Current Research

Below is a brief description of the 14 new research projects hosted by the Center this fiscal year; for a complete list of active research projects at the Center see Appendix A. This year five of our new research projects were led by faculty, whereas, three were post-doctoral projects, three were Ph.D. dissertation projects, and one was a master's thesis project. Half of these projects are associated with a University of California campus, six are associated with Universities from other states, such as University of Illinois, University of Arizona, and Princeton, while one is affiliated with York University in Toronto, Canada (Table 3). These projects are funded by a variety of sources, including National Science Foundation, Mathias Grant, Cooper Ornithological Society, Natural Sciences and Engineering Research Council of Canada, American Society of Mammologists, and the University of California President's Postdoctoral Fellowship Program.

Project Title: Entrapped sand as a plant defense: effects on herbivore performance and preference
Researcher(s): Eric LoPresti, Richard Karban
Affiliation(s): University of California Davis
Funding: NSF-PRFB, $130,000; UC Davis Jastro Sheilds Award, $7,140; Hardmann Native Plant Award, $2,719; Mathias Grant, $2,992; UC Davis Botanical Society Award, $1,500
Description: Ph.D. Dissertation. Eric LoPresti is a graduate student in Dr. Richard Karban's laboratory at UC Davis. Eric is interested in the various types of stickiness on plants and how they affect herbivores. In particular, he studies several psammophorous, or sand-entrapping, plants that live in coastal dunes or on sandy substrates in the desert. His research is focused on testing whether the sand armor is truly a defense against herbivores, and if so whether it achieves this as a result of acting like camouflage or whether the sand acts more as a physical defense against the herbivore. His previous studies show that the sand definitely impacts the herbivores by causing wear on their mandibles, and this leads to reduced digestive efficiency and decreased growth rates Figure 11).

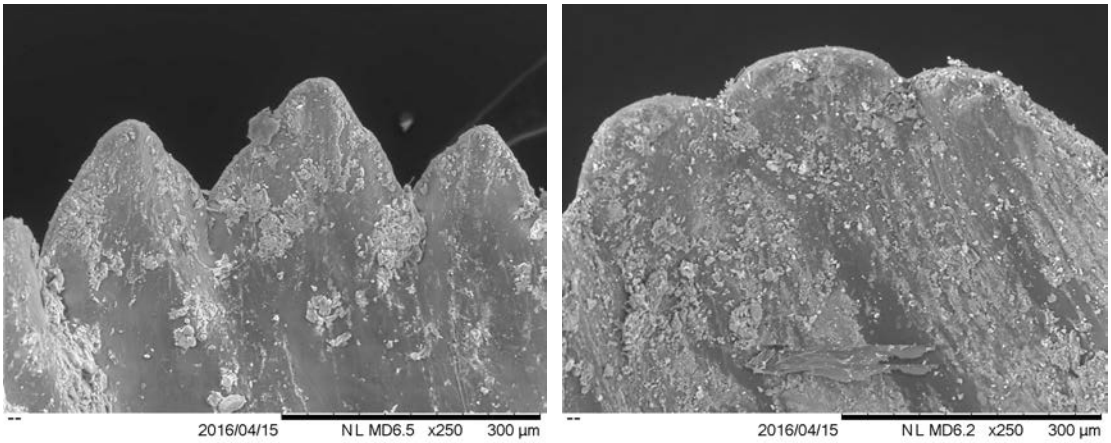

Figure 11. Left photo: A white-lined sphinx moth (*Hyles lineata)* mandible from a caterpillar fed on "clean" *Abronia latifolia* leaves. Right Photo: A worn-down mandible of a caterpillar fed on "sandy" *A. latifolia* leaves. Images by Eric LoPresti.

Project Title: Perennial grass-dominated plant communities of the eastern Mojave Desert region
Researcher(s): Joseph McAuliffe
Affiliation(s): Desert Botanical Gardens, Phoenix, AZ
Funding: None
Description: Faculty Research. Joseph McAuliffe, Ph. D., is a senior research scientist at the Desert Botanical Garden in Phoenix, AZ. He is recognized as a leading arid lands ecologist, largely due to his multidisciplinary approach to studying arid land ecosystems. His research in the eastern Mojave Desert of California focuses on plant-soil relationships, plant communities dominated by perennial-grasses, as well as population dynamics of long-lived perennials. His most recent efforts have been focused on the eastern Mojave Desert region of southeastern California, southern Nevada, and west-central Arizona where he has described the natural history of the vegetation communities in the context of soil, geology, hydrology, and climate. His research has shown that since the 1890s, livestock ranching has negatively impacted the native perennial grass-dominated vegetation in this region and that removal of livestock, coupled with years of abundant warm-season precipitation, and in some cases combined with wildfire, has led to a resurgence of these unique perennial grass communities

Project Title: Synergism between an ant parasitoid and a desert plant
Researcher(s): John Heraty
Affiliation(s): University of California Riverside
Funding: National Science Foundation, $566,600, DEB 1257733ARTS: Classification and Evolution of the Ant-parasitic Genus *Orasema* (Hymenoptera: Eucharitidae)
Description: Faculty Research. John Heraty, Ph.D., studies the systematics, phylogeny, and biogeography of the superfamily Chalcidoidea (Hymenoptera), which ranks numerically as one of the largest groups of insects on the planet. Within this group, the family Eucharitidae are exclusively parasitoids of the larval and pupal stages of ants; one wasp genus, *Orasema,* is common in the Southwest and is of particular interest to Dr. Heraty and his students. Their recent studies have focused on *Orasema simulatrix*, which lays its eggs near extrafloral nectaries on the leaves and flowers of *Chilopsis linearis* (desert willow). It is

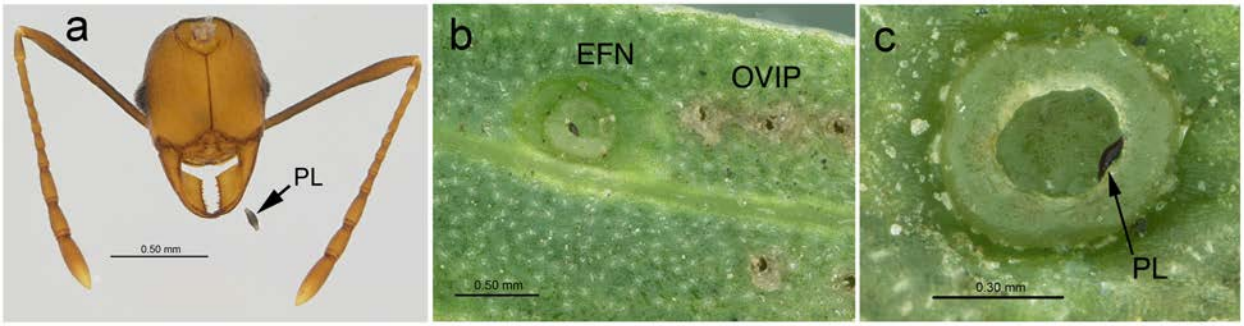

Figure 12. *Orasema simulatrix* and its host. Head of *Pheidole desertorum* next to planidium (PL) of *O. simulatrix* (a); oviposition punctures (OVIP) next to extrafloral nectary (EFN) on *Chilopsis linearis* leaf (b); EFN with planidium (c). Images by John Heraty.

postulated that the ant host, *Pheidole desertorum,* ingests the planidium (first instar larva) while scavenging for nectar on the plant (Figure 12) and then deposits the planidium back in the nest where it becomes an endoparasite on the ant larvae. There are many questions that remain unanswered about this fascinating three-species relationship, for example, the exact method in which the ant host carries the eggs back to the nest is still unclear. In addition, they want to conduct experiments to determine whether the flow of nectar is impacted by mechanical damage from the ovipositor on the wasp. These questions, and more, can be applied to the other *Orasema* species that occur sympatrically in this area, and will likely keep Heraty and his team busy for many years to come.

Project Title: Digital Cultural Atlas of the Mojave Desert
Researcher(s): Nicholas Bauch
Affiliation(s): University of Oklahoma
Funding: University of Oklahoma Junior Faculty Fellowship, $7,000
Description: Faculty Research. Nicholas Bauch, Ph.D., is an Assistant Professor in the Department of Geography & Environmental Sustainability at the University of Oklahoma. His research explores the link between geography and the humanities, specifically the way we imagine, design, understand, and represent the lands and lives of everyday places. Dr. Bauch has spent his career exploring the way people have used words (e.g., literature, stories, blogs), pictures (e.g., art, photography, television, video, cinema), music, and maps to assign meaning to places. In his current project he plans to collate disparate archival material to describe the various ways that societies over the past 500 years have understood and physically altered landscapes in this seemingly barren but actually very humanized region (Figure 13). His goal is to address the dynamic cultural attitudes about American deserts, ranging from wasteland to sanctuary and more specifically, to address what myriad cultural values have permeated this

Figure 13. An artistic interpretation of an old watering trough found in the desert. Images by Nicholas Bauch.

landscape and how have those values have become entwined with material changes in the physical landscape. Dr. Bauch is one of the leading academics in a new field of digital humanities where researchers combine the traditional tools of the historian and geographer, such as archival research and cartography, with web-based or digital mediums. These digital mapping projects allow for new ways to visualize, analyze, and interpret data through alternative spatial representations and digital cartographic platforms.

Project Title: Characterizing the genetics behind the timing of germination of desert annuals to both seasonal temperature changes and unpredictable rainfall cues.
Researcher(s): Alejandra Martinez-Berdeja
Affiliation(s): University of California, Davis
Funding: None
Description: Post-Doctoral Research. Alejandra Martinez-Berdeja, Ph.D., is a postdoctoral researcher in the lab of Dr. Johanna Schmitt at UC Davis. Dr. Martinez-Berdeja is interested in how plants adapt to variable environments and to environmental cues occurring at different time and spatial scales. More specifically, she is focused on seed germination, which is a life-history trait that allows annual plants to cope with different levels of environmental variability. The goal of this study is to investigate the genetics behind the timing of germination in the desert annual *Mimulus bigelovii* (Figure 14). Seeds for germination trials will be collected from various desert regions that differ in their seasonal rainfall patterns. Experimental treatments will be conduted in the greenhouse and will test for dormancy cues using varying temperatures and water potentials. Eventually, the goal is to use QTL mapping to understand the genetics behind different types of phenotypically plastic responses that allow annual plants to cope with seasonal temperature changes and unpredictable rainfall patterns.

Figure 14. *Mimulus bigelovii*, one of many showy winter annuals in the California desert. Photo by Tasha La Doux.

Project Title: Taxonomic Classification of the Deserticolae Agavaceae in southeastern California
Researcher(s): Greg Starr
Affiliation(s): University of Arizona, Starr Nursery
Funding: None
Description: Independent Research. Gregg Starr is an independent researcher in the Phoenix area; he is recognized as one of the leading experts on the genus *Agave*. His research to date suggests a surprising ancestry for *Agave deserti* var. *simplex* (Gentry, 1982), which is the only agave to have been identified in the Granite

Mountains. This taxon is known to occur across western and south-central Arizona, including the type locality in the Harquahala Mountains, however interesting varietal differences have been observed over the course of many years. Starr has determined that many vegetative and floral characteristics of the specimens found in the Granite Mountains appear intermediate between *A. deserti var. simplex* and another species, *A. parryi*, which is not found in the region. Evidence suggestive of an ancient *A. parryi*-like presence also extends to extreme southern Nevada and the Hualapai Mountains in western Arizona. Starr hopes to learn more about the origin of *Agave deserti* var. *simplex* and specifically whether it includes the likes of *Agave parryi* in the form of ancient introgression, or perhaps a common ancestor by including plants from the Granite Mountains.

Project Title: Breeding System of *Physalis crassifolia*
Researcher(s): Boris Igic
Affiliation(s): University of Illinois, Chicago
Funding: National Science Foundation (NSF)
Description: Faculty Research. Boris Igic, Ph.D., is an Assistant Professor at University of Illinois, Chicago, in the Department of Biological Sciences. Dr. Igic studies mating system evolution and how the traits associated with mating systems have influenced diversification in angiosperms. He has spent many years working on self-incompatibility in Solanaceae, one member being *Physalis crassifolia* (Figure 15), which is a self-incompatible desert perennial found here in the Granite Mountains. In this project, Dr. Igic plans to perform controlled crosses in the field and observe any pollinator activity, thus learning more about the pollination biology of this species and whether there are any self-compatible individuals in the wild. He will also collect tissue samples for the study of geographic diversity within the species, as well as S-locus haplotype assembly (with the aid of later laboratory crosses and RNAseq).

Figure 15. *Physalis crassifolia* (Solanaceae), a short-lived perennial with self-incompatibility, often found on rocky slopes in the desert. Photo by Tasha La Doux.

Project Title: The evolutionary history of darkling beetles (Coleoptera: Tenebrionidae)
Researcher(s): Aaron Smith, Rolf Aalbu
Affiliation(s): Northern Arizona University, California Academy of Sciences
Funding: National Science Foundation DEB, Advancing Revisionary Taxonomy and Systematics (ARTS) Award#1523605 ($290,526), Award#1754630 ($878,751)
Description: Faculty Research. Dr. Aaron Smith is broadly interested in patterns of biodiversity, ecology, and evolutionary history of insects. More specifically, his research has focused on uncovering the evolutionary history of darkling beetles (Coleoptera: Tenebrionidae) by studying larval and adult morphology, behavior, as well as producing taxonomic revisions based on phylogenetic analyses. Dr. Smith, along with a team of collaborators, are concentrating on darkling beetles that live in desert environments across the world: from the Mojave and Sonoran Deserts of the southwestern to the Kalahari Desert in Namibia. This research will describe hundreds of species new to science, explore where these beetles live and how they are related to each other across the planet, and investigate the various adaptations that have allowed these beetles to thrive and diversify across the world's deserts.

Project Title: Behavioral plasticity in the phainopepla
Researcher(s): Daniel Baldassarre
Affiliation(s): Princeton University
Funding: Cooper Ornithological Society Young Professional Award
Description: Postdoctoral Research. Daniel Baldassarre, Ph.D., is a Postdoctoral Research Associate in Christie Riehl's laboratory at Princeton University. Daniel is studying phenotypic plasticity in desert and woodland breeding populations of the Phainopepla (Figure 16) in southern California. Phainopeplas are extremely unusual birds that breed in two distinct habitats during the same season. Studying the behaviors that change in response to these two drastically different environments will provide insight into the limits of behavioral plasticity in birds. He will be capturing and banding birds, taking blood samples for genetic analyses of paternity, and deploying miniaturized GPS transmitters to track migration. By combining GPS tracking, population genomics, and spatial analyses this research will begin to document the unusual life-history strategy of the Phainopepla.

Figure 16. Fledgling Phainopepla hiding in a rock crevice at the Granite Mountains.
Photo by Malory Owen.

Project Title: Using desiccation-tolerant ferns to elucidate mechanisms of vascular plant resurrection
Researcher(s): Helen Holmlund, Jarmilla Pitterman
Affiliation(s): UC Santa Cruz
Funding: NSF Graduate Research Fellow ($102,000); Langenheim Fellowship ($1500)
Description: Ph.D. Dissertation. Helen Holmlund is a graduate student at UC Santa Cruz working in the laboratory of Dr. Jarmila Pittermann at the University of California, Santa Cruz. Helen is interested in the physiological ecology of resurrection ferns. Many desert ferns are desiccation tolerant, which means that they completely desiccate at the onset of drought and revive (resurrect) following even a tiny amount of rainfall. Desiccation tolerance is believed to be an effective strategy for desert survival because it maximizes photosynthesis during the wet seasons. Although the cellular and biochemical mechanisms of desiccation tolerance and resurrection have been extensively studied, much less is known about the whole-plant physiology of vascular plant resurrection. Helen will be conducting lab and field experiments to identify the relative contributions of leaf water uptake, capillary rise, and positive root pressure to the resurrection of desiccated ferns. Here at the Granite Mountains, Helen has identified two species of ferns, *Cheilanthes covillei* and *C. viscida,* that she will measure chloroplast health (dark-adapted Fv/Fm), leaf curling index (calculated from leaf dimensions), and positive root pressure during an induced resurrection from various watering schemes.

Project Title: Mojave Desert Living Collection
Researcher(s): Vanessa Handley
Affiliation(s): UC Berkeley
Funding: UCBG, Lester and Anne Packer Donation
Description: Independent Research. Vanessa Handley is the Director of Research and Collections at the University of California Botanical Garden (UCBG). She is embarking on a multi-year project to renovate the regional beds of the California living collection. The renovations will improve cultural conditions for the existing collection and allow for new accessions to be incorporated. Beyond the general value of these public displays, the objective is to enhance materials available

Figure 17. Jim André and Tasha La Doux (top left and right) led the UC Berkeley Botanical Garden crew (Ben Anderson and Clare Al-Witri in the foreground) into Cottonwood Basin for a collecting trip in April. Photo by V. Handley.

for research and instruction. UCBG currently has one of the largest live collections of California native plants in the world and most accessions are wild collected, with fully documented provenance. This ensures that the collections have maximum utility for research, conservation and education purposes. The current priority in this project is to rejuvenate and expand the California Desert beds, a section that is heavily used by faculty, students and researchers from UCB and beyond. The Granite Mountains Desert Research Center was chosen as the ideal base for preliminary explorations given the available Flora, the on-site herbarium and the botanical expertise of GMDRC staff. A team from UCBG will be making several desert trips to document species assemblages, investigate parameters relevant to cultivation, and conduct limited collecting (voucher specimens and seeds/propagules), the first of which occurred in April 2017 (Figure 17).

Project Title: Predator-prey interactions between kangaroo rats and rattlesnakes
Researcher(s): Malachi Whitford, Grace Freymil, Rulon Clark, Tim Higham
Affiliation(s): San Diego State University, UC Davis, UC Riverside
Funding: San Diego State University, Animal Behavior Society, and American Society of Mammalogists
Description: Ph.D. Dissertation. Malachi Whitford and Grace Freymil (Figure 18) are both graduate students conducting their dissertation work through a Joint Doctoral Program between UCD-SDSU and UCR-SDSU, respectively. They are

Figure 18. Grace Freymil and Malachi Whitford performing surgery on a sidewinder (*Crotalus cerastes*). Photo by T. La Doux.

working in the laboratory of Rulon Clark, Ph.D., at SDSU on a collaborative project studying predator-prey interactions between rattlesnakes and kangaroo rats. When confronted with predators, many animals engage in lengthy, conspicuous interactions involving several stereotyped signals and displays. These antipredator signals have been studied mainly in regard to their function as warning signals directed toward conspecifics, even though they may also serve to communicate with predators. However, the study of the impact of these signals on predators has been rare because predation is infrequent and difficult to observe in the field; consequently, data on natural predator responses to antipredator signals is lacking. Past studies have shown that kangaroo rats often direct antipredator displays towards rattlesnakes. This team of scientists will use a combination of radio telemetry and videography to record and analyze predator-prey interactions between free ranging rattlesnakes and kangaroo rats. These methods will allow them to address several fundamental questions concerning communication dynamics and the evolution of antipredator signaling behavior.

Project Title: Transfiguring anthropocene streams: Stochastic re-imaginings of human-beaver-salmon worlds.
Researcher(s): Cleo Woelfle-Erskine, July Cole
Affiliation(s): UC Santa Cruz
Funding: University of California: President's Postdoctoral Fellowship Program
Description: Postdoctoral Research. Cleo Woelfle-Erskine, Ph.D., is working in the Feminist Studies Department at UC Santa Cruz with mentor Karen Barad, Ph.D., to explore queer, transgender, and decolonial possibilities for ecological science. Dr. Woelfle-Erskine is focused on ecological and social dimensions of human relations to rivers and their multi-species inhabitants. He and his colleague, July Cole, Ph.D., visited the Center in order to work on completing a book manuscript that explores the lingering presence of Manifest Destiny and the ways that this injurious "destiny" can be transfigured and overturned to renew ecological, socio-scientific, and psychological relationships between humans, water, and nature. They are interested in how queer theory can expand the kinds of problems that ecologists study and in particular the way ecologists study multispecies communities.

Project Title: An examination of the spatial dimensions of pollination facilitation in an arid ecosystem
Researcher(s): Jenna Braun, Chris Lortie
Affiliation(s): York University
Funding: Natural Sciences and Engineering Research Council of Canada Discovery Grant, Ontario Graduate Scholarship
Description: Master of Science Thesis. Jenna Braun is a Master of Science student working with Dr. Christopher Lortie in the Department of Biology at York University. Jenna is interested in testing how key shrubs in the ecosystem act as pollinator magnets, and more specifically how those magnet shrubs may positively or negatively impact other plants through direct or indirect facilitation. Very few

studies have addressed indirect interactions involving pollinators in stressful environments such as deserts, however recent evidence suggests that the density and spatial distribution of a magnet plant can manipulate the behavior of pollinators, thereby affecting the fitness of neighboring plants. The objectives of this study are three-fold: 1) To test if shrubs and cacti are acting as magnets for pollinators within the system, and determine which species of pollinator are being shared; 2) To construct a pollen transfer network to quantify interactions between individual plants and pollinator guilds; and 3) To create a vegetation map of shrubs and cacti to guide future experiments. Jenna used a Polaroid Cube+ video recorder to capture continuous HD videos (1080 p) of pollinator activity on potted transplants of *M. glabrata* (Figure 19). This approach not only decreases physical interference by the observer, but also allows for much more data collection than a person could collect by sitting next to the plant.

Figure 19. Polaroid Cube+ video camera recording pollinator visitation. Photo by J. Braun.