

Title:

Conserving the endangered Mexican long-nosed bat (*Leptonycteris nivalis*) through community bat-friendly agave management in northeast Mexico

Project Leader:

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Project Location:

Nuevo León and Coahuila, Mexico

Dates:

May 1, 2017 – May 1, 2019

Project Summary:

The main goal of this project, which formed the basis of my PhD, was to understand how to implement community agave programs for conservation of the endangered Mexican long-nosed bat (*Leptonycteris nivalis*) in northeast Mexico. Through my Kate Barlow Award project, my collaborators and I have made significant progress in our work to protect the endangered Mexican long-nosed bat and its foraging habitat. I conducted field research that informed our revision of the Species Status Assessment for the U.S. Fish and Wildlife Service, a document that will guide federal recovery plans for the species. In collaboration with Bat Conservation International, Protected Area managers, and local Mexican communities, we are now leading an agave restoration initiative with local communities in northeast Mexico to create high-quality foraging habitat across the bats' migratory range. This is a huge step in the recovery of the species. We also led two Bat Fests in Monterrey, Mexico to educate the public about bats and the importance of their conservation.

In addition, I presented this project at eight regional, national, and international academic conferences, including BCT's National Bat Conference in 2018 (remotely) and 2019. My project was also featured in BCT's *Bat News* ("Not Just Tequila", June 2017) and Bat Conservation International *Bats Magazine* ("Bat-friendly agriculture: Conserving the Mexican long-nosed bat with bat-friendly agave harvesting", September 2017). I have also presented the project to general public audiences on numerous occasions.

This project was the first to join analyses from the natural sciences and social sciences to understand the ecological and social aspects of agave restoration initiatives for bat conservation in northeast Mexico. Ultimately, the information gained from this project has helped fill critical knowledge gaps and has directly informed ongoing bat conservation and community engagement efforts in the region.

Introduction:

The Mexican long-nosed bat (*Leptonycteris nivalis*) is listed as endangered in the United States and by the International Union for the Conservation of Nature. Populations of the species have declined by approximately 50% in 15 years, a decline expected to continue without immediate conservation action. Each spring, pregnant females migrate north from central Mexico to give birth to and raise their pups in the northern part of their range, including in the northeast Mexican states of Nuevo León and Coahuila where this project is located. During this journey, they rely on agave nectar for food, and in turn provide critical pollination services for agaves.

Agaves are also important economic and cultural resources for Mexican farmers and communities that harvest them for beverages, fibers, and food. However, loss and fragmentation of agave habitat and therefore the bats' foraging resources is one of the key threats to the species. Current conservation efforts are focusing on augmenting agave populations across the bats' migratory range to counteract these losses and aid in recovery of the species. These efforts, including Bat Conservation International's (BCI's) Agaves for Bats

Restoration Initiative, aim to work directly with local communities that harvest and use agaves. However, there is a critical lack of information about the foraging behavior and requirements of *L. nivalis* particularly in the northern part of its migratory range where two important maternity caves are found and where this study took place (northeast Mexico). In addition, little is known about the uses and management of agaves by rural people in this area and how human use may be affecting agave populations and flowering, as well as the local social contexts of the communities and how proposed conservation actions may affect local people.

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Project Results and Impact:

This project formed the basis of my PhD dissertation which I successfully defended in June 2020. The complete dissertation will be available in August 2020. I used an interdisciplinary approach that combined the natural and social sciences to address the following objectives:

Objective 1 (Determine individual agave and landscape characteristics that provide high quality food resources for bats): My field team and I conducted a bat foraging study by counting bat feeding visits to flowering agaves at night using infrared cameras. At each monitoring site, we also conducted agave population surveys to measure characteristics of individual agaves and the surrounding landscape. From these data, I created generalized linear mixed models of bat visitations as a function of these characteristics and AICc model selection to determine which characteristics are important predictors of bat visitation and should therefore be included in the design of agave programs for bats. In total, we monitored bat foraging at 62 flowering agaves on 46 nights (688 hours) and recorded a total of 26,128 bat feeding visits. Our results showed that bat feeding visitation rate was higher at agaves with more open flowers and at agaves with flowers open lower on the stalk (i.e. agaves in an earlier flowering stage), indicating that both nectar availability and flowering phenology are important considerations when designing agave programs for bats. This information can be used to target specific agave species (e.g. larger agaves with more flowers) in agave planting programs. In addition, results showed that bat feeding visitation rate was higher on focal agaves with higher densities of old/dead standing stalks within 30 meters, indicating that agave programs should leave at least some dead standing stalks on the landscape to attract foraging bats. This foraging study formed the second chapter of my PhD dissertation and will be submitted for publication in a peer-reviewed journal.

Objective 2 (Determine the optimal spatial arrangement of flowering agaves on the landscape to maximize bats' energy efficiency): I initially proposed to use agent-based modeling (ABM) to achieve this objective. When creating an agent-based model, data is required to parameterize and test the model. Unfortunately, with the limited data that was available at the time, I was

not able to pursue this objective. I instead focused on the statistical analyses from Objective 1 to ensure enough data was collected to successfully complete that aspect of the project.

Objective 3 (Identify communities that are most open to participating in agave programs for bats) and Objective 4 (Identify options for creating local support for agave programs for bats): I conducted semi-structured interviews with 52 community leaders and agave harvesters from 13 communities in the study area. I then conducted a thematic analysis of responses to gain an understanding of the current social contexts (economic, political, etc.) of each community, how people use agaves for their livelihoods, how these social factors may affect their willingness to participate in bat/agave programs, and how to design these programs in ways that fit with local social conditions and livelihoods. Our results highlighted several key opportunities to join bat conservation goals with local livelihood goals, including: planting agaves during restoration programs along *bordos* (raised lines of soil around agricultural plots) to help retain soil and water for the crops while providing food for bats and planting agaves as “living fences” around crops to protect them from livestock damage while providing food for bats. One proposed agave augmentation strategy (fencing off areas to protect agaves from livestock damage) was described as potentially detrimental to local livestock-based livelihoods, but through our interviews we identified ways that this strategy could be implemented with minimal negative consequences (i.e. creating small fenced areas in each community that would not impede livestock grazing). These objectives formed the basis of the third and fourth chapters of my PhD dissertation and will be submitted for publication in scientific journals.

Objective 5 (Create educational programming about pollinating bats): I worked with my in-country collaborator organization (Especies, Sociedad y Hábitat, A.C.) to develop an educational program to enhance peoples’ understanding of the ecological and economic importance of pollinating bats and how they can contribute to their conservation. We hosted a bat workshop for a summer camp in Monterrey, Nuevo León, which consisted of approximately 20 middle school girls. We also hosted two “Bat Fests” in Monterrey, which were attended by over 500 people each. The events introduced the public to bats and their ecological and economic importance. We led bat kid’s activities and crafts, gave research presentations, and took attendees on “bat walks” to demonstrate the use of specialized research equipment. I gave a presentation about this project during the Bat Fest.

Overall, this project contributed significantly to the revision of the U.S. Species Status Assessment for the U.S. Fish and Wildlife Service (which I helped revised) and is guiding revision of the Recovery Plan for *L. nivalis* (which I am helping to draft), as well as guiding implementation of Bat Conservation International’s Agaves for Bats restoration initiative.

Lessons Learned:

I finished the last field season of my PhD in summer 2018, with support from the Kate Barlow Award. During 2018 field work, we successfully monitored Mexican long-nosed bats foraging on flowering agaves (Objective 1) and interviewed agaves harvesters and community leaders (Objectives 3 and 4). The Kate Barlow Award supported the rental of a field vehicle and hiring of

local field assistants, both of which were invaluable to completing these objectives. I was able to successfully use the methodology detailed in my grant application, with the exception of Objective 2 (the agent-based modeling objective, due to limited data availability for parameterizing the model). However, I am hoping to pursue this analytical approach in future work.

Our main difficulty in the field was finding flowering agaves to monitor. The timing of flowering can vary year to year based on precipitation and other factors, and in 2018 the blooming was later than in previous years. However, we used some of the “down” time to search for new bat roosting site. With the help of local landowners, we surveyed four abandoned mines and two caves near two known roosts of Mexican long-nosed bats (Rosillo Cave in Coahuila and Infierno Cave in Nuevo Leon). We discovered the threatened Mexican long-tongued bat (*Choeronycteris mexicana*), roosting in two of the caves. The cave that contained *C. mexicana* is often visited by locals and there was much evidence of vandalism (graffiti, trash, etc.). My local collaborators will begin work with the local communities to protect these caves from future disturbance.

One of the most valuable lessons I learned from this project is that flexibility is key to a project’s success. Planning, particularly for field work in remote areas, is vital, but when things don’t go according to plan, you must be able to adjust quickly. We ran into issues such as weather preventing monitoring and difficulty finding suitable agaves to monitor for bats, but we used that “extra” time to survey new caves and mines and ended up discovering several bat roosts, which is important for our future conservation efforts!

Another lesson for those working with local communities is that patience is a must. Sometimes we set up an interview with an agave harvester ahead of time, but when we showed up at that time he wasn’t there. While this is of course frustrating, it is important to remember that you are a guest in the community and it is important that you don’t interfere with their daily needs. This lesson can be applied for anyone working in communities!

Conclusion:

This project filled critical knowledge gaps for implementation of agave restoration programs for the endangered Mexican long-nosed bat, specifically regarding their foraging preferences and the feasibility of implementing agave programs with rural Mexican communities. One of the important aspects of the project was to strengthen the capacity for conservation work and enhance local community interest in bat conservation efforts. Through my work, I contributed to the development of several key groups:

The project also directly supported the professional development of local students. I recruited and trained eight Mexican undergraduate students from the local university (the Universidad Autónoma de Nuevo Leon) on biological research methods. I worked closely with them in the field and trained them on data analysis methods. I have continued to provide mentorship as they have prepared their own Honors thesis papers and presentations for research conferences.

Throughout my project I have worked closely with a local conservation NGO (Especies, Sociedad y Habitat, A.C.) as well as Bat Conservation International to ensure that the work addresses information gaps and conservation needs for the Mexican long-nosed bat and significantly builds local and international capacity for bat conservation. The field work component of my project contributed vital data to inform these organizations' bat conservation efforts. Information gathered from the project contributed to the revision of the Species Status Assessment for *L. nivalis*, which will allow the U.S. Fish and Wildlife Service to complete an updated federal Species Recovery Plan and target federal research and conservation efforts where they are most needed. The SSA provides the basis and support for continued funding for partner organizations like Bat Conservation International and is an integral component of building their capacity to effectively, conduct evidence-based conservation work. The SSA is helping guide BCI's Agaves for Bats initiative and their range-wide conservation plan.

My Mexican collaborators and I also hosted a symposium on pollinating bats and their conservation in northeast Mexico for Protected Area managers, environmental NGOs, communities, and other stakeholders in July 2018. 45 people attended from 19 organizations. Through this event we garnered significant interest in conducting collaborative research and conservation for pollinating bats in the future. We followed up this meeting with a species recovery planning meeting in May 2019, during which we detailed specific priority actions for conservation of the Mexican long-nosed bat. Finally, we hosted an agave seed collection workshop in fall 2019, during which we provided training on proper collection, cataloguing, and storage of agave seeds. This was an important first step in our Agaves for Bats initiative. With this training, members of ESHAC will now go into local communities to train them on how to collect and plant their own agave seeds for sustainable propagation and use of agaves.

I am excited that I will be joining BCI as the Endangered Species Specialist leading the Agaves for Bats initiative, through which I will be able to continue and expand upon the work from this project. Throughout my field work in Mexico, I established connections with people in the local communities, who are excited to participate in the Agaves for Bats initiative. The work I completed with support from the Kate Barlow Award laid the groundwork for successful ongoing conservation efforts and engagement with local communities, and I am excited to take these conservation efforts to the next level.