

Title of the Project: Distribution and population status of Arkansas bumble bees

Project Summary:

The goal of this project is to determine the distribution and population status of bumble bees in Arkansas. This study will update the bumble bee species in Arkansas as well as update the biogeography of these species across the state. This project will provide baseline distribution and population status data for bumble bee species and address their vulnerability to climate change and habitat degradation. Outcomes are expected to identify locally adapted populations, determine species that may be of greatest risk for extirpation in Arkansas and identify climactic and habitat factors that influence bumble bee distributions.

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Project Partners:

- Dr. Jeffery K. Barnes, Curator, University of Arkansas Arthropod Museum, (479) 575-4795, jbarnes@uark.edu

Total Amount of the Project: \$94,494 (2 year grant)

Total Amount of State Wildlife Grant (SWG) Money Requested: \$63,375

Matching Funds and Inkind Services: \$31,119 Agriculture Experiment Station, University of Arkansas

- \$17,247 salary, plus \$13,010 tuition, plus \$862 fringe benefits for Graduate Research Assistant

Project Statement: **Distribution and Population Status of Arkansas Bumble Bees: A Baseline for Monitoring the Effects of Habitat Fragmentation and Climate Change**

a) Need

Bumble bees are important native insects known to pollinate a wide-variety of native plant species, yet many species are thought to be declining world-wide (Goulson *et al.* 2008). Climate change and habitat fragmentation may have an impact on locally adapted populations resulting in displacement or loss of *Bombus* diversity in Arkansas. Little is known about current state of the species of bumble bees that occur in Arkansas, but there are indications that at least one species, the American bumble bee *B. pensylvanicus*, is declining. In a 1965 survey, it was listed as the most abundant species in the state (Chandler and McCoy 1965), yet a recent observational citizen science survey conducted by the Arkansas Natural Heritage Commission (2005-2006) reported low numbers of American bumble bee sightings. This species has also been cited as declining in Illinois (Lozier and Cameron 2009).

Although the survey conducted by the Arkansas Natural Heritage Commission provided invaluable preliminary data on the status of Arkansas bumble bees, there remains a need to create a baseline of bumble bee distribution in the state and determine the resilience of our local populations in the face of climate and land use changes. Elsewhere, both the diversity and the distribution of bumble bee species have been shown to be influenced by climate and habitat factors (Hines and Hendrix 2005, Greenleaf and Kremen 2006, Kirilenko and Hanley 2007), but these factors have not been addressed for most of the species occurring in Arkansas. Comparisons between historical and contemporary populations using molecular methods can be used to assess the genetic diversity and population structure of Arkansas bumble bees, allowing for the identification of declining populations and vulnerable species. This project addresses the need to establish a baseline for population monitoring of all bumble bee species in the state as well as examine the stability of populations and determine factors that influence their historical and contemporary distributions.

b) Objective

The goal of this project is to update the distribution and population status of bumble bees in Arkansas. It is intended to address the gap in knowledge in these important native pollinators in Arkansas. This will provide a baseline for the potential impact of climate and habitat changes on bumble bee species diversity in the state. Outcomes are expected to identify vulnerable species and local populations.

c) Expected Results and Benefits

- **Update of Species Records:** This study will provide an update of the records of bumble bee species and their distribution in Arkansas (last survey by Chandler and McCoy 1965). GIS analysis will be used to identify ecoregional patterns and may aid in the identification of suitable habitats.
- **Population Status of Arkansas Bumble Bees:** Population genetic analysis will be conducted to determine the population structure of Arkansas bumble bees and identify those that are genetically distinct and most vulnerable to climate and habitat changes.
- **Genetic Diversity of Bumble Bees:** Comparisons of historical and contemporary genetic diversity within each species will be used to identify species that have undergone recent declines in population numbers and may be at risk.
- **Impact of Climate Change:** Differences in the abundance and genetic diversity of bumble bee species that occur in different climatic zones may provide an indication of the impact of climate change on these species. GIS analysis of temporal genetic changes may provide an indication of the effects of recent climate change and aid in the prediction of future impacts.
- **Presentations and Peer-Reviewed Publications:** Research from this study will be presented at scientific meetings including the annual meeting of the Arkansas Entomological Society and the annual meeting of the Entomological Society of America. Results will be published in a peer-reviewed entomology publication.
- **Samples Added to the Arkansas Arthropod Museum:** The Arkansas *Bombus* collection of the Arkansas Arthropod Museum currently consists of 8 taxa totaling 342 specimens. Our study will

greatly enhance this collection in terms of species, sample numbers and geographic coverage of the state. This collection will then be available for loan to other scientists. Digital images will be taken of samples and will be made available online at bugguide.net.

- **Citizen Involvement:** We will involve beekeepers and Master Gardeners from across Arkansas, along with students from two entomology classes for collecting bumble bees.
- **Predictive Indicators of *Bombus* spp. Distributions:** GIS analysis of climactic and landscape variables may yield data on the suitability of various climates and habitats for *Bombus* spp. in Arkansas, enabling predictions for potential future distributions that can inform conservation efforts.

d) Approach

1. Collection and Identification of Specimens

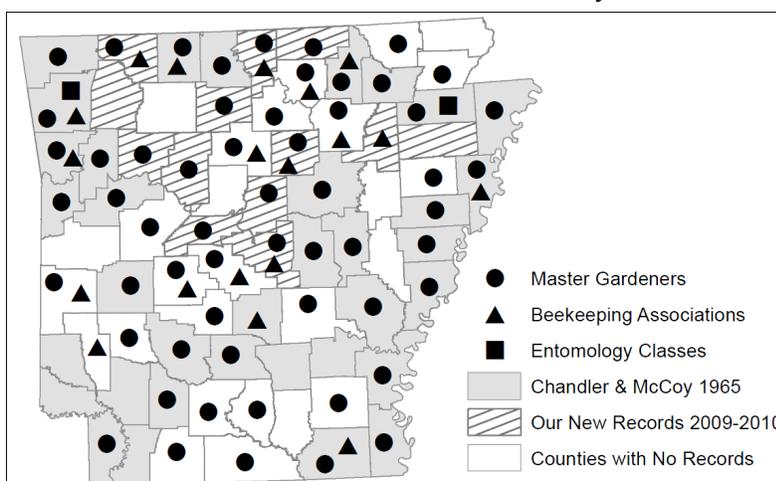
Bumble bee samples will be obtained from our own collection efforts as well as from Arkansas entomology students, master gardeners and local beekeeping associations. Students will collect bumble bees as part of their insect collections for entomology classes at the University of Arkansas (Dr. Jeff Barnes) and Arkansas State University (Dr. Tanja McKay). The University of Arkansas Master Gardener Coordinator, Janet B. Carson has agreed to assist us with having Master Gardeners collect samples in the 57 counties with Master Gardener programs. In conjunction with Ed Levi, State Apiarist, Arkansas Plant Board, we will contact beekeepers from the beekeeping associations from across Arkansas to assist with collecting bumble bees for the study (see map). A collection kit containing instructions, plastic vials containing 80% ethanol and a stamped returned envelope will be made available to all participants. To avoid impacting populations, collection efforts will be restricted to no more than 10 non-reproductive workers per citizen collector. Our own collection efforts will attempt to survey areas with no record of bumble bees in the state (see map), as well as resurvey areas in which *B. pensylvanicus* was formerly abundant. We will also have access to specimens in the University of Arkansas Arthropod Museum, which will be used to determine the historical diversity and distribution of bumble bees within the state. Morphological identification of *Bombus* species will be performed using the keys of Chandler and McCoy (1965), Mitchell (1962) and Williams (2010) and deposited at the University of Arkansas Arthropod Museum in Fayetteville, AR.

2. Genetic Analysis

The genetic diversity of both historical and contemporary Arkansas bumble bee specimens will be determined by assessing the variation found in the 16S mtDNA gene and assigning a haplotype to each specimen. Populations will be assigned based upon geographic and genetic distances. Diversity indices and population structuring will be analyzed for temporal and geographic distribution patterns to identify vulnerable and stable species. New sequences will be made available to other researchers on GenBank.

3. GIS Analysis

The collecting locations and haplotype designations of all historical and contemporary bumble bee specimens will be databased and mapped using ArcMap 10. The contribution of landscape and climate variables to the observed distributions will be analyzed to determine the likelihood of species and



haplotype occurrence. Patterns found in the distributions of bumble bee species and populations will be analyzed to identify the associated climactic and habitat variables that may be capable of explaining bumble bee distributions across the state. Potential variables under consideration are ecoregion variables such as Omernik's Level III classifications, climate variables such as temperature, precipitation and plant hardiness zones and habitat

variables such as the proportion of impervious land cover and land use designations (e.g. agricultural, urban, forest). If variables are identified as indicators of current or historical *Bombus* spp. genetic diversity or distributions, predictive models will be developed that may aid in bumble bee conservation efforts.

4. Preliminary Data

We have collected 363 bumble bee specimens of six species (*B. auricomis*, *B. bimaculatus*, *B. griseocollis*, *B. impatiens*, *B. fraternus* and *B. pensylvanicus*) from 27 counties in Arkansas thus far, resulting in 46 new county-level species occurrence records. No specimens of *B. variabilis*, a species listed in the Chandler and McCoy (1965) survey have been collected. The American bumble bee, *B. pensylvanicus*, only accounted for 5.5% of the specimens, providing greater evidence of the likelihood of its decline in the state. Haplotypes of *B. auricomus* (1), *B. bimaculatus* (7), *B. griseocollis* (9), *B. impatiens* (5) and *B. pensylvanicus* (2) have been identified using the 16S mtDNA marker (N = 121). Genetic data has been successfully extracted from 35 museum specimens up to 50 years old.

e) Location of Work (see map)

Because so little is known about the current status of bumble bee species within the state, a state-wide survey will be conducted across all Arkansas Ecoregions. Results of this project should identify areas of concern for future conservation efforts.

f) Budget Justification

Salaries: Salary and fringe benefits for 1/2 PhD student research assistantship (Amber Tripodi). Dr. Szalanski will act as advisors for this student. Amber will be responsible for coordinating the collection of samples, DNA extractions, PCR, DNA sequencing, GIS analysis and interpretation of results.

Travel: \$8,750. Funds for collecting bumble bee samples in Arkansas as well as travel to the annual meeting of the Entomological Society of America are requested in order to present research results.

Research Supplies: \$27,250. \$5,000 is requested and includes collection vials, DNA extraction kits, PCR reagents, and PCR purification kits), and **\$22,250** is requested genetic analysis.

Publication Costs: \$1000 is requested for publication page and reprint charges.

Item	SWG	Match	Total
GRA support	17,247	17,247	34,494
GRA tuition	0	13,010	13,010
Benefits GRA	862	862	1724
Materials & Supplies	27,250	0	27,250
Publication	1000	0	1000
Travel	8,750	0	8,750
Indirect Costs	8,266	0	8,266
Total	63,375	31,119	94,494

Experience and Roles

Principal Investigator:

Dr. Szalanski has a BS, MS, and PhD in Entomology and is currently an Associate Professor at the University of Arkansas, Department of Entomology. He has a strong background in insect genetics, specializing in population genetics, molecular systematics and molecular diagnostics of Hymenoptera, Isoptera and Diptera. He teaches a course in molecular methods for insect genetics and his Insect Genetics Laboratory at the University of Arkansas focuses on the phylogenetic and phylogeographic relationships within and across insect populations. He has over 95 refereed publications, including over 24 relative to social insects and three in conservation genetics. Dr. Szalanski will serve as the principle investigator on this project and oversee the work of the graduate student.

Graduate Student:

Amber Tripodi has a BS in Biology, with a minor in Entomology (3.9 GPA) and an MS in Environmental Sciences, with a concentration in Ecosystems (4.0 GPA). She has four refereed publications, two of which she is primary author. Currently, she is pursuing a PhD in Entomology at the University of Arkansas with Dr. Allen Szalanski. Her primary research interests are the conservation genetics of bumble bees in the United States and how native pollinators may respond to climate and land use changes. In addition to classwork in entomology, GIS, sustainability, environmental science, genetics and statistics she has a strong research record in laboratory, farm and natural settings, as well as statistical and GIS analysis. Ms. Tripodi will conduct the collection of specimens, as well as the genetic and GIS analyses.

Organizations Involved

- Department of Entomology, University of Arkansas, Fayetteville, AR
- Department of Biology, Arkansas State University, Jonesboro, AR
- Arkansas Plant Board, Little Rock, AR
- Arkansas Beekeeping Associations
- Arkansas Master Gardeners