species with contrasting spatial ecologies.' ($900) She was also invited to speak at The Wildlife Society's Wildlife Reintroduction Symposium (Sept 2007).

Franta Majs received an Outstanding Student Paper award for his presentation titled "*Evaluation of soluble phosphate sources for nickel and uranium immobilization in contaminated sediments*" given at the 2006 Fall Meeting of the American Geophysical Union in San Francisco.

Kimberly Andrews was awarded the Institute of Ecology's Dean Lindholm Memorial Award for travel expenses to field research sites. She was also inducted into the Blue Key Honor Society, a national society that recognizes students for "all-around excellence in scholarship, leadership, and service."

The cover of the February 2007 issue of the *Journal of Zoology* features a color photograph of an eastern cottonmouth taken by **J. D. Willson**. The lead article in the issue is SREL reprint #3010. J. D. was awarded the Student Research Award at the meeting of the Association of Southeastern Biologists. He

also won the Brooks/Cole Student Research Award in Aquatic Biology presented at the same meeting,

Brian Todd won the Best Student Paper in Applied Ecology from the Institute of Ecology and also the UGA Graduate School's Dissertation Completion Assistantship.

David Scott organized a community outreach project at Hidden Bay, a Carolina bay in Aiken originally purchased by the Aiken County Open Land Trust and then transferred to the City of Aiken. The work was part of a larger watershed education and restoration project designed to eliminate invasive, non-native plants and replace them with native species.

Chris Winne won the Outstanding Student Paper in Herpetology Award at the American Society of Ichthyologists and Herpetologists, Southeastern Division at the Joint Meeting of Ichthyologists and Herpetologists in St. Louis, MO. Chris was awarded an Honorable Mention by the Ecological Society of America, Southeastern Chapter for the best ecological paper presented by a student at the Annual Meeting of the Association of Southeastern Biologists, Columbia, SC. A Travel Award from the Society of Wetland Scientists helped fund his trip to the Annual Meeting of the Association of Southeastern Biologists in Columbia.

Evan Eskew, a 2006 summer intern from the South Carolina Governor's School for Science and Mathematics, was awarded first place for Outstanding Oral Presentation and Written Research in Zoology by the South Carolina Junior Academy of Science.

Matt Jarrett was awarded the Miriam Watts-Wheeler Travel Award ($600) and the Miriam Watts-Wheeler Graduate Studies Award from the Department of Geology at UGA ($300). He also received the Steven J. Gould research grant from the Paleontological Society ($500).

Weidong Zhao's accomplishments in 2007 included: The Best Poster Award for “Archaea: Ecology, Metabolism & Molecular Biology” presented at the Gordon Research Conference Andover, NH; a Graduate student travel award from The Graduate School, University of Georgia; the Interridge Theoretical Institute travel award, to attend a meeting at the Woods Hole Oceanographical Institute, Woods Hole, MA; and a Gordon Research Conference travel award.

Thomas Luhring was awarded the Theodore Roosevelt Memorial Fund ($2000) from the American Museum of Natural History for his project entitled “Unveiling the secret lives of greater siren, *Siren lacertina*” through multi-year mark recapture studies and the development of sex-linked markers.

Lucy Dueck presented, with Kenneth M. Cameron (New York Botanical Garden), a contributed paper "Sequencing re-defines *Piranhas* relationships, with implications for rare and endangered taxa" at the IUCN's 3rd International Orchid Conservation Conference, San Jose, Costa Rica, March 2007.

AN OVERVIEW OF RESEARCH THEMES

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 FY07 SREL research plan responded to guidance from the DOE Site Manager (Jeffrey M. Allison) to the former SREL Director (Paul M. Bertsch) identifying DOE support for research in three critical areas:

(1) *environmental characterization*,
(2) *ecological risks and effects, and*
(3) *remediation and restoration*.

Research at SREL addresses knowledge gaps in these areas by taking advantage of unique expertise in the 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 half-century.

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 it is also a critical component of NEPA 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.

Report on FY2007 Environmental Characterization Milestones

GOAL: Develop long-term ecological databases to determine whether any changes being observed are the result of natural fluctuations or operational impacts.

Environmental Characterization of Herpetofaunal Abundance and Distribution on the SRS

Investigator: J. Whitfield Gibbons

The purpose of this research effort has been to continue long-term studies to characterize amphibian and reptile populations in and around wetlands of the SRS. These ongoing studies have been supported at SREL by DOE for more than 30 years. The studies build upon a large existing database and herpetological experience to support environmental policies and commitments from DOE and other SRS organizations. Efforts include documenting responses of organisms to local contamination and land use changes, determining distribution and abundance of protected species that could restrict construction projects and other site activities, and establishing the extent of dispersal of organisms from contaminated and uncontaminated sites.

The value of using herpetofauna (amphibians and reptiles) as study species hinges on the high species richness of the Southeast in general and of the SRS in particular. The SRS is the largest tract of land in North America for which herpetofaunal species abundance, distribution, and diversity have been measured on a long-term basis, resulting in the documentation of high numbers of individuals from dozens of sites and more species of herpetofauna than reported from any other public land area in the United States. Amphibians and reptiles are excellent bioindicators of environmental health because certain aspects of their physiology, morphology, behavior, life history, and ecology may increase their susceptibility to environmental stress. SREL's early and ongoing involvement in characterizing the SRS environment and changes to it make SREL uniquely qualified to advise DOE on environmental issues regarding future uses of the SRS.

During the past year, studies continued to document patterns of distribution and abundance of herpetofauna on the SRS, as well as the movement of reptiles and amphibians among wetlands and other SRS habitats. The juxtaposition of numerous uncontaminated sites on the SRS with operational facilities and contaminated sites creates an excellent research opportunity for comparative studies.

Traditional approaches, such as radiotelemetry, drift fences, and coverboard arrays were employed to assess habitat use. GIS methods and stable isotope techniques were also used to quantify spatial relationships and physiological processes. Efficient, cost-effective techniques for sampling and studying

herpetofauna are needed as various agencies adopt reptiles and amphibians as bioindicators in monitoring programs. SREL continues to be a major contributor to the development, testing and advancement of techniques for animal monitoring, inventory, stable isotopes technology, DNA analyses and GIS habitat mapping.

Data from these studies have continued to be published in the peer-reviewed scientific literature, added to existing SRS databases and GIS layers, and used in documents and reports required by state and federal regulators. The most tangible indicators of success and accomplishments in the program are scientific and technical publications. Those from the past two years are as follows:

Andrews, K. M. and J. W. Gibbons (2007) "Ecological attributes of snakes on roads: sex and body size are significant within and among species." In J. C. Mitchell, R. E. Jung and S. C. Walls (eds.). Urban Herpetology. Society for the Study of Amphibians and Reptiles, Herpetological Conservation Volume 3, Salt Lake City, UT. (In Press)

Baughman, B. and B. D. Todd (2007). "Role of Substrate Cues in Habitat Selection by Recently Metamorphosed *Bufo terrestris* and *Scaphiopus holbrookii*." Journal of Herpetology 41: 153-156.

Croshaw, D. A. and D. E. Scott (2006). "Marbled salamanders (*Ambystoma opacum*) choose low elevation nest sites when cover availability is controlled." Amphibia-Reptilia 27: 359-364.

Fletcher, D. E., W. A. Hopkins, T. Saldana, J. A. Baionno, C. Arribas, M. M. Standora and C. Fernandez-Delgado (2006). "Geckos as indicators of mining pollution." Environmental Toxicology and Chemistry 25(9): 2432-2445.

Gibbons, J. W., C. T. Winne, D. E. Scott, J. D. Willson, X. Glaudas, K. M. Andrews, B. D. Todd, L. A. Fedewa, L. Wilkinson, R. N. Tsaliagos, S. J. Harper, J. L. Greene, T. D. Tuberville, B. S. Metts, M. E. Dorcas, J. P. Nestor, C. A. Young, T. Akre, R. N. Reed, K. A. Buhlmann, J. Norman, D. A. Croshaw, C. Hagen and B. B. Rothermel (2006). "Remarkable Amphibian Biomass and Abundance in an Isolated Wetland: Implications for Wetland Conservation." Conservation Biology 20: 1457-1465.

Glaudas, X. and C. T. Winne (2007). "Do warning displays predict striking behavior in a viperid snake, the cottonmouth *(Agkistrodon piscivorus)*?" Canadian Journal of Zoology 85(2007): 574-578.

Glaudas, X., K. M. Andrews, J. D. Willson and J. W. Gibbons (2007). "Migration patterns in a population of cottonmouths (*Agkistrodon piscivorus*) inhabiting an isolated wetland." Journal of Zoology 271: 119-124.

Hopkins, W. A. and C. T. Winne (2006). "Influence of body size on swimming performance of four species of neonatal natricine snakes acutely exposed to a cholinesterase-inhibiting pesticide." Environmental Toxicology and Chemistry 25: 1208-1213.

Rothermel, B. B. and R. D. Semlitsch (2006). "Consequences of forest fragmentation for juvenile survival in spotted *(Ambystoma maculatum)* and marbled *(Ambystoma opacum)* salamanders." Canadian Journal for Zoology 84: 797-807.

Scott, D. E., D. A. Croshaw, and R. A. Estes. "The costs of reproduction in two ambystomatid species." (to be submitted to Oikos).

Scott, D. E., E. D. Casey, M. F. Donovan, and T. K. Lynch (2007). Amphibian lipid levels at metamorphosis correlate to post-metamorphic terrestrial survival. Oecologia 153:521-532.

Scott, D. E., M. J. Komoroski, and D. A. Croshaw. Terrestrial distribution of pond-breeding salamanders around an isolated wetland. (to be submitted to Conservation Biology).

Smith, L.L., T.D. Tuberville, and R.A. Seigel (2006). Workshop on the ecology, status, and management of the gopher tortoise (*Gopherus polyphemus*), Joseph W. Jones Ecological Research Center, Newton, GA, 16-17 January 2003: Final results and recommendations. Chelonian Conservation and Biology 5: 326-330.

Todd, B.D., and B.B. Rothermel (2006). Assessing quality of clearcut habitats for amphibians: effects on abundances versus vital rates in the southern toad (Bufo terrestris). Biological Conservation 133(2): 178-185.

Todd, B.D., and D. E. Scott. Climate change influences on amphibian breeding phenology--a 28 year record. (to be submitted to Ecology)

Willson, J. D., C. T. Winne, M. E. Dorcas, and J. W. Gibbons. Post-drought responses of semi-aquatic snakes inhabiting an isolated wetland: Insights on different strategies for persisting in a dynamic habitat. Wetlands. (In Press)

Winne, C. T. and W. A. Hopkins (2006). “Influence of sex and reproductive condition on terrestrial and aquatic locomotor performance in the semi-aquatic snake Seminatrix pygaea.” Functional Ecology 20: 1054-1061.
Winne, C. T., J. D. Willson and J. W. Gibbons (2006). “Income breeding allows an aquatic snake *Seminatrix pygaea* to reproduce normally following prolonged drought-induced aestivation.” Journal of Animal Ecology 75: 1352-1360.
Winne, C. T., J. D. Willson, B. D. Todd, K. M. Andrews, and J. W. Gibbons (2007). Enigmatic decline of a protected population of Eastern Kingsnakes, *Lampropeltis getula*, in South Carolina. Copeia 2007:507-519.

Studies of the Microbial Communities of Contaminated and Uncontaminated Streams

Investigator: J Vaun McArthur

It has been hypothesized that metal and antibiotic resistance traits may be co-selected for in bacteria, thus we would predict that bacterial exposure to metals would result in increased resistance to both metals and antibiotics. Anthropogenic-derived sources of selection are typically implicated as mechanisms for maintaining antibiotic resistance in the environment. Here we report an additional mechanism for maintaining antibiotic resistance in the environment through bacterial exposure to metal contamination. Using culture-independent techniques, we found that bacteria sampled along a gradient of metal contamination in Beaver Dam Creek, which drains coal ash settling basins, were more tolerant of antibiotics and metals than those bacteria from a reference site in Meyers Branch. This evidence supports our hypothesis that metal contamination directly selects for metal tolerant bacteria while indirectly selecting for antibiotic tolerant bacteria.

Additionally, to assess how antibiotic- and metal-tolerance may be transported through a stream network, we studied antibiotic and metal-tolerance patterns over four months in bacteria collected from multiple stream microhabitats including the water column, biofilm, sediment, and *Corbicula fluminea* (Asiatic clam) digestive tracts. Sediment bacteria were the most tolerant to antibiotics and metals, while bacteria from *Corbicula* were the least tolerant. Differences between these microhabitats may be important for predicting antibiotic resistance transfer and transport in stream environments. Further, temporal dynamics suggest that tolerance patterns within microhabitats are linked to a complex interaction of physicochemical characteristics of the stream. In addition we measured the abundance of integron genes in these habitats. Integrons are mobile genetic elements that often carry antibiotic resistance genes. Significantly higher abundances of these genes were found in all microhabitats in the contaminated stream but little to none was found in the reference stream.

Revegetation Success in Restoration of Small Carolina Bay Depressional Wetlands

Investigator: Rebecca R. Sharitz

The SRS Carolina Bay Restoration Project was initiated in 1998 by SREL, the U.S. Forest Service, the U.S. Fish and Wildlife Service, and several universities. Sixteen drained and severely degraded Carolina bays were chosen for experimental restoration, and DOE-SR will receive credits to its wetland mitigation bank for this project. Initial treatments included the closure of drainage ditches in an effort to restore the hydrology of these bays, and clear-cut removal of woody species that had invaded the drained bays (Barton et al. 2004). The restoration project was designed to use passive natural processes (plant recruitment from seed banks and seed dispersal) as the main revegetation method to achieve emergent herbaceous wetland communities. In eight wetlands, the passive method was supplemented by planting seedlings of typical wetland tree species–*Taxodium distichum* (baldcypress) and *Nyssa biflora* (swamp tupelo) –with a longer-term goal of achieving forested wetlands.

In each of the restoration wetlands, percent cover of all plant species was recorded yearly from 2000 to 2005 in permanent 4-m^2 plots. For planted trees, a sample of marked seedlings (up to 100 per species per site) was censused yearly in spring (April/May) for survival and height growth. For analysis, plant

species were classed using the National Wetland Indicator Classification as “wetland” (OBL, FACW), “facultative” (FAC+, FAC), or “non-wetland” (FAC-, FACU, UPL). From reference wetland datasets (De Steven and Toner 2004), threshold values were established to determine successful wetland restoration. For all the restoration bays, both percentage and relative cover of wetland species had to meet or exceed a reference threshold of 60%. The forested restorations had a required minimum survival rate of 50% for planted trees (Barton et al. 2007).

Although wetland hydrologic conditions recovered after drainage ditches were closed, vegetation recovery was influenced by an early drought in 2001-2002. By 2005, average values for percent wetland species averaged 61% (range 34–76% across all bays) and relative cover of wetland species averaged 62% (range 11–96%; DeSteven et al. 2006). Thus, while average performance met desired thresholds for wetland recovery (values of 60% wetland species), some individual bays did not reach desired values. The constraints for these wetlands were: 1) resprouting of harvested trees and woody vines, most of which were not wetland species, and 2) restored hydroperiods that may have been too short to support a predominance of wetland species. However, nearly all wetlands showed net improvements within the limits allowed by restored hydroperiods.

In the eight planned “forested” wetlands, survival of planted tree seedlings averaged 79% for cypress (range 54–95% across the bays) and 23% for tupelo (range 2–32%) by 2005 (Sharitz et al. 2006). Cypress survival exceeded the expected 50% success threshold in all eight planted sites, but tupelo met the survival criterion in only one wetland. Possible reasons for high tupelo mortality in the first two years included drought sensitivity, planting into some unsuitable microsites (e.g., under water), or smaller initial seedling size (Sharitz et al. 2006). Attained tree heights typically ranged between 1.4–2.6 m for cypress (maximum 4.0) and between 0.6–1.8 m (maximum 3.1) for tupelo.

These vegetation studies addressed two questions: 1) were passive methods an adequate source of wetland plant species for revegetation? and 2) did vegetation composition, as influenced by restored hydroperiods, meet appropriate success criteria at the end of the 5-year assessment period?
The first question was answered affirmatively, but with some caveats (De Steven et al. 2006). The seed banks were dominated by wetland herb species and were adequate to establish high emergent cover. However, seed bank species composition did not fully resemble that of natural reference wetlands, and unpredictable drought during the first two years favored woody resprouting that was difficult to control effectively. The second question was not answered affirmatively in all the bays. Even after hydrologic restoration, some small shallow depressions may have natural hydroperiods that remain too short to support herbaceous wetland communities. If persistent emergent wetland vegetation is desired, more effective means to control hardwood resprouting may be needed. In addition, planting native wetland species, such as perennial grasses, may supplement passive restoration approaches (De Steven and Sharitz 2007).

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Conservation of Sandhills Threatened, Endangered and Sensitive (TES) Species

Investigator: Rebecca R. Sharitz

Along the southeastern Fall Line region, there are extensive areas of sandhills and related xeric forests that support a unique flora and fauna, including a suite of threatened, endangered and sensitive (TES) plant and animal species. Nine TES plant species, listed as Species of Conservation Concern for Georgia and South Carolina, were chosen for study on several Federal lands along the Fall Line, including the SRS and military installations. The goals of this research, which is leveraged by funds from the Strategic Environmental Research and Development Program (SERDP), are to evaluate the effects of land management activities on sandhills communities, to assess whether there is a combination of management activities that is suitable for all or most of the sandhills TES species, and to make recommendations for multiple-species management.

Sixty-three populations of nine TES plant species were sampled and habitat characteristics, including soil properties, canopy openness, and vegetative composition of the surrounding community, were measured. GIS maps of potential habitat locations for each species were generated based upon Landsat-7 enhanced thematic mapper plus (ETM+) satellite imagery acquired during periods of leaf-on and leaf-off and maps of soils associated with known population locations. Since these nine species occur in similar habitats, composite maps of potential habitat for multiple TES were generated by overlaying individual maps. In surveys to validate these maps, populations of TES species were found at more than 50% of the predicted sites, and more than 78% of the sites had soils and vegetation characteristics similar to known TES plant habitats.

The greatest conservation focus in the sandhills, however, is on the federally-endangered red-cockaded woodpecker and on the gopher tortoise which is proposed for federal listing, rather than on TES plants. The plant habitat maps were combined with information on known locations of tortoise burrows and woodpecker colonies. There was substantial overlap among habitats of these sandhills animals and plants. Of 8395 mapped gopher tortoise burrows at Fort Gordon, 4854 (or 58%) were within areas mapped as probable habitat for one to five TES plant species. Furthermore, the areas of highest occurrence of both plant and animal TES species were in the most xeric sandhills areas. Thus, management for multiple TES species may be a feasible option for protecting rare sandhills plants.

Alligator Population and Genetic Studies

Investigator: Travis C. Glenn

Alligators were collected opportunistically, especially in conjunction with education and outreach activities, to extend a long-term database on alligator population genetics. SREL's DNA laboratory co-sponsored the 3rd International Workshop on Crocodilian Genetics and Genomics at the Smithsonian's Tropical Research Institute, Panama.

Update and Enhancement of the Wildlife Literature Survey (WLS) and GIS Databases

Investigator: Charles E. Davis

WSRC-SGCP continued in FY07 to contract with SREL to provide biannual updates to a literature and GIS database on wildlife receptor species for use in SRS Ecological Risk Assessments and for incorporation into the Site's IOU GIS project. As part of these updates, SREL reviewed SREL and USFS-SR publications, theses, and dissertations and other reports generated since 2001 and assemble records and site locations for 77 vertebrate and 1 mollusk receptor species. Appropriate data extracted from these publications included: species scientific and common names, reference citation, specific and relative geographic SRS location(s) of studies, habitats as described by the reference(s), habitat as described by

the 1997 habitat map (Pinder 1998), document kind/keywords, and study years. Site locations for receptor species were determined and shape files and accompanying metadata were created. Updates to the database tables continued in the Microsoft Access 2000 and Excel formats as directed by WSRC-SGCP. Abstracts were generated for all new publications and provided in html format. All information including databases, html documents, metadata, and any new geo-spatial data were provided on CD in html, PDF, and ArcView shape file (UTM) formats. These data were incorporated into the existing GIS Wildlife Literature Survey database and released to WSRC-SGCP for use in conducting risk assessments on the SRS.

In FY07, WLS Update Versions 16 and 17 (July 2006 to June 2007) were completed and delivered to WSRC-SGCP in CD formats. These updates were produced from 32 publications including 21 SREL reprints, 2 theses and dissertations, and 7 reports/publications provided by the USFS-SR. Based on these publications, 486 new records were added to the Access databases, 3 new shape files were generated with source information, 32 new abstracts were generated, and 2 new metadata files for the WLS shapefiles were updated. No new receptor species were recommended for adding to the WLS this FY. The Access databases now have a total of 20,624 records coming from 1,146 publications. In addition to these updates, SREL continued with the spatial refinement of the current database and worked to restore and maintain the Excel spreadsheet database (Wildlife.dbf) associated with the original stand-alone ArcView project**.** The restoration of this database is a work in progress and now contains a total of 12,870 entries.

SREL demonstrated the original stand-alone ArcView project to WSRC-SGCP and DOE personnel during this reporting period. In addition, discussions have begun to re-visit the Access database format using the latest version of Arc-GIS for the purpose of determining the need to maintain the survey which is readily accessible to the regulators.

Assessing the Ecological Health of Stream Systems and Watersheds of the SRS: Modeling the Herpetofaunal Habitat-Biodiversity Relationship (Year 2)

Investigator: J. Whitfield Gibbons

This task is a continuation of our efforts to quantify the amphibian and reptile (herpetofauna) biodiversity of the D-Area Integrated Operable Unit (IOU), and assess the ecological health of this contaminated system. SREL's historic sampling of herpetofauna in a variety of habitat types across the SRS provides a baseline of "expected species" for a given habitat type; any IOU of interest can be sampled and compared to the "expected value" of species richness for that habitat type. In conjunction with simultaneous sampling at control sites, these data provide one measure of ecosystem health. In previous studies of D-Area settling basins, it was found that coal combustion residues have a variety of effects on herpetofauna, particularly pond-breeding amphibians that use the basins (Rowe and Hopkins 2003). Also, Roe et al. (2005) identified trace element tissue concentration patterns in two anuran species from reference, ash plume, and ash-settling basin wetlands, and found that amphibians from the D-Area ash plume wetland had intermediate levels of As, Cu, Se, and Sr. By coupling site sampling of species richness with experimentally derived estimates of reproductive and larval success for targeted subsets of amphibian species, we can determine whether an IOU truly functions as a healthy system or is an ecological trap (sensu Kristan 2003).

During the past year we have reviewed all relevant publications that we are aware of and are examining current and historically relevant data sets collected by SREL and other SRS subcontractors that are applicable to distribution and abundance determinations of reptiles and amphibians on SRS. We are awaiting the receipt of certain data sets that were collected with DOE support but that were not archived and must be acquired from the original investigators who are no longer on the SRS. We have selected and examined the ash plume wetland as the study site at the D-Area IOU for herpetofaunal sampling and have also located comparable control sites, with consideration of vegetation, hydrology, and topography. We have been in contact with colleagues at other universities who formerly worked in D-Area to get additional suggestions for control sites.

Diversity and Abundance of Ammonium-Oxidation Archaea In Heavily Contaminated Soils at the Savannah River Site (SRS)

Investigators: Gary Mills and Chuanlun Zhang

The effects of heavy metals on soil archaeal community structures were investigated in soil samples collected from three sites with different contamination sources (former nuclear processing and coal combustion) on the DOE's Savannah River Site in South Carolina, USA. Analysis of the archaeal 16S rDNA clone library revealed that sequences retrieved from these samples were significantly different from each other. For instance, members of the nonthermophilic group 1.1a and 1.1c *crenarchaeota* constituted an important fraction in the samples obtained from the LTH-ST system with M-area, which received discharge of waste water from nuclear and metallurgical processes. In contrast, archaeal community composition was observed to be dominated by members of group 1.3b *creanarchaeota* in soil obtained from the chemical, metal and pesticide (CMP) pits. The similar proportions of *Crenarchahaeota* (47.5%) and the *Euryachaeota* (52.5%) clones were present in Beaver Dam Creek soils within D-area, which were contaminated by coal combustions. Glycerol dialkyl glycerol tetraethers (GDGTs) profiles showed distinct patterns among the samples from different locations. In particular, crenarchaeol, a specific lipid biomarker of pelagic *Crenarchaeota* within Group 1.1a, was detected only in samples from LTH-ST system. This result was consistent with the phylogenetic analysis. Diversity of ammonia-oxidizing archaea was examined by targeting the archaeal ammonia monooxygenase -subunit (*amoA*) gene on the same samples to better understand the ecological functions of *Crenarchaeata*. 93.5% of the total AOA sequences from all six samples fell into water column/soil/sediment cluster. Furthermore, quantitative real-time PCR analysis showed that ratios of copies of archaeal *amoA* genes (AOA) to those of bacterial *amoA* genes (AOB) ranged from 0.72 to 9.81 in six studied samples. The lowest ratio (0.72) of AOA to AOB in Beaver Dam Creek soil may be in relation to the relative lower proportion of crenarchaeotal clones in its library. Our results provide evidence that Crenarchaeota may play a significant role in ammonium oxidation in radionuclide and heavy-metal contaminated environments.

GOAL: Determine the biogeochemical processes that control chemical speciation and mobility of toxic metals, organic contaminants, and radionuclides.

Uranium and Nickel Speciation in the Steed Pond-Tims Branch System

Investigator: Paul M. Bertsch

The sequestration of heavy metal ions, including transition metals, metalloids, and actinides (hereafter, metals) by soils and sediments strongly influences the fertility hazard posed by contaminated environments. Understanding the biogeochemical processes that control the mobility of heavy metals is essential for realistic estimates of human health and ecological risks and prudent remediation and management of contaminated lands. Bulk chemical characterization methods such as total digestions and sequential extractions provide important information but often fall short of describing in adequate detail or with sufficient confidence the physical distribution and chemical speciation of contaminants of concern. Advanced analytical techniques such as IR, Raman, luminescence, and X-ray absorption spectroscopy, are capable of filling this gap. However, when applied at macroscopic scales (i.e., 100 µm or greater), contaminant heterogeneity at the soil mineral/humic matter assemblage scale is concealed. Consequently, microprobe techniques with spatial resolution on the order of 10's of micrometers and below are essential for obtaining elemental distributions and chemical speciation information for discrete soil mineral phases, particles, and organic structures.

Electron microscopy and electron microprobe analysis (EMPA) are environmental characterization workhorses but suffer from limitations imposed by sample preparation requirements, the use of high vacuum in the sample chamber, limited penetration depths, and reduced sensitivity for higher Z elements. Moreover, speciation information is not available from most electron beam techniques, and electron beam damage to the sample can be substantial. The development of synchrotron-based X-ray microprobes for environmental analysis has overcome many of these limitations.

Natural Attenuation of PCE/TCE in Pen Branch Hyporheic Sediments

Investigators: Gary L. Mills and Chuanlun Zhang

Natural physical, chemical, and biological processes often act to reduce the concentration, mobility, and toxicity of contaminants in the environment. Monitored natural attenuation (MNA) assesses the contribution of these processes in the cleanup of contaminated soils and groundwater. MNA is often considered as part of an overall remediation plan that includes the use of engineered treatment technologies to achieve acceptable levels of risk to human health and the environment. Saturated floodplain soils and sediments adjoining streams generally provide conditions favoring microbial degradation of volatile organic carbon compounds (VOCs), including PCE and TCE. These compounds have been the focus of several MNA studies at the SRS including plumes migrating towards Pen Branch Creek, Fourmile Branch, and Castor Creek. However, no studies have explicitly examined natural attenuation processes within the subsurface stream sediments that are directly linked to stream surface water. This region is called the hyporheic zone and has been shown to play a critical role in controlling the flux of groundwater solutes to surface waters. With regard to MNA, it is the final interface before contaminants outcrop into regulated receiving waters.

The goal of this study was to examine the role of MNA processes within the hyporheic zone in mitigating the flux of PCE, TCE, and carbon Tetrachloride (CT) into the groundwater plume from the Chemical, Metals, and Pesticide (CMP) pit waste site before the plume emerged into Pen Branch Creek. The study is a collaborative effort with Dr. John Williams and undergraduate interns from South Carolina State University. Seven sampling locations in Pen Branch Creek between Road C and Youman Road were established in July 2005 based on existing data from well water monitoring and passive diffusion samplers in the lower flood plain as well as from the predicted plume flow from a numerical transport model (Council et al., 2002). Similar to our sampling in 2005 and 2006, hyporheic sediment cores were collected by augering within a PVC pipe which isolated the cores from the stream surface waters. Sediment sections in roughly 10 cm intervals were sampled from the sediment-water interface to the confining layer at a depth of about 90 cm. Two replicate sediment samples for VOC analysis were collected from each core. Water samples were collected from infiltrating groundwater pumped from the bottom of the core holes. In addition to direct VOC analysis of hole water and sediments, passive diffusion bag (PDB) samplers were placed into most holes to cumulatively sample VOCs for intervals of up to three weeks duration. PDBs were constructed similar to Harte et al. (2000). Two replicate samples for VOC analysis were collected from each PDB. All samples were subsequently analyzed using gas chromatography (GC).

Supporting our previous studies, the results demonstrate significant degradation of TCE and PCE is occurring as the CMP plume moves within the Pen Branch hyporheic zone. At nearly all stations, cis-DCE was much higher in concentration than TCE or PCE (Figure 1). Natural attenuation accomplished VOC degradation for a large portion of the original plume of TCE and PCE. As observed in previous years, VOC concentrations were highest in the stream sediments around Station 5. This pattern is consistent with modeled plume flow and provides support of the accuracy of the hydrological transport model.

A comparison of cis-DCE concentrations measured using different sampling techniques showed similar trends but quantitative differences (Figure 2). In general, highest concentrations were found in the PDB samples. Diffusion samplers provide a measure which has been integrated over a 3 week sampling period, as opposed to the time-specific grab-samples taken from sediment or hole water. This was a relatively wet period following an extended period of little rainfall. It is likely that precipitation and daily hydrological flow variations account for the observed differences between the grab sampling and the more averaged diffusion samplers.

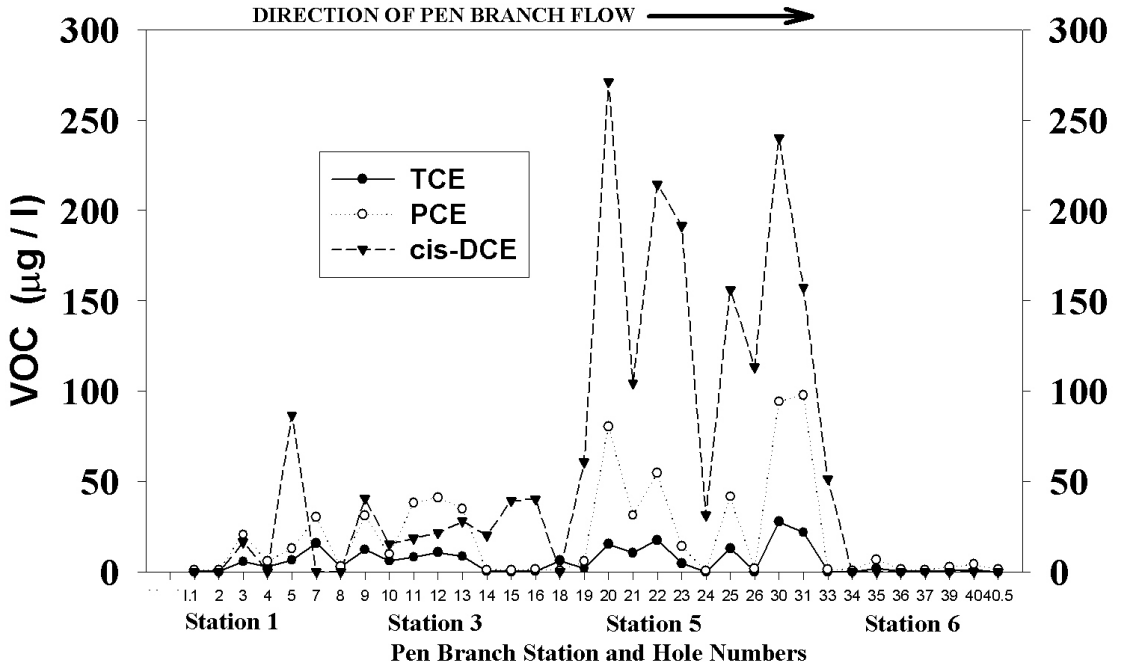

FIGURE 1. Mean hole water TCE vs PCE vs cis-DCE in Pen Branch hyporheic zone during June - August 2007

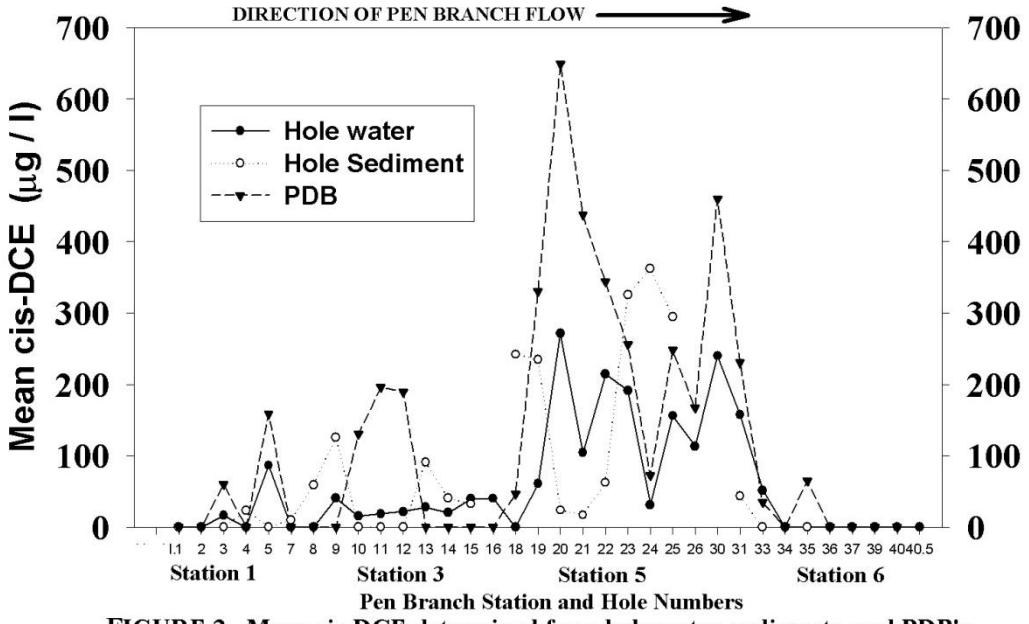

FIGURE 2. Mean cis-DCE determined from hole water, sediments, and PDB's in Pen Branch hyporheic zone during June - August 2007

Our results indicate significant concentrations of PCE and TCE are present in the shallow hyporheic sediments within the Pen Branch Creek sediments. Concentrations of DCE were variable but generally increased then subsequently decreased or disappeared in the stream surface waters and were consistent with microbial degradation in the hyporheic zone. Our results also showed concentrations in the stream hyporheic zone were often much higher than the values measured in the adjoining floodplain groundwater; indicating there may be significant migration of contaminants or that they are transported in preferential flow paths. This also suggests careful monitoring of the system is needed to determine if the system has reached a stable, steady-state or is progressing towards a more contaminated state. All current natural attenuation assessments of PCE/TCE remediation on the SRS are predicated on upland and floodplain studies and consequently, degradation processes in hyporheic sediments are not considered. Our results suggest that the attenuation capacity of the floodplain ecosystem for the CMP plume may be exceeded and contaminants are approaching the stream interface. Alternatively, preferential flow path may provide a transport route that circumvents the attenuation processes associated with floodplain soils. Clearly, assessing the natural attenuation capacity of the hyporheic zone is critical for predicting further migration of contaminants and evaluating the longer term feasibility of natural attenuation.

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Harte, P.T., M.J. Brayton, and W. Ives. 2000. Use of Passive Diffusion Samplers for Monitoring Volatile Organic Compounds in Ground Water. USGS Fact Sheet 088-00. 4p.

Development of Lipid-Biomarkers and Carbon Isotopes for Monitoring of Environmental Changes at the SRS

Investigators: Christopher S. Romanek, Chuanlun Zhang, and Gary L. Mills

Past activities of the Department of Energy (DOE) have created significant environmental contamination, which can have adverse effects on all forms of life including microorganisms. On the other hand, certain groups of microorganisms are known to enhance the degradation of organic pollutants and the transformation and immobilization of heavy metals and radionuclides.

Considerable research has been conducted by DOE to determine the transport and fate of contaminants in soils and groundwater. Technologies have also been developed to enhance biodegradation of chlorinated organics and petroleum hydrocarbons and biotransformation of heavy metals and radionuclides at SRS. However, a deeper understanding of microbial diversity, community structure and activity is needed to better accomplish DOE missions and respond to new DOE initiatives and environmental bioremediation strategies (OBER Strategic Plan, 2003; SREL Workshop, 2003).

The overarching goal of this research is to determine the diversity, community structure, and ecological functions of microorganisms at the Savannah River Site to provide valuable scientific information for sound decision-making on remediation-practices at SRS. This goal will be achieved by integrating advanced technologies in molecular DNA, lipid biomarkers, and stable isotope signatures in the context of fundamental soil chemistry, hydrology, and ecological modeling of the riparian system that is representative of DOE contamination in wetlands (SREL Workshop, 2003).

This project tested the application of integrating lipid biomarkers and their carbon isotopes for a better understanding of community structure and function in an Iron Creek at the D-Area, which is impacted by the seepage of a holding pond for remediation practices, and in an Algal Creek near the Savannah River Ecology Laboratory. Lipid extraction from soil and sediments followed procedures of White et al. (1979), which resulted in the neutral, glycol, and polar fractions. The polar fraction (phospholipids) was treated using a mild alkaline methanolysis to produce fatty acid methyl esters. Carbon isotope compositions of methylated fatty acids were determined on a HP 6890 gas chromatograph connected to a Finnigan MAT Delta+-XL mass spectrometer via a GC-C III interface (Zhang et al., 2002).

Results indicate that lipid profiles are similar for the surface mat in the Iron Creek and the algae in the Algal Creek (Fig. 1). However, the carbon isotopic signatures of these lipid biomarkers and total biomass are dramatically different (Fig. 1). The depletion of ^{13}C in the Iron Creek reflects intense carbon cycling coupled between the autotrophic community in the surface mat and the heterotrophic community underneath the mat. The autotrophic community (algae) in the Algal Creek lacks this interaction with a heterotrophic community. A combination of lipid biomarkers and isotope signatures is expected to be a valuable tool for understanding microbial community structures and ecological functions in contaminated sediments at SRS.

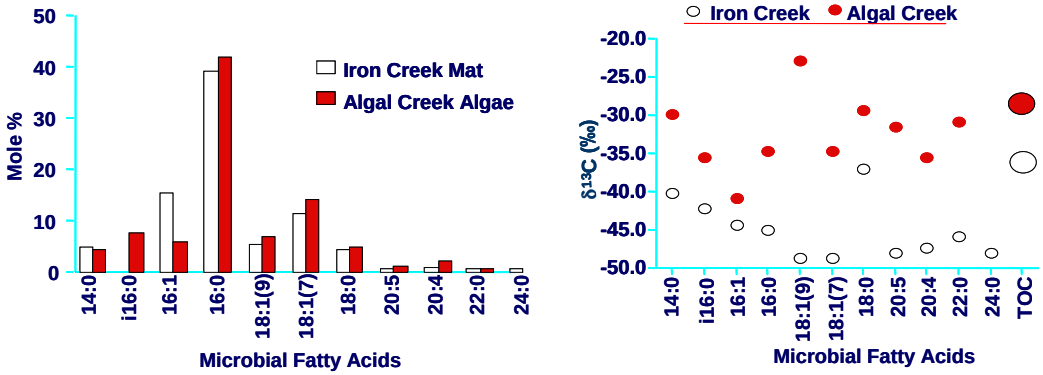

Fig. 1. Lipid profiles (left panel) and isotopic compositions of lipids (right panel) of bacteria from the iron creek in D-Area and an algal creek near SREL.

Application of Surface Complexation Models to Predicting Actinide Fate and Transport in Variably Saturated Systems

Investigator: J. C. Seaman

This is a comprehensive study in which a surface complexation model (SCM) would be used to describe contaminant retardation in an unsaturated system. Our goal is to model and perform laboratory studies of sorption in unsaturated zone systems with undisturbed soil columns at variable solution application rates and saturation.

Our specific objective is to evaluate the application of surface complexation modeling (SCM) approaches to predicting uranium fate and transport behavior in the vadose zone by conducting a series of batch experiments using ideal mineral standards (kaolinite) and synthetic surrogates such as goethite and hematite, as well as a limited set of bulk sediment samples typical of the materials present at the SRS.

Project Activities Completed:

- Identification and initial characterization of mineral standards and synthetic analogs (kaolinite, goethite, hematite, etc.) thought to control U(VI) sorption behavior in SRS soils.

- Extensive characterization of typical SRS soils in terms of physicochemical factors controlling U(VI) migration, i.e., pH, OM content, texture and grain-size analysis, BET surface area, x-ray diffraction, etc.

- Construction of the modified vacuum-based Wierenga system for conducting unsaturated solute transport experiments using large intact cores was completed. A large intact soil core was subsequently collected from the field for use in the unsaturated contaminant transport experiments. After excavation, the core was placed on a vacuum plate, encased in paraffin, and

instrumented with microtensiometers to determine soil matric potential as a function of depth. A rainfall overflow cylinder and a rainfall simulator were installed at the top of the core to facilitate saturated and unsaturated experiments.

Ongoing:

- Initial unsaturated tracer experiments conducted using the modified centrifuge system, i.e., the Unsaturated Flow Apparatus (UFA), in an effort to develop standard protocols for conducting the U transport studies under steady state moisture conditions

- Initial batch sorption edges for U(VI) using mineral standards and SRS soils under a range of pH and pCO_2 conditions.

- Sorption parameters calibrated to batch data for various stoichiometric sorption reactions and model formulations based on reaction scheme simplicity and goodness-of-fit using FITEQL 4.0 (Herbelin and Westall, 1999).

GOAL: Assess whether sentinel species or other sensors can be used to characterize environmental health.

Studies of the Effects of Nickel Exposures in Turtles

Investigator: Paul M. Bertsch

With funding from Dr. Karen Gaines, Eastern Illinois University, we have maintained the turtles that were previously exposed to Ni and hope to identify additional sources of funding in the upcoming years to harvest the bone tissues and conduct the spatially resolved synchrotron-based X-ray microprobe analysis to definitively establish the usefulness of using turtles as indicators of environmental exposure. This information will be critical for developing robust ecological risk assessment in the Steed Pond-Tims Branch system and for the Upper Three Runs IOU analysis.

Studies of the Relationship Between Microbial Antibiotic Resistance and Environmental Contamination

Investigator: J Vaun McArthur

Various enteric bacteria have been used as indicators of water-borne pathogens. Phenotypic characterization of *E. coli* isolates demonstrated that most had greater than two resistance traits and as such demonstrated multi-antibiotic resistances (MAR). While MAR was observed at all collection sites along the southeastern coastal region, the complexity of the relationships changed as a function of location. The most contaminated site, Shipyard Creek (SYC) had the most complex patterns. At SYC resistance was observed for every antibiotic screened including many frontline drugs except one. Penicillin and erythromycin were the most common antibiotics that our isolates were resistant to. Interestingly, most of the isolates from the pristine estuary were susceptible to the newer antibiotics. These data suggest that exposure to industrial contamination increases the complexity of the resistance profiles of *E. coli*. If only the ACE Basin and SYC had been sampled, these data would suggest that human fecal contamination was driving the high levels of MAR found at SYC. However, the intermediate, but still complex, antibiotic phenotypes found at the LCP Chemicals (near Brunswick, GA) where no fecal contamination was detected would suggest otherwise. The combination of fecal and metal contamination produced the most complex MAR profiles. *E. coli* isolates from all sites were screened to determine whether they carried any class 1 integrons. The proportion (integrase positive abundance to 16S RNA abundance) of isolates carrying integrons was highest at SYC, followed by the LCP site, with essentially none found at the ACE Basin. Interestingly, higher abundances of integrase genes were found in the ebb and flood tidal waters instead of the sediments at the contaminated sites. A statistically significant proportion of MAR isolates originated from the polluted sites ($P > 0.05$). In addition, a significant number of these highly resistant *E. coli*

also contained class-1 integrases, a mobile element associated with HGT in clinical and environmental bacteria. Average resistance of isolates with integrons is 8.75 antibiotics compared to 2.75 for the rest of the community ($P > 0.05$). Thus, isolates which could easily transfer antibiotic resistance traits via integrons carry a statistically higher number of resistances per isolate.

Using Freshwater Mollusks to Monitor Water Chemistry

Investigator: Christopher S. Romanek

There was insufficient funding for continued research but one manuscript, "Shell Layer Variation in Trace Element Concentration for the Freshwater Bivalve, *Elliptio complanata"* was submitted for publication from previous year's research. An abstract of that publication follows.

> The trace element chemistry of mollusk shells contains valuable environmental information that is sometimes obscured by biological overprinting. Geochemical information stored in freshwater bivalves is especially challenging to interpret given the wide range of aqueous chemistries known in freshwater environments. Freshwater bivalves from several streams were studied to determine if different shell layers record similar elemental information or if biological factors influence their geochemical records. The concentration of the trace elements manganese, copper, strontium and barium were analyzed by laser ablation inductively coupled mass spectrometry (LA-ICP-MS) across the growth record of the inner and outer nacreous shell layers and compared to stream data collected over the period of shell growth. The results indicate that elemental concentrations of the inner and outer nacreous layers are functionally related, yet the inner layer has significantly higher concentrations of Mn, Sr, and Ba than the outer layer. Copper concentration does not change between layers but seems to be related to the organic matrix of the shell. This indicates that biologically processes are at least partially responsible for shell growth. Nonetheless, both layers do respond to changes in environmental concentrations and should be explored as archives of environmental information.

Continued Research at the Mixed Waste Management Facility

Investigator: John C. Seaman

In support of 2007 remediation efforts at the Mixed Waste Management Facility (MWMF), SREL has been working in collaboration with the DOE (P. Prater), US Forest Service (D. Strawbridge, and M. Lloyd), and SGCP (S. Bell, S. Fuller, and M. Kasraii) to assist with site management and provide the evapotranspiration efficiency estimates required for the Corrective Action Report (CAR). SREL representatives meet with the MWMF management team on a weekly basis to coordinate all activities, and maintain, update and report the results from the 1D tritium efficiency model originally developed by researchers from Cornell. To that end, efforts in November and December of 2006 focused on collecting and analyzing bi-annual soil cores. Six 3-meter cores were analyzed for soil physical properties and tritium concentration in the lab in preparation for the end-of year CAR. Early in 2007 the data collected throughout 2006 were summarized and included in the 2006 CAR Efficiency Report for the MWMF. Also included in the report were the Cornell Model estimates of tritium use efficiencies and mass balance tritium use efficiencies for 2006. Efficiencies for the MWMF were calculated based on irrigation schedules, climate data, and soil core analysis from plots within the facility. The semiannual report documenting the soil tritium data, evapotranspiration efficiency estimates, and updated results from the Cornell model was provided to SGCP in early February 2007. Additional soil cores were taken in plots not regularly monitored for comparison with plots included in the CAR. These cores were analyzed in a similar fashion to those from the regularly monitored plots. Similar efforts were conducted in June, July, and August 2007 for the Mid-year CAR.

SREL continued assisting the US Forest Service in updating the irrigation system and automating various monitoring system components. Lab tests calibrating irrigation flow meters were completed and work on field installation of a test unit was completed. Also, pond recharge rates were calculated using depth gauge measurements from the pond as it refilled. These estimates were provided to USFS and SGCP. Pond depths were continually monitored throughout the year. Additionally, work is continuing on

correlating pond depths with outflow volumes associated with the sheet pile dam weir. Progress has been made in adapting the automated weather data collected on-site into the water deficit calculations performed by USFS personnel. Work integrating automated data collection into daily management of MWMF procedures is on going.

SREL has been preparing plot 20 for a fertigation experiment that will test application rates and resident times of fertilizers applied through the irrigation system. This involved checking, repairing, and calibrating all sensors and sampling devices in the experimental plot.

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."*

Report on FY2007 Risks and Effects Milestones

GOAL: Determine how changes in contaminant speciation influence dose-response and toxicity relationships.

Determination of Contaminant Concentrations within Aquatic Biota from Fourmile Creek near H and F Areas and Potential Risks to Piscivorous Wildlife and Humans

Investigators: A. Larry Bryan and John C. Seaman

The Fourmile Creek drainage near H and F areas has a history of contamination by radiocesium (^{137}Cs), tritium, mercury and other contaminants through direct release into this stream and migration via groundwater from area seepage basins down gradient to the drainage. Contaminated groundwater reaches the surface before entering the creek at the seepline located at the transition of upland and wetland vegetation associated with the creek. Earlier monitoring studies have documented the movement of these contaminants to Fourmile Creek water and sediments and, to a lesser extent, into biota, but potential risks to piscivorous wildlife have not been assessed. We conducted a one-year study of aquatic biota within the Fourmile Creek area impacted by H and F areas to document contaminant levels and determine potential risks to piscivorous wildlife and possibly humans. We sampled biota along the Fourmile Creek gradient to include locations above, adjacent to, and below the impacted areas (F & H areas). Beaver impoundments were selected as sampling locations, allowing comparison with existing data (fish Hg concentrations) from impoundments on other drainages on the SRS. Biota included an invertebrate (crayfish) and fish species of different trophic levels to examine effects of trophic position. The project focused on mercury, other metals, radiocesium, and tritium. Data collected here will provide contaminant information for risk assessments incorporating trophic transfers and can be used in existing receptor species models of piscivorous wildlife (wading birds/wood storks, river otters, etc.). Concentrations from larger fish can be used to assess human health risks.

To date, all samples have been collected and analyzed for the various contaminants. These data are currently being analyzed relative to position along the Fourmile gradient and existing contaminant databases from aquatic prey of other on-site locations.

Factors Affecting Metal Concentration Variation in Fish Species Along the Tims Branch Gradient

Investigators: A. Larry Bryan and Christopher S. Romanek

Historical inputs from the M-area facility into the Tims Branch/Steed Pond drainage resulted in extensive contamination of this drainage by uranium (U), nickel (Ni), and, to a lesser extent, other metals. Ni and U are typically linked to sediments, but conditions and/or events within the riparian corridor can affect how aquatic biota accumulates these elements. The presence of beaver ponds on this drainage (and the historical Steed Pond site) provides landscape features that may impact contamination bioavailability by

altering the wetland/chemical processes within this riparian system. Such impoundments can be managed (removal or additions of artificial impoundments) depending on their possible impacts.

A preliminary assessment of contaminants in fish occurred at four locations on Tims Branch in 2001. This assessment suggested two contaminants (Ni and U) were present in more highly elevated concentrations in the Steeds Pond site than in the lower stream reaches, but downstream concentrations varied by element, habitat type, and fish species, particularly for Ni. Nickel concentrations were elevated in the downstream beaver pond and/or the old Pond 25 site for some species. Also, in 2005, as part of an overall evaluation of mercury (Hg) in beaver ponds, fish were collected from two beaver impoundments on Tims Branch and analyzed for Hg. Comparison of Hg concentrations in three species in one of these ponds between years (2001 vs. 2005) indicated a three-fold increase in Hg in fish collected during 2005, suggesting other conditions/events were impacting wetland processes affecting annual concentrations for this element.

To examine the potential impacts of landscape features within Tims Branch on contaminant levels in aquatic prey, we collected prey in four beaver ponds and five adjacent stream reaches and analyzed them for Hg and other metals. Specifically, we examined contaminant concentrations along the Tims Branch gradient, compared concentrations in prey from impounded waters and from flowing waters, compared metal concentrations in fish in this study to the two aforementioned preliminary studies (including analysis of the 2005 fish for Ni, U and other metals) to examine accumulation over time, and utilized stable isotope analyses to assess trophic position of biota within different stream habitats relative to accumulation. Such studies will determine the impacts of historical contamination on accumulation of metals by fish, document possible changes in accumulation over time for some locations, and allow better determination of whether or not the Tims Branch system poses threats to piscivorous wildlife. Additionally, if impoundments are found to affect contaminant concentration levels, they may influence management/ remediation of this aquatic system (e.g., addition or removal of impoundments). These data (metals concentrations and stable isotope values for aquatic biota) will be a contribution to a future large-scale trophic level assessment of this ecosystem.

To date, all aquatic prey have been collected and analyzed for mercury and other metals. Stable isotope analysis will be completed shortly and statistical analysis relative to gradient position, impounded vs. flowing waters, prey trophic position, and historical concentrations is on-going.

Transgenerational Effects of Chronic Low-Dose Irradiation in a Medaka Fish Model System

Investigators: Travis C. Glenn, Thomas G. Hinton, and Olga V. Tsyusko

The overall goal of this project is to gain an understanding of how gene activity and mutations in microsatellite DNA occur, using a promising model organism [Japanese Medaka fish (*Oryzias latipes*)], in response to low doses of radiation delivered either: a) to parent fish and not offspring; or b) continuously throughout a number of progeny generations. Additionally, we are interested in how the genetic responses relate to effects at higher levels of biological organization.

We are now exposing the fifth generation of medaka to chronic irradiation in the Low-Dose Rate Irradiation Facility (LoDIF) at SREL. The founding generation (G0) was initiated to the radiation exposures as subadults, subsequently matured and produced the next generation, G1. All generations since the founders (G_1 through G_4) have been chronically exposed to irradiation from eggs through reproductive adults. Representative cohorts of the generations have been periodically pulled from the LoDIF and sent to Colorado State University for genetic analysis including analysis of DNA damage. Studies on markers for mutations in microsatellite DNA from irradiated medaka are being conducted at SREL, and cohorts of irradiated fish have also been used in controlled breeding trials at SREL.

At CSU, we have conducted mechanistic studies to define the relationship between specific DNA damage (8-hydroxydeoxyguanosine, double-strand breaks) and the gene products that are known to act on this damage. As expected, based on the data from previously published studies, cellular factors that

participate in cellular response to double-strand DNA damage via the NHEJ (non-homologous end joining) pathway are post-translationally regulated and show flat mRNA level curves after irradiation. These data help us confirm that medaka exhibits a response to oxidative DNA damage similar to higher organisms.

In order to examine the effects of transgenerational chronic low-dose irradiation on DNA damage, we are studying the yields of DNA double-strand breaks (DSB) in liver and muscle tissue of medaka fish. Our initial goal is to obtain dose-response curves and compare the yields of DNA DSB formed in chronically irradiated G0 fish and chronically transgenerationally irradiated G1 fish. We chronically exposed young adult (~4 month) medaka (G0) in the LoDIF to three different dose rates (1.1, 10, and 100 mGy/day). The total doses for chronic irradiation were 0.2cGy (control), 4 and 38 cGy. Another group of specimens were bred in order to obtain next generation (G1) fish. The G1 fish were chronically irradiated through the embryogenesis stage and until they attained the age of 4 months. The irradiation regime was similar to that described above. The total doses for the G1 group under chronic irradiation were 0.1 cGy (control), 3 and 26 cGy. The data show that the dose dependencies of unrepaired DSB in muscle tissue are linear for both G0 and G1 groups. In addition, the data points obtained for G0 and G1 fish fall on the same line, suggesting that the level of DSB in the G1 group is similar to the level in the G0 group for all radiation doses studied. In contrast, for liver tissue the dose dependence of unrepaired DSB for the G1 group shows a higher radiation yield of the DNA damage compared with the G0 group, and suggests that a transgenerational effect is being observed. These experiments are being repeated.

An additional study was designed to determine if radiation's effects on mutation rate are immediate, or delayed. Eight pairs of medaka were bred and their pre-exposed offspring collected. Pairs were then exposed acutely to two doses of either 0.1 or 0.5 Gy of ionizing radiation using a Co-60 source. Pairs were bred and eggs subsequently collected at 3 stages of spermatogenesis: 1-3, 5-9 and 30-40 days post-irradiation. Two months after the initial dose of radiation (after two full cycles of spermatogenesis) the same exposed males were mated with new unexposed females where offspring were also collected. An additional two control pairs never exposed to radiation, but served as sham-exposure controls and were maintained and bred under the same conditions as the experimental fish. Eggs were collected and hatched from all pairs at five time points (pre-irradiation and, 1-3, 5-9, 30-40 and 60+ days post-irradiation). DNA was extracted from all control and experimental families from one-day old hatchlings (45 to 120 per family) using a Chelex method (Sweet et al., 1996)., Nine microsatellite markers (Tsyusko et al., 2007) were used to amplify microsatellite regions of the extracted DNA from all parents and offspring. Parental and non-parental alleles were tallied at all loci and mutation rates estimated and analyzed using a repeated measures ANOVA.

Although there was a large difference in background mutation rates among families, as seen in previous analyses, there was a significant increase in the overall mutation rate of exposed versus control offspring. Interestingly, where offspring were available for all time points, 5 of 6 families display a pattern of increased mutation rate over time. Although the overall effect can be seen in both exposure rates, the effects on the mutation rate are more highly variable in the higher exposure. The results to date suggest that the impact of radiation may increase over time, with the more deleterious effects delayed farther than originally thought. Previous studies using mice (Dubrova et al., 2002) demonstrated persistence of the mutation rates in the consequent generations but the current study is the first one that showed unexpected increase in mutation rates in the same individual families after two full cycles of spermatogenesis.

Also during this funding cycle, we continuously irradiated medaka fish in their early developmental stages through sexual maturity, and then examined survival rate, breeding productivity, and mass of testes (one of the most radiosensitive organs) within the irradiated generation (G0), as well as survival and malformation rate in the next, unexposed generation (G1). Furthermore, a radiation sensitive mutant strain, previously isolated by ENU mutagenesis, was examined along with a wild-type strain. A draft paper of this research has been completed. The research is important because it shows that acute and chronic exposure regimes result in different responses that are quantifiable at higher level endpoints (fecundity and fertility) than the molecular ones assayed by Kovalchuck et al. (2004). Our results show that responses from low dose irradiation are dependent on exposure regime, and are indeed measurable in

reproductive characteristics that might ultimately impact a population's viability. More broadly, our results emphasize the futility of extrapolating results derived from acute exposures to animals exposed under chronic conditions; the huge uncertainties of such extrapolations are unacceptable.

GOAL: Determine the potential effects and interactions from exposure to mixed contaminants.

Determine the Impacts of Metal Contamination on Microbial Communities.

Investigator: J Vaun McArthur

There is growing concern that metal contamination acts as a selective agent in the attenuation and proliferation of antibiotic resistance. Of particular concern, metal contamination may represent a recalcitrant and globally distributed selection pressure. *Vibrio vulnificus* is a serious opportunistic human pathogen commonly found in subtropical coastal waters, and is the leading cause of seafood-borne mortality in the USA. This taxon does not sustain prolonged presence in clinical or agricultural settings, where it would undergo human-induced selection for antibiotic resistance. Therefore, few studies have verified the effectiveness of commonly prescribed antibiotics in *V. vulnificus* treatment. Here we screened 151 coastal isolates and 10 primary septicaemia isolates against 26 antimicrobial agents representing diverse modes of action. The frequency of multiple resistances to antibiotics from all sources was unexpectedly high, particularly during summer months, and a substantial proportion of isolates (17.3%) were resistant to 8 or more antimicrobial agents. Numerous isolates demonstrated resistance to antibiotics routinely prescribed for *V. vulnificus* infections, such as doxycycline, tetracycline, aminoglycosides and cephalosporins. These resistances were detected at similar frequencies in virulent and non-virulent strains (RAPD-based virulence typing) and were present in septicaemia isolates, underlying the public health implications of our findings. Among environmental isolates, there were no consistent differences in the frequency of resistance between pristine and anthropogenically impacted estuaries, suggesting natural rather than human-derived sources of resistance traits. This report is the first to demonstrate prevalent antibiotic resistance in a human pathogen with no clinical reservoirs, implying the importance of environmental studies in understanding the spread, evolution and public health relevance of antibiotic resistance factors.

Effects of Low-Dose Rate Ionizing Radiation on Frogs and Toads

Investigator: Thomas G. Hinton

This research was designed to test whether the proposed dose rate limits for non-human biota, recommended by the International Atomic Energy Agency, were applicable to amphibians. Basically, no radiation treatment effects were observed at exposures that exceeded the guideline by an order of magnitude. Only the density of animals influenced the measured endpoints, and it had profound and obvious impact. This research was primarily conducted by Karolina Stark, Ph.D. student from the University of Stockholm, Sweden.

Assess the Influence of Nickel and Uranium on TCE Degradation by Bacteria.

Investigator: Paul M. Bertsch

Hydroxyl apatite (HA) has been shown to effectively immobilize a number of contaminant metals and metalloids. Our studies have been focused on evaluating the effectiveness of HA as an in situ method for remediating riparian zones along the Tims Branch system heavily contaminated with Uranium, Nickel and other metals. Of particular interest is toxicity of these metals to microorganisms that would normally be involved in the degradation of the co-contaminant TCE that is beginning to outcrop in the riparian zones. We have previously demonstrated that Ni is toxic to a number of key microorganisms in these sediments. Using the constitutive TCE degrader, *Burkholderia veitnamensis*, we have demonstrated that HA additions reduce or eliminate toxicity and facilitate TCE degradation at Ni concentrations indicative of Tims Branch contamination levels. Additional studies to be conducted in contaminated Tims Branch sediments had to be cancelled due to lack of funding.

Publications:

Van Nostrand, Joy D., Tatiana J. Khijniak, Benjamin Neely, M. Abdus Sattar, Andrew G, Sowder, Gary Mills, Paul M. Bertsch and Pamela J. Morris. 2007. Reduction of Nickel and Uranium Toxicity and Enhanced Trichloroethylene Degradation to *Burkholderia vietnamiensis* Pr1301 with Hydroxyl apatite Amendment. Environmental Science and Technology. Environ. Sci. Technol. 41:1877-1882

Van Nostrand, J.D.,T.V. Khijniak, T.J. Gentry, M.T. Novak, A.G. Sowder, J.Z. Zhou, P. M. Bertsch and P.J. Morris. 2007. Isolation and Characterization of Four Gram-Positive Nickel-Tolerant Microorganisms from Contaminated Sediments. Microbial Ecology 53:670-682.

GOAL: Define more clearly the risks from low dose-rate, chronic exposure to radiation.

Radiation-induced Untargeted Germline Mutations in Japanese Medaka

Investigators: Tom M. Hinton and Travis C. Glenn

The report has been merged with "Transgenerational Effects of Chronic Low-Dose Irradiation in a Medaka Fish Model System" section in the Ecological Risks and Effects research theme.

REMEDIATION AND RESTORATION

The knowledge and expertise based 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.

Report on FY2007 Remediation and Restoration Milestones

GOAL: Identify the traits of native species and populations that best determine their suitability for use in remediation and restoration.

Evaluation of Native Plants Most Successful in Restoration of Carolina Bays

Investigator: Rebecca R. Sharitz

Merged with '"Revegetation Success in Restorations of Small Carolina Bay Depressional Wetlands" section found the in the Environmental Characterization' research theme.

Survival and Growth of Sandhills TES Plant Species Under Different Land Management Regimes

Investigator: Rebecca R. Sharitz

Sandhills and related xeric forests that occur along the Fall Line region of the southeastern Coastal Plain contain a suite of threatened, endangered and sensitive (TES) plant species. The responses of these TES plants to habitat disturbances are not known, and forest management practices in this region have the potential to destroy populations, causing them to become even rarer. Conservation of these TES species requires an understanding of their responses to specific disturbance conditions, and their potential for transplantation from highly disturbed to less disturbed sites. The effects of disturbance associated with forest management and military training activities (as occur on numerous Department of Defense installations along the Fall Line), are being evaluated in an experimental study leveraged by funds from the Strategic Environmental Research and Development Program (SERDP). Twelve experimental gardens were established in spring 2005 to mimic high disturbance (motorized vehicle use, burning or mechanical forest understory removal), low disturbance (foot traffic, foxhole digging), and no disturbance. Four perennial sandhills TES –*Baptisia lanceolata* (lance-leaf wild indigo), *Carphephorus bellidifolius* (sandywoods chaffhead)*, Nolina georgiana* (Georgia beargrass)*, Stylisma pickeringii*) (Pickering's dawnflower) – were selected for planting because their life forms are characteristic of many of the sandhills TES plants.

At the end of the first growing season, overall survival of the four species ranged from 10% to 65%. The highest survival occurred in the most highly disturbed experimental sites that mimicked motorized vehicle training. However, the four species differed in response to the disturbance treatments. *Baptisia* and *Carphephorus* had higher survival in the most highly disturbed sites, *Nolina* survived best in the undisturbed sites, and *Stylisma* faired equally well across all treatments. All species had higher growth rates in the more open canopy areas of the highly disturbed sites.

By the fall of 2007, three of the four TES species were in a reproductive state. *Baptisia lanceolata* and *Stylisma pickeringii* were producing seed in only the most highly disturbed gardens. *Carphephorus bellidifolius* was flowering extensively in gardens across the range of disturbance treatments. *Nolina georgiana*, which requires several years to reach reproductive maturity, was not yet producing seeds, but *Nolina* plants were growing larger in the more highly disturbed gardens. Continued sampling of these

experimental populations is needed and planned for a full assessment of the individual species' survival and reproductive success across the range of disturbances. This information will be valuable to resource managers at federal installations along the Fall Line.

Studies on Plant Species Most Useful for Phytoremediation

Investigator: Lee A. Newman

We have completed several studies looking at native species of plants to determine those with the best suitability for both remediation and restoration purposes.

We have an article accepted for publication in the International Journal of Phytoremediation on the study that examined native SE deciduous trees and compared them to a remediation standard, the hybrid poplar. We found that sweet gum trees are comparable to poplar in both volumes of water/ contaminant uptake and metabolic potential. The native willow species did poorly and displayed a toxic response to the trichloroethylene (TCE) not seen in the other species.

We have a second article accepted for publication in the International Journal of Phytoremediation on the study looking at native SE coniferous trees and comparing the rapidly growing Leyland cypress to hybrid poplar. None of these trees had the water/contaminant uptake potential of the poplar, but the longleaf pine seemed to be quite competent at metabolizing the TCE.

These two studies show that native plants have equal potential for uptake and degradation of TCE. While the coniferous trees do not have the water uptake potential, they have the advantage of being active year round.

We have also studied switch cane, a native grass species used for streamside restoration and *Arundo donax*, a non-native that is useful for biofuel production. Both plants showed the ability to take up and metabolize TCE into expected metabolites within the leaf tissue. We will be submitting a manuscript on this study by May 2008.

Studies of Plant Species Useful for Biodiesel Production in the Southeast

Investigator: Lee A. Newman

We have grown several species of plants, including Brassica, sunflower, soybean, and castor bean using three fertilizer regimes to determine the best plant/fertilizer to produce biodiesel. We used native soil, conventional fertilizer, or biosolids for the fertilizer, and so far all plants have responded best with the biosolids. This would allow for the use of a waste product for the production of fuel. We have also determined that the species of sunflower used is important, and there is a susceptibility to fungal infections in humid climates. The plants were all harvested and the tissue dried. It was determined that the castor bean produced the most biomass of the plants tested, and also produced the largest mass of seed for oil production.

We are currently looking for other funding sources to do a second year study on these crops to confirm the findings, and to do analysis of the oil from the different seeds.

Studies of Nitrogen-fixing Plant Species for Phytoremediation

Investigator: Lee A. Newman

During the summer 2007, we had two undergraduate REU students work on a project looking at TCE uptake and degradation by nitrogen fixing plants. We looked at *Crotalaria*, *Sesbania* and *Mimosa* plants exposed to trichloroethylene, and compared metabolite formation in leaves, roots and root nodules. Both the *Mimosa* and the *Crotalaria* had increased concentrations of metabolites in the nodules compared to the bulk roots, while the *Sesbania* had decreased concentrations of metabolites in the nodules. This may be due to the fact that different bacterial species form nodules in each of these plants. We are currently

working with researchers at the University of Missouri Rolla to isolate the bacteria, and test each for their abilities to degrade TCE.

Studies of the Applicability of Using Hyperspectral Imaging for Solvent Plume Delineation

Investigator: Lee A. Newman

There is a need to develop less expensive and less intrusive ways to determine the extent of plume migration for chlorinated solvent contamination. We examined the possibility of using hyperspectral imaging of leaves to determine if they have been in contact with contaminated groundwater. This work involved greenhouse control exposures and imaging, as well as field sampling at Marshall Space Center.

This work was primarily funded by NASA, with funding for a technician to assist on the project coming from DOE. This work has shown that it is possible to distinguish between exposed and non-exposed plant leaves using the hyperspectral analysis. This work is being continued through NASA funding.

Studies on the Use of Endophytic Bacteria to Increase Biomass Production for Biofuels

Investigator: Lee A. Newman

The need to switch away from fossil fuels to bio-based fuel systems has become of great interest in this country. However, the use of cropland for the production of biomass has the potential to have a severe negative impact on food production. Therefore, the use of marginal lands to produce biomass in the form of short rotation woody crops is a viable alternative.

Dr. Daniel van der Lelie at Brookhaven National Laboratory has identified several strains of endophytic bacteria that, in greenhouse studies, increased the rooting and growth of the hybrid poplar line DN-34.

In our collaboration with Dr. van der Lelie, we used several of the stains to inoculate the hybrid poplar line OP-367. We examined these plants for increased growth, and changes in the formation of metabolites when the plants are exposed to chlorinated solvents.

We saw the same increases in growth rate in the greenhouse, and there were intriguing changes in metabolite profiles of the TCE exposed plants. We are currently analyzing the data and are in the process of writing up the results of this work.

We also worked with Dr. Mark Coleman of the USFS on the SRS, and did field growth studies of poplar OP-367, 15-029, and two strains of native willow inoculated with the most promising of the growth enhancing endophytes. The trees were harvested, and we are in the process of analyzing the data to determine if the increases in growth observed in the greenhouse also translate into increased growth under field conditions.

GOAL: Determine the primary mechanisms by which natural attenuation and engineered remediation processes immobilize contaminants, and identify the appropriate geochemical and biological endpoints to assess sustainability

Effectiveness of Hydroxyl Apatite Amendments on TCE Degradation by Microbes

Investigator: Paul M. Bertsch

This research is described as part of the following project, “Assess the influence of nickel and uranium on TCE degradation by bacteria,” in the Ecological Risks and Effects research theme.

Analyses of Field-Scale Tracer Data from H-Area Subsurface Injections Experiments

Investigator: John C. Seaman

Hydrodynamic dispersion is an important factor controlling contaminant migration in the subsurface environment. However, few comprehensive three-dimensional data sets exist for critically evaluating the impact of travel distance and site heterogeneity on solute dispersion, and the conservative nature of several commonly used groundwater tracers is still in question. Therefore, a series of field-scale experiments using tritiated water and bromide (Br) as tracers was conducted in the water-table aquifer on the SRS. For each experiment, tracer-free groundwater was injected for approximately 24 h (56.7 L min^{-1}) to establish a steady-state forced radial gradient prior to the introduction of a tracer pulse. After the tracer pulse that lasted from 256 to 560 min, the forced gradient was maintained throughout the experiment using non-labeled groundwater. Tracer migration was monitored using six multi-level monitoring wells radially spaced at approximate distances of 2.0-, 3.0-, and 4.5-m from the central injection well. Each sampling well was further divided into three discrete sampling depths that were pumped continuously (≈ 0.1 L min^{-1}) throughout the course of the experiments. Longitudinal dispersivity (α_L) and travel times for tritium breakthrough were estimated by fitting the field data to analytical approximations of the advection-dispersion equation (ADE) for uniform and radial flow conditions.

Dispersivity varied greatly between wells located at similar transport distances and even between zones within a given well, which was attributed to variability in the hydraulic conductivity at the study site. The radial flow equation generally described tritium breakthrough better than the uniform flow solution, as indicated by the coefficient of determination, r^2, yielding lower α_L while accounting for breakthrough tailing inherent to radial flow conditions. Multiple-peak breakthrough patterns were observed within certain sampling zones, indicative of multiple major flow paths and the superposition of resulting breakthrough curves. A strong correlation between α_L and arrival times was observed from one experiment to the next, indicative of the general reproducibility of the tracer results. Moment analysis was used to evaluate tracer migration rate as an indicator of variations in hydraulic conductivity and flow velocity, as well as mass recovery and retardation for the ionic solutes compared to tritiated water. Retardation factors for Br^- ranged from 0.99 to 1.67 with no clear trend with respect to transport distance; however, Br^- mass recovery decreased with distance, suggesting that the retardation values are biased in terms of early arrival because of limited detection and an insufficient monitoring duration. Anion retardation was attributed to sorption by Fe oxides. The assumption of conservative behavior for the anionic tracers would generally result in higher α_L values and lower estimated flow velocities.

RESEARCH SUPPORT PROGRAMS

Several SREL programs provide critical support to the research, outreach, and education missions of the Laboratory. These support programs include:

Environmental Health and Safety Program
Quality Assurance Program
Research Data Archive Activities
SREL Undergraduate and Graduate Education Programs
Environmental Outreach Program
DOE Research Set-Aside Areas

Environmental Health and Safety (EH&S) Program

Donald R. Mosser, SREL EH&S Manager

The Savannah River Ecology Laboratory (SREL) continues to operate successfully under the work-smart safety and environmental standards that resulted from SREL's participation in U.S. Department of Energy's (DOE) Necessary and Sufficient process. These standards continue to address the hazards associated with SREL operations by permitting a focused effort on the health and safety issues most pertinent to SREL operations. SREL supports and promotes an integrated approach to SRS environmental health and safety issues as a signatory to the SRS Workplace Safety, Health and Security Policy and the SRS Environmental Management System Policy Statement.

SREL maintains a commitment of one, full-time position (SREL EH&S Manager) dedicated to the support of the SREL EH&S Program. Also several laboratory research technicians also provide support to the SREL EH&S Program by serving as laboratory Chemical Coordinators. Chemical Coordinators are responsible for maintaining chemical inventory information and providing support in the identification, accumulation, and storage of hazardous wastes.

In an effort to increase the efficiency and effectiveness of the SREL EH&S Program, an emphasis continues to be placed on safety and environmental training of SREL personnel. All new SREL personnel receive a two-hour 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 job specific safety training provided for by their SREL supervisor. Approximately 28 new SREL personnel received this required training during FY2007. Additionally, SREL personnel received EH&S related training during FY2007 in the following functional areas as their job tasks required:

Chemical Coordinator Training – chemical inventories and hazardous waste generation and management

Radiological Training – Radiological Worker Training, Radioactive Sealed Source User Training, and Radiation Generating Device training

Remote worker training in accordance with SRS remote worker requirements

Hazardous Waste Management (RCRA) Training for workers responsible for handling or storage of hazardous wastes

Georgia Right-To-Know Law (GRTK- HAZCOM equivalent) chemical specific training for UGA/SREL employees who utilize hazardous chemicals in the work place

SREL's internal computer network was used to provide targeted safety information to specific groups in the laboratory. Approximately 29 targeted Lessons Learned bulletins were distributed to SREL personnel during FY2007. Additionally, relevant SRS environmental health and safety information and bulletins distributed by the SRS e-mail system were reviewed and forwarded to SREL personnel as required. The SREL EH&S Manager functions as an interface with other SRS organizations in receiving and distributing applicable 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.

The SREL EH&S Manager reviewed and approved approximately 200 hazardous chemical procurement requests for hazard potential identification and waste minimization efforts. Waste minimization and chemical disposal issues continue to be emphasized to increase efficiency and cost effectiveness. Waste minimization techniques such as source reduction and bench-top treatment continue to be incorporated into experimental protocols, reducing the burden associated with waste disposal procedures while supporting SREL's pollution prevention efforts. Although SREL generated small amounts of hazardous wastes in FY2007, no hazardous waste shipments occurred during this year due to changes in WSRC

hazardous waste disposal processes, such as the discontinuation and centralization of SRS Labpack waste shipments.

Due to DOE budgetary reductions during FY2007 for SREL, the University of Georgia (UGA) communicated to DOE their intent to reduce SREL operations and facilities on the SRS. In support of those reductions, the SREL EH&S Manager conducted an assessment of all potential SREL hazardous, radioactive, or mixed wastes that would likely be generated during FY2008 as the result of ongoing SREL facility consolidation or closure. SREL maintains an ongoing dialogue with DOE-SR officials and WSRC Waste Division personnel regarding support and priorities for SREL's anticipated waste disposition.

The SREL EH&S Manager provided weekly reports of recordable personnel accidents or injuries to DOE-SR line management. SREL also provided monthly SREL personnel work hour statistics to DOE-SR. SREL personnel reported no recordable work related injuries/illnesses during FY2007. This represents a significant decrease from the four recordable injuries reported during FY2006. However, this decrease may be attributable to significant reductions in funded work tasks and subsequent SREL work force reductions which occurred during FY2007.

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. SREL also participated in the SRS's annual, comprehensive review and declaration process for Integrated Safety Management Systems (ISMS). As part of the annual ISMS declaration, SREL revised its Integrated Safety Management System Description Document, reviewed its FY2007 safety performance, and established its FY2008 safety performance goals. SREL received no Notices of Violation in FY2007 as the result of external or internal reviews, inspections, or assessments.

Quality Assurance Program

SREL has continued to maintain a formal, U.S. Department of Energy (DOE)-approved Quality Assurance (QA) program. The program is devoted to assuring the continuing quality of SREL research. These SREL "Good Research Practices" highlight research concepts and context, research logistics, and the conduct of research and are available to all SREL personnel on the Lab's intranet web site. All new Laboratory research personnel are required to familiarize themselves with this material prior to beginning work at SREL.

Research Data Archive Activities

Responsible management of research data holdings plays an important role in preserving the SREL's corporate memory. Since 1989, SREL has been actively building a centralized repository of research data files and the associated "metadata" necessary to make these data fully accessible. The goals of SREL's Research Data Archive activity are to avoid the inadvertent loss of data and to use advanced electronic computer/communication technology, including the use of computer networks and the Internet, to provide access to important data as efficiently as possible. Inclusion of new and historical research information into the SREL data archives continued during FY07 and the Central Archive Data Repository now has information covering over 521 separate studies containing 1,678 data files.

The web-based SREL data archive system that allows users to upload metadata information and actual data files directly from their office desktop computers continued to work well during FY07. Anyone at SREL or on the SRS can search for data using this new web-based system; however, decisions about releasing original data to third parties are retained by the principal investigators.

SREL Undergraduate and Graduate Education Program

Travis C. Glenn

The objectives of the SREL Education Program are to (1) recruit and develop additional professionals to the environmental sciences, with an emphasis on recruitment from under-represented minority groups, and (2) enhance environmental awareness and research opportunities among undergraduate and graduate students with emphasis on conducting ecological research important to the Savannah River Site mission. Undergraduate and graduate student participants in FY07 are listed in Table 1 and 2, respectively.

The SREL Education Program has a long history of training undergraduate students. Undergraduate students from more than 275 different colleges and universities have coauthored more than 150 peer reviewed research publications and more than 200 of these students have gone on to pursue careers in science. The Research Experience for Undergraduates (REU) program, funded by the National Science Foundation, sponsored six students this past year.

SREL also has a long history of funding graduates students. Since 1967, an average of six students per year has completed graduate studies at SREL, resulting in a total of more than 325 dissertations and theses. During FY07 four Ph.D. students completed their degree requirements (Table 3). Since 1985, our graduate students have won over 200 awards from regional, national, and international competitions at numerous professional societies and foundations. During the past Year, SREL graduate students continued to compete successfully for various national and regional awards. Some of these are listed in the section on Special Accomplishments.

Due to changes in funding and reduced faculty and support staff levels, the SREL education program has undergone significant reorganization in FY07. All graduate students were transitioned to the domain of departments at their home institutions. SREL hosted a full group of NSF REU students, and plans to host a smaller group in FY08 on funds left from FY07, as submission for the renewal of the REU program was postponed for one year. Assuming we are successful in the renewal, the REU program should return to its 2007 or 2006 level by FY09.

Table 1. SREL Undergraduate Student Program Participants

Student	Academic Institution	Faculty Advisor
Jonah Butler	New College, Florida	Lee Newman
Michael Najarro	University of California, Santa Cruz	J Vaun McArthur
Luis Matos Rodriguez	University of Puerto Rico, Ponce	Travis Glenn/Olga Tsyusko
Christopher Schalk	State University of New York	J. Whitfield Gibbons/Thomas Luhring
Martina Tam	Seattle University, Washington	Lee Newman
Rose Roman Torres	University of Puerto Rico, Mayaguez	Andrew Neal
Kaitlin Wagner	Boston College, Massachusetts	Travis Glenn/Olga Tsyusko
Alison Willis	Antioch College, Ohio	Jason Unrine

Table 2. SREL Graduate Student Program Participants

Student	Degree	Institution	Faculty Advisor
Kimberly Andrews	Ph.D.	University of Georgia, Athens	J. W. Gibbons
Ellen Breazel	Ph.D.	University of Georgia, Athens	T. C. Glenn
Elizabeth Burgess	Ph.D.	University of Georgia, Athens	A. L. Neal
Monica Carroll	Ph.D.	University of Georgia, Athens	C. S. Romanek
Dana Cook	Ph.D.	University of Georgia, Athens	A. L. Neal
Jaclin DuRant	M.S.	University of Georgia, Athens	R. R. Sharitz
William Duval	Ph.D.	University of Georgia, Athens	R. R. Sharitz
Julie Fiser	M.S.	University of Georgia, Athens	C. S. Romanek
Aaliyah Green	M.S.	University of Georgia, Athens	J. W. Gibbons/C. S. Romanek
Ma Hongbo	Ph.D.	University of Georgia, Athens	T. C. Glenn/P. M. Bertsch
Matthew Jarrett	M.S.	University of Georgia, Athens	C. S. Romanek
Takeshi Katoh	M. S.	Colorado State University, Ft. Collins	T. G. Hinton
Linda Lee	M.S.	University of Georgia, Athens	R. R. Sharitz
Thomas Luhring	M.S.	University of Georgia, Athens	J. W. Gibbons
Frantisek Majs	Ph.D.	University of Georgia, Athens	J. C. Seaman
Lucas Odum	M.S.	University of South Carolina, Columbia	L. Newman
Julian Singer	Ph.D.	University of Georgia, Athens	J. C. Seaman
Brian Todd	Ph.D.	University of Georgia, Athens	J. W. Gibbons
Tracey Tuberville	Ph.D.	University of Georgia, Athens	J. W. Gibbons
John Willson	Ph.D.	University of Georgia, Athens	J. W. Gibbons
Christopher Winne	Ph.D.	University of Georgia, Athens	J. W. Gibbons
Meredith Wright	Ph.D.	University of Georgia, Athens	J V. McArthur
Qi Ye	Ph.D.	University of Georgia, Athens	C. L. Zhang
Weidong Zhao	Ph.D.	University of Georgia, Athens	C. L. Zhang/ C. S. Romanek

Table 3. SREL Graduate Students Completing Degree Requirements in FY07:

Student	Degree	University	Faculty Advisor
Monica Carroll	Ph.D.	University of Georgia, Athens	C. S. Romanek
Karolina Stark	Ph.D.	University of Stockholm, Sweden	T. G. Hinton
Steven Stoddard	Ph.D.	University of Illinois	R. R. Sharitz
Meredith Wright	Ph.D.	University of Georgia, Athens	J Vaun McArthur

Environmental Outreach Program

J. Whitfield Gibbons

GOAL: Maintain public outreach and communication programs to enhance the public's understanding of environmental issues affecting the SRS and to increase general ecological awareness.

The Savannah River Ecology Laboratory (SREL) Outreach Program uses information from SREL research efforts to educate the public locally, regionally, and nationally. The Outreach Program is designed to enhance SREL's overall mission of acquiring and communicating environmental knowledge and highlight the U.S. Department of Energy's (DOE) focus on environmental issues. Issues as diverse as amphibian and reptile population declines, potential responses of organisms to contamination, distribution and abundance of sensitive species, monitored natural attenuation, and dispersal of organisms from radioactively or chemically contaminated sites all are important beyond SREL. Public education during FY07, especially for K-12 audiences, was accomplished through a variety of programs and materials, despite reduction in staff over the last two years to one full-time equivalent position. Personnel involved in the Outreach Program were mostly supported by the University of Georgia, revenue generated by talks and programs, and funding from DOE.

During the past year SREL scheduled 94 talks, 17 tours, 9 exhibits, and 25 workshops, reaching a total of 21,904 people. Topics for these presentations included reptiles, amphibians, southeastern plants and habitats, long-term research, safety, biodiversity, local wetlands and watersheds, conservation, and careers in ecology and research.

Student groups from 22 schools enjoyed field trips to the Laboratory's Conference Center to participate in the Ecologist-for-a-Day program.

Outreach programs include: *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; *Ecologist for a Day* visits allow 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; civic group presentations; and ecological tours. All school programs incorporate science standards and curricula for particular school districts. In many of these programs participants get an opportunity to work with SREL staff as they catch, mark, and measure various species of reptiles, amphibians, fish, small mammals, and invertebrates. In addition, the Outreach Program offers tours of SREL facilities, as well as exhibits and workshops for the general public.

During the past year SREL continued a watershed project funded by the Five-Star Restoration Matching Grants Program, administered by the National Fish and Wildlife Foundation (NFWF) and the U.S. Environmental Protection Agency (EPA). The grant, titled "Watershed Restoration and Education in Aiken County, South Carolina," is focused on restoring habitat in an Aiken County Open Land Trust (ACOLT) parcel. Community volunteers began removing invasive plant species at the project site in April 2006, and planted native species throughout 2006-2007. Watershed education included classroom presentations at local schools, teacher training, and an educational tri-fold flier.

The main SREL Outreach site (http:/ /www.uga.edu/srel/outreach.htm) receives numerous hits, as it has links to the popular *Ecologist for a Day* program, Outreach fact sheets and products, and the Ecoviews newspaper column. SREL also continues the website for *Kids Do Science* (www.kidsdoscience.org) that provides all the necessary materials for 10 hands-on activities developed as part of the hands-on science program with the AHF. This site is frequented by teachers from throughout the country who use the materials in their own classes.

SREL distributes thousands of copies of educational products and materials nationwide to schools, organizations, and the general public. Educational materials include two six-foot-long full-color posters describing the importance of wetlands to reptiles and amphibians, along with teachers' guides. The full-color brochure *Snakes of Georgia and South Carolina* (currently in its fifth printing) has proved to be an

extremely successful educational product that reflects positively on DOE and the SRS. The book has

been placed at no charge in every public library in Georgia and South Carolina and is also widely distributed at no cost to hospital emergency rooms, veterinary clinics, ambulance services, classrooms, scout leaders, and to various other organizations such as the Boys and Girls Clubs in Aiken and Augusta. Articles referencing the book have appeared in numerous newspapers and magazines including publications in Florida and Texas.

The Outreach Program also continued to distribute educational materials including fliers on *Carnivorous Plants and Their Habitats*; *An Amphibian's Eye View of Wetlands*; and *Is it a Water Moccasin?*; a children's comic book entitled *Stepping into Ecology: the Ecological Adventures of Mud E. Boot*; a sticker on *Chemistry – it's all about the nature of things*, and the *Metric System Rap* bookmark, as well as the numerous fact sheets available through the website. All of these products have been extremely popular and thousands of copies have been distributed during the past year. Previously created full-color fact sheets and research "snapshots" on a wide variety of research topics were distributed as well.

The Outreach Program continues to respond to inquiries from the press, directing reporters to the most appropriate researchers for their stories. In addition, SREL encourages researchers to initiate press contacts and submit research information to appropriate audiences. From 2006-07 SREL researchers provided information to such diverse outlets as the *SC Wildlife Magazine,* as well as local news outlets in the Southeast such as *The Aiken Standard, The Atlanta Journal-Constitution, The Augusta Chronicle, Bluffton Today, The Athens Banner-Herald, and The State.* Topics in the news included: animal behavior, SREL research specialties such as stable isotopes and 'extremophile' work, environmental analysis using high-tech instrumentation, environmental impacts related to contaminants, and SREL researcher profiles.

DOE Research Set-Aside Areas

Charles E. Davis

The SRS's Set-Aside Program began in the 1960s when the AEC established 10, relatively small *SREL Reserve Areas* to represent the various habitats on the SRP 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 UTRC, and to buffer SREL's long-term research from encroaching 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-Aside Areas are critical to the DOE's Environmental Stewardship mission: they provide for long-term study sites as well as sanctuary and protection for many of the SRS's sensitive flora and fauna species, as well as protection for many archaeological sites. They also serve as benchmarks or baseline controls for conducting ecological risk assessments, contaminant transport studies, and site remediation work. They exist today in strong support of the SRS being a National Environmental Research Park.

Administration and Management of the Set-Aside Areas

Under a Cooperative Agreement with the DOE, SREL serves as custodian for the 30 Set-Asides and provides day-to-day administration of the SRS Set-Aside Program, including boundary maintenance, developing and implementing stewardship management plans, Site Use coordination, and maintaining research and GIS databases. SREL chairs the DOE's Set-Aside Task Group which approves management prescriptions and ensures protection from on site land use activities. In recent years, the DOE's funding support for this program has diminished; however, SREL continues the day-to-day management and implementation of those management treatments in Set-Asides that have approved Site-Use Permits.

Management treatments in the form of silvicultural thinnings are prescribed for timber stands/vegetation types in various Set-Aside Areas to move overstocked plantation pine into a healthier, more natural plant

community that is more suitable to the soil and less likely to attract beetle infestation. It also reduces the potential for a damaging wildfire by reducing the fuel build up.

Accomplishments for the Set-Aside program for this FY include:

- Approximately 103 acres (41.7 ha) of the commercial SRS forest were added to the Set-Aside program this FY. These additions included 2 acres (.81 ha) from the Ruth Patrick/Meyer's Branch Set-Aside (Area No. 11), 22 acres (8.9 ha) from the Cypress Bay Set-Aside, which included 2 Carolina Bays one of which was Bay 93, the first research/restoration bays on the SRS. Also 79 acres (32 ha) was added to the Oak Hickory Forest (Area No. 12) and the E. P. Odum Wetland Set-Aside (Area No.30).
- The forest thinning treatment (17 acres; 6.9 ha) in the Rainbow Bay Set-Aside was accomplished. Approximately 268 CCF board feet of pine and hardwood pulpwood and saw timber was removed from the Set-Aside generating $10,962 in sales revenue for the DOE.
- The Craig's Pond Scientific Advisory requested a prescribed growing season burn for Craig Pond and SREL worked in cooperation with the USFS-SR and Chem-Nuclear to accomplish a late spring treatment.
- SREL released an updated version of the Set-Aside GIS boundary layer to Site Services to reflect administrative boundary changes.
- Prescribed winter season burning coordination continued between SREL and the USFS-SR to reduce potential impacts to Set-Asides.
- Members of the Set-Aside Task Group addressed potential erosion impact issues to the E. P. Odum Wetland Set-Aside (Reedy Branch area) that was associated with WSI/DOE authorizing timber removal that was to provide a vegetative buffer to the expansion of the ATTA range.
- SREL cleared interferences for 12 Site Use Permits for potential impacts to the Set-Aside Areas.
- SREL coordinated with SCE&G for vegetation ROW clearance. Ellenton Bay (Area No. 1), Risher Pond Set-Aside (Area No. 10), and Area No. 30 were treated.
- A new Pitcher plant population (*Sarracenia rubra*) was identified by the USFS-SR in the Ruth Patrick/Meyer's Branch Set-Aside (Area No. 11).

Research and* Outreach *in Set-Aside Areas

Long-term research continued in Set-Aside Areas this fiscal year using traditional study sites and reference sites for collections of uncontaminated plants, animals, soils, or water. SREL produced 21 publications that used Set-Asides, and a majority of these were devoted to amphibian research in depressional wetland Set-Asides. Studies were conducted in the Steel Creek Bay Set-Aside (Area No. 8) and Area No. 23 where aquatic vertebrates and invertebrates were sampled to look at seasonal activity levels, and tissue samples were collected from greater sirens for use in population genetics and for the development of a sex-linked marker. In Area No. 23, a mark-recapture population analysis is being conducted on greater siren and two-toed amphiuma using PIT tags. SREL continued its long-term amphibian community studies with daily sampling in the Rainbow Bay (Area No. 16) and Ginger's Bay (Area No. 19) Set-Asides. The Rainbow Bay study, the longest continuous amphibian study in the world, completed its 29th year; the Ginger's Bay study has been ongoing for 21 years. Data from these studies continue to be used to better understand salamander, frog, and toad survival patterns and population dynamics. Since the chytrid fungus has been reported on the SRS from several locales, an understanding of the factors that drive populations up and down will be increasingly important in years to come.

Select amphibian species at all Carolina bay Set-Asides are being sampled to help determine how genetically isolated populations are from one another. Combined with estimates of terrestrial distributions and movements of salamanders from the Ginger's Bay Set-Aside, these site-wide genetic data will allow researchers to model connections among wetlands and the likelihood of recovery from local extinctions.

Plant studies were also conducted in Set-Asides this fiscal year. Two Set-Asides (Areas No. 3 and 29) continued to be used as controls to evaluate impacts from military training and forest management on TES species. USFS-SR sponsored research used *Ilex* spp. cuttings from plants in the Craig Pond/Sarracenia Bay Set-Aside (Area No. 17). The cuttings will be used in a pollination study to support

the USFS-SR Corridor Study. Archaeologists with the USC-Savannah River Archaeologist Research Program continued their investigations at the Flamingo Bay Set-Aside this year.

SREL's Outreach program continued this fiscal year to focus on the E. P Odum Wetland (UTRC) when conducting Ecologist for a Day at the UGA Conference Center.

Externally Funded Grants

PI	Paul Bertsch
Project Title	Bioavailability, Toxicity and Trophic Transfer of Manufactured ZnO Nanoparticles: A View from the Bottom
Funding Agency	U.S. Environmental Protection Agency
Period	July 1, 2005—September 30, 2008
Budget	$363,680

PI	Paul Bertsch
Project Title	Watershed Restoration and Education in Aiken County, South Carolina
Funding Agency	National Fish and Wildlife Foundation
Period	October 1, 2005—September 30, 2007
Budget	$15,000

PI	I. Lehr Brisbin
Project Title	Ecological Studies of Birds in the Vicinity of the Augusta Regional Airport at Bush Field and the Messerly Wastewater Treatment Plant
Funding Agency	Augusta-Richmond County
Period	October 1, 2006—December 31, 2007
Budget	$96,065

PI	I. Lehr Brisbin
Project Title	UGA Foundation Canine Research
Funding Agency	UGA Foundation
Period	Open
Budget	$2,524

PI	Larry Bryan
Project Title	Determination of Wood Stork Breeding Success in Georgia
Funding Agency	U.S. Department of the Interior-FWS
Period	April 1, 2004—June 30, 2009
Budget	$46,666

PI	Larry Bryan
Project Title	Determination of Wood Stork Colony Breeding Success on Kings Bay Naval Submarine Base
Funding Agency	U.S. Department of the Interior-USFWS
Period	March 1, 2006—September 30, 2009
Budget	$8,414

PI	Larry Bryan
Project Title	Determination of Core Foraging Areas for Wood Stork Nesting Colonies in Northern Florida
Funding Agency	U.S. Department of the Interior-USFWS
Period	March 1, 2006—September 30, 2009
Budget	$30,000

PI	Larry Bryan
Project Title	Determination of Wood Stork Colony Breeding Success in Georgia and South Carolina in 2007
Funding Agency	U.S. Department of the Interior-USFWS
Period	April 1, 2006—September 20, 2009
Budget	$8,496

PI	Larry Bryan
Project Title	Contaminant Concentrations in Aquatic Biota from Four Mile Creek
Funding Agency	Washington Savannah River Company-SGCP
Period	October 1, 2006—September 30, 2007
Budget	$79,000

PI	Larry Bryan
Project Title	Factors Affecting Metal Concentrations and Variation in Fish Species along Tims Branch
Funding Agency	Washington Savannah River Company-SCCP
Period	October 1, 2006—September 30, 2007
Budget	$83,000

PI	Charles Davis
Project Title	Wildlife Literature Survey and GIS Database Update
Funding Agency	Washington Savannah River Company-SGCP
Period	October 1, 2006—September 30, 2007
Budget	$30,000

PI	Whit Gibbons
Project Title	Land Use Practices and Persistence of Amphibian Populations
Funding Agency	National Science Foundation
Period	May 15, 2003—April 30, 2009
Budget	$283,452

PI	Whit Gibbons
Project Title	Feasibility of Translocation as a Management Tool for Diamondback Rattlesnakes
Funding Agency	South Carolina Department of Natural Resources
Period	January 1, 2006—September 30, 2008
Budget	$96,000

PI	Whit Gibbons
Project Title	Wildlife Highway Crossing Study: Investigation of the Use of Highway Culverts by Wildlife
Funding Agency	U.S. Department of the Interior-USGS
Period	February 17, 2006—September 30, 2007
Budget	$74,939

PI	Whit Gibbons
Project Title	Website Maintenance and Scientific Oversight of the North American Reporting Center for Amphibian Malformations
Funding Agency	U.S. Department of the Interior-USGS
Period	April 1, 2006—December 31, 2008
Budget	$133,893

PI	Whit Gibbons
Project Title	Investigating Effects of Ecologically Conservative Residential Development on Snake Movement Patterns and Survivorship
Funding Agency	Palmetto Bluff Conservancy
Period	April 1, 2006—April 30, 2009
Budget	$75,000

PI	Whit Gibbons

Project Title	Development of Amphibian Monitoring Methodologies for the Gulf Coast Network
Funding Agency	Cooperative Ecosystem Studies Unit-Piedmont
Period	September 12, 2006—March 31, 2008
Budget	$81,000

PI	Whit Gibbons
Project Title	Modeling Extinction Risk of Native and Translocated Gopher Tortoise Populations: Developing a Decision Tree for Managing “At Risk” Populations
Funding Agency	U.S. Department of the Army
Period	April 27, 2006—September 30, 2007
Budget	$43,699

PI	Whit Gibbons
Project Title	Incidence of Chytrid Fungal Parasitism in Southeastern Parks
Funding Agency	Cooperative Ecosystem Studies Unit-Piedmont
Period	May 1, 2006—December 31, 2007
Budget	$31,243

PI	Whit Gibbons
Project Title	Herpetofaunal Habitat-Biodiversity Relationships in the D-Area Ash Basins
Funding Agency	Washington Savannah River Company-SGCP
Period	October 1, 2006—September 30, 2007
Budget	$60,000

PI	Whit Gibbons
Project Title	Ecology of the Gopher Tortoise (*Gopherus polyphemus*) in South Carolina’s Tillman Sand Ridge Heritage Preserve
Funding Agency	South Carolina Department of Natural Resources
Period	March 3, 2007—September 30, 2007
Budget	$8,000

PI	Travis Glenn
Project Title	Development of *Peromyscus* Genomics
Funding Agency	University of South Carolina
Period	August 1, 2004—July 31, 2008
Budget	$377,007

PI	Travis Glenn
Project Title	The Evolution of Heterostylous Breeding Systems in Populations of *Oxalis alpina* in the Sky Islands of the United States and Mexico
Funding Agency	National Science Foundation
Period	October 1, 2006—September 30, 2008
Budget	$95,299

PI	Travis Glenn
Project Title	The Evolution of Heterostylous Breeding Systems in Populations of *Oxalis alpina* in the Sky Islands of the United States and Mexico
Funding Agency	National Science Foundation
Period	October 2, 2006—September 30, 2007
Budget	$5,614

PI	Tom Hinton
Project Title	Transgeneration Effects from Chronic Low-Dose Irradiation in a Medaka Fish Model System
Funding Agency	Colorado State University-DOE
Period	July 1, 2005—June 30, 2008
Budget	$318,874

PI	Tom Hinton
Project Title	Estimation of Radioactive Contamination of Media and Terrestrial Biota at the Territories Adjoining Chernobyl NPP's Cooling Pond
Funding Agency	Civilian Research and Development Foundation
Period	August 1, 2007—July 31, 2009
Budget	$4,500

PI	Charles H. Jagoe
Project Title	REU-Effects of Energy Technologies on Environmental Systems
Funding Agency	National Science Foundation
Period	May 1, 2005–April 30, 2007
Budget	$175,400

PI	Robert Kennamer
Project Title	Cost of Incubation: Linking incubation-Induced Alterations in Phenotype to Changes in Fitness
Funding Agency	Virginia Polytechnic Institute
Period	January 1, 2007-August 31, 2008
Budget	$31,933

PI	J Vaun McArthur
Project Title	Fellowship for Meredith Wright: Transfer and Transport of Antibiotic Resistance
Funding Agency	US Environmental Protection Agency
Period	August 13, 2004–August 13, 2007
Budget	$19,859

PI	Ken McLeod
Project Title	Water Quality Studies at the A-01 and H-02 Constructed Wetlands
Funding Agency	Department of Energy-NNSA
Period	October 1, 2006—September 30, 2007
Budget	$150,000

PI	Gary Mills
Project Title	Impact of MOX Facility Effluent Discharges to Upper Three Runs Creek Watershed
Funding Agency	Department of Energy-NNSA
Period	July 1, 2007—June 30, 2008
Budget	$185,000

PI	Andrew Neal
Project Title	Molecular Mechanisms of Bacterial Attachment to Fe(III)-Oxide Surfaces
Funding Agency	U.S. Department of Energy-Office of Science
Period	June 1, 2005—September 14, 2007
Budget	$453,295

PI	Christopher Romanek
Project Title	Holocene Shell Accumulation from the Southeast Brazilian Bight: Multi-Centennial Dynamics of Oceanographic, Environmental, and Ecological Changes
Funding Agency	National Science Foundation
Period	July 1, 2006—June 30, 2009
Budget	$94,776

PI	Betsie Rothermel
Project Title	Assessing the Susceptibility of North American Plethodontid Salamanders to Chytrid Fungal Infection
Funding Agency	World Conservation Union
Period	April 1, 2006–March 31, 2007
Budget	$2,000

PI	John Seaman
Project Title	Application of Surface Complexation Models to Predicting Actinide Fate and Transport in Variably Saturated Systems
Funding Agency	Clark Atlanta University-DOE
Period	October 1, 2005-February 28, 2008
Budget	$20,193

PI	John Seaman
Project Title	Tritium Distribution at the Tritiated Water Management Facility
Funding Agency	Washington Savannah River Company-SGCP
Period	October 1, 2006—September 30, 2007
Budget	$99,000

PI	John Seaman
Project Title	Preparing Sediments at a Steady State Moisture Content Using the Unsaturated Flow Apparatus and for BET Surface Area Measurements
Funding Agency	Washington Savannah River Company
Period	June 4, 2007—October 31, 2007
Budget	$16,319

PI	John C. Seaman
Project Title	Tritium Distribution, Mixing, and Transport at the Tritiated Water Management Facility
Funding Agency	USDA Forest Service
Period	April 15, 2003–August 25, 2007
Budget	$88,160

PI	Rebecca Sharitz
Project Title	Long-term Effects of Wind Disturbance on the Old-Growth Forests and Lianas of the Congaree National Park
Funding Agency	Cooperative Ecosystem Studies Unit-Piedmont
Period	October 1, 2005—September 30, 2007
Budget	$49,491

PI	Rebecca R. Sharitz
Project Title	Proposed Floodplain Plant and Invertebrate Studies for the Savannah River Flows Project (2005-2007)
Funding Agency	The Nature Conservancy
Period	August 1, 2005–July 31, 2007
Budget	$25,000

PI	Rebecca Sharitz
Project Title	On-Site Field Studies and Long-Term Monitoring Required for BRAC Implementation, Environmental Compliance, Technology Integration Assistance…
Funding Agency	Cooperative Ecosystem Studies Unit-Gulf
Period	August 16, 2006—March 31, 2008
Budget	$302,909

PI	Ramunas Stephanauskas
Project Title	The Role of Metal Contamination in the Proliferation of Antibiotic Resistance in Coastal Water-Borne Pathogens
Funding Agency	US Department of Commerce/NOAA
Budget	$534,311
Period	September 1, 2004–August 31, 2007

PI	Carl Strojan
Project Title	Technical Review/Comments–SRS Environmental Report for 2006
Funding Agency	Westinghouse Savannah River Company
Period	January 17, 2007–October 16, 2007
Budget	$4,841

PI	Barbara Taylor
Project Title	Enhancement of Disturbed Upper Coastal Plain Stream Systems: Establishing Restoration Criteria and Strategies for a Stream Mitigation Bank
Funding Agency	University of Kentucky-U.S. Forest Service
Period	February 1, 2006—September 30, 2008
Budget	$223,946

PI	Jason Unrine
Project Title	The Fate and Effects of Nanosized Metal Particles along a Simulated Terrestrial Food Chain Investigated using Genomic and Microspectroscopic.
Funding Agency	U.S. Environmental Protection Agency
Period	May 5, 2007—April 30, 2010
Budget	$397,000

PI	Chuanlun Zhang
Project Title	Microbial Interactions and Processes: Diversity, Function and Biogeochemical Consequences of Chemolithoautotrophic Archaea in Nevada Hot Springs
Funding Agency	National Science Foundation
Period	June 1, 2004—July 31, 2008
Budget	$357,032

PI	Chuanlun Zhang
Project Title	Genomic and Lipid Biomarker Monitoring of Microbial Communities Affecting the Formation and Degradation of Gas Hydrate in the Gulf of Mexico: Implications for Microbial Ecology and Global Climate Change
Funding Agency	University of Mississippi-NOAA
Period	September 1, 2005—September 30, 2008
Budget	$189,533

PI	Chuanlun Zhang
Project Title	Community Structure and Methane Oxidation in the Water Column above Gas Hydrates in the Gulf of Mexico: Implications for Global Climate Change
Funding Agency	University of Mississippi-NOAA
Period	October 1, 2006—September 30, 2007
Budget	$151,953

Publications

Journal Articles Published In FY2007

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2987 Croshaw, D. A. and D. E. Scott. 2006. Marbled salamanders (*Ambystoma opacum*) choose low elevation nest sites when cover availability is controlled. Amphibia-Reptilia 27:359-364.

2988 Meshaka, W. E. and J. W. Gibbons. 2006. *Kinosternon subrubrum* - Eastern Mud Turtle. Chelonian Research Monographs 3:189-196.

2989 Fokidis, H. B., C. Robertson, and T. S. Risch. 2006. Keeping Tabs: Are redundant marking systems needed for rodents? Wildlife Society Bulletin 34:764-771.

2990 Waldron, J. L., S. H. Bennett, S. M. Welch, M. E. Dorcas, J. D. Lanham, and W. Kalinowsky. 2006. Habitat specificity and home-range size as attributes of species vulnerability to extinction: a case study using sympatric rattlesnakes. Animal Conservation 9:414-420.

2991 Carrillo-Gonzalez, R., J. Simunek, S. Sauve, and D. Adriano. 2006. Mechanisms and pathways of trace element mobility in soils. Advances in Agronomy 91:111-178.

2992 Winne, C. T. and W. A. Hopkins. 2006. Influence of sex and reproductive condition on terrestrial and aquatic locomotor performance in the semi-aquatic snake *Seminatrix pygaea*. Functional Ecology 20:1054-1061.

2993 Zhao, W., C. S. Romanek, G. Mills, J. Wiegel, and C. L. Zhang. 2005. Geochemistry and microbiology of hot springs in Kamchatka, Russia. Geological Journal of China Universities 11:217-223.

2994 Lee, Y. J., I. D. Wagner, M. E. Brice, V. V. Kevbrin, G. Mills, C. S. Romanek, and J. Wiegel. 2005. *Thermosediminibacter oceani* gen. nov., sp. nov. and *Thermosediminibacter litoriperuensis* sp. nov., new anaerobic thermophilic bacteria isolated from Peru Margin. Extremophiles 9:375-383.

2995 Novak, J. M., K. F. Gaines, J. C. Cumbee, G. Mills, A. Rodriguez-Navarro, and C. S. Romanek. 2005. The Clapper Rail as an indicator species of estuarine-marsh health. Studies in Avian Biology 32:270-281.

2996 Lee, Y. J., C. S. Romanek, G. Mills, R. C. Davis, W. B. Whitman, and J. Wiegel. 2006. *Gracilibacter thermotolerans* gen. nov., sp. nov., an anaerobic, thermotolerant bacterium from a constructed wetland receiving acid sulfate water. International Journal of Systematic and Evolutionary Microbiology 56:2089-2093.

2997 Viamajala, S., W. A. Smith, R. K. Sani, W. A. Apel, J. N. Petersen, A. L. Neal, F. F. Roberto, D. T. Newby, and B. M. Peyton. 2007. Isolation and characterization of Cr(VI) reducing *Cellulomonas* spp. from subsurface soils: Implications for long-term chromate reduction. Bioresource Technology 98:612-622.

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SREL Organizational Chart

Director
Carl W. Bergmann

Faculty
- J. Whitfield Gibbons
- Travis C. Glenn
- Thomas G. Hinton
- J Vaun McArthur
- Gary L. Mills
- Lee A, Newman
- Christopher S. Romanek
- John C. Seaman
- Rebecca R. Sharitz
- Jason M. Unrine
- Chuanlun Zhang

Emeritus Faculty
- Domy C. Adriano
- I. Lehr Brisbin, Jr.
- Justin D. Congdon
- Kenneth W. McLeod

Administrative Financial Director
- Robert L. Nestor

Safety and Environmental Manager
- Donald R. Mosser

Computer Service and GIS Lab Manager
- Joshua Dooley

Education Program
- Travis C. Glenn

Outreach Program
- J. Whitfield Gibbons

Research and Facilities Technical Services
- Mark Edwards
- Malcolm Squires

Administrative Services
- Marie Roberts
- Cherie Summer
- Vera Taylor

(As of 1/1/2008)