

NSRL NEWS

Natural Science Research Laboratory
Museum of Texas Tech University

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Research Highlight: Chasing Desert Bighorn Sheep Across the Trans-Pecos

NSRL Researchers Aim to Use Genomics and Metagenomics to Characterize Population Structure, Connectivity, Genetic Variation, and Health of *Ovis canadensis*

Glassing mountains at sunrise or sunset in the Trans-Pecos Region of Texas offers a unique opportunity to catch a glimpse of one of Texas' most iconic mammals, desert bighorn sheep (*Ovis canadensis*). These elusive ungulates traverse steep, rocky outposts with ease, thanks to physical adaptations such as "cushioned heels." Although their population status currently is classified as rare, present-day wild desert bighorn sheep in Texas are faring much better than their recent predecessors.

In 1903, desert bighorn sheep hunting was banned in Texas, as there were only an estimated 500 remaining in the Trans-Pecos. By the 1960s, desert bighorn sheep were extirpated due to a variety of issues, including overharvesting for meat and horns, competition and diseases from domestic sheep and goats, and the impact of net-wire fencing that supported the domestic sheep and goat industry in the region. Thanks to restoration and translocation efforts by the Texas Parks and Wildlife Department (TPWD), desert bighorn populations have increased from ~14 in 1959 to >1,500 across 11 mountain ranges in 2018.

TPWD staff and biologists have partnered with other states in these extensive translocation efforts, which kick-started the desert bighorn sheep recovery in Texas in the early 1970's. Similarly, the Texas Bighorn Society (TBS) has been active in desert bighorn sheep restoration and has collaborated closely with TPWD on sheep restoration and habitat improvements, via extensive fundraising efforts, engaging landowners, and annual work projects often focused upon guzzlers and fence modification.

During conversations among biologists at Texas Tech University (TTU), it became clear that the facilities and mission of the NSRL could enhance bighorn research efforts. Primarily, the long-term archival options (liquid nitrogen freezers) and data storage abilities of the NSRL could provide a central site for coordinating bighorn research across the

western U.S. Further, strategic research projects among some TTU faculty were applicable to conducting state-of-the-art research on bighorn translocation and disease.

TTU's official involvement in bighorn sheep research in Texas began in 2015, with an invitation from Dr. Sam Cunningham to attend a TBS Board meeting in Lubbock. From those initial conversations, TBS members, TTU faculty (Drs. Robert Bradley, Warren Conway, and Caleb Phillips), Froylan Hernandez and Dr. Bob Dittmar from TPWD, and Clay Brewer from the Wild Sheep Foundation (WSF) focused the conversation towards ways to dovetail our Texas-centric research with the range-wide Disease Management Venture (DMV) objectives set forth by the Wild Sheep Working Group of the Western Association of Fish and Wildlife Agencies. Researchers at TTU will be providing baseline information relative to population structure and connectivity, genetic diversity, and health, with the goal of optimizing future trans-



location efforts. These efforts will address DMV-identified challenges associated with respiratory disease surveillance, estimates of disease prevalence, and efforts to collaboratively develop solutions to these management issues. In June 2017, the Texas Bighorn Society and the Wild Sheep Foundation generously donated a combined \$210,000 gift to Texas Tech to support this broad scale research effort, and set the table for a long-term, collaborative research project involving students, biologists, staff, and faculty members from TTU, TPWD, TBS, WSF, Sul Ross State University–Borderlands Research Institute, and many private landowners.

Two TTU graduate students, Emily Wright and Rachael Wiedmeier, are involved in these bighorn sheep research initiatives. Emily Wright began in the summer 2018 and is transitioning from a M.S. to a Ph.D. As she wraps up her M.S. research, she is capturing bighorn and aoudad (also known as Barbary sheep, *Ammotragus lervia*), and reading literature on wildlife diseases and population genetics methodology. For her dissertation, Emily will employ classic population genetics parameters, mitochondrial DNA, as well as new genomic techniques (RAD-Seq and others) to characterize population genetic structure, current connectivity, and potential signatures (and mixing) of the original bighorn sheep stock (if any remained in Texas), translocated stock from other states, and present-day bighorn sheep, with the goal of elucidating how gene pools have changed over the past century. After completing her Ph.D., Emily plans to continue her education and pursue a Doctorate of Veterinary Medicine to achieve her ultimate goal of specializing in the rehabilitation and reintroduction of species into their native habitats.

Rachael Wiedmeier joined the project in Fall 2018. After graduating with her B.S. in biology from Black Hills State University in 2016, Rachael has spent the last two



years working as a technician on various ungulate projects. She spent six months working with Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) to determine the effects of removing chronic shedders of *Mycoplasma ovipneumoniae*, the bacteria that causes pneumonia, from the population. Rachael hopes to combine all of her interests in research, teaching, field work, and large mammal diseases and zoonoses by continuing her education to obtain a Ph.D., with the goal of becoming a professor at a research university.

The first phase of Emily and Rachael’s research is to understand the origins of translocated desert bighorn sheep in Texas and the potential disease risks relative to those source-stock origins. In 1912, Vernon Bailey described Texas bighorn sheep as *Ovis canadensis texianus*. This subspecies was extirpated in the early 1960s and with it, any genetic information provided by the original individuals. Restocking efforts during two periods (1971–1978 and 1983–1994) have utilized *O. c. nelsoni* from Nevada, Utah, Arizona, Mexico, as well as some from in-state brood facilities at the Black Gap and Sierra Diablo Wildlife Management Area (WMA). To determine the degree of genetic similarity and differences between the original Texas bighorn subspecies, *O. c. texianus*, and the introduced *O. c. nelsoni*, it is imperative to obtain hair and tissue samples from trophy mounts and museum specimens (because pure *O. c. texianus* are extinct) collected prior to 1960 and after 1960, along with samples from live or recently collected individuals. From this, we hope to more clearly understand the effects of several translocations over a period of approximately 50 years on desert bighorn sheep populations in several Texas mountain ranges. Depending on the original population size and the number of translocated individuals into each original population, desert bighorn sheep populations may have experienced inbreeding, genetic drift, and some founder effects. These are the underpinnings to Emily Wright’s dissertation research.

It is well documented that bighorn sheep are susceptible to several epizootic diseases, such as pneumonia, bluetongue, and others, that potentially impede population persistence, augmentation, and translocation success, and these disease-focused concerns are at the root of the range-wide DMV. Although diseases usually target individuals with compromised immune systems, this may not be the case with *Mycoplasma ovipneumoniae*, given the bacteria’s ability to impact all age and sex classes, particularly within small, isolated populations. In collaboration with TPWD, we have participated in disease-sampling captures in 2016, 2017, and 2018, where we have collected blood, serum, nasal/tonsil swabs, and skin tissue samples from >100 desert bighorn sheep in several different mountain ranges in Texas. These samples have been sent to the Texas A&M Veterinary Medical Diagnostic Laboratory and Washington Animal Disease Diagnostic Lab where serological screening, PCR, and culture testing is performed to determine a current health



of pathogenic disease on resident microbes and the extent of these effects at the organismal and population levels.

The last five months of 2018 were exciting, as Emily and Rachael were chasing not only desert bighorn sheep, but freezers and aoudad, too. In a 36-hour whirlwind trip driving from Boise, Idaho to Lubbock, Texas, Emily and Rachael retrieved a -80°C freezer with 23,000 bacterial isolates from the Idaho Game and Fish Department. Of the 23,000 samples, 9,358 samples were from bighorn sheep from 11 states and two Canadian provinces. The samples are composed primarily of swabs and other cultures that will be incorporated into the disease and health monitoring aspect of this research.

Two opportunities on private ranches in the Trans-Pecos focused on removing aoudad. Aoudad are an invasive species of wild sheep from Northern Africa that were introduced in the 1940's for big game hunting purposes. Aoudad tend to outcompete desert bighorn sheep for access to food and water, and they also are behaviorally dominant. Aoudad populations are continuing to expand and grow, presenting a clear and present conservation concern for desert bighorn sheep health and population restoration in Texas. NSRL researchers hypothesize that potential disease transmission from aoudad to desert bighorn sheep could be deleterious and compromise desert bighorn sheep health regionally, and more specific research focused upon aoudad disease prevalence has been opportunistically initiated during the last few months of 2018 and early 2019.

record of each individual. Rachael's thesis research aims to employ metagenomic methods using nasal and tonsil swabs from bighorn sheep to characterize entire microbial communities within bighorn nasal and oral passages. This type of approach provides an 'inside look' at the structure and effects

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NSRL CURATORIAL AND SUPPORT STAFF



Heath Garner is the NSRL Curator of Collections. His role is to facilitate the daily operations and maintenance of the NSRL collections. His duties include specimen processing, cataloging, and tracking, loan processing, student worker and volunteer training and supervision, documentation, and collections preventative conservation.

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Kathy MacDonald is the Collections Manager for the Genetic Resources Collection. Her primary duties include the organization and processing of incoming samples and the subsampling and processing of loans. Other duties include maintaining the NSRL website, assisting with specimen tracking in the collections, and data management and design.

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Lisa Bradley is the Production Editor for Occasional Papers and Special Publications. Her duties include coordinating the review and revision process, copy editing, and final layout and design. She also assists in the writing and editing of scientific articles published by NSRL staff, the preparation of grant proposals, and the development of NSRL exhibits for the Museum.

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Jennifer Girón is a Research Associate and a volunteer in the Invertebrate Zoology Collection. See the story on page 11 for more information about Jennifer and the collection.

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NSRL FACULTY CURATORS



Dr. Robert D. Bradley is Director of the NSRL, Curator of Mammals, and Professor of Biological Sciences. Dr. Bradley's research foci are systematics and molecular evolution of New World rodents; hybridization; infectious zoonotic diseases; and natural history of mammals. He has been a faculty member since 1994. He currently is advising 4 PhD, 2 MS, 1 MA, and 4 undergraduate students. He has graduated 19 MS, 2 MA, and 11 PhD students, and he has published 1 book and 176 peer-reviewed articles.

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Dr. Nancy McIntyre is the NSRL Curator of Birds and a Professor of Biological Sciences. She is a landscape ecologist whose research focuses on how land conversion and climate change are fragmenting migratory habitats for wildlife in the Great Plains of North America. Dr. McIntyre has served as Curator of Birds since 2006. She currently is advising 1 MS and 2 PhD students.

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Dr. Caleb D. Phillips is the Curator of Genetic Resources of the NSRL and an Assistant Professor of Biological Sciences. The Phillips' lab studies how gene expression and microbiome communities evolve in support of mammalian life histories; bioinformatics; and the evolutionary/developmental process of mammalian divergence. He currently is advising 1 PhD and 3 MS students.

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Dr. Richard Stevens was appointed as Assistant Curator of Mammals in 2018 and is a Professor of Natural Resources Management. He is a bat and rodent community ecologist, macroecologist, and biogeographer. His lab conducts collections-based ecological work in Paraguay, Colombia, Mojave Desert, and Texas. He currently is advising 9 PhD, 1 MS, and 3 undergraduate students.

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NSRL COLLECTIONS - SUMMARY AND STATISTICS

The Natural Science Research Laboratory (NSRL) is a division of the Museum of Texas Tech University that archives biological samples and their associated data. These collections serve as a library of our natural heritage for education and research purposes. Natural history collections provide the foundation for our understanding of biodiversity. They serve as a historical reference for documenting changes in our environment and the effects of those changes on wildlife and, ultimately, on humans.

The collections maintained by the NSRL are available to researchers at academic, scientific, and government institutions around the world for scientific investigation, discovery, and problem-solving in the natural sciences. The causes and/or effects of animal-borne diseases, environmental pollutants, parasites, climate change, habitat loss, geographic isolation, and natural evolutionary processes and speciation are just a few examples of the investigations that can be conducted utilizing specimens and tissues archived in a natural history collection. Further, the resources of the NSRL are utilized by the academic and scientific communities to train and educate students at the undergraduate and graduate levels for careers in the natural sciences as well as museum science.

Mammal Collection



The Mammal Collection currently contains 141,153 cataloged specimens of an estimated 1,441 species. Specimen preparation types include preserved skins, skeletal materials, alcohol-preserved specimens, and taxidermy mounts. From July through December 2018, the Mammal Collection cataloged 567 specimens and granted 23 loans totaling 330 specimens.

Bird Collection



The Bird Collection currently contains 5,530 cataloged bird specimens, as well as eggs and nests, of approximately 890 species. From July through December 2018, the Bird Collection cataloged 2 new specimens and granted 1 loan of 9 specimens.

Invertebrate Zoology Collection



The Invertebrate Zoology Collection contains an estimated 4.5 million specimens. These include insects, crustacea, endo- and ecto-parasites, and arachnids. Specimen preservation methods include dried, fluid (ethanol or formalin), slide-mounted, and frozen.

Genetic Resources Collection



The Genetic Resources Collection contains >409,000 samples of tissues, blood, and extracted DNA from >100,000 specimens of mammals and other taxa. From July through December 2018, the GRC granted 18 loans totaling 486 samples. The Collection incorporated 3,383 new samples obtained from 548 individuals.

As a whole, the NSRL hosted 166 visitors and volunteers from July through December, including researchers utilizing the collections, students taking classes, individuals and groups on tours, and volunteers assisting in the collections. The NSRL also filled 68 data requests by researchers. Fourteen students (10 graduate, 4 undergraduate) were employed by the NSRL during all or part of the July through December time period.

FACULTY AND STAFF GRANTS (active July–December 2018)

Bradley, R.D. “Natural History: Development of a liquid nitrogen system for the Genetic Resources Collection, Natural Science Research Laboratory, Museum of Texas Tech University.” NSF (Collections in Support of Biological Research).

Farmer, M., **T. Kingston**, R. Verble, S. Fritts. “Sustainable development of a tropical agroforestry program in the rural Borneo Highlands.” NSF-IRES.

Kahl, S., R.D. Cox, C. Portillo-Quintero, G. Perry, and **N. McIntyre**. “Landscape assessment of west and south Texas grasslands to inform conservation of two native reptile species of concern in Texas.” Texas Comptroller of Public Accounts.

Kingston, T. “Southeast Asian Bat Conservation Research Unit.” NSF-Research Coordination Networks.

Kingston, T., and C.D. Phillips. “Community processes structuring assembly and disassembly of bat gut-microbial communities across a gradient of habitat degradation.” NSF.

Longing, S., R. Cox, **N.E. McIntyre**, C. McKenney, and C. West. “Demonstration of pollinator conservation practices and a framework for regional implementation on the Southern High Plains.” USDA Natural Resources Conservation Service - Conservation Innovation Grants.

McGuire, L.P., J.G. Boyles, and W.F. Frick. “Manipulating microclimates to reduce disease severity from white-nose syndrome”. National Fish and Wildlife Foundation.

McIntyre, N.E., and K. Hayhoe. “Collaborative proposal: Climatic and anthropogenic forcing of wetland landscape connectivity in the Great Plains.” NSF-Macrosystems Biology.

Morgan, G., E. Johnson, J. Hoffman, and **R.D. Bradley**. “Biodiversity of the Llano Estacado.” The Helen Jones Foundation.

Olson, S.H., **L.P. McGuire**, R.K. Plowright, D.T.S. Hayman, B.G. Dickson, and C.L. Lausen. “Assessing white-nose syndrome in the context of non-stationary conditions in an advancing continental epidemic.” Department of Defense-Strategic Environmental Research and Development Program.

Phillips, C.D. “Status, distribution, morphology and genetics of *Sigmodon fulviventer dalquesti* in the Chihuahuan Desert Ecoregion.” Texas Parks and Wildlife Department.

Phillips, C.D. “Genetic species identification of *Cicurina* sp.” Zara Environmental LLC.

Plowright, R.K., O. Restif, **L.P. McGuire**, N. Bharti, E. Shanahan, P. Eby, M. Taylor, H. McCallum, and A. Peel.

“Dynamics of zoonotic systems: Human-bat-pathogen interactions.” National Science Foundation, Dynamics of Coupled Natural and Human Systems.

Ray, D. RoL: FELS: EAGER: “Genomics of exceptions to scaling of longevity to body size.” NSF.

Ray, D., R.D. Stevens, and R.D. Bradley. “Population and conservation status of Texas pocket gophers (*Geomys* and *Thomomys*) in Texas with a focus on the subspecific status of *Thomomys bottae* via populations genomic tools.” Texas Parks and Wildlife Department.

Ray, D.A. and R.D. Stevens. “Comparing genetic diversity of the threatened northern long-eared bat across their range using whole-genome and RADSeq approaches.” U.S. Forest Service.

Stevens, R.D. “Habitat affinities and day roost characteristics of the Northern Long-eared Bat (*Myotis septentrionalis*) in Louisiana.” USFWS/Louisiana Department of Wildlife and Fisheries.

Stevens, R.D. “Winter day-roost characteristics of the Northern Long-eared Bat (*Myotis septentrionalis*) in Louisiana.” U.S. Forest Service.

Stevens, R.D. and S. Fritts. “Fort Wolters bat surveys.” Texas Army National Guard.

Stevens, R.D. and S. Fritts. “Camp Maxey herpetofauna surveys.” Texas Military Department.

Stevens, R.D. “Interactions between bats and highway structures on the Trans Pecos of Texas.” Texas Department of Transportation.

Stevens, R.D. and D.A. Ray. “Distribution and conservation genetics of *Myotis* and other critically imperiled bats in Louisiana.” United States Fish and Wildlife Service/Louisiana Department of Wildlife and Fisheries.

Stevens, R.D. and L. McGuire. “Winter site-occupancy and foraging activity of bats on the coastal plain of the southeastern United States with particular focus on Northern Long-Eared Bats (*Myotis septentrionalis*).” National Council for Air and Stream Improvements, Inc.

Stevens, R.D., D. Ray, R.N. Platt, and R.D. Bradley. “RFP No. 209f for endangered species research projects for the Texas Kangaroo Rat.” Texas State Comptroller.

Varela, R., **J. Salazar-Bravo**, et al. “Identification of peptides isolated from the slime of the Giant African snail (*Achatina fulica*) and their antimicrobial activity”. COLCIENCIAS, Colombia.

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Emily and Rachael, along with biologists from TPWD, the Borderlands Research Institute at Sul Ross State University, and Texas A&M University, began 2019 on a private ranch in the Trans-Pecos where they captured 31 desert bighorn sheep, 42 mule deer, and 9 aoudad during a week-long field effort. They collected blood, nasal, and tonsil swabs, fecal pellets, and skin tissue samples, and collared the animals. This is the first study to determine, utilizing iridium GPS tracking collars, how these three species interact on the landscape.



An ongoing aoudad removal project organized by Palo Duro and Caprock Canyons State Parks was approved in late December. Emily supplied sample kits to both State Parks for public aoudad hunts. Given that aoudad were released in this region in 1957, these samples will provide baseline data on the populations in the Panhandle and a unique opportunity to examine the potential genetic and microbiome differences between aoudad from the Panhandle and Trans-Pecos regions.

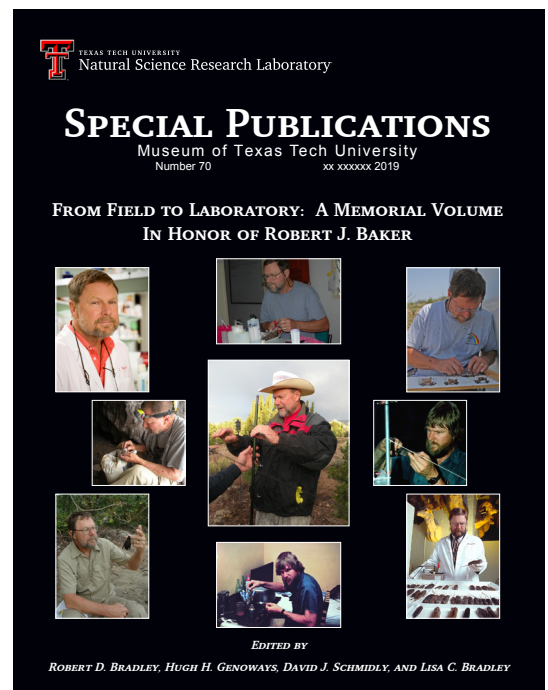
With two interrelated facets (disease and genetics), this research provides a unique opportunity to provide information relevant for management and conservation purposes, assess inbreeding and “genetic health,” optimize future translocation efforts, and develop parameters for tracking genotype fitness. Although the focus is on wild Texas desert bighorn sheep, the goal is to collaborate with partners in the western United States and Canada to produce applicable and useful results for the conservation of bighorn sheep range-wide.

Whether it is at the NSRL, Department of Biological Sciences, Department of Natural Resources Management, Palo Duro Canyon, Caprock Canyons State Parks, or the Trans-Pecos, innovative research is being conducted to further enhance Texas desert bighorn sheep. Using samples at the NSRL, characterization of bighorn sheep using mtDNA and disease-testing using serum and nasal and tonsil swabs is underway. Further DNA analysis utilizing RAD-Seq and metagenomic methods to detect microbiomes of nasal and tonsil passages is in preliminary stages and plan to be up and running by 2020. As Vernon Bailey (1905) stated in the Biological Survey of Texas, bighorn sheep “Not only should... be protected by law, but the law should be made effective by an appreciation on the part of residents of the country of the importance of preserving for all time these splendid animals.”

Coming Soon!

In 2019, the NSRL will be publishing “From Field to Laboratory: A Memorial Volume in Honor of Robert J. Baker” in its *Special Publications* series. This volume, edited by Robert D. Bradley, Hugh H. Genoways, David J. Schmidly, and Lisa C. Bradley, will contain 40+ papers submitted by Dr. Baker’s former students and colleagues. The papers include a diverse array of studies in mammalogy, as well as papers on non-mammal taxa, bioterrorism, education, natural history, forensics, philosophical reflections, and an extensive, scientometric analysis of Dr. Baker’s contributions to mammalogy. The volume also will include a number of encomia and photographs.

Contributions toward the publishing costs of this volume are welcome and appreciated. If you wish to donate, please contact Lisa Bradley at lisa.bradley@ttu.edu.



RECENT PUBLICATIONS BY NSRL FACULTY, STAFF, AND STUDENTS

- Airaldi-Wood, K., M. E. Torres, M. B. Barreto, A. Weiler, G. Gonzalez de Weston, G. Zarate, y R. D. Stevens. 2018. Quiropteros del campus de la Universidad Nacional de Asuncion Paraguay. *Boletín del Museo Nacional de Historia Nacional del Paraguay* 22:45–56.
- Castillo-Figueroa, D., E. E. Bohlender, J. Perez-Torres, and R. D. Stevens. Observation of adoption in Seba's short-tailed bat (*Carollia perspicillata*). *Neotropical Biology and Conservation*, In Press.
- Delgado, E., L. F. Pacheco, J. Salazar-Bravo, and O. Rocha. 2018. Rediscovery of the chinchilla in Bolivia. *Oryx* 52:13–14. doi:10.1017/S003060531700179X.
- Delgado, E., L. F. Pacheco, J. Salazar-Bravo, and O. Rocha. 2018. Chinchilla real (*Chinchilla chinchilla*) en Bolivia: comentarios sobre localidades reportadas y bases para su conservación. *Ecología en Bolivia* 53:31–38.
- Dunnam, J. L., B. S. McLean, R. C. Dowler, and the Systematic Collection Committee of the American Society of Mammalogists. 2018. Mammal collections of the Western Hemisphere: a survey and directory of collections. *Journal of Mammalogy* 99:1307–1322.
- Genoways, H. H., L. C. Bradley, R. D. Bradley, J. J. Bull, M. J. Hamilton, P. Larsen, K. McBee, and D. J. Schmidly. 2018. Obituary: Robert James Baker (1942–2018). *Journal of Mammalogy* 99:983–1012.
- Houlahan, J. E., K. Cottenie, G. S. Cumming, D. J. Currie, C. S. Findlay, S. D. Fuhlendorf, U. Gaedke, P. Legendre, E. H. Muldavin, R. Russell, R. D. Stevens, T. J. Willis, I. P. Woivod and S. M. Wondzell. 2018. Negative relationships between species richness and temporal variability in abundance are common in natural systems. *Ecology* 99:2592–2604.
- Kohl K. D., K. F. Oakeson, T. J. Orr, A. W. Miller, J. S. Forbey, C. D. Phillips, C. Dale, R. B. Weiss, and M. D. Dearing. 2018. Metagenomic sequencing provides insights into microbial detoxication in the guts of small mammalian herbivores (*Neotoma* spp.). *FEMS Microbiology Ecology* 92(12). <https://doi.org/10.1093/femsec/y184>.
- Krauel, J. J., L. P. McGuire, and J. G. Boyles. 2018. Testing traditional assumptions about regional migration in bats. *Mammal Research* 63:115–23.
- Legesse, J. W., C. D. Dunn, M. R. Mauldin, N. Ordóñez-Garza, G. R. Rowden, Y. Mekasha Gebre, M. Y. Kurtu, S. A. Mohammed Ali, W. D. Whibesilassie, M. Ballou, M. Tefera, G. Perry, and R. D. Bradley. 2018. Morphometric and genetic variation in 8 breeds of Ethiopian camel (*Camelus dromedarius*). *Journal of Animal Sciences* 96:4925–4934.
- Limon, D. A., C. J. Garcia, B. B. Gregory, R. D. Stevens, and M. A. Barnes. 2018. *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome, not detected using traditional nor genetic methods in Louisiana culverts. *Southwestern Naturalist*, In Press.
- Mayberry, H. W., L. P. McGuire, and C. K. R. Willis. 2018. Hibernating little brown bats exhibit pronounced behavioural activity at torpid body temperatures: implications for hibernation energetics and white-nose syndrome. *Journal of Comparative Physiology B* 188:333–343.
- McGuire, L. P., L. A. Kelly, D. E. Baloun, W. A. Boyle, T. L. Cheng, J. Clerc, N. W. Fuller, A. R. Gerson, K. A. Jonasson, E. J. Rogers, A. S. Sommers, and C. G. Guglielmo. 2018. Common condition indices are no more effective than body mass for estimating fat stores in insectivorous bats. *Journal of Mammalogy* 99:1065–1071.
- Montero, B. K., M. Sagot, C. D. Phillips, R. J. Baker, and E. H. Gillam. 2018. Geographic variation of contact calls suggest distinct modes of vocal transmission in a leaf-roosting bat. *Behavioral Ecology and Sociobiology* 72:125.
- Murray, S., F. A. A. Anwarali, T. Kingston, A. Zubaid and P. Campbell. 2018. A new species in the *Hipposideros bicolor* group (Chiroptera: Hipposideridae) from Peninsular Malaysia. *Acta Chiropterologica* 20:1–30.
- Phelps, K., J. Reizl, M. Labonite, and T. Kingston. 2018. Assemblage and species threshold responses to environmental and disturbance gradients shape bat diversity in disturbed cave landscapes. *Diversity* 10, 55. <https://doi.org/10.3390/d10030055>
- Prater, C. M., C. Garcia, L. P. McGuire, and J. A. Carr. 2018. Tectal corticotropin-releasing factor (CRF) neurons respond to fasting and a reactive stressor in the African Clawed Frog, *Xenopus laevis*. *General Comparative Endocrinology* 258:91–98.
- Sabino-Santos, Jr., G., F. G. Motta Maia, R. Bragança-Martins, T. Gagliardi, W. de Souza, R. Lara Muylaert, L. de Souza Luna, D. Melo, R. Cardoso, N. da Silva, M. Cornejo Pontelli, P. Mamani-Zapana, T. Vieira, N. Melo, C. Jonsson, D. Goodin, J. Salazar-Bravo, L. daSilva, E. Arruda, and L. Figueiredo. 2018. Natural infection of Neotropical bats with hantavirus in Brazil. *Scientific Reports* 8, article number: 9018. <http://www.nature.com/articles/s41598-018-27442-w>.
- Sánchez J., M. Lareschi, J. Salazar-Bravo, and S. L. Gardner. 2018. Fleas of genus *Neotyphloceras* associated with rodents from Bolivia: New host and distributional records, description of a new species and remarks on the morphology of *Neotyphloceras rosenbergi*. *Medical and Veterinary Entomology* 32:462–472. <https://doi.org/10.1111/mve.12314>.
- Sánchez-Vendizú, P., J. A. Cook, J. Wood, and J. Salazar-Bravo. 2018. First record of *Proechimys pattoni* da Silva, 1998 (Rodentia, Echimyidae) in northwestern Bolivia. *Check List* 14(6):1115–1121. <https://doi.org/10.15560/14.6.1115>.
- Stevens, R. D., R. J. Rowe, and C. Badgley. 2018. Mammalian diversity gradients through space and time. *Journal of Mammalogy*, In Press.
- Stevens, R. D., and J. Sebastian Tello. 2018. A latitudinal gradient in dimensionality of biodiversity. *Ecography* 41:2016–2026.
- Thomson, S., R. Pyle, S. Ah Yong, M. Alonso-Zarazaga, et al. 2018. Taxonomy based on science is necessary for global conservation. *PLoS Biol* 16(3):e2005075. <https://doi.org/10.1371/journal.pbio.2005075>.

STUDENT GRANTS AND RESEARCH AWARDS

Ezra Auerbach, graduate student, Nancy McIntyre. TTU Graduate Recruitment Fellowship/The CH Foundation Graduate Fellowship.

Lucas Heintzman, graduate student, Nancy McIntyre. Elo and Olga Urbanovsky Assistantship; TTU Water Conservation Research Scholarship.

Nicole Paulat, graduate student, David Ray. TTU Association of Biologists, Grants in Aid; Graduate Student Research Support Award, TTU Office of Parent and Family Relations, Graduate Assembly, and Graduate School.

Ben Obitte, graduate student, Tigga Kingston. Research Award, National Geographic; Michelle Knapp Scholarship, TTU Biological Sciences; Umu Igbo Unite Cares International Student Scholarship.

OCCASIONAL PAPERS AND SPECIAL PUBLICATIONS OF THE MUSEUM OF TEXAS TECH UNIVERSITY

The NSRL produces two peer-reviewed publication series, Occasional Papers and Special Publications, both of which are edited by Dr. Robert D. Bradley, Director of the NSRL. These series provide outlets for scholarly works resulting from museum-based natural history research. Relevant topics include, but are not limited to, taxonomic studies, faunal lists, species descriptions, zoonoses research, distributional records, and field and museum techniques and methodology, including molecular methods that are applicable to field or museum research. Publication in these series is available to all authors without regard to their association with Texas Tech University. Authors who plan to submit manuscripts to these series should refer to both the Museum Publications Policy and the Guidelines and Procedures for Authors, available at our website, www.nsrl.ttu.edu/publications, for more information.

Lisa Bradley serves as the Production Editor for both series. Our goal is to produce 10–12 Occasional Papers and 1–2 Special Publications per year. Feel free to contact Lisa, lisa.bradley@ttu.edu, if you are interested in submitting manuscripts or monographs to the Occasional Papers or Special Publications series.

Publications produced July–December 2018:

Occasional Paper 356. Non-geographic variation of *Chaetodipus eremicus* and *Chaetodipus nelsoni* from the Chinati Mountains State Natural Area, Presidio County, Texas, with comparison to populations of the same species from Brewster County, Texas. Jim R. Goetze, Richard W. Manning, and Franklin D. Yancey, II.

Occasional Paper 357. Mammals of Yacuri National Park, Loja Province, Ecuador. Thomas E. Lee, Jr., Nicolas Tinoco, Maya J. Feller, Daisy Gomez, J. Delton Hanson, M. Alejandra Camacho, and Santiago F. Burneo.

Occasional Paper 358. Composition and characteristics of a diverse Didelphid community (Mammalia: Didelphimorphia) in Sub-tropical South America. Robert D. Owen, Humberto Sánchez, Laura Rodríguez, and Colleen B. Jonsson.

Special Publication 67. Harvestmen of the Family Phalangidae (Arachnida, Opiliones) in the Americas. James C. Cokendolpher and Robert G. Holmberg.

Special Publication 68. Bats of Saint Vincent, Lesser Antilles. Gary G. Kwiecinski, Scott C. Pedersen, Hugh H. Genoways, Peter A. Larsen, Roxanne J. Larsen, Justin D. Hoffman, Fitzroy Springer, Carleton J. Phillips, and Robert J. Baker.

Special Publication 69. Bats of Saint Lucia, Lesser Antilles. Scott C. Pedersen, Gary G. Kwiecinski, Hugh H. Genoways, Roxanne J. Larsen, Peter A. Larsen, Carleton J. Phillips, and Robert J. Baker.

View and download Occasional Papers and Special Publications at the NSRL website:
www.nsrl.ttu.edu/publications

Alumni Highlight: Brian Amman



My name is Brian Amman and I am an alumni of Texas Tech University's Department of Biology and the Natural Science Research Laboratory of the Museum. I graduated from TTU with a Ph.D. in Zoology in May of 2005. Currently, I am a Disease Ecologist with the Centers for Disease Control and Prevention's Viral Special Pathogens Branch. As a disease ecologist, I endeavor to first identify natural reservoirs of zoonotic viruses like Ebola and Marburg virus, and then work to understand the ecological relationships between these viruses and their reservoir hosts and how they impact human lives all over the world. My job requires a great deal of time spent working in the forests and jungles of Africa and other locations around the world collecting animal specimens for virologic testing and data for ecological research. The training and experience I acquired while at TTU and the NSRL have had an immeasurable impact on my ability to carry out my work for the CDC.

My training at the NSRL occurred while I was a graduate student studying molecular systematic of rodents in the laboratory of Dr. Robert Bradley. This training was unique

in that the majority of the samples we used in our phylogenetic analyses were obtained directly from the field where these rodents naturally occurred. I often regale my colleagues with stories of my time in the field with my fellow lab mates and Dr. Bradley—long days and nights capturing and processing small mammals for museum specimens and collecting samples for current or future phylogenetic research projects. Included in these stories are the early morning trap checks and the late night bat collections; the rapid learning curve associated with how to distinguish between a large rat and a snake in a Sherman trap just by the “feel of it”; and the necessity of good peripheral vision to avoid falling into a hole dug by a feral pig while traversing the southwest Texas chaparral at night and holding steady the shine of a raccoon's eyes in the beam of your headlamp. These and many other lessons learned in the field provided me with a skillset that has served me well in my career, where field work and sample collection are critical aspects of zoonotic disease ecology and outbreak response. The organization, preparation, and work ethic I learned while preparing for and conducting field work at TTU, the NSRL, and more specifically, in Dr. Bradley's lab, have become the foundation upon which every field excursion, outbreak response, and research project I undertake are based while in the performance of my duties at the CDC. Moreover, a necessity for accuracy in recording of data and attention to detail in everything from species identification to completing field notes has served me well in my career, all of which was made possible through my interactions with Dr. Bradley, my lab mates, and the NSRL.

UNDERGRADUATE RESEARCH

During the period July through December 2018, at least 12 undergraduate students were conducting research under the direction of 3 NSRL faculty associates.

STUDENT PRESENTATIONS

During July through December 2018, at least 11 graduate students gave 7 oral and 6 poster presentations of their research at 3 national and 3 international conferences and society meetings.

Collection Update: Invertebrate Zoology Collection Now “Open for Business”

The NSRL is pleased to announce that Jennifer Girón has been appointed as a Research Associate of the NSRL, where she will be providing her time and expertise to the Invertebrate Zoology Collection on a volunteer basis. Jennifer is an entomologist who specializes in beetle taxonomy. She currently is in the final stages of her PhD candidacy at the University of Kansas. Jennifer’s website, including her CV, is accessible here: <https://sites.google.com/view/jcgiron/home>.

The Invertebrate Zoology Collection had been temporarily unavailable following the retirement of Assistant Curator James Cokendolpher and subsequent budget cuts that prevented the hiring of a staff member in that position. Although our budget has not been restored, the NSRL is grateful to have Jennifer join us as she generously donates her time and expertise to provide curatorial and collection management duties, including the handling of loans, data requests, and new deposits to the collection.

The Invertebrate Zoology Collection at the NSRL is the largest collection (in number of specimens) of the Museum of Texas Tech. It is estimated to contain approximately 4.5 million specimens of spiders, ants, beetles, flies, butterflies, parasites, mollusks, and many other representatives of invertebrate biodiversity. Although the majority of specimens were collected from the southwestern United States, the collection has specimens from across the world, featuring several exotic and very showy species. The specimens are preserved following standard museum practices by various methods, depending on the features of the specimens. For example, most of the arachnids are preserved in glass vials and jars with ethanol, most insects are dry-mounted on pins, and most of the medically important specimens are mounted on microscope slides.



The Invertebrate Zoology Collection is a product of the time and effort of many people over the course of five decades. It has been fundamental for teaching, for scientific research, and for the professional development of many TTU faculty members and students. At least 50 TTU students have received experience and training in collections care by sorting, mounting, labeling, entering data, and taking photos of specimens. Texas Tech Master’s students and PhD students also have utilized the collection for their thesis and dissertation research. Beyond TTU, specimens housed in the collection have been studied by numerous scientists and students from more than 30 institutions over the years, including foreign institutions such as the National Museum in Rio de Janeiro in Brazil and the National Autonomous University of Mexico.

But the value of the collection lies not only in the number of specimens it contains. Value is added during each curatorial step, including collecting of specimens in the field, sorting specimens at the lab, pinning every single bug or beetle, making and placing the labels, organizing and identifying the processed specimens, and making the data available via a searchable public database. Currently, Jennifer’s focus in the Invertebrate Zoology Collection is on reorganizing the collection and updating the existing database by adding identification information for specimens that are missing this piece of information.

Jennifer is currently recruiting undergraduate students and external volunteers that would like to learn about and gain hands-on experience with the activities involved in managing a collection. If you are interested in volunteering in the Invertebrate Zoology Collection at the NSRL, please contact Jennifer at: Jennifer.Giron@ttu.edu.

Student Profiles



Brett Anderson, Ph.D. student, Department of Biological Sciences. Advisors: Liam McGuire and Richard D. Stevens.

Brett currently is studying the activity patterns of bats overwintering in the southeastern United States to identify spatial and temporal trends in occurrence. Additionally, he is investigating the summer origins of these bats by analyzing hydrogen isotope ratios in the fur.



Emma Guest, B.S. student, Department of Natural Resources Management. Advisor: Richard D. Stevens.

Emma currently is an undergraduate research assistant in the Department of Natural Resources Management conducting research on morphometric variation in wings of the bat genus *Artibeus*. She will graduate in May 2019 with a degree in Wildlife Biology and hopes to further her education by pursuing a master's degree in an ecology-related field.



J. Clint Perkins, Ph.D. student, Department of Natural Resources Management. Advisor: Richard D. Stevens.

Clint is interested in meso-carnivore ecology and conservation. Clint, Dr. Stevens, and Dr. Robert Dowler (Angelo State University) are researching spatial ecology and population dynamics of the eastern spotted skunk in a coastal prairie ecosystem. Clint's dissertation research focuses on the eastern spotted skunk's home range dynamics, landscape level habitat associations, and meso-carnivore community interactions with a focus on the eastern spotted skunk.



Heidi Stevens, M.A. student, Museum Science. Advisor: Robert D. Bradley.

Heidi is interested in improving curatorial practices as they relate to conservation of genetic resource materials. She is currently working on determining degradation rates in mammalian tissues for long term storage in liquid nitrogen.



Rachel Wiedmeier, M.S. student, Department of Biological Sciences. Advisor: Caleb Phillips.

Rachel's research focus is on understanding nasal, throat, and fecal microbiomes of bighorn sheep, especially in regard to disease. She is developing her study design using specimens from previously sampled individuals from various locations in the United States in addition to on-going collecting efforts in Texas. Her goal is to use community ecology approaches to characterize spatio-temporal variation in healthy bighorn sheep microbiomes, and to understand how disease susceptibility may relate to the diversity and composition of microbial communities living in association with bighorn. This information may prove informative to future management strategy.

AUGUST AND DECEMBER 2018 GRADUATES

Howard Huynh, Ph.D. Chair: Caleb D. Phillips. Dissertation title: Taxonomic Delineation and Natural History of Some Mammals from Atlantic Canada. Current position: Postdoctoral Research Fellow, University of New Brunswick, Canada.

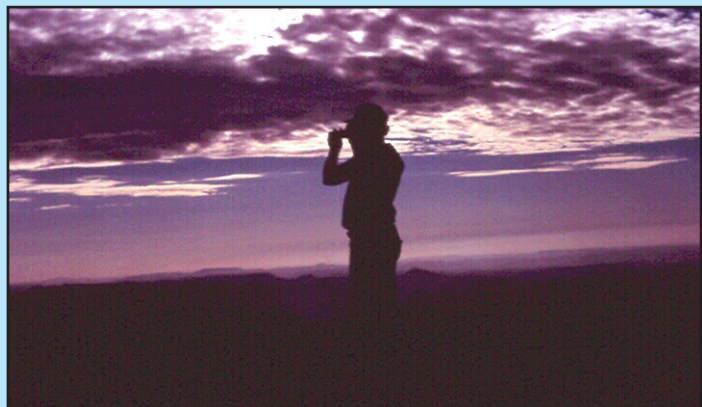
Sydney Kerby (nee Pope), M.S., non-thesis. Advisor: Jorge Salazar-Bravo. Current position: Science teacher, Frenship High School, Lubbock, Texas.

Elizabeth Rogers, M.S. Chair: Liam McGuire. Thesis title: Seasonal Flexibility in Lipid Metabolism in Brazilian Free-tailed Bats.

Scott M. Starr, Ph.D. Chair: Nancy McIntyre. Dissertation title: The Effects of Land Use and Climate Change on Playa Wetlands and their Invertebrate Communities. Current position: Biology Instructor, South Plains College, Levelland, Texas.

OUTREACH

In October, Daniela Arenas-Viveros, a graduate student of Jorge Salazar-Bravo, taught two short-courses in Arequipa, Peru. With funds from the Universidad Nacional de San Agustín (UNSA), and organized by the Department of Biology and the Museum of Natural History of UNSA, the courses revolved around the topics of “Laboratory Biosafety Protocols” and “Methods in DNA extraction and PCR amplification.”



Looking for good students! Bradley in Davis Mountains, Texas.

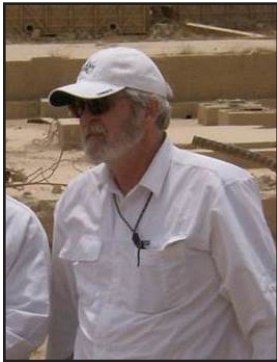
A Message to Prospective Students:

Faculty and staff associated with the NSRL are very active in field- and specimen-based research. Our faculty and students have interests in mammalogy, ornithology, invertebrate zoology, molecular systematics, genomics, ecology, and museum science. Most of the undergraduate and graduate students that are affiliated with the NSRL receive degrees in the Department of Biological Sciences or the Department of Natural Resources Management. We

also have students who are part of the Museum Science program. Together, we have a strong core of faculty and undergraduate and graduate students, and we are always on the look-out for potential new students. If you are interested in pursuing a graduate degree or undergraduate research opportunities, please contact any of the faculty members highlighted in this newsletter.

TTU FACULTY ASSOCIATES OF THE NATURAL SCIENCE RESEARCH LABORATORY

The following faculty at Texas Tech University have research programs that both contribute to and benefit from a working relationship with the Natural Science Research Laboratory. Graduate and undergraduate students of these faculty members, as well as those of the faculty Curators of the NSRL, conduct field-based research studies that result in growth of the NSRL collections and conduct laboratory-based research utilizing the resources of the NSRL to advance the sciences of mammalogy, ornithology, invertebrate zoology, wildlife ecology, and many other disciplines. The NSRL's strong history of field-based and organismal research, and continued commitment to such endeavors, set us apart from many other natural history programs.



Dr. Ron Chesser is a Professor of Biological Sciences. His research program focuses on assessing radioactive contamination, reconstructing flow of radioactive materials into the environment, and modeling the impacts and recovery of mammal populations affected by radiation. He has conducted research at Chernobyl, Ukraine, since 1992. He worked in Iraq for eight years (2005–2013) dismantling the former nuclear infrastructure, and he has contracted with the US Department of State, Department of Energy, International Atomic Energy Agency, Great Britain Ministry of Industry, US Civilian Research & Development Foundation, and the European Commission.

ron.chesser@ttu.edu

<http://www.faculty.biol.ttu.edu/chesser/homepage/>



Dr. Warren Conway is the Bricker Endowed Chair in Wildlife Management within the Department of Natural Resources Management. He and his students are involved in a variety of research projects in Texas, New Mexico, and Oklahoma with common themes of wildlife-habitat relationships, population and community dynamics, population management, restoration, and conservation, and toxicology and disease prevalence. Current projects include mule deer and pronghorn survival and habitat selection; urban mesocarnivore community ecology; elk response to prescribed fire and thinning; wildlife genetics; and disease and toxicology of populations of bighorn sheep, axis deer, and American woodcock.

warren.conway@ttu.edu

https://www.depts.ttu.edu/nrm/people/faculty/faculty_pages/warrenconway/conway.php



Dr. Tigga Kingston is an Associate Professor of Biological Sciences. Her research and activities are dedicated to the conservation ecology of Paleotropical bats. She has been working on the conservation ecology of bats of Southeast Asia for more than 20 years, with projects in Malaysia, Indonesia, Myanmar, Philippines, and Vietnam. More recently, she has student projects and collaborations in Africa, specifically Nigeria, Kenya, and South Africa.

tigga.kingston@ttu.edu

<http://kingstonlab.org/>



Dr. Joseph D. Manthey is an Assistant Professor of Biological Sciences. His research group uses a combination of fieldwork, specimens, ecological data, genomics, and bioinformatics to study how organisms (mostly birds) evolve across both geographic and genomic landscapes. Major research themes include: (1) how and why species' genomes change through evolutionary time, (2) diversification at different spatial and temporal scales in sky islands, and (3) impacts of fragmentation on population connectivity in sky islands.

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mantheylab.org



Dr. Liam McGuire is an Assistant Professor of Biological Sciences. His research focuses on the ecology and physiology of bats and birds in situations of energy limitation (e.g., migration, hibernation) and the strategies these animals use to cope with environmental variation, often in the context of conservation issues. He takes an integrative approach using techniques ranging from molecular biology and biochemistry, to whole animal physiology, behavioral and movement ecology. Current research foci include the physiological ecology of bat migration, and the physiological ecology and pathophysiology of hibernating bats affected by white-nose syndrome, a devastating fungal disease responsible for killing millions of North American bats.

liam.mcguire@ttu.edu

<https://www.depts.ttu.edu/biology/people/Faculty/McGuire/>



Dr. David A. Ray is an Associate Professor of Biological Sciences. The Ray laboratory focuses on the study of genomes and genome evolution with an emphasis on transposable elements and their role in the diversification of species. Model organisms include bats, several other mammals, and crocodylians.

david.4.ray@gmail.com

<http://www.davidraylab.com/>



Dr. Brenda Rodgers is an Associate Professor of Biological Sciences. Her research centers on the impacts of radiation on small mammals, mechanisms of adaptation to low dose radiation in pregnant females and fetuses, and human health issues in contaminated environments. She has worked on mammal population impacts at Chernobyl, Ukraine, since 1997. She worked for eight years in Iraq evaluating human impacts in contaminated regions and training scientists on laboratory practices, and she has contracted with the US Department of Energy (Low-dose Program), US Department of State, and the Civilian Research & Development Foundation.

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<http://www.depts.ttu.edu/biology/people/Faculty/Rodgers/>



Dr. Jorge Salazar-Bravo is an Associate Professor of Biological Sciences. His research revolves around two basic themes: developing and testing phylogenetic hypotheses for mammalian taxa at various hierarchical levels; and using first principles in ecology and evolution to understand the triggers for disease emergence. Research topics he has pursued, as represented in his publications, include: systematics, biogeography, evolution, and conservation of Neotropical mammals; the ecology and evolution of virus/host co-evolution; and the interplay between ecology and disease.

j.salazar-bravo@ttu.edu

<http://www.depts.ttu.edu/biology/people/Faculty/Salazar-Bravo/>



PLEASE SUPPORT THE NSRL

Dear Former Students, Colleagues, and Friends:

In 2015, a fund-raising initiative for the NSRL was established. The NSRL Fund for Excellence is designed to help support the many collections activities of the NSRL. Our goal is to use these funds to establish a student curatorial position. This position would enable the NSRL to improve curatorial and collection management activities, as well as help support students with a professional interest in natural history collections. As this fund grows, we envision that we will be able to financially support multiple students.

Your contribution to the Natural Science Research Laboratory Fund for Excellence is very important to the future of the NSRL. With limited, and often declining, funding from state and federal sources, the NSRL needs your help to ensure our continued service to the academic and scientific communities. We appreciate your consideration in giving a tax deductible donation in support of the NSRL's operations and research. Many of you benefited from the resources provided by the NSRL, now we ask that you help the NSRL continue its quest to be among the premier natural history collections in the world.

Donations to the NSRL Fund for Excellence may be made through the Texas Tech Foundation, Inc. To donate by check, please make the check payable to Texas Tech Foundation, designate NSRL Fund for Excellence on the memo line, and mail to: Texas Tech University System, Financial Services, Box 45025, Lubbock, TX, 79409-5025. To give by phone, call toll free: 1-866-448-3888. To donate online, visit the website of TTU Institutional Advancement at <http://donate.give2tech.com/> and enter Natural Science Research Laboratory Fund for Excellence in the search box.

YOUR SUPPORT IS APPRECIATED! THANK YOU!

NSRL News is produced biannually by Lisa Bradley with assistance from the staff, research scientists, and graduate students of the NSRL. Please contact Lisa to request a hard copy or to submit comments or contributions for upcoming issues of *NSRL News*.

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NATURAL SCIENCE
RESEARCH LABORATORY

at the Museum of Texas Tech University

